

Framework for Improving Critical Infrastructure Cybersecurity

Version 1.1

National Institute of Standards and Technology

April 16, 2018

Note to Readers on the Update

Version 1.1 of this Cybersecurity Framework refines, clarifies, and enhances Version 1.0, which was issued in February 2014. It incorporates comments received on the two drafts of Version 1.1.

Version 1.1 is intended to be implemented by first-time and current Framework users. Current users should be able to implement Version 1.1 with minimal or no disruption; compatibility with Version 1.0 has been an explicit objective.

The following table summarizes the changes made between Version 1.0 and Version 1.1.

Table NTR-1 - Summary of changes between Framework Version 1.0 and Version 1.1.

Update	Description of Update
Clarified that terms like “compliance” can be confusing and mean something very different to various Framework stakeholders	Added clarity that the Framework has utility as a structure and language for organizing and expressing compliance with an organization’s own cybersecurity requirements. However, the variety of ways in which the Framework can be used by an organization means that phrases like “compliance with the Framework” can be confusing.
A new section on self-assessment	Added Section 4.0 <i>Self-Assessing Cybersecurity Risk with the Framework</i> to explain how the Framework can be used by organizations to understand and assess their cybersecurity risk, including the use of measurements.
Greatly expanded explanation of using Framework for Cyber Supply Chain Risk Management purposes	An expanded Section 3.3 <i>Communicating Cybersecurity Requirements with Stakeholders</i> helps users better understand Cyber Supply Chain Risk Management (SCRM), while a new Section 3.4 Buying Decisions highlights use of the Framework in understanding risk associated with commercial off-the-shelf products and services. Additional Cyber SCRM criteria were added to the Implementation Tiers. Finally, a Supply Chain Risk Management Category, including multiple Subcategories, has been added to the Framework Core.
Refinements to better account for authentication, authorization, and identity proofing	The language of the Access Control Category has been refined to better account for authentication, authorization, and identity proofing. This included adding one Subcategory each for Authentication and Identity Proofing. Also, the Category has been renamed to Identity Management and Access Control (PR.AC) to better represent the scope of the Category and corresponding Subcategories.
Better explanation of the relationship between Implementation Tiers and Profiles	Added language to Section 3.2 <i>Establishing or Improving a Cybersecurity Program</i> on using Framework Tiers in Framework implementation. Added language to Framework Tiers to reflect integration of Framework considerations within organizational risk management programs. The Framework Tier concepts were also refined. Updated Figure 2.0 to include actions from the Framework Tiers.

Consideration of Coordinated Vulnerability Disclosure	A Subcategory related to the vulnerability disclosure lifecycle was added.
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As with Version 1.0, Version 1.1 users are encouraged to customize the Framework to maximize individual organizational value.

Acknowledgements

This publication is the result of an ongoing collaborative effort involving industry, academia, and government. The National Institute of Standards and Technology (NIST) launched the project by convening private- and public-sector organizations and individuals in 2013. Published in 2014 and revised during 2017 and 2018, this *Framework for Improving Critical Infrastructure Cybersecurity* has relied upon eight public workshops, multiple Requests for Comment or Information, and thousands of direct interactions with stakeholders from across all sectors of the United States along with many sectors from around the world.

The impetus to change Version 1.0 and the changes that appear in this Version 1.1 were based on:

- Feedback and frequently asked questions to NIST since release of Framework Version 1.0;
- [105 responses](#) to the December 2015 request for information (RFI), [Views on the Framework for Improving Critical Infrastructure Cybersecurity](#);
- Over [85 comments](#) on a December 5, 2017 proposed [second draft of Version 1.1](#);
- Over [120 comments](#) on a January 10, 2017, proposed [first draft Version 1.1](#); and
- Input from over 1,200 attendees at the [2016](#) and [2017](#) Framework workshops.

In addition, NIST previously released Version 1.0 of the Cybersecurity Framework with a companion document, [NIST Roadmap for Improving Critical Infrastructure Cybersecurity](#). This Roadmap highlighted key “areas of improvement” for further development, alignment, and collaboration. Through private and public-sector efforts, some areas of improvement have advanced enough to be included in this Framework Version 1.1.

NIST acknowledges and thanks all of those who have contributed to this Framework.

Executive Summary

The United States depends on the reliable functioning of critical infrastructure. Cybersecurity threats exploit the increased complexity and connectivity of critical infrastructure systems, placing the Nation's security, economy, and public safety and health at risk. Similar to financial and reputational risks, cybersecurity risk affects a company's bottom line. It can drive up costs and affect revenue. It can harm an organization's ability to innovate and to gain and maintain customers. Cybersecurity can be an important and amplifying component of an organization's overall risk management.

To better address these risks, the Cybersecurity Enhancement Act of 2014¹ (CEA) updated the role of the National Institute of Standards and Technology (NIST) to include identifying and developing cybersecurity risk frameworks for voluntary use by critical infrastructure owners and operators. Through CEA, NIST must identify "a prioritized, flexible, repeatable, performance-based, and cost-effective approach, including information security measures and controls that may be voluntarily adopted by owners and operators of critical infrastructure to help them identify, assess, and manage cyber risks." This formalized NIST's previous work developing Framework Version 1.0 under Executive Order (EO) 13636, "Improving Critical Infrastructure Cybersecurity" (February 2013), and provided guidance for future Framework evolution. The Framework that was developed under EO 13636, and continues to evolve according to CEA, uses a common language to address and manage cybersecurity risk in a cost-effective way based on business and organizational needs without placing additional regulatory requirements on businesses.

The Framework focuses on using business drivers to guide cybersecurity activities and considering cybersecurity risks as part of the organization's risk management processes. The Framework consists of three parts: the Framework Core, the Implementation Tiers, and the Framework Profiles. The Framework Core is a set of cybersecurity activities, outcomes, and informative references that are common across sectors and critical infrastructure. Elements of the Core provide detailed guidance for developing individual organizational Profiles. Through use of Profiles, the Framework will help an organization to align and prioritize its cybersecurity activities with its business/mission requirements, risk tolerances, and resources. The Tiers provide a mechanism for organizations to view and understand the characteristics of their approach to managing cybersecurity risk, which will help in prioritizing and achieving cybersecurity objectives.

While this document was developed to improve cybersecurity risk management in critical infrastructure, the Framework can be used by organizations in any sector or community. The Framework enables organizations – regardless of size, degree of cybersecurity risk, or cybersecurity sophistication – to apply the principles and best practices of risk management to improving security and resilience.

The Framework provides a common organizing structure for multiple approaches to cybersecurity by assembling standards, guidelines, and practices that are working effectively today. Moreover, because it references globally recognized standards for cybersecurity, the

¹See 15 U.S.C. § 272(e)(1)(A)(i). The Cybersecurity Enhancement Act of 2014 (S.1353) became public law 113-274 on December 18, 2014 and may be found at: <https://www.congress.gov/bill/113th-congress/senate-bill/1353/text>.

Framework can serve as a model for international cooperation on strengthening cybersecurity in critical infrastructure as well as other sectors and communities.

The Framework offers a flexible way to address cybersecurity, including cybersecurity's effect on physical, cyber, and people dimensions. It is applicable to organizations relying on technology, whether their cybersecurity focus is primarily on information technology (IT), industrial control systems (ICS), cyber-physical systems (CPS), or connected devices more generally, including the Internet of Things (IoT). The Framework can assist organizations in addressing cybersecurity as it affects the privacy of customers, employees, and other parties. Additionally, the Framework's outcomes serve as targets for workforce development and evolution activities.

The Framework is not a one-size-fits-all approach to managing cybersecurity risk for critical infrastructure. Organizations will continue to have unique risks – different threats, different vulnerabilities, different risk tolerances. They also will vary in how they customize practices described in the Framework. Organizations can determine activities that are important to critical service delivery and can prioritize investments to maximize the impact of each dollar spent. Ultimately, the Framework is aimed at reducing and better managing cybersecurity risks.

To account for the unique cybersecurity needs of organizations, there are a wide variety of ways to use the Framework. The decision about how to apply it is left to the implementing organization. For example, one organization may choose to use the Framework Implementation Tiers to articulate envisioned risk management practices. Another organization may use the Framework's five Functions to analyze its entire risk management portfolio; that analysis may or may not rely on more detailed companion guidance, such as controls catalogs. There sometimes is discussion about “compliance” with the Framework, and the Framework has utility as a structure and language for organizing and expressing compliance with an organization’s own cybersecurity requirements. Nevertheless, the variety of ways in which the Framework can be used by an organization means that phrases like “compliance with the Framework” can be confusing and mean something very different to various stakeholders.

The Framework is a living document and will continue to be updated and improved as industry provides feedback on implementation. NIST will continue coordinating with the private sector and government agencies at all levels. As the Framework is put into greater practice, additional lessons learned will be integrated into future versions. This will ensure the Framework is meeting the needs of critical infrastructure owners and operators in a dynamic and challenging environment of new threats, risks, and solutions.

Expanded and more effective use and sharing of best practices of this voluntary Framework are the next steps to improve the cybersecurity of our Nation’s critical infrastructure – providing evolving guidance for individual organizations while increasing the cybersecurity posture of the Nation’s critical infrastructure and the broader economy and society.

Table of Contents

Note to Readers on the Update	ii
Acknowledgements	iv
Executive Summary	v
1.0 Framework Introduction	1
2.0 Framework Basics.....	6
3.0 How to Use the Framework	13
4.0 Self-Assessing Cybersecurity Risk with the Framework.....	20
Appendix A: Framework Core.....	22
Appendix B: Glossary	45
Appendix C: Acronyms	48

List of Figures

Figure 1: Framework Core Structure	6
Figure 2: Notional Information and Decision Flows within an Organization	12
Figure 3: Cyber Supply Chain Relationships.....	17

List of Tables

Table 1: Function and Category Unique Identifiers	23
Table 2: Framework Core	24
Table 3: Framework Glossary.....	45

1.0 Framework Introduction

The United States depends on the reliable functioning of its critical infrastructure. Cybersecurity threats exploit the increased complexity and connectivity of critical infrastructure systems, placing the Nation's security, economy, and public safety and health at risk. Similar to financial and reputational risks, cybersecurity risk affects a company's bottom line. It can drive up costs and affect revenue. It can harm an organization's ability to innovate and to gain and maintain customers. Cybersecurity can be an important and amplifying component of an organization's overall risk management.

To strengthen the resilience of this infrastructure, the Cybersecurity Enhancement Act of 2014² (CEA) updated the role of the National Institute of Standards and Technology (NIST) to "facilitate and support the development of" cybersecurity risk frameworks. Through CEA, NIST must identify "a prioritized, flexible, repeatable, performance-based, and cost-effective approach, including information security measures and controls that may be voluntarily adopted by owners and operators of critical infrastructure to help them identify, assess, and manage cyber risks." This formalized NIST's previous work developing Framework Version 1.0 under Executive Order 13636, "Improving Critical Infrastructure Cybersecurity," issued in February 2013³, and provided guidance for future Framework evolution.

Critical infrastructure⁴ is defined in the U.S. Patriot Act of 2001⁵ as "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters." Due to the increasing pressures from external and internal threats, organizations responsible for critical infrastructure need to have a consistent and iterative approach to identifying, assessing, and managing cybersecurity risk. This approach is necessary regardless of an organization's size, threat exposure, or cybersecurity sophistication today.

The critical infrastructure community includes public and private owners and operators, and other entities with a role in securing the Nation's infrastructure. Members of each critical infrastructure sector perform functions that are supported by the broad category of technology, including information technology (IT), industrial control systems (ICS), cyber-physical systems (CPS), and connected devices more generally, including the Internet of Things (IoT). This reliance on technology, communication, and interconnectivity has changed and expanded the potential vulnerabilities and increased potential risk to operations. For example, as technology and the data it produces and processes are increasingly used to deliver critical services and support business/mission decisions, the potential impacts of a cybersecurity incident on an

² See 15 U.S.C. § 272(e)(1)(A)(i). The Cybersecurity Enhancement Act of 2014 (S.1353) became public law 113-274 on December 18, 2014 and may be found at: <https://www.congress.gov/bill/113th-congress/senate-bill/1353/text>.

³ Executive Order no. 13636, *Improving Critical Infrastructure Cybersecurity*, DCPD-201300091, February 12, 2013. <https://www.gpo.gov/fdsys/pkg/CFR-2014-title3-vol1/pdf/CFR-2014-title3-vol1-eo13636.pdf>

⁴ The Department of Homeland Security (DHS) Critical Infrastructure program provides a listing of the sectors and their associated critical functions and value chains. <http://www.dhs.gov/critical-infrastructure-sectors>

⁵ See 42 U.S.C. § 5195c(e)). The U.S. Patriot Act of 2001 (H.R.3162) became public law 107-56 on October 26, 2001 and may be found at: <https://www.congress.gov/bill/107th-congress/house-bill/3162>

organization, the health and safety of individuals, the environment, communities, and the broader economy and society should be considered.

To manage cybersecurity risks, a clear understanding of the organization's business drivers and security considerations specific to its use of technology is required. Because each organization's risks, priorities, and systems are unique, the tools and methods used to achieve the outcomes described by the Framework will vary.

Recognizing the role that the protection of privacy and civil liberties plays in creating greater public trust, the Framework includes a methodology to protect individual privacy and civil liberties when critical infrastructure organizations conduct cybersecurity activities. Many organizations already have processes for addressing privacy and civil liberties. The methodology is designed to complement such processes and provide guidance to facilitate privacy risk management consistent with an organization's approach to cybersecurity risk management. Integrating privacy and cybersecurity can benefit organizations by increasing customer confidence, enabling more standardized sharing of information, and simplifying operations across legal regimes.

The Framework remains effective and supports technical innovation because it is technology neutral, while also referencing a variety of existing standards, guidelines, and practices that evolve with technology. By relying on those global standards, guidelines, and practices developed, managed, and updated by industry, the tools and methods available to achieve the Framework outcomes will scale across borders, acknowledge the global nature of cybersecurity risks, and evolve with technological advances and business requirements. The use of existing and emerging standards will enable economies of scale and drive the development of effective products, services, and practices that meet identified market needs. Market competition also promotes faster diffusion of these technologies and practices and realization of many benefits by the stakeholders in these sectors.

Building from those standards, guidelines, and practices, the Framework provides a common taxonomy and mechanism for organizations to:

- 1) Describe their current cybersecurity posture;
- 2) Describe their target state for cybersecurity;
- 3) Identify and prioritize opportunities for improvement within the context of a continuous and repeatable process;
- 4) Assess progress toward the target state;
- 5) Communicate among internal and external stakeholders about cybersecurity risk.

The Framework is not a one-size-fits-all approach to managing cybersecurity risk for critical infrastructure. Organizations will continue to have unique risks – different threats, different vulnerabilities, different risk tolerances. They also will vary in how they customize practices described in the Framework. Organizations can determine activities that are important to critical service delivery and can prioritize investments to maximize the impact of each dollar spent. Ultimately, the Framework is aimed at reducing and better managing cybersecurity risks.

To account for the unique cybersecurity needs of organizations, there are a wide variety of ways to use the Framework. The decision about how to apply it is left to the implementing organization. For example, one organization may choose to use the Framework Implementation Tiers to articulate envisioned risk management practices. Another organization may use the Framework’s five Functions to analyze its entire risk management portfolio; that analysis may or may not rely on more detailed companion guidance, such as controls catalogs. There sometimes is discussion about “compliance” with the Framework, and the Framework has utility as a structure and language for organizing and expressing compliance with an organization’s own cybersecurity requirements. Nevertheless, the variety of ways in which the Framework can be used by an organization means that phrases like “compliance with the Framework” can be confusing and mean something very different to various stakeholders.

The Framework complements, and does not replace, an organization’s risk management process and cybersecurity program. The organization can use its current processes and leverage the Framework to identify opportunities to strengthen and communicate its management of cybersecurity risk while aligning with industry practices. Alternatively, an organization without an existing cybersecurity program can use the Framework as a reference to establish one.

While the Framework has been developed to improve cybersecurity risk management as it relates to critical infrastructure, it can be used by organizations in any sector of the economy or society. It is intended to be useful to companies, government agencies, and not-for-profit organizations regardless of their focus or size. The common taxonomy of standards, guidelines, and practices that it provides also is not country-specific. Organizations outside the United States may also use the Framework to strengthen their own cybersecurity efforts, and the Framework can contribute to developing a common language for international cooperation on critical infrastructure cybersecurity.

1.1 Overview of the Framework

The Framework is a risk-based approach to managing cybersecurity risk, and is composed of three parts: the Framework Core, the Framework Implementation Tiers, and the Framework Profiles. Each Framework component reinforces the connection between business/mission drivers and cybersecurity activities. These components are explained below.

- The *Framework Core* is a set of cybersecurity activities, desired outcomes, and applicable references that are common across critical infrastructure sectors. The Core presents industry standards, guidelines, and practices in a manner that allows for communication of cybersecurity activities and outcomes across the organization from the executive level to the implementation/operations level. The Framework Core consists of five concurrent and continuous Functions—Identify, Protect, Detect, Respond, Recover. When considered together, these Functions provide a high-level, strategic view of the lifecycle of an organization’s management of cybersecurity risk. The Framework Core then identifies underlying key Categories and Subcategories – which are discrete outcomes – for each Function, and matches them with example Informative References such as existing standards, guidelines, and practices for each Subcategory.
- *Framework Implementation Tiers* (“Tiers”) provide context on how an organization views cybersecurity risk and the processes in place to manage that risk. Tiers describe the degree to which an organization’s cybersecurity risk management practices exhibit the

characteristics defined in the Framework (e.g., risk and threat aware, repeatable, and adaptive). The Tiers characterize an organization’s practices over a range, from Partial (Tier 1) to Adaptive (Tier 4). These Tiers reflect a progression from informal, reactive responses to approaches that are agile and risk-informed. During the Tier selection process, an organization should consider its current risk management practices, threat environment, legal and regulatory requirements, business/mission objectives, and organizational constraints.

- A *Framework Profile* (“Profile”) represents the outcomes based on business needs that an organization has selected from the Framework Categories and Subcategories. The Profile can be characterized as the alignment of standards, guidelines, and practices to the Framework Core in a particular implementation scenario. Profiles can be used to identify opportunities for improving cybersecurity posture by comparing a “Current” Profile (the “as is” state) with a “Target” Profile (the “to be” state). To develop a Profile, an organization can review all of the Categories and Subcategories and, based on business/mission drivers and a risk assessment, determine which are most important; it can add Categories and Subcategories as needed to address the organization’s risks. The Current Profile can then be used to support prioritization and measurement of progress toward the Target Profile, while factoring in other business needs including cost-effectiveness and innovation. Profiles can be used to conduct self-assessments and communicate within an organization or between organizations.

1.2 Risk Management and the Cybersecurity Framework

Risk management is the ongoing process of identifying, assessing, and responding to risk. To manage risk, organizations should understand the likelihood that an event will occur and the potential resulting impacts. With this information, organizations can determine the acceptable level of risk for achieving their organizational objectives and can express this as their risk tolerance.

With an understanding of risk tolerance, organizations can prioritize cybersecurity activities, enabling organizations to make informed decisions about cybersecurity expenditures.

Implementation of risk management programs offers organizations the ability to quantify and communicate adjustments to their cybersecurity programs. Organizations may choose to handle risk in different ways, including mitigating the risk, transferring the risk, avoiding the risk, or accepting the risk, depending on the potential impact to the delivery of critical services. The Framework uses risk management processes to enable organizations to inform and prioritize decisions regarding cybersecurity. It supports recurring risk assessments and validation of business drivers to help organizations select target states for cybersecurity activities that reflect desired outcomes. Thus, the Framework gives organizations the ability to dynamically select and direct improvement in cybersecurity risk management for the IT and ICS environments.

The Framework is adaptive to provide a flexible and risk-based implementation that can be used with a broad array of cybersecurity risk management processes. Examples of cybersecurity risk management processes include International Organization for Standardization (ISO)

31000:2009⁶, ISO/International Electrotechnical Commission (IEC) 27005:2011⁷, NIST Special Publication (SP) 800-39⁸, and the *Electricity Subsector Cybersecurity Risk Management Process* (RMP) guideline⁹.

1.3 Document Overview

The remainder of this document contains the following sections and appendices:

- [Section 2](#) describes the Framework components: the Framework Core, the Tiers, and the Profiles.
- [Section 3](#) presents examples of how the Framework can be used.
- [Section 4](#) describes how to use the Framework for self-assessing and demonstrating cybersecurity through measurements.
- [Appendix A](#) presents the Framework Core in a tabular format: the Functions, Categories, Subcategories, and Informative References.
- [Appendix B](#) contains a glossary of selected terms.
- [Appendix C](#) lists acronyms used in this document.

⁶ International Organization for Standardization, *Risk management – Principles and guidelines*, ISO 31000:2009, 2009. <http://www.iso.org/iso/home/standards/iso31000.htm>

⁷ International Organization for Standardization/International Electrotechnical Commission, *Information technology – Security techniques – Information security risk management*, ISO/IEC 27005:2011, 2011. <https://www.iso.org/standard/56742.html>

⁸ Joint Task Force Transformation Initiative, *Managing Information Security Risk: Organization, Mission, and Information System View*, NIST Special Publication 800-39, March 2011. <https://doi.org/10.6028/NIST.SP.800-39>

⁹ U.S. Department of Energy, *Electricity Subsector Cybersecurity Risk Management Process*, DOE/OE-0003, May 2012. <https://energy.gov/sites/prod/files/Cybersecurity%20Risk%20Management%20Process%20Guideline%20-%20Final%20-%20May%202012.pdf>

2.0 Framework Basics

The Framework provides a common language for understanding, managing, and expressing cybersecurity risk to internal and external stakeholders. It can be used to help identify and prioritize actions for reducing cybersecurity risk, and it is a tool for aligning policy, business, and technological approaches to managing that risk. It can be used to manage cybersecurity risk across entire organizations or it can be focused on the delivery of critical services within an organization. Different types of entities – including sector coordinating structures, associations, and organizations – can use the Framework for different purposes, including the creation of common Profiles.

2.1 Framework Core

The *Framework Core* provides a set of activities to achieve specific cybersecurity *outcomes*, and references examples of guidance to achieve those outcomes. The Core is not a checklist of actions to perform. It presents key cybersecurity outcomes identified by stakeholders as helpful in managing cybersecurity risk. The Core comprises four elements: Functions, Categories, Subcategories, and Informative References, depicted in **Figure 1**:

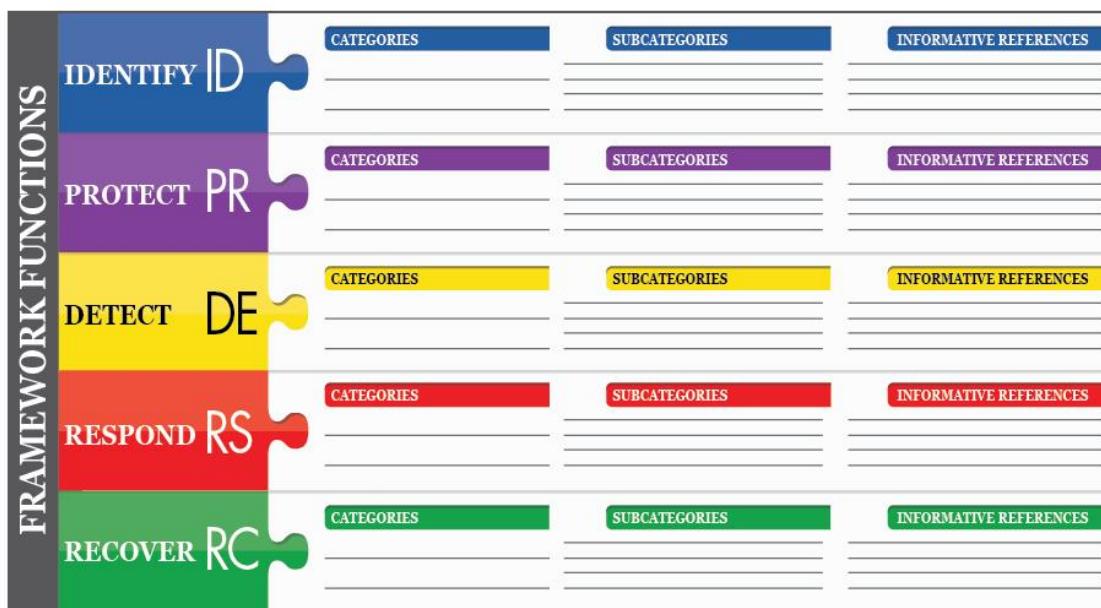


Figure 1: Framework Core Structure

The Framework Core elements work together as follows:

- **Functions** organize basic cybersecurity activities at their highest level. These Functions are Identify, Protect, Detect, Respond, and Recover. They aid an organization in expressing its management of cybersecurity risk by organizing information, enabling risk management decisions, addressing threats, and improving by learning from previous activities. The Functions also align with existing methodologies for incident management and help show the impact of investments in cybersecurity. For example, investments in planning and exercises support timely response and recovery actions, resulting in reduced impact to the delivery of services.

- **Categories** are the subdivisions of a Function into groups of cybersecurity outcomes closely tied to programmatic needs and particular activities. Examples of Categories include “Asset Management,” “Identity Management and Access Control,” and “Detection Processes.”
- **Subcategories** further divide a Category into specific outcomes of technical and/or management activities. They provide a set of results that, while not exhaustive, help support achievement of the outcomes in each Category. Examples of Subcategories include “External information systems are catalogued,” “Data-at-rest is protected,” and “Notifications from detection systems are investigated.”
- **Informative References** are specific sections of standards, guidelines, and practices common among critical infrastructure sectors that illustrate a method to achieve the outcomes associated with each Subcategory. The Informative References presented in the Framework Core are illustrative and not exhaustive. They are based upon cross-sector guidance most frequently referenced during the Framework development process.

The five Framework Core Functions are defined below. These Functions are not intended to form a serial path or lead to a static desired end state. Rather, the Functions should be performed concurrently and continuously to form an operational culture that addresses the dynamic cybersecurity risk. See [Appendix A](#) for the complete Framework Core listing.

- **Identify** – Develop an organizational understanding to manage cybersecurity risk to systems, people, assets, data, and capabilities.

The activities in the Identify Function are foundational for effective use of the Framework. Understanding the business context, the resources that support critical functions, and the related cybersecurity risks enables an organization to focus and prioritize its efforts, consistent with its risk management strategy and business needs. Examples of outcome Categories within this Function include: Asset Management; Business Environment; Governance; Risk Assessment; and Risk Management Strategy.
- **Protect** – Develop and implement appropriate safeguards to ensure delivery of critical services.

The Protect Function supports the ability to limit or contain the impact of a potential cybersecurity event. Examples of outcome Categories within this Function include: Identity Management and Access Control; Awareness and Training; Data Security; Information Protection Processes and Procedures; Maintenance; and Protective Technology.
- **Detect** – Develop and implement appropriate activities to identify the occurrence of a cybersecurity event.

The Detect Function enables timely discovery of cybersecurity events. Examples of outcome Categories within this Function include: Anomalies and Events; Security Continuous Monitoring; and Detection Processes.

- **Respond** – Develop and implement appropriate activities to take action regarding a detected cybersecurity incident.
The Respond Function supports the ability to contain the impact of a potential cybersecurity incident. Examples of outcome Categories within this Function include: Response Planning; Communications; Analysis; Mitigation; and Improvements.
- **Recover** – Develop and implement appropriate activities to maintain plans for resilience and to restore any capabilities or services that were impaired due to a cybersecurity incident.
The Recover Function supports timely recovery to normal operations to reduce the impact from a cybersecurity incident. Examples of outcome Categories within this Function include: Recovery Planning; Improvements; and Communications.

2.2 Framework Implementation Tiers

The Framework Implementation Tiers (“Tiers”) provide context on how an organization views cybersecurity risk and the processes in place to manage that risk. Ranging from Partial (Tier 1) to Adaptive (Tier 4), Tiers describe an increasing degree of rigor and sophistication in cybersecurity risk management practices. They help determine the extent to which cybersecurity risk management is informed by business needs and is integrated into an organization’s overall risk management practices. Risk management considerations include many aspects of cybersecurity, including the degree to which privacy and civil liberties considerations are integrated into an organization’s management of cybersecurity risk and potential risk responses.

The Tier selection process considers an organization’s current risk management practices, threat environment, legal and regulatory requirements, information sharing practices, business/mission objectives, supply chain cybersecurity requirements, and organizational constraints.

Organizations should determine the desired Tier, ensuring that the selected level meets the organizational goals, is feasible to implement, and reduces cybersecurity risk to critical assets and resources to levels acceptable to the organization. Organizations should consider leveraging external guidance obtained from Federal government departments and agencies, Information Sharing and Analysis Centers (ISACs), Information Sharing and Analysis Organizations (ISAOs), existing maturity models, or other sources to assist in determining their desired tier.

While organizations identified as Tier 1 (Partial) are encouraged to consider moving toward Tier 2 or greater, Tiers do not represent maturity levels. Tiers are meant to support organizational decision making about how to manage cybersecurity risk, as well as which dimensions of the organization are higher priority and could receive additional resources. Progression to higher Tiers is encouraged when a cost-benefit analysis indicates a feasible and cost-effective reduction of cybersecurity risk.

Successful implementation of the Framework is based upon achieving the outcomes described in the organization's Target Profile(s) and not upon Tier determination. Still, Tier selection and designation naturally affect Framework Profiles. The Tier recommendation by Business/Process Level managers, as approved by the Senior Executive Level, will help set the overall tone for how cybersecurity risk will be managed within the organization, and should influence prioritization within a Target Profile and assessments of progress in addressing gaps.

The Tier definitions are as follows:

Tier 1: Partial

- *Risk Management Process* – Organizational cybersecurity risk management practices are not formalized, and risk is managed in an *ad hoc* and sometimes reactive manner. Prioritization of cybersecurity activities may not be directly informed by organizational risk objectives, the threat environment, or business/mission requirements.
- *Integrated Risk Management Program* – There is limited awareness of cybersecurity risk at the organizational level. The organization implements cybersecurity risk management on an irregular, case-by-case basis due to varied experience or information gained from outside sources. The organization may not have processes that enable cybersecurity information to be shared within the organization.
- *External Participation* – The organization does not understand its role in the larger ecosystem with respect to either its dependencies or dependents. The organization does not collaborate with or receive information (e.g., threat intelligence, best practices, technologies) from other entities (e.g., buyers, suppliers, dependencies, dependents, ISAOs, researchers, governments), nor does it share information. The organization is generally unaware of the cyber supply chain risks of the products and services it provides and that it uses.

Tier 2: Risk Informed

- *Risk Management Process* – Risk management practices are approved by management but may not be established as organizational-wide policy. Prioritization of cybersecurity activities and protection needs is directly informed by organizational risk objectives, the threat environment, or business/mission requirements.
- *Integrated Risk Management Program* – There is an awareness of cybersecurity risk at the organizational level, but an organization-wide approach to managing cybersecurity risk has not been established. Cybersecurity information is shared within the organization on an informal basis. Consideration of cybersecurity in organizational objectives and programs may occur at some but not all levels of the organization. Cyber risk assessment of organizational and external assets occurs, but is not typically repeatable or reoccurring.
- *External Participation* – Generally, the organization understands its role in the larger ecosystem with respect to either its own dependencies or dependents, but not both. The organization collaborates with and receives some information from other entities and generates some of its own information, but may not share information with others. Additionally, the organization is aware of the cyber supply chain risks associated with the products and services it provides and uses, but does not act consistently or formally upon those risks.

Tier 3: Repeatable

- *Risk Management Process* – The organization’s risk management practices are formally approved and expressed as policy. Organizational cybersecurity practices are regularly updated based on the application of risk management processes to changes in business/mission requirements and a changing threat and technology landscape.
- *Integrated Risk Management Program* – There is an organization-wide approach to manage cybersecurity risk. Risk-informed policies, processes, and procedures are defined, implemented as intended, and reviewed. Consistent methods are in place to respond effectively to changes in risk. Personnel possess the knowledge and skills to perform their appointed roles and responsibilities. The organization consistently and accurately monitors cybersecurity risk of organizational assets. Senior cybersecurity and non-cybersecurity executives communicate regularly regarding cybersecurity risk. Senior executives ensure consideration of cybersecurity through all lines of operation in the organization.
- *External Participation* - The organization understands its role, dependencies, and dependents in the larger ecosystem and may contribute to the community’s broader understanding of risks. It collaborates with and receives information from other entities regularly that complements internally generated information, and shares information with other entities. The organization is aware of the cyber supply chain risks associated with the products and services it provides and that it uses. Additionally, it usually acts formally upon those risks, including mechanisms such as written agreements to communicate baseline requirements, governance structures (e.g., risk councils), and policy implementation and monitoring.

Tier 4: Adaptive

- *Risk Management Process* – The organization adapts its cybersecurity practices based on previous and current cybersecurity activities, including lessons learned and predictive indicators. Through a process of continuous improvement incorporating advanced cybersecurity technologies and practices, the organization actively adapts to a changing threat and technology landscape and responds in a timely and effective manner to evolving, sophisticated threats.
- *Integrated Risk Management Program* – There is an organization-wide approach to managing cybersecurity risk that uses risk-informed policies, processes, and procedures to address potential cybersecurity events. The relationship between cybersecurity risk and organizational objectives is clearly understood and considered when making decisions. Senior executives monitor cybersecurity risk in the same context as financial risk and other organizational risks. The organizational budget is based on an understanding of the current and predicted risk environment and risk tolerance. Business units implement executive vision and analyze system-level risks in the context of the organizational risk tolerances. Cybersecurity risk management is part of the organizational culture and evolves from an awareness of previous activities and continuous awareness of activities on their systems and networks. The organization can quickly and efficiently account for changes to business/mission objectives in how risk is approached and communicated.

- *External Participation* - The organization understands its role, dependencies, and dependents in the larger ecosystem and contributes to the community's broader understanding of risks. It receives, generates, and reviews prioritized information that informs continuous analysis of its risks as the threat and technology landscapes evolve. The organization shares that information internally and externally with other collaborators. The organization uses real-time or near real-time information to understand and consistently act upon cyber supply chain risks associated with the products and services it provides and that it uses. Additionally, it communicates proactively, using formal (e.g. agreements) and informal mechanisms to develop and maintain strong supply chain relationships.

2.3 Framework Profile

The Framework Profile (“Profile”) is the alignment of the Functions, Categories, and Subcategories with the business requirements, risk tolerance, and resources of the organization. A Profile enables organizations to establish a roadmap for reducing cybersecurity risk that is well aligned with organizational and sector goals, considers legal/regulatory requirements and industry best practices, and reflects risk management priorities. Given the complexity of many organizations, they may choose to have multiple profiles, aligned with particular components and recognizing their individual needs.

Framework Profiles can be used to describe the current state or the desired target state of specific cybersecurity activities. The Current Profile indicates the cybersecurity outcomes that are currently being achieved. The Target Profile indicates the outcomes needed to achieve the desired cybersecurity risk management goals. Profiles support business/mission requirements and aid in communicating risk within and between organizations. This Framework does not prescribe Profile templates, allowing for flexibility in implementation.

Comparison of Profiles (e.g., the Current Profile and Target Profile) may reveal gaps to be addressed to meet cybersecurity risk management objectives. An action plan to address these gaps to fulfill a given Category or Subcategory can contribute to the roadmap described above. Prioritizing the mitigation of gaps is driven by the organization’s business needs and risk management processes. This risk-based approach enables an organization to gauge the resources needed (e.g., staffing, funding) to achieve cybersecurity goals in a cost-effective, prioritized manner. Furthermore, the Framework is a risk-based approach where the applicability and fulfillment of a given Subcategory is subject to the Profile’s scope.

2.4 Coordination of Framework Implementation

Figure 2 describes a common flow of information and decisions at the following levels within an organization:

- Executive
- Business/Process
- Implementation/Operations

The executive level communicates the mission priorities, available resources, and overall risk tolerance to the business/process level. The business/process level uses the information as inputs into the risk management process, and then collaborates with the implementation/operations level to communicate business needs and create a Profile. The implementation/operations level communicates the Profile implementation progress to the business/process level. The business/process level management reports the outcomes of that impact assessment to the executive level to inform the organization's overall risk management process and to the implementation/operations level for awareness of business impact.

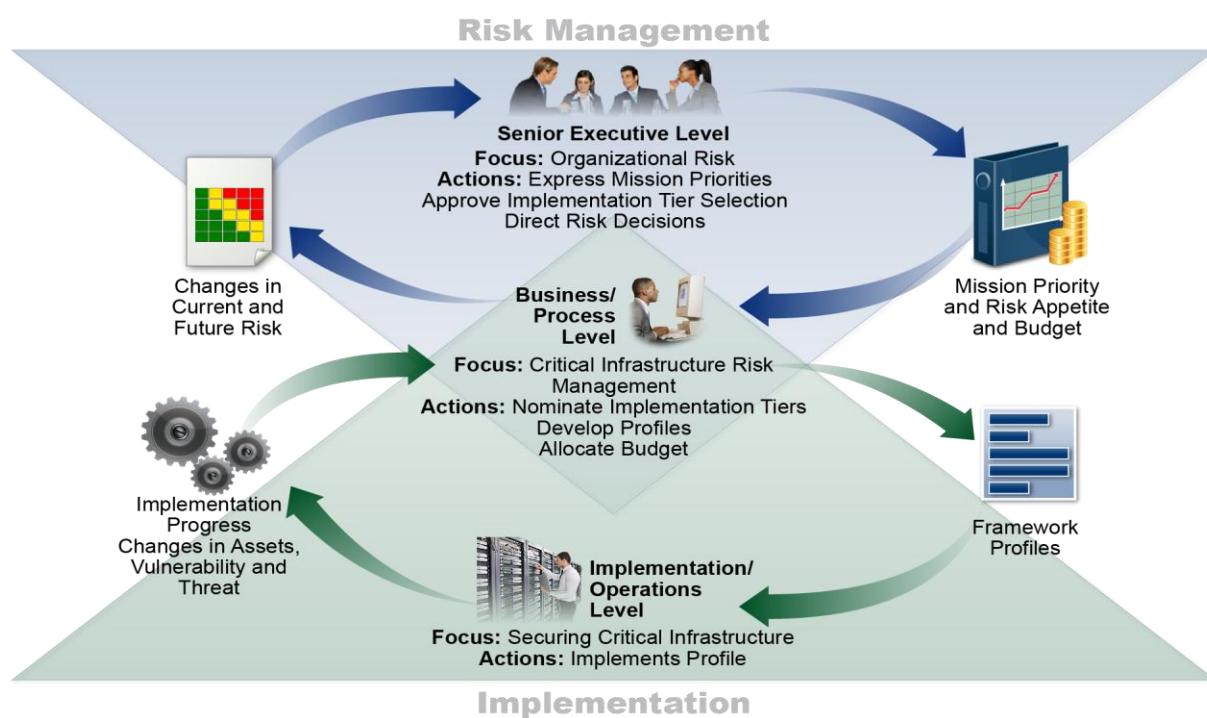


Figure 2: Notional Information and Decision Flows within an Organization

3.0 How to Use the Framework

An organization can use the Framework as a key part of its systematic process for identifying, assessing, and managing cybersecurity risk. The Framework is not designed to replace existing processes; an organization can use its current process and overlay it onto the Framework to determine gaps in its current cybersecurity risk approach and develop a roadmap to improvement. Using the Framework as a cybersecurity risk management tool, an organization can determine activities that are most important to critical service delivery and prioritize expenditures to maximize the impact of the investment.

The Framework is designed to complement existing business and cybersecurity operations. It can serve as the foundation for a new cybersecurity program or a mechanism for improving an existing program. The Framework provides a means of expressing cybersecurity requirements to business partners and customers and can help identify gaps in an organization's cybersecurity practices. It also provides a general set of considerations and processes for considering privacy and civil liberties implications in the context of a cybersecurity program.

The Framework can be applied throughout the life cycle phases of plan, design, build/buy, deploy, operate, and decommission. The plan phase begins the cycle of any system and lays the groundwork for everything that follows. Overarching cybersecurity considerations should be declared and described as clearly as possible. The plan should recognize that those considerations and requirements are likely to evolve during the remainder of the life cycle. The design phase should account for cybersecurity requirements as a part of a larger multi-disciplinary systems engineering process.¹⁰ A key milestone of the design phase is validation that the system cybersecurity specifications match the needs and risk disposition of the organization as captured in a Framework Profile. The desired cybersecurity outcomes prioritized in a Target Profile should be incorporated when a) developing the system during the build phase and b) purchasing or outsourcing the system during the buy phase. That same Target Profile serves as a list of system cybersecurity features that should be assessed when deploying the system to verify all features are implemented. The cybersecurity outcomes determined by using the Framework then should serve as a basis for ongoing operation of the system. This includes occasional reassessment, capturing results in a Current Profile, to verify that cybersecurity requirements are still fulfilled. Typically, a complex web of dependencies (e.g., compensating and common controls) among systems means the outcomes documented in Target Profiles of related systems should be carefully considered as systems are decommissioned.

The following sections present different ways in which organizations can use the Framework.

3.1 Basic Review of Cybersecurity Practices

The Framework can be used to compare an organization's current cybersecurity activities with those outlined in the Framework Core. Through the creation of a Current Profile, organizations can examine the extent to which they are achieving the outcomes described in the Core Categories and Subcategories, aligned with the five high-level Functions: Identify, Protect, Detect, Respond, and Recover. An organization may find that it is already achieving the desired

¹⁰ NIST Special Publication 800-160 Volume 1, *System Security Engineering, Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems*, Ross et al, November 2016 (updated March 21, 2018), <https://doi.org/10.6028/NIST.SP.800-160v1>

outcomes, thus managing cybersecurity commensurate with the known risk. Alternatively, an organization may determine that it has opportunities to (or needs to) improve. The organization can use that information to develop an action plan to strengthen existing cybersecurity practices and reduce cybersecurity risk. An organization may also find that it is overinvesting to achieve certain outcomes. The organization can use this information to reprioritize resources.

While they do not replace a risk management process, these five high-level Functions will provide a concise way for senior executives and others to distill the fundamental concepts of cybersecurity risk so that they can assess how identified risks are managed, and how their organization stacks up at a high level against existing cybersecurity standards, guidelines, and practices. The Framework can also help an organization answer fundamental questions, including “How are we doing?” Then they can move in a more informed way to strengthen their cybersecurity practices where and when deemed necessary.

3.2 Establishing or Improving a Cybersecurity Program

The following steps illustrate how an organization could use the Framework to create a new cybersecurity program or improve an existing program. These steps should be repeated as necessary to continuously improve cybersecurity.

Step 1: Prioritize and Scope. The organization identifies its business/mission objectives and high-level organizational priorities. With this information, the organization makes strategic decisions regarding cybersecurity implementations and determines the scope of systems and assets that support the selected business line or process. The Framework can be adapted to support the different business lines or processes within an organization, which may have different business needs and associated risk tolerance. Risk tolerances may be reflected in a target Implementation Tier.

Step 2: Orient. Once the scope of the cybersecurity program has been determined for the business line or process, the organization identifies related systems and assets, regulatory requirements, and overall risk approach. The organization then consults sources to identify threats and vulnerabilities applicable to those systems and assets.

Step 3: Create a Current Profile. The organization develops a Current Profile by indicating which Category and Subcategory outcomes from the Framework Core are currently being achieved. If an outcome is partially achieved, noting this fact will help support subsequent steps by providing baseline information.

Step 4: Conduct a Risk Assessment. This assessment could be guided by the organization’s overall risk management process or previous risk assessment activities. The organization analyzes the operational environment in order to discern the likelihood of a cybersecurity event and the impact that the event could have on the organization. It is important that organizations identify emerging risks and use cyber threat information from internal and external sources to gain a better understanding of the likelihood and impact of cybersecurity events.

Step 5: Create a Target Profile. The organization creates a Target Profile that focuses on the assessment of the Framework Categories and Subcategories describing the organization’s desired cybersecurity outcomes. Organizations also may develop their own additional Categories and

Subcategories to account for unique organizational risks. The organization may also consider influences and requirements of external stakeholders such as sector entities, customers, and business partners when creating a Target Profile. The Target Profile should appropriately reflect criteria within the target Implementation Tier.

Step 6: Determine, Analyze, and Prioritize Gaps. The organization compares the Current Profile and the Target Profile to determine gaps. Next, it creates a prioritized action plan to address gaps – reflecting mission drivers, costs and benefits, and risks – to achieve the outcomes in the Target Profile. The organization then determines resources, including funding and workforce, necessary to address the gaps. Using Profiles in this manner encourages the organization to make informed decisions about cybersecurity activities, supports risk management, and enables the organization to perform cost-effective, targeted improvements.

Step 7: Implement Action Plan. The organization determines which actions to take to address the gaps, if any, identified in the previous step and then adjusts its current cybersecurity practices in order to achieve the Target Profile. For further guidance, the Framework identifies example Informative References regarding the Categories and Subcategories, but organizations should determine which standards, guidelines, and practices, including those that are sector specific, work best for their needs.

An organization repeats the steps as needed to continuously assess and improve its cybersecurity. For instance, organizations may find that more frequent repetition of the orient step improves the quality of risk assessments. Furthermore, organizations may monitor progress through iterative updates to the Current Profile, subsequently comparing the Current Profile to the Target Profile. Organizations may also use this process to align their cybersecurity program with their desired Framework Implementation Tier.

3.3 Communicating Cybersecurity Requirements with Stakeholders

The Framework provides a common language to communicate requirements among interdependent stakeholders responsible for the delivery of essential critical infrastructure products and services. Examples include:

- An organization may use a Target Profile to express cybersecurity risk management requirements to an external service provider (e.g., a cloud provider to which it is exporting data).
- An organization may express its cybersecurity state through a Current Profile to report results or to compare with acquisition requirements.
- A critical infrastructure owner/operator, having identified an external partner on whom that infrastructure depends, may use a Target Profile to convey required Categories and Subcategories.
- A critical infrastructure sector may establish a Target Profile that can be used among its constituents as an initial baseline Profile to build their tailored Target Profiles.
- An organization can better manage cybersecurity risk among stakeholders by assessing their position in the critical infrastructure and the broader digital economy using Implementation Tiers.

Communication is especially important among stakeholders up and down supply chains. Supply chains are complex, globally distributed, and interconnected sets of resources and processes

between multiple levels of organizations. Supply chains begin with the sourcing of products and services and extend from the design, development, manufacturing, processing, handling, and delivery of products and services to the end user. Given these complex and interconnected relationships, supply chain risk management (SCRM) is a critical organizational function.¹¹

Cyber SCRM is the set of activities necessary to manage cybersecurity risk associated with external parties. More specifically, cyber SCRM addresses both the cybersecurity effect an organization has on external parties and the cybersecurity effect external parties have on an organization.

A primary objective of cyber SCRM is to identify, assess, and mitigate “products and services that may contain potentially malicious functionality, are counterfeit, or are vulnerable due to poor manufacturing and development practices within the cyber supply chain¹². Cyber SCRM activities may include:

- Determining cybersecurity requirements for suppliers,
- Enacting cybersecurity requirements through formal agreement (e.g., contracts),
- Communicating to suppliers how those cybersecurity requirements will be verified and validated,
- Verifying that cybersecurity requirements are met through a variety of assessment methodologies, and
- Governing and managing the above activities.

As depicted in Figure 3, cyber SCRM encompasses technology suppliers and buyers, as well as non-technology suppliers and buyers, where technology is minimally composed of information technology (IT), industrial control systems (ICS), cyber-physical systems (CPS), and connected devices more generally, including the Internet of Things (IoT). Figure 3 depicts an organization at a single point in time. However, through the normal course of business operations, most organizations will be both an upstream supplier and downstream buyer in relation to other organizations or end users.

¹¹ Communicating Cybersecurity Requirements (Section 3.3) and Buying Decisions (Section 3.4) address only two uses of the Framework for cyber SCRM and are not intended to address cyber SCRM comprehensively.

¹² NIST Special Publication 800-161, *Supply Chain Risk Management Practices for Federal Information Systems and Organizations*, Boyens et al, April 2015, <https://doi.org/10.6028/NIST.SP.800-161>

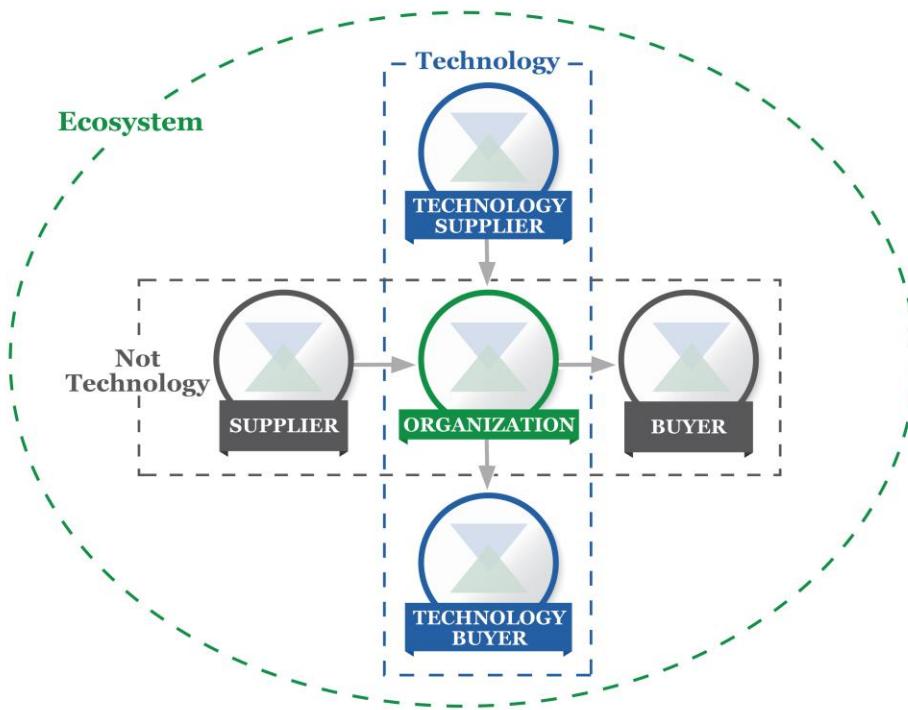


Figure 3: Cyber Supply Chain Relationships

The parties described in Figure 3 comprise an organization’s cybersecurity ecosystem. These relationships highlight the crucial role of cyber SCRM in addressing cybersecurity risk in critical infrastructure and the broader digital economy. These relationships, the products and services they provide, and the risks they present should be identified and factored into the protective and detective capabilities of organizations, as well as their response and recovery protocols.

In the figure above, “Buyer” refers to the downstream people or organizations that consume a given product or service from an organization, including both for-profit and not-for-profit organizations. “Supplier” encompasses upstream product and service providers that are used for an organization’s internal purposes (e.g., IT infrastructure) or integrated into the products or services provided to the Buyer. These terms are applicable for both technology-based and non-technology-based products and services.

Whether considering individual Subcategories of the Core or the comprehensive considerations of a Profile, the Framework offers organizations and their partners a method to help ensure the new product or service meets critical security outcomes. By first selecting outcomes that are relevant to the context (e.g., transmission of Personally Identifiable Information (PII), mission critical service delivery, data verification services, product or service integrity) the organization then can evaluate partners against those criteria. For example, if a system is being purchased that will monitor Operational Technology (OT) for anomalous network communication, availability may be a particularly important cybersecurity objective to achieve and should drive a Technology Supplier evaluation against applicable Subcategories (e.g., ID.BE-4, ID.SC-3, ID.SC-4, ID.SC-5, PR.DS-4, PR.DS-6, PR.DS-7, PR.DS-8, PR.IP-1, DE.AE-5).

3.4 Buying Decisions

Since a Framework Target Profile is a prioritized list of organizational cybersecurity requirements, Target Profiles can be used to inform decisions about buying products and services. This transaction varies from Communicating Cybersecurity Requirements with Stakeholders (addressed in Section 3.3) in that it may not be possible to impose a set of cybersecurity requirements on the supplier. The objective should be to make the best buying decision among multiple suppliers, given a carefully determined list of cybersecurity requirements. Often, this means some degree of trade-off, comparing multiple products or services with known gaps to the Target Profile.

Once a product or service is purchased, the Profile also can be used to track and address residual cybersecurity risk. For example, if the service or product purchased did not meet all the objectives described in the Target Profile, the organization can address the residual risk through other management actions. The Profile also provides the organization a method for assessing if the product meets cybersecurity outcomes through periodic review and testing mechanisms.

3.5 Identifying Opportunities for New or Revised In informative References

The Framework can be used to identify opportunities for new or revised standards, guidelines, or practices where additional Informative References would help organizations address emerging needs. An organization implementing a given Subcategory, or developing a new Subcategory, might discover that there are few Informative References, if any, for a related activity. To address that need, the organization might collaborate with technology leaders and/or standards bodies to draft, develop, and coordinate standards, guidelines, or practices.

3.6 Methodology to Protect Privacy and Civil Liberties

This section describes a methodology to address individual privacy and civil liberties implications that may result from cybersecurity. This methodology is intended to be a general set of considerations and processes since privacy and civil liberties implications may differ by sector or over time and organizations may address these considerations and processes with a range of technical implementations. Nonetheless, not all activities in a cybersecurity program engender privacy and civil liberties considerations. Technical privacy standards, guidelines, and additional best practices may need to be developed to support improved technical implementations.

Privacy and cybersecurity have a strong connection. An organization's cybersecurity activities also can create risks to privacy and civil liberties when personal information is used, collected, processed, maintained, or disclosed. Some examples include: cybersecurity activities that result in the over-collection or over-retention of personal information; disclosure or use of personal information unrelated to cybersecurity activities; and cybersecurity mitigation activities that result in denial of service or other similar potentially adverse impacts, including some types of incident detection or monitoring that may inhibit freedom of expression or association.

The government and its agents have a responsibility to protect civil liberties arising from cybersecurity activities. As referenced in the methodology below, government or its agents that own or operate critical infrastructure should have a process in place to support compliance of cybersecurity activities with applicable privacy laws, regulations, and Constitutional requirements.

To address privacy implications, organizations may consider how their cybersecurity program might incorporate privacy principles such as: data minimization in the collection, disclosure, and retention of personal information material related to the cybersecurity incident; use limitations outside of cybersecurity activities on any information collected specifically for cybersecurity activities; transparency for certain cybersecurity activities; individual consent and redress for adverse impacts arising from use of personal information in cybersecurity activities; data quality, integrity, and security; and accountability and auditing.

As organizations assess the Framework Core in [Appendix A](#), the following processes and activities may be considered as a means to address the above-referenced privacy and civil liberties implications:

Governance of cybersecurity risk

- An organization's assessment of cybersecurity risk and potential risk responses considers the privacy implications of its cybersecurity program.
- Individuals with cybersecurity-related privacy responsibilities report to appropriate management and are appropriately trained.
- Process is in place to support compliance of cybersecurity activities with applicable privacy laws, regulations, and Constitutional requirements.
- Process is in place to assess implementation of the above organizational measures and controls.

Approaches to identifying, authenticating, and authorizing individuals to access organizational assets and systems

- Steps are taken to identify and address the privacy implications of identity management and access control measures to the extent that they involve collection, disclosure, or use of personal information.

Awareness and training measures

- Applicable information from organizational privacy policies is included in cybersecurity workforce training and awareness activities.
- Service providers that provide cybersecurity-related services for the organization are informed about the organization's applicable privacy policies.

Anomalous activity detection and system and assets monitoring

- Process is in place to conduct a privacy review of an organization's anomalous activity detection and cybersecurity monitoring.

Response activities, including information sharing or other mitigation efforts

- Process is in place to assess and address whether, when, how, and the extent to which personal information is shared outside the organization as part of cybersecurity information sharing activities.
- Process is in place to conduct a privacy review of an organization's cybersecurity mitigation efforts.

4.0 Self-Assessing Cybersecurity Risk with the Framework

The Cybersecurity Framework is designed to reduce risk by improving the management of cybersecurity risk to organizational objectives. Ideally, organizations using the Framework will be able to measure and assign values to their risk *along with* the cost and benefits of steps taken to reduce risk to acceptable levels. The better an organization is able to measure its risk, costs, and benefits of cybersecurity strategies and steps, the more rational, effective, and valuable its cybersecurity approach and investments will be.

Over time, self-assessment and measurement should improve decision making about investment priorities. For example, measuring – or at least robustly characterizing – aspects of an organization’s cybersecurity state and trends over time can enable that organization to understand and convey meaningful risk information to dependents, suppliers, buyers, and other parties. An organization can accomplish this internally or by seeking a third-party assessment. If done properly and with an appreciation of limitations, these measurements can provide a basis for strong trusted relationships, both inside and outside of an organization.

To examine the effectiveness of investments, an organization must first have a clear understanding of its organizational objectives, the relationship between those objectives and supportive cybersecurity outcomes, and how those discrete cybersecurity outcomes are implemented and managed. While measurements of all those items is beyond the scope of the Framework, the cybersecurity outcomes of the Framework Core support self-assessment of investment effectiveness and cybersecurity activities in the following ways:

- Making choices about how different portions of the cybersecurity operation should influence the selection of Target Implementation Tiers,
- Evaluating the organization’s approach to cybersecurity risk management by determining Current Implementation Tiers,
- Prioritizing cybersecurity outcomes by developing Target Profiles,
- Determining the degree to which specific cybersecurity steps achieve desired cybersecurity outcomes by assessing Current Profiles, and
- Measuring the degree of implementation for controls catalogs or technical guidance listed as Informative References.

The development of cybersecurity performance metrics is evolving. Organizations should be thoughtful, creative, and careful about the ways in which they employ measurements to optimize use, while avoiding reliance on artificial indicators of current state and progress in improving cybersecurity risk management. Judging cyber risk requires discipline and should be revisited periodically. Any time measurements are employed as part of the Framework process, organizations are encouraged to clearly identify and know why these measurements are important and how they will contribute to the overall management of cybersecurity risk. They also should be clear about the limitations of measurements that are used.

For example, tracking security measures and business outcomes may provide meaningful insight as to how changes in granular security controls affect the completion of organizational objectives. Verifying achievement of some organizational objectives requires analyzing the data only *after* that objective was to have been achieved. This type of lagging measure is more

absolute. However, it is often more valuable to predict whether a cybersecurity risk *may* occur, and the impact it *might* have, using a leading measure.

Organizations are encouraged to innovate and customize how they incorporate measurements into their application of the Framework with a full appreciation of their usefulness and limitations.

Appendix A: Framework Core

This appendix presents the Framework Core: a listing of Functions, Categories, Subcategories, and Informative References that describe specific cybersecurity activities that are common across all critical infrastructure sectors. The chosen presentation format for the Framework Core does not suggest a specific implementation order or imply a degree of importance of the Categories, Subcategories, and Informative References. The Framework Core presented in this appendix represents a common set of activities for managing cybersecurity risk. While the Framework is not exhaustive, it is extensible, allowing organizations, sectors, and other entities to use Subcategories and Informative References that are cost-effective and efficient and that enable them to manage their cybersecurity risk. Activities can be selected from the Framework Core during the Profile creation process and additional Categories, Subcategories, and Informative References may be added to the Profile. An organization's risk management processes, legal/regulatory requirements, business/mission objectives, and organizational constraints guide the selection of these activities during Profile creation. Personal information is considered a component of data or assets referenced in the Categories when assessing security risks and protections.

While the intended outcomes identified in the Functions, Categories, and Subcategories are the same for IT and ICS, the operational environments and considerations for IT and ICS differ. ICS have a direct effect on the physical world, including potential risks to the health and safety of individuals, and impact on the environment. Additionally, ICS have unique performance and reliability requirements compared with IT, and the goals of safety and efficiency must be considered when implementing cybersecurity measures.

For ease of use, each component of the Framework Core is given a unique identifier. Functions and Categories each have a unique alphabetic identifier, as shown in Table 1. Subcategories within each Category are referenced numerically; the unique identifier for each Subcategory is included in Table 2.

Additional supporting material, including Informative References, relating to the Framework can be found on the NIST website at <http://www.nist.gov/cyberframework/>.

Table 1: Function and Category Unique Identifiers

Function Unique Identifier	Function	Category Unique Identifier	Category
ID	Identify	ID.AM	Asset Management
		ID.BE	Business Environment
		ID.GV	Governance
		ID.RA	Risk Assessment
		ID.RM	Risk Management Strategy
		ID.SC	Supply Chain Risk Management
PR	Protect	PR.AC	Identity Management and Access Control
		PR.AT	Awareness and Training
		PR.DS	Data Security
		PR.IP	Information Protection Processes and Procedures
		PR.MA	Maintenance
		PR.PT	Protective Technology
DE	Detect	DE.AE	Anomalies and Events
		DE.CM	Security Continuous Monitoring
		DE.DP	Detection Processes
RS	Respond	RS.RP	Response Planning
		RS.CO	Communications
		RS.AN	Analysis
		RS.MI	Mitigation
		RS.IM	Improvements
RC	Recover	RC.RP	Recovery Planning
		RC.IM	Improvements
		RC.CO	Communications

Table 2: Framework Core

Function	Category	Subcategory	Informative References
IDENTIFY (ID)	Asset Management (ID.AM): The data, personnel, devices, systems, and facilities that enable the organization to achieve business purposes are identified and managed consistent with their relative importance to organizational objectives and the organization's risk strategy.	ID.AM-1: Physical devices and systems within the organization are inventoried	CIS CSC 1 COBIT 5 BAI09.01, BAI09.02 ISA 62443-2-1:2009 4.2.3.4 ISA 62443-3-3:2013 SR 7.8 ISO/IEC 27001:2013 A.8.1.1, A.8.1.2 NIST SP 800-53 Rev. 4 CM-8, PM-5
		ID.AM-2: Software platforms and applications within the organization are inventoried	CIS CSC 2 COBIT 5 BAI09.01, BAI09.02, BAI09.05 ISA 62443-2-1:2009 4.2.3.4 ISA 62443-3-3:2013 SR 7.8 ISO/IEC 27001:2013 A.8.1.1, A.8.1.2, A.12.5.1 NIST SP 800-53 Rev. 4 CM-8, PM-5
		ID.AM-3: Organizational communication and data flows are mapped	CIS CSC 12 COBIT 5 DSS05.02 ISA 62443-2-1:2009 4.2.3.4 ISO/IEC 27001:2013 A.13.2.1, A.13.2.2 NIST SP 800-53 Rev. 4 AC-4, CA-3, CA-9, PL-8
		ID.AM-4: External information systems are catalogued	CIS CSC 12 COBIT 5 APO02.02, APO10.04, DSS01.02 ISO/IEC 27001:2013 A.11.2.6 NIST SP 800-53 Rev. 4 AC-20, SA-9
		ID.AM-5: Resources (e.g., hardware, devices, data, time, personnel, and software) are prioritized based on their classification, criticality, and business value	CIS CSC 13, 14 COBIT 5 APO03.03, APO03.04, APO12.01, BAI04.02, BAI09.02 ISA 62443-2-1:2009 4.2.3.6 ISO/IEC 27001:2013 A.8.2.1 NIST SP 800-53 Rev. 4 CP-2, RA-2, SA-14, SC-6
		ID.AM-6: Cybersecurity roles and responsibilities for the entire workforce and	CIS CSC 17, 19 COBIT 5 APO01.02, APO07.06, APO13.01, DSS06.03

Function	Category	Subcategory	Informative References
		third-party stakeholders (e.g., suppliers, customers, partners) are established	ISA 62443-2-1:2009 4.3.2.3.3 ISO/IEC 27001:2013 A.6.1.1 NIST SP 800-53 Rev. 4 CP-2, PS-7, PM-11
	Business Environment (ID.BE): The organization's mission, objectives, stakeholders, and activities are understood and prioritized; this information is used to inform cybersecurity roles, responsibilities, and risk management decisions.	ID.BE-1: The organization's role in the supply chain is identified and communicated	COBIT 5 APO08.01, APO08.04, APO08.05, APO10.03, APO10.04, APO10.05 ISO/IEC 27001:2013 A.15.1.1, A.15.1.2, A.15.1.3, A.15.2.1, A.15.2.2 NIST SP 800-53 Rev. 4 CP-2, SA-12
		ID.BE-2: The organization's place in critical infrastructure and its industry sector is identified and communicated	COBIT 5 APO02.06, APO03.01 ISO/IEC 27001:2013 Clause 4.1 NIST SP 800-53 Rev. 4 PM-8
		ID.BE-3: Priorities for organizational mission, objectives, and activities are established and communicated	COBIT 5 APO02.01, APO02.06, APO03.01 ISA 62443-2-1:2009 4.2.2.1, 4.2.3.6 NIST SP 800-53 Rev. 4 PM-11, SA-14
		ID.BE-4: Dependencies and critical functions for delivery of critical services are established	COBIT 5 APO10.01, BAI04.02, BAI09.02 ISO/IEC 27001:2013 A.11.2.2, A.11.2.3, A.12.1.3 NIST SP 800-53 Rev. 4 CP-8, PE-9, PE-11, PM-8, SA-14
		ID.BE-5: Resilience requirements to support delivery of critical services are established for all operating states (e.g. under duress/attack, during recovery, normal operations)	COBIT 5 BAI03.02, DSS04.02 ISO/IEC 27001:2013 A.11.1.4, A.17.1.1, A.17.1.2, A.17.2.1 NIST SP 800-53 Rev. 4 CP-2, CP-11, SA-13, SA-14
	Governance (ID.GV): The policies, procedures, and processes to manage and monitor the organization's regulatory, legal, risk, environmental, and operational requirements are understood and inform the	ID.GV-1: Organizational cybersecurity policy is established and communicated	CIS CSC 19 COBIT 5 APO01.03, APO13.01, EDM01.01, EDM01.02 ISA 62443-2-1:2009 4.3.2.6 ISO/IEC 27001:2013 A.5.1.1 NIST SP 800-53 Rev. 4 -1 controls from all security control families

Function	Category	Subcategory	Informative References
Risk Management Functions	management of cybersecurity risk.	ID.GV-2: Cybersecurity roles and responsibilities are coordinated and aligned with internal roles and external partners	CIS CSC 19 COBIT 5 APO01.02, APO10.03, APO13.02, DSS05.04 ISA 62443-2-1:2009 4.3.2.3.3 ISO/IEC 27001:2013 A.6.1.1, A.7.2.1, A.15.1.1 NIST SP 800-53 Rev. 4 PS-7, PM-1, PM-2
		ID.GV-3: Legal and regulatory requirements regarding cybersecurity, including privacy and civil liberties obligations, are understood and managed	CIS CSC 19 COBIT 5 BAI02.01, MEA03.01, MEA03.04 ISA 62443-2-1:2009 4.4.3.7 ISO/IEC 27001:2013 A.18.1.1, A.18.1.2, A.18.1.3, A.18.1.4, A.18.1.5 NIST SP 800-53 Rev. 4 - 1 controls from all security control families
		ID.GV-4: Governance and risk management processes address cybersecurity risks	COBIT 5 EDM03.02, APO12.02, APO12.05, DSS04.02 ISA 62443-2-1:2009 4.2.3.1, 4.2.3.3, 4.2.3.8, 4.2.3.9, 4.2.3.11, 4.3.2.4.3, 4.3.2.6.3 ISO/IEC 27001:2013 Clause 6 NIST SP 800-53 Rev. 4 SA-2, PM-3, PM-7, PM-9, PM-10, PM-11
	Risk Assessment (ID.RA): The organization understands the cybersecurity risk to organizational operations (including mission, functions, image, or reputation), organizational assets, and individuals.	ID.RA-1: Asset vulnerabilities are identified and documented	CIS CSC 4 COBIT 5 APO12.01, APO12.02, APO12.03, APO12.04, DSS05.01, DSS05.02 ISA 62443-2-1:2009 4.2.3, 4.2.3.7, 4.2.3.9, 4.2.3.12 ISO/IEC 27001:2013 A.12.6.1, A.18.2.3 NIST SP 800-53 Rev. 4 CA-2, CA-7, CA-8, RA-3, RA-5, SA-5, SA-11, SI-2, SI-4, SI-5
		ID.RA-2: Cyber threat intelligence is received from information sharing forums and sources	CIS CSC 4 COBIT 5 BAI08.01 ISA 62443-2-1:2009 4.2.3, 4.2.3.9, 4.2.3.12 ISO/IEC 27001:2013 A.6.1.4 NIST SP 800-53 Rev. 4 SI-5, PM-15, PM-16

Function	Category	Subcategory	Informative References
		ID.RA-3: Threats, both internal and external, are identified and documented	CIS CSC 4 COBIT 5 APO12.01, APO12.02, APO12.03, APO12.04 ISA 62443-2-1:2009 4.2.3, 4.2.3.9, 4.2.3.12 ISO/IEC 27001:2013 Clause 6.1.2 NIST SP 800-53 Rev. 4 RA-3, SI-5, PM-12, PM-16
		ID.RA-4: Potential business impacts and likelihoods are identified	CIS CSC 4 COBIT 5 DSS04.02 ISA 62443-2-1:2009 4.2.3, 4.2.3.9, 4.2.3.12 ISO/IEC 27001:2013 A.16.1.6, Clause 6.1.2 NIST SP 800-53 Rev. 4 RA-2, RA-3, SA-14, PM-9, PM-11
		ID.RA-5: Threats, vulnerabilities, likelihoods, and impacts are used to determine risk	CIS CSC 4 COBIT 5 APO12.02 ISO/IEC 27001:2013 A.12.6.1 NIST SP 800-53 Rev. 4 RA-2, RA-3, PM-16
		ID.RA-6: Risk responses are identified and prioritized	CIS CSC 4 COBIT 5 APO12.05, APO13.02 ISO/IEC 27001:2013 Clause 6.1.3 NIST SP 800-53 Rev. 4 PM-4, PM-9
	Risk Management Strategy (ID.RM): The organization's priorities, constraints, risk tolerances, and assumptions are established and used to support operational risk decisions.	ID.RM-1: Risk management processes are established, managed, and agreed to by organizational stakeholders	CIS CSC 4 COBIT 5 APO12.04, APO12.05, APO13.02, BAI02.03, BAI04.02 ISA 62443-2-1:2009 4.3.4.2 ISO/IEC 27001:2013 Clause 6.1.3, Clause 8.3, Clause 9.3 NIST SP 800-53 Rev. 4 PM-9
		ID.RM-2: Organizational risk tolerance is determined and clearly expressed	COBIT 5 APO12.06 ISA 62443-2-1:2009 4.3.2.6.5 ISO/IEC 27001:2013 Clause 6.1.3, Clause 8.3 NIST SP 800-53 Rev. 4 PM-9

Function	Category	Subcategory	Informative References
		ID.RM-3: The organization's determination of risk tolerance is informed by its role in critical infrastructure and sector specific risk analysis	COBIT 5 APO12.02 ISO/IEC 27001:2013 Clause 6.1.3, Clause 8.3 NIST SP 800-53 Rev. 4 SA-14, PM-8, PM-9, PM-11
	Supply Chain Risk Management (ID.SC): The organization's priorities, constraints, risk tolerances, and assumptions are established and used to support risk decisions associated with managing supply chain risk. The organization has established and implemented the processes to identify, assess and manage supply chain risks.	ID.SC-1: Cyber supply chain risk management processes are identified, established, assessed, managed, and agreed to by organizational stakeholders	CIS CSC 4 COBIT 5 APO10.01, APO10.04, APO12.04, APO12.05, APO13.02, BAI01.03, BAI02.03, BAI04.02 ISA 62443-2-1:2009 4.3.4.2 ISO/IEC 27001:2013 A.15.1.1, A.15.1.2, A.15.1.3, A.15.2.1, A.15.2.2 NIST SP 800-53 Rev. 4 SA-9, SA-12, PM-9
		ID.SC-2: Suppliers and third party partners of information systems, components, and services are identified, prioritized, and assessed using a cyber supply chain risk assessment process	COBIT 5 APO10.01, APO10.02, APO10.04, APO10.05, APO12.01, APO12.02, APO12.03, APO12.04, APO12.05, APO12.06, APO13.02, BAI02.03 ISA 62443-2-1:2009 4.2.3.1, 4.2.3.2, 4.2.3.3, 4.2.3.4, 4.2.3.6, 4.2.3.8, 4.2.3.9, 4.2.3.10, 4.2.3.12, 4.2.3.13, 4.2.3.14 ISO/IEC 27001:2013 A.15.2.1, A.15.2.2 NIST SP 800-53 Rev. 4 RA-2, RA-3, SA-12, SA-14, SA-15, PM-9
		ID.SC-3: Contracts with suppliers and third-party partners are used to implement appropriate measures designed to meet the objectives of an organization's cybersecurity program and Cyber Supply Chain Risk Management Plan.	COBIT 5 APO10.01, APO10.02, APO10.03, APO10.04, APO10.05 ISA 62443-2-1:2009 4.3.2.6.4, 4.3.2.6.7 ISO/IEC 27001:2013 A.15.1.1, A.15.1.2, A.15.1.3 NIST SP 800-53 Rev. 4 SA-9, SA-11, SA-12, PM-9
		ID.SC-4: Suppliers and third-party partners are routinely assessed using audits, test results, or other forms of evaluations to confirm they are meeting their contractual obligations.	COBIT 5 APO10.01, APO10.03, APO10.04, APO10.05, MEA01.01, MEA01.02, MEA01.03, MEA01.04, MEA01.05 ISA 62443-2-1:2009 4.3.2.6.7 ISA 62443-3-3:2013 SR 6.1 ISO/IEC 27001:2013 A.15.2.1, A.15.2.2

Function	Category	Subcategory	Informative References
			NIST SP 800-53 Rev. 4 AU-2, AU-6, AU-12, AU-16, PS-7, SA-9, SA-12
PROTECT (PR)	Identity Management, Authentication and Access Control (PR.AC): Access to physical and logical assets and associated facilities is limited to authorized users, processes, and devices, and is managed consistent with the assessed risk of unauthorized access to authorized activities and transactions.	ID.SC-5: Response and recovery planning and testing are conducted with suppliers and third-party providers	CIS CSC 19, 20 COBIT 5 DSS04.04 ISA 62443-2-1:2009 4.3.2.5.7, 4.3.4.5.11 ISA 62443-3-3:2013 SR 2.8, SR 3.3, SR.6.1, SR 7.3, SR 7.4 ISO/IEC 27001:2013 A.17.1.3 NIST SP 800-53 Rev. 4 CP-2, CP-4, IR-3, IR-4, IR-6, IR-8, IR-9
		PR.AC-1: Identities and credentials are issued, managed, verified, revoked, and audited for authorized devices, users and processes	CIS CSC 1, 5, 15, 16 COBIT 5 DSS05.04, DSS06.03 ISA 62443-2-1:2009 4.3.3.5.1 ISA 62443-3-3:2013 SR 1.1, SR 1.2, SR 1.3, SR 1.4, SR 1.5, SR 1.7, SR 1.8, SR 1.9 ISO/IEC 27001:2013 A.9.2.1, A.9.2.2, A.9.2.3, A.9.2.4, A.9.2.6, A.9.3.1, A.9.4.2, A.9.4.3 NIST SP 800-53 Rev. 4 AC-1, AC-2, IA-1, IA-2, IA-3, IA-4, IA-5, IA-6, IA-7, IA-8, IA-9, IA-10, IA-11
		PR.AC-2: Physical access to assets is managed and protected	COBIT 5 DSS01.04, DSS05.05 ISA 62443-2-1:2009 4.3.3.3.2, 4.3.3.3.8 ISO/IEC 27001:2013 A.11.1.1, A.11.1.2, A.11.1.3, A.11.1.4, A.11.1.5, A.11.1.6, A.11.2.1, A.11.2.3, A.11.2.5, A.11.2.6, A.11.2.7, A.11.2.8 NIST SP 800-53 Rev. 4 PE-2, PE-3, PE-4, PE-5, PE-6, PE-8
		PR.AC-3: Remote access is managed	CIS CSC 12 COBIT 5 APO13.01, DSS01.04, DSS05.03 ISA 62443-2-1:2009 4.3.3.6.6 ISA 62443-3-3:2013 SR 1.13, SR 2.6 ISO/IEC 27001:2013 A.6.2.1, A.6.2.2, A.11.2.6, A.13.1.1, A.13.2.1

Function	Category	Subcategory	Informative References
			NIST SP 800-53 Rev. 4 AC-1, AC-17, AC-19, AC-20, SC-15
		PR.AC-4: Access permissions and authorizations are managed, incorporating the principles of least privilege and separation of duties	CIS CSC 3, 5, 12, 14, 15, 16, 18 COBIT 5 DSS05.04 ISA 62443-2-1:2009 4.3.3.7.3 ISA 62443-3-3:2013 SR 2.1 ISO/IEC 27001:2013 A.6.1.2, A.9.1.2, A.9.2.3, A.9.4.1, A.9.4.4, A.9.4.5 NIST SP 800-53 Rev. 4 AC-1, AC-2, AC-3, AC-5, AC-6, AC-14, AC-16, AC-24
		PR.AC-5: Network integrity is protected (e.g., network segregation, network segmentation)	CIS CSC 9, 14, 15, 18 COBIT 5 DSS01.05, DSS05.02 ISA 62443-2-1:2009 4.3.3.4 ISA 62443-3-3:2013 SR 3.1, SR 3.8 ISO/IEC 27001:2013 A.13.1.1, A.13.1.3, A.13.2.1, A.14.1.2, A.14.1.3 NIST SP 800-53 Rev. 4 AC-4, AC-10, SC-7
		PR.AC-6: Identities are proofed and bound to credentials and asserted in interactions	CIS CSC , 16 COBIT 5 DSS05.04, DSS05.05, DSS05.07, DSS06.03 ISA 62443-2-1:2009 4.3.3.2.2, 4.3.3.5.2, 4.3.3.7.2, 4.3.3.7.4 ISA 62443-3-3:2013 SR 1.1, SR 1.2, SR 1.4, SR 1.5, SR 1.9, SR 2.1 ISO/IEC 27001:2013 , A.7.1.1, A.9.2.1 NIST SP 800-53 Rev. 4 AC-1, AC-2, AC-3, AC-16, AC-19, AC-24, IA-1, IA-2, IA-4, IA-5, IA-8, PE-2, PS-3
		PR.AC-7: Users, devices, and other assets are authenticated (e.g., single-factor, multi-factor) commensurate with the risk of the transaction (e.g., individuals' security and privacy risks and other organizational risks)	CIS CSC 1, 12, 15, 16 COBIT 5 DSS05.04, DSS05.10, DSS06.10 ISA 62443-2-1:2009 4.3.3.6.1, 4.3.3.6.2, 4.3.3.6.3, 4.3.3.6.4, 4.3.3.6.5, 4.3.3.6.6, 4.3.3.6.7, 4.3.3.6.8, 4.3.3.6.9

Function	Category	Subcategory	Informative References
			ISA 62443-3-3:2013 SR 1.1, SR 1.2, SR 1.5, SR 1.7, SR 1.8, SR 1.9, SR 1.10 ISO/IEC 27001:2013 A.9.2.1, A.9.2.4, A.9.3.1, A.9.4.2, A.9.4.3, A.18.1.4 NIST SP 800-53 Rev. 4 AC-7, AC-8, AC-9, AC-11, AC-12, AC-14, IA-1, IA-2, IA-3, IA-4, IA-5, IA-8, IA-9, IA-10, IA-11
Awareness and Training (PR.AT): The organization's personnel and partners are provided cybersecurity awareness education and are trained to perform their cybersecurity-related duties and responsibilities consistent with related policies, procedures, and agreements.	PR.AT-1: All users are informed and trained PR.AT-2: Privileged users understand their roles and responsibilities PR.AT-3: Third-party stakeholders (e.g., suppliers, customers, partners) understand their roles and responsibilities PR.AT-4: Senior executives understand their roles and responsibilities PR.AT-5: Physical and cybersecurity personnel understand their roles and responsibilities	PR.AT-1: All users are informed and trained	CIS CSC 17, 18 COBIT 5 APO07.03, BAI05.07 ISA 62443-2-1:2009 4.3.2.4.2 ISO/IEC 27001:2013 A.7.2.2, A.12.2.1 NIST SP 800-53 Rev. 4 AT-2, PM-13
		PR.AT-2: Privileged users understand their roles and responsibilities	CIS CSC 5, 17, 18 COBIT 5 APO07.02, DSS05.04, DSS06.03 ISA 62443-2-1:2009 4.3.2.4.2, 4.3.2.4.3 ISO/IEC 27001:2013 A.6.1.1, A.7.2.2 NIST SP 800-53 Rev. 4 AT-3, PM-13
		PR.AT-3: Third-party stakeholders (e.g., suppliers, customers, partners) understand their roles and responsibilities	CIS CSC 17 COBIT 5 APO07.03, APO07.06, APO10.04, APO10.05 ISA 62443-2-1:2009 4.3.2.4.2 ISO/IEC 27001:2013 A.6.1.1, A.7.2.1, A.7.2.2 NIST SP 800-53 Rev. 4 PS-7, SA-9, SA-16
		PR.AT-4: Senior executives understand their roles and responsibilities	CIS CSC 17, 19 COBIT 5 EDM01.01, APO01.02, APO07.03 ISA 62443-2-1:2009 4.3.2.4.2 ISO/IEC 27001:2013 A.6.1.1, A.7.2.2 NIST SP 800-53 Rev. 4 AT-3, PM-13
		PR.AT-5: Physical and cybersecurity personnel understand their roles and responsibilities	CIS CSC 17 COBIT 5 APO07.03 ISA 62443-2-1:2009 4.3.2.4.2 ISO/IEC 27001:2013 A.6.1.1, A.7.2.2

Function	Category	Subcategory	Informative References
			NIST SP 800-53 Rev. 4 AT-3, IR-2, PM-13
	Data Security (PR.DS): Information and records (data) are managed consistent with the organization's risk strategy to protect the confidentiality, integrity, and availability of information.	PR.DS-1: Data-at-rest is protected	CIS CSC 13, 14 COBIT 5 APO01.06, BAI02.01, BAI06.01, DSS04.07, DSS05.03, DSS06.06 ISA 62443-3-3:2013 SR 3.4, SR 4.1 ISO/IEC 27001:2013 A.8.2.3 NIST SP 800-53 Rev. 4 MP-8, SC-12, SC-28
		PR.DS-2: Data-in-transit is protected	CIS CSC 13, 14 COBIT 5 APO01.06, DSS05.02, DSS06.06 ISA 62443-3-3:2013 SR 3.1, SR 3.8, SR 4.1, SR 4.2 ISO/IEC 27001:2013 A.8.2.3, A.13.1.1, A.13.2.1, A.13.2.3, A.14.1.2, A.14.1.3 NIST SP 800-53 Rev. 4 SC-8, SC-11, SC-12
		PR.DS-3: Assets are formally managed throughout removal, transfers, and disposition	CIS CSC 1 COBIT 5 BAI09.03 ISA 62443-2-1:2009 4.3.3.3.9, 4.3.4.4.1 ISA 62443-3-3:2013 SR 4.2 ISO/IEC 27001:2013 A.8.2.3, A.8.3.1, A.8.3.2, A.8.3.3, A.11.2.5, A.11.2.7 NIST SP 800-53 Rev. 4 CM-8, MP-6, PE-16
		PR.DS-4: Adequate capacity to ensure availability is maintained	CIS CSC 1, 2, 13 COBIT 5 APO13.01, BAI04.04 ISA 62443-3-3:2013 SR 7.1, SR 7.2 ISO/IEC 27001:2013 A.12.1.3, A.17.2.1 NIST SP 800-53 Rev. 4 AU-4, CP-2, SC-5
		PR.DS-5: Protections against data leaks are implemented	CIS CSC 13 COBIT 5 APO01.06, DSS05.04, DSS05.07, DSS06.02 ISA 62443-3-3:2013 SR 5.2 ISO/IEC 27001:2013 A.6.1.2, A.7.1.1, A.7.1.2, A.7.3.1, A.8.2.2, A.8.2.3, A.9.1.1, A.9.1.2, A.9.2.3, A.9.4.1, A.9.4.4, A.9.4.5, A.10.1.1, A.11.1.4,

Function	Category	Subcategory	Informative References
			A.11.1.5, A.11.2.1, A.13.1.1, A.13.1.3, A.13.2.1, A.13.2.3, A.13.2.4, A.14.1.2, A.14.1.3 NIST SP 800-53 Rev. 4 AC-4, AC-5, AC-6, PE-19, PS-3, PS-6, SC-7, SC-8, SC-13, SC-31, SI-4
		PR.DS-6: Integrity checking mechanisms are used to verify software, firmware, and information integrity	CIS CSC 2, 3 COBIT 5 APO01.06, BAI06.01, DSS06.02 ISA 62443-3-3:2013 SR 3.1, SR 3.3, SR 3.4, SR 3.8 ISO/IEC 27001:2013 A.12.2.1, A.12.5.1, A.14.1.2, A.14.1.3, A.14.2.4 NIST SP 800-53 Rev. 4 SC-16, SI-7
		PR.DS-7: The development and testing environment(s) are separate from the production environment	CIS CSC 18, 20 COBIT 5 BAI03.08, BAI07.04 ISO/IEC 27001:2013 A.12.1.4 NIST SP 800-53 Rev. 4 CM-2
		PR.DS-8: Integrity checking mechanisms are used to verify hardware integrity	COBIT 5 BAI03.05 ISA 62443-2-1:2009 4.3.4.4.4 ISO/IEC 27001:2013 A.11.2.4 NIST SP 800-53 Rev. 4 SA-10, SI-7
	Information Protection Processes and Procedures (PR.IP): Security policies (that address purpose, scope, roles, responsibilities, management commitment, and coordination among organizational entities), processes, and procedures are maintained and used to manage protection of information systems and assets.	PR.IP-1: A baseline configuration of information technology/industrial control systems is created and maintained incorporating security principles (e.g. concept of least functionality)	CIS CSC 3, 9, 11 COBIT 5 BAI10.01, BAI10.02, BAI10.03, BAI10.05 ISA 62443-2-1:2009 4.3.4.3.2, 4.3.4.3.3 ISA 62443-3-3:2013 SR 7.6 ISO/IEC 27001:2013 A.12.1.2, A.12.5.1, A.12.6.2, A.14.2.2, A.14.2.3, A.14.2.4 NIST SP 800-53 Rev. 4 CM-2, CM-3, CM-4, CM-5, CM-6, CM-7, CM-9, SA-10
		PR.IP-2: A System Development Life Cycle to manage systems is implemented	CIS CSC 18 COBIT 5 APO13.01, BAI03.01, BAI03.02, BAI03.03 ISA 62443-2-1:2009 4.3.4.3.3

Function	Category	Subcategory	Informative References
			ISO/IEC 27001:2013 A.6.1.5, A.14.1.1, A.14.2.1, A.14.2.5 NIST SP 800-53 Rev. 4 PL-8, SA-3, SA-4, SA-8, SA-10, SA-11, SA-12, SA-15, SA-17, SI-12, SI-13, SI-14, SI-16, SI-17
		PR.IP-3: Configuration change control processes are in place	CIS CSC 3, 11 COBIT 5 BAI01.06, BAI06.01 ISA 62443-2-1:2009 4.3.4.3.2, 4.3.4.3.3 ISA 62443-3-3:2013 SR 7.6 ISO/IEC 27001:2013 A.12.1.2, A.12.5.1, A.12.6.2, A.14.2.2, A.14.2.3, A.14.2.4 NIST SP 800-53 Rev. 4 CM-3, CM-4, SA-10
		PR.IP-4: Backups of information are conducted, maintained, and tested	CIS CSC 10 COBIT 5 APO13.01, DSS01.01, DSS04.07 ISA 62443-2-1:2009 4.3.4.3.9 ISA 62443-3-3:2013 SR 7.3, SR 7.4 ISO/IEC 27001:2013 A.12.3.1, A.17.1.2, A.17.1.3, A.18.1.3 NIST SP 800-53 Rev. 4 CP-4, CP-6, CP-9
		PR.IP-5: Policy and regulations regarding the physical operating environment for organizational assets are met	COBIT 5 DSS01.04, DSS05.05 ISA 62443-2-1:2009 4.3.3.3.1 4.3.3.3.2, 4.3.3.3.3, 4.3.3.3.5, 4.3.3.3.6 ISO/IEC 27001:2013 A.11.1.4, A.11.2.1, A.11.2.2, A.11.2.3 NIST SP 800-53 Rev. 4 PE-10, PE-12, PE-13, PE-14, PE-15, PE-18
		PR.IP-6: Data is destroyed according to policy	COBIT 5 BAI09.03, DSS05.06 ISA 62443-2-1:2009 4.3.4.4.4 ISA 62443-3-3:2013 SR 4.2 ISO/IEC 27001:2013 A.8.2.3, A.8.3.1, A.8.3.2, A.11.2.7 NIST SP 800-53 Rev. 4 MP-6

Function	Category	Subcategory	Informative References
		PR.IP-7: Protection processes are improved	COBIT 5 APO11.06, APO12.06, DSS04.05 ISA 62443-2-1:2009 4.4.3.1, 4.4.3.2, 4.4.3.3, 4.4.3.4, 4.4.3.5, 4.4.3.6, 4.4.3.7, 4.4.3.8 ISO/IEC 27001:2013 A.16.1.6, Clause 9, Clause 10 NIST SP 800-53 Rev. 4 CA-2, CA-7, CP-2, IR-8, PL-2, PM-6
		PR.IP-8: Effectiveness of protection technologies is shared	COBIT 5 BAI08.04, DSS03.04 ISO/IEC 27001:2013 A.16.1.6 NIST SP 800-53 Rev. 4 AC-21, CA-7, SI-4
		PR.IP-9: Response plans (Incident Response and Business Continuity) and recovery plans (Incident Recovery and Disaster Recovery) are in place and managed	CIS CSC 19 COBIT 5 APO12.06, DSS04.03 ISA 62443-2-1:2009 4.3.2.5.3, 4.3.4.5.1 ISO/IEC 27001:2013 A.16.1.1, A.17.1.1, A.17.1.2, A.17.1.3 NIST SP 800-53 Rev. 4 CP-2, CP-7, CP-12, CP-13, IR-7, IR-8, IR-9, PE-17
		PR.IP-10: Response and recovery plans are tested	CIS CSC 19, 20 COBIT 5 DSS04.04 ISA 62443-2-1:2009 4.3.2.5.7, 4.3.4.5.11 ISA 62443-3-3:2013 SR 3.3 ISO/IEC 27001:2013 A.17.1.3 NIST SP 800-53 Rev. 4 CP-4, IR-3, PM-14
		PR.IP-11: Cybersecurity is included in human resources practices (e.g., deprovisioning, personnel screening)	CIS CSC 5, 16 COBIT 5 APO07.01, APO07.02, APO07.03, APO07.04, APO07.05 ISA 62443-2-1:2009 4.3.3.2.1, 4.3.3.2.2, 4.3.3.2.3 ISO/IEC 27001:2013 A.7.1.1, A.7.1.2, A.7.2.1, A.7.2.2, A.7.2.3, A.7.3.1, A.8.1.4 NIST SP 800-53 Rev. 4 PS-1, PS-2, PS-3, PS-4, PS-5, PS-6, PS-7, PS-8, SA-21

Function	Category	Subcategory	Informative References
		PR.IP-12: A vulnerability management plan is developed and implemented	CIS CSC 4, 18, 20 COBIT 5 BAI03.10, DSS05.01, DSS05.02 ISO/IEC 27001:2013 A.12.6.1, A.14.2.3, A.16.1.3, A.18.2.2, A.18.2.3 NIST SP 800-53 Rev. 4 RA-3, RA-5, SI-2
	Maintenance (PR.MA): Maintenance and repairs of industrial control and information system components are performed consistent with policies and procedures.	PR.MA-1: Maintenance and repair of organizational assets are performed and logged, with approved and controlled tools	COBIT 5 BAI03.10, BAI09.02, BAI09.03, DSS01.05 ISA 62443-2-1:2009 4.3.3.3.7 ISO/IEC 27001:2013 A.11.1.2, A.11.2.4, A.11.2.5, A.11.2.6 NIST SP 800-53 Rev. 4 MA-2, MA-3, MA-5, MA-6
		PR.MA-2: Remote maintenance of organizational assets is approved, logged, and performed in a manner that prevents unauthorized access	CIS CSC 3, 5 COBIT 5 DSS05.04 ISA 62443-2-1:2009 4.3.3.6.5, 4.3.3.6.6, 4.3.3.6.7, 4.3.3.6.8 ISO/IEC 27001:2013 A.11.2.4, A.15.1.1, A.15.2.1 NIST SP 800-53 Rev. 4 MA-4
	Protective Technology (PR.PT): Technical security solutions are managed to ensure the security and resilience of systems and assets, consistent with related policies, procedures, and agreements.	PR.PT-1: Audit/log records are determined, documented, implemented, and reviewed in accordance with policy	CIS CSC 1, 3, 5, 6, 14, 15, 16 COBIT 5 APO11.04, BAI03.05, DSS05.04, DSS05.07, MEA02.01 ISA 62443-2-1:2009 4.3.3.3.9, 4.3.3.5.8, 4.3.4.4.7, 4.4.2.1, 4.4.2.2, 4.4.2.4 ISA 62443-3-3:2013 SR 2.8, SR 2.9, SR 2.10, SR 2.11, SR 2.12 ISO/IEC 27001:2013 A.12.4.1, A.12.4.2, A.12.4.3, A.12.4.4, A.12.7.1 NIST SP 800-53 Rev. 4 AU Family
		PR.PT-2: Removable media is protected and its use restricted according to policy	CIS CSC 8, 13 COBIT 5 APO13.01, DSS05.02, DSS05.06 ISA 62443-3-3:2013 SR 2.3 ISO/IEC 27001:2013 A.8.2.1, A.8.2.2, A.8.2.3, A.8.3.1, A.8.3.3, A.11.2.9

Function	Category	Subcategory	Informative References
PROTECT (PT)			NIST SP 800-53 Rev. 4 MP-2, MP-3, MP-4, MP-5, MP-7, MP-8
		PR.PT-3: The principle of least functionality is incorporated by configuring systems to provide only essential capabilities	CIS CSC 3, 11, 14 COBIT 5 DSS05.02, DSS05.05, DSS06.06 ISA 62443-2-1:2009 4.3.3.5.1, 4.3.3.5.2, 4.3.3.5.3, 4.3.3.5.4, 4.3.3.5.5, 4.3.3.5.6, 4.3.3.5.7, 4.3.3.5.8, 4.3.3.6.1, 4.3.3.6.2, 4.3.3.6.3, 4.3.3.6.4, 4.3.3.6.5, 4.3.3.6.6, 4.3.3.6.7, 4.3.3.6.8, 4.3.3.6.9, 4.3.3.7.1, 4.3.3.7.2, 4.3.3.7.3, 4.3.3.7.4 ISA 62443-3-3:2013 SR 1.1, SR 1.2, SR 1.3, SR 1.4, SR 1.5, SR 1.6, SR 1.7, SR 1.8, SR 1.9, SR 1.10, SR 1.11, SR 1.12, SR 1.13, SR 2.1, SR 2.2, SR 2.3, SR 2.4, SR 2.5, SR 2.6, SR 2.7 ISO/IEC 27001:2013 A.9.1.2 NIST SP 800-53 Rev. 4 AC-3, CM-7
		PR.PT-4: Communications and control networks are protected	CIS CSC 8, 12, 15 COBIT 5 DSS05.02, APO13.01 ISA 62443-3-3:2013 SR 3.1, SR 3.5, SR 3.8, SR 4.1, SR 4.3, SR 5.1, SR 5.2, SR 5.3, SR 7.1, SR 7.6 ISO/IEC 27001:2013 A.13.1.1, A.13.2.1, A.14.1.3 NIST SP 800-53 Rev. 4 AC-4, AC-17, AC-18, CP-8, SC-7, SC-19, SC-20, SC-21, SC-22, SC-23, SC-24, SC-25, SC-29, SC-32, SC-36, SC-37, SC-38, SC-39, SC-40, SC-41, SC-43
		PR.PT-5: Mechanisms (e.g., failsafe, load balancing, hot swap) are implemented to achieve resilience requirements in normal and adverse situations	COBIT 5 BAI04.01, BAI04.02, BAI04.03, BAI04.04, BAI04.05, DSS01.05 ISA 62443-2-1:2009 4.3.2.5.2 ISA 62443-3-3:2013 SR 7.1, SR 7.2 ISO/IEC 27001:2013 A.17.1.2, A.17.2.1 NIST SP 800-53 Rev. 4 CP-7, CP-8, CP-11, CP-13, PL-8, SA-14, SC-6
DETECT (DE)	Anomalies and Events (DE.AE): Anomalous activity is detected	DE.AE-1: A baseline of network operations and expected data flows for	CIS CSC 1, 4, 6, 12, 13, 15, 16 COBIT 5 DSS03.01 ISA 62443-2-1:2009 4.4.3.3

Function	Category	Subcategory	Informative References
	and the potential impact of events is understood.	users and systems are established and managed	ISO/IEC 27001:2013 A.12.1.1, A.12.1.2, A.13.1.1, A.13.1.2 NIST SP 800-53 Rev. 4 AC-4, CA-3, CM-2, SI-4
		DE.AE-2: Detected events are analyzed to understand attack targets and methods	CIS CSC 3, 6, 13, 15 COBIT 5 DSS05.07 ISA 62443-2-1:2009 4.3.4.5.6, 4.3.4.5.7, 4.3.4.5.8 ISA 62443-3-3:2013 SR 2.8, SR 2.9, SR 2.10, SR 2.11, SR 2.12, SR 3.9, SR 6.1, SR 6.2 ISO/IEC 27001:2013 A.12.4.1, A.16.1.1, A.16.1.4 NIST SP 800-53 Rev. 4 AU-6, CA-7, IR-4, SI-4
		DE.AE-3: Event data are collected and correlated from multiple sources and sensors	CIS CSC 1, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16 COBIT 5 BAI08.02 ISA 62443-3-3:2013 SR 6.1 ISO/IEC 27001:2013 A.12.4.1, A.16.1.7 NIST SP 800-53 Rev. 4 AU-6, CA-7, IR-4, IR-5, IR-8, SI-4
		DE.AE-4: Impact of events is determined	CIS CSC 4, 6 COBIT 5 APO12.06, DSS03.01 ISO/IEC 27001:2013 A.16.1.4 NIST SP 800-53 Rev. 4 CP-2, IR-4, RA-3, SI-4
		DE.AE-5: Incident alert thresholds are established	CIS CSC 6, 19 COBIT 5 APO12.06, DSS03.01 ISA 62443-2-1:2009 4.2.3.10 ISO/IEC 27001:2013 A.16.1.4 NIST SP 800-53 Rev. 4 IR-4, IR-5, IR-8
	Security Continuous Monitoring (DE.CM): The information system and assets are monitored to identify cybersecurity events and verify	DE.CM-1: The network is monitored to detect potential cybersecurity events	CIS CSC 1, 7, 8, 12, 13, 15, 16 COBIT 5 DSS01.03, DSS03.05, DSS05.07 ISA 62443-3-3:2013 SR 6.2 NIST SP 800-53 Rev. 4 AC-2, AU-12, CA-7, CM-3, SC-5, SC-7, SI-4

Function	Category	Subcategory	Informative References
	the effectiveness of protective measures.	DE.CM-2: The physical environment is monitored to detect potential cybersecurity events	COBIT 5 DSS01.04, DSS01.05 ISA 62443-2-1:2009 4.3.3.3.8 ISO/IEC 27001:2013 A.11.1.1, A.11.1.2 NIST SP 800-53 Rev. 4 CA-7, PE-3, PE-6, PE-20
		DE.CM-3: Personnel activity is monitored to detect potential cybersecurity events	CIS CSC 5, 7, 14, 16 COBIT 5 DSS05.07 ISA 62443-3-3:2013 SR 6.2 ISO/IEC 27001:2013 A.12.4.1, A.12.4.3 NIST SP 800-53 Rev. 4 AC-2, AU-12, AU-13, CA-7, CM-10, CM-11
		DE.CM-4: Malicious code is detected	CIS CSC 4, 7, 8, 12 COBIT 5 DSS05.01 ISA 62443-2-1:2009 4.3.4.3.8 ISA 62443-3-3:2013 SR 3.2 ISO/IEC 27001:2013 A.12.2.1 NIST SP 800-53 Rev. 4 SI-3, SI-8
		DE.CM-5: Unauthorized mobile code is detected	CIS CSC 7, 8 COBIT 5 DSS05.01 ISA 62443-3-3:2013 SR 2.4 ISO/IEC 27001:2013 A.12.5.1, A.12.6.2 NIST SP 800-53 Rev. 4 SC-18, SI-4, SC-44
		DE.CM-6: External service provider activity is monitored to detect potential cybersecurity events	COBIT 5 APO07.06, APO10.05 ISO/IEC 27001:2013 A.14.2.7, A.15.2.1 NIST SP 800-53 Rev. 4 CA-7, PS-7, SA-4, SA-9, SI-4
		DE.CM-7: Monitoring for unauthorized personnel, connections, devices, and software is performed	CIS CSC 1, 2, 3, 5, 9, 12, 13, 15, 16 COBIT 5 DSS05.02, DSS05.05 ISO/IEC 27001:2013 A.12.4.1, A.14.2.7, A.15.2.1 NIST SP 800-53 Rev. 4 AU-12, CA-7, CM-3, CM-8, PE-3, PE-6, PE-20, SI-4
		DE.CM-8: Vulnerability scans are performed	CIS CSC 4, 20

Function	Category	Subcategory	Informative References
			COBIT 5 BAI03.10, DSS05.01 ISA 62443-2-1:2009 4.2.3.1, 4.2.3.7 ISO/IEC 27001:2013 A.12.6.1 NIST SP 800-53 Rev. 4 RA-5
Detection Processes (DE.DP): Detection processes and procedures are maintained and tested to ensure awareness of anomalous events.	DE.DP-1: Roles and responsibilities for detection are well defined to ensure accountability	DE.DP-1: Roles and responsibilities for detection are well defined to ensure accountability	CIS CSC 19 COBIT 5 APO01.02, DSS05.01, DSS06.03 ISA 62443-2-1:2009 4.4.3.1 ISO/IEC 27001:2013 A.6.1.1, A.7.2.2 NIST SP 800-53 Rev. 4 CA-2, CA-7, PM-14
	DE.DP-2: Detection activities comply with all applicable requirements	DE.DP-2: Detection activities comply with all applicable requirements	COBIT 5 DSS06.01, MEA03.03, MEA03.04 ISA 62443-2-1:2009 4.4.3.2 ISO/IEC 27001:2013 A.18.1.4, A.18.2.2, A.18.2.3 NIST SP 800-53 Rev. 4 AC-25, CA-2, CA-7, SA-18, SI-4, PM-14
	DE.DP-3: Detection processes are tested	DE.DP-3: Detection processes are tested	COBIT 5 APO13.02, DSS05.02 ISA 62443-2-1:2009 4.4.3.2 ISA 62443-3-3:2013 SR 3.3 ISO/IEC 27001:2013 A.14.2.8 NIST SP 800-53 Rev. 4 CA-2, CA-7, PE-3, SI-3, SI-4, PM-14
	DE.DP-4: Event detection information is communicated	DE.DP-4: Event detection information is communicated	CIS CSC 19 COBIT 5 APO08.04, APO12.06, DSS02.05 ISA 62443-2-1:2009 4.3.4.5.9 ISA 62443-3-3:2013 SR 6.1 ISO/IEC 27001:2013 A.16.1.2, A.16.1.3 NIST SP 800-53 Rev. 4 AU-6, CA-2, CA-7, RA-5, SI-4
	DE.DP-5: Detection processes are continuously improved	DE.DP-5: Detection processes are continuously improved	COBIT 5 APO11.06, APO12.06, DSS04.05 ISA 62443-2-1:2009 4.4.3.4 ISO/IEC 27001:2013 A.16.1.6 NIST SP 800-53 Rev. 4 , CA-2, CA-7, PL-2, RA-5, SI-4, PM-14

Function	Category	Subcategory	Informative References
RESPOND (RS)	Response Planning (RS.RP): Response processes and procedures are executed and maintained, to ensure response to detected cybersecurity incidents.	RS.RP-1: Response plan is executed during or after an incident	CIS CSC 19 COBIT 5 APO12.06, BAI01.10 ISA 62443-2-1:2009 4.3.4.5.1 ISO/IEC 27001:2013 A.16.1.5 NIST SP 800-53 Rev. 4 CP-2, CP-10, IR-4, IR-8
	Communications (RS.CO): Response activities are coordinated with internal and external stakeholders (e.g. external support from law enforcement agencies).	RS.CO-1: Personnel know their roles and order of operations when a response is needed	CIS CSC 19 COBIT 5 EDM03.02, APO01.02, APO12.03 ISA 62443-2-1:2009 4.3.4.5.2, 4.3.4.5.3, 4.3.4.5.4 ISO/IEC 27001:2013 A.6.1.1, A.7.2.2, A.16.1.1 NIST SP 800-53 Rev. 4 CP-2, CP-3, IR-3, IR-8
		RS.CO-2: Incidents are reported consistent with established criteria	CIS CSC 19 COBIT 5 DSS01.03 ISA 62443-2-1:2009 4.3.4.5.5 ISO/IEC 27001:2013 A.6.1.3, A.16.1.2 NIST SP 800-53 Rev. 4 AU-6, IR-6, IR-8
		RS.CO-3: Information is shared consistent with response plans	CIS CSC 19 COBIT 5 DSS03.04 ISA 62443-2-1:2009 4.3.4.5.2 ISO/IEC 27001:2013 A.16.1.2, Clause 7.4, Clause 16.1.2 NIST SP 800-53 Rev. 4 CA-2, CA-7, CP-2, IR-4, IR-8, PE-6, RA-5, SI-4
		RS.CO-4: Coordination with stakeholders occurs consistent with response plans	CIS CSC 19 COBIT 5 DSS03.04 ISA 62443-2-1:2009 4.3.4.5.5 ISO/IEC 27001:2013 Clause 7.4 NIST SP 800-53 Rev. 4 CP-2, IR-4, IR-8
		RS.CO-5: Voluntary information sharing occurs with external stakeholders to achieve broader cybersecurity situational awareness	CIS CSC 19 COBIT 5 BAI08.04 ISO/IEC 27001:2013 A.6.1.4 NIST SP 800-53 Rev. 4 SI-5, PM-15

Function	Category	Subcategory	Informative References
	Analysis (RS.AN): Analysis is conducted to ensure effective response and support recovery activities.	RS.AN-1: Notifications from detection systems are investigated	CIS CSC 4, 6, 8, 19 COBIT 5 DSS02.04, DSS02.07 ISA 62443-2-1:2009 4.3.4.5.6, 4.3.4.5.7, 4.3.4.5.8 ISA 62443-3-3:2013 SR 6.1 ISO/IEC 27001:2013 A.12.4.1, A.12.4.3, A.16.1.5 NIST SP 800-53 Rev. 4 AU-6, CA-7, IR-4, IR-5, PE-6, SI-4
		RS.AN-2: The impact of the incident is understood	COBIT 5 DSS02.02 ISA 62443-2-1:2009 4.3.4.5.6, 4.3.4.5.7, 4.3.4.5.8 ISO/IEC 27001:2013 A.16.1.4, A.16.1.6 NIST SP 800-53 Rev. 4 CP-2, IR-4
		RS.AN-3: Forensics are performed	COBIT 5 APO12.06, DSS03.02, DSS05.07 ISA 62443-3-3:2013 SR 2.8, SR 2.9, SR 2.10, SR 2.11, SR 2.12, SR 3.9, SR 6.1 ISO/IEC 27001:2013 A.16.1.7 NIST SP 800-53 Rev. 4 AU-7, IR-4
		RS.AN-4: Incidents are categorized consistent with response plans	CIS CSC 19 COBIT 5 DSS02.02 ISA 62443-2-1:2009 4.3.4.5.6 ISO/IEC 27001:2013 A.16.1.4 NIST SP 800-53 Rev. 4 CP-2, IR-4, IR-5, IR-8
		RS.AN-5: Processes are established to receive, analyze and respond to vulnerabilities disclosed to the organization from internal and external sources (e.g. internal testing, security bulletins, or security researchers)	CIS CSC 4, 19 COBIT 5 EDM03.02, DSS05.07 NIST SP 800-53 Rev. 4 SI-5, PM-15
	Mitigation (RS.MI): Activities are performed to prevent expansion of an event, mitigate its effects, and resolve the incident.	RS.MI-1: Incidents are contained	CIS CSC 19 COBIT 5 APO12.06 ISA 62443-2-1:2009 4.3.4.5.6 ISA 62443-3-3:2013 SR 5.1, SR 5.2, SR 5.4 ISO/IEC 27001:2013 A.12.2.1, A.16.1.5

Function	Category	Subcategory	Informative References
			NIST SP 800-53 Rev. 4 IR-4
		RS.MI-2: Incidents are mitigated	CIS CSC 4, 19 COBIT 5 APO12.06 ISA 62443-2-1:2009 4.3.4.5.6, 4.3.4.5.10 ISO/IEC 27001:2013 A.12.2.1, A.16.1.5 NIST SP 800-53 Rev. 4 IR-4
		RS.MI-3: Newly identified vulnerabilities are mitigated or documented as accepted risks	CIS CSC 4 COBIT 5 APO12.06 ISO/IEC 27001:2013 A.12.6.1 NIST SP 800-53 Rev. 4 CA-7, RA-3, RA-5
	Improvements (RS.IM): Organizational response activities are improved by incorporating lessons learned from current and previous detection/response activities.	RS.IM-1: Response plans incorporate lessons learned	COBIT 5 BAI01.13 ISA 62443-2-1:2009 4.3.4.5.10, 4.4.3.4 ISO/IEC 27001:2013 A.16.1.6, Clause 10 NIST SP 800-53 Rev. 4 CP-2, IR-4, IR-8
		RS.IM-2: Response strategies are updated	COBIT 5 BAI01.13, DSS04.08 ISO/IEC 27001:2013 A.16.1.6, Clause 10 NIST SP 800-53 Rev. 4 CP-2, IR-4, IR-8
RECOVER (RC)	Recovery Planning (RC.RP): Recovery processes and procedures are executed and maintained to ensure restoration of systems or assets affected by cybersecurity incidents.	RC.RP-1: Recovery plan is executed during or after a cybersecurity incident	CIS CSC 10 COBIT 5 APO12.06, DSS02.05, DSS03.04 ISO/IEC 27001:2013 A.16.1.5 NIST SP 800-53 Rev. 4 CP-10, IR-4, IR-8
	Improvements (RC.IM): Recovery planning and processes are improved by incorporating lessons learned into future activities.	RC.IM-1: Recovery plans incorporate lessons learned	COBIT 5 APO12.06, BAI05.07, DSS04.08 ISA 62443-2-1:2009 4.4.3.4 ISO/IEC 27001:2013 A.16.1.6, Clause 10 NIST SP 800-53 Rev. 4 CP-2, IR-4, IR-8
		RC.IM-2: Recovery strategies are updated	COBIT 5 APO12.06, BAI07.08 ISO/IEC 27001:2013 A.16.1.6, Clause 10 NIST SP 800-53 Rev. 4 CP-2, IR-4, IR-8

Function	Category	Subcategory	Informative References
	Communications (RC.CO): Restoration activities are coordinated with internal and external parties (e.g. coordinating centers, Internet Service Providers, owners of attacking systems, victims, other CSIRTS, and vendors).	RC.CO-1: Public relations are managed	COBIT 5 EDM03.02 ISO/IEC 27001:2013 A.6.1.4, Clause 7.4
		RC.CO-2: Reputation is repaired after an incident	COBIT 5 MEA03.02 ISO/IEC 27001:2013 Clause 7.4
		RC.CO-3: Recovery activities are communicated to internal and external stakeholders as well as executive and management teams	COBIT 5 APO12.06 ISO/IEC 27001:2013 Clause 7.4 NIST SP 800-53 Rev. 4 CP-2, IR-4

Information regarding Informative References described in Appendix A may be found at the following locations:

- Control Objectives for Information and Related Technology (COBIT): <http://www.isaca.org/COBIT/Pages/default.aspx>
- CIS Critical Security Controls for Effective Cyber Defense (CIS Controls): <https://www.cisecurity.org>
- American National Standards Institute/International Society of Automation (ANSI/ISA)-62443-2-1 (99.02.01)-2009, *Security for Industrial Automation and Control Systems: Establishing an Industrial Automation and Control Systems Security Program*: <https://www.isa.org/templates/one-column.aspx?pageid=111294&productId=116731>
- ANSI/ISA-62443-3-3 (99.03.03)-2013, *Security for Industrial Automation and Control Systems: System Security Requirements and Security Levels*: <https://www.isa.org/templates/one-column.aspx?pageid=111294&productId=116785>
- ISO/IEC 27001, *Information technology -- Security techniques -- Information security management systems -- Requirements*: <https://www.iso.org/standard/54534.html>
- NIST SP 800-53 Rev. 4 - NIST Special Publication 800-53 Revision 4, *Security and Privacy Controls for Federal Information Systems and Organizations*, April 2013 (including updates as of January 22, 2015). <https://doi.org/10.6028/NIST.SP.800-53r4>. Informative References are only mapped to the control level, though any control enhancement might be found useful in achieving a subcategory outcome.

Mappings between the Framework Core Subcategories and the specified sections in the Informative References are not intended to definitively determine whether the specified sections in the Informative References provide the desired Subcategory outcome.

Informative References are not exhaustive, in that not every element (e.g., control, requirement) of a given Informative Reference is mapped to Framework Core Subcategories.

Appendix B: Glossary

This appendix defines selected terms used in the publication.

Table 3: Framework Glossary

Buyer	The people or organizations that consume a given product or service.
Category	The subdivision of a Function into groups of cybersecurity outcomes, closely tied to programmatic needs and particular activities. Examples of Categories include “Asset Management,” “Identity Management and Access Control,” and “Detection Processes.”
Critical Infrastructure	Systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on cybersecurity, national economic security, national public health or safety, or any combination of those matters.
Cybersecurity	The process of protecting information by preventing, detecting, and responding to attacks.
Cybersecurity Event	A cybersecurity change that may have an impact on organizational operations (including mission, capabilities, or reputation).
Cybersecurity Incident	A cybersecurity event that has been determined to have an impact on the organization prompting the need for response and recovery.
Detect (function)	Develop and implement the appropriate activities to identify the occurrence of a cybersecurity event.
Framework	A risk-based approach to reducing cybersecurity risk composed of three parts: the Framework Core, the Framework Profile, and the Framework Implementation Tiers. Also known as the “Cybersecurity Framework.”
Framework Core	A set of cybersecurity activities and references that are common across critical infrastructure sectors and are organized around particular outcomes. The Framework Core comprises four types of elements: Functions, Categories, Subcategories, and Informative References.
Framework Implementation Tier	A lens through which to view the characteristics of an organization’s approach to risk—how an organization views cybersecurity risk and the processes in place to manage that risk.

Framework Profile	A representation of the outcomes that a particular system or organization has selected from the Framework Categories and Subcategories.
Function	One of the main components of the Framework. Functions provide the highest level of structure for organizing basic cybersecurity activities into Categories and Subcategories. The five functions are Identify, Protect, Detect, Respond, and Recover.
Identify (function)	Develop the organizational understanding to manage cybersecurity risk to systems, assets, data, and capabilities.
Informative Reference	A specific section of standards, guidelines, and practices common among critical infrastructure sectors that illustrates a method to achieve the outcomes associated with each Subcategory. An example of an Informative Reference is ISO/IEC 27001 Control A.10.8.3, which supports the “Data-in-transit is protected” Subcategory of the “Data Security” Category in the “Protect” function.
Mobile Code	A program (e.g., script, macro, or other portable instruction) that can be shipped unchanged to a heterogeneous collection of platforms and executed with identical semantics.
Protect (function)	Develop and implement the appropriate safeguards to ensure delivery of critical infrastructure services.
Privileged User	A user that is authorized (and, therefore, trusted) to perform security-relevant functions that ordinary users are not authorized to perform.
Recover (function)	Develop and implement the appropriate activities to maintain plans for resilience and to restore any capabilities or services that were impaired due to a cybersecurity event.
Respond (function)	Develop and implement the appropriate activities to take action regarding a detected cybersecurity event.
Risk	A measure of the extent to which an entity is threatened by a potential circumstance or event, and typically a function of: (i) the adverse impacts that would arise if the circumstance or event occurs; and (ii) the likelihood of occurrence.
Risk Management	The process of identifying, assessing, and responding to risk.
Subcategory	The subdivision of a Category into specific outcomes of technical and/or management activities. Examples of Subcategories include “External information systems are catalogued,” “Data-at-rest is protected,” and “Notifications from detection systems are investigated.”

Supplier	Product and service providers used for an organization's internal purposes (e.g., IT infrastructure) or integrated into the products of services provided to that organization's Buyers.
Taxonomy	A scheme of classification.

Appendix C: Acronyms

This appendix defines selected acronyms used in the publication.

ANSI	American National Standards Institute
CEA	Cybersecurity Enhancement Act of 2014
CIS	Center for Internet Security
COBIT	Control Objectives for Information and Related Technology
CPS	Cyber-Physical Systems
CSC	Critical Security Control
DHS	Department of Homeland Security
EO	Executive Order
ICS	Industrial Control Systems
IEC	International Electrotechnical Commission
IoT	Internet of Things
IR	Interagency Report
ISA	International Society of Automation
ISAC	Information Sharing and Analysis Center
ISAO	Information Sharing and Analysis Organization
ISO	International Organization for Standardization
IT	Information Technology
NIST	National Institute of Standards and Technology
OT	Operational Technology
PII	Personally Identifiable Information
RFI	Request for Information
RMP	Risk Management Process
SCRM	Supply Chain Risk Management
SP	Special Publication

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U.S. Department of Commerce
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There may be references in this publication to other publications currently under development by NIST in accordance with its assigned statutory responsibilities. The information in this publication, including concepts, practices, and methodologies may be used by federal agencies even before the completion of such companion publications. Thus, until each publication is completed, current requirements, guidelines, and procedures, where they exist, remain operative. For planning and transition purposes, federal agencies may wish to closely follow the development of these new publications by NIST.

Organizations are encouraged to review draft publications during the designated public comment periods and provide feedback to NIST. Many NIST publications, other than the ones noted above, are available at <https://csrc.nist.gov/publications>.

Comments on this publication may be submitted to:

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All comments are subject to release under the Freedom of Information Act (FOIA) [[FOIA96](#)].

Reports on Computer Systems Technology

The National Institute of Standards and Technology (NIST) Information Technology Laboratory (ITL) promotes the U.S. economy and public welfare by providing technical leadership for the Nation's measurement and standards infrastructure. ITL develops tests, test methods, reference data, proof of concept implementations, and technical analyses to advance the development and productive use of information technology (IT). ITL's responsibilities include the development of management, administrative, technical, and physical standards and guidelines for the cost-effective security of other than national security-related information in federal information systems. The Special Publication 800-series reports on ITL's research, guidelines, and outreach efforts in information systems security and privacy and its collaborative activities with industry, government, and academic organizations.

Abstract

This publication provides a catalog of security and privacy controls for information systems and organizations to protect organizational operations and assets, individuals, other organizations, and the Nation from a diverse set of threats and risks, including hostile attacks, human errors, natural disasters, structural failures, foreign intelligence entities, and privacy risks. The controls are flexible and customizable and implemented as part of an organization-wide process to manage risk. The controls address diverse requirements derived from mission and business needs, laws, executive orders, directives, regulations, policies, standards, and guidelines. Finally, the consolidated control catalog addresses security and privacy from a functionality perspective (i.e., the strength of functions and mechanisms provided by the controls) and from an assurance perspective (i.e., the measure of confidence in the security or privacy capability provided by the controls). Addressing functionality and assurance helps to ensure that information technology products and the systems that rely on those products are sufficiently trustworthy.

Keywords

Assurance; availability; computer security; confidentiality; control; cybersecurity; FISMA; information security; information system; integrity; personally identifiable information; Privacy Act; privacy controls; privacy functions; privacy requirements; Risk Management Framework; security controls; security functions; security requirements; system; system security.

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Patent Disclosure Notice

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RISK MANAGEMENT

Organizations must exercise *due diligence* in managing information security and privacy risk. This is accomplished, in part, by establishing a comprehensive risk management program that uses the flexibility inherent in NIST publications to categorize systems, select and implement security and privacy controls that meet mission and business needs, assess the effectiveness of the controls, authorize the systems for operation, and continuously monitor the systems. Exercising due diligence and implementing robust and comprehensive information security and privacy risk management programs can facilitate compliance with applicable laws, regulations, executive orders, and governmentwide policies. Risk management frameworks and risk management processes are essential in developing, implementing, and maintaining the protection measures necessary to address stakeholder needs and the current threats to organizational operations and assets, individuals, other organizations, and the Nation. Employing effective risk-based processes, procedures, methods, and technologies ensures that information systems and organizations have the necessary trustworthiness and resiliency to support essential mission and business functions, the U.S. critical infrastructure, and continuity of government.

COMMON SECURITY AND PRIVACY FOUNDATIONS

In working with the Office of Management and Budget to develop standards and guidelines required by FISMA, NIST consults with federal agencies, state, local, and tribal governments, and private sector organizations to improve information security and privacy, avoid unnecessary and costly duplication of effort, and help ensure that its publications are complementary with the standards and guidelines used for the protection of national security systems. In addition to a comprehensive and transparent public review and comment process, NIST is engaged in a collaborative partnership with the Office of Management and Budget, Office of the Director of National Intelligence, Department of Defense, Committee on National Security Systems, Federal CIO Council, and Federal Privacy Council to establish a Risk Management Framework (RMF) for information security and privacy for the Federal Government. This common foundation provides the Federal Government and their contractors with cost-effective, flexible, and consistent ways to manage security and privacy risks to organizational operations and assets, individuals, other organizations, and the Nation. The framework provides a basis for the reciprocal acceptance of security and privacy control assessment evidence and authorization decisions and facilitates information sharing and collaboration. NIST continues to work with public and private sector entities to establish mappings and relationships between the standards and guidelines developed by NIST and those developed by other organizations. NIST anticipates using these mappings and the gaps they identify to improve the control catalog.

DEVELOPMENT OF INFORMATION SYSTEMS, COMPONENTS, AND SERVICES

With a renewed emphasis on the use of trustworthy, secure information systems and supply chain security, it is essential that organizations express their security and privacy requirements with clarity and specificity in order to obtain the systems, components, and services necessary for mission and business success. Accordingly, this publication provides controls in the System and Services Acquisition (SA) and Supply Chain Risk Management (SR) families that are directed at developers. The scope of the controls in those families includes information system, system component, and system service development *and* the associated developers whether the development is conducted internally by organizations or externally through the contracting and acquisition processes. The affected controls in the control catalog include [SA-8](#), [SA-10](#), [SA-11](#), [SA-15](#), [SA-16](#), [SA-17](#), [SA-20](#), [SA-21](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-6](#), [SR-7](#), [SR-8](#), [SR-9](#), and [SR-11](#).

INFORMATION SYSTEMS — A BROAD-BASED PERSPECTIVE

As we push computers to “the edge,” building an increasingly complex world of interconnected systems and devices, security and privacy continue to dominate the national dialogue. There is an urgent need to further strengthen the underlying systems, products, and services that we depend on in every sector of the critical infrastructure to ensure that those systems, products, and services are sufficiently trustworthy and provide the necessary resilience to support the economic and national security interests of the United States. NIST Special Publication 800-53, Revision 5, responds to this need by embarking on a proactive and systemic approach to develop and make available to a broad base of public and private sector organizations a comprehensive set of security and privacy safeguarding measures for all types of computing platforms, including general purpose computing systems, cyber-physical systems, cloud systems, mobile systems, industrial control systems, and Internet of Things (IoT) devices. Safeguarding measures include both security and privacy controls to protect the critical and essential operations and assets of organizations and the privacy of individuals. The objective is to make the systems we depend on more penetration resistant to attacks, limit the damage from those attacks when they occur, and make the systems resilient, survivable, and protective of individuals’ privacy.

CONTROL BASELINES

The control baselines that have previously been included in NIST Special Publication 800-53 have been relocated to [NIST Special Publication 800-53B](#). SP 800-53B contains security and privacy control baselines for federal information systems and organizations. It provides guidance for tailoring control baselines and for developing overlays to support the security and privacy requirements of stakeholders and their organizations. [CNSS Instruction 1253](#) provides control baselines and guidance for security categorization and security control selection for national security systems.

USE OF EXAMPLES IN THIS PUBLICATION

Throughout this publication, *examples* are used to illustrate, clarify, or explain certain items in chapter sections, controls, and control enhancements. These examples are illustrative in nature and are *not* intended to limit or constrain the application of controls or control enhancements by organizations.

FEDERAL RECORDS MANAGEMENT COLLABORATION

Federal records management processes have a nexus with certain information security and privacy requirements and controls. For example, records officers may be managing records retention, including when records will be deleted. Collaborating with records officers on the selection and implementation of security and privacy controls related to records management can support consistency and efficiency and ultimately strengthen the organization's security and privacy posture.

Table of Contents

CHAPTER ONE INTRODUCTION	1
1.1 PURPOSE AND APPLICABILITY	2
1.2 TARGET AUDIENCE	3
1.3 ORGANIZATIONAL RESPONSIBILITIES.....	3
1.4 RELATIONSHIP TO OTHER PUBLICATIONS.....	5
1.5 REVISIONS AND EXTENSIONS	5
1.6 PUBLICATION ORGANIZATION	5
CHAPTER TWO THE FUNDAMENTALS.....	7
2.1 REQUIREMENTS AND CONTROLS	7
2.2 CONTROL STRUCTURE AND ORGANIZATION	8
2.3 CONTROL IMPLEMENTATION APPROACHES.....	11
2.4 SECURITY AND PRIVACY CONTROLS.....	13
2.5 TRUSTWORTHINESS AND ASSURANCE.....	14
CHAPTER THREE THE CONTROLS	16
3.1 ACCESS CONTROL	18
3.2 AWARENESS AND TRAINING	59
3.3 AUDIT AND ACCOUNTABILITY	65
3.4 ASSESSMENT, AUTHORIZATION, AND MONITORING	83
3.5 CONFIGURATION MANAGEMENT	96
3.6 CONTINGENCY PLANNING	115
3.7 IDENTIFICATION AND AUTHENTICATION	131
3.8 INCIDENT RESPONSE.....	149
3.9 MAINTENANCE.....	162
3.10 MEDIA PROTECTION	171
3.11 PHYSICAL AND ENVIRONMENTAL PROTECTION	179
3.12 PLANNING	194
3.13 PROGRAM MANAGEMENT	203
3.14 PERSONNEL SECURITY	222
3.15 PERSONALLY IDENTIFIABLE INFORMATION PROCESSING AND TRANSPARENCY	229
3.16 RISK ASSESSMENT.....	238
3.17 SYSTEM AND SERVICES ACQUISITION	249
3.18 SYSTEM AND COMMUNICATIONS PROTECTION	292
3.19 SYSTEM AND INFORMATION INTEGRITY	332
3.20 SUPPLY CHAIN RISK MANAGEMENT.....	363
REFERENCES	374
APPENDIX A GLOSSARY.....	394
APPENDIX B ACRONYMS.....	424
APPENDIX C CONTROL SUMMARIES	428

Executive Summary

As we push computers to “the edge,” building an increasingly complex world of connected information systems and devices, security and privacy will continue to dominate the national dialogue. In its 2017 report, *Task Force on Cyber Deterrence* [[DSB 2017](#)], the Defense Science Board (DSB) provides a sobering assessment of the current vulnerabilities in the U.S. critical infrastructure and the information systems that support mission-essential operations and assets in the public and private sectors.

“...The Task Force notes that the cyber threat to U.S. critical infrastructure is outpacing efforts to reduce pervasive vulnerabilities, so that for the next decade at least the United States must lean significantly on deterrence to address the cyber threat posed by the most capable U.S. adversaries. It is clear that a more proactive and systematic approach to U.S. cyber deterrence is urgently needed...”

There is an urgent need to further strengthen the underlying information systems, component products, and services that the Nation depends on in every sector of the critical infrastructure—ensuring that those systems, components, and services are sufficiently trustworthy and provide the necessary resilience to support the economic and national security interests of the United States. This update to NIST Special Publication (SP) 800-53 responds to the call by the DSB by embarking on a proactive and systemic approach to develop and make available to a broad base of public and private sector organizations a comprehensive set of safeguarding measures for all types of computing platforms, including general purpose computing systems, cyber-physical systems, cloud-based systems, mobile devices, Internet of Things (IoT) devices, weapons systems, space systems, communications systems, environmental control systems, super computers, and industrial control systems. Those safeguarding measures include implementing security and privacy controls to protect the critical and essential operations and assets of organizations and the privacy of individuals. The objectives are to make the information systems we depend on more penetration-resistant, limit the damage from attacks when they occur, make the systems cyber-resilient and survivable, and protect individuals’ privacy.

Revision 5 of this foundational NIST publication represents a multi-year effort to develop the next generation of security and privacy controls that will be needed to accomplish the above objectives. It includes changes to make the controls more usable by diverse consumer groups (e.g., enterprises conducting mission and business functions; engineering organizations developing information systems, IoT devices, and systems-of-systems; and industry partners building system components, products, and services). The most significant changes to this publication include:

- Making the controls more *outcome-based* by removing the entity responsible for satisfying the control (i.e., information system, organization) from the control statement;
- Integrating information security and privacy controls into a seamless, consolidated control catalog for information systems and organizations;
- Establishing a new supply chain risk management control family;
- Separating control selection processes from the *controls*, thereby allowing the controls to be used by different communities of interest, including systems engineers, security architects, software developers, enterprise architects, systems security and privacy engineers, and mission or business owners;

- Removing control baselines and tailoring guidance from the publication and transferring the content to NIST SP 800-53B, *Control Baselines for Information Systems and Organizations*;
- Clarifying the relationship between requirements and controls and the relationship between security and privacy controls; and
- Incorporating new, state-of-the-practice controls (e.g., controls to support cyber resiliency, support secure systems design, and strengthen security and privacy governance and accountability) based on the latest threat intelligence and cyber-attack data.

In separating the process of control selection from the controls and removing the control baselines, a significant amount of guidance and other informative material previously contained in SP 800-53 was eliminated. That content will be moved to other NIST publications such as SP 800-37 (Risk Management Framework) and SP 800-53B during the next update cycle. In the near future, NIST also plans to offer the content of SP 800-53, SP 800-53A, and SP 800-53B to a web-based portal to provide its customers interactive, online access to all control, control baseline, overlay, and assessment information.

Prologue

“...Through the process of risk management, leaders must consider risk to US interests from adversaries using cyberspace to their advantage and from our own efforts to employ the global nature of cyberspace to achieve objectives in military, intelligence, and business operations...”

“...For operational plans development, the combination of threats, vulnerabilities, and impacts must be evaluated in order to identify important trends and decide where effort should be applied to eliminate or reduce threat capabilities; eliminate or reduce vulnerabilities; and assess, coordinate, and deconflict all cyberspace operations...”

“...Leaders at all levels are accountable for ensuring readiness and security to the same degree as in any other domain...”

THE NATIONAL STRATEGY FOR CYBERSPACE OPERATIONS
OFFICE OF THE CHAIRMAN, JOINT CHIEFS OF STAFF, U.S. DEPARTMENT OF DEFENSE

“Networking and information technology [are] transforming life in the 21st century, changing the way people, businesses, and government interact. Vast improvements in computing, storage, and communications are creating new opportunities for enhancing our social wellbeing; improving health and health care; eliminating barriers to education and employment; and increasing efficiencies in many sectors such as manufacturing, transportation, and agriculture.

The promise of these new applications often stems from their ability to create, collect, transmit, process, and archive information on a massive scale. However, the vast increase in the quantity of personal information that is being collected and retained, combined with the increased ability to analyze it and combine it with other information, is creating valid concerns about privacy and about the ability of entities to manage these unprecedented volumes of data responsibly.... A key challenge of this era is to assure that growing capabilities to create, capture, store, and process vast quantities of information will not damage the core values of the country....”

“...When systems process personal information, whether by collecting, analyzing, generating, disclosing, retaining, or otherwise using the information, they can impact privacy of individuals. System designers need to account for individuals as stakeholders in the overall development of the solution....Designing for privacy must connect individuals’ privacy desires with system requirements and controls in a way that effectively bridges the aspirations with development....”

THE NATIONAL PRIVACY RESEARCH STRATEGY
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL, NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT PROGRAM

Errata

This table contains changes that have been incorporated into SP 800-53, Revision 5. Errata updates can include corrections, clarifications, or other minor changes in the publication that are either *editorial* or *substantive* in nature. Any potential updates for this document that are not yet published in an errata update or revision—including additional issues and potential corrections—will be posted as they are identified; see the SP 800-53, Revision 5 [publication details](#).

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	Acknowledgements (ODNI): Add “Matthew A. Kozma, Chief Information Officer”	iii
12-10-2020	Editorial	Acknowledgements (ODNI): Add “Michael E. Waschull, Deputy Chief Information Officer”	iii
12-10-2020	Editorial	Acknowledgements (ODNI): Add “Clifford M. Conner, Cybersecurity Group and IC CISO”	iii
12-10-2020	Editorial	Call Out Box: Change “Special Publication 800-53B contains control baselines” to “SP 800-53B contains security and privacy control baselines”	x
12-10-2020	Editorial	Chapter One (Footnote 7): Add “[SP 800-53A]”	1
12-10-2020	Editorial	Section 1.4: Delete “The controls have also been mapped to the requirements for federal information systems included in [OMB A-130].”	5
12-10-2020	Editorial	Section 1.4 (Footnote 23): Delete “[OMB A-130] establishes policy for the planning, budgeting, governance, acquisition, and management of federal information, personnel, equipment, funds, IT resources, and supporting infrastructure and services.”	5
12-10-2020	Editorial	Section 2.4 (first paragraph): Change “personally identifiable information (PII)” to “PII”	13
12-10-2020	Editorial	Control AC-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	18
12-10-2020	Editorial	Control AC-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	18
12-10-2020	Editorial	Control Enhancement AC-3(2) Discussion: Change “authorization duties to other individuals” to “authorization duties”	23
12-10-2020	Editorial	Control Enhancement AC-3(9) Discussion: Change “mitigating control” to “mitigation measure”	26
12-10-2020	Editorial	Control Enhancement AC-3(14) Related Controls: Add “, PT-6”	28
12-10-2020	Editorial	Control Enhancement AC-4(17): Change “organization, system, application, service, individual” to “organization; system; application; service; individual”	33
12-10-2020	Editorial	Control Enhancement AC-4(25): Change “Selection (one or more:” to “Selection (one or more):”	34
12-10-2020	Editorial	Control AC-12: Change “conditions,” to “conditions”	43
12-10-2020	Editorial	Control AC-14 Discussion: Change “assignment” to “assignment operation”	44
12-10-2020	Editorial	Control AC-19 Discussion: Change “the organizational network” to “its network”	52

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	Control AC-19 Discussion: Change “Many controls for mobile devices are reflected in other controls allocated to the initial control baselines as starting points for the development of security plans and overlays using the tailoring process. There may also be some overlap by the security controls within the different families of controls.” to “Many safeguards for mobile devices are reflected in other controls.”	52
12-10-2020	Editorial	Control AC-20 Discussion: Change “organizational systems” to “organizational systems,”	53
12-10-2020	Editorial	Control Enhancement AC-20(3) Discussion: Change “AC-20(6)” to “AC-20 b.”	54
12-10-2020	Editorial	Control AT-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	59
12-10-2020	Editorial	Control AT-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	59
12-10-2020	Editorial	Control AT-2d.: Change “security or privacy incidents” to “security incidents or breaches”	60
12-10-2020	Editorial	Control AT-2 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	60
12-10-2020	Editorial	Control AT-3c.: Change “security or privacy incidents” to “security incidents or breaches”	62
12-10-2020	Editorial	Control AT-3 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	63
12-10-2020	Editorial	Control AT-3 Related Controls: Change “IR-10” to “IR-4”	63
12-10-2020	Editorial	Control AT-6 Discussion: Change “assessment and update” to “evaluation and update”	64
12-10-2020	Editorial	Control AT-6 Discussion: Change “organization training” to “organizational training”	64
12-10-2020	Editorial	Control AU-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	65
12-10-2020	Editorial	Control AU-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	65
12-10-2020	Editorial	Control CA-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	83
12-10-2020	Editorial	Control CA-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	83
12-10-2020	Editorial	Control CA-1 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	84
12-10-2020	Editorial	Control CA-1 References: Add “[SP 800-137A],”	84
12-10-2020	Editorial	Control Enhancement CA-2(2): Change “data loss assessment” to “data loss assessment;”	86
12-10-2020	Editorial	Control CA-3 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	88
12-10-2020	Editorial	Control CA-7 Discussion: Change “SC-18c” to “SC-18b”	91
12-10-2020	Editorial	Control CM-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	96
12-10-2020	Editorial	Control CM-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	96
12-10-2020	Editorial	Control CM-2b.2.: Change “Assignment” to “Assignment:”	97
12-10-2020	Editorial	Control Enhancement CM-7(4) Title: Change “UNAUTHORIZED SOFTWARE” to “UNAUTHORIZED SOFTWARE – DENY-BY-EXCEPTION”	106

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	Control Enhancement CM-7(5) Title: Change “AUTHORIZED SOFTWARE” to “AUTHORIZED SOFTWARE – ALLOW-BY-EXCEPTION”	106
12-10-2020	Editorial	Control CM-8 Related Controls: Add “CP-9,”	108
12-10-2020	Editorial	Control CP-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	115
12-10-2020	Editorial	Control CP-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	115
12-10-2020	Editorial	Control CP-3 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	119
12-10-2020	Editorial	Control Enhancement CP-9(7) Title: Change “DUAL AUTHORIZATION” to “DUAL AUTHORIZATION FOR DELETION OR DESTRUCTION”	127
12-10-2020	Editorial	Control Enhancement CP-10(3): Change “tailoring procedures” to “tailoring”	128
12-10-2020	Editorial	Control IA-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	131
12-10-2020	Editorial	Control IA-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	131
12-10-2020	Editorial	Control Enhancement IA-2(1) Discussion: Change “Common Access Card” to “Common Access Card (CAC)”	132
12-10-2020	Editorial	Control Enhancement IA-2(7) Title: Change “ACCESS” to “NETWORK ACCESS”	134
12-10-2020	Editorial	Control Enhancement IA-8(5) Discussion: Change “Personal Identity Verification (PIV)” to “PIV”	145
12-10-2020	Editorial	Control IR-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	149
12-10-2020	Editorial	Control IR-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	149
12-10-2020	Editorial	Control Enhancement IR-2(1) Discussion: Delete “Incident response training includes tabletop exercises that simulate a breach. See IR-2(3).”	150
12-10-2020	Editorial	Control IR-4 Related Controls: Add “IR-5,”	152
12-10-2020	Editorial	Control IR-5 Related Controls: Add “IR-4, IR-6,”	156
12-10-2020	Editorial	Control Enhancement IR-5(1) Related Controls: Change “AU-7, IR-4” to “None”	156
12-10-2020	Editorial	Control IR-10: Change “Incident Analysis” to “Integrated Information Security Analysis Team”	161
12-10-2020	Editorial	Control IR-10: Change “Incorporated into” to “Moved to”	161
12-10-2020	Editorial	Control MA-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	162
12-10-2020	Editorial	Control MA-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	162
12-10-2020	Editorial	Control Enhancement MA-4(2): Change “MA-1, MA-4” to “MA-1 and MA-4”	166
12-10-2020	Editorial	Control MP-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	171
12-10-2020	Editorial	Control MP-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	171
12-10-2020	Editorial	Control MP-3 References: Add “[EO 13556],”	172

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	Control PE-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	179
12-10-2020	Editorial	Control PE-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	179
12-10-2020	Editorial	Control Enhancement PE-3(8) Discussion: Delete “, or mantrap,”	183
12-10-2020	Editorial	Control Enhancement PE-3(8) Discussion: Change “Mantraps” to “Vestibules”	183
12-10-2020	Editorial	Control Enhancement PE-19(1) Title: Delete “AND TEMPEST”	192
12-10-2020	Editorial	Control PL-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	194
12-10-2020	Editorial	Control PL-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	194
12-10-2020	Editorial	Control PL-2 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	196
12-10-2020	Editorial	Control PL-7 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	198
12-10-2020	Editorial	Control PL-11 Discussion: Change “[FISMA] and [PRIVACT]” to “[FISMA], [PRIVACT], and [OMB A-130]”	201
12-10-2020	Editorial	Control PM-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	204
12-10-2020	Editorial	Control PM-2 References: Add “, [SP 800-181]”	204
12-10-2020	Editorial	Control PM-5 References: Add “[OMB A-130],”	206
12-10-2020	Editorial	Control PM-8 References: Add “[EO 13636],”	207
12-10-2020	Editorial	Control PM-10 References: Add “, [SP 800-181]”	208
12-10-2020	Editorial	Control PM-11 Related Controls: Add “RA-9,”	209
12-10-2020	Editorial	Control PM-12 References: Add “[NITP12],”	210
12-10-2020	Editorial	Control PM-17 References: Add “[SP 800-172],”	212
12-10-2020	Editorial	Control PM-19 Related Controls: Add “, PM-27”	213
12-10-2020	Editorial	Control PM-22 References: Add “[OMB M-19-15],”	216
12-10-2020	Editorial	Control PM-24 Related Controls: Add “PT-2,”	216
12-10-2020	Editorial	Control PM-24 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	217
12-10-2020	Editorial	Control PM-25 Related Controls: Add “, SI-12”	217
12-10-2020	Editorial	Control PM-25 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	217
12-10-2020	Editorial	Control PM-29 References: Add “, [SP 800-181]”	219
12-10-2020	Editorial	Control PM-30 References: Add “[CNSSD 505],”	220
12-10-2020	Editorial	Control PM-31 Discussion: Change “SC-18c” to “SC-18b”	220
12-10-2020	Editorial	Control PM-31 References: Add “, [SP 800-137A]”	221
12-10-2020	Editorial	Control PM-32 References: Change “[SP 800-137]” to “[SP 800-160-1], [SP 800-160-2]”	221
12-10-2020	Editorial	Control PS-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	222
12-10-2020	Editorial	Control PS-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	222
12-10-2020	Editorial	Control Enhancement PS-3(3) Title: Change “WITH” to “REQUIRING”	224
12-10-2020	Editorial	Control PT-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	229
12-10-2020	Editorial	Control PT-1 Discussion: Change “privacy breaches” to “breaches”	229

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	Control Enhancement PT-2(1): Change “permissible” to “authorized”	230
12-10-2020	Editorial	Control PT-2 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	231
12-10-2020	Editorial	Control PT-3a.: Change “[Assignment organization-defined purpose(s)]” to “[Assignment: organization-defined purpose(s)]”	231
12-10-2020	Editorial	Control PT-3 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	232
12-10-2020	Editorial	Control PT-5 Related Controls: Add “SC-42,”	234
12-10-2020	Editorial	Control Enhancement PT-6(2): Change “[Assignment: organization-defined frequency]” to “[Assignment: organization-defined frequency]”	235
12-10-2020	Editorial	Control PT-7 References: Add “, [NARA CUI]”	236
12-10-2020	Editorial	Control PT-8 References: Add “[CMPPA],”	237
12-10-2020	Editorial	Control RA-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	238
12-10-2020	Editorial	Control RA-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	238
12-10-2020	Editorial	Control RA-2 References: Add “, [NARA CUI]”	240
12-10-2020	Editorial	Control RA-3 Related Controls: Add “PT-2,”	240
12-10-2020	Editorial	Control RA-8 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	247
12-10-2020	Editorial	Control RA-9 Related Controls: Add “PM-11,”	247
12-10-2020	Editorial	Control SA-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	249
12-10-2020	Editorial	Control SA-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	249
12-10-2020	Editorial	Control SA-2 References: Add “[SP 800-37],”	250
12-10-2020	Editorial	Control SA-4 References: Add “[ISO 29148],”	255
12-10-2020	Editorial	Control Enhancement SA-9(5) Discussion: Change “security or privacy incidents” to “security incidents or breaches”	273
12-10-2020	Editorial	Control Enhancement SA-10(2) Title: Change “ALTERNATIVE CONFIGURATION MANAGEMENT” to “ALTERNATIVE CONFIGURATION MANAGEMENT PROCESSES”	274
12-10-2020	Editorial	Control SA-11a.: Change “assessments” to “control assessments”	276
12-10-2020	Editorial	Control Enhancement SA-12(13): Change “MA-6, RA-9” to “MA-6 and RA-9”	280
12-10-2020	Editorial	Control Enhancement SA-12(14): Change “SR-4(1), SR-4(2)” to “SR-4(1) and SR-4(2)”	280
12-10-2020	Editorial	Control Enhancement SA-17(4)(b): Change “informal demonstration,” to “informal demonstration;”	286
12-10-2020	Editorial	Control SA-23: Change “design modification, augmentation, reconfiguration” to “design; modification; augmentation; reconfiguration”	291
12-10-2020	Editorial	Control SC-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	292
12-10-2020	Editorial	Control SC-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	292
12-10-2020	Editorial	Control SC-6: Change “Selection (one or more);” to “Selection (one or more).”	297

DATE	TYPE	REVISION	PAGE
12-10-2020	Substantive	Control SC-7 Discussion: Add “[SP 800-189] provides additional information on source address validation techniques to prevent ingress and egress of traffic with spoofed addresses.”	297
12-10-2020	Substantive	Control Enhancement SC-7(4) Discussion: Delete “Unauthorized control plane traffic can occur through a technique known as spoofing.”	298
12-10-2020	Substantive	Control Enhancement SC-7(4) Discussion: Change “routing” to “Border Gateway Protocol (BGP) routing”	298
12-10-2020	Substantive	Control Enhancement SC-7(4) Discussion: Change “management” to “management protocols”	298
12-10-2020	Substantive	Control Enhancement SC-7(4) Discussion: Add “See [SP 800-189] for additional information on the use of the resource public key infrastructure (RPKI) to protect BGP routes and detect unauthorized BGP announcements.”	298
12-10-2020	Editorial	Control Enhancement SC-7(4) Related Controls: Add “, SC-20, SC-21, SC-22”	298
12-10-2020	Editorial	Control Enhancement SC-7(5): Change “Selection (one or more);” to “Selection (one or more).”	298
12-10-2020	Editorial	Control SC-14: Change “SI-7,” to “SI-7, and”	309
12-10-2020	Editorial	Control SC-17 Discussion: Change “Public Key Infrastructure” to “Public Key Infrastructure (PKI)”	311
12-10-2020	Editorial	Control SC-19: Change “addressed by other controls for protocols” to “addressed as any other technology or protocol”	313
12-10-2020	Editorial	Control Enhancement SC-30(4) Related Controls: Change “SC-26” to “None”	319
12-10-2020	Editorial	Control Enhancement SC-31(2): Change “Selection (one or more);” to “Selection (one or more).”	320
12-10-2020	Editorial	Control SC-42b.: Change “class of users” to “group of users”	326
12-10-2020	Editorial	Control SI-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	332
12-10-2020	Editorial	Control SI-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	332
12-10-2020	Editorial	Control SI-3c.1.: Change “Selection (one or more);” to “Selection (one or more).”	334
12-10-2020	Editorial	Control SI-9: Change “AC-5,” to “AC-5, and”	349
12-10-2020	Editorial	Control SI-10 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	351
12-10-2020	Editorial	Control Enhancement SI-12(1): Change “PII” to “personally identifiable information”	352
12-10-2020	Editorial	Control Enhancement SI-12(1) Related Controls: Delete “PT-2, PT-3, RA-3”	352
12-10-2020	Editorial	Control Enhancement SI-12(3) Related Controls: Change “MP-6” to “None”	353
12-10-2020	Editorial	Control SI-12 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	353
12-10-2020	Editorial	Control SI-18 Related Controls: Add “PT-2,”	356
12-10-2020	Editorial	Control Enhancement SI-18(1) Related Controls: Delete “PM-22,”	357
12-10-2020	Editorial	Control Enhancement SI-18(4) Related Controls: Change “PM-22” to “None”	358
12-10-2020	Editorial	Control SI-18 References: Add “[OMB M-19-15],”	358
12-10-2020	Editorial	Control SI-19 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	360
12-10-2020	Editorial	Control SI-20 References: Change “[OMB A-130, Appendix II]” to “[OMB A-130]”	361

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	Control SR-1a.1.: Change “organization-level; mission/business process-level; system-level” to “Organization-level; Mission/business process-level; System-level”	363
12-10-2020	Editorial	Control SR-1 Discussion: Change “security or privacy incidents” to “security incidents or breaches”	363
12-10-2020	Editorial	Control SR-1 References: Add “[CNSSD 505],”	364
12-10-2020	Editorial	Control SR-2 References: Add “[SP 800-181],”	365
12-10-2020	Editorial	Control SR-2 References: Add “[CNSSD 505],”	365
12-10-2020	Editorial	Control Enhancement SR-5(2) Related Controls: Delete “SR-9”	369
12-10-2020	Editorial	Control Enhancement SR-6(1): Change “ <i>organizational analysis, independent third-party analysis, organizational testing, independent third-party testing</i> ” to “ <i>organizational analysis; independent third-party analysis; organizational testing; independent third-party testing</i> ”	370
12-10-2020	Editorial	References [ATOM54]: Change “Atomic Energy Act (P.L. 107)” to “Atomic Energy Act (P.L. 83-703)”	374
12-10-2020	Editorial	References [ISO 15026-1]: Change “International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 15026-1:2013, Systems and software engineering — Systems and software assurance — Part 1: Concepts and vocabulary, November 2013. https://www.iso.org/standard/62526.html ” to “International Organization for Standardization/International Electrotechnical Commission/Institute of Electrical and Electronics Engineers (ISO/IEC/IEEE) 15026-1:2019, Systems and software engineering — Systems and software assurance — Part 1: Concepts and vocabulary, March 2019. https://www.iso.org/standard/73567.html ”	377
12-10-2020	Editorial	References: Delete “[ISO 28001]”	378
12-10-2020	Editorial	References [ISO 29148]: Change “International Organization for Standardization/International Electrotechnical Commission/Institute of Electrical and Electronics Engineers (ISO/IEC/IEEE) 29148:2011, Systems and software engineering—Life cycle processes—Requirements engineering, December 2011. https://www.iso.org/standard/45171.html ” to “International Organization for Standardization/International Electrotechnical Commission/Institute of Electrical and Electronics Engineers (ISO/IEC/IEEE) 29148:2018, Systems and software engineering—Life cycle processes—Requirements engineering, November 2018. https://www.iso.org/standard/72089.html ”	379
12-10-2020	Editorial	References [SP 800-53B]: Change “Draft NIST” to “NIST”	381
12-10-2020	Editorial	References [SP 800-53B]: Change “ https://doi.org/10.6028/NIST.SP.800-53B-draft ” to “ https://doi.org/10.6028/NIST.SP.800-53B ”	381
12-10-2020	Editorial	References: Delete “[SP 800-58]”	382
12-10-2020	Editorial	References: Add “[SP 800-137A] Dempsey KL, Pillitteri VY, Baer C, Niemeyer R, Rudman R, Urban S (2020) Assessing Information Security Continuous Monitoring (ISCM) Programs: Developing an ISCM Program Assessment. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) 800-137A. https://doi.org/10.6028/NIST.SP.800-137A ”	387
12-10-2020	Editorial	References: Delete “[SP 800-161-1]”	387

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	References [SP 800-181]: Change “Newhouse WD, Witte GA, Scribner B, Keith S (2017) National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) 800-181. https://doi.org/10.6028/NIST.SP.800-181 ” to “Petersen R, Santos D, Smith MC, Wetzel KA, Witte G (2020) Workforce Framework for Cybersecurity (NICE Framework). (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) 800-181, Rev. 1. https://doi.org/10.6028/NIST.SP.800-181r1 ”	388
12-10-2020	Editorial	References [DODTERMS]: Change “ http://www.dtic.mil/dtic/tr/fulltext/u2/a485800.pdf ” to “ https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf ”	391
12-10-2020	Editorial	Appendix A Glossary (counterfeit): Change “[SP 800-161-1]” to [SP 800-161]”	400
12-10-2020	Editorial	Appendix A Glossary (supplier): Delete “[SP 800-161-1]”	419
12-10-2020	Editorial	Appendix A Glossary (supply chain): Delete “[SP 800-161-1]”	419
12-10-2020	Editorial	Appendix A Glossary (supply chain risk): Delete “[SP 800-161-1]”	420
12-10-2020	Editorial	Appendix A Glossary (supply chain risk assessment): Delete “[SP 800-161-1]”	420
12-10-2020	Editorial	Appendix A Glossary (supply chain risk management): Delete “[SP 800-161-1]”	420
12-10-2020	Editorial	Appendix B Acronyms: Add “BGP Border Gateway Protocol”	424
12-10-2020	Editorial	Appendix B Acronyms: Add “CAC Common Access Card”	424
12-10-2020	Editorial	Appendix B Acronyms: Add “CONOPS Concept of Operations”	424
12-10-2020	Editorial	Appendix B Acronyms: Add “DSB Defense Science Board”	424
12-10-2020	Editorial	Appendix B Acronyms: Add “FICAM Federal Identity, Credential, and Access Management”	425
12-10-2020	Editorial	Appendix B Acronyms: Add “IEEE Institute of Electrical and Electronics Engineers”	425
12-10-2020	Editorial	Appendix B Acronyms: Add “ISAC Information Sharing and Analysis Centers”	425
12-10-2020	Editorial	Appendix B Acronyms: Add “ISAO Information Sharing and Analysis Organizations”	425
12-10-2020	Editorial	Appendix B Acronyms: Add “ITL Information Technology Laboratory”	425
12-10-2020	Editorial	Appendix B Acronyms: Add “MLS Multilevel Secure”	425
12-10-2020	Editorial	Appendix B Acronyms: Add “NDA Non-Disclosure Agreement”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “ODNI Office of the Director of National Intelligence”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “OPM Office of Personnel Management”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “PDS Position Designation System”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “RPKI Resource Public Key Infrastructure”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “SCRM Supply Chain Risk Management”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “SDLC System Development Life Cycle”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “SIEM Security Information and Event Management”	426
12-10-2020	Editorial	Appendix B Acronyms: Add “SWID Software Identification”	427
12-10-2020	Editorial	Appendix B Acronyms: Add “TIC Trusted Internet Connections”	427
12-10-2020	Editorial	Appendix B Acronyms: Add “UEFI Unified Extensible Firmware Interface”	427

DATE	TYPE	REVISION	PAGE
12-10-2020	Editorial	Appendix B Acronyms: Add “UPS Uninterruptible Power Supply”	427
12-10-2020	Editorial	Appendix C Control Summaries: Change “w” to “W”	428
12-10-2020	Editorial	Table C-1 (AC-3(1)) Title: Change “FUNCTION” to “FUNCTIONS”	429
12-10-2020	Editorial	Table C-1 (AC-3(6)): Change “MP-4, SC-28” to “MP-4 and SC-28”	429
12-10-2020	Editorial	Table C-1 (AC-13): Change “AC-2, AU-6” to “AC-2 and AU-6”	431
12-10-2020	Editorial	Table C-3 (AU-7(2)) Title: Change “SEARCH AND SORT” to “SORT AND SEARCH”	434
12-10-2020	Editorial	Table C-3 AU-15: Change “Incorporated into” to “Moved to”	435
12-10-2020	Editorial	Table C-4 (CA-3(1)) Title: Change “CONNECTIONS” to “SYSTEM CONNECTIONS”	436
12-10-2020	Editorial	Table C-5 (CM-7(4)) Title: Change “UNAUTHORIZED SOFTWARE” to “UNAUTHORIZED SOFTWARE – DENY-BY-EXCEPTION”	437
12-10-2020	Editorial	Table C-5 (CM-7(5)) Title: Change “AUTHORIZED SOFTWARE” to “AUTHORIZED SOFTWARE – ALLOW-BY-EXCEPTION”	437
12-10-2020	Editorial	Table C-5: Delete duplicate row CM-8(5).	438
12-10-2020	Editorial	Table C-6 (CP-9(7)) Title: Change “DUAL AUTHORIZATION” to “DUAL AUTHORIZATION FOR DELETION OR DESTRUCTION”	440
12-10-2020	Editorial	Table C-7 (IA-5(11)): Change “IA-2(1)(2)” to “IA-2(1) and IA-2(2)”	441
12-10-2020	Editorial	Table C-8 (IR-10) Title: Change “Integrated Information Security Analysis” to “Integrated Information Security Analysis Team”	444
12-10-2020	Editorial	Table C-9 (MA-4(2)): Change “MA-1, MA-4” to “MA-1 and MA-4”	445
12-10-2020	Editorial	Table C-11 (PE-7): Change “PE-2, PE-3” to “PE-2 and PE-3”	447
12-10-2020	Editorial	Table C-11 (PE-19(1)) Title: Delete “AND TEMPEST”	448
12-10-2020	Editorial	Table C-14 (PS-3(1)) Title: Change “INFORMATION” to “INFORMATION”	451
12-10-2020	Editorial	Table C-14 (PS-3(3)) Title: Change “WITH” to “REQUIRING”	451
12-10-2020	Editorial	Table C-17 (SA-6): Change “CM-10, SI-7” to “CM-10 and SI-7”	454
12-10-2020	Editorial	Table C-17 (SA-7): Change “CM-11, SI-7” to “CM-11 and SI-7”	454
12-10-2020	Editorial	Table C-17 (SA-12(13)): Change “MA-6, RA-9” to “MA-6 and RA-9”	456
12-10-2020	Editorial	Table C-17 (SA-12(14)): Change “SR-4(1)(2)” to “SR-4(1) and SR-4(2)”	456
12-10-2020	Editorial	Table C-17 (SA-12(15)) Title: Change “PROCESS” to “PROCESSES”	456
12-10-2020	Editorial	Table C-18 (SC-7(25)) Title: Change “CONNECTIONS” to “SYSTEM CONNECTIONS”	459
12-10-2020	Editorial	Table C-18 (SC-12(4)): Change “SC-12” to “SC-12(3)”	459
12-10-2020	Editorial	Table C-18 (SC-12(5)): Change “SC-12” to “SC-12(3)”	459
12-10-2020	Editorial	Table C-18 (SC-14): Change “SI-7,” to “SI-7, and”	459
12-10-2020	Editorial	Table C-18 (SC-19): Change “addressed by other controls for protocols” to “addressed as any other technology or protocol.”	460
12-10-2020	Editorial	Table C-19 (SI-9): Change “AC-5,” to “AC-5, and”	463
12-10-2020	Editorial	Table C-19 (SI-19(7)) Title: Change “SOFTWARE” to “AND SOFTWARE”	464

CHAPTER ONE

INTRODUCTION

THE NEED TO PROTECT INFORMATION, SYSTEMS, ORGANIZATIONS, AND INDIVIDUALS

Modern information systems¹ can include a variety of computing platforms (e.g., industrial control systems, general purpose computing systems, cyber-physical systems, super computers, weapons systems, communications systems, environmental control systems, medical devices, embedded devices, sensors, and mobile devices such as smart phones and tablets). These platforms all share a common foundation—computers with complex hardware, software and firmware providing a capability that supports the essential mission and business functions of organizations.²

Security controls are the safeguards or countermeasures employed within a system or an organization to protect the confidentiality, integrity, and availability of the system and its information and to manage information security³ risk. Privacy controls are the administrative, technical, and physical safeguards employed within a system or an organization to manage privacy risks and to ensure compliance with applicable privacy requirements.⁴ Security and privacy controls are selected and implemented to satisfy security and privacy requirements levied on a system or organization. Security and privacy requirements are derived from applicable laws, executive orders, directives, regulations, policies, standards, and mission needs to ensure the confidentiality, integrity, and availability of information processed, stored, or transmitted and to manage risks to individual privacy.

The selection, design, and implementation of security and privacy controls⁵ are important tasks that have significant implications for the operations⁶ and assets of organizations as well as the welfare of individuals and the Nation. Organizations should answer several key questions when addressing information security and privacy controls:

- What security and privacy controls are needed to satisfy security and privacy requirements and to adequately manage mission/business risks or risks to individuals?
- Have the selected controls been implemented or is there a plan in place to do so?
- What is the required level of assurance (i.e., grounds for confidence) that the selected controls, as designed and implemented, are effective?⁷

¹ An *information system* is a discrete set of information resources organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information [[OMB A-130](#)].

² The term *organization* describes an entity of any size, complexity, or positioning within an organizational structure (e.g., a federal agency or, as appropriate, any of its operational elements).

³ The two terms *information security* and *security* are used synonymously in this publication.

⁴ [[OMB A-130](#)] defines *security* and *privacy controls*.

⁵ Controls provide safeguards and countermeasures in systems security and privacy engineering processes to reduce risk during the system development life cycle.

⁶ Organizational operations include mission, functions, image, and reputation.

⁷ Security and privacy control effectiveness addresses the extent to which the controls are implemented correctly, operating as intended, and producing the desired outcome with respect to meeting the designated security and privacy requirements [[SP 800-53A](#)].

The answers to these questions are not given in isolation but rather in the context of a risk management process for the organization that identifies, assesses, responds to, and monitors security and privacy risks arising from its information and systems on an ongoing basis.⁸ The security and privacy controls in this publication are recommended for use by organizations to satisfy their information security and privacy requirements. The control catalog can be viewed as a toolbox containing a collection of safeguards, countermeasures, techniques, and processes to respond to security and privacy risks. The controls are employed as part of a well-defined risk management process that supports organizational information security and privacy programs. In turn, those information security and privacy programs lay the foundation for the success of the mission and business functions of the organization.

It is important that responsible officials understand the security and privacy risks that could adversely affect organizational operations and assets, individuals, other organizations, and the Nation.⁹ These officials must also understand the current status of their security and privacy programs and the controls planned or in place to protect information, information systems, and organizations in order to make informed judgments and investments that respond to identified risks in an acceptable manner. The objective is to manage these risks through the selection and implementation of security and privacy controls.

1.1 PURPOSE AND APPLICABILITY

This publication establishes controls for systems and organizations. The controls can be implemented within any organization or system that processes, stores, or transmits information. The use of these controls is mandatory for federal information systems¹⁰ in accordance with Office of Management and Budget (OMB) Circular A-130 [[OMB A-130](#)] and the provisions of the Federal Information Security Modernization Act¹¹ [[FISMA](#)], which requires the implementation of minimum controls to protect federal information and information systems.¹² This publication, along with other supporting NIST publications, is designed to help organizations identify the security and privacy controls needed to manage risk and to satisfy the security and privacy requirements in FISMA, the Privacy Act of 1974 [[PRIVACT](#)], OMB policies (e.g., [[OMB A-130](#)]), and designated Federal Information Processing Standards (FIPS), among others. It accomplishes this objective by providing a comprehensive and flexible catalog of security and privacy controls to meet current and future protection needs based on changing threats, vulnerabilities, requirements, and technologies. The publication also improves communication among organizations by providing a common lexicon that supports the discussion of security, privacy, and risk management concepts.

⁸ The Risk Management Framework in [[SP 800-37](#)] is an example of a comprehensive risk management process.

⁹ This includes risk to critical infrastructure and key resources described in [[HSPD-7](#)].

¹⁰ A *federal information system* is an information system used or operated by an agency, a contractor of an agency, or another organization on behalf of an agency.

¹¹ Information systems that have been designated as national security systems, as defined in 44 U.S.C., Section 3542, are not subject to the requirements in [[FISMA](#)]. However, the controls established in this publication may be selected for national security systems as otherwise required (e.g., the Privacy Act of 1974) or with the approval of federal officials exercising policy authority over such systems. [[CNSSP 22](#)] and [[CNSSI 1253](#)] provide guidance for national security systems. [[DODI 8510.01](#)] provides guidance for the Department of Defense.

¹² While the controls established in this publication are mandatory for federal information systems and organizations, other organizations such as state, local, and tribal governments as well as private sector organizations are encouraged to consider using these guidelines, as appropriate. See [[SP 800-53B](#)] for federal control baselines.

Finally, the controls are independent of the process employed to select those controls. The control selection process can be part of an organization-wide risk management process, a systems engineering process [[SP 800-160-1](#)],¹³ the Risk Management Framework [[SP 800-37](#)], the Cybersecurity Framework [[NIST CSF](#)], or the Privacy Framework [[NIST PF](#)].¹⁴ The control selection criteria can be guided and informed by many factors, including mission and business needs, stakeholder protection needs, threats, vulnerabilities, and requirements to comply with federal laws, executive orders, directives, regulations, policies, standards, and guidelines. The combination of a catalog of security and privacy controls and a risk-based control selection process can help organizations comply with stated security and privacy requirements, obtain adequate security for their information systems, and protect the privacy of individuals.

1.2 TARGET AUDIENCE

This publication is intended to serve a diverse audience, including:

- Individuals with system, information security, privacy, or risk management and oversight responsibilities, including authorizing officials, chief information officers, senior agency information security officers, and senior agency officials for privacy;
- Individuals with system development responsibilities, including mission owners, program managers, system engineers, system security engineers, privacy engineers, hardware and software developers, system integrators, and acquisition or procurement officials;
- Individuals with logistical or disposition-related responsibilities, including program managers, procurement officials, system integrators, and property managers;
- Individuals with security and privacy implementation and operations responsibilities, including mission or business owners, system owners, information owners or stewards, system administrators, continuity planners, and system security or privacy officers;
- Individuals with security and privacy assessment and monitoring responsibilities, including auditors, Inspectors General, system evaluators, control assessors, independent verifiers and validators, and analysts; and
- Commercial entities, including industry partners, producing component products and systems, creating security and privacy technologies, or providing services or capabilities that support information security or privacy.

1.3 ORGANIZATIONAL RESPONSIBILITIES

Managing security and privacy risks is a complex, multifaceted undertaking that requires:

- Well-defined security and privacy requirements for systems and organizations;
- The use of trustworthy information system components based on state-of-the-practice hardware, firmware, and software development and acquisition processes;

¹³ Risk management is an integral part of systems engineering, systems security engineering, and privacy engineering.

¹⁴ [[OMB A-130](#)] requires federal agencies to implement the NIST Risk Management Framework for the selection of controls for federal information systems. [[EO 13800](#)] requires federal agencies to implement the NIST *Framework for Improving Critical Infrastructure Cybersecurity* to manage cybersecurity risk. The NIST frameworks are also available to nonfederal organizations as optional resources.

- Rigorous security and privacy planning and system development life cycle management;
- The application of system security and privacy engineering principles and practices to securely develop and integrate system components into information systems;
- The employment of security and privacy practices that are properly documented and integrated into and supportive of the institutional and operational processes of organizations; and
- Continuous monitoring of information systems and organizations to determine the ongoing effectiveness of controls, changes in information systems and environments of operation, and the state of security and privacy organization-wide.

Organizations continuously assess the security and privacy risks to organizational operations and assets, individuals, other organizations, and the Nation. Security and privacy risks arise from the planning and execution of organizational mission and business functions, placing information systems into operation, or continuing system operations. Realistic assessments of risk require a thorough understanding of the susceptibility to threats based on the specific vulnerabilities in information systems and organizations and the likelihood and potential adverse impacts of successful exploitations of such vulnerabilities by those threats.¹⁵ Risk assessments also require an understanding of privacy risks.¹⁶

To address the organization's concerns about assessment and determination of risk, security and privacy requirements are satisfied with the knowledge and understanding of the organizational risk management strategy.¹⁷ The risk management strategy considers the cost, schedule, performance, and supply chain issues associated with the design, development, acquisition, deployment, operation, sustainment, and disposal of organizational systems. A risk management process is then applied to manage risk on an ongoing basis.¹⁸

The catalog of security and privacy controls can be effectively used to protect organizations, individuals, and information systems from traditional and advanced persistent threats and privacy risks arising from the processing of personally identifiable information (PII) in varied operational, environmental, and technical scenarios. The controls can be used to demonstrate compliance with a variety of governmental, organizational, or institutional security and privacy requirements. Organizations have the responsibility to select the appropriate security and privacy controls, to implement the controls correctly, and to demonstrate the effectiveness of the controls in satisfying security and privacy requirements.¹⁹ Security and privacy controls can also be used in developing specialized *baselines* or *overlays* for unique or specialized missions or business applications, information systems, threat concerns, operational environments, technologies, or communities of interest.²⁰

¹⁵ [SP 800-30] provides guidance on the risk assessment process.

¹⁶ [IR 8062] introduces privacy risk concepts.

¹⁷ [SP 800-39] provides guidance on risk management processes and strategies.

¹⁸ [SP 800-37] provides a comprehensive risk management process.

¹⁹ [SP 800-53A] provides guidance on assessing the effectiveness of controls.

²⁰ [SP 800-53B] provides guidance for tailoring security and privacy control baselines and for developing overlays to support the specific protection needs and requirements of stakeholders and their organizations.

Organizational risk assessments are used, in part, to inform the security and privacy control selection process. The selection process results in an agreed-upon set of security and privacy controls addressing specific mission or business needs consistent with organizational risk tolerance.²¹ The process preserves, to the greatest extent possible, the agility and flexibility that organizations need to address an increasingly sophisticated and hostile threat space, mission and business requirements, rapidly changing technologies, complex supply chains, and many types of operational environments.

1.4 RELATIONSHIP TO OTHER PUBLICATIONS

This publication defines controls to satisfy a diverse set of security and privacy requirements that have been levied on information systems and organizations and that are consistent with and complementary to other recognized national and international information security and privacy standards. To develop a broadly applicable and technically sound set of controls for information systems and organizations, many sources were considered during the development of this publication. These sources included requirements and controls from the manufacturing, defense, financial, healthcare, transportation, energy, intelligence, industrial control, and audit communities as well as national and international standards organizations. In addition, the controls in this publication are used by the national security community in publications such as Committee on National Security Systems (CNSS) Instruction No. 1253 [[CNSSI 1253](#)] to provide guidance specific to systems designated as national security systems. Whenever possible, the controls have been mapped to international standards to help ensure maximum usability and applicability.²² The relationship of this publication to other risk management, security, privacy, and publications can be found at [[FISMA IMP](#)].

1.5 REVISIONS AND EXTENSIONS

The security and privacy controls described in this publication represent the state-of-the-practice protection measures for individuals, information systems, and organizations. The controls are reviewed and revised periodically to reflect the experience gained from using the controls; new or revised laws, executive orders, directives, regulations, policies, and standards; changing security and privacy requirements; emerging threats, vulnerabilities, attack and information processing methods; and the availability of new technologies.

The security and privacy controls in the control catalog are also expected to change over time as controls are withdrawn, revised, and added. In addition to the need for change, the need for stability is addressed by requiring that proposed modifications to security and privacy controls go through a rigorous and transparent public review process to obtain public and private sector feedback and to build a consensus for such change. The review process provides a technically sound, flexible, and stable set of security and privacy controls for the organizations that use the control catalog.

1.6 PUBLICATION ORGANIZATION

The remainder of this special publication is organized as follows:

²¹ Authorizing officials or their designated representatives, by accepting the security and privacy plans, agree to the security and privacy controls proposed to meet the security and privacy requirements for organizations and systems.

²² Mapping tables are available at [[SP 800-53 RES](#)].

- **[Chapter Two](#)** describes the fundamental concepts associated with security and privacy controls, including the structure of the controls, how the controls are organized in the consolidated catalog, control implementation approaches, the relationship between security and privacy controls, and trustworthiness and assurance.
- **[Chapter Three](#)** provides a consolidated catalog of security and privacy controls including a discussion section to explain the purpose of each control and to provide useful information regarding control implementation and assessment, a list of related controls to show the relationships and dependencies among controls, and a list of references to supporting publications that may be helpful to organizations.
- **[References](#)**, **[Glossary](#)**, **[Acronyms](#)**, and **[Control Summaries](#)** provide additional information on the use of security and privacy controls.²³

²³ Unless otherwise stated, all references to NIST publications refer to the most recent version of those publications.

CHAPTER TWO

THE FUNDAMENTALS

STRUCTURE, TYPE, AND ORGANIZATION OF SECURITY AND PRIVACY CONTROLS

This chapter presents the fundamental concepts associated with security and privacy controls, including the relationship between requirements and controls, the structure of controls, how controls are organized in the consolidated control catalog, the different control implementation approaches for information systems and organizations, the relationship between security and privacy controls, the importance of the concepts of trustworthiness and assurance for security and privacy controls, and the effects of the controls on achieving trustworthy, secure, and resilient systems.

2.1 REQUIREMENTS AND CONTROLS

It is important to understand the relationship between requirements and controls. For federal information security and privacy policies, the term *requirement* is generally used to refer to information security and privacy obligations imposed on organizations. For example, [[OMB A-130](#)] imposes information security and privacy requirements with which federal agencies must comply when managing information resources. The term *requirement* can also be used in a broader sense to refer to an expression of stakeholder protection needs for a particular system or organization. Stakeholder protection needs and the corresponding security and privacy 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 *requirement*, 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 necessary characteristics of the system—encompassing security, privacy, and assurance.²⁴

Organizations may divide security and privacy requirements into more granular categories, depending on where the requirements are employed in the system development life cycle (SDLC) and for what purpose. Organizations may use the term *capability requirement* to describe a capability that the system or organization must provide to satisfy a stakeholder protection need. In addition, organizations may refer to system requirements that pertain to particular hardware, software, and firmware components of a system as *specification requirements*—that is, capabilities that implement all or part of a control and that may be assessed (i.e., as part of the verification, validation, testing, and evaluation processes). Finally, organizations may use the term *statement of work requirements* to refer to actions that must be performed operationally or during system development.

²⁴ The system characteristics that impact security and privacy vary and include the system type and function in terms of its primary purpose; the system make-up in terms of its technology, mechanical, physical, and human elements; the modes and states within which the system delivers its functions and services; the criticality or importance of the system and its constituent functions and services; the sensitivity of the data or information processed, stored, or transmitted; the consequence of loss, failure, or degradation relative to the ability of the system to execute correctly and to provide for its own protection (i.e., self-protection); and monetary or other value [[SP 800-160-1](#)].

Controls can be viewed as descriptions of the safeguards and protection capabilities appropriate for achieving the particular security and privacy objectives of the organization and reflecting the protection needs of organizational stakeholders. Controls are selected and implemented by the organization in order to satisfy the system requirements. Controls can include administrative, technical, and physical aspects. In some cases, the selection and implementation of a control may necessitate additional specification by the organization in the form of *derived requirements* or instantiated control parameter values. The derived requirements and control parameter values may be necessary to provide the appropriate level of implementation detail for particular controls within the SDLC.

2.2 CONTROL STRUCTURE AND ORGANIZATION

Security and privacy controls described in this publication have a well-defined organization and structure. For ease of use in the security and privacy control selection and specification process, controls are organized into 20 *families*.²⁵ Each family contains controls that are related to the specific topic of the family. A two-character identifier uniquely identifies each control family (e.g., PS for Personnel Security). Security and privacy controls may involve aspects of policy, oversight, supervision, manual processes, and automated mechanisms that are implemented by systems or actions by individuals. Table 1 lists the security and privacy control families and their associated family identifiers.

TABLE 1: SECURITY AND PRIVACY CONTROL FAMILIES

ID	FAMILY	ID	FAMILY
<u>AC</u>	Access Control	<u>PE</u>	Physical and Environmental Protection
<u>AT</u>	Awareness and Training	<u>PL</u>	Planning
<u>AU</u>	Audit and Accountability	<u>PM</u>	Program Management
<u>CA</u>	Assessment, Authorization, and Monitoring	<u>PS</u>	Personnel Security
<u>CM</u>	Configuration Management	<u>PT</u>	PII Processing and Transparency
<u>CP</u>	Contingency Planning	<u>RA</u>	Risk Assessment
<u>IA</u>	Identification and Authentication	<u>SA</u>	System and Services Acquisition
<u>IR</u>	Incident Response	<u>SC</u>	System and Communications Protection
<u>MA</u>	Maintenance	<u>SI</u>	System and Information Integrity
<u>MP</u>	Media Protection	<u>SR</u>	Supply Chain Risk Management

Families of controls contain base controls and control enhancements, which are directly related to their base controls. Control enhancements either add functionality or specificity to a base control or increase the strength of a base control. Control enhancements are used in systems and environments of operation that require greater protection than the protection provided by the base control. The need for organizations to select and implement control enhancements is due to the potential adverse organizational or individual impacts or when organizations require additions to the base control functionality or assurance based on assessments of risk. The

²⁵ Of the 20 control families in NIST SP 800-53, 17 are aligned with the minimum security requirements in [FIPS 200]. The Program Management (PM), PII Processing and Transparency (PT), and Supply Chain Risk Management (SR) families address enterprise-level program management, privacy, and supply chain risk considerations pertaining to federal mandates emergent since [FIPS 200].

selection and implementation of control enhancements *always* requires the selection and implementation of the base control.

The families are arranged in alphabetical order, while the controls and control enhancements within each family are in numerical order. The order of the families, controls, and control enhancements does *not* imply any logical progression, level of prioritization or importance, or order in which the controls or control enhancements are to be implemented. Rather, it reflects the order in which they were included in the catalog. Control designations are not re-used when a control is withdrawn.

Security and privacy controls have the following structure: a *base control* section, a *discussion* section, a *related controls* section, a *control enhancements* section, and a *references* section. Figure 1 illustrates the structure of a typical control.

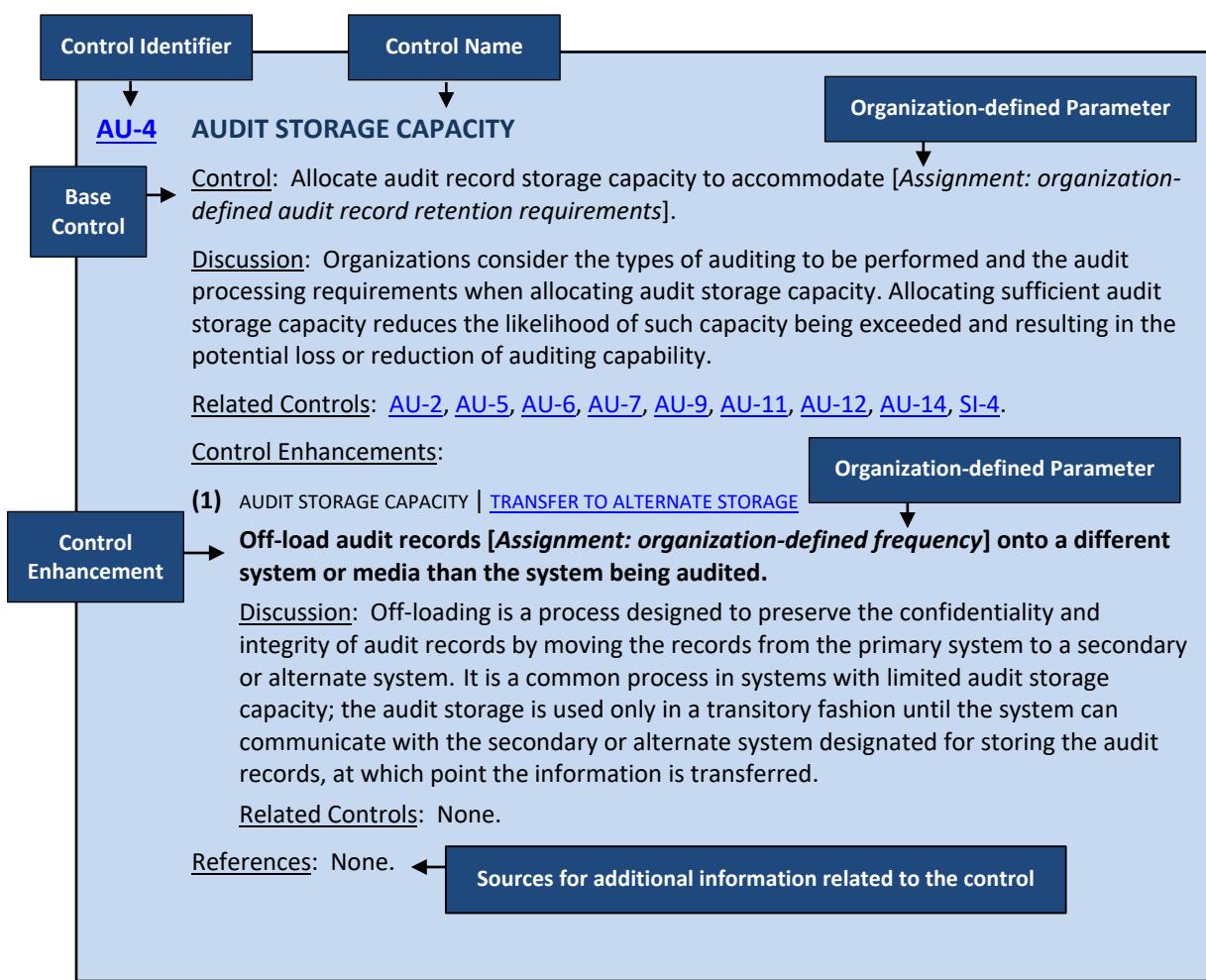


FIGURE 1: CONTROL STRUCTURE

The *control* section prescribes a security or privacy capability to be implemented. Security and privacy capabilities are achieved by the activities or actions, automated or nonautomated, carried out by information systems and organizations. Organizations designate the responsibility for control development, implementation, assessment, and monitoring. Organizations have the

flexibility to implement the controls selected in whatever manner that satisfies organizational mission or business needs consistent with law, regulation, and policy.

The *discussion* section provides additional information about a control. Organizations can use the information as needed when developing, tailoring, implementing, assessing, or monitoring controls. The information provides important considerations for implementing controls based on mission or business requirements, operational environments, or assessments of risk. The additional information can also explain the purpose of controls and often includes examples. Control enhancements may also include a separate discussion section when the discussion information is applicable only to a specific control enhancement.

The *related controls* section provides a list of controls from the control catalog that impact or support the implementation of a particular control or control enhancement, address a related security or privacy capability, or are referenced in the discussion section. Control enhancements are inherently related to their base control. Thus, related controls that are referenced in the base control are not repeated in the control enhancements. However, there may be related controls identified for control enhancements that are not referenced in the base control (i.e., the related control is only associated with the specific control enhancement). Controls may also be related to enhancements of other base controls. When a control is designated as a related control, a corresponding designation is made on that control in its source location in the catalog to illustrate the two-way relationship. Additionally, each control in a given family is inherently related to the -1 control (Policy and Procedures) in the same family. Therefore, the relationship between the -1 control and the other controls in the same family is not specified in the *related controls* section for each control.

The *control enhancements* section provides statements of security and privacy capability that augment a base control. The control enhancements are numbered sequentially within each control so that the enhancements can be easily identified when selected to supplement the base control. Each control enhancement has a short subtitle to indicate the intended function or capability provided by the enhancement. In the AU-4 example, if the control enhancement is selected, the control designation becomes AU-4(1). The numerical designation of a control enhancement is used only to identify that enhancement within the control. The designation is not indicative of the strength of the control enhancement, level of protection, priority, degree of importance, or any hierarchical relationship among the enhancements. Control enhancements are not intended to be selected independently. That is, if a control enhancement is selected, then the corresponding base control is also selected and implemented.

The *references* section includes a list of applicable laws, policies, standards, guidelines, websites, and other useful references that are relevant to a specific control or control enhancement.²⁶ The references section also includes hyperlinks to publications for obtaining additional information for control development, implementation, assessment, and monitoring.

For some controls, additional flexibility is provided by allowing organizations to define specific values for designated parameters associated with the controls. Flexibility is achieved as part of a tailoring process using *assignment* and *selection* operations embedded within the controls and

²⁶ References are provided to assist organizations in understanding and implementing the security and privacy controls and are not intended to be inclusive or complete.

enclosed by brackets. The assignment and selection operations give organizations the capability to customize controls based on organizational security and privacy requirements. In contrast to assignment operations which allow complete flexibility in the designation of parameter values, selection operations narrow the range of potential values by providing a specific list of items from which organizations choose.

Determination of the organization-defined parameters can evolve from many sources, including laws, executive orders, directives, regulations, policies, standards, guidance, and mission or business needs. Organizational risk assessments and risk tolerance are also important factors in determining the values for control parameters. Once specified by the organization, the values for the assignment and selection operations become a part of the control. Organization-defined control parameters used in the base controls also apply to the control enhancements associated with those controls. The implementation of the control is assessed for effectiveness against the completed control statement.

In addition to assignment and selection operations embedded in a control, additional flexibility is achieved through *iteration* and *refinement* actions. Iteration allows organizations to use a control multiple times with different assignment and selection values, perhaps being applied in different situations or when implementing multiple policies. For example, an organization may have multiple systems implementing a control but with different parameters established to address different risks for each system and environment of operation. Refinement is the process of providing additional implementation detail to a control. Refinement can also be used to narrow the scope of a control in conjunction with iteration to cover all applicable scopes (e.g., applying different authentication mechanisms to different system interfaces). The combination of assignment and selection operations and iteration and refinement actions when applied to controls provides the needed flexibility to allow organizations to satisfy a broad base of security and privacy requirements at the organization, mission and business process, and system levels of implementation.

SECURITY AS A DESIGN PROBLEM

"Providing satisfactory security controls in a computer system is....a system design problem. A combination of hardware, software, communications, physical, personnel and administrative-procedural safeguards is required for comprehensive security....software safeguards alone are not sufficient."

-- *The Ware Report*

Defense Science Board Task Force on Computer Security, 1970

2.3 CONTROL IMPLEMENTATION APPROACHES

There are three approaches to implementing the controls in [Chapter Three](#): (1) a *common* (inheritable) control implementation approach, (2) a *system-specific* control implementation approach, and (3) a *hybrid* control implementation approach. The control implementation approaches define the scope of applicability for the control, the shared nature or inheritability of the control, and the responsibility for control development, implementation, assessment, and

authorization. Each control implementation approach has a specific objective and focus that helps organizations select the appropriate controls, implement the controls in an effective manner, and satisfy security and privacy requirements. A specific control implementation approach may achieve cost benefits by leveraging security and privacy capabilities across multiple systems and environments of operation.²⁷

Common controls are controls whose implementation results in a capability that is *inheritable* by multiple systems or programs. A control is deemed inheritable when the system or program receives protection from the implemented control, but the control is developed, implemented, assessed, authorized, and monitored by an internal or external entity other than the entity responsible for the system or program. The security and privacy capabilities provided by common controls can be inherited from many sources, including mission or business lines, organizations, enclaves, environments of operation, sites, or other systems or programs. Implementing controls as common controls can introduce the risk of a single point of failure.

Many of the controls needed to protect organizational information systems—including many physical and environmental protection controls, personnel security controls, and incident response controls—are inheritable and, therefore, are good candidates for common control status. Common controls can also include technology-based controls, such as identification and authentication controls, boundary protection controls, audit and accountability controls, and access controls. The cost of development, implementation, assessment, authorization, and monitoring can be amortized across multiple systems, organizational elements, and programs using the common control implementation approach.

Controls not implemented as common controls are implemented as *system-specific* or *hybrid* controls. System-specific controls are the primary responsibility of the system owner and the authorizing official for a given system. Implementing system-specific controls can introduce risk if the control implementations are not interoperable with common controls. Organizations can implement a control as *hybrid* if one part of the control is common (inheritable) and the other part is system-specific. For example, an organization may implement control [CP-2](#) using a predefined template for the contingency plan for all organizational information systems with individual system owners tailoring the plan for system-specific uses, where appropriate. The division of a hybrid control into its common (inheritable) and system-specific parts may vary by organization, depending on the types of information technologies employed, the approach used by the organization to manage its controls, and assignment of responsibilities. When a control is implemented as a hybrid control, the common control provider is responsible for ensuring the implementation, assessment, and monitoring of the *common* part of the hybrid control, and the system owner is responsible for ensuring the implementation, assessment, and monitoring of the *system-specific* part of the hybrid control. Implementing controls as hybrid controls can introduce risk if the responsibility for the implementation and ongoing management of the common and system-specific parts of the controls is unclear.

The determination as to the appropriate control implementation approach (i.e., common, hybrid, or system-specific) is context-dependent. The control implementation approach cannot be determined to be common, hybrid, or system-specific simply based on the language of the

²⁷ [\[SP 800-37\]](#) provides additional guidance on control implementation approaches (formerly referred to as control designations) and how the different approaches are used in the *Risk Management Framework*.

control. Identifying the control implementation approach can result in significant savings to organizations in implementation and assessment costs and a more consistent application of the controls organization-wide. Typically, the identification of the control implementation approach is straightforward. However, the implementation takes significant planning and coordination.

Planning for the implementation approach of a control (i.e., common, hybrid, or system-specific) is best carried out early in the system development life cycle and coordinated with the entities providing the control [[SP 800-37](#)]. Similarly, if a control is to be inheritable, coordination is required with the inheriting entity to ensure that the control meets its needs. This is especially important given the nature of control parameters. An inheriting entity cannot assume that controls are the same and mitigate the appropriate risk to the system just because the control identifiers (e.g., [AC-1](#)) are the same. It is essential to examine the control parameters (e.g., assignment or selection operations) when determining if a common control is adequate to mitigate system-specific risks.

2.4 SECURITY AND PRIVACY CONTROLS

The selection and implementation of security and privacy controls reflect the objectives of information security and privacy programs and how those programs manage their respective risks. Depending on the circumstances, these objectives and risks can be independent or overlapping. Federal information security programs are responsible for protecting information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction (i.e., unauthorized activity or system behavior) to provide confidentiality, integrity, and availability. Those programs are also responsible for managing security risk and for ensuring compliance with applicable security requirements. Federal privacy programs are responsible for managing risks to individuals associated with the creation, collection, use, processing, storage, maintenance, dissemination, disclosure, or disposal (collectively referred to as “processing”) of PII and for ensuring compliance with applicable privacy requirements.²⁸ When a system processes PII, the information security program and the privacy program have a shared responsibility for managing the security risks for the PII in the system. Due to this overlap in responsibilities, the controls that organizations select to manage these security risks will generally be the same regardless of their designation as security or privacy controls in control baselines or program or system plans.

There also may be circumstances in which the selection and/or implementation of the control or control enhancement affects the ability of a program to achieve its objectives and manage its respective risks. The control discussion section may highlight specific security and/or privacy considerations so that organizations can take these considerations into account as they determine the most effective method to implement the control. However, these considerations are not exhaustive.

For example, an organization might select [AU-3](#) (Content of Audit Records) to support monitoring for unauthorized access to an information asset that does not include PII. Since the

²⁸ Privacy programs may also choose to consider the risks to individuals that may arise from their interactions with information systems, where the processing of personally identifiable information may be less impactful than the effect that the system has on individuals’ behavior or activities. Such effects would constitute risks to individual autonomy, and organizations may need to take steps to manage those risks in addition to information security and privacy risks.

potential loss of confidentiality of the information asset does not affect privacy, security objectives are the primary driver for the selection of the control. However, the implementation of the control with respect to monitoring for unauthorized access could involve the processing of PII which may result in privacy risks and affect privacy program objectives. The discussion section in [AU-3](#) includes privacy risk considerations so that organizations can take those considerations into account as they determine the best way to implement the control. Additionally, the control enhancement [AU-3\(3\)](#) (Limit Personally Identifiable Information Elements) could be selected to support managing these privacy risks.

Due to permutations in the relationship between information security and privacy program objectives and risk management, there is a need for close collaboration between programs to select and implement the appropriate controls for information systems processing PII. Organizations consider how to promote and institutionalize collaboration between the two programs to ensure that the objectives of both disciplines are met and risks are appropriately managed.²⁹

2.5 TRUSTWORTHINESS AND ASSURANCE

The trustworthiness of systems, system components, and system services is an important part of the risk management strategies developed by organizations.³⁰ *Trustworthiness*, in this context, means worthy of being trusted to fulfill whatever requirements may be needed for a component, subsystem, system, network, application, mission, business function, enterprise, or other entity.³¹ Trustworthiness requirements can include attributes of reliability, dependability, performance, resilience, safety, security, privacy, and survivability under a range of potential adversity in the form of disruptions, hazards, threats, and privacy risks. Effective measures of trustworthiness are meaningful only to the extent that the requirements are complete, well-defined, and can be accurately assessed.

Two fundamental concepts that affect the trustworthiness of systems are *functionality* and *assurance*. Functionality is defined in terms of the security and privacy features, functions, mechanisms, services, procedures, and architectures implemented within organizational systems and programs and the environments in which those systems and programs operate. Assurance is the measure of confidence that the system functionality is implemented correctly, operating as intended, and producing the desired outcome with respect to meeting the security and privacy requirements for the system—thus possessing the capability to accurately mediate and enforce established security and privacy policies.

In general, the task of providing meaningful assurance that a system is likely to do what is expected of it can be enhanced by techniques that simplify or narrow the analysis by, for example, increasing the discipline applied to the system architecture, software design, specifications, code style, and configuration management. Security and privacy controls address functionality and assurance. Certain controls focus primarily on functionality while other controls focus primarily on assurance. Some controls can support functionality and assurance.

²⁹ Resources to support information security and privacy program collaboration are available at [[SP 800-53 RES](#)].

³⁰ [[SP 800-160-1](#)] provides guidance on systems security engineering and the application of security design principles to achieve trustworthy systems.

³¹ See [[NEUM04](#)].

Organizations can select assurance-related controls to define system development activities, generate evidence about the functionality and behavior of the system, and trace the evidence to the system elements that provide such functionality or exhibit such behavior. The evidence is used to obtain a degree of confidence that the system satisfies the stated security and privacy requirements while supporting the organization's mission and business functions. Assurance-related controls are identified in the control summary tables in [Appendix C](#).

EVIDENCE OF CONTROL IMPLEMENTATION

During control selection and implementation, it is important for organizations to consider the evidence (e.g., artifacts, documentation) that will be needed to support current and future control assessments. Such assessments help determine whether the controls are implemented correctly, operating as intended, and satisfying security and privacy policies—thus, providing essential information for senior leaders to make informed *risk-based* decisions.

CHAPTER THREE

THE CONTROLS

SECURITY AND PRIVACY CONTROLS AND CONTROL ENHANCEMENTS

This catalog of security and privacy controls provides protective measures for systems, organizations, and individuals.³² The controls are designed to facilitate risk management and compliance with applicable federal laws, executive orders, directives, regulations, policies, and standards. With few exceptions, the security and privacy controls in the catalog are policy-, technology-, and sector-neutral, meaning that the controls focus on the fundamental measures necessary to protect information and the privacy of individuals across the information life cycle. While the security and privacy controls are largely policy-, technology-, and sector-neutral, that does not imply that the controls are policy-, technology-, and sector-unaware. Understanding policies, technologies, and sectors is necessary so that the controls are relevant when they are implemented. Employing a policy-, technology-, and sector-neutral control catalog has many benefits. It encourages organizations to:

- Focus on the security and privacy functions and capabilities required for mission and business success and the protection of information and the privacy of individuals, irrespective of the technologies that are employed in organizational systems;
- Analyze each security and privacy control for its applicability to specific technologies, environments of operation, mission and business functions, and communities of interest; and
- Specify security and privacy policies as part of the tailoring process for controls that have variable parameters.

In the few cases where specific technologies are referenced in controls, organizations are cautioned that the need to manage security and privacy risks may go beyond the requirements in a single control associated with a technology. The additional needed protection measures are obtained from the other controls in the catalog. [Federal Information Processing Standards](#), [Special Publications](#), and [Interagency/Internal Reports](#) provide guidance on selecting security and privacy controls that reduce risk for specific technologies and sector-specific applications, including smart grid, cloud, healthcare, mobile, industrial control systems, and Internet of Things (IoT) devices.³³ NIST publications are cited as references as applicable to specific controls in Sections 3.1 through 3.20.

Security and privacy controls in the catalog are expected to change over time as controls are withdrawn, revised, and added. To maintain stability in security and privacy plans, controls are not renumbered each time a control is withdrawn. Rather, notations of the controls that have been withdrawn are maintained in the control catalog for historical purposes. Controls may be withdrawn for a variety of reasons, including when the function or capability provided by the control has been incorporated into another control, the control is redundant to an existing control, or the control is deemed to be no longer necessary or effective.

³² The controls in this publication are available online and can be obtained in various formats. See [[NVD 800-53](#)].

³³ For example, [[SP 800-82](#)] provides guidance on risk management and control selection for industrial control systems.

New controls are developed on a regular basis using threat and vulnerability information and information on the tactics, techniques, and procedures used by adversaries. In addition, new controls are developed based on a better understanding of how to mitigate information security risks to systems and organizations and risks to the privacy of individuals arising from information processing. Finally, new controls are developed based on new or changing requirements in laws, executive orders, regulations, policies, standards, or guidelines. Proposed modifications to the controls are carefully analyzed during each revision cycle, considering the need for stability of controls and the need to be responsive to changing technologies, threats, vulnerabilities, types of attack, and processing methods. The objective is to adjust the level of information security and privacy over time to meet the needs of organizations and individuals.

3.1 ACCESS CONTROL

[Quick link to Access Control Summary Table](#)

AC-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] access control policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the access control policy and the associated access controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the access control policy and procedures; and
- c. Review and update the current access control:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Access control policy and procedures address the controls in the AC family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of access control policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies reflecting the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to access control policy and procedures include assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [IA-1](#), [PM-9](#), [PM-24](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#), [\[IR 7874\]](#).

AC-2 ACCOUNT MANAGEMENT**Control:**

- a. Define and document the types of accounts allowed and specifically prohibited for use within the system;
- b. Assign account managers;
- c. Require [*Assignment: organization-defined prerequisites and criteria*] for group and role membership;
- d. Specify:
 1. Authorized users of the system;
 2. Group and role membership; and
 3. Access authorizations (i.e., privileges) and [*Assignment: organization-defined attributes (as required)*] for each account;
- e. Require approvals by [*Assignment: organization-defined personnel or roles*] for requests to create accounts;
- f. Create, enable, modify, disable, and remove accounts in accordance with [*Assignment: organization-defined policy, procedures, prerequisites, and criteria*];
- g. Monitor the use of accounts;
- h. Notify account managers and [*Assignment: organization-defined personnel or roles*] within:
 1. [*Assignment: organization-defined time period*] when accounts are no longer required;
 2. [*Assignment: organization-defined time period*] when users are terminated or transferred; and
 3. [*Assignment: organization-defined time period*] when system usage or need-to-know changes for an individual;
- i. Authorize access to the system based on:
 1. A valid access authorization;
 2. Intended system usage; and
 3. [*Assignment: organization-defined attributes (as required)*];
- j. Review accounts for compliance with account management requirements [*Assignment: organization-defined frequency*];
- k. Establish and implement a process for changing shared or group account authenticators (if deployed) when individuals are removed from the group; and
- l. Align account management processes with personnel termination and transfer processes.

Discussion: Examples of system account types include individual, shared, group, system, guest, anonymous, emergency, developer, temporary, and service. Identification of authorized system users and the specification of access privileges reflect the requirements in other controls in the security plan. Users requiring administrative privileges on system accounts receive additional scrutiny by organizational personnel responsible for approving such accounts and privileged access, including system owner, mission or business owner, senior agency information security officer, or senior agency official for privacy. Types of accounts that organizations may wish to prohibit due to increased risk include shared, group, emergency, anonymous, temporary, and guest accounts.

Where access involves personally identifiable information, security programs collaborate with the senior agency official for privacy to establish the specific conditions for group and role membership; specify authorized users, group and role membership, and access authorizations for each account; and create, adjust, or remove system accounts in accordance with organizational policies. Policies can include such information as account expiration dates or other factors that trigger the disabling of accounts. Organizations may choose to define access privileges or other attributes by account, type of account, or a combination of the two. Examples of other attributes required for authorizing access include restrictions on time of day, day of week, and point of origin. In defining other system account attributes, organizations consider system-related requirements and mission/business requirements. Failure to consider these factors could affect system availability.

Temporary and emergency accounts are intended for short-term use. Organizations establish temporary accounts as part of normal account activation procedures when there is a need for short-term accounts without the demand for immediacy in account activation. Organizations establish emergency accounts in response to crisis situations and with the need for rapid account activation. Therefore, emergency account activation may bypass normal account authorization processes. Emergency and temporary accounts are not to be confused with infrequently used accounts, including local logon accounts used for special tasks or when network resources are unavailable (may also be known as accounts of last resort). Such accounts remain available and are not subject to automatic disabling or removal dates. Conditions for disabling or deactivating accounts include when shared/group, emergency, or temporary accounts are no longer required and when individuals are transferred or terminated. Changing shared/group authenticators when members leave the group is intended to ensure that former group members do not retain access to the shared or group account. Some types of system accounts may require specialized training.

Related Controls: [AC-3](#), [AC-5](#), [AC-6](#), [AC-17](#), [AC-18](#), [AC-20](#), [AC-24](#), [AU-2](#), [AU-12](#), [CM-5](#), [IA-2](#), [IA-4](#), [IA-5](#), [IA-8](#), [MA-3](#), [MA-5](#), [PE-2](#), [PL-4](#), [PS-2](#), [PS-4](#), [PS-5](#), [PS-7](#), [PT-2](#), [PT-3](#), [SC-7](#), [SC-12](#), [SC-13](#), [SC-37](#).

Control Enhancements:

(1) ACCOUNT MANAGEMENT | [AUTOMATED SYSTEM ACCOUNT MANAGEMENT](#)

Support the management of system accounts using [Assignment: organization-defined automated mechanisms].

Discussion: Automated system account management includes using automated mechanisms to create, enable, modify, disable, and remove accounts; notify account managers when an account is created, enabled, modified, disabled, or removed, or when users are terminated or transferred; monitor system account usage; and report atypical system account usage. Automated mechanisms can include internal system functions and email, telephonic, and text messaging notifications.

Related Controls: None.

(2) ACCOUNT MANAGEMENT | [AUTOMATED TEMPORARY AND EMERGENCY ACCOUNT MANAGEMENT](#)

Automatically [Selection: remove; disable] temporary and emergency accounts after [Assignment: organization-defined time period for each type of account].

Discussion: Management of temporary and emergency accounts includes the removal or disabling of such accounts automatically after a predefined time period rather than at the convenience of the system administrator. Automatic removal or disabling of accounts provides a more consistent implementation.

Related Controls: None.

(3) ACCOUNT MANAGEMENT | [DISABLE ACCOUNTS](#)

Disable accounts within [Assignment: organization-defined time period] when the accounts:

- (a) Have expired;
- (b) Are no longer associated with a user or individual;
- (c) Are in violation of organizational policy; or
- (d) Have been inactive for [Assignment: organization-defined time period].

Discussion: Disabling expired, inactive, or otherwise anomalous accounts supports the concepts of least privilege and least functionality which reduce the attack surface of the system.

Related Controls: None.

(4) ACCOUNT MANAGEMENT | [AUTOMATED AUDIT ACTIONS](#)

Automatically audit account creation, modification, enabling, disabling, and removal actions.

Discussion: Account management audit records are defined in accordance with [AU-2](#) and reviewed, analyzed, and reported in accordance with [AU-6](#).

Related Controls: [AU-2](#), [AU-6](#).

(5) ACCOUNT MANAGEMENT | [INACTIVITY LOGOUT](#)

Require that users log out when [Assignment: organization-defined time period of expected inactivity or description of when to log out].

Discussion: Inactivity logout is behavior- or policy-based and requires users to take physical action to log out when they are expecting inactivity longer than the defined period.

Automatic enforcement of inactivity logout is addressed by [AC-11](#).

Related Controls: [AC-11](#).

(6) ACCOUNT MANAGEMENT | [DYNAMIC PRIVILEGE MANAGEMENT](#)

Implement [Assignment: organization-defined dynamic privilege management capabilities].

Discussion: In contrast to access control approaches that employ static accounts and predefined user privileges, dynamic access control approaches rely on runtime access control decisions facilitated by dynamic privilege management, such as attribute-based access control. While user identities remain relatively constant over time, user privileges typically change more frequently based on ongoing mission or business requirements and the operational needs of organizations. An example of dynamic privilege management is the immediate revocation of privileges from users as opposed to requiring that users terminate and restart their sessions to reflect changes in privileges. Dynamic privilege management can also include mechanisms that change user privileges based on dynamic rules as opposed to editing specific user profiles. Examples include automatic adjustments of user privileges if they are operating out of their normal work times, if their job function or assignment changes, or if systems are under duress or in emergency situations. Dynamic privilege management includes the effects of privilege changes, for example, when there are changes to encryption keys used for communications.

Related Controls: [AC-16](#).

(7) ACCOUNT MANAGEMENT | [PRIVILEGED USER ACCOUNTS](#)

- (a) Establish and administer privileged user accounts in accordance with [Selection: a role-based access scheme; an attribute-based access scheme];
- (b) Monitor privileged role or attribute assignments;
- (c) Monitor changes to roles or attributes; and
- (d) Revoke access when privileged role or attribute assignments are no longer appropriate.

Discussion: Privileged roles are organization-defined roles assigned to individuals that allow those individuals to perform certain security-relevant functions that ordinary users are not authorized to perform. Privileged roles include key management, account management, database administration, system and network administration, and web administration. A role-based access scheme organizes permitted system access and privileges into roles. In contrast, an attribute-based access scheme specifies allowed system access and privileges based on attributes.

Related Controls: None.

(8) ACCOUNT MANAGEMENT | [DYNAMIC ACCOUNT MANAGEMENT](#)

Create, activate, manage, and deactivate [Assignment: organization-defined system accounts] dynamically.

Discussion: Approaches for dynamically creating, activating, managing, and deactivating system accounts rely on automatically provisioning the accounts at runtime for entities that were previously unknown. Organizations plan for the dynamic management, creation, activation, and deactivation of system accounts by establishing trust relationships, business rules, and mechanisms with appropriate authorities to validate related authorizations and privileges.

Related Controls: [AC-16](#).

(9) ACCOUNT MANAGEMENT | [RESTRICTIONS ON USE OF SHARED AND GROUP ACCOUNTS](#)

Only permit the use of shared and group accounts that meet [Assignment: organization-defined conditions for establishing shared and group accounts].

Discussion: Before permitting the use of shared or group accounts, organizations consider the increased risk due to the lack of accountability with such accounts.

Related Controls: None.

(10) ACCOUNT MANAGEMENT | SHARED AND GROUP ACCOUNT CREDENTIAL CHANGE

[Withdrawn: Incorporated into [AC-2k](#).]

(11) ACCOUNT MANAGEMENT | [USAGE CONDITIONS](#)

Enforce [Assignment: organization-defined circumstances and/or usage conditions] for [Assignment: organization-defined system accounts].

Discussion: Specifying and enforcing usage conditions helps to enforce the principle of least privilege, increase user accountability, and enable effective account monitoring. Account monitoring includes alerts generated if the account is used in violation of organizational parameters. Organizations can describe specific conditions or circumstances under which system accounts can be used, such as by restricting usage to certain days of the week, time of day, or specific durations of time.

Related Controls: None.

(12) ACCOUNT MANAGEMENT | [ACCOUNT MONITORING FOR ATYPICAL USAGE](#)

- (a) Monitor system accounts for [Assignment: organization-defined atypical usage]; and**
- (b) Report atypical usage of system accounts to [Assignment: organization-defined personnel or roles].**

Discussion: Atypical usage includes accessing systems at certain times of the day or from locations that are not consistent with the normal usage patterns of individuals. Monitoring for atypical usage may reveal rogue behavior by individuals or an attack in progress. Account monitoring may inadvertently create privacy risks since data collected to identify atypical usage may reveal previously unknown information about the behavior of individuals. Organizations assess and document privacy risks from monitoring accounts for atypical

usage in their privacy impact assessment and make determinations that are in alignment with their privacy program plan.

Related Controls: [AU-6](#), [AU-7](#), [CA-7](#), [IR-8](#), [SI-4](#).

(13) ACCOUNT MANAGEMENT | [DISABLE ACCOUNTS FOR HIGH-RISK INDIVIDUALS](#)

Disable accounts of individuals within [Assignment: organization-defined time period] of discovery of [Assignment: organization-defined significant risks].

Discussion: Users who pose a significant security and/or privacy risk include individuals for whom reliable evidence indicates either the intention to use authorized access to systems to cause harm or through whom adversaries will cause harm. Such harm includes adverse impacts to organizational operations, organizational assets, individuals, other organizations, or the Nation. Close coordination among system administrators, legal staff, human resource managers, and authorizing officials is essential when disabling system accounts for high-risk individuals.

Related Controls: [AU-6](#), [SI-4](#).

References: [\[SP 800-162\]](#), [\[SP 800-178\]](#), [\[SP 800-192\]](#).

[AC-3](#) ACCESS ENFORCEMENT

Control: Enforce approved authorizations for logical access to information and system resources in accordance with applicable access control policies.

Discussion: Access control policies control access between active entities or subjects (i.e., users or processes acting on behalf of users) and passive entities or objects (i.e., devices, files, records, domains) in organizational systems. In addition to enforcing authorized access at the system level and recognizing that systems can host many applications and services in support of mission and business functions, access enforcement mechanisms can also be employed at the application and service level to provide increased information security and privacy. In contrast to logical access controls that are implemented within the system, physical access controls are addressed by the controls in the Physical and Environmental Protection ([PE](#)) family.

Related Controls: [AC-2](#), [AC-4](#), [AC-5](#), [AC-6](#), [AC-16](#), [AC-17](#), [AC-18](#), [AC-19](#), [AC-20](#), [AC-21](#), [AC-22](#), [AC-24](#), [AC-25](#), [AT-2](#), [AT-3](#), [AU-9](#), [CA-9](#), [CM-5](#), [CM-11](#), [IA-2](#), [IA-5](#), [IA-6](#), [IA-7](#), [IA-11](#), [MA-3](#), [MA-4](#), [MA-5](#), [MP-4](#), [PM-2](#), [PS-3](#), [PT-2](#), [PT-3](#), [SA-17](#), [SC-2](#), [SC-3](#), [SC-4](#), [SC-12](#), [SC-13](#), [SC-28](#), [SC-31](#), [SC-34](#), [SI-4](#), [SI-8](#).

Control Enhancements:

(1) ACCESS ENFORCEMENT | RESTRICTED ACCESS TO PRIVILEGED FUNCTIONS

[Withdrawn: Incorporated into [AC-6](#).]

(2) ACCESS ENFORCEMENT | [DUAL AUTHORIZATION](#)

Enforce dual authorization for [Assignment: organization-defined privileged commands and/or other organization-defined actions].

Discussion: Dual authorization, also known as two-person control, reduces risk related to insider threats. Dual authorization mechanisms require the approval of two authorized individuals to execute. To reduce the risk of collusion, organizations consider rotating dual authorization duties. Organizations consider the risk associated with implementing dual authorization mechanisms when immediate responses are necessary to ensure public and environmental safety.

Related Controls: [CP-9](#), [MP-6](#).

(3) ACCESS ENFORCEMENT | [MANDATORY ACCESS CONTROL](#)

Enforce [Assignment: organization-defined mandatory access control policy] over the set of covered subjects and objects specified in the policy, and where the policy:

- (a) Is uniformly enforced across the covered subjects and objects within the system;
- (b) Specifies that a subject that has been granted access to information is constrained from doing any of the following;
 - (1) Passing the information to unauthorized subjects or objects;
 - (2) Granting its privileges to other subjects;
 - (3) Changing one or more security attributes (specified by the policy) on subjects, objects, the system, or system components;
 - (4) Choosing the security attributes and attribute values (specified by the policy) to be associated with newly created or modified objects; and
 - (5) Changing the rules governing access control; and
- (c) Specifies that [Assignment: organization-defined subjects] may explicitly be granted [Assignment: organization-defined privileges] such that they are not limited by any defined subset (or all) of the above constraints.

Discussion: Mandatory access control is a type of nondiscretionary access control.

Mandatory access control policies constrain what actions subjects can take with information obtained from objects for which they have already been granted access. This prevents the subjects from passing the information to unauthorized subjects and objects. Mandatory access control policies constrain actions that subjects can take with respect to the propagation of access control privileges; that is, a subject with a privilege cannot pass that privilege to other subjects. The policy is uniformly enforced over all subjects and objects to which the system has control. Otherwise, the access control policy can be circumvented. This enforcement is provided by an implementation that meets the reference monitor concept as described in [AC-25](#). The policy is bounded by the system (i.e., once the information is passed outside of the control of the system, additional means may be required to ensure that the constraints on the information remain in effect).

The trusted subjects described above are granted privileges consistent with the concept of least privilege (see [AC-6](#)). Trusted subjects are only given the minimum privileges necessary for satisfying organizational mission/business needs relative to the above policy. The control is most applicable when there is a mandate that establishes a policy regarding access to controlled unclassified information or classified information and some users of the system are not authorized access to all such information resident in the system. Mandatory access control can operate in conjunction with discretionary access control as described in [AC-3\(4\)](#). A subject constrained in its operation by mandatory access control policies can still operate under the less rigorous constraints of AC-3(4), but mandatory access control policies take precedence over the less rigorous constraints of AC-3(4). For example, while a mandatory access control policy imposes a constraint that prevents a subject from passing information to another subject operating at a different impact or classification level, AC-3(4) permits the subject to pass the information to any other subject with the same impact or classification level as the subject. Examples of mandatory access control policies include the Bell-LaPadula policy to protect confidentiality of information and the Biba policy to protect the integrity of information.

Related Controls: [SC-7](#).

(4) ACCESS ENFORCEMENT | [DISCRETIONARY ACCESS CONTROL](#)

Enforce [Assignment: organization-defined discretionary access control policy] over the set of covered subjects and objects specified in the policy, and where the policy specifies that a subject that has been granted access to information can do one or more of the following:

- (a) Pass the information to any other subjects or objects;

- (b) Grant its privileges to other subjects;
- (c) Change security attributes on subjects, objects, the system, or the system's components;
- (d) Choose the security attributes to be associated with newly created or revised objects; or
- (e) Change the rules governing access control.

Discussion: When discretionary access control policies are implemented, subjects are not constrained with regard to what actions they can take with information for which they have already been granted access. Thus, subjects that have been granted access to information are not prevented from passing the information to other subjects or objects (i.e., subjects have the discretion to pass). Discretionary access control can operate in conjunction with mandatory access control as described in [AC-3\(3\)](#) and [AC-3\(15\)](#). A subject that is constrained in its operation by mandatory access control policies can still operate under the less rigorous constraints of discretionary access control. Therefore, while [AC-3\(3\)](#) imposes constraints that prevent a subject from passing information to another subject operating at a different impact or classification level, [AC-3\(4\)](#) permits the subject to pass the information to any subject at the same impact or classification level. The policy is bounded by the system. Once the information is passed outside of system control, additional means may be required to ensure that the constraints remain in effect. While traditional definitions of discretionary access control require identity-based access control, that limitation is not required for this particular use of discretionary access control.

Related Controls: None.

(5) ACCESS ENFORCEMENT | [SECURITY-RELEVANT INFORMATION](#)

Prevent access to [Assignment: organization-defined security-relevant information] except during secure, non-operable system states.

Discussion: Security-relevant information is information within systems that can potentially impact the operation of security functions or the provision of security services in a manner that could result in failure to enforce system security and privacy policies or maintain the separation of code and data. Security-relevant information includes access control lists, filtering rules for routers or firewalls, configuration parameters for security services, and cryptographic key management information. Secure, non-operable system states include the times in which systems are not performing mission or business-related processing, such as when the system is offline for maintenance, boot-up, troubleshooting, or shut down.

Related Controls: [CM-6](#), [SC-39](#).

(6) ACCESS ENFORCEMENT | PROTECTION OF USER AND SYSTEM INFORMATION

[Withdrawn: Incorporated into [MP-4](#) and [SC-28](#).]

(7) ACCESS ENFORCEMENT | [ROLE-BASED ACCESS CONTROL](#)

Enforce a role-based access control policy over defined subjects and objects and control access based upon [Assignment: organization-defined roles and users authorized to assume such roles].

Discussion: Role-based access control (RBAC) is an access control policy that enforces access to objects and system functions based on the defined role (i.e., job function) of the subject. Organizations can create specific roles based on job functions and the authorizations (i.e., privileges) to perform needed operations on the systems associated with the organization-defined roles. When users are assigned to specific roles, they inherit the authorizations or privileges defined for those roles. RBAC simplifies privilege administration for organizations because privileges are not assigned directly to every user (which can be a large number of individuals) but are instead acquired through role assignments. RBAC can also increase

privacy and security risk if individuals assigned to a role are given access to information beyond what they need to support organizational missions or business functions. RBAC can be implemented as a mandatory or discretionary form of access control. For organizations implementing RBAC with mandatory access controls, the requirements in [AC-3\(3\)](#) define the scope of the subjects and objects covered by the policy.

Related Controls: None.

(8) ACCESS ENFORCEMENT | [REVOCATION OF ACCESS AUTHORIZATIONS](#)

Enforce the revocation of access authorizations resulting from changes to the security attributes of subjects and objects based on [Assignment: organization-defined rules governing the timing of revocations of access authorizations].

Discussion: Revocation of access rules may differ based on the types of access revoked. For example, if a subject (i.e., user or process acting on behalf of a user) is removed from a group, access may not be revoked until the next time the object is opened or the next time the subject attempts to access the object. Revocation based on changes to security labels may take effect immediately. Organizations provide alternative approaches on how to make revocations immediate if systems cannot provide such capability and immediate revocation is necessary.

Related Controls: None.

(9) ACCESS ENFORCEMENT | [CONTROLLED RELEASE](#)

Release information outside of the system only if:

- (a) The receiving [Assignment: organization-defined system or system component] provides [Assignment: organization-defined controls]; and**
- (b) [Assignment: organization-defined controls] are used to validate the appropriateness of the information designated for release.**

Discussion: Organizations can only directly protect information when it resides within the system. Additional controls may be needed to ensure that organizational information is adequately protected once it is transmitted outside of the system. In situations where the system is unable to determine the adequacy of the protections provided by external entities, as a mitigation measure, organizations procedurally determine whether the external systems are providing adequate controls. The means used to determine the adequacy of controls provided by external systems include conducting periodic assessments (inspections/tests), establishing agreements between the organization and its counterpart organizations, or some other process. The means used by external entities to protect the information received need not be the same as those used by the organization, but the means employed are sufficient to provide consistent adjudication of the security and privacy policy to protect the information and individuals' privacy.

Controlled release of information requires systems to implement technical or procedural means to validate the information prior to releasing it to external systems. For example, if the system passes information to a system controlled by another organization, technical means are employed to validate that the security and privacy attributes associated with the exported information are appropriate for the receiving system. Alternatively, if the system passes information to a printer in organization-controlled space, procedural means can be employed to ensure that only authorized individuals gain access to the printer.

Related Controls: [CA-3](#), [PT-7](#), [PT-8](#), [SA-9](#), [SC-16](#).

(10) ACCESS ENFORCEMENT | [AUDITED OVERRIDE OF ACCESS CONTROL MECHANISMS](#)

Employ an audited override of automated access control mechanisms under [Assignment: organization-defined conditions] by [Assignment: organization-defined roles].

Discussion: In certain situations, such as when there is a threat to human life or an event that threatens the organization's ability to carry out critical missions or business functions, an override capability for access control mechanisms may be needed. Override conditions are defined by organizations and used only in those limited circumstances. Audit events are defined in [AU-2](#). Audit records are generated in [AU-12](#).

Related Controls: [AU-2](#), [AU-6](#), [AU-10](#), [AU-12](#), [AU-14](#).

(11) ACCESS ENFORCEMENT | [RESTRICT ACCESS TO SPECIFIC INFORMATION TYPES](#)

Restrict access to data repositories containing [Assignment: organization-defined information types].

Discussion: Restricting access to specific information is intended to provide flexibility regarding access control of specific information types within a system. For example, role-based access could be employed to allow access to only a specific type of personally identifiable information within a database rather than allowing access to the database in its entirety. Other examples include restricting access to cryptographic keys, authentication information, and selected system information.

Related Controls: [CM-8](#), [CM-12](#), [CM-13](#), [PM-5](#).

(12) ACCESS ENFORCEMENT | [ASSERT AND ENFORCE APPLICATION ACCESS](#)

- (a) Require applications to assert, as part of the installation process, the access needed to the following system applications and functions: [Assignment: organization-defined system applications and functions];**
- (b) Provide an enforcement mechanism to prevent unauthorized access; and**
- (c) Approve access changes after initial installation of the application.**

Discussion: Asserting and enforcing application access is intended to address applications that need to access existing system applications and functions, including user contacts, global positioning systems, cameras, keyboards, microphones, networks, phones, or other files.

Related Controls: [CM-7](#).

(13) ACCESS ENFORCEMENT | [ATTRIBUTE-BASED ACCESS CONTROL](#)

Enforce attribute-based access control policy over defined subjects and objects and control access based upon [Assignment: organization-defined attributes to assume access permissions].

Discussion: Attribute-based access control is an access control policy that restricts system access to authorized users based on specified organizational attributes (e.g., job function, identity), action attributes (e.g., read, write, delete), environmental attributes (e.g., time of day, location), and resource attributes (e.g., classification of a document). Organizations can create rules based on attributes and the authorizations (i.e., privileges) to perform needed operations on the systems associated with organization-defined attributes and rules. When users are assigned to attributes defined in attribute-based access control policies or rules, they can be provisioned to a system with the appropriate privileges or dynamically granted access to a protected resource. Attribute-based access control can be implemented as either a mandatory or discretionary form of access control. When implemented with mandatory access controls, the requirements in [AC-3\(3\)](#) define the scope of the subjects and objects covered by the policy.

Related Controls: None.

(14) ACCESS ENFORCEMENT | [INDIVIDUAL ACCESS](#)

Provide [Assignment: organization-defined mechanisms] to enable individuals to have access to the following elements of their personally identifiable information: [Assignment: organization-defined elements].

Discussion: Individual access affords individuals the ability to review personally identifiable information about them held within organizational records, regardless of format. Access helps individuals to develop an understanding about how their personally identifiable information is being processed. It can also help individuals ensure that their data is accurate. Access mechanisms can include request forms and application interfaces. For federal agencies, [PRIVACT] processes can be located in systems of record notices and on agency websites. Access to certain types of records may not be appropriate (e.g., for federal agencies, law enforcement records within a system of records may be exempt from disclosure under the [PRIVACT]) or may require certain levels of authentication assurance. Organizational personnel consult with the senior agency official for privacy and legal counsel to determine appropriate mechanisms and access rights or limitations.

Related Controls: [IA-8](#), [PM-22](#), [PM-20](#), [PM-21](#), [PT-6](#).

(15) ACCESS ENFORCEMENT | [DISCRETIONARY AND MANDATORY ACCESS CONTROL](#)

- (a) Enforce [Assignment: organization-defined mandatory access control policy] over the set of covered subjects and objects specified in the policy; and**
- (b) Enforce [Assignment: organization-defined discretionary access control policy] over the set of covered subjects and objects specified in the policy.**

Discussion: Simultaneously implementing a mandatory access control policy and a discretionary access control policy can provide additional protection against the unauthorized execution of code by users or processes acting on behalf of users. This helps prevent a single compromised user or process from compromising the entire system.

Related Controls: [SC-2](#), [SC-3](#), [AC-4](#).

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), [\[SP 800-57-3\]](#), [\[SP 800-162\]](#), [\[SP 800-178\]](#), [\[IR 7874\]](#).

AC-4 INFORMATION FLOW ENFORCEMENT

Control: Enforce approved authorizations for controlling the flow of information within the system and between connected systems based on [Assignment: organization-defined information flow control policies].

Discussion: Information flow control regulates where information can travel within a system and between systems (in contrast to who is allowed to access the information) and without regard to subsequent accesses to that information. Flow control restrictions include blocking external traffic that claims to be from within the organization, keeping export-controlled information from being transmitted in the clear to the Internet, restricting web requests that are not from the internal web proxy server, and limiting information transfers between organizations based on data structures and content. Transferring information between organizations may require an agreement specifying how the information flow is enforced (see [CA-3](#)). Transferring information between systems in different security or privacy domains with different security or privacy policies introduces the risk that such transfers violate one or more domain security or privacy policies. In such situations, information owners/stewards provide guidance at designated policy enforcement points between connected systems. Organizations consider mandating specific architectural solutions to enforce specific security and privacy policies. Enforcement includes prohibiting information transfers between connected systems (i.e., allowing access only), verifying write permissions before accepting information from another security or privacy domain or connected system, employing hardware mechanisms to enforce one-way information

flows, and implementing trustworthy regrading mechanisms to reassign security or privacy attributes and labels.

Organizations commonly 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 a message-filtering capability based on message content. Organizations also consider the trustworthiness of filtering and/or inspection mechanisms (i.e., hardware, firmware, and software components) that are critical to information flow enforcement. Control enhancements 3 through 32 primarily address cross-domain solution needs that focus on more advanced filtering techniques, in-depth analysis, and stronger flow enforcement mechanisms implemented in cross-domain products, such as high-assurance guards. Such capabilities are generally not available in commercial off-the-shelf products. Information flow enforcement also applies to control plane traffic (e.g., routing and DNS).

Related Controls: [AC-3](#), [AC-6](#), [AC-16](#), [AC-17](#), [AC-19](#), [AC-21](#), [AU-10](#), [CA-3](#), [CA-9](#), [CM-7](#), [PL-9](#), [PM-24](#), [SA-17](#), [SC-4](#), [SC-7](#), [SC-16](#), [SC-31](#).

Control Enhancements:

(1) INFORMATION FLOW ENFORCEMENT | [OBJECT SECURITY AND PRIVACY ATTRIBUTES](#)

Use [Assignment: organization-defined security and privacy attributes] associated with [Assignment: organization-defined information, source, and destination objects] to enforce [Assignment: organization-defined information flow control policies] as a basis for flow control decisions.

Discussion: Information flow enforcement mechanisms compare security and privacy attributes associated with information (i.e., data content and structure) and source and destination objects and respond appropriately when the enforcement mechanisms encounter information flows not explicitly allowed by information flow policies. For example, an information object labeled *Secret* would be allowed to flow to a destination object labeled *Secret*, but an information object labeled *Top Secret* would not be allowed to flow to a destination object labeled *Secret*. A dataset of personally identifiable information may be tagged with restrictions against combining with other types of datasets and, thus, would not be allowed to flow to the restricted dataset. Security and privacy attributes can also include source and destination addresses employed in traffic filter firewalls. Flow enforcement using explicit security or privacy attributes can be used, for example, to control the release of certain types of information.

Related Controls: None.

(2) INFORMATION FLOW ENFORCEMENT | [PROCESSING DOMAINS](#)

Use protected processing domains to enforce [Assignment: organization-defined information flow control policies] as a basis for flow control decisions.

Discussion: Protected processing domains within systems are processing spaces that have controlled interactions with other processing spaces, enabling control of information flows between these spaces and to/from information objects. A protected processing domain can be provided, for example, by implementing domain and type enforcement. In domain and type enforcement, system processes are assigned to domains, information is identified by types, and information flows are controlled based on allowed information accesses (i.e., determined by domain and type), allowed signaling among domains, and allowed process transitions to other domains.

Related Controls: [SC-39](#).

(3) INFORMATION FLOW ENFORCEMENT | [DYNAMIC INFORMATION FLOW CONTROL](#)

Enforce [Assignment: organization-defined information flow control policies].

Discussion: Organizational policies regarding dynamic information flow control include allowing or disallowing information flows based on changing conditions or mission or operational considerations. Changing conditions include changes in risk tolerance due to changes in the immediacy of mission or business needs, changes in the threat environment, and detection of potentially harmful or adverse events.

Related Controls: [SI-4](#).

(4) INFORMATION FLOW ENFORCEMENT | [FLOW CONTROL OF ENCRYPTED INFORMATION](#)

Prevent encrypted information from bypassing [Assignment: organization-defined information flow control mechanisms] by [Selection (one or more): decrypting the information; blocking the flow of the encrypted information; terminating communications sessions attempting to pass encrypted information; [Assignment: organization-defined procedure or method]].

Discussion: Flow control mechanisms include content checking, security policy filters, and data type identifiers. The term encryption is extended to cover encoded data not recognized by filtering mechanisms.

Related Controls: [SI-4](#).

(5) INFORMATION FLOW ENFORCEMENT | [EMBEDDED DATA TYPES](#)

Enforce [Assignment: organization-defined limitations] on embedding data types within other data types.

Discussion: Embedding data types within other data types may result in reduced flow control effectiveness. Data type embedding includes inserting files as objects within other files and using compressed or archived data types that may include multiple embedded data types. Limitations on data type embedding consider the levels of embedding and prohibit levels of data type embedding that are beyond the capability of the inspection tools.

Related Controls: None.

(6) INFORMATION FLOW ENFORCEMENT | [METADATA](#)

Enforce information flow control based on [Assignment: organization-defined metadata].

Discussion: Metadata is information that describes the characteristics of data. Metadata can include structural metadata describing data structures or descriptive metadata describing data content. Enforcement of allowed information flows based on metadata enables simpler and more effective flow control. Organizations consider the trustworthiness of metadata regarding data accuracy (i.e., knowledge that the metadata values are correct with respect to the data), data integrity (i.e., protecting against unauthorized changes to metadata tags), and the binding of metadata to the data payload (i.e., employing sufficiently strong binding techniques with appropriate assurance).

Related Controls: [AC-16](#), [SI-7](#).

(7) INFORMATION FLOW ENFORCEMENT | [ONE-WAY FLOW MECHANISMS](#)

Enforce one-way information flows through hardware-based flow control mechanisms.

Discussion: One-way flow mechanisms may also be referred to as a unidirectional network, unidirectional security gateway, or data diode. One-way flow mechanisms can be used to prevent data from being exported from a higher impact or classified domain or system while permitting data from a lower impact or unclassified domain or system to be imported.

Related Controls: None.

(8) INFORMATION FLOW ENFORCEMENT | [SECURITY AND PRIVACY POLICY FILTERS](#)

- (a) Enforce information flow control using [Assignment: organization-defined security or privacy policy filters] as a basis for flow control decisions for [Assignment: organization-defined information flows]; and**
- (b) [Selection (one or more): Block; Strip; Modify; Quarantine] data after a filter processing failure in accordance with [Assignment: organization-defined security or privacy policy].**

Discussion: Organization-defined security or privacy policy filters can address data structures and content. For example, security or privacy policy filters for data structures can check for maximum file lengths, maximum field sizes, and data/file types (for structured and unstructured data). Security or privacy policy filters for data content can check for specific words, enumerated values or data value ranges, and hidden content. Structured data permits the interpretation of data content by applications. Unstructured data refers to digital information without a data structure or with a data structure that does not facilitate the development of rule sets to address the impact or classification level of the information conveyed by the data or the flow enforcement decisions. Unstructured data consists of bitmap objects that are inherently non-language-based (i.e., image, video, or audio files) and textual objects that are based on written or printed languages. Organizations can implement more than one security or privacy policy filter to meet information flow control objectives.

Related Controls: None.

(9) INFORMATION FLOW ENFORCEMENT | [HUMAN REVIEWS](#)

Enforce the use of human reviews for [Assignment: organization-defined information flows] under the following conditions: [Assignment: organization-defined conditions].

Discussion: Organizations define security or privacy policy filters for all situations where automated flow control decisions are possible. When a fully automated flow control decision is not possible, then a human review may be employed in lieu of or as a complement to automated security or privacy policy filtering. Human reviews may also be employed as deemed necessary by organizations.

Related Controls: None.

(10) INFORMATION FLOW ENFORCEMENT | [ENABLE AND DISABLE SECURITY OR PRIVACY POLICY FILTERS](#)

Provide the capability for privileged administrators to enable and disable [Assignment: organization-defined security or privacy policy filters] under the following conditions: [Assignment: organization-defined conditions].

Discussion: For example, as allowed by the system authorization, administrators can enable security or privacy policy filters to accommodate approved data types. Administrators also have the capability to select the filters that are executed on a specific data flow based on the type of data that is being transferred, the source and destination security domains, and other security or privacy relevant features, as needed.

Related Controls: None.

(11) INFORMATION FLOW ENFORCEMENT | [CONFIGURATION OF SECURITY OR PRIVACY POLICY FILTERS](#)

Provide the capability for privileged administrators to configure [Assignment: organization-defined security or privacy policy filters] to support different security or privacy policies.

Discussion: Documentation contains detailed information for configuring security or privacy policy filters. For example, administrators can configure security or privacy policy filters to include the list of inappropriate words that security or privacy policy mechanisms check in accordance with the definitions provided by organizations.

Related Controls: None.

(12) INFORMATION FLOW ENFORCEMENT | [DATA TYPE IDENTIFIERS](#)

When transferring information between different security domains, use [Assignment: organization-defined data type identifiers] to validate data essential for information flow decisions.

Discussion: Data type identifiers include filenames, file types, file signatures or tokens, and multiple internal file signatures or tokens. Systems only allow transfer of data that is compliant with data type format specifications. Identification and validation of data types is based on defined specifications associated with each allowed data format. The filename and number alone are not used for data type identification. Content is validated syntactically and semantically against its specification to ensure that it is the proper data type.

Related Controls: None.

(13) INFORMATION FLOW ENFORCEMENT | [DECOMPOSITION INTO POLICY-RELEVANT SUBCOMPONENTS](#)

When transferring information between different security domains, decompose information into [Assignment: organization-defined policy-relevant subcomponents] for submission to policy enforcement mechanisms.

Discussion: Decomposing information into policy-relevant subcomponents prior to information transfer facilitates policy decisions on source, destination, certificates, classification, attachments, and other security- or privacy-related component differentiators. Policy enforcement mechanisms apply filtering, inspection, and/or sanitization rules to the policy-relevant subcomponents of information to facilitate flow enforcement prior to transferring such information to different security domains.

Related Controls: None.

(14) INFORMATION FLOW ENFORCEMENT | [SECURITY OR PRIVACY POLICY FILTER CONSTRAINTS](#)

When transferring information between different security domains, implement [Assignment: organization-defined security or privacy policy filters] requiring fully enumerated formats that restrict data structure and content.

Discussion: Data structure and content restrictions reduce the range of potential malicious or unsanctioned content in cross-domain transactions. Security or privacy policy filters that restrict data structures include restricting file sizes and field lengths. Data content policy filters include encoding formats for character sets, restricting character data fields to only contain alpha-numeric characters, prohibiting special characters, and validating schema structures.

Related Controls: None.

(15) INFORMATION FLOW ENFORCEMENT | [DETECTION OF UNSANCTIONED INFORMATION](#)

When transferring information between different security domains, examine the information for the presence of [Assignment: organization-defined unsanctioned information] and prohibit the transfer of such information in accordance with the [Assignment: organization-defined security or privacy policy].

Discussion: Unsanctioned information includes malicious code, information that is inappropriate for release from the source network, or executable code that could disrupt or harm the services or systems on the destination network.

Related Controls: [SI-3](#).

(16) INFORMATION FLOW ENFORCEMENT | INFORMATION TRANSFERS ON INTERCONNECTED SYSTEMS

[Withdrawn: Incorporated into [AC-4](#).]

(17) INFORMATION FLOW ENFORCEMENT | [DOMAIN AUTHENTICATION](#)

Uniquely identify and authenticate source and destination points by [Selection (one or more): organization; system; application; service; individual] for information transfer.

Discussion: Attribution is a critical component of a security and privacy concept of operations. The ability to identify source and destination points for information flowing within systems allows the forensic reconstruction of events and encourages policy compliance by attributing policy violations to specific organizations or individuals. Successful domain authentication requires that system labels distinguish among systems, organizations, and individuals involved in preparing, sending, receiving, or disseminating information. Attribution also allows organizations to better maintain the lineage of personally identifiable information processing as it flows through systems and can facilitate consent tracking, as well as correction, deletion, or access requests from individuals.

Related Controls: [IA-2](#), [IA-3](#), [IA-9](#).

(18) INFORMATION FLOW ENFORCEMENT | SECURITY ATTRIBUTE BINDING

[Withdrawn: Incorporated into [AC-16](#).]

(19) INFORMATION FLOW ENFORCEMENT | VALIDATION OF METADATA

When transferring information between different security domains, implement [Assignment: organization-defined security or privacy policy filters] on metadata.

Discussion: All information (including metadata and the data to which the metadata applies) is subject to filtering and inspection. Some organizations distinguish between metadata and data payloads (i.e., only the data to which the metadata is bound). Other organizations do not make such distinctions and consider metadata and the data to which the metadata applies to be part of the payload.

Related Controls: None.

(20) INFORMATION FLOW ENFORCEMENT | APPROVED SOLUTIONS

Employ [Assignment: organization-defined solutions in approved configurations] to control the flow of [Assignment: organization-defined information] across security domains.

Discussion: Organizations define approved solutions and configurations in cross-domain policies and guidance in accordance with the types of information flows across classification boundaries. The National Security Agency (NSA) National Cross Domain Strategy and Management Office provides a listing of approved cross-domain solutions. Contact ncdsmo@nsa.gov for more information.

Related Controls: None.

(21) INFORMATION FLOW ENFORCEMENT | PHYSICAL OR LOGICAL SEPARATION OF INFORMATION FLOWS

Separate information flows logically or physically using [Assignment: organization-defined mechanisms and/or techniques] to accomplish [Assignment: organization-defined required separations by types of information].

Discussion: Enforcing the separation of information flows associated with defined types of data can enhance protection by ensuring that information is not commingled while in transit and by enabling flow control by transmission paths that are not otherwise achievable. Types of separable information include inbound and outbound communications traffic, service requests and responses, and information of differing security impact or classification levels.

Related Controls: [SC-32](#).

(22) INFORMATION FLOW ENFORCEMENT | ACCESS ONLY

Provide access from a single device to computing platforms, applications, or data residing in multiple different security domains, while preventing information flow between the different security domains.

Discussion: The system provides a capability for users to access each connected security domain without providing any mechanisms to allow users to transfer data or information between the different security domains. An example of an access-only solution is a terminal that provides a user access to information with different security classifications while assuredly keeping the information separate.

Related Controls: None.

(23) INFORMATION FLOW ENFORCEMENT | [MODIFY NON-RELEASABLE INFORMATION](#)

When transferring information between different security domains, modify non-releasable information by implementing [Assignment: organization-defined modification action].

Discussion: Modifying non-releasable information can help prevent a data spill or attack when information is transferred across security domains. Modification actions include masking, permutation, alteration, removal, or redaction.

Related Controls: None.

(24) INFORMATION FLOW ENFORCEMENT | [INTERNAL NORMALIZED FORMAT](#)

When transferring information between different security domains, parse incoming data into an internal normalized format and regenerate the data to be consistent with its intended specification.

Discussion: Converting data into normalized forms is one of most effective mechanisms to stop malicious attacks and large classes of data exfiltration.

Related Controls: None.

(25) INFORMATION FLOW ENFORCEMENT | [DATA SANITIZATION](#)

When transferring information between different security domains, sanitize data to minimize [Selection (one or more): delivery of malicious content, command and control of malicious code, malicious code augmentation, and steganography encoded data; spillage of sensitive information] in accordance with [Assignment: organization-defined policy]].

Discussion: Data sanitization is the process of irreversibly removing or destroying data stored on a memory device (e.g., hard drives, flash memory/solid state drives, mobile devices, CDs, and DVDs) or in hard copy form.

Related Controls: [MP-6](#).

(26) INFORMATION FLOW ENFORCEMENT | [AUDIT FILTERING ACTIONS](#)

When transferring information between different security domains, record and audit content filtering actions and results for the information being filtered.

Discussion: Content filtering is the process of inspecting information as it traverses a cross-domain solution and determines if the information meets a predefined policy. Content filtering actions and the results of filtering actions are recorded for individual messages to ensure that the correct filter actions were applied. Content filter reports are used to assist in troubleshooting actions by, for example, determining why message content was modified and/or why it failed the filtering process. Audit events are defined in [AU-2](#). Audit records are generated in [AU-12](#).

Related Controls: [AU-2](#), [AU-3](#), [AU-12](#).

(27) INFORMATION FLOW ENFORCEMENT | [REDUNDANT/INDEPENDENT FILTERING MECHANISMS](#)

When transferring information between different security domains, implement content filtering solutions that provide redundant and independent filtering mechanisms for each data type.

Discussion: Content filtering is the process of inspecting information as it traverses a cross-domain solution and determines if the information meets a predefined policy. Redundant

and independent content filtering eliminates a single point of failure filtering system. Independence is defined as the implementation of a content filter that uses a different code base and supporting libraries (e.g., two JPEG filters using different vendors' JPEG libraries) and multiple, independent system processes.

Related Controls: None.

(28) INFORMATION FLOW ENFORCEMENT | [LINEAR FILTER PIPELINES](#)

When transferring information between different security domains, implement a linear content filter pipeline that is enforced with discretionary and mandatory access controls.

Discussion: Content filtering is the process of inspecting information as it traverses a cross-domain solution and determines if the information meets a predefined policy. The use of linear content filter pipelines ensures that filter processes are non-bypassable and always invoked. In general, the use of parallel filtering architectures for content filtering of a single data type introduces bypass and non-invocation issues.

Related Controls: None.

(29) INFORMATION FLOW ENFORCEMENT | [FILTER ORCHESTRATION ENGINES](#)

When transferring information between different security domains, employ content filter orchestration engines to ensure that:

- (a) Content filtering mechanisms successfully complete execution without errors; and**
- (b) Content filtering actions occur in the correct order and comply with [Assignment: organization-defined policy].**

Discussion: Content filtering is the process of inspecting information as it traverses a cross-domain solution and determines if the information meets a predefined security policy. An orchestration engine coordinates the sequencing of activities (manual and automated) in a content filtering process. Errors are defined as either anomalous actions or unexpected termination of the content filter process. This is not the same as a filter failing content due to non-compliance with policy. Content filter reports are a commonly used mechanism to ensure that expected filtering actions are completed successfully.

Related Controls: None.

(30) INFORMATION FLOW ENFORCEMENT | [FILTER MECHANISMS USING MULTIPLE PROCESSES](#)

When transferring information between different security domains, implement content filtering mechanisms using multiple processes.

Discussion: The use of multiple processes to implement content filtering mechanisms reduces the likelihood of a single point of failure.

Related Controls: None.

(31) INFORMATION FLOW ENFORCEMENT | [FAILED CONTENT TRANSFER PREVENTION](#)

When transferring information between different security domains, prevent the transfer of failed content to the receiving domain.

Discussion: Content that failed filtering checks can corrupt the system if transferred to the receiving domain.

Related Controls: None.

(32) INFORMATION FLOW ENFORCEMENT | [PROCESS REQUIREMENTS FOR INFORMATION TRANSFER](#)

When transferring information between different security domains, the process that transfers information between filter pipelines:

- (a) Does not filter message content;**
- (b) Validates filtering metadata;**

- (c) Ensures the content associated with the filtering metadata has successfully completed filtering; and
- (d) Transfers the content to the destination filter pipeline.

Discussion: The processes transferring information between filter pipelines have minimum complexity and functionality to provide assurance that the processes operate correctly.

Related Controls: None.

References: [\[SP-800-160-1\]](#), [\[SP 800-162\]](#), [\[SP 800-178\]](#), [\[IR 8112\]](#).

AC-5 SEPARATION OF DUTIES

Control:

- a. Identify and document [Assignment: organization-defined duties of individuals requiring separation]; and
- b. Define system access authorizations to support separation of duties.

Discussion: Separation of duties addresses the potential for abuse of authorized privileges and helps to reduce the risk of malevolent activity without collusion. Separation of duties includes dividing mission or business functions and support functions among different individuals or roles, conducting system support functions with different individuals, and ensuring that security personnel who administer access control functions do not also administer audit functions.

Because separation of duty violations can span systems and application domains, organizations consider the entirety of systems and system components when developing policy on separation of duties. Separation of duties is enforced through the account management activities in [AC-2](#), access control mechanisms in [AC-3](#), and identity management activities in [IA-2](#), [IA-4](#), and [IA-12](#).

Related Controls: [AC-2](#), [AC-3](#), [AC-6](#), [AU-9](#), [CM-5](#), [CM-11](#), [CP-9](#), [IA-2](#), [IA-4](#), [IA-5](#), [IA-12](#), [MA-3](#), [MA-5](#), [PS-2](#), [SA-8](#), [SA-17](#).

Control Enhancements: None.

References: None.

AC-6 LEAST PRIVILEGE

Control: Employ the principle of least privilege, allowing only authorized accesses for users (or processes acting on behalf of users) that are necessary to accomplish assigned organizational tasks.

Discussion: Organizations employ least privilege for specific duties and systems. The principle of least privilege is also applied to system processes, ensuring that the processes have access to systems and operate at privilege levels no higher than necessary to accomplish organizational missions or business functions. Organizations consider the creation of additional processes, roles, and accounts as necessary to achieve least privilege. Organizations apply least privilege to the development, implementation, and operation of organizational systems.

Related Controls: [AC-2](#), [AC-3](#), [AC-5](#), [AC-16](#), [CM-5](#), [CM-11](#), [PL-2](#), [PM-12](#), [SA-8](#), [SA-15](#), [SA-17](#), [SC-38](#).

Control Enhancements:

(1) LEAST PRIVILEGE | AUTHORIZE ACCESS TO SECURITY FUNCTIONS

Authorize access for [Assignment: organization-defined individuals or roles] to:

- (a) [Assignment: organization-defined security functions (deployed in hardware, software, and firmware)]; and
- (b) [Assignment: organization-defined security-relevant information].

Discussion: Security functions include establishing system accounts, configuring access authorizations (i.e., permissions, privileges), configuring settings for events to be audited, and establishing intrusion detection parameters. Security-relevant information includes filtering rules for routers or firewalls, configuration parameters for security services, cryptographic key management information, and access control lists. Authorized personnel include security administrators, system administrators, system security officers, system programmers, and other privileged users.

Related Controls: [AC-17](#), [AC-18](#), [AC-19](#), [AU-9](#), [PE-2](#).

(2) LEAST PRIVILEGE | [NON-PRIVILEGED ACCESS FOR NONSECURITY FUNCTIONS](#)

Require that users of system accounts (or roles) with access to [Assignment: organization-defined security functions or security-relevant information] use non-privileged accounts or roles, when accessing nonsecurity functions.

Discussion: Requiring the use of non-privileged accounts when accessing nonsecurity functions limits exposure when operating from within privileged accounts or roles. The inclusion of roles addresses situations where organizations implement access control policies, such as role-based access control, and where a change of role provides the same degree of assurance in the change of access authorizations for the user and the processes acting on behalf of the user as would be provided by a change between a privileged and non-privileged account.

Related Controls: [AC-17](#), [AC-18](#), [AC-19](#), [PL-4](#).

(3) LEAST PRIVILEGE | [NETWORK ACCESS TO PRIVILEGED COMMANDS](#)

Authorize network access to [Assignment: organization-defined privileged commands] only for [Assignment: organization-defined compelling operational needs] and document the rationale for such access in the security plan for the system.

Discussion: Network access is any access across a network connection in lieu of local access (i.e., user being physically present at the device).

Related Controls: [AC-17](#), [AC-18](#), [AC-19](#).

(4) LEAST PRIVILEGE | [SEPARATE PROCESSING DOMAINS](#)

Provide separate processing domains to enable finer-grained allocation of user privileges.

Discussion: Providing separate processing domains for finer-grained allocation of user privileges includes using virtualization techniques to permit additional user privileges within a virtual machine while restricting privileges to other virtual machines or to the underlying physical machine, implementing separate physical domains, and employing hardware or software domain separation mechanisms.

Related Controls: [AC-4](#), [SC-2](#), [SC-3](#), [SC-30](#), [SC-32](#), [SC-39](#).

(5) LEAST PRIVILEGE | [PRIVILEGED ACCOUNTS](#)

Restrict privileged accounts on the system to [Assignment: organization-defined personnel or roles].

Discussion: Privileged accounts, including super user accounts, are typically described as system administrator for various types of commercial off-the-shelf operating systems. Restricting privileged accounts to specific personnel or roles prevents day-to-day users from accessing privileged information or privileged functions. Organizations may differentiate in the application of restricting privileged accounts between allowed privileges for local accounts and for domain accounts provided that they retain the ability to control system configurations for key parameters and as otherwise necessary to sufficiently mitigate risk.

Related Controls: [IA-2](#), [MA-3](#), [MA-4](#).

(6) LEAST PRIVILEGE | [PRIVILEGED ACCESS BY NON-ORGANIZATIONAL USERS](#)

Prohibit privileged access to the system by non-organizational users.

Discussion: An organizational user is an employee or an individual considered by the organization to have the equivalent status of an employee. Organizational users include contractors, guest researchers, or individuals detailed from other organizations. A non-organizational user is a user who is not an organizational user. Policies and procedures for granting equivalent status of employees to individuals include a need-to-know, citizenship, and the relationship to the organization.

Related Controls: [AC-18](#), [AC-19](#), [IA-2](#), [IA-8](#).

(7) LEAST PRIVILEGE | [REVIEW OF USER PRIVILEGES](#)

- (a) Review [Assignment: organization-defined frequency] the privileges assigned to [Assignment: organization-defined roles or classes of users] to validate the need for such privileges; and**
- (b) Reassign or remove privileges, if necessary, to correctly reflect organizational mission and business needs.**

Discussion: The need for certain assigned user privileges may change over time to reflect changes in organizational mission and business functions, environments of operation, technologies, or threats. A periodic review of assigned user privileges is necessary to determine if the rationale for assigning such privileges remains valid. If the need cannot be revalidated, organizations take appropriate corrective actions.

Related Controls: [CA-7](#).

(8) LEAST PRIVILEGE | [PRIVILEGE LEVELS FOR CODE EXECUTION](#)

Prevent the following software from executing at higher privilege levels than users executing the software: [Assignment: organization-defined software].

Discussion: In certain situations, software applications or programs need to execute with elevated privileges to perform required functions. However, depending on the software functionality and configuration, if the privileges required for execution are at a higher level than the privileges assigned to organizational users invoking such applications or programs, those users may indirectly be provided with greater privileges than assigned.

Related Controls: None.

(9) LEAST PRIVILEGE | [LOG USE OF PRIVILEGED FUNCTIONS](#)

Log the execution of privileged functions.

Discussion: The misuse of privileged functions, either intentionally or unintentionally by authorized users or by unauthorized external entities that have compromised system accounts, is a serious and ongoing concern and can have significant adverse impacts on organizations. Logging and analyzing the use of privileged functions is one way to detect such misuse and, in doing so, help mitigate the risk from insider threats and the advanced persistent threat.

Related Controls: [AU-2](#), [AU-3](#), [AU-12](#).

(10) LEAST PRIVILEGE | [PROHIBIT NON-PRIVILEGED USERS FROM EXECUTING PRIVILEGED FUNCTIONS](#)

Prevent non-privileged users from executing privileged functions.

Discussion: Privileged functions include disabling, circumventing, or altering implemented security or privacy controls, establishing system accounts, performing system integrity checks, and administering cryptographic key management activities. Non-privileged users are individuals who do not possess appropriate authorizations. Privileged functions that require protection from non-privileged users include circumventing intrusion detection and

prevention mechanisms or malicious code protection mechanisms. Preventing non-privileged users from executing privileged functions is enforced by [AC-3](#).

Related Controls: None.

References: None.

[AC-7](#) UNSUCCESSFUL LOGON ATTEMPTS

Control:

- a. Enforce a limit of [Assignment: organization-defined number] consecutive invalid logon attempts by a user during a [Assignment: organization-defined time period]; and
- b. Automatically [Selection (one or more): lock the account or node for an [Assignment: organization-defined time period]; lock the account or node until released by an administrator; delay next logon prompt per [Assignment: organization-defined delay algorithm]; notify system administrator; take other [Assignment: organization-defined action]] when the maximum number of unsuccessful attempts is exceeded.

Discussion: The need to limit unsuccessful logon attempts and take subsequent action when the maximum number of attempts is exceeded applies regardless of whether the logon occurs via a local or network connection. Due to the potential for denial of service, automatic lockouts initiated by systems are usually temporary and automatically release after a predetermined, organization-defined time period. If a delay algorithm is selected, organizations may employ different algorithms for different components of the system based on the capabilities of those components. Responses to unsuccessful logon attempts may be implemented at the operating system and the application levels. Organization-defined actions that may be taken when the number of allowed consecutive invalid logon attempts is exceeded include prompting the user to answer a secret question in addition to the username and password, invoking a lockdown mode with limited user capabilities (instead of full lockout), allowing users to only logon from specified Internet Protocol (IP) addresses, requiring a CAPTCHA to prevent automated attacks, or applying user profiles such as location, time of day, IP address, device, or Media Access Control (MAC) address. If automatic system lockout or execution of a delay algorithm is not implemented in support of the availability objective, organizations consider a combination of other actions to help prevent brute force attacks. In addition to the above, organizations can prompt users to respond to a secret question before the number of allowed unsuccessful logon attempts is exceeded. Automatically unlocking an account after a specified period of time is generally not permitted. However, exceptions may be required based on operational mission or need.

Related Controls: [AC-2](#), [AC-9](#), [AU-2](#), [AU-6](#), [IA-5](#).

Control Enhancements:

(1) UNSUCCESSFUL LOGON ATTEMPTS | AUTOMATIC ACCOUNT LOCK

[Withdrawn: Incorporated into [AC-7](#).]

(2) UNSUCCESSFUL LOGON ATTEMPTS | [PURGE OR WIPE MOBILE DEVICE](#)

Purge or wipe information from [Assignment: organization-defined mobile devices] based on [Assignment: organization-defined purging or wiping requirements and techniques] after [Assignment: organization-defined number] consecutive, unsuccessful device logon attempts.

Discussion: A mobile device is a computing device that has a small form factor such that it can be carried by a single individual; is designed to operate without a physical connection; possesses local, non-removable or removable data storage; and includes a self-contained power source. Purging or wiping the device applies only to mobile devices for which the organization-defined number of unsuccessful logons occurs. The logon is to the mobile

device, not to any one account on the device. Successful logons to accounts on mobile devices reset the unsuccessful logon count to zero. Purging or wiping may be unnecessary if the information on the device is protected with sufficiently strong encryption mechanisms.

Related Controls: [AC-19](#), [MP-5](#), [MP-6](#).

(3) UNSUCCESSFUL LOGON ATTEMPTS | [BIOMETRIC ATTEMPT LIMITING](#)

Limit the number of unsuccessful biometric logon attempts to [Assignment: organization-defined number].

Discussion: Biometrics are probabilistic in nature. The ability to successfully authenticate can be impacted by many factors, including matching performance and presentation attack detection mechanisms. Organizations select the appropriate number of attempts for users based on organizationally-defined factors.

Related Controls: [IA-3](#).

(4) UNSUCCESSFUL LOGON ATTEMPTS | [USE OF ALTERNATE AUTHENTICATION FACTOR](#)

- (a) Allow the use of [Assignment: organization-defined authentication factors] that are different from the primary authentication factors after the number of organization-defined consecutive invalid logon attempts have been exceeded; and**
- (b) Enforce a limit of [Assignment: organization-defined number] consecutive invalid logon attempts through use of the alternative factors by a user during a [Assignment: organization-defined time period].**

Discussion: The use of alternate authentication factors supports the objective of availability and allows a user who has inadvertently been locked out to use additional authentication factors to bypass the lockout.

Related Controls: [IA-3](#).

References: [\[SP 800-63-3\]](#), [\[SP 800-124\]](#).

AC-8 SYSTEM USE NOTIFICATION

Control:

- a. Display [Assignment: organization-defined system use notification message or banner] to users before granting access to the system that provides privacy and security notices consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines and state that:
 1. Users are accessing a U.S. Government system;
 2. System usage may be monitored, recorded, and subject to audit;
 3. Unauthorized use of the system is prohibited and subject to criminal and civil penalties; and
 4. Use of the system indicates consent to monitoring and recording;
- b. Retain the notification message or banner on the screen until users acknowledge the usage conditions and take explicit actions to log on to or further access the system; and
- c. For publicly accessible systems:
 1. Display system use information [Assignment: organization-defined conditions], before granting further access to the publicly accessible system;
 2. Display references, if any, to monitoring, recording, or auditing that are consistent with privacy accommodations for such systems that generally prohibit those activities; and

3. Include a description of the authorized uses of the system.

Discussion: System use notifications can be implemented using messages or warning banners displayed before individuals log in to systems. System use notifications are used only for access via logon interfaces with human users. Notifications are not required when human interfaces do not exist. Based on an assessment of risk, organizations consider whether or not a secondary system use notification is needed to access applications or other system resources after the initial network logon. Organizations consider system use notification messages or banners displayed in multiple languages based on organizational needs and the demographics of system users. Organizations consult with the privacy office for input regarding privacy messaging and the Office of the General Counsel or organizational equivalent for legal review and approval of warning banner content.

Related Controls: [AC-14](#), [PL-4](#), [SI-4](#).

Control Enhancements: None.

References: None.

AC-9 PREVIOUS LOGON NOTIFICATION

Control: Notify the user, upon successful logon to the system, of the date and time of the last logon.

Discussion: Previous logon notification is applicable to system access via human user interfaces and access to systems that occurs in other types of architectures. Information about the last successful logon allows the user to recognize if the date and time provided is not consistent with the user's last access.

Related Controls: [AC-7](#), [PL-4](#).

Control Enhancements:

(1) PREVIOUS LOGON NOTIFICATION | [UNSUCCESSFUL LOGONS](#)

Notify the user, upon successful logon, of the number of unsuccessful logon attempts since the last successful logon.

Discussion: Information about the number of unsuccessful logon attempts since the last successful logon allows the user to recognize if the number of unsuccessful logon attempts is consistent with the user's actual logon attempts.

Related Controls: None.

(2) PREVIOUS LOGON NOTIFICATION | [SUCCESSFUL AND UNSUCCESSFUL LOGONS](#)

Notify the user, upon successful logon, of the number of [Selection: successful logons; unsuccessful logon attempts; both] during [Assignment: organization-defined time period].

Discussion: Information about the number of successful and unsuccessful logon attempts within a specified time period allows the user to recognize if the number and type of logon attempts are consistent with the user's actual logon attempts.

Related Controls: None.

(3) PREVIOUS LOGON NOTIFICATION | [NOTIFICATION OF ACCOUNT CHANGES](#)

Notify the user, upon successful logon, of changes to [Assignment: organization-defined security-related characteristics or parameters of the user's account] during [Assignment: organization-defined time period].

Discussion: Information about changes to security-related account characteristics within a specified time period allows users to recognize if changes were made without their knowledge.

Related Controls: None.

(4) PREVIOUS LOGON NOTIFICATION | [ADDITIONAL LOGON INFORMATION](#)

Notify the user, upon successful logon, of the following additional information: [Assignment: organization-defined additional information].

Discussion: Organizations can specify additional information to be provided to users upon logon, including the location of the last logon. User location is defined as information that can be determined by systems, such as Internet Protocol (IP) addresses from which network logons occurred, notifications of local logons, or device identifiers.

Related Controls: None.

References: None.

[AC-10 CONCURRENT SESSION CONTROL](#)

Control: Limit the number of concurrent sessions for each [Assignment: organization-defined account and/or account type] to [Assignment: organization-defined number].

Discussion: Organizations may define the maximum number of concurrent sessions for system accounts globally, by account type, by account, or any combination thereof. For example, organizations may limit the number of concurrent sessions for system administrators or other individuals working in particularly sensitive domains or mission-critical applications. Concurrent session control addresses concurrent sessions for system accounts. It does not, however, address concurrent sessions by single users via multiple system accounts.

Related Controls: [SC-23](#).

Control Enhancements: None.

References: None.

[AC-11 DEVICE LOCK](#)

Control:

- a. Prevent further access to the system by [Selection (one or more); initiating a device lock after [Assignment: organization-defined time period] of inactivity; requiring the user to initiate a device lock before leaving the system unattended]; and
- b. Retain the device lock until the user reestablishes access using established identification and authentication procedures.

Discussion: Device locks are temporary actions taken to prevent logical access to organizational systems when users stop work and move away from the immediate vicinity of those systems but do not want to log out because of the temporary nature of their absences. Device locks can be implemented at the operating system level or at the application level. A proximity lock may be used to initiate the device lock (e.g., via a Bluetooth-enabled device or dongle). User-initiated device locking is behavior or policy-based and, as such, requires users to take physical action to initiate the device lock. Device locks are not an acceptable substitute for logging out of systems, such as when organizations require users to log out at the end of workdays.

Related Controls: [AC-2](#), [AC-7](#), [IA-11](#), [PL-4](#).

Control Enhancements:

(1) DEVICE LOCK | [PATTERN-HIDING DISPLAYS](#)

Conceal, via the device lock, information previously visible on the display with a publicly viewable image.

Discussion: The pattern-hiding display can include static or dynamic images, such as patterns used with screen savers, photographic images, solid colors, clock, battery life indicator, or a blank screen with the caveat that controlled unclassified information is not displayed.

Related Controls: None.

References: None.

AC-12 SESSION TERMINATION

Control: Automatically terminate a user session after [Assignment: organization-defined conditions or trigger events requiring session disconnect].

Discussion: Session termination addresses the termination of user-initiated logical sessions (in contrast to [SC-10](#), which addresses the termination of network connections associated with communications sessions (i.e., network disconnect)). A logical session (for local, network, and remote access) is initiated whenever a user (or process acting on behalf of a user) accesses an organizational system. Such user sessions can be terminated without terminating network sessions. Session termination ends all processes associated with a user's logical session except for those processes that are specifically created by the user (i.e., session owner) to continue after the session is terminated. Conditions or trigger events that require automatic termination of the session include organization-defined periods of user inactivity, targeted responses to certain types of incidents, or time-of-day restrictions on system use.

Related Controls: [MA-4](#), [SC-10](#), [SC-23](#).

Control Enhancements:

(1) SESSION TERMINATION | [USER-INITIATED LOGOUTS](#)

Provide a logout capability for user-initiated communications sessions whenever authentication is used to gain access to [Assignment: organization-defined information resources].

Discussion: Information resources to which users gain access via authentication include local workstations, databases, and password-protected websites or web-based services.

Related Controls: None.

(2) SESSION TERMINATION | [TERMINATION MESSAGE](#)

Display an explicit logout message to users indicating the termination of authenticated communications sessions.

Discussion: Logout messages for web access can be displayed after authenticated sessions have been terminated. However, for certain types of sessions, including file transfer protocol (FTP) sessions, systems typically send logout messages as final messages prior to terminating sessions.

Related Controls: None.

(3) SESSION TERMINATION | [TIMEOUT WARNING MESSAGE](#)

Display an explicit message to users indicating that the session will end in [Assignment: organization-defined time until end of session].

Discussion: To increase usability, notify users of pending session termination and prompt users to continue the session. The pending session termination time period is based on the parameters defined in the [AC-12](#) base control.

Related Controls: None.

References: None.

AC-13 SUPERVISION AND REVIEW — ACCESS CONTROL

[Withdrawn: Incorporated into [AC-2](#) and [AU-6](#).]

AC-14 PERMITTED ACTIONS WITHOUT IDENTIFICATION OR AUTHENTICATIONControl:

- a. Identify [Assignment: organization-defined user actions] that can be performed on the system without identification or authentication consistent with organizational mission and business functions; and
- b. Document and provide supporting rationale in the security plan for the system, user actions not requiring identification or authentication.

Discussion: Specific user actions may be permitted without identification or authentication if organizations determine that identification and authentication are not required for the specified user actions. Organizations may allow a limited number of user actions without identification or authentication, including when individuals access public websites or other publicly accessible federal systems, when individuals use mobile phones to receive calls, or when facsimiles are received. Organizations identify actions that normally require identification or authentication but may, under certain circumstances, allow identification or authentication mechanisms to be bypassed. Such bypasses may occur, for example, via a software-readable physical switch that commands bypass of the logon functionality and is protected from accidental or unmonitored use. Permitting actions without identification or authentication does not apply to situations where identification and authentication have already occurred and are not repeated but rather to situations where identification and authentication have not yet occurred. Organizations may decide that there are no user actions that can be performed on organizational systems without identification and authentication, and therefore, the value for the assignment operation can be “none.”

Related Controls: [AC-8](#), [IA-2](#), [PL-2](#).

Control Enhancements: None.

(1) PERMITTED ACTIONS WITHOUT IDENTIFICATION OR AUTHENTICATION | NECESSARY USES

[Withdrawn: Incorporated into [AC-14](#).]

References: None.

AC-15 AUTOMATED MARKING

[Withdrawn: Incorporated into [MP-3](#).]

AC-16 SECURITY AND PRIVACY ATTRIBUTESControl:

- a. Provide the means to associate [Assignment: organization-defined types of security and privacy attributes] with [Assignment: organization-defined security and privacy attribute values] for information in storage, in process, and/or in transmission;
- b. Ensure that the attribute associations are made and retained with the information;
- c. Establish the following permitted security and privacy attributes from the attributes defined in [AC-16a](#) for [Assignment: organization-defined systems]: [Assignment: organization-defined security and privacy attributes];

-
- d. Determine the following permitted attribute values or ranges for each of the established attributes: *[Assignment: organization-defined attribute values or ranges for established attributes]*;
 - e. Audit changes to attributes; and
 - f. Review *[Assignment: organization-defined security and privacy attributes]* for applicability *[Assignment: organization-defined frequency]*.

Discussion: Information is represented internally within systems using abstractions known as data structures. Internal data structures can represent different types of entities, both active and passive. Active entities, also known as *subjects*, are typically associated with individuals, devices, or processes acting on behalf of individuals. Passive entities, also known as *objects*, are typically associated with data structures, such as records, buffers, tables, files, inter-process pipes, and communications ports. Security attributes, a form of metadata, are abstractions that represent the basic properties or characteristics of active and passive entities with respect to safeguarding information. Privacy attributes, which may be used independently or in conjunction with security attributes, represent the basic properties or characteristics of active or passive entities with respect to the management of personally identifiable information. Attributes can be either explicitly or implicitly associated with the information contained in organizational systems or system components.

Attributes may be associated with active entities (i.e., subjects) that have the potential to send or receive information, cause information to flow among objects, or change the system state. These attributes may also be associated with passive entities (i.e., objects) that contain or receive information. The association of attributes to subjects and objects by a system is referred to as binding and is inclusive of setting the attribute value and the attribute type. Attributes, when bound to data or information, permit the enforcement of security and privacy policies for access control and information flow control, including data retention limits, permitted uses of personally identifiable information, and identification of personal information within data objects. Such enforcement occurs through organizational processes or system functions or mechanisms. The binding techniques implemented by systems affect the strength of attribute binding to information. Binding strength and the assurance associated with binding techniques play important parts in the trust that organizations have in the information flow enforcement process. The binding techniques affect the number and degree of additional reviews required by organizations. The content or assigned values of attributes can directly affect the ability of individuals to access organizational information.

Organizations can define the types of attributes needed for systems to support missions or business functions. There are many values that can be assigned to a security attribute. By specifying the permitted attribute ranges and values, organizations ensure that attribute values are meaningful and relevant. Labeling refers to the association of attributes with the subjects and objects represented by the internal data structures within systems. This facilitates system-based enforcement of information security and privacy policies. Labels include classification of information in accordance with legal and compliance requirements (e.g., top secret, secret, confidential, controlled unclassified), information impact level; high value asset information, access authorizations, nationality; data life cycle protection (i.e., encryption and data expiration), personally identifiable information processing permissions, including individual consent to personally identifiable information processing, and contractor affiliation. A related term to labeling is marking. Marking refers to the association of attributes with objects in a human-readable form and displayed on system media. Marking enables manual, procedural, or process-based enforcement of information security and privacy policies. Security and privacy labels may have the same value as media markings (e.g., top secret, secret, confidential). See [MP-3 \(Media Marking\)](#).

Related Controls: [AC-3](#), [AC-4](#), [AC-6](#), [AC-21](#), [AC-25](#), [AU-2](#), [AU-10](#), [MP-3](#), [PE-22](#), [PT-2](#), [PT-3](#), [PT-4](#), [SC-11](#), [SC-16](#), [SI-12](#), [SI-18](#).

Control Enhancements:

(1) SECURITY AND PRIVACY ATTRIBUTES | [DYNAMIC ATTRIBUTE ASSOCIATION](#)

Dynamically associate security and privacy attributes with [Assignment: organization-defined subjects and objects] in accordance with the following security and privacy policies as information is created and combined: [Assignment: organization-defined security and privacy policies].

Discussion: Dynamic association of attributes is appropriate whenever the security or privacy characteristics of information change over time. Attributes may change due to information aggregation issues (i.e., characteristics of individual data elements are different from the combined elements), changes in individual access authorizations (i.e., privileges), changes in the security category of information, or changes in security or privacy policies. Attributes may also change situationally.

Related Controls: None.

(2) SECURITY AND PRIVACY ATTRIBUTES | [ATTRIBUTE VALUE CHANGES BY AUTHORIZED INDIVIDUALS](#)

Provide authorized individuals (or processes acting on behalf of individuals) the capability to define or change the value of associated security and privacy attributes.

Discussion: The content or assigned values of attributes can directly affect the ability of individuals to access organizational information. Therefore, it is important for systems to be able to limit the ability to create or modify attributes to authorized individuals.

Related Controls: None.

(3) SECURITY AND PRIVACY ATTRIBUTES | [MAINTENANCE OF ATTRIBUTE ASSOCIATIONS BY SYSTEM](#)

Maintain the association and integrity of [Assignment: organization-defined security and privacy attributes] to [Assignment: organization-defined subjects and objects].

Discussion: Maintaining the association and integrity of security and privacy attributes to subjects and objects with sufficient assurance helps to ensure that the attribute associations can be used as the basis of automated policy actions. The integrity of specific items, such as security configuration files, may be maintained through the use of an integrity monitoring mechanism that detects anomalies and changes that deviate from “known good” baselines. Automated policy actions include retention date expirations, access control decisions, information flow control decisions, and information disclosure decisions.

Related Controls: None.

(4) SECURITY AND PRIVACY ATTRIBUTES | [ASSOCIATION OF ATTRIBUTES BY AUTHORIZED INDIVIDUALS](#)

Provide the capability to associate [Assignment: organization-defined security and privacy attributes] with [Assignment: organization-defined subjects and objects] by authorized individuals (or processes acting on behalf of individuals).

Discussion: Systems, in general, provide the capability for privileged users to assign security and privacy attributes to system-defined subjects (e.g., users) and objects (e.g., directories, files, and ports). Some systems provide additional capability for general users to assign security and privacy attributes to additional objects (e.g., files, emails). The association of attributes by authorized individuals is described in the design documentation. The support provided by systems can include prompting users to select security and privacy attributes to be associated with information objects, employing automated mechanisms to categorize information with attributes based on defined policies, or ensuring that the combination of the security or privacy attributes selected is valid. Organizations consider the creation, deletion, or modification of attributes when defining auditable events.

Related Controls: None.

(5) SECURITY AND PRIVACY ATTRIBUTES | [ATTRIBUTE DISPLAYS ON OBJECTS TO BE OUTPUT](#)

Display security and privacy attributes in human-readable form on each object that the system transmits to output devices to identify [Assignment: organization-defined special dissemination, handling, or distribution instructions] using [Assignment: organization-defined human-readable, standard naming conventions].

Discussion: System outputs include printed pages, screens, or equivalent items. System output devices include printers, notebook computers, video displays, smart phones, and tablets. To mitigate the risk of unauthorized exposure of information (e.g., shoulder surfing), the outputs display full attribute values when unmasked by the subscriber.

Related Controls: None.

(6) SECURITY AND PRIVACY ATTRIBUTES | [MAINTENANCE OF ATTRIBUTE ASSOCIATION](#)

Require personnel to associate and maintain the association of [Assignment: organization-defined security and privacy attributes] with [Assignment: organization-defined subjects and objects] in accordance with [Assignment: organization-defined security and privacy policies].

Discussion: Maintaining attribute association requires individual users (as opposed to the system) to maintain associations of defined security and privacy attributes with subjects and objects.

Related Controls: None.

(7) SECURITY AND PRIVACY ATTRIBUTES | [CONSISTENT ATTRIBUTE INTERPRETATION](#)

Provide a consistent interpretation of security and privacy attributes transmitted between distributed system components.

Discussion: To enforce security and privacy policies across multiple system components in distributed systems, organizations provide a consistent interpretation of security and privacy attributes employed in access enforcement and flow enforcement decisions. Organizations can establish agreements and processes to help ensure that distributed system components implement attributes with consistent interpretations in automated access enforcement and flow enforcement actions.

Related Controls: None.

(8) SECURITY AND PRIVACY ATTRIBUTES | [ASSOCIATION TECHNIQUES AND TECHNOLOGIES](#)

Implement [Assignment: organization-defined techniques and technologies] in associating security and privacy attributes to information.

Discussion: The association of security and privacy attributes to information within systems is important for conducting automated access enforcement and flow enforcement actions. The association of such attributes to information (i.e., binding) can be accomplished with technologies and techniques that provide different levels of assurance. For example, systems can cryptographically bind attributes to information using digital signatures that support cryptographic keys protected by hardware devices (sometimes known as hardware roots of trust).

Related Controls: [SC-12](#), [SC-13](#).

(9) SECURITY AND PRIVACY ATTRIBUTES | [ATTRIBUTE REASSIGNMENT — REGRADING MECHANISMS](#)

Change security and privacy attributes associated with information only via regrading mechanisms validated using [Assignment: organization-defined techniques or procedures].

Discussion: A regrading mechanism is a trusted process authorized to re-classify and re-label data in accordance with a defined policy exception. Validated regrading mechanisms are

used by organizations to provide the requisite levels of assurance for attribute reassignment activities. The validation is facilitated by ensuring that regrading mechanisms are single purpose and of limited function. Since security and privacy attribute changes can directly affect policy enforcement actions, implementing trustworthy regrading mechanisms is necessary to help ensure that such mechanisms perform in a consistent and correct mode of operation.

Related Controls: None.

(10) SECURITY AND PRIVACY ATTRIBUTES | [ATTRIBUTE CONFIGURATION BY AUTHORIZED INDIVIDUALS](#)

Provide authorized individuals the capability to define or change the type and value of security and privacy attributes available for association with subjects and objects.

Discussion: The content or assigned values of security and privacy attributes can directly affect the ability of individuals to access organizational information. Thus, it is important for systems to be able to limit the ability to create or modify the type and value of attributes available for association with subjects and objects to authorized individuals only.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[FIPS 140-3\]](#), [\[FIPS 186-4\]](#), [\[SP 800-162\]](#), [\[SP 800-178\]](#).

AC-17 REMOTE ACCESS

Control:

- a. Establish and document usage restrictions, configuration/connection requirements, and implementation guidance for each type of remote access allowed; and
- b. Authorize each type of remote access to the system prior to allowing such connections.

Discussion: Remote access is access to organizational systems (or processes acting on behalf of users) that communicate through external networks such as the Internet. Types of remote access include dial-up, broadband, and wireless. Organizations use encrypted virtual private networks (VPNs) to enhance confidentiality and integrity for remote connections. The use of encrypted VPNs provides sufficient assurance to the organization that it can effectively treat such connections as internal networks if the cryptographic mechanisms used are implemented in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Still, VPN connections traverse external networks, and the encrypted VPN does not enhance the availability of remote connections. VPNs with encrypted tunnels can also affect the ability to adequately monitor network communications traffic for malicious code. Remote access controls apply to systems other than public web servers or systems designed for public access. Authorization of each remote access type addresses authorization prior to allowing remote access without specifying the specific formats for such authorization. While organizations may use information exchange and system connection security agreements to manage remote access connections to other systems, such agreements are addressed as part of [CA-3](#). Enforcing access restrictions for remote access is addressed via [AC-3](#).

Related Controls: [AC-2](#), [AC-3](#), [AC-4](#), [AC-18](#), [AC-19](#), [AC-20](#), [CA-3](#), [CM-10](#), [IA-2](#), [IA-3](#), [IA-8](#), [MA-4](#), [PE-17](#), [PL-2](#), [PL-4](#), [SC-10](#), [SC-12](#), [SC-13](#), [SI-4](#).

Control Enhancements:

(1) REMOTE ACCESS | [MONITORING AND CONTROL](#)

Employ automated mechanisms to monitor and control remote access methods.

Discussion: Monitoring and control of remote access methods allows organizations to detect attacks and help ensure compliance with remote access policies by auditing the connection activities of remote users on a variety of system components, including servers,

notebook computers, workstations, smart phones, and tablets. Audit logging for remote access is enforced by [AU-2](#). Audit events are defined in [AU-2a](#).

Related Controls: [AU-2](#), [AU-6](#), [AU-12](#), [AU-14](#).

(2) REMOTE ACCESS | [PROTECTION OF CONFIDENTIALITY AND INTEGRITY USING ENCRYPTION](#)

Implement cryptographic mechanisms to protect the confidentiality and integrity of remote access sessions.

Discussion: Virtual private networks can be used to protect the confidentiality and integrity of remote access sessions. Transport Layer Security (TLS) is an example of a cryptographic protocol that provides end-to-end communications security over networks and is used for Internet communications and online transactions.

Related Controls: [SC-8](#), [SC-12](#), [SC-13](#).

(3) REMOTE ACCESS | [MANAGED ACCESS CONTROL POINTS](#)

Route remote accesses through authorized and managed network access control points.

Discussion: Organizations consider the Trusted Internet Connections (TIC) initiative [[DHS TIC](#)] requirements for external network connections since limiting the number of access control points for remote access reduces attack surfaces.

Related Controls: [SC-7](#).

(4) REMOTE ACCESS | [PRIVILEGED COMMANDS AND ACCESS](#)

(a) Authorize the execution of privileged commands and access to security-relevant information via remote access only in a format that provides assessable evidence and for the following needs: [Assignment: organization-defined needs]; and

(b) Document the rationale for remote access in the security plan for the system.

Discussion: Remote access to systems represents a significant potential vulnerability that can be exploited by adversaries. As such, restricting the execution of privileged commands and access to security-relevant information via remote access reduces the exposure of the organization and the susceptibility to threats by adversaries to the remote access capability.

Related Controls: [AC-6](#), [SC-12](#), [SC-13](#).

(5) REMOTE ACCESS | [MONITORING FOR UNAUTHORIZED CONNECTIONS](#)

[Withdrawn: Incorporated into [SI-4](#).]

(6) REMOTE ACCESS | [PROTECTION OF MECHANISM INFORMATION](#)

Protect information about remote access mechanisms from unauthorized use and disclosure.

Discussion: Remote access to organizational information by non-organizational entities can increase the risk of unauthorized use and disclosure about remote access mechanisms. The organization considers including remote access requirements in the information exchange agreements with other organizations, as applicable. Remote access requirements can also be included in rules of behavior (see [PL-4](#)) and access agreements (see [PS-6](#)).

Related Controls: [AT-2](#), [AT-3](#), [PS-6](#).

(7) REMOTE ACCESS | [ADDITIONAL PROTECTION FOR SECURITY FUNCTION ACCESS](#)

[Withdrawn: Incorporated into [AC-3\(10\)](#).]

(8) REMOTE ACCESS | [DISABLE NONSECURE NETWORK PROTOCOLS](#)

[Withdrawn: Incorporated into [CM-7](#).]

(9) REMOTE ACCESS | [DISCONNECT OR DISABLE ACCESS](#)

Provide the capability to disconnect or disable remote access to the system within [Assignment: organization-defined time period].

Discussion: The speed of system disconnect or disablement varies based on the criticality of missions or business functions and the need to eliminate immediate or future remote access to systems.

Related Controls: None.

(10) REMOTE ACCESS | [AUTHENTICATE REMOTE COMMANDS](#)

Implement [Assignment: organization-defined mechanisms] to authenticate [Assignment: organization-defined remote commands].

Discussion: Authenticating remote commands protects against unauthorized commands and the replay of authorized commands. The ability to authenticate remote commands is important for remote systems for which loss, malfunction, misdirection, or exploitation would have immediate or serious consequences, such as injury, death, property damage, loss of high value assets, failure of mission or business functions, or compromise of classified or controlled unclassified information. Authentication mechanisms for remote commands ensure that systems accept and execute commands in the order intended, execute only authorized commands, and reject unauthorized commands. Cryptographic mechanisms can be used, for example, to authenticate remote commands.

Related Controls: [SC-12](#), [SC-13](#), [SC-23](#).

References: [\[SP 800-46\]](#), [\[SP 800-77\]](#), [\[SP 800-113\]](#), [\[SP 800-114\]](#), [\[SP 800-121\]](#), [\[IR 7966\]](#).

[AC-18](#) WIRELESS ACCESS

Control:

- a. Establish configuration requirements, connection requirements, and implementation guidance for each type of wireless access; and
- b. Authorize each type of wireless access to the system prior to allowing such connections.

Discussion: Wireless technologies include microwave, packet radio (ultra-high frequency or very high frequency), 802.11x, and Bluetooth. Wireless networks use authentication protocols that provide authenticator protection and mutual authentication.

Related Controls: [AC-2](#), [AC-3](#), [AC-17](#), [AC-19](#), [CA-9](#), [CM-7](#), [IA-2](#), [IA-3](#), [IA-8](#), [PL-4](#), [SC-40](#), [SC-43](#), [SI-4](#).

Control Enhancements:

(1) WIRELESS ACCESS | [AUTHENTICATION AND ENCRYPTION](#)

Protect wireless access to the system using authentication of [Selection (one or more): users; devices] and encryption.

Discussion: Wireless networking capabilities represent a significant potential vulnerability that can be exploited by adversaries. To protect systems with wireless access points, strong authentication of users and devices along with strong encryption can reduce susceptibility to threats by adversaries involving wireless technologies.

Related Controls: [SC-8](#), [SC-12](#), [SC-13](#).

(2) WIRELESS ACCESS | MONITORING UNAUTHORIZED CONNECTIONS

[Withdrawn: Incorporated into [SI-4](#).]

(3) WIRELESS ACCESS | [DISABLE WIRELESS NETWORKING](#)

Disable, when not intended for use, wireless networking capabilities embedded within system components prior to issuance and deployment.

Discussion: Wireless networking capabilities that are embedded within system components represent a significant potential vulnerability that can be exploited by adversaries. Disabling wireless capabilities when not needed for essential organizational missions or functions can reduce susceptibility to threats by adversaries involving wireless technologies.

Related Controls: None.

(4) WIRELESS ACCESS | [RESTRICT CONFIGURATIONS BY USERS](#)

Identify and explicitly authorize users allowed to independently configure wireless networking capabilities.

Discussion: Organizational authorizations to allow selected users to configure wireless networking capabilities are enforced, in part, by the access enforcement mechanisms employed within organizational systems.

Related Controls: [SC-7](#), [SC-15](#).

(5) WIRELESS ACCESS | [ANTENNAS AND TRANSMISSION POWER LEVELS](#)

Select radio antennas and calibrate transmission power levels to reduce the probability that signals from wireless access points can be received outside of organization-controlled boundaries.

Discussion: Actions that may be taken to limit unauthorized use of wireless communications outside of organization-controlled boundaries include reducing the power of wireless transmissions so that the transmissions are less likely to emit a signal that can be captured outside of the physical perimeters of the organization, employing measures such as emissions security to control wireless emanations, and using directional or beamforming antennas that reduce the likelihood that unintended receivers will be able to intercept signals. Prior to taking such mitigating actions, organizations can conduct periodic wireless surveys to understand the radio frequency profile of organizational systems as well as other systems that may be operating in the area.

Related Controls: [PE-19](#).

References: [\[SP 800-94\]](#), [\[SP 800-97\]](#).

AC-19 ACCESS CONTROL FOR MOBILE DEVICES

Control:

- a. Establish configuration requirements, connection requirements, and implementation guidance for organization-controlled mobile devices, to include when such devices are outside of controlled areas; and
- b. Authorize the connection of mobile devices to organizational systems.

Discussion: A mobile device is a 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; possesses local, non-removable or removable data storage; and includes a self-contained power source. Mobile device functionality may also include voice communication capabilities, on-board sensors that allow the device to capture information, and/or built-in features for synchronizing local data with remote locations. Examples include smart phones and tablets. Mobile devices are typically associated with a single individual. The processing, storage, and transmission capability of the mobile device may be comparable to or merely a subset of notebook/desktop systems, depending on the nature and intended purpose of the device. Protection and control of mobile devices is behavior or policy-based and requires users to take physical action to protect and control such devices when outside of controlled areas. Controlled areas are spaces for which organizations provide physical or procedural controls to meet the requirements established for protecting information and systems.

Due to the large variety of mobile devices with different characteristics and capabilities, organizational restrictions may vary for the different classes or types of such devices. Usage restrictions and specific implementation guidance for mobile devices include configuration management, device identification and authentication, implementation of mandatory protective software, scanning devices for malicious code, updating virus protection software, scanning for critical software updates and patches, conducting primary operating system (and possibly other resident software) integrity checks, and disabling unnecessary hardware.

Usage restrictions and authorization to connect may vary among organizational systems. For example, the organization may authorize the connection of mobile devices to its network and impose a set of usage restrictions, while a system owner may withhold authorization for mobile device connection to specific applications or impose additional usage restrictions before allowing mobile device connections to a system. Adequate security for mobile devices goes beyond the requirements specified in [AC-19](#). Many safeguards for mobile devices are reflected in other controls. [AC-20](#) addresses mobile devices that are not organization-controlled.

Related Controls: [AC-3](#), [AC-4](#), [AC-7](#), [AC-11](#), [AC-17](#), [AC-18](#), [AC-20](#), [CA-9](#), [CM-2](#), [CM-6](#), [IA-2](#), [IA-3](#), [MP-2](#), [MP-4](#), [MP-5](#), [MP-7](#), [PL-4](#), [SC-7](#), [SC-34](#), [SC-43](#), [SI-3](#), [SI-4](#).

Control Enhancements:

- (1) ACCESS CONTROL FOR MOBILE DEVICES | USE OF WRITABLE AND PORTABLE STORAGE DEVICES
[Withdrawn: Incorporated into [MP-7](#).]
- (2) ACCESS CONTROL FOR MOBILE DEVICES | USE OF PERSONALLY OWNED PORTABLE STORAGE DEVICES
[Withdrawn: Incorporated into [MP-7](#).]
- (3) ACCESS CONTROL FOR MOBILE DEVICES | USE OF PORTABLE STORAGE DEVICES WITH NO IDENTIFIABLE OWNER
[Withdrawn: Incorporated into [MP-7](#).]
- (4) ACCESS CONTROL FOR MOBILE DEVICES | [RESTRICTIONS FOR CLASSIFIED INFORMATION](#)
 - (a) Prohibit the use of unclassified mobile devices in facilities containing systems processing, storing, or transmitting classified information unless specifically permitted by the authorizing official; and
 - (b) Enforce the following restrictions on individuals permitted by the authorizing official to use unclassified mobile devices in facilities containing systems processing, storing, or transmitting classified information:
 - (1) Connection of unclassified mobile devices to classified systems is prohibited;
 - (2) Connection of unclassified mobile devices to unclassified systems requires approval from the authorizing official;
 - (3) Use of internal or external modems or wireless interfaces within the unclassified mobile devices is prohibited; and
 - (4) Unclassified mobile devices and the information stored on those devices are subject to random reviews and inspections by [Assignment: organization-defined security officials], and if classified information is found, the incident handling policy is followed.
 - (c) Restrict the connection of classified mobile devices to classified systems in accordance with [Assignment: organization-defined security policies].

Discussion: None.

Related Controls: [CM-8](#), [IR-4](#).

- (5) ACCESS CONTROL FOR MOBILE DEVICES | [FULL DEVICE OR CONTAINER-BASED ENCRYPTION](#)

Employ [Selection: full-device encryption; container-based encryption] to protect the confidentiality and integrity of information on [Assignment: organization-defined mobile devices].

Discussion: Container-based encryption provides a more fine-grained approach to data and information encryption on mobile devices, including encrypting selected data structures such as files, records, or fields.

Related Controls: [SC-12](#), [SC-13](#), [SC-28](#).

References: [\[SP 800-114\]](#), [\[SP 800-124\]](#).

AC-20 USE OF EXTERNAL SYSTEMS

Control:

- a. [Selection (one or more): Establish [Assignment: organization-defined terms and conditions]; Identify [Assignment: organization-defined controls asserted to be implemented on external systems]], consistent with the trust relationships established with other organizations owning, operating, and/or maintaining external systems, allowing authorized individuals to:
 1. Access the system from external systems; and
 2. Process, store, or transmit organization-controlled information using external systems; or
- b. Prohibit the use of [Assignment: organizationally-defined types of external systems].

Discussion: External systems are systems that are used by but not part of organizational systems, and for which the organization has no direct control over the implementation of required controls or the assessment of control effectiveness. External systems include personally owned systems, components, or devices; privately owned computing and communications devices in commercial or public facilities; systems owned or controlled by nonfederal organizations; systems managed by contractors; and federal information systems that are not owned by, operated by, or under the direct supervision or authority of the organization. External systems also include systems owned or operated by other components within the same organization and systems within the organization with different authorization boundaries. Organizations have the option to prohibit the use of any type of external system or prohibit the use of specified types of external systems, (e.g., prohibit the use of any external system that is not organizationally owned or prohibit the use of personally-owned systems).

For some external systems (i.e., systems operated by other organizations), the trust relationships that have been established between those organizations and the originating organization may be such that no explicit terms and conditions are required. Systems within these organizations may not be considered external. These situations occur when, for example, there are pre-existing information exchange agreements (either implicit or explicit) established between organizations or components or when such agreements are specified by applicable laws, executive orders, directives, regulations, policies, or standards. Authorized individuals include organizational personnel, contractors, or other individuals with authorized access to organizational systems and over which organizations have the authority to impose specific rules of behavior regarding system access. Restrictions that organizations impose on authorized individuals need not be uniform, as the restrictions may vary depending on trust relationships between organizations. Therefore, organizations may choose to impose different security restrictions on contractors than on state, local, or tribal governments.

External systems used to access public interfaces to organizational systems are outside the scope of [AC-20](#). Organizations establish specific terms and conditions for the use of external systems in accordance with organizational security policies and procedures. At a minimum, terms and conditions address the specific types of applications that can be accessed on organizational

systems from external systems and the highest security category of information that can be processed, stored, or transmitted on external systems. If the terms and conditions with the owners of the external systems cannot be established, organizations may impose restrictions on organizational personnel using those external systems.

Related Controls: [AC-2](#), [AC-3](#), [AC-17](#), [AC-19](#), [CA-3](#), [PL-2](#), [PL-4](#), [SA-9](#), [SC-7](#).

Control Enhancements:

(1) USE OF EXTERNAL SYSTEMS | [LIMITS ON AUTHORIZED USE](#)

Permit authorized individuals to use an external system to access the system or to process, store, or transmit organization-controlled information only after:

- (a) Verification of the implementation of controls on the external system as specified in the organization's security and privacy policies and security and privacy plans; or**
- (b) Retention of approved system connection or processing agreements with the organizational entity hosting the external system.**

Discussion: Limiting authorized use recognizes circumstances where individuals using external systems may need to access organizational systems. Organizations need assurance that the external systems contain the necessary controls so as not to compromise, damage, or otherwise harm organizational systems. Verification that the required controls have been implemented can be achieved by external, independent assessments, attestations, or other means, depending on the confidence level required by organizations.

Related Controls: [CA-2](#).

(2) USE OF EXTERNAL SYSTEMS | [PORTABLE STORAGE DEVICES — RESTRICTED USE](#)

Restrict the use of organization-controlled portable storage devices by authorized individuals on external systems using [Assignment: organization-defined restrictions].

Discussion: Limits on the use of organization-controlled portable storage devices in external systems include restrictions on how the devices may be used and under what conditions the devices may be used.

Related Controls: [MP-7](#), [SC-41](#).

(3) USE OF EXTERNAL SYSTEMS | [NON-ORGANIZATIONALLY OWNED SYSTEMS — RESTRICTED USE](#)

Restrict the use of non-organizationally owned systems or system components to process, store, or transmit organizational information using [Assignment: organization-defined restrictions].

Discussion: Non-organizationally owned systems or system components include systems or system components owned by other organizations as well as personally owned devices. There are potential risks to using non-organizationally owned systems or components. In some cases, the risk is sufficiently high as to prohibit such use (see [AC-20 b.](#)). In other cases, the use of such systems or system components may be allowed but restricted in some way. Restrictions include requiring the implementation of approved controls prior to authorizing the connection of non-organizationally owned systems and components; limiting access to types of information, services, or applications; using virtualization techniques to limit processing and storage activities to servers or system components provisioned by the organization; and agreeing to the terms and conditions for usage. Organizations consult with the Office of the General Counsel regarding legal issues associated with using personally owned devices, including requirements for conducting forensic analyses during investigations after an incident.

Related Controls: None.

(4) USE OF EXTERNAL SYSTEMS | [NETWORK ACCESSIBLE STORAGE DEVICES — PROHIBITED USE](#)

Prohibit the use of [Assignment: organization-defined network accessible storage devices] in external systems.

Discussion: Network-accessible storage devices in external systems include online storage devices in public, hybrid, or community cloud-based systems.

Related Controls: None.

(5) USE OF EXTERNAL SYSTEMS | [PORTABLE STORAGE DEVICES — PROHIBITED USE](#)

Prohibit the use of organization-controlled portable storage devices by authorized individuals on external systems.

Discussion: Limits on the use of organization-controlled portable storage devices in external systems include a complete prohibition of the use of such devices. Prohibiting such use is enforced using technical methods and/or nontechnical (i.e., process-based) methods.

Related Controls: [MP-7](#), [PL-4](#), [PS-6](#), [SC-41](#).

References: [\[FIPS 199\]](#), [\[SP 800-171\]](#), [\[SP 800-172\]](#).

[AC-21](#) INFORMATION SHARING

Control:

- a. Enable authorized users to determine whether access authorizations assigned to a sharing partner match the information's access and use restrictions for [Assignment: organization-defined information sharing circumstances where user discretion is required]; and
- b. Employ [Assignment: organization-defined automated mechanisms or manual processes] to assist users in making information sharing and collaboration decisions.

Discussion: Information sharing applies to information that may be restricted in some manner based on some formal or administrative determination. Examples of such information include, contract-sensitive information, classified information related to special access programs or compartments, privileged information, proprietary information, and personally identifiable information. Security and privacy risk assessments as well as applicable laws, regulations, and policies can provide useful inputs to these determinations. Depending on the circumstances, sharing partners may be defined at the individual, group, or organizational level. Information may be defined by content, type, security category, or special access program or compartment. Access restrictions may include non-disclosure agreements (NDA). Information flow techniques and security attributes may be used to provide automated assistance to users making sharing and collaboration decisions.

Related Controls: [AC-3](#), [AC-4](#), [AC-16](#), [PT-2](#), [PT-7](#), [RA-3](#), [SC-15](#).

Control Enhancements:

(1) INFORMATION SHARING | [AUTOMATED DECISION SUPPORT](#)

Employ [Assignment: organization-defined automated mechanisms] to enforce information-sharing decisions by authorized users based on access authorizations of sharing partners and access restrictions on information to be shared.

Discussion: Automated mechanisms are used to enforce information sharing decisions.

Related Controls: None.

(2) INFORMATION SHARING | [INFORMATION SEARCH AND RETRIEVAL](#)

Implement information search and retrieval services that enforce [Assignment: organization-defined information sharing restrictions].

Discussion: Information search and retrieval services identify information system resources relevant to an information need.

Related Controls: None.

References: [[OMB A-130](#)], [[SP 800-150](#)], [[IR 8062](#)].

AC-22 PUBLICLY ACCESSIBLE CONTENT

Control:

- a. Designate individuals authorized to make information publicly accessible;
- b. Train authorized individuals to ensure that publicly accessible information does not contain nonpublic information;
- c. Review the proposed content of information prior to posting onto the publicly accessible system to ensure that nonpublic information is not included; and
- d. Review the content on the publicly accessible system for nonpublic information
[Assignment: organization-defined frequency] and remove such information, if discovered.

Discussion: In accordance with applicable laws, executive orders, directives, policies, regulations, standards, and guidelines, the public is not authorized to have access to nonpublic information, including information protected under the [[PRIVACT](#)] and proprietary information. Publicly accessible content addresses systems that are controlled by the organization and accessible to the public, typically without identification or authentication. Posting information on non-organizational systems (e.g., non-organizational public websites, forums, and social media) is covered by organizational policy. While organizations may have individuals who are responsible for developing and implementing policies about the information that can be made publicly accessible, publicly accessible content addresses the management of the individuals who make such information publicly accessible.

Related Controls: [AC-3](#), [AT-2](#), [AT-3](#), [AU-13](#).

Control Enhancements: None.

References: [[PRIVACT](#)].

AC-23 DATA MINING PROTECTION

Control: Employ [Assignment: organization-defined data mining prevention and detection techniques] for [Assignment: organization-defined data storage objects] to detect and protect against unauthorized data mining.

Discussion: Data mining is an analytical process that attempts to find correlations or patterns in large data sets for the purpose of data or knowledge discovery. Data storage objects include database records and database fields. Sensitive information can be extracted from data mining operations. When information is personally identifiable information, it may lead to unanticipated revelations about individuals and give rise to privacy risks. Prior to performing data mining activities, organizations determine whether such activities are authorized. Organizations may be subject to applicable laws, executive orders, directives, regulations, or policies that address data mining requirements. Organizational personnel consult with the senior agency official for privacy and legal counsel regarding such requirements.

Data mining prevention and detection techniques include limiting the number and frequency of database queries to increase the work factor needed to determine the contents of databases, limiting types of responses provided to database queries, applying differential privacy techniques or homomorphic encryption, and notifying personnel when atypical database queries or accesses occur. Data mining protection focuses on protecting information from data mining while such information resides in organizational data stores. In contrast, [AU-13](#) focuses on monitoring for organizational information that may have been mined or otherwise obtained from data stores

and is available as open-source information residing on external sites, such as social networking or social media websites.

[[EO 13587](#)] requires the establishment of an insider threat program for deterring, detecting, and mitigating insider threats, including the safeguarding of sensitive information from exploitation, compromise, or other unauthorized disclosure. Data mining protection requires organizations to identify appropriate techniques to prevent and detect unnecessary or unauthorized data mining. Data mining can be used by an insider to collect organizational information for the purpose of exfiltration.

Related Controls: [PM-12](#), [PT-2](#).

Control Enhancements: None.

References: [[EO 13587](#)].

AC-24 ACCESS CONTROL DECISIONS

Control: [Selection: Establish procedures; Implement mechanisms] to ensure [Assignment: organization-defined access control decisions] are applied to each access request prior to access enforcement.

Discussion: Access control decisions (also known as authorization decisions) occur when authorization information is applied to specific accesses. In contrast, access enforcement occurs when systems enforce access control decisions. While it is common to have access control decisions and access enforcement implemented by the same entity, it is not required, and it is not always an optimal implementation choice. For some architectures and distributed systems, different entities may make access control decisions and enforce access.

Related Controls: [AC-2](#), [AC-3](#).

Control Enhancements:

(1) ACCESS CONTROL DECISIONS | [TRANSMIT ACCESS AUTHORIZATION INFORMATION](#)

Transmit [Assignment: organization-defined access authorization information] using [Assignment: organization-defined controls] to [Assignment: organization-defined systems] that enforce access control decisions.

Discussion: Authorization processes and access control decisions may occur in separate parts of systems or in separate systems. In such instances, authorization information is transmitted securely (e.g., using cryptographic mechanisms) so that timely access control decisions can be enforced at the appropriate locations. To support the access control decisions, it may be necessary to transmit as part of the access authorization information supporting security and privacy attributes. This is because in distributed systems, there are various access control decisions that need to be made, and different entities make these decisions in a serial fashion, each requiring those attributes to make the decisions. Protecting access authorization information ensures that such information cannot be altered, spoofed, or compromised during transmission.

Related Controls: [AU-10](#).

(2) ACCESS CONTROL DECISIONS | [NO USER OR PROCESS IDENTITY](#)

Enforce access control decisions based on [Assignment: organization-defined security or privacy attributes] that do not include the identity of the user or process acting on behalf of the user.

Discussion: In certain situations, it is important that access control decisions can be made without information regarding the identity of the users issuing the requests. These are generally instances where preserving individual privacy is of paramount importance. In other

situations, user identification information is simply not needed for access control decisions, and especially in the case of distributed systems, transmitting such information with the needed degree of assurance may be very expensive or difficult to accomplish. MAC, RBAC, ABAC, and label-based control policies, for example, might not include user identity as an attribute.

Related Controls: None.

References: [\[SP 800-162\]](#), [\[SP 800-178\]](#).

AC-25 REFERENCE MONITOR

Control: Implement a reference monitor for [*Assignment: organization-defined access control policies*] that is tamperproof, always invoked, and small enough to be subject to analysis and testing, the completeness of which can be assured.

Discussion: A reference monitor is a set of design requirements on a reference validation mechanism that, as a key component of an operating system, enforces an access control policy over all subjects and objects. A reference validation mechanism is always invoked, tamper-proof, and small enough to be subject to analysis and tests, the completeness of which can be assured (i.e., verifiable). Information is represented internally within systems using abstractions known as data structures. Internal data structures can represent different types of entities, both active and passive. Active entities, also known as subjects, are associated with individuals, devices, or processes acting on behalf of individuals. Passive entities, also known as objects, are associated with data structures, such as records, buffers, communications ports, tables, files, and inter-process pipes. Reference monitors enforce access control policies that restrict access to objects based on the identity of subjects or groups to which the subjects belong. The system enforces the access control policy based on the rule set established by the policy. The tamper-proof property of the reference monitor prevents determined adversaries from compromising the functioning of the reference validation mechanism. The always invoked property prevents adversaries from bypassing the mechanism and violating the security policy. The smallness property helps to ensure completeness in the analysis and testing of the mechanism to detect any weaknesses or deficiencies (i.e., latent flaws) that would prevent the enforcement of the security policy.

Related Controls: [AC-3](#), [AC-16](#), [SA-8](#), [SA-17](#), [SC-3](#), [SC-11](#), [SC-39](#), [SI-13](#).

Control Enhancements: None.

References: None.

3.2 AWARENESS AND TRAINING

[Quick link to Awareness and Training Summary Table](#)

AT-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] awareness and training policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the awareness and training policy and the associated awareness and training controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the awareness and training policy and procedures; and
- c. Review and update the current awareness and training:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Awareness and training policy and procedures address the controls in the AT family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of awareness and training policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to awareness and training policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-50\]](#), [\[SP 800-100\]](#).

AT-2 LITERACY TRAINING AND AWARENESS

Control:

- a. Provide security and privacy literacy training to system users (including managers, senior executives, and contractors):
 1. As part of initial training for new users and [Assignment: organization-defined frequency] thereafter; and
 2. When required by system changes or following [Assignment: organization-defined events];
- b. Employ the following techniques to increase the security and privacy awareness of system users [Assignment: organization-defined awareness techniques];
- c. Update literacy training and awareness content [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
- d. Incorporate lessons learned from internal or external security incidents or breaches into literacy training and awareness techniques.

Discussion: Organizations provide basic and advanced levels of literacy training to system users, including measures to test the knowledge level of users. Organizations determine the content of literacy training and awareness based on specific organizational requirements, the systems to which personnel have authorized access, and work environments (e.g., telework). The content includes an understanding of the need for security and privacy as well as actions by users to maintain security and personal privacy and to respond to suspected incidents. The content addresses the need for operations security and the handling of personally identifiable information.

Awareness techniques include displaying posters, offering supplies inscribed with security and privacy reminders, displaying logon screen messages, generating email advisories or notices from organizational officials, and conducting awareness events. Literacy training after the initial training described in [AT-2a.1](#) is conducted at a minimum frequency consistent with applicable laws, directives, regulations, and policies. Subsequent literacy training may be satisfied by one or more short ad hoc sessions and include topical information on recent attack schemes, changes to organizational security and privacy policies, revised security and privacy expectations, or a subset of topics from the initial training. Updating literacy training and awareness content on a regular basis helps to ensure that the content remains relevant. Events that may precipitate an update to literacy training and awareness content include, but are not limited to, assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: [AC-3](#), [AC-17](#), [AC-22](#), [AT-3](#), [AT-4](#), [CP-3](#), [IA-4](#), [IR-2](#), [IR-7](#), [IR-9](#), [PL-4](#), [PM-13](#), [PM-21](#), [PS-7](#), [PT-2](#), [SA-8](#), [SA-16](#).

Control Enhancements:

(1) LITERACY TRAINING AND AWARENESS | [PRACTICAL EXERCISES](#)

Provide practical exercises in literacy training that simulate events and incidents.

Discussion: Practical exercises include no-notice social engineering attempts to collect information, gain unauthorized access, or simulate the adverse impact of opening malicious email attachments or invoking, via spear phishing attacks, malicious web links.

Related Controls: [CA-2](#), [CA-7](#), [CP-4](#), [IR-3](#).

(2) LITERACY TRAINING AND AWARENESS | [INSIDER THREAT](#)

Provide literacy training on recognizing and reporting potential indicators of insider threat.

Discussion: Potential indicators and possible precursors of insider threat can include behaviors such as inordinate, long-term job dissatisfaction; attempts to gain access to information not required for job performance; unexplained access to financial resources; bullying or harassment of fellow employees; workplace violence; and other serious violations of policies, procedures, directives, regulations, rules, or practices. Literacy training includes how to communicate the concerns of employees and management regarding potential indicators of insider threat through channels established by the organization and in accordance with established policies and procedures. Organizations may consider tailoring insider threat awareness topics to the role. For example, training for managers may be focused on changes in the behavior of team members, while training for employees may be focused on more general observations.

Related Controls: [PM-12](#).

(3) LITERACY TRAINING AND AWARENESS | [SOCIAL ENGINEERING AND MINING](#)

Provide literacy training on recognizing and reporting potential and actual instances of social engineering and social mining.

Discussion: Social engineering is an attempt to trick an individual into revealing information or taking an action that can be used to breach, compromise, or otherwise adversely impact a system. Social engineering includes phishing, pretexting, impersonation, baiting, quid pro quo, thread-jacking, social media exploitation, and tailgating. Social mining is an attempt to gather information about the organization that may be used to support future attacks. Literacy training includes information on how to communicate the concerns of employees and management regarding potential and actual instances of social engineering and data mining through organizational channels based on established policies and procedures.

Related Controls: None.

(4) LITERACY TRAINING AND AWARENESS | [SUSPICIOUS COMMUNICATIONS AND ANOMALOUS SYSTEM BEHAVIOR](#)

Provide literacy training on recognizing suspicious communications and anomalous behavior in organizational systems using [Assignment: organization-defined indicators of malicious code].

Discussion: A well-trained workforce provides another organizational control that can be employed as part of a defense-in-depth strategy to protect against malicious code coming into organizations via email or the web applications. Personnel are trained to look for indications of potentially suspicious email (e.g., receiving an unexpected email, receiving an email containing strange or poor grammar, or receiving an email from an unfamiliar sender that appears to be from a known sponsor or contractor). Personnel are also trained on how to respond to suspicious email or web communications. For this process to work effectively, personnel are trained and made aware of what constitutes suspicious communications. Training personnel on how to recognize anomalous behaviors in systems can provide organizations with early warning for the presence of malicious code. Recognition of anomalous behavior by organizational personnel can supplement malicious code detection and protection tools and systems employed by organizations.

Related Controls: None.

(5) LITERACY TRAINING AND AWARENESS | [ADVANCED PERSISTENT THREAT](#)

Provide literacy training on the advanced persistent threat.

Discussion: An effective way to detect advanced persistent threats (APT) and to preclude successful attacks is to provide specific literacy training for individuals. Threat literacy training includes educating individuals on the various ways that APTs can infiltrate the organization (e.g., through websites, emails, advertisement pop-ups, articles, and social

engineering). Effective training includes techniques for recognizing suspicious emails, use of removable systems in non-secure settings, and the potential targeting of individuals at home.

Related Controls: None.

(6) LITERACY TRAINING AND AWARENESS | [CYBER THREAT ENVIRONMENT](#)

- (a) Provide literacy training on the cyber threat environment; and**
- (b) Reflect current cyber threat information in system operations.**

Discussion: Since threats continue to change over time, threat literacy training by the organization is dynamic. Moreover, threat literacy training is not performed in isolation from the system operations that support organizational mission and business functions.

Related Controls: [RA-3](#).

References: [\[OMB A-130\]](#), [\[SP 800-50\]](#), [\[SP 800-160-2\]](#), [\[SP 800-181\]](#), [\[ODNI CTF\]](#).

AT-3 ROLE-BASED TRAINING

Control:

- a. Provide role-based security and privacy training to personnel with the following roles and responsibilities: *[Assignment: organization-defined roles and responsibilities]*:
 1. Before authorizing access to the system, information, or performing assigned duties, and *[Assignment: organization-defined frequency]* thereafter; and
 2. When required by system changes;
- b. Update role-based training content *[Assignment: organization-defined frequency]* and following *[Assignment: organization-defined events]*; and
- c. Incorporate lessons learned from internal or external security incidents or breaches into role-based training.

Discussion: Organizations determine the content of training based on the assigned roles and responsibilities of individuals as well as the security and privacy requirements of organizations and the systems to which personnel have authorized access, including technical training specifically tailored for assigned duties. Roles that may require role-based training include senior leaders or management officials (e.g., head of agency/chief executive officer, chief information officer, senior accountable official for risk management, senior agency information security officer, senior agency official for privacy), system owners; authorizing officials; system security officers; privacy officers; acquisition and procurement officials; enterprise architects; systems engineers; software developers; systems security engineers; privacy engineers; system, network, and database administrators; auditors; personnel conducting configuration management activities; personnel performing verification and validation activities; personnel with access to system-level software; control assessors; personnel with contingency planning and incident response duties; personnel with privacy management responsibilities; and personnel with access to personally identifiable information.

Comprehensive role-based training addresses management, operational, and technical roles and responsibilities covering physical, personnel, and technical controls. Role-based training also includes policies, procedures, tools, methods, and artifacts for the security and privacy roles defined. Organizations provide the training necessary for individuals to fulfill their responsibilities related to operations and supply chain risk management within the context of organizational security and privacy programs. Role-based training also applies to contractors who provide services to federal agencies. Types of training include web-based and computer-based training, classroom-style training, and hands-on training (including micro-training). Updating role-based

training on a regular basis helps to ensure that the content remains relevant and effective. Events that may precipitate an update to role-based training content include, but are not limited to, assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: [AC-3](#), [AC-17](#), [AC-22](#), [AT-2](#), [AT-4](#), [CP-3](#), [IR-2](#), [IR-4](#), [IR-7](#), [IR-9](#), [PL-4](#), [PM-13](#), [PM-23](#), [PS-7](#), [PS-9](#), [SA-3](#), [SA-8](#), [SA-11](#), [SA-16](#), [SR-5](#), [SR-6](#), [SR-11](#).

Control Enhancements:

(1) ROLE-BASED TRAINING | [ENVIRONMENTAL CONTROLS](#)

Provide [Assignment: organization-defined personnel or roles] with initial and [Assignment: organization-defined frequency] training in the employment and operation of environmental controls.

Discussion: Environmental controls include fire suppression and detection devices or systems, sprinkler systems, handheld fire extinguishers, fixed fire hoses, smoke detectors, temperature or humidity, heating, ventilation, air conditioning, and power within the facility.

Related Controls: [PE-1](#), [PE-11](#), [PE-13](#), [PE-14](#), [PE-15](#).

(2) ROLE-BASED TRAINING | [PHYSICAL SECURITY CONTROLS](#)

Provide [Assignment: organization-defined personnel or roles] with initial and [Assignment: organization-defined frequency] training in the employment and operation of physical security controls.

Discussion: Physical security controls include physical access control devices, physical intrusion and detection alarms, operating procedures for facility security guards, and monitoring or surveillance equipment.

Related Controls: [PE-2](#), [PE-3](#), [PE-4](#).

(3) ROLE-BASED TRAINING | [PRACTICAL EXERCISES](#)

Provide practical exercises in security and privacy training that reinforce training objectives.

Discussion: Practical exercises for security include training for software developers that addresses simulated attacks that exploit common software vulnerabilities or spear or whale phishing attacks targeted at senior leaders or executives. Practical exercises for privacy include modules with quizzes on identifying and processing personally identifiable information in various scenarios or scenarios on conducting privacy impact assessments.

Related Controls: None.

(4) ROLE-BASED TRAINING | SUSPICIOUS COMMUNICATIONS AND ANOMALOUS SYSTEM BEHAVIOR

[Withdrawn: Moved to [AT-2\(4\)](#)].

(5) ROLE-BASED TRAINING | [PROCESSING PERSONALLY IDENTIFIABLE INFORMATION](#)

Provide [Assignment: organization-defined personnel or roles] with initial and [Assignment: organization-defined frequency] training in the employment and operation of personally identifiable information processing and transparency controls.

Discussion: Personally identifiable information processing and transparency controls include the organization's authority to process personally identifiable information and personally identifiable information processing purposes. Role-based training for federal agencies addresses the types of information that may constitute personally identifiable information and the risks, considerations, and obligations associated with its processing. Such training also considers the authority to process personally identifiable information documented in privacy policies and notices, system of records notices, computer matching agreements and

notices, privacy impact assessments, [PRIVACT] statements, contracts, information sharing agreements, memoranda of understanding, and/or other documentation.

Related Controls: [PT-2](#), [PT-3](#), [PT-5](#), [PT-6](#).

References: [\[OMB A-130\]](#), [\[SP 800-50\]](#), [\[SP 800-181\]](#).

[AT-4](#) TRAINING RECORDS

Control:

- a. Document and monitor information security and privacy training activities, including security and privacy awareness training and specific role-based security and privacy training; and
- b. Retain individual training records for *[Assignment: organization-defined time period]*.

Discussion: Documentation for specialized training may be maintained by individual supervisors at the discretion of the organization. The National Archives and Records Administration provides guidance on records retention for federal agencies.

Related Controls: [AT-2](#), [AT-3](#), [CP-3](#), [IR-2](#), [PM-14](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#).

[AT-5](#) CONTACTS WITH SECURITY GROUPS AND ASSOCIATIONS

[Withdrawn: Incorporated into [PM-15](#).]

[AT-6](#) TRAINING FEEDBACK

Control: Provide feedback on organizational training results to the following personnel
[Assignment: organization-defined frequency]: *[Assignment: organization-defined personnel]*.

Discussion: Training feedback includes awareness training results and role-based training results. Training results, especially failures of personnel in critical roles, can be indicative of a potentially serious problem. Therefore, it is important that senior managers are made aware of such situations so that they can take appropriate response actions. Training feedback supports the evaluation and update of organizational training described in [AT-2b](#) and [AT-3b](#).

Related Controls: None.

Control Enhancements: None.

References: None.

3.3 AUDIT AND ACCOUNTABILITY

[Quick link to Audit and Accountability Summary Table](#)

AU-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] audit and accountability policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the audit and accountability policy and the associated audit and accountability controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the audit and accountability policy and procedures; and
- c. Review and update the current audit and accountability:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Audit and accountability policy and procedures address the controls in the AU family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of audit and accountability policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to audit and accountability policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

AU-2 EVENT LOGGING

Control:

- a. Identify the types of events that the system is capable of logging in support of the audit function: [Assignment: organization-defined event types that the system is capable of logging];
- b. Coordinate the event logging function with other organizational entities requiring audit-related information to guide and inform the selection criteria for events to be logged;
- c. Specify the following event types for logging within the system: [Assignment: organization-defined event types (subset of the event types defined in AU-2a.) along with the frequency of (or situation requiring) logging for each identified event type];
- d. Provide a rationale for why the event types selected for logging are deemed to be adequate to support after-the-fact investigations of incidents; and
- e. Review and update the event types selected for logging [Assignment: organization-defined frequency].

Discussion: An event is an observable occurrence in a system. The types of events that require logging are those events that are significant and relevant to the security of systems and the privacy of individuals. Event logging also supports specific monitoring and auditing needs. Event types include password changes, failed logons or failed accesses related to systems, security or privacy attribute changes, administrative privilege usage, PIV credential usage, data action changes, query parameters, or external credential usage. In determining the set of event types that require logging, organizations consider the monitoring and auditing appropriate for each of the controls to be implemented. For completeness, event logging includes all protocols that are operational and supported by the system.

To balance monitoring and auditing requirements with other system needs, event logging requires identifying the subset of event types that are logged at a given point in time. For example, organizations may determine that systems need the capability to log every file access successful and unsuccessful, but not activate that capability except for specific circumstances due to the potential burden on system performance. The types of events that organizations desire to be logged may change. Reviewing and updating the set of logged events is necessary to help ensure that the events remain relevant and continue to support the needs of the organization. Organizations consider how the types of logging events can reveal information about individuals that may give rise to privacy risk and how best to mitigate such risks. For example, there is the potential to reveal personally identifiable information in the audit trail, especially if the logging event is based on patterns or time of usage.

Event logging requirements, including the need to log specific event types, may be referenced in other controls and control enhancements. These include [AC-2\(4\)](#), [AC-3\(10\)](#), [AC-6\(9\)](#), [AC-17\(1\)](#), [CM-3f](#), [CM-5\(1\)](#), [IA-3\(3.b\)](#), [MA-4\(1\)](#), [MP-4\(2\)](#), [PE-3](#), [PM-21](#), [PT-7](#), [RA-8](#), [SC-7\(9\)](#), [SC-7\(15\)](#), [SI-3\(8\)](#), [SI-4\(22\)](#), [SI-7\(8\)](#), and [SI-10\(1\)](#). Organizations include event types that are required by applicable laws, executive orders, directives, policies, regulations, standards, and guidelines. Audit records can be generated at various levels, including at the packet level as information traverses the network. Selecting the appropriate level of event logging is an important part of a monitoring and auditing capability and can identify the root causes of problems. When defining event types, organizations consider the logging necessary to cover related event types, such as the steps in distributed, transaction-based processes and the actions that occur in service-oriented architectures.

Related Controls: [AC-2](#), [AC-3](#), [AC-6](#), [AC-7](#), [AC-8](#), [AC-16](#), [AC-17](#), [AU-3](#), [AU-4](#), [AU-5](#), [AU-6](#), [AU-7](#), [AU-11](#), [AU-12](#), [CM-3](#), [CM-5](#), [CM-6](#), [CM-13](#), [IA-3](#), [MA-4](#), [MP-4](#), [PE-3](#), [PM-21](#), [PT-2](#), [PT-7](#), [RA-8](#), [SA-8](#), [SC-7](#), [SC-18](#), [SI-3](#), [SI-4](#), [SI-7](#), [SI-10](#), [SI-11](#).

Control Enhancements:

- (1) EVENT LOGGING | COMPILED AUDIT RECORDS FROM MULTIPLE SOURCES
[Withdrawn: Incorporated into [AU-12](#).]
- (2) EVENT LOGGING | SELECTION OF AUDIT EVENTS BY COMPONENT
[Withdrawn: Incorporated into [AU-12](#).]
- (3) EVENT LOGGING | REVIEWS AND UPDATES
[Withdrawn: Incorporated into [AU-2](#).]
- (4) EVENT LOGGING | PRIVILEGED FUNCTIONS
[Withdrawn: Incorporated into [AC-6\(9\)](#).]

References: [\[OMB A-130\]](#), [\[SP 800-92\]](#).

AU-3 CONTENT OF AUDIT RECORDS

Control: Ensure that audit records contain information that establishes the following:

- a. What type of event occurred;
- b. When the event occurred;
- c. Where the event occurred;
- d. Source of the event;
- e. Outcome of the event; and
- f. Identity of any individuals, subjects, or objects/entities associated with the event.

Discussion: Audit record content that may be necessary to support the auditing function includes event descriptions (item a), time stamps (item b), source and destination addresses (item c), user or process identifiers (items d and f), success or fail indications (item e), and filenames involved (items a, c, e, and f). Event outcomes include indicators of event success or failure and event-specific results, such as the system security and privacy posture after the event occurred. Organizations consider how audit records can reveal information about individuals that may give rise to privacy risks and how best to mitigate such risks. For example, there is the potential to reveal personally identifiable information in the audit trail, especially if the trail records inputs or is based on patterns or time of usage.

Related Controls: [AU-2](#), [AU-8](#), [AU-12](#), [AU-14](#), [MA-4](#), [PL-9](#), [SA-8](#), [SI-7](#), [SI-11](#).

Control Enhancements:

- (1) CONTENT OF AUDIT RECORDS | [ADDITIONAL AUDIT INFORMATION](#)

Generate audit records containing the following additional information: [Assignment: organization-defined additional information].

Discussion: The ability to add information generated in audit records is dependent on system functionality to configure the audit record content. Organizations may consider additional information in audit records including, but not limited to, access control or flow control rules invoked and individual identities of group account users. Organizations may also consider limiting additional audit record information to only information that is explicitly needed for audit requirements. This facilitates the use of audit trails and audit logs by not including information in audit records that could potentially be misleading, make it more difficult to locate information of interest, or increase the risk to individuals' privacy.

Related Controls: None.

- (2) CONTENT OF AUDIT RECORDS | CENTRALIZED MANAGEMENT OF PLANNED AUDIT RECORD CONTENT
[Withdrawn: Incorporated into [PL-9](#).]

- (3) CONTENT OF AUDIT RECORDS | [LIMIT PERSONALLY IDENTIFIABLE INFORMATION ELEMENTS](#)

Limit personally identifiable information contained in audit records to the following elements identified in the privacy risk assessment: [Assignment: organization-defined elements].

Discussion: Limiting personally identifiable information in audit records when such information is not needed for operational purposes helps reduce the level of privacy risk created by a system.

Related Controls: [RA-3](#).

References: [\[OMB A-130\]](#), [\[IR 8062\]](#).

AU-4 AUDIT LOG STORAGE CAPACITY

Control: Allocate audit log storage capacity to accommodate [Assignment: organization-defined audit log retention requirements].

Discussion: Organizations consider the types of audit logging to be performed and the audit log processing requirements when allocating audit log storage capacity. Allocating sufficient audit log storage capacity reduces the likelihood of such capacity being exceeded and resulting in the potential loss or reduction of audit logging capability.

Related Controls: [AU-2](#), [AU-5](#), [AU-6](#), [AU-7](#), [AU-9](#), [AU-11](#), [AU-12](#), [AU-14](#), [SI-4](#).

Control Enhancements:

- (1) AUDIT LOG STORAGE CAPACITY | [TRANSFER TO ALTERNATE STORAGE](#)

Transfer audit logs [Assignment: organization-defined frequency] to a different system, system component, or media other than the system or system component conducting the logging.

Discussion: Audit log transfer, also known as off-loading, is a common process in systems with limited audit log storage capacity and thus supports availability of the audit logs. The initial audit log storage is only used in a transitory fashion until the system can communicate with the secondary or alternate system allocated to audit log storage, at which point the audit logs are transferred. Transferring audit logs to alternate storage is similar to [AU-9\(2\)](#) in that audit logs are transferred to a different entity. However, the purpose of selecting [AU-9\(2\)](#) is to protect the confidentiality and integrity of audit records. Organizations can select either control enhancement to obtain the benefit of increased audit log storage capacity and preserving the confidentiality, integrity, and availability of audit records and logs.

Related Controls: None.

References: None.

AU-5 RESPONSE TO AUDIT LOGGING PROCESS FAILURES

Control:

- a. Alert [Assignment: organization-defined personnel or roles] within [Assignment: organization-defined time period] in the event of an audit logging process failure; and
- b. Take the following additional actions: [Assignment: organization-defined additional actions].

Discussion: Audit logging process failures include software and hardware errors, failures in audit log capturing mechanisms, and reaching or exceeding audit log storage capacity. Organization-defined actions include overwriting oldest audit records, shutting down the system, and stopping

the generation of audit records. Organizations may choose to define additional actions for audit logging process failures based on the type of failure, the location of the failure, the severity of the failure, or a combination of such factors. When the audit logging process failure is related to storage, the response is carried out for the audit log storage repository (i.e., the distinct system component where the audit logs are stored), the system on which the audit logs reside, the total audit log storage capacity of the organization (i.e., all audit log storage repositories combined), or all three. Organizations may decide to take no additional actions after alerting designated roles or personnel.

Related Controls: [AU-2](#), [AU-4](#), [AU-7](#), [AU-9](#), [AU-11](#), [AU-12](#), [AU-14](#), [SI-4](#), [SI-12](#).

Control Enhancements:

(1) RESPONSE TO AUDIT LOGGING PROCESS FAILURES | [STORAGE CAPACITY WARNING](#)

Provide a warning to [Assignment: organization-defined personnel, roles, and/or locations] within [Assignment: organization-defined time period] when allocated audit log storage volume reaches [Assignment: organization-defined percentage] of repository maximum audit log storage capacity.

Discussion: Organizations may have multiple audit log storage repositories distributed across multiple system components with each repository having different storage volume capacities.

Related Controls: None.

(2) RESPONSE TO AUDIT LOGGING PROCESS FAILURES | [REAL-TIME ALERTS](#)

Provide an alert within [Assignment: organization-defined real-time period] to [Assignment: organization-defined personnel, roles, and/or locations] when the following audit failure events occur: [Assignment: organization-defined audit logging failure events requiring real-time alerts].

Discussion: Alerts provide organizations with urgent messages. Real-time alerts provide these messages at information technology speed (i.e., the time from event detection to alert occurs in seconds or less).

Related Controls: None.

(3) RESPONSE TO AUDIT LOGGING PROCESS FAILURES | [CONFIGURABLE TRAFFIC VOLUME THRESHOLDS](#)

Enforce configurable network communications traffic volume thresholds reflecting limits on audit log storage capacity and [Selection: reject; delay] network traffic above those thresholds.

Discussion: Organizations have the capability to reject or delay the processing of network communications traffic if audit logging information about such traffic is determined to exceed the storage capacity of the system audit logging function. The rejection or delay response is triggered by the established organizational traffic volume thresholds that can be adjusted based on changes to audit log storage capacity.

Related Controls: None.

(4) RESPONSE TO AUDIT LOGGING PROCESS FAILURES | [SHUTDOWN ON FAILURE](#)

Invoke a [Selection: full system shutdown; partial system shutdown; degraded operational mode with limited mission or business functionality available] in the event of [Assignment: organization-defined audit logging failures], unless an alternate audit logging capability exists.

Discussion: Organizations determine the types of audit logging failures that can trigger automatic system shutdowns or degraded operations. Because of the importance of ensuring mission and business continuity, organizations may determine that the nature of the audit logging failure is not so severe that it warrants a complete shutdown of the system

supporting the core organizational mission and business functions. In those instances, partial system shutdowns or operating in a degraded mode with reduced capability may be viable alternatives.

Related Controls: [AU-15](#).

(5) RESPONSE TO AUDIT LOGGING PROCESS FAILURES | [ALTERNATE AUDIT LOGGING CAPABILITY](#)

Provide an alternate audit logging capability in the event of a failure in primary audit logging capability that implements [Assignment: organization-defined alternate audit logging functionality].

Discussion: Since an alternate audit logging capability may be a short-term protection solution employed until the failure in the primary audit logging capability is corrected, organizations may determine that the alternate audit logging capability need only provide a subset of the primary audit logging functionality that is impacted by the failure.

Related Controls: [AU-9](#).

References: None.

[AU-6 AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING](#)

Control:

- a. Review and analyze system audit records [Assignment: organization-defined frequency] for indications of [Assignment: organization-defined inappropriate or unusual activity] and the potential impact of the inappropriate or unusual activity;
- b. Report findings to [Assignment: organization-defined personnel or roles]; and
- c. Adjust the level of audit record review, analysis, and reporting within the system when there is a change in risk based on law enforcement information, intelligence information, or other credible sources of information.

Discussion: Audit record review, analysis, and reporting covers information security- and privacy-related logging performed by organizations, including logging that results from the monitoring of account usage, remote access, wireless connectivity, mobile device connection, configuration settings, system component inventory, use of maintenance tools and non-local maintenance, physical access, temperature and humidity, equipment delivery and removal, communications at system interfaces, and use of mobile code or Voice over Internet Protocol (VoIP). Findings can be reported to organizational entities that include the incident response team, help desk, and security or privacy offices. If organizations are prohibited from reviewing and analyzing audit records or unable to conduct such activities, the review or analysis may be carried out by other organizations granted such authority. The frequency, scope, and/or depth of the audit record review, analysis, and reporting may be adjusted to meet organizational needs based on new information received.

Related Controls: [AC-2](#), [AC-3](#), [AC-5](#), [AC-6](#), [AC-7](#), [AC-17](#), [AU-7](#), [AU-16](#), [CA-2](#), [CA-7](#), [CM-2](#), [CM-5](#), [CM-6](#), [CM-10](#), [CM-11](#), [IA-2](#), [IA-3](#), [IA-5](#), [IA-8](#), [IR-5](#), [MA-4](#), [MP-4](#), [PE-3](#), [PE-6](#), [RA-5](#), [SA-8](#), [SC-7](#), [SI-3](#), [SI-4](#), [SI-7](#).

Control Enhancements:

(1) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [AUTOMATED PROCESS INTEGRATION](#)

Integrate audit record review, analysis, and reporting processes using [Assignment: organization-defined automated mechanisms].

Discussion: Organizational processes that benefit from integrated audit record review, analysis, and reporting include incident response, continuous monitoring, contingency planning, investigation and response to suspicious activities, and Inspector General audits.

Related Controls: [PM-7](#).

- (2) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | AUTOMATED SECURITY ALERTS
[Withdrawn: Incorporated into [SI-4](#).]
- (3) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [CORRELATE AUDIT RECORD REPOSITORIES](#)
Analyze and correlate audit records across different repositories to gain organization-wide situational awareness.
Discussion: Organization-wide situational awareness includes awareness across all three levels of risk management (i.e., organizational level, mission/business process level, and information system level) and supports cross-organization awareness.
Related Controls: [AU-12](#), [IR-4](#).
- (4) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [CENTRAL REVIEW AND ANALYSIS](#)
Provide and implement the capability to centrally review and analyze audit records from multiple components within the system.
Discussion: Automated mechanisms for centralized reviews and analyses include Security Information and Event Management products.
Related Controls: [AU-2](#), [AU-12](#).
- (5) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [INTEGRATED ANALYSIS OF AUDIT RECORDS](#)
Integrate analysis of audit records with analysis of [Selection (one or more): vulnerability scanning information; performance data; system monitoring information; [Assignment: organization-defined data/information collected from other sources]] to further enhance the ability to identify inappropriate or unusual activity.
Discussion: Integrated analysis of audit records does not require vulnerability scanning, the generation of performance data, or system monitoring. Rather, integrated analysis requires that the analysis of information generated by scanning, monitoring, or other data collection activities is integrated with the analysis of audit record information. Security Information and Event Management tools can facilitate audit record aggregation or consolidation from multiple system components as well as audit record correlation and analysis. The use of standardized audit record analysis scripts developed by organizations (with localized script adjustments, as necessary) provides more cost-effective approaches for analyzing audit record information collected. The correlation of audit record information with vulnerability scanning information is important in determining the veracity of vulnerability scans of the system and in correlating attack detection events with scanning results. Correlation with performance data can uncover denial-of-service attacks or other types of attacks that result in the unauthorized use of resources. Correlation with system monitoring information can assist in uncovering attacks and in better relating audit information to operational situations.
Related Controls: [AU-12](#), [IR-4](#).
- (6) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [CORRELATION WITH PHYSICAL MONITORING](#)
Correlate information from audit records with information obtained from monitoring physical access to further enhance the ability to identify suspicious, inappropriate, unusual, or malevolent activity.
Discussion: The correlation of physical audit record information and the audit records from systems may assist organizations in identifying suspicious behavior or supporting evidence of such behavior. For example, the correlation of an individual's identity for logical access to certain systems with the additional physical security information that the individual was present at the facility when the logical access occurred may be useful in investigations.
Related Controls: None.

(7) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [PERMITTED ACTIONS](#)

Specify the permitted actions for each [Selection (one or more): system process; role; user] associated with the review, analysis, and reporting of audit record information.

Discussion: Organizations specify permitted actions for system processes, roles, and users associated with the review, analysis, and reporting of audit records through system account management activities. Specifying permitted actions on audit record information is a way to enforce the principle of least privilege. Permitted actions are enforced by the system and include read, write, execute, append, and delete.

Related Controls: None.

(8) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [FULL TEXT ANALYSIS OF PRIVILEGED COMMANDS](#)

Perform a full text analysis of logged privileged commands in a physically distinct component or subsystem of the system, or other system that is dedicated to that analysis.

Discussion: Full text analysis of privileged commands requires a distinct environment for the analysis of audit record information related to privileged users without compromising such information on the system where the users have elevated privileges, including the capability to execute privileged commands. Full text analysis refers to analysis that considers the full text of privileged commands (i.e., commands and parameters) as opposed to analysis that considers only the name of the command. Full text analysis includes the use of pattern matching and heuristics.

Related Controls: [AU-3](#), [AU-9](#), [AU-11](#), [AU-12](#).

(9) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | [CORRELATION WITH INFORMATION FROM NONTECHNICAL SOURCES](#)

Correlate information from nontechnical sources with audit record information to enhance organization-wide situational awareness.

Discussion: Nontechnical sources include records that document organizational policy violations related to harassment incidents and the improper use of information assets. Such information can lead to a directed analytical effort to detect potential malicious insider activity. Organizations limit access to information that is available from nontechnical sources due to its sensitive nature. Limited access minimizes the potential for inadvertent release of privacy-related information to individuals who do not have a need to know. The correlation of information from nontechnical sources with audit record information generally occurs only when individuals are suspected of being involved in an incident. Organizations obtain legal advice prior to initiating such actions.

Related Controls: [PM-12](#).

(10) AUDIT RECORD REVIEW, ANALYSIS, AND REPORTING | AUDIT LEVEL ADJUSTMENT

[Withdrawn: Incorporated into [AU-6](#).]

References: [\[SP 800-86\]](#), [\[SP 800-101\]](#).

AU-7 AUDIT RECORD REDUCTION AND REPORT GENERATION

Control: Provide and implement an audit record reduction and report generation capability that:

- a. Supports on-demand audit record review, analysis, and reporting requirements and after-the-fact investigations of incidents; and
- b. Does not alter the original content or time ordering of audit records.

Discussion: Audit record reduction is a process that manipulates collected audit log information and organizes it into a summary format that is more meaningful to analysts. Audit record

reduction and report generation capabilities do not always emanate from the same system or from the same organizational entities that conduct audit logging activities. The audit record reduction capability includes modern data mining techniques with advanced data filters to identify anomalous behavior in audit records. The report generation capability provided by the system can generate customizable reports. Time ordering of audit records can be an issue if the granularity of the timestamp in the record is insufficient.

Related Controls: [AC-2](#), [AU-2](#), [AU-3](#), [AU-4](#), [AU-5](#), [AU-6](#), [AU-12](#), [AU-16](#), [CM-5](#), [IA-5](#), [IR-4](#), [PM-12](#), [SI-4](#).

Control Enhancements:

(1) AUDIT RECORD REDUCTION AND REPORT GENERATION | [AUTOMATIC PROCESSING](#)

Provide and implement the capability to process, sort, and search audit records for events of interest based on the following content: [Assignment: organization-defined fields within audit records].

Discussion: Events of interest can be identified by the content of audit records, including system resources involved, information objects accessed, identities of individuals, event types, event locations, event dates and times, Internet Protocol addresses involved, or event success or failure. Organizations may define event criteria to any degree of granularity required, such as locations selectable by a general networking location or by specific system component.

Related Controls: None.

(2) AUDIT RECORD REDUCTION AND REPORT GENERATION | AUTOMATIC SORT AND SEARCH

[Withdrawn: Incorporated into [AU-7\(1\)](#).]

References: None.

AU-8 TIME STAMPS

Control:

- a. Use internal system clocks to generate time stamps for audit records; and
- b. Record time stamps for audit records that meet [Assignment: organization-defined granularity of time measurement] and that use Coordinated Universal Time, have a fixed local time offset from Coordinated Universal Time, or that include the local time offset as part of the time stamp.

Discussion: Time stamps generated by the system include date and time. Time is commonly expressed in Coordinated Universal Time (UTC), a modern continuation of Greenwich Mean Time (GMT), or local time with an offset from UTC. Granularity of time measurements refers to the degree of synchronization between system clocks and reference clocks (e.g., clocks synchronizing within hundreds of milliseconds or tens of milliseconds). Organizations may define different time granularities for different system components. Time service can be critical to other security capabilities such as access control and identification and authentication, depending on the nature of the mechanisms used to support those capabilities.

Related Controls: [AU-3](#), [AU-12](#), [AU-14](#), [SC-45](#).

Control Enhancements:

(1) TIME STAMPS | SYNCHRONIZATION WITH AUTHORITATIVE TIME SOURCE

[Withdrawn: Moved to [SC-45\(1\)](#).]

(2) TIME STAMPS | SECONDARY AUTHORITATIVE TIME SOURCE

[Withdrawn: Moved to [SC-45\(2\)](#).]

References: None.

AU-9 PROTECTION OF AUDIT INFORMATION

Control:

- a. Protect audit information and audit logging tools from unauthorized access, modification, and deletion; and
- b. Alert [Assignment: organization-defined personnel or roles] upon detection of unauthorized access, modification, or deletion of audit information.

Discussion: Audit information includes all information needed to successfully audit system activity, such as audit records, audit log settings, audit reports, and personally identifiable information. Audit logging tools are those programs and devices used to conduct system audit and logging activities. Protection of audit information focuses on technical protection and limits the ability to access and execute audit logging tools to authorized individuals. Physical protection of audit information is addressed by both media protection controls and physical and environmental protection controls.

Related Controls: [AC-3](#), [AC-6](#), [AU-6](#), [AU-11](#), [AU-14](#), [AU-15](#), [MP-2](#), [MP-4](#), [PE-2](#), [PE-3](#), [PE-6](#), [SA-8](#), [SC-8](#), [SI-4](#).

Control Enhancements:

(1) PROTECTION OF AUDIT INFORMATION | [HARDWARE WRITE-ONCE MEDIA](#)

Write audit trails to hardware-enforced, write-once media.

Discussion: Writing audit trails to hardware-enforced, write-once media applies to the initial generation of audit trails (i.e., the collection of audit records that represents the information to be used for detection, analysis, and reporting purposes) and to the backup of those audit trails. Writing audit trails to hardware-enforced, write-once media does not apply to the initial generation of audit records prior to being written to an audit trail. Write-once, read-many (WORM) media includes Compact Disc-Recordable (CD-R), Blu-Ray Disc Recordable (BD-R), and Digital Versatile Disc-Recordable (DVD-R). In contrast, the use of switchable write-protection media, such as tape cartridges, Universal Serial Bus (USB) drives, Compact Disc Re-Writeable (CD-RW), and Digital Versatile Disc-Read Write (DVD-RW) results in write-protected but not write-once media.

Related Controls: [AU-4](#), [AU-5](#).

(2) PROTECTION OF AUDIT INFORMATION | [STORE ON SEPARATE PHYSICAL SYSTEMS OR COMPONENTS](#)

Store audit records [Assignment: organization-defined frequency] in a repository that is part of a physically different system or system component than the system or component being audited.

Discussion: Storing audit records in a repository separate from the audited system or system component helps to ensure that a compromise of the system being audited does not also result in a compromise of the audit records. Storing audit records on separate physical systems or components also preserves the confidentiality and integrity of audit records and facilitates the management of audit records as an organization-wide activity. Storing audit records on separate systems or components applies to initial generation as well as backup or long-term storage of audit records.

Related Controls: [AU-4](#), [AU-5](#).

(3) PROTECTION OF AUDIT INFORMATION | [CRYPTOGRAPHIC PROTECTION](#)

Implement cryptographic mechanisms to protect the integrity of audit information and audit tools.

Discussion: Cryptographic mechanisms used for protecting the integrity of audit information include signed hash functions using asymmetric cryptography. This enables the distribution of the public key to verify the hash information while maintaining the confidentiality of the secret key used to generate the hash.

Related Controls: [AU-10](#), [SC-12](#), [SC-13](#).

(4) PROTECTION OF AUDIT INFORMATION | [ACCESS BY SUBSET OF PRIVILEGED USERS](#)

Authorize access to management of audit logging functionality to only [Assignment: organization-defined subset of privileged users or roles].

Discussion: Individuals or roles with privileged access to a system and who are also the subject of an audit by that system may affect the reliability of the audit information by inhibiting audit activities or modifying audit records. Requiring privileged access to be further defined between audit-related privileges and other privileges limits the number of users or roles with audit-related privileges.

Related Controls: [AC-5](#).

(5) PROTECTION OF AUDIT INFORMATION | [DUAL AUTHORIZATION](#)

Enforce dual authorization for [Selection (one or more): movement; deletion] of [Assignment: organization-defined audit information].

Discussion: Organizations may choose different selection options for different types of audit information. Dual authorization mechanisms (also known as two-person control) require the approval of two authorized individuals to execute audit functions. To reduce the risk of collusion, organizations consider rotating dual authorization duties to other individuals. Organizations do not require dual authorization mechanisms when immediate responses are necessary to ensure public and environmental safety.

Related Controls: [AC-3](#).

(6) PROTECTION OF AUDIT INFORMATION | [READ-ONLY ACCESS](#)

Authorize read-only access to audit information to [Assignment: organization-defined subset of privileged users or roles].

Discussion: Restricting privileged user or role authorizations to read-only helps to limit the potential damage to organizations that could be initiated by such users or roles, such as deleting audit records to cover up malicious activity.

Related Controls: None.

(7) PROTECTION OF AUDIT INFORMATION | [STORE ON COMPONENT WITH DIFFERENT OPERATING SYSTEM](#)

Store audit information on a component running a different operating system than the system or component being audited.

Discussion: Storing auditing information on a system component running a different operating system reduces the risk of a vulnerability specific to the system, resulting in a compromise of the audit records.

Related controls: [AU-4](#), [AU-5](#), [AU-11](#), [SC-29](#).

References: [\[FIPS 140-3\]](#), [\[FIPS 180-4\]](#), [\[FIPS 202\]](#).

AU-10 NON-REPUDIATION

Control: Provide irrefutable evidence that an individual (or process acting on behalf of an individual) has performed [Assignment: organization-defined actions to be covered by non-repudiation].

Discussion: Types of individual actions covered by non-repudiation include creating information, sending and receiving messages, and approving information. Non-repudiation protects against claims by authors of not having authored certain documents, senders of not having transmitted messages, receivers of not having received messages, and signatories of not having signed documents. Non-repudiation services can be used to determine if information originated from an individual or if an individual took specific actions (e.g., sending an email, signing a contract, approving a procurement request, or receiving specific information). Organizations obtain non-repudiation services by employing various techniques or mechanisms, including digital signatures and digital message receipts.

Related Controls: [AU-9](#), [PM-12](#), [SA-8](#), [SC-8](#), [SC-12](#), [SC-13](#), [SC-16](#), [SC-17](#), [SC-23](#).

Control Enhancements:

(1) NON-REPUDIATION | [ASSOCIATION OF IDENTITIES](#)

- (a) Bind the identity of the information producer with the information to [Assignment: organization-defined strength of binding]; and**
- (b) Provide the means for authorized individuals to determine the identity of the producer of the information.**

Discussion: Binding identities to the information supports audit requirements that provide organizational personnel with the means to identify who produced specific information in the event of an information transfer. Organizations determine and approve the strength of attribute binding between the information producer and the information based on the security category of the information and other relevant risk factors.

Related Controls: [AC-4](#), [AC-16](#).

(2) NON-REPUDIATION | [VALIDATE BINDING OF INFORMATION PRODUCER IDENTITY](#)

- (a) Validate the binding of the information producer identity to the information at [Assignment: organization-defined frequency]; and**
- (b) Perform [Assignment: organization-defined actions] in the event of a validation error.**

Discussion: Validating the binding of the information producer identity to the information prevents the modification of information between production and review. The validation of bindings can be achieved by, for example, using cryptographic checksums. Organizations determine if validations are in response to user requests or generated automatically.

Related Controls: [AC-3](#), [AC-4](#), [AC-16](#).

(3) NON-REPUDIATION | [CHAIN OF CUSTODY](#)

Maintain reviewer or releaser credentials within the established chain of custody for information reviewed or released.

Discussion: Chain of custody is a process that tracks the movement of evidence through its collection, safeguarding, and analysis life cycle by documenting each individual who handled the evidence, the date and time the evidence was collected or transferred, and the purpose for the transfer. If the reviewer is a human or if the review function is automated but separate from the release or transfer function, the system associates the identity of the reviewer of the information to be released with the information and the information label. In the case of human reviews, maintaining the credentials of reviewers or releasers provides

the organization with the means to identify who reviewed and released the information. In the case of automated reviews, it ensures that only approved review functions are used.

Related Controls: [AC-4](#), [AC-16](#).

(4) NON-REPUDIATION | [VALIDATE BINDING OF INFORMATION REVIEWER IDENTITY](#)

(a) Validate the binding of the information reviewer identity to the information at the transfer or release points prior to release or transfer between [Assignment: organization-defined security domains]; and

(b) Perform [Assignment: organization-defined actions] in the event of a validation error.

Discussion: Validating the binding of the information reviewer identity to the information at transfer or release points prevents the unauthorized modification of information between review and the transfer or release. The validation of bindings can be achieved by using cryptographic checksums. Organizations determine if validations are in response to user requests or generated automatically.

Related Controls: [AC-4](#), [AC-16](#).

(5) NON-REPUDIATION | DIGITAL SIGNATURES

[Withdrawn: Incorporated into [SI-7](#).]

References: [\[FIPS 140-3\]](#), [\[FIPS 180-4\]](#), [\[FIPS 186-4\]](#), [\[FIPS 202\]](#), [\[SP 800-177\]](#).

AU-11 AUDIT RECORD RETENTION

Control: Retain audit records for [Assignment: organization-defined time period consistent with records retention policy] to provide support for after-the-fact investigations of incidents and to meet regulatory and organizational information retention requirements.

Discussion: Organizations retain audit records until it is determined that the records are no longer needed for administrative, legal, audit, or other operational purposes. This includes the retention and availability of audit records relative to Freedom of Information Act (FOIA) requests, subpoenas, and law enforcement actions. Organizations develop standard categories of audit records relative to such types of actions and standard response processes for each type of action. The National Archives and Records Administration (NARA) General Records Schedules provide federal policy on records retention.

Related Controls: [AU-2](#), [AU-4](#), [AU-5](#), [AU-6](#), [AU-9](#), [AU-14](#), [MP-6](#), [RA-5](#), [SI-12](#).

Control Enhancements:

(1) AUDIT RECORD RETENTION | [LONG-TERM RETRIEVAL CAPABILITY](#)

Employ [Assignment: organization-defined measures] to ensure that long-term audit records generated by the system can be retrieved.

Discussion: Organizations need to access and read audit records requiring long-term storage (on the order of years). Measures employed to help facilitate the retrieval of audit records include converting records to newer formats, retaining equipment capable of reading the records, and retaining the necessary documentation to help personnel understand how to interpret the records.

Related Controls: None.

References: [\[OMB A-130\]](#).

AU-12 AUDIT RECORD GENERATION

Control:

- a. Provide audit record generation capability for the event types the system is capable of auditing as defined in [AU-2a](#) on [Assignment: organization-defined system components];
- b. Allow [Assignment: organization-defined personnel or roles] to select the event types that are to be logged by specific components of the system; and
- c. Generate audit records for the event types defined in [AU-2c](#) that include the audit record content defined in [AU-3](#).

Discussion: Audit records can be generated from many different system components. The event types specified in [AU-2d](#) are the event types for which audit logs are to be generated and are a subset of all event types for which the system can generate audit records.

Related Controls: [AC-6](#), [AC-17](#), [AU-2](#), [AU-3](#), [AU-4](#), [AU-5](#), [AU-6](#), [AU-7](#), [AU-14](#), [CM-5](#), [MA-4](#), [MP-4](#), [PM-12](#), [SA-8](#), [SC-18](#), [SI-3](#), [SI-4](#), [SI-7](#), [SI-10](#).

Control Enhancements:

(1) AUDIT RECORD GENERATION | [SYSTEM-WIDE AND TIME-CORRELATED AUDIT TRAIL](#)

Compile audit records from [Assignment: organization-defined system components] into a system-wide (logical or physical) audit trail that is time-correlated to within [Assignment: organization-defined level of tolerance for the relationship between time stamps of individual records in the audit trail].

Discussion: Audit trails are time-correlated if the time stamps in the individual audit records can be reliably related to the time stamps in other audit records to achieve a time ordering of the records within organizational tolerances.

Related Controls: [AU-8](#), [SC-45](#).

(2) AUDIT RECORD GENERATION | [STANDARDIZED FORMATS](#)

Produce a system-wide (logical or physical) audit trail composed of audit records in a standardized format.

Discussion: Audit records that follow common standards promote interoperability and information exchange between devices and systems. Promoting interoperability and information exchange facilitates the production of event information that can be readily analyzed and correlated. If logging mechanisms do not conform to standardized formats, systems may convert individual audit records into standardized formats when compiling system-wide audit trails.

Related Controls: None.

(3) AUDIT RECORD GENERATION | [CHANGES BY AUTHORIZED INDIVIDUALS](#)

Provide and implement the capability for [Assignment: organization-defined individuals or roles] to change the logging to be performed on [Assignment: organization-defined system components] based on [Assignment: organization-defined selectable event criteria] within [Assignment: organization-defined time thresholds].

Discussion: Permitting authorized individuals to make changes to system logging enables organizations to extend or limit logging as necessary to meet organizational requirements. Logging that is limited to conserve system resources may be extended (either temporarily or permanently) to address certain threat situations. In addition, logging may be limited to a specific set of event types to facilitate audit reduction, analysis, and reporting. Organizations can establish time thresholds in which logging actions are changed (e.g., near real-time, within minutes, or within hours).

Related Controls: [AC-3](#).

(4) AUDIT RECORD GENERATION | [QUERY PARAMETER AUDITS OF PERSONALLY IDENTIFIABLE INFORMATION](#)

Provide and implement the capability for auditing the parameters of user query events for data sets containing personally identifiable information.

Discussion: Query parameters are explicit criteria that an individual or automated system submits to a system to retrieve data. Auditing of query parameters for datasets that contain personally identifiable information augments the capability of an organization to track and understand the access, usage, or sharing of personally identifiable information by authorized personnel.

Related Controls: None.

References: None.

AU-13 MONITORING FOR INFORMATION DISCLOSURE

Control:

- a. Monitor [Assignment: organization-defined open-source information and/or information sites] [Assignment: organization-defined frequency] for evidence of unauthorized disclosure of organizational information; and
- b. If an information disclosure is discovered:
 1. Notify [Assignment: organization-defined personnel or roles]; and
 2. Take the following additional actions: [Assignment: organization-defined additional actions].

Discussion: Unauthorized disclosure of information is a form of data leakage. Open-source information includes social networking sites and code-sharing platforms and repositories. Examples of organizational information include personally identifiable information retained by the organization or proprietary information generated by the organization.

Related Controls: [AC-22](#), [PE-3](#), [PM-12](#), [RA-5](#), [SC-7](#), [SI-20](#).

Control Enhancements:

(1) MONITORING FOR INFORMATION DISCLOSURE | [USE OF AUTOMATED TOOLS](#)

Monitor open-source information and information sites using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms include commercial services that provide notifications and alerts to organizations and automated scripts to monitor new posts on websites.

Related Controls: None.

(2) MONITORING FOR INFORMATION DISCLOSURE | [REVIEW OF MONITORED SITES](#)

Review the list of open-source information sites being monitored [Assignment: organization-defined frequency].

Discussion: Reviewing the current list of open-source information sites being monitored on a regular basis helps to ensure that the selected sites remain relevant. The review also provides the opportunity to add new open-source information sites with the potential to provide evidence of unauthorized disclosure of organizational information. The list of sites monitored can be guided and informed by threat intelligence of other credible sources of information.

Related Controls: None.

(3) MONITORING FOR INFORMATION DISCLOSURE | [UNAUTHORIZED REPLICATION OF INFORMATION](#)

Employ discovery techniques, processes, and tools to determine if external entities are replicating organizational information in an unauthorized manner.

Discussion: The unauthorized use or replication of organizational information by external entities can cause adverse impacts on organizational operations and assets, including damage to reputation. Such activity can include the replication of an organizational website by an adversary or hostile threat actor who attempts to impersonate the web-hosting organization. Discovery tools, techniques, and processes used to determine if external entities are replicating organizational information in an unauthorized manner include scanning external websites, monitoring social media, and training staff to recognize the unauthorized use of organizational information.

Related Controls: None.

References: None.

AU-14 SESSION AUDIT

Control:

- a. Provide and implement the capability for [Assignment: organization-defined users or roles] to [Selection (one or more): record; view; hear; log] the content of a user session under [Assignment: organization-defined circumstances]; and
- b. Develop, integrate, and use session auditing activities in consultation with legal counsel and in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Discussion: Session audits can include monitoring keystrokes, tracking websites visited, and recording information and/or file transfers. Session audit capability is implemented in addition to event logging and may involve implementation of specialized session capture technology. Organizations consider how session auditing can reveal information about individuals that may give rise to privacy risk as well as how to mitigate those risks. Because session auditing can impact system and network performance, organizations activate the capability under well-defined situations (e.g., the organization is suspicious of a specific individual). Organizations consult with legal counsel, civil liberties officials, and privacy officials to ensure that any legal, privacy, civil rights, or civil liberties issues, including the use of personally identifiable information, are appropriately addressed.

Related Controls: [AC-3](#), [AC-8](#), [AU-2](#), [AU-3](#), [AU-4](#), [AU-5](#), [AU-8](#), [AU-9](#), [AU-11](#), [AU-12](#).

Control Enhancements:

(1) SESSION AUDIT | [SYSTEM START-UP](#)

Initiate session audits automatically at system start-up.

Discussion: The automatic initiation of session audits at startup helps to ensure that the information being captured on selected individuals is complete and not subject to compromise through tampering by malicious threat actors.

Related Controls: None.

(2) SESSION AUDIT | [CAPTURE AND RECORD CONTENT](#)

[Withdrawn: Incorporated into [AU-14](#).]

(3) SESSION AUDIT | [REMOTE VIEWING AND LISTENING](#)

Provide and implement the capability for authorized users to remotely view and hear content related to an established user session in real time.

Discussion: None.

Related Controls: [AC-17](#).

References: None.

AU-15 ALTERNATE AUDIT LOGGING CAPABILITY

[Withdrawn: Moved to [AU-5\(5\)](#).]

AU-16 CROSS-ORGANIZATIONAL AUDIT LOGGING

Control: Employ [Assignment: organization-defined methods] for coordinating [Assignment: organization-defined audit information] among external organizations when audit information is transmitted across organizational boundaries.

Discussion: When organizations use systems or services of external organizations, the audit logging capability necessitates a coordinated, cross-organization approach. For example, maintaining the identity of individuals who request specific services across organizational boundaries may often be difficult, and doing so may prove to have significant performance and privacy ramifications. Therefore, it is often the case that cross-organizational audit logging simply captures the identity of individuals who issue requests at the initial system, and subsequent systems record that the requests originated from authorized individuals. Organizations consider including processes for coordinating audit information requirements and protection of audit information in information exchange agreements.

Related Controls: [AU-3](#), [AU-6](#), [AU-7](#), [CA-3](#), [PT-7](#).

Control Enhancements:

(1) CROSS-ORGANIZATIONAL AUDIT LOGGING | [IDENTITY PRESERVATION](#)

Preserve the identity of individuals in cross-organizational audit trails.

Discussion: Identity preservation is applied when there is a need to be able to trace actions that are performed across organizational boundaries to a specific individual.

Related Controls: [IA-2](#), [IA-4](#), [IA-5](#), [IA-8](#).

(2) CROSS-ORGANIZATIONAL AUDIT LOGGING | [SHARING OF AUDIT INFORMATION](#)

Provide cross-organizational audit information to [Assignment: organization-defined organizations] based on [Assignment: organization-defined cross-organizational sharing agreements].

Discussion: Due to the distributed nature of the audit information, cross-organization sharing of audit information may be essential for effective analysis of the auditing being performed. For example, the audit records of one organization may not provide sufficient information to determine the appropriate or inappropriate use of organizational information resources by individuals in other organizations. In some instances, only individuals' home organizations have the appropriate knowledge to make such determinations, thus requiring the sharing of audit information among organizations.

Related Controls: [IR-4](#), [SI-4](#).

(3) CROSS-ORGANIZATIONAL AUDITING | [DISASSOCIABILITY](#)

Implement [Assignment: organization-defined measures] to disassociate individuals from audit information transmitted across organizational boundaries.

Discussion: Preserving identities in audit trails could have privacy ramifications, such as enabling the tracking and profiling of individuals, but may not be operationally necessary. These risks could be further amplified when transmitting information across organizational boundaries. Implementing privacy-enhancing cryptographic techniques can disassociate individuals from audit information and reduce privacy risk while maintaining accountability.

Related Controls: None.

References: None.

3.4 ASSESSMENT, AUTHORIZATION, AND MONITORING

[Quick link to Assessment, Authorization, and Monitoring Summary Table](#)

CA-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] assessment, authorization, and monitoring policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the assessment, authorization, and monitoring policy and the associated assessment, authorization, and monitoring controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the assessment, authorization, and monitoring policy and procedures; and
- c. Review and update the current assessment, authorization, and monitoring:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Assessment, authorization, and monitoring policy and procedures address the controls in the CA family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of assessment, authorization, and monitoring policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to assessment, authorization, and monitoring policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [OMB A-130], [SP 800-12], [SP 800-30], [SP 800-37], [SP 800-39], [SP 800-53A], [SP 800-100], [SP 800-137], [SP 800-137A], [IR 8062].

CA-2 CONTROL ASSESSMENTS

Control:

- a. Select the appropriate assessor or assessment team for the type of assessment to be conducted;
- b. Develop a control assessment plan that describes the scope of the assessment including:
 1. Controls and control enhancements under assessment;
 2. Assessment procedures to be used to determine control effectiveness; and
 3. Assessment environment, assessment team, and assessment roles and responsibilities;
- c. Ensure the control assessment plan is reviewed and approved by the authorizing official or designated representative prior to conducting the assessment;
- d. Assess the controls in the system and its environment of operation [*Assignment: organization-defined frequency*] to determine the extent to which the controls are implemented correctly, operating as intended, and producing the desired outcome with respect to meeting established security and privacy requirements;
- e. Produce a control assessment report that document the results of the assessment; and
- f. Provide the results of the control assessment to [*Assignment: organization-defined individuals or roles*].

Discussion: Organizations ensure that control assessors possess the required skills and technical expertise to develop effective assessment plans and to conduct assessments of system-specific, hybrid, common, and program management controls, as appropriate. The required skills include general knowledge of risk management concepts and approaches as well as comprehensive knowledge of and experience with the hardware, software, and firmware system components implemented.

Organizations assess controls in systems and the environments in which those systems operate as part of initial and ongoing authorizations, continuous monitoring, FISMA annual assessments, system design and development, systems security engineering, privacy engineering, and the system development life cycle. Assessments help to ensure that organizations meet information security and privacy requirements, identify weaknesses and deficiencies in the system design and development process, provide essential information needed to make risk-based decisions as part of authorization processes, and comply with vulnerability mitigation procedures. Organizations conduct assessments on the implemented controls as documented in security and privacy plans. Assessments can also be conducted throughout the system development life cycle as part of systems engineering and systems security engineering processes. The design for controls can be assessed as RFPs are developed, responses assessed, and design reviews conducted. If a design to implement controls and subsequent implementation in accordance with the design are assessed during development, the final control testing can be a simple confirmation utilizing previously completed control assessment and aggregating the outcomes.

Organizations may develop a single, consolidated security and privacy assessment plan for the system or maintain separate plans. A consolidated assessment plan clearly delineates the roles and responsibilities for control assessment. If multiple organizations participate in assessing a system, a coordinated approach can reduce redundancies and associated costs.

Organizations can use other types of assessment activities, such as vulnerability scanning and system monitoring, to maintain the security and privacy posture of systems during the system

life cycle. Assessment reports document assessment results in sufficient detail, as deemed necessary by organizations, to determine the accuracy and completeness of the reports and whether the controls are implemented correctly, operating as intended, and producing the desired outcome with respect to meeting requirements. Assessment results are provided to the individuals or roles appropriate for the types of assessments being conducted. For example, assessments conducted in support of authorization decisions are provided to authorizing officials, senior agency officials for privacy, senior agency information security officers, and authorizing official designated representatives.

To satisfy annual assessment requirements, organizations can use assessment results from the following sources: initial or ongoing system authorizations, continuous monitoring, systems engineering processes, or system development life cycle activities. Organizations ensure that assessment results are current, relevant to the determination of control effectiveness, and obtained with the appropriate level of assessor independence. Existing control assessment results can be reused to the extent that the results are still valid and can also be supplemented with additional assessments as needed. After the initial authorizations, organizations assess controls during continuous monitoring. Organizations also establish the frequency for ongoing assessments in accordance with organizational continuous monitoring strategies. External audits, including audits by external entities such as regulatory agencies, are outside of the scope of [CA-2](#).

Related Controls: [AC-20](#), [CA-5](#), [CA-6](#), [CA-7](#), [PM-9](#), [RA-5](#), [RA-10](#), [SA-11](#), [SC-38](#), [SI-3](#), [SI-12](#), [SR-2](#), [SR-3](#).

Control Enhancements:

(1) CONTROL ASSESSMENTS | [INDEPENDENT ASSESSORS](#)

Employ independent assessors or assessment teams to conduct control assessments.

Discussion: Independent assessors or assessment teams are individuals or groups who conduct impartial assessments of systems. Impartiality means that assessors are free from any perceived or actual conflicts of interest regarding the development, operation, sustainment, or management of the systems under assessment or the determination of control effectiveness. To achieve impartiality, assessors do not create a mutual or conflicting interest with the organizations where the assessments are being conducted, assess their own work, act as management or employees of the organizations they are serving, or place themselves in positions of advocacy for the organizations acquiring their services.

Independent assessments can be obtained from elements within organizations or be contracted to public or private sector entities outside of organizations. Authorizing officials determine the required level of independence based on the security categories of systems and/or the risk to organizational operations, organizational assets, or individuals. Authorizing officials also determine if the level of assessor independence provides sufficient assurance that the results are sound and can be used to make credible, risk-based decisions. Assessor independence determination includes whether contracted assessment services have sufficient independence, such as when system owners are not directly involved in contracting processes or cannot influence the impartiality of the assessors conducting the assessments. During the system design and development phase, having independent assessors is analogous to having independent SMEs involved in design reviews.

When organizations that own the systems are small or the structures of the organizations require that assessments be conducted by individuals that are in the developmental, operational, or management chain of the system owners, independence in assessment processes can be achieved by ensuring that assessment results are carefully reviewed and analyzed by independent teams of experts to validate the completeness, accuracy, integrity, and reliability of the results. Assessments performed for purposes other than to support

authorization decisions are more likely to be useable for such decisions when performed by assessors with sufficient independence, thereby reducing the need to repeat assessments.

Related Controls: None.

(2) CONTROL ASSESSMENTS | [SPECIALIZED ASSESSMENTS](#)

Include as part of control assessments, [Assignment: organization-defined frequency], [Selection: announced; unannounced], [Selection (one or more): in-depth monitoring; security instrumentation; automated security test cases; vulnerability scanning; malicious user testing; insider threat assessment; performance and load testing; data leakage or data loss assessment; [Assignment: organization-defined other forms of assessment]].

Discussion: Organizations can conduct specialized assessments, including verification and validation, system monitoring, insider threat assessments, malicious user testing, and other forms of testing. These assessments can improve readiness by exercising organizational capabilities and indicating current levels of performance as a means of focusing actions to improve security and privacy. Organizations conduct specialized assessments in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Authorizing officials approve the assessment methods in coordination with the organizational risk executive function. Organizations can include vulnerabilities uncovered during assessments into vulnerability remediation processes. Specialized assessments can also be conducted early in the system development life cycle (e.g., during initial design, development, and unit testing).

Related Controls: [PE-3](#), [SI-2](#).

(3) CONTROL ASSESSMENTS | [LEVERAGING RESULTS FROM EXTERNAL ORGANIZATIONS](#)

Leverage the results of control assessments performed by [Assignment: organization-defined external organization] on [Assignment: organization-defined system] when the assessment meets [Assignment: organization-defined requirements].

Discussion: Organizations may rely on control assessments of organizational systems by other (external) organizations. Using such assessments and reusing existing assessment evidence can decrease the time and resources required for assessments by limiting the independent assessment activities that organizations need to perform. The factors that organizations consider in determining whether to accept assessment results from external organizations can vary. Such factors include the organization's past experience with the organization that conducted the assessment, the reputation of the assessment organization, the level of detail of supporting assessment evidence provided, and mandates imposed by applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Accredited testing laboratories that support the Common Criteria Program [[ISO 15408-1](#)], the NIST Cryptographic Module Validation Program (CMVP), or the NIST Cryptographic Algorithm Validation Program (CAVP) can provide independent assessment results that organizations can leverage.

Related Controls: [SA-4](#).

References: [\[OMB A-130\]](#), [\[FIPS 199\]](#), [\[SP 800-18\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-53A\]](#), [\[SP 800-115\]](#), [\[SP 800-137\]](#), [\[IR 8011-1\]](#), [\[IR 8062\]](#).

CA-3 INFORMATION EXCHANGE

Control:

- a. Approve and manage the exchange of information between the system and other systems using [Selection (one or more): interconnection security agreements; information exchange security agreements; memoranda of understanding or agreement; service level agreements;

- user agreements; nondisclosure agreements; [Assignment: organization-defined type of agreement]];*
- b. Document, as part of each exchange agreement, the interface characteristics, security and privacy requirements, controls, and responsibilities for each system, and the impact level of the information communicated; and
 - c. Review and update the agreements [Assignment: organization-defined frequency].

Discussion: System information exchange requirements apply to information exchanges between two or more systems. System information exchanges include connections via leased lines or virtual private networks, connections to internet service providers, database sharing or exchanges of database transaction information, connections and exchanges with cloud services, exchanges via web-based services, or exchanges of files via file transfer protocols, network protocols (e.g., IPv4, IPv6), email, or other organization-to-organization communications. Organizations consider the risk related to new or increased threats that may be introduced when systems exchange information with other systems that may have different security and privacy requirements and controls. This includes systems within the same organization and systems that are external to the organization. A joint authorization of the systems exchanging information, as described in [CA-6\(1\)](#) or [CA-6\(2\)](#), may help to communicate and reduce risk.

Authorizing officials determine the risk associated with system information exchange and the controls needed for appropriate risk mitigation. The types of agreements selected are based on factors such as the impact level of the information being exchanged, the relationship between the organizations exchanging information (e.g., government to government, government to business, business to business, government or business to service provider, government or business to individual), or the level of access to the organizational system by users of the other system. If systems that exchange information have the same authorizing official, organizations need not develop agreements. Instead, the interface characteristics between the systems (e.g., how the information is being exchanged, how the information is protected) are described in the respective security and privacy plans. If the systems that exchange information have different authorizing officials within the same organization, the organizations can develop agreements or provide the same information that would be provided in the appropriate agreement type from [CA-3a](#) in the respective security and privacy plans for the systems. Organizations may incorporate agreement information into formal contracts, especially for information exchanges established between federal agencies and nonfederal organizations (including service providers, contractors, system developers, and system integrators). Risk considerations include systems that share the same networks.

Related Controls: [AC-4](#), [AC-20](#), [AU-16](#), [CA-6](#), [IA-3](#), [IR-4](#), [PL-2](#), [PT-7](#), [RA-3](#), [SA-9](#), [SC-7](#), [SI-12](#).

Control Enhancements:

- (1) SYSTEM CONNECTIONS | UNCLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS
[Withdrawn: Moved to [SC-7\(25\)](#).]
- (2) SYSTEM CONNECTIONS | CLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS
[Withdrawn: Moved to [SC-7\(26\)](#).]
- (3) SYSTEM CONNECTIONS | UNCLASSIFIED NON-NATIONAL SECURITY SYSTEM CONNECTIONS
[Withdrawn: Moved to [SC-7\(27\)](#).]
- (4) SYSTEM CONNECTIONS | CONNECTIONS TO PUBLIC NETWORKS
[Withdrawn: Moved to [SC-7\(28\)](#).]
- (5) SYSTEM CONNECTIONS | RESTRICTIONS ON EXTERNAL SYSTEM CONNECTIONS

[Withdrawn: Moved to [SC-7\(5\)](#).]

(6) INFORMATION EXCHANGE | [TRANSFER AUTHORIZATIONS](#)

Verify that individuals or systems transferring data between interconnecting systems have the requisite authorizations (i.e., write permissions or privileges) prior to accepting such data.

Discussion: To prevent unauthorized individuals and systems from making information transfers to protected systems, the protected system verifies—via independent means—whether the individual or system attempting to transfer information is authorized to do so. Verification of the authorization to transfer information also applies to control plane traffic (e.g., routing and DNS) and services (e.g., authenticated SMTP relays).

Related Controls: [AC-2](#), [AC-3](#), [AC-4](#).

(7) INFORMATION EXCHANGE | [TRANSITIVE INFORMATION EXCHANGES](#)

(a) Identify transitive (downstream) information exchanges with other systems through the systems identified in [CA-3a](#); and

(b) Take measures to ensure that transitive (downstream) information exchanges cease when the controls on identified transitive (downstream) systems cannot be verified or validated.

Discussion: Transitive or “downstream” information exchanges are information exchanges between the system or systems with which the organizational system exchanges information and other systems. For mission-essential systems, services, and applications, including high value assets, it is necessary to identify such information exchanges. The transparency of the controls or protection measures in place in such downstream systems connected directly or indirectly to organizational systems is essential to understanding the security and privacy risks resulting from those information exchanges. Organizational systems can inherit risk from downstream systems through transitive connections and information exchanges, which can make the organizational systems more susceptible to threats, hazards, and adverse impacts.

Related Controls: [SC-7](#).

References: [\[OMB A-130\]](#), [\[FIPS 199\]](#), [\[SP 800-47\]](#).

CA-4 SECURITY CERTIFICATION

[Withdrawn: Incorporated into [CA-2](#).]

[CA-5 PLAN OF ACTION AND MILESTONES](#)

Control:

- a. Develop a plan of action and milestones for the system to document the planned remediation actions of the organization to correct weaknesses or deficiencies noted during the assessment of the controls and to reduce or eliminate known vulnerabilities in the system; and
- b. Update existing plan of action and milestones [Assignment: *organization-defined frequency*] based on the findings from control assessments, independent audits or reviews, and continuous monitoring activities.

Discussion: Plans of action and milestones are useful for any type of organization to track planned remedial actions. Plans of action and milestones are required in authorization packages and subject to federal reporting requirements established by OMB.

Related Controls: [CA-2](#), [CA-7](#), [PM-4](#), [PM-9](#), [RA-7](#), [SI-2](#), [SI-12](#).

Control Enhancements:**(1) PLAN OF ACTION AND MILESTONES | [AUTOMATION SUPPORT FOR ACCURACY AND CURRENCY](#)**

Ensure the accuracy, currency, and availability of the plan of action and milestones for the system using [Assignment: organization-defined automated mechanisms].

Discussion: Using automated tools helps maintain the accuracy, currency, and availability of the plan of action and milestones and facilitates the coordination and sharing of security and privacy information throughout the organization. Such coordination and information sharing help to identify systemic weaknesses or deficiencies in organizational systems and ensure that appropriate resources are directed at the most critical system vulnerabilities in a timely manner.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[SP 800-37\]](#).

CA-6 AUTHORIZATION**Control:**

- a. Assign a senior official as the authorizing official for the system;
- b. Assign a senior official as the authorizing official for common controls available for inheritance by organizational systems;
- c. Ensure that the authorizing official for the system, before commencing operations:
 1. Accepts the use of common controls inherited by the system; and
 2. Authorizes the system to operate;
- d. Ensure that the authorizing official for common controls authorizes the use of those controls for inheritance by organizational systems;
- e. Update the authorizations [Assignment: organization-defined frequency].

Discussion: Authorizations are official management decisions by senior officials to authorize operation of systems, authorize the use of common controls for inheritance by organizational systems, and explicitly accept the risk to organizational operations and assets, individuals, other organizations, and the Nation based on the implementation of agreed-upon controls. Authorizing officials provide budgetary oversight for organizational systems and common controls or assume responsibility for the mission and business functions supported by those systems or common controls. The authorization process is a federal responsibility, and therefore, authorizing officials must be federal employees. Authorizing officials are both responsible and accountable for security and privacy risks associated with the operation and use of organizational systems. Nonfederal organizations may have similar processes to authorize systems and senior officials that assume the authorization role and associated responsibilities.

Authorizing officials issue ongoing authorizations of systems based on evidence produced from implemented continuous monitoring programs. Robust continuous monitoring programs reduce the need for separate reauthorization processes. Through the employment of comprehensive continuous monitoring processes, the information contained in authorization packages (i.e., security and privacy plans, assessment reports, and plans of action and milestones) is updated on an ongoing basis. This provides authorizing officials, common control providers, and system owners with an up-to-date status of the security and privacy posture of their systems, controls, and operating environments. To reduce the cost of reauthorization, authorizing officials can leverage the results of continuous monitoring processes to the maximum extent possible as the basis for rendering reauthorization decisions.

Related Controls: [CA-2](#), [CA-3](#), [CA-7](#), [PM-9](#), [PM-10](#), [RA-3](#), [SA-10](#), [SI-12](#).

Control Enhancements:

(1) AUTHORIZATION | [JOINT AUTHORIZATION — INTRA-ORGANIZATION](#)

Employ a joint authorization process for the system that includes multiple authorizing officials from the same organization conducting the authorization.

Discussion: Assigning multiple authorizing officials from the same organization to serve as co-authorizing officials for the system increases the level of independence in the risk-based decision-making process. It also implements the concepts of separation of duties and dual authorization as applied to the system authorization process. The intra-organization joint authorization process is most relevant for connected systems, shared systems, and systems with multiple information owners.

Related Controls: [AC-6](#).

(2) AUTHORIZATION | [JOINT AUTHORIZATION — INTER-ORGANIZATION](#)

Employ a joint authorization process for the system that includes multiple authorizing officials with at least one authorizing official from an organization external to the organization conducting the authorization.

Discussion: Assigning multiple authorizing officials, at least one of whom comes from an external organization, to serve as co-authorizing officials for the system increases the level of independence in the risk-based decision-making process. It implements the concepts of separation of duties and dual authorization as applied to the system authorization process. Employing authorizing officials from external organizations to supplement the authorizing official from the organization that owns or hosts the system may be necessary when the external organizations have a vested interest or equities in the outcome of the authorization decision. The inter-organization joint authorization process is relevant and appropriate for connected systems, shared systems or services, and systems with multiple information owners. The authorizing officials from the external organizations are key stakeholders of the system undergoing authorization.

Related Controls: [AC-6](#).

References: [\[OMB A-130\]](#), [\[SP 800-37\]](#), [\[SP 800-137\]](#).

CA-7 CONTINUOUS MONITORING

Control: Develop a system-level continuous monitoring strategy and implement continuous monitoring in accordance with the organization-level continuous monitoring strategy that includes:

- a. Establishing the following system-level metrics to be monitored: [*Assignment: organization-defined system-level metrics*];
- b. Establishing [*Assignment: organization-defined frequencies*] for monitoring and [*Assignment: organization-defined frequencies*] for assessment of control effectiveness;
- c. Ongoing control assessments in accordance with the continuous monitoring strategy;
- d. Ongoing monitoring of system and organization-defined metrics in accordance with the continuous monitoring strategy;
- e. Correlation and analysis of information generated by control assessments and monitoring;
- f. Response actions to address results of the analysis of control assessment and monitoring information; and

- g. Reporting the security and privacy status of the system to [Assignment: organization-defined personnel or roles] [Assignment: organization-defined frequency].

Discussion: Continuous monitoring at the system level facilitates ongoing awareness of the system security and privacy posture to support organizational risk management decisions. The terms “continuous” and “ongoing” imply that organizations assess and monitor their controls and risks at a frequency sufficient to support risk-based decisions. Different types of controls may require different monitoring frequencies. The results of continuous monitoring generate risk response actions by organizations. When monitoring the effectiveness of multiple controls that have been grouped into capabilities, a root-cause analysis may be needed to determine the specific control that has failed. Continuous monitoring programs allow organizations to maintain the authorizations of systems and common controls in highly dynamic environments of operation with changing mission and business needs, threats, vulnerabilities, and technologies. Having access to security and privacy information on a continuing basis through reports and dashboards gives organizational officials the ability to make effective and timely risk management decisions, including ongoing authorization decisions.

Automation supports more frequent updates to hardware, software, and firmware inventories, authorization packages, and other system information. Effectiveness is further enhanced when continuous monitoring outputs are formatted to provide information that is specific, measurable, actionable, relevant, and timely. Continuous monitoring activities are scaled in accordance with the security categories of systems. Monitoring requirements, including the need for specific monitoring, may be referenced in other controls and control enhancements, such as [AC-2g](#), [AC-2\(7\)](#), [AC-2\(12\)\(a\)](#), [AC-2\(7\)\(b\)](#), [AC-2\(7\)\(c\)](#), [AC-17\(1\)](#), [AT-4a](#), [AU-13](#), [AU-13\(1\)](#), [AU-13\(2\)](#), [CM-3f](#), [CM-6d](#), [CM-11c](#), [IR-5](#), [MA-2b](#), [MA-3a](#), [MA-4a](#), [PE-3d](#), [PE-6](#), [PE-14b](#), [PE-16](#), [PE-20](#), [PM-6](#), [PM-23](#), [PM-31](#), [PS-7e](#), [SA-9c](#), [SR-4](#), [SC-5\(3\)\(b\)](#), [SC-7a](#), [SC-7\(24\)\(b\)](#), [SC-18b](#), [SC-43b](#), and [SI-4](#).

Related Controls: [AC-2](#), [AC-6](#), [AC-17](#), [AT-4](#), [AU-6](#), [AU-13](#), [CA-2](#), [CA-5](#), [CA-6](#), [CM-3](#), [CM-4](#), [CM-6](#), [CM-11](#), [IA-5](#), [IR-5](#), [MA-2](#), [MA-3](#), [MA-4](#), [PE-3](#), [PE-6](#), [PE-14](#), [PE-16](#), [PE-20](#), [PL-2](#), [PM-4](#), [PM-6](#), [PM-9](#), [PM-10](#), [PM-12](#), [PM-14](#), [PM-23](#), [PM-28](#), [PM-31](#), [PS-7](#), [PT-7](#), [RA-3](#), [RA-5](#), [RA-7](#), [RA-10](#), [SA-8](#), [SA-9](#), [SA-11](#), [SC-5](#), [SC-7](#), [SC-18](#), [SC-38](#), [SC-43](#), [SI-3](#), [SI-4](#), [SI-12](#), [SR-6](#).

Control Enhancements:

(1) CONTINUOUS MONITORING | [INDEPENDENT ASSESSMENT](#)

Employ independent assessors or assessment teams to monitor the controls in the system on an ongoing basis.

Discussion: Organizations maximize the value of control assessments by requiring that assessments be conducted by assessors with appropriate levels of independence. The level of required independence is based on organizational continuous monitoring strategies. Assessor independence provides a degree of impartiality to the monitoring process. To achieve such impartiality, assessors do not create a mutual or conflicting interest with the organizations where the assessments are being conducted, assess their own work, act as management or employees of the organizations they are serving, or place themselves in advocacy positions for the organizations acquiring their services.

Related Controls: None.

(2) CONTINUOUS MONITORING | [TYPES OF ASSESSMENTS](#)

[Withdrawn: Incorporated into [CA-2](#).]

(3) CONTINUOUS MONITORING | [TREND ANALYSES](#)

Employ trend analyses to determine if control implementations, the frequency of continuous monitoring activities, and the types of activities used in the continuous monitoring process need to be modified based on empirical data.

Discussion: Trend analyses include examining recent threat information that addresses the types of threat events that have occurred in the organization or the Federal Government, success rates of certain types of attacks, emerging vulnerabilities in technologies, evolving social engineering techniques, the effectiveness of configuration settings, results from multiple control assessments, and findings from Inspectors General or auditors.

Related Controls: None.

(4) CONTINUOUS MONITORING | [RISK MONITORING](#)

Ensure risk monitoring is an integral part of the continuous monitoring strategy that includes the following:

- (a) Effectiveness monitoring;**
- (b) Compliance monitoring; and**
- (c) Change monitoring.**

Discussion: Risk monitoring is informed by the established organizational risk tolerance. Effectiveness monitoring determines the ongoing effectiveness of the implemented risk response measures. Compliance monitoring verifies that required risk response measures are implemented. It also verifies that security and privacy requirements are satisfied. Change monitoring identifies changes to organizational systems and environments of operation that may affect security and privacy risk.

Related Controls: None.

(5) CONTINUOUS MONITORING | [CONSISTENCY ANALYSIS](#)

Employ the following actions to validate that policies are established and implemented controls are operating in a consistent manner: [Assignment: organization-defined actions].

Discussion: Security and privacy controls are often added incrementally to a system. As a result, policies for selecting and implementing controls may be inconsistent, and the controls could fail to work together in a consistent or coordinated manner. At a minimum, the lack of consistency and coordination could mean that there are unacceptable security and privacy gaps in the system. At worst, it could mean that some of the controls implemented in one location or by one component are actually impeding the functionality of other controls (e.g., encrypting internal network traffic can impede monitoring). In other situations, failing to consistently monitor all implemented network protocols (e.g., a dual stack of IPv4 and IPv6) may create unintended vulnerabilities in the system that could be exploited by adversaries. It is important to validate—through testing, monitoring, and analysis—that the implemented controls are operating in a consistent, coordinated, non-interfering manner.

Related Controls: None.

(6) CONTINUOUS MONITORING | [AUTOMATION SUPPORT FOR MONITORING](#)

Ensure the accuracy, currency, and availability of monitoring results for the system using [Assignment: organization-defined automated mechanisms].

Discussion: Using automated tools for monitoring helps to maintain the accuracy, currency, and availability of monitoring information which in turns helps to increase the level of ongoing awareness of the system security and privacy posture in support of organizational risk management decisions.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-53A\]](#), [\[SP 800-115\]](#), [\[SP 800-137\]](#), [\[IR 8011-1\]](#), [\[IR 8062\]](#).

CA-8 PENETRATION TESTING

Control: Conduct penetration testing [*Assignment: organization-defined frequency*] on [*Assignment: organization-defined systems or system components*].

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 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. Penetration testing attempts to duplicate the actions of adversaries and provides a more in-depth analysis of security- and privacy-related weaknesses or deficiencies. Penetration testing is especially important when organizations are transitioning from older technologies to newer technologies (e.g., transitioning from IPv4 to IPv6 network protocols).

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 a pretest analysis based on full knowledge of the system, pretest identification of potential vulnerabilities based on the pretest analysis, and testing designed to determine the exploitability of vulnerabilities. All parties agree to the rules of engagement before commencing penetration testing scenarios. Organizations correlate the rules of engagement for the penetration tests with the tools, techniques, and procedures that are anticipated to be employed by adversaries. Penetration testing may result in the exposure of information that is protected by laws or regulations, to individuals conducting the testing. Rules of engagement, contracts, or other appropriate mechanisms can be used to communicate expectations for how to protect this information. Risk assessments guide the decisions on the level of independence required for the personnel conducting penetration testing.

Related Controls: [RA-5](#), [RA-10](#), [SA-11](#), [SR-5](#), [SR-6](#).

Control Enhancements:

(1) PENETRATION TESTING | [INDEPENDENT PENETRATION TESTING AGENT OR TEAM](#)

Employ an independent penetration testing agent or team to perform penetration testing on the system or system components.

Discussion: Independent penetration testing agents or teams are individuals or groups who conduct impartial penetration testing of organizational systems. Impartiality implies that penetration testing agents or teams are free from perceived or actual conflicts of interest with respect to the development, operation, or management of the systems that are the targets of the penetration testing. [CA-2\(1\)](#) provides additional information on independent assessments that can be applied to penetration testing.

Related Controls: [CA-2](#).

(2) PENETRATION TESTING | [RED TEAM EXERCISES](#)

Employ the following red-team exercises to simulate attempts by adversaries to compromise organizational systems in accordance with applicable rules of engagement: [*Assignment: organization-defined red team exercises*].

Discussion: Red team exercises extend the objectives of penetration testing by examining the security and privacy posture of organizations and the capability to implement effective cyber defenses. Red team exercises simulate attempts by adversaries to compromise mission and business functions and provide a comprehensive assessment of the security and

privacy posture of systems and organizations. Such attempts may include technology-based attacks and social engineering-based attacks. Technology-based attacks include interactions with hardware, software, or firmware components and/or mission and business processes. Social engineering-based attacks include interactions via email, telephone, shoulder surfing, or personal conversations. Red team exercises are most effective when conducted by penetration testing agents and teams with knowledge of and experience with current adversarial tactics, techniques, procedures, and tools. While penetration testing may be primarily laboratory-based testing, organizations can use red team exercises to provide more comprehensive assessments that reflect real-world conditions. The results from red team exercises can be used by organizations to improve security and privacy awareness and training and to assess control effectiveness.

Related Controls: None.

(3) PENETRATION TESTING | [FACILITY PENETRATION TESTING](#)

Employ a penetration testing process that includes [Assignment: organization-defined frequency] [Selection: announced; unannounced] attempts to bypass or circumvent controls associated with physical access points to the facility.

Discussion: Penetration testing of physical access points can provide information on critical vulnerabilities in the operating environments of organizational systems. Such information can be used to correct weaknesses or deficiencies in physical controls that are necessary to protect organizational systems.

Related Controls: [CA-2](#), [PE-3](#).

References: None.

[CA-9](#) INTERNAL SYSTEM CONNECTIONS

Control:

- a. Authorize internal connections of [Assignment: organization-defined system components or classes of components] to the system;
- b. Document, for each internal connection, the interface characteristics, security and privacy requirements, and the nature of the information communicated;
- c. Terminate internal system connections after [Assignment: organization-defined conditions]; and
- d. Review [Assignment: organization-defined frequency] the continued need for each internal connection.

Discussion: Internal system connections are connections between organizational systems and separate constituent system components (i.e., connections between components that are part of the same system) including components used for system development. Intra-system connections include connections with mobile devices, notebook and desktop computers, tablets, printers, copiers, facsimile machines, scanners, sensors, and servers. Instead of authorizing each internal system connection individually, organizations can authorize internal connections for a class of system components with common characteristics and/or configurations, including printers, scanners, and copiers with a specified processing, transmission, and storage capability or smart phones and tablets with a specific baseline configuration. The continued need for an internal system connection is reviewed from the perspective of whether it provides support for organizational missions or business functions.

Related Controls: [AC-3](#), [AC-4](#), [AC-18](#), [AC-19](#), [CM-2](#), [IA-3](#), [SC-7](#), [SI-12](#).

Control Enhancements:

(1) INTERNAL SYSTEM CONNECTIONS | [COMPLIANCE CHECKS](#)

Perform security and privacy compliance checks on constituent system components prior to the establishment of the internal connection.

Discussion: Compliance checks include verification of the relevant baseline configuration.

Related Controls: [CM-6](#).

References: [\[SP 800-124\]](#), [\[IR 8023\]](#).

3.5 CONFIGURATION MANAGEMENT

[Quick link to Configuration Management Summary Table](#)

CM-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] configuration management policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the configuration management policy and the associated configuration management controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the configuration management policy and procedures; and
- c. Review and update the current configuration management:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Configuration management policy and procedures address the controls in the CM family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of configuration management policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission/business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to configuration management policy and procedures include, but are not limited to, assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SA-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

CM-2 BASELINE CONFIGURATION

Control:

- a. Develop, document, and maintain under configuration control, a current baseline configuration of the system; and
- b. Review and update the baseline configuration of the system:
 1. [Assignment: organization-defined frequency];
 2. When required due to [Assignment: organization-defined circumstances]; and
 3. When system components are installed or upgraded.

Discussion: Baseline configurations for systems and system components include connectivity, operational, and communications aspects of systems. Baseline configurations are documented, formally reviewed, and agreed-upon specifications for systems or configuration items within those systems. Baseline configurations serve as a basis for future builds, releases, or changes to systems and include security and privacy control implementations, operational procedures, information about system components, network topology, and logical placement of components in the system architecture. Maintaining baseline configurations requires creating new baselines as organizational systems change over time. Baseline configurations of systems reflect the current enterprise architecture.

Related Controls: [AC-19](#), [AU-6](#), [CA-9](#), [CM-1](#), [CM-3](#), [CM-5](#), [CM-6](#), [CM-8](#), [CM-9](#), [CP-9](#), [CP-10](#), [CP-12](#), [MA-2](#), [PL-8](#), [PM-5](#), [SA-8](#), [SA-10](#), [SA-15](#), [SC-18](#).

Control Enhancements:

(1) BASELINE CONFIGURATION | REVIEWS AND UPDATES

[Withdrawn: Incorporated into [CM-2](#).]

(2) BASELINE CONFIGURATION | AUTOMATION SUPPORT FOR ACCURACY AND CURRENCY

Maintain the currency, completeness, accuracy, and availability of the baseline configuration of the system using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms that help organizations maintain consistent baseline configurations for systems include configuration management tools, hardware, software, firmware inventory tools, and network management tools. Automated tools can be used at the organization level, mission and business process level, or system level on workstations, servers, notebook computers, network components, or mobile devices. Tools can be used to track version numbers on operating systems, applications, types of software installed, and current patch levels. Automation support for accuracy and currency can be satisfied by the implementation of [CM-8\(2\)](#) for organizations that combine system component inventory and baseline configuration activities.

Related Controls: [CM-7](#), [IA-3](#), [RA-5](#).

(3) BASELINE CONFIGURATION | RETENTION OF PREVIOUS CONFIGURATIONS

Retain [Assignment: organization-defined number] of previous versions of baseline configurations of the system to support rollback.

Discussion: Retaining previous versions of baseline configurations to support rollback include hardware, software, firmware, configuration files, configuration records, and associated documentation.

Related Controls: None.

(4) BASELINE CONFIGURATION | UNAUTHORIZED SOFTWARE

[Withdrawn: Incorporated into [CM-7\(4\)](#).]

(5) BASELINE CONFIGURATION | AUTHORIZED SOFTWARE

[Withdrawn: Incorporated into [CM-7\(5\)](#).]

(6) BASELINE CONFIGURATION | DEVELOPMENT AND TEST ENVIRONMENTS

Maintain a baseline configuration for system development and test environments that is managed separately from the operational baseline configuration.

Discussion: Establishing separate baseline configurations for development, testing, and operational environments protects systems from unplanned or unexpected events related to development and testing activities. Separate baseline configurations allow organizations to apply the configuration management that is most appropriate for each type of configuration. For example, the management of operational configurations typically emphasizes the need for stability, while the management of development or test configurations requires greater flexibility. Configurations in the test environment mirror configurations in the operational environment to the extent practicable so that the results of the testing are representative of the proposed changes to the operational systems. Separate baseline configurations do not necessarily require separate physical environments.

Related Controls: [CM-4](#), [SC-3](#), [SC-7](#).

(7) BASELINE CONFIGURATION | CONFIGURE SYSTEMS AND COMPONENTS FOR HIGH-RISK AREAS

(a) Issue [Assignment: organization-defined systems or system components] with [Assignment: organization-defined configurations] to individuals traveling to locations that the organization deems to be of significant risk; and

(b) Apply the following controls to the systems or components when the individuals return from travel: [Assignment: organization-defined controls].

Discussion: When it is known that systems or system components will be in high-risk areas external to the organization, additional controls may be implemented to counter the increased threat in such areas. For example, organizations can take actions for notebook computers used by individuals departing on and returning from travel. Actions include determining the locations that are of concern, defining the required configurations for the components, ensuring that components are configured as intended before travel is initiated, and applying controls to the components after travel is completed. Specially configured notebook computers include computers with sanitized hard drives, limited applications, and more stringent configuration settings. Controls applied to mobile devices upon return from travel include examining the mobile device for signs of physical tampering and purging and reimaging disk drives. Protecting information that resides on mobile devices is addressed in the [MP](#) (Media Protection) family.

Related Controls: [MP-4](#), [MP-5](#).

References: [\[SP 800-124\]](#), [\[SP 800-128\]](#).

CM-3 CONFIGURATION CHANGE CONTROL

Control:

- a. Determine and document the types of changes to the system that are configuration-controlled;
- b. Review proposed configuration-controlled changes to the system and approve or disapprove such changes with explicit consideration for security and privacy impact analyses;
- c. Document configuration change decisions associated with the system;
- d. Implement approved configuration-controlled changes to the system;

- e. Retain records of configuration-controlled changes to the system for [Assignment: organization-defined time period];
- f. Monitor and review activities associated with configuration-controlled changes to the system; and
- g. Coordinate and provide oversight for configuration change control activities through [Assignment: organization-defined configuration change control element] that convenes [Selection (one or more): [Assignment: organization-defined frequency]]; when [Assignment: organization-defined configuration change conditions]].

Discussion: Configuration change control for organizational systems involves the systematic proposal, justification, implementation, testing, review, and disposition of system changes, including system upgrades and modifications. Configuration change control includes changes to baseline configurations, configuration items of systems, operational procedures, configuration settings for system components, remediate vulnerabilities, and unscheduled or unauthorized changes. Processes for managing configuration changes to systems include Configuration Control Boards or Change Advisory Boards that review and approve proposed changes. For changes that impact privacy risk, the senior agency official for privacy updates privacy impact assessments and system of records notices. For new systems or major upgrades, organizations consider including representatives from the development organizations on the Configuration Control Boards or Change Advisory Boards. Auditing of changes includes activities before and after changes are made to systems and the auditing activities required to implement such changes. See also [SA-10](#).

Related Controls: [CA-7](#), [CM-2](#), [CM-4](#), [CM-5](#), [CM-6](#), [CM-9](#), [CM-11](#), [IA-3](#), [MA-2](#), [PE-16](#), [PT-6](#), [RA-8](#), [SA-8](#), [SA-10](#), [SC-28](#), [SC-34](#), [SC-37](#), [SI-2](#), [SI-3](#), [SI-4](#), [SI-7](#), [SI-10](#), [SR-11](#).

Control Enhancements:

(1) CONFIGURATION CHANGE CONTROL | [AUTOMATED DOCUMENTATION, NOTIFICATION, AND PROHIBITION OF CHANGES](#)

Use [Assignment: organization-defined automated mechanisms] to:

- (a) Document proposed changes to the system;
- (b) Notify [Assignment: organization-defined approval authorities] of proposed changes to the system and request change approval;
- (c) Highlight proposed changes to the system that have not been approved or disapproved within [Assignment: organization-defined time period];
- (d) Prohibit changes to the system until designated approvals are received;
- (e) Document all changes to the system; and
- (f) Notify [Assignment: organization-defined personnel] when approved changes to the system are completed.

Discussion: None.

Related Controls: None.

(2) CONFIGURATION CHANGE CONTROL | [TESTING, VALIDATION, AND DOCUMENTATION OF CHANGES](#)

Test, validate, and document changes to the system before finalizing the implementation of the changes.

Discussion: Changes to systems include modifications to hardware, software, or firmware components and configuration settings defined in [CM-6](#). Organizations ensure that testing does not interfere with system operations that support organizational mission and business functions. Individuals or groups conducting tests understand security and privacy policies and procedures, system security and privacy policies and procedures, and the health, safety, and environmental risks associated with specific facilities or processes. Operational systems

may need to be taken offline, or replicated to the extent feasible, before testing can be conducted. If systems must be taken offline for testing, the tests are scheduled to occur during planned system outages whenever possible. If the testing cannot be conducted on operational systems, organizations employ compensating controls.

Related Controls: None.

(3) CONFIGURATION CHANGE CONTROL | [AUTOMATED CHANGE IMPLEMENTATION](#)

Implement changes to the current system baseline and deploy the updated baseline across the installed base using [Assignment: organization-defined automated mechanisms].

Discussion: Automated tools can improve the accuracy, consistency, and availability of configuration baseline information. Automation can also provide data aggregation and data correlation capabilities, alerting mechanisms, and dashboards to support risk-based decision-making within the organization.

Related Controls: None.

(4) CONFIGURATION CHANGE CONTROL | [SECURITY AND PRIVACY REPRESENTATIVES](#)

Require [Assignment: organization-defined security and privacy representatives] to be members of the [Assignment: organization-defined configuration change control element].

Discussion: Information security and privacy representatives include system security officers, senior agency information security officers, senior agency officials for privacy, or system privacy officers. Representation by personnel with information security and privacy expertise is important because changes to system configurations can have unintended side effects, some of which may be security- or privacy-relevant. Detecting such changes early in the process can help avoid unintended, negative consequences that could ultimately affect the security and privacy posture of systems. The configuration change control element referred to in the second organization-defined parameter reflects the change control elements defined by organizations in [CM-3g](#).

Related Controls: None.

(5) CONFIGURATION CHANGE CONTROL | [AUTOMATED SECURITY RESPONSE](#)

Implement the following security responses automatically if baseline configurations are changed in an unauthorized manner: [Assignment: organization-defined security responses].

Discussion: Automated security responses include halting selected system functions, halting system processing, and issuing alerts or notifications to organizational personnel when there is an unauthorized modification of a configuration item.

Related Controls: None.

(6) CONFIGURATION CHANGE CONTROL | [CRYPTOGRAPHY MANAGEMENT](#)

Ensure that cryptographic mechanisms used to provide the following controls are under configuration management: [Assignment: organization-defined controls].

Discussion: The controls referenced in the control enhancement refer to security and privacy controls from the control catalog. Regardless of the cryptographic mechanisms employed, processes and procedures are in place to manage those mechanisms. For example, if system components use certificates for identification and authentication, a process is implemented to address the expiration of those certificates.

Related Controls: [SC-12](#).

(7) CONFIGURATION CHANGE CONTROL | [REVIEW SYSTEM CHANGES](#)

Review changes to the system [*Assignment: organization-defined frequency*] or when [*Assignment: organization-defined circumstances*] to determine whether unauthorized changes have occurred.

Discussion: Indications that warrant a review of changes to the system and the specific circumstances justifying such reviews may be obtained from activities carried out by organizations during the configuration change process or continuous monitoring process.

Related Controls: [AU-6](#), [AU-7](#), [CM-3](#).

(8) CONFIGURATION CHANGE CONTROL | [PREVENT OR RESTRICT CONFIGURATION CHANGES](#)

Prevent or restrict changes to the configuration of the system under the following circumstances: [*Assignment: organization-defined circumstances*].

Discussion: System configuration changes can adversely affect critical system security and privacy functionality. Change restrictions can be enforced through automated mechanisms.

Related Controls: None.

References: [\[SP 800-124\]](#), [\[SP 800-128\]](#), [\[IR 8062\]](#).

CM-4 IMPACT ANALYSES

Control: Analyze changes to the system to determine potential security and privacy impacts prior to change implementation.

Discussion: Organizational personnel with security or privacy responsibilities conduct impact analyses. Individuals conducting impact analyses possess the necessary skills and technical expertise to analyze the changes to systems as well as the security or privacy ramifications. Impact analyses include reviewing security and privacy plans, policies, and procedures to understand control requirements; reviewing system design documentation and operational procedures to understand control implementation and how specific system changes might affect the controls; reviewing the impact of changes on organizational supply chain partners with stakeholders; and determining how potential changes to a system create new risks to the privacy of individuals and the ability of implemented controls to mitigate those risks. Impact analyses also include risk assessments to understand the impact of the changes and determine if additional controls are required.

Related Controls: [CA-7](#), [CM-3](#), [CM-8](#), [CM-9](#), [MA-2](#), [RA-3](#), [RA-5](#), [RA-8](#), [SA-5](#), [SA-8](#), [SA-10](#), [SI-2](#).

Control Enhancements:

(1) IMPACT ANALYSES | [SEPARATE TEST ENVIRONMENTS](#)

Analyze changes to the system in a separate test environment before implementation in an operational environment, looking for security and privacy impacts due to flaws, weaknesses, incompatibility, or intentional malice.

Discussion: A separate test environment requires an environment that is physically or logically separate and distinct from the operational environment. The separation is sufficient to ensure that activities in the test environment do not impact activities in the operational environment and that information in the operational environment is not inadvertently transmitted to the test environment. Separate environments can be achieved by physical or logical means. If physically separate test environments are not implemented, organizations determine the strength of mechanism required when implementing logical separation.

Related Controls: [SA-11](#), [SC-7](#).

(2) IMPACT ANALYSES | [VERIFICATION OF CONTROLS](#)

After system changes, verify that the impacted controls are implemented correctly, operating as intended, and producing the desired outcome with regard to meeting the security and privacy requirements for the system.

Discussion: Implementation in this context refers to installing changed code in the operational system that may have an impact on security or privacy controls.

Related Controls: [SA-11](#), [SC-3](#), [SI-6](#).

References: [\[SP 800-128\]](#).

[CM-5 ACCESS RESTRICTIONS FOR CHANGE](#)

Control: Define, document, approve, and enforce physical and logical access restrictions associated with changes to the system.

Discussion: Changes to the hardware, software, or firmware components of systems or the operational procedures related to the system can potentially have significant effects on the security of the systems or individuals' privacy. Therefore, organizations permit only qualified and authorized individuals to access systems for purposes of initiating changes. Access restrictions include physical and logical access controls (see [AC-3](#) and [PE-3](#)), software libraries, workflow automation, media libraries, abstract layers (i.e., changes implemented into external interfaces rather than directly into systems), and change windows (i.e., changes occur only during specified times).

Related Controls: [AC-3](#), [AC-5](#), [AC-6](#), [CM-9](#), [PE-3](#), [SC-28](#), [SC-34](#), [SC-37](#), [SI-2](#), [SI-10](#).

Control Enhancements:

(1) ACCESS RESTRICTIONS FOR CHANGE | [AUTOMATED ACCESS ENFORCEMENT AND AUDIT RECORDS](#)

- (a) Enforce access restrictions using [Assignment: organization-defined automated mechanisms]; and**
- (b) Automatically generate audit records of the enforcement actions.**

Discussion: Organizations log system accesses associated with applying configuration changes to ensure that configuration change control is implemented and to support after-the-fact actions should organizations discover any unauthorized changes.

Related Controls: [AU-2](#), [AU-6](#), [AU-7](#), [AU-12](#), [CM-6](#), [CM-11](#), [SI-12](#).

(2) ACCESS RESTRICTIONS FOR CHANGE | [REVIEW SYSTEM CHANGES](#)

[Withdrawn: Incorporated into [CM-3\(7\)](#).]

(3) ACCESS RESTRICTIONS FOR CHANGE | [SIGNED COMPONENTS](#)

[Withdrawn: Moved to [CM-14](#).]

(4) ACCESS RESTRICTIONS FOR CHANGE | [DUAL AUTHORIZATION](#)

Enforce dual authorization for implementing changes to [Assignment: organization-defined system components and system-level information].

Discussion: Organizations employ dual authorization to help ensure that any changes to selected system components and 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 approved changes. The individuals are also accountable for the changes. Dual authorization may also be known as two-person control. To reduce the risk of collusion, organizations consider rotating dual authorization duties to other individuals. System-level information includes operational procedures.

Related Controls: [AC-2](#), [AC-5](#), [CM-3](#).

(5) ACCESS RESTRICTIONS FOR CHANGE | [PRIVILEGE LIMITATION FOR PRODUCTION AND OPERATION](#)

- (a) Limit privileges to change system components and system-related information within a production or operational environment; and**
- (b) Review and reevaluate privileges [Assignment: organization-defined frequency].**

Discussion: In many organizations, systems support multiple mission and business functions. Limiting privileges to change system components with respect to operational systems is necessary because changes to a system component may have far-reaching effects on mission and business processes supported by the system. The relationships between systems and mission/business processes are, in some cases, unknown to developers. System-related information includes operational procedures.

Related Controls: [AC-2](#).

(6) ACCESS RESTRICTIONS FOR CHANGE | [LIMIT LIBRARY PRIVILEGES](#)

Limit privileges to change software resident within software libraries.

Discussion: Software libraries include privileged programs.

Related Controls: [AC-2](#).

(7) ACCESS RESTRICTIONS FOR CHANGE | AUTOMATIC IMPLEMENTATION OF SECURITY SAFEGUARDS

[Withdrawn: Incorporated into [SI-7](#).]

References: [\[FIPS 140-3\]](#); [\[FIPS 186-4\]](#).

CM-6 CONFIGURATION SETTINGS

Control:

- a. Establish and document configuration settings for components employed within the system that reflect the most restrictive mode consistent with operational requirements using [Assignment: organization-defined common secure configurations];
- b. Implement the configuration settings;
- c. Identify, document, and approve any deviations from established configuration settings for [Assignment: organization-defined system components] based on [Assignment: organization-defined operational requirements]; and
- d. Monitor and control changes to the configuration settings in accordance with organizational policies and procedures.

Discussion: Configuration settings are the parameters that can be changed in the hardware, software, or firmware components of the system that affect the security and privacy posture or functionality of the system. Information technology products for which configuration settings can be defined include mainframe computers, servers, workstations, operating systems, mobile devices, input/output devices, protocols, and applications. Parameters that impact the security posture of systems include registry settings; account, file, or directory permission settings; and settings for functions, protocols, ports, services, and remote connections. Privacy parameters are parameters impacting the privacy posture of systems, including the parameters required to satisfy other privacy controls. Privacy parameters include settings for access controls, data processing preferences, and processing and retention permissions. Organizations establish organization-wide configuration settings and subsequently derive specific configuration settings for systems. The established settings become part of the configuration baseline for the system.

Common secure configurations (also known as security configuration checklists, lockdown and hardening guides, and security reference guides) provide recognized, standardized, and established benchmarks that stipulate secure configuration settings for information technology

products and platforms as well as instructions for configuring those products or platforms to meet operational requirements. Common secure configurations can be developed by a variety of organizations, including information technology product developers, manufacturers, vendors, federal agencies, consortia, academia, industry, and other organizations in the public and private sectors.

Implementation of a common secure configuration may be mandated at the organization level, mission and business process level, system level, or at a higher level, including by a regulatory agency. Common secure configurations include the United States Government Configuration Baseline [[USGCB](#)] and security technical implementation guides (STIGs), which affect the implementation of [CM-6](#) and other controls such as [AC-19](#) and [CM-7](#). The Security Content Automation Protocol (SCAP) and the defined standards within the protocol provide an effective method to uniquely identify, track, and control configuration settings.

Related Controls: [AC-3](#), [AC-19](#), [AU-2](#), [AU-6](#), [CA-9](#), [CM-2](#), [CM-3](#), [CM-5](#), [CM-7](#), [CM-11](#), [CP-7](#), [CP-9](#), [CP-10](#), [IA-3](#), [IA-5](#), [PL-8](#), [PL-9](#), [RA-5](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-9](#), [SC-18](#), [SC-28](#), [SC-43](#), [SI-2](#), [SI-4](#), [SI-6](#).

Control Enhancements:

(1) CONFIGURATION SETTINGS | [AUTOMATED MANAGEMENT, APPLICATION, AND VERIFICATION](#)

Manage, apply, and verify configuration settings for [Assignment: organization-defined system components] using [Assignment: organization-defined automated mechanisms].

Discussion: Automated tools (e.g., hardening tools, baseline configuration tools) can improve the accuracy, consistency, and availability of configuration settings information. Automation can also provide data aggregation and data correlation capabilities, alerting mechanisms, and dashboards to support risk-based decision-making within the organization.

Related Controls: [CA-7](#).

(2) CONFIGURATION SETTINGS | [RESPOND TO UNAUTHORIZED CHANGES](#)

Take the following actions in response to unauthorized changes to [Assignment: organization-defined configuration settings]: [Assignment: organization-defined actions].

Discussion: Responses to unauthorized changes to configuration settings include alerting designated organizational personnel, restoring established configuration settings, or—in extreme cases—halting affected system processing.

Related Controls: [IR-4](#), [IR-6](#), [SI-7](#).

(3) CONFIGURATION SETTINGS | UNAUTHORIZED CHANGE DETECTION

[Withdrawn: Incorporated into [SI-7](#).]

(4) CONFIGURATION SETTINGS | CONFORMANCE DEMONSTRATION

[Withdrawn: Incorporated into [CM-4](#).]

References: [\[SP 800-70\]](#), [\[SP 800-126\]](#), [\[SP 800-128\]](#), [\[USGCB\]](#), [\[NCPR\]](#), [\[DOD STIG\]](#).

CM-7 LEAST FUNCTIONALITY

Control:

- a. Configure the system to provide only [Assignment: organization-defined mission essential capabilities]; and
- b. Prohibit or restrict the use of the following functions, ports, protocols, software, and/or services: [Assignment: organization-defined prohibited or restricted functions, system ports, protocols, software, and/or services].

Discussion: Systems provide a wide variety of functions and services. Some of the functions and services routinely provided by default may not be necessary to support essential organizational missions, functions, or operations. Additionally, it is sometimes convenient to provide multiple services from a single system component, but doing so increases risk over limiting the services provided by that single component. Where feasible, organizations limit component functionality to a single function per component. Organizations consider removing unused or unnecessary software and disabling unused or unnecessary physical and logical ports and protocols to prevent unauthorized connection of components, transfer of information, and tunneling. Organizations employ network scanning tools, intrusion detection and prevention systems, and end-point protection technologies, such as firewalls and host-based intrusion detection systems, to identify and prevent the use of prohibited functions, protocols, ports, and services. Least functionality can also be achieved as part of the fundamental design and development of the system (see [SA-8](#), [SC-2](#), and [SC-3](#)).

Related Controls: [AC-3](#), [AC-4](#), [CM-2](#), [CM-5](#), [CM-6](#), [CM-11](#), [RA-5](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-9](#), [SA-15](#), [SC-2](#), [SC-3](#), [SC-7](#), [SC-37](#), [SI-4](#).

Control Enhancements:

(1) LEAST FUNCTIONALITY | [PERIODIC REVIEW](#)

- (a) Review the system [Assignment: *organization-defined frequency*] to identify unnecessary and/or nonsecure functions, ports, protocols, software, and services; and**
- (b) Disable or remove [Assignment: *organization-defined functions, ports, protocols, software, and services within the system deemed to be unnecessary and/or nonsecure*].**

Discussion: Organizations review functions, ports, protocols, and services provided by systems or system components to determine the functions and services that are candidates for elimination. Such reviews are especially important during transition periods from older technologies to newer technologies (e.g., transition from IPv4 to IPv6). These technology transitions may require implementing the older and newer technologies simultaneously during the transition period and returning to minimum essential functions, ports, protocols, and services at the earliest opportunity. Organizations can either decide the relative security of the function, port, protocol, and/or service or base the security decision on the assessment of other entities. Unsecure protocols include Bluetooth, FTP, and peer-to-peer networking.

Related Controls: [AC-18](#).

(2) LEAST FUNCTIONALITY | [PREVENT PROGRAM EXECUTION](#)

Prevent program execution in accordance with [Selection (one or more): [Assignment: *organization-defined policies, rules of behavior, and/or access agreements regarding software program usage and restrictions*]; rules authorizing the terms and conditions of software program usage].

Discussion: Prevention of program execution addresses organizational policies, rules of behavior, and/or access agreements that restrict software usage and the terms and conditions imposed by the developer or manufacturer, including software licensing and copyrights. Restrictions include prohibiting auto-execute features, restricting roles allowed to approve program execution, permitting or prohibiting specific software programs, or restricting the number of program instances executed at the same time.

Related Controls: [CM-8](#), [PL-4](#), [PL-9](#), [PM-5](#), [PS-6](#).

(3) LEAST FUNCTIONALITY | [REGISTRATION COMPLIANCE](#)

Ensure compliance with [Assignment: *organization-defined registration requirements for functions, ports, protocols, and services*].

Discussion: Organizations use the registration process to manage, track, and provide oversight for systems and implemented functions, ports, protocols, and services.

Related Controls: None.

- (4) LEAST FUNCTIONALITY | [UNAUTHORIZED SOFTWARE — DENY-BY-EXCEPTION](#)
- (a) Identify [Assignment: organization-defined software programs not authorized to execute on the system];
 - (b) Employ an allow-all, deny-by-exception policy to prohibit the execution of unauthorized software programs on the system; and
 - (c) Review and update the list of unauthorized software programs [Assignment: organization-defined frequency].

Discussion: Unauthorized software programs can be limited to specific versions or from a specific source. The concept of prohibiting the execution of unauthorized software may also be applied to user actions, system ports and protocols, IP addresses/ranges, websites, and MAC addresses.

Related Controls: [CM-6](#), [CM-8](#), [CM-10](#), [PL-9](#), [PM-5](#).

- (5) LEAST FUNCTIONALITY | [AUTHORIZED SOFTWARE — ALLOW-BY-EXCEPTION](#)
- (a) Identify [Assignment: organization-defined software programs authorized to execute on the system];
 - (b) Employ a deny-all, permit-by-exception policy to allow the execution of authorized software programs on the system; and
 - (c) Review and update the list of authorized software programs [Assignment: organization-defined frequency].

Discussion: Authorized software programs can be limited to specific versions or from a specific source. To facilitate a comprehensive authorized software process and increase the strength of protection for attacks that bypass application level authorized software, software programs may be decomposed into and monitored at different levels of detail. These levels include applications, application programming interfaces, application modules, scripts, system processes, system services, kernel functions, registries, drivers, and dynamic link libraries. The concept of permitting the execution of authorized software may also be applied to user actions, system ports and protocols, IP addresses/ranges, websites, and MAC addresses. Organizations consider verifying the integrity of authorized software programs using digital signatures, cryptographic checksums, or hash functions. Verification of authorized software can occur either prior to execution or at system startup. The identification of authorized URLs for websites is addressed in [CA-3\(5\)](#) and [SC-7](#).

Related Controls: [CM-2](#), [CM-6](#), [CM-8](#), [CM-10](#), [PL-9](#), [PM-5](#), [SA-10](#), [SC-34](#), [SI-7](#).

- (6) LEAST FUNCTIONALITY | [CONFINED ENVIRONMENTS WITH LIMITED PRIVILEGES](#)
- Require that the following user-installed software execute in a confined physical or virtual machine environment with limited privileges: [Assignment: organization-defined user-installed software].**

Discussion: Organizations identify software that may be of concern regarding its origin or potential for containing malicious code. For this type of software, user installations occur in confined environments of operation to limit or contain damage from malicious code that may be executed.

Related Controls: [CM-11](#), [SC-44](#).

- (7) LEAST FUNCTIONALITY | [CODE EXECUTION IN PROTECTED ENVIRONMENTS](#)

Allow execution of binary or machine-executable code only in confined physical or virtual machine environments and with the explicit approval of [Assignment: organization-defined personnel or roles] when such code is:

- (a) Obtained from sources with limited or no warranty; and/or
- (b) Without the provision of source code.

Discussion: Code execution in protected environments applies to all sources of binary or machine-executable code, including commercial software and firmware and open-source software.

Related Controls: [CM-10](#), [SC-44](#).

(8) LEAST FUNCTIONALITY | [BINARY OR MACHINE EXECUTABLE CODE](#)

- (a) Prohibit the use of binary or machine-executable code from sources with limited or no warranty or without the provision of source code; and
- (b) Allow exceptions only for compelling mission or operational requirements and with the approval of the authorizing official.

Discussion: Binary or machine executable code applies to all sources of binary or machine-executable code, including commercial software and firmware and open-source software. Organizations assess software products without accompanying source code or from sources with limited or no warranty for potential security impacts. The assessments address the fact that software products without the provision of source code may be difficult to review, repair, or extend. In addition, there may be no owners to make such repairs on behalf of organizations. If open-source software is used, the assessments address the fact that there is no warranty, the open-source software could contain back doors or malware, and there may be no support available.

Related Controls: [SA-5](#), [SA-22](#).

(9) LEAST FUNCTIONALITY | [PROHIBITING THE USE OF UNAUTHORIZED HARDWARE](#)

- (a) Identify [Assignment: organization-defined hardware components authorized for system use];
- (b) Prohibit the use or connection of unauthorized hardware components;
- (c) Review and update the list of authorized hardware components [Assignment: organization-defined frequency].

Discussion: Hardware components provide the foundation for organizational systems and the platform for the execution of authorized software programs. Managing the inventory of hardware components and controlling which hardware components are permitted to be installed or connected to organizational systems is essential in order to provide adequate security.

Related Controls: None.

References: [\[FIPS 140-3\]](#), [\[FIPS 180-4\]](#), [\[FIPS 186-4\]](#), [\[FIPS 202\]](#), [\[SP 800-167\]](#).

[CM-8](#) SYSTEM COMPONENT INVENTORY

Control:

- a. Develop and document an inventory of system components that:
 1. Accurately reflects the system;
 2. Includes all components within the system;
 3. Does not include duplicate accounting of components or components assigned to any other system;

4. Is at the level of granularity deemed necessary for tracking and reporting; and
 5. Includes the following information to achieve system component accountability:
[Assignment: organization-defined information deemed necessary to achieve effective system component accountability]; and
- b. Review and update the system component inventory [Assignment: organization-defined frequency].

Discussion: System components are discrete, identifiable information technology assets that include hardware, software, and firmware. Organizations may choose to implement centralized system component inventories that include components from all organizational systems. In such situations, organizations ensure that the inventories include system-specific information required for component accountability. The information necessary for effective accountability of system components includes the system name, software owners, software version numbers, hardware inventory specifications, software license information, and for networked components, the machine names and network addresses across all implemented protocols (e.g., IPv4, IPv6). Inventory specifications include date of receipt, cost, model, serial number, manufacturer, supplier information, component type, and physical location.

Preventing duplicate accounting of system components addresses the lack of accountability that occurs when component ownership and system association is not known, especially in large or complex connected systems. Effective prevention of duplicate accounting of system components necessitates use of a unique identifier for each component. For software inventory, centrally managed software that is accessed via other systems is addressed as a component of the system on which it is installed and managed. Software installed on multiple organizational systems and managed at the system level is addressed for each individual system and may appear more than once in a centralized component inventory, necessitating a system association for each software instance in the centralized inventory to avoid duplicate accounting of components. Scanning systems implementing multiple network protocols (e.g., IPv4 and IPv6) can result in duplicate components being identified in different address spaces. The implementation of [CM-8\(7\)](#) can help to eliminate duplicate accounting of components.

Related Controls: [CM-2](#), [CM-7](#), [CM-9](#), [CM-10](#), [CM-11](#), [CM-13](#), [CP-2](#), [CP-9](#), [MA-2](#), [MA-6](#), [PE-20](#), [PL-9](#), [PM-5](#), [SA-4](#), [SA-5](#), [SI-2](#), [SR-4](#).

Control Enhancements:

(1) SYSTEM COMPONENT INVENTORY | [UPDATES DURING INSTALLATION AND REMOVAL](#)

Update the inventory of system components as part of component installations, removals, and system updates.

Discussion: Organizations can improve the accuracy, completeness, and consistency of system component inventories if the inventories are updated as part of component installations or removals or during general system updates. If inventories are not updated at these key times, there is a greater likelihood that the information will not be appropriately captured and documented. System updates include hardware, software, and firmware components.

Related Controls: [PM-16](#).

(2) SYSTEM COMPONENT INVENTORY | [AUTOMATED MAINTENANCE](#)

Maintain the currency, completeness, accuracy, and availability of the inventory of system components using [Assignment: organization-defined automated mechanisms].

Discussion: Organizations maintain system inventories to the extent feasible. For example, virtual machines can be difficult to monitor because such machines are not visible to the network when not in use. In such cases, organizations maintain as up-to-date, complete, and

accurate an inventory as is deemed reasonable. Automated maintenance can be achieved by the implementation of [CM-2\(2\)](#) for organizations that combine system component inventory and baseline configuration activities.

Related Controls: None.

- (3) SYSTEM COMPONENT INVENTORY | [AUTOMATED UNAUTHORIZED COMPONENT DETECTION](#)**
- (a) Detect the presence of unauthorized hardware, software, and firmware components within the system using [Assignment: organization-defined automated mechanisms] [Assignment: organization-defined frequency]; and**
 - (b) Take the following actions when unauthorized components are detected: [Selection (one or more): disable network access by such components; isolate the components; notify [Assignment: organization-defined personnel or roles]].**

Discussion: Automated unauthorized component detection is applied in addition to the monitoring for unauthorized remote connections and mobile devices. Monitoring for unauthorized system components may be accomplished on an ongoing basis or by the periodic scanning of systems for that purpose. Automated mechanisms may also be used to prevent the connection of unauthorized components (see [CM-7\(9\)](#)). Automated mechanisms can be implemented in systems or in separate system components. When acquiring and implementing automated mechanisms, organizations consider whether such mechanisms depend on the ability of the system component to support an agent or supplicant in order to be detected since some types of components do not have or cannot support agents (e.g., IoT devices, sensors). Isolation can be achieved , for example, by placing unauthorized system components in separate domains or subnets or quarantining such components. This type of component isolation is commonly referred to as “sandboxing.”

Related Controls: [AC-19](#), [CA-7](#), [RA-5](#), [SC-3](#), [SC-39](#), [SC-44](#), [SI-3](#), [SI-4](#), [SI-7](#).

- (4) SYSTEM COMPONENT INVENTORY | [ACCOUNTABILITY INFORMATION](#)**
- Include in the system component inventory information, a means for identifying by [Selection (one or more): name; position; role], individuals responsible and accountable for administering those components.**

Discussion: Identifying individuals who are responsible and accountable for administering system components ensures that the assigned components are properly administered and that organizations can contact those individuals if some action is required (e.g., when the component is determined to be the source of a breach, needs to be recalled or replaced, or needs to be relocated).

Related Controls: [AC-3](#).

- (5) SYSTEM COMPONENT INVENTORY | NO DUPLICATE ACCOUNTING OF COMPONENTS**
[Withdrawn: Incorporated into [CM-8](#).]
- (6) SYSTEM COMPONENT INVENTORY | [ASSESSED CONFIGURATIONS AND APPROVED DEVIATIONS](#)**
- Include assessed component configurations and any approved deviations to current deployed configurations in the system component inventory.**

Discussion: Assessed configurations and approved deviations focus on configuration settings established by organizations for system components, the specific components that have been assessed to determine compliance with the required configuration settings, and any approved deviations from established configuration settings.

Related Controls: None.

- (7) SYSTEM COMPONENT INVENTORY | [CENTRALIZED REPOSITORY](#)**
- Provide a centralized repository for the inventory of system components.**

Discussion: Organizations may implement centralized system component inventories that include components from all organizational systems. Centralized repositories of component inventories provide opportunities for efficiencies in accounting for organizational hardware, software, and firmware assets. Such repositories may also help organizations rapidly identify the location and responsible individuals of components that have been compromised, breached, or are otherwise in need of mitigation actions. Organizations ensure that the resulting centralized inventories include system-specific information required for proper component accountability.

Related Controls: None.

(8) SYSTEM COMPONENT INVENTORY | [AUTOMATED LOCATION TRACKING](#)

Support the tracking of system components by geographic location using [Assignment: organization-defined automated mechanisms].

Discussion: The use of automated mechanisms to track the location of system components can increase the accuracy of component inventories. Such capability may help organizations rapidly identify the location and responsible individuals of system components that have been compromised, breached, or are otherwise in need of mitigation actions. The use of tracking mechanisms can be coordinated with senior agency officials for privacy if there are implications that affect individual privacy.

Related Controls: None.

(9) SYSTEM COMPONENT INVENTORY | [ASSIGNMENT OF COMPONENTS TO SYSTEMS](#)

(a) Assign system components to a system; and

(b) Receive an acknowledgement from [Assignment: organization-defined personnel or roles] of this assignment.

Discussion: System components that are not assigned to a system may be unmanaged, lack the required protection, and become an organizational vulnerability.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), [\[SP 800-57-3\]](#), [\[SP 800-128\]](#), [\[IR 8011-2\]](#), [\[IR 8011-3\]](#).

CM-9 CONFIGURATION MANAGEMENT PLAN

Control: Develop, document, and implement a configuration management plan for the system that:

- a. Addresses roles, responsibilities, and configuration management processes and procedures;
- b. Establishes a process for identifying configuration items throughout the system development life cycle and for managing the configuration of the configuration items;
- c. Defines the configuration items for the system and places the configuration items under configuration management;
- d. Is reviewed and approved by [Assignment: organization-defined personnel or roles]; and
- e. Protects the configuration management plan from unauthorized disclosure and modification.

Discussion: Configuration management activities occur throughout the system development life cycle. As such, there are developmental configuration management activities (e.g., the control of code and software libraries) and operational configuration management activities (e.g., control of installed components and how the components are configured). Configuration management plans satisfy the requirements in configuration management policies while being tailored to

individual systems. Configuration management plans define processes and procedures for how configuration management is used to support system development life cycle activities.

Configuration management plans are generated during the development and acquisition stage of the system development life cycle. The plans describe how to advance changes through change management processes; update configuration settings and baselines; maintain component inventories; control development, test, and operational environments; and develop, release, and update key documents.

Organizations can employ templates to help ensure the consistent and timely development and implementation of configuration management plans. Templates can represent a configuration management plan for the organization with subsets of the plan implemented on a system by system basis. Configuration management approval processes include the designation of key stakeholders responsible for reviewing and approving proposed changes to systems, and personnel who conduct security and privacy impact analyses prior to the implementation of changes to the systems. Configuration items are the system components, such as the hardware, software, firmware, and documentation to be configuration-managed. As systems continue through the system development life cycle, new configuration items may be identified, and some existing configuration items may no longer need to be under configuration control.

Related Controls: [CM-2](#), [CM-3](#), [CM-4](#), [CM-5](#), [CM-8](#), [PL-2](#), [RA-8](#), [SA-10](#), [SI-12](#).

Control Enhancements:

(1) CONFIGURATION MANAGEMENT PLAN | [ASSIGNMENT OF RESPONSIBILITY](#)

Assign responsibility for developing the configuration management process to organizational personnel that are not directly involved in system development.

Discussion: In the absence of dedicated configuration management teams assigned within organizations, system developers may be tasked with developing configuration management processes using personnel who are not directly involved in system development or system integration. This separation of duties ensures that organizations establish and maintain a sufficient degree of independence between the system development and integration processes and configuration management processes to facilitate quality control and more effective oversight.

Related Controls: None.

References: [\[SP 800-128\]](#).

[CM-10 SOFTWARE USAGE RESTRICTIONS](#)

Control:

- a. Use software and associated documentation in accordance with contract agreements and copyright laws;
- b. Track the use of software and associated documentation protected by quantity licenses to control copying and distribution; and
- c. Control and document the use of peer-to-peer file sharing technology to ensure that this capability is not used for the unauthorized distribution, display, performance, or reproduction of copyrighted work.

Discussion: Software license tracking can be accomplished by manual or automated methods, depending on organizational needs. Examples of contract agreements include software license agreements and non-disclosure agreements.

Related Controls: [AC-17](#), [AU-6](#), [CM-7](#), [CM-8](#), [PM-30](#), [SC-7](#).

Control Enhancements:**(1) SOFTWARE USAGE RESTRICTIONS | [OPEN-SOURCE SOFTWARE](#)**

Establish the following restrictions on the use of open-source software: [Assignment: organization-defined restrictions].

Discussion: Open-source software refers to software that is available in source code form. Certain software rights normally reserved for copyright holders are routinely provided under software license agreements that permit individuals to study, change, and improve the software. From a security perspective, the major advantage of open-source software is that it provides organizations with the ability to examine the source code. In some cases, there is an online community associated with the software that inspects, tests, updates, and reports on issues found in software on an ongoing basis. However, remediating vulnerabilities in open-source software may be problematic. There may also be licensing issues associated with open-source software, including the constraints on derivative use of such software. Open-source software that is available only in binary form may increase the level of risk in using such software.

Related Controls: [SI-7](#).

References: None.

CM-11 USER-INSTALLED SOFTWARE**Control:**

- a. Establish [Assignment: organization-defined policies] governing the installation of software by users;
- b. Enforce software installation policies through the following methods: [Assignment: organization-defined methods]; and
- c. Monitor policy compliance [Assignment: organization-defined frequency].

Discussion: If provided the necessary privileges, users can install software in organizational systems. To maintain control over the software installed, organizations identify permitted and prohibited actions regarding software installation. Permitted software installations include updates and security patches to existing software and downloading new applications from organization-approved “app stores.” Prohibited software installations include software with unknown or suspect pedigrees or software that organizations consider potentially malicious. Policies selected for governing user-installed software are organization-developed or provided by some external entity. Policy enforcement methods can include procedural methods and automated methods.

Related Controls: [AC-3](#), [AU-6](#), [CM-2](#), [CM-3](#), [CM-5](#), [CM-6](#), [CM-7](#), [CM-8](#), [PL-4](#), [SI-4](#), [SI-7](#).

Control Enhancements:**(1) USER-INSTALLED SOFTWARE | ALERTS FOR UNAUTHORIZED INSTALLATIONS**

[Withdrawn: Incorporated into [CM-8\(3\)](#).]

(2) USER-INSTALLED SOFTWARE | [SOFTWARE INSTALLATION WITH PRIVILEGED STATUS](#)

Allow user installation of software only with explicit privileged status.

Discussion: Privileged status can be obtained, for example, by serving in the role of system administrator.

Related Controls: [AC-5](#), [AC-6](#).

(3) USER-INSTALLED SOFTWARE | [AUTOMATED ENFORCEMENT AND MONITORING](#)

Enforce and monitor compliance with software installation policies using [Assignment: organization-defined automated mechanisms].

Discussion: Organizations enforce and monitor compliance with software installation policies using automated mechanisms to more quickly detect and respond to unauthorized software installation which can be an indicator of an internal or external hostile attack.

Related Controls: None.

References: None.

CM-12 INFORMATION LOCATION

Control:

- a. Identify and document the location of [Assignment: organization-defined information] and the specific system components on which the information is processed and stored;
- b. Identify and document the users who have access to the system and system components where the information is processed and stored; and
- c. Document changes to the location (i.e., system or system components) where the information is processed and stored.

Discussion: Information location addresses the need to understand where information is being processed and stored. Information location includes identifying where specific information types and information reside in system components and how information is being processed so that information flow can be understood and adequate protection and policy management provided for such information and system components. The security category of the information is also a factor in determining the controls necessary to protect the information and the system component where the information resides (see [FIPS 199](#)). The location of the information and system components is also a factor in the architecture and design of the system (see [SA-4](#), [SA-8](#), [SA-17](#), [SC-4](#), [SC-16](#), [SC-28](#), [SI-4](#), [SI-7](#)).

Related Controls: [AC-2](#), [AC-3](#), [AC-4](#), [AC-6](#), [AC-23](#), [CM-8](#), [PM-5](#), [RA-2](#), [SA-4](#), [SA-8](#), [SA-17](#), [SC-4](#), [SC-16](#), [SC-28](#), [SI-4](#), [SI-7](#).

Control Enhancements:

(1) INFORMATION LOCATION | AUTOMATED TOOLS TO SUPPORT INFORMATION LOCATION

Use automated tools to identify [Assignment: organization-defined information by information type] on [Assignment: organization-defined system components] to ensure controls are in place to protect organizational information and individual privacy.

Discussion: The use of automated tools helps to increase the effectiveness and efficiency of the information location capability implemented within the system. Automation also helps organizations manage the data produced during information location activities and share such information across the organization. The output of automated information location tools can be used to guide and inform system architecture and design decisions.

Related Controls: None.

References: [\[FIPS 199\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#).

CM-13 DATA ACTION MAPPING

Control: Develop and document a map of system data actions.

Discussion: Data actions are system operations that process personally identifiable information. The processing of such information encompasses the full information life cycle, which includes collection, generation, transformation, use, disclosure, retention, and disposal. A map of system

data actions includes discrete data actions, elements of personally identifiable information being processed in the data actions, system components involved in the data actions, and the owners or operators of the system components. Understanding what personally identifiable information is being processed (e.g., the sensitivity of the personally identifiable information), how personally identifiable information is being processed (e.g., if the data action is visible to the individual or is processed in another part of the system), and by whom (e.g., individuals may have different privacy perceptions based on the entity that is processing the personally identifiable information) provides a number of contextual factors that are important to assessing the degree of privacy risk created by the system. Data maps can be illustrated in different ways, and the level of detail may vary based on the mission and business needs of the organization. The data map may be an overlay of any system design artifact that the organization is using. The development of this map may necessitate coordination between the privacy and security programs regarding the covered data actions and the components that are identified as part of the system.

Related Controls: [AC-3](#), [CM-4](#), [CM-12](#), [PM-5](#), [PM-27](#), [PT-2](#), [PT-3](#), [RA-3](#), [RA-8](#).

CM-14 SIGNED COMPONENTS

Control: Prevent the installation of [Assignment: organization-defined software and firmware components] without verification that the component has been digitally signed using a certificate that is recognized and approved by the organization.

Discussion: Software and firmware components prevented from installation unless signed with recognized and approved certificates include software and firmware version updates, patches, service packs, device drivers, and basic input/output system updates. Organizations can identify applicable software and firmware components by type, by specific items, or a combination of both. Digital signatures and organizational verification of such signatures is a method of code authentication.

Related Controls: [CM-7](#), [SC-12](#), [SC-13](#), [SI-7](#).

References: [\[IR 8062\]](#).

3.6 CONTINGENCY PLANNING

[Quick link to Contingency Planning Summary Table](#)

CP-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] contingency planning policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the contingency planning policy and the associated contingency planning controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the contingency planning policy and procedures; and
- c. Review and update the current contingency planning:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Contingency planning policy and procedures address the controls in the CP family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of contingency planning policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to contingency planning policy and procedures include assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-34\]](#), [\[SP 800-39\]](#), [\[SP 800-50\]](#), [\[SP 800-100\]](#).

CP-2 CONTINGENCY PLAN**Control:**

- a. Develop a contingency plan for the system that:
 1. Identifies essential mission and business functions and associated contingency requirements;
 2. Provides recovery objectives, restoration priorities, and metrics;
 3. Addresses contingency roles, responsibilities, assigned individuals with contact information;
 4. Addresses maintaining essential mission and business functions despite a system disruption, compromise, or failure;
 5. Addresses eventual, full system restoration without deterioration of the controls originally planned and implemented;
 6. Addresses the sharing of contingency information; and
 7. Is reviewed and approved by [Assignment: organization-defined personnel or roles];
- b. Distribute copies of the contingency plan to [Assignment: organization-defined key contingency personnel (*identified by name and/or by role*) and organizational elements];
- c. Coordinate contingency planning activities with incident handling activities;
- d. Review the contingency plan for the system [Assignment: organization-defined frequency];
- e. Update the contingency plan to address changes to the organization, system, or environment of operation and problems encountered during contingency plan implementation, execution, or testing;
- f. Communicate contingency plan changes to [Assignment: organization-defined key contingency personnel (*identified by name and/or by role*) and organizational elements];
- g. Incorporate lessons learned from contingency plan testing, training, or actual contingency activities into contingency testing and training; and
- h. Protect the contingency plan from unauthorized disclosure and modification.

Discussion: Contingency planning for systems is part of an overall program for achieving continuity of operations for organizational mission and business functions. Contingency planning addresses system restoration and implementation of alternative mission or business processes when systems are compromised or breached. Contingency planning is considered throughout the system development life cycle and is a fundamental part of the system design. Systems can be designed for redundancy, to provide backup capabilities, and for resilience. Contingency plans reflect the degree of restoration required for organizational systems since not all systems need to fully recover to achieve the level of continuity of operations desired. System recovery objectives reflect applicable laws, executive orders, directives, regulations, policies, standards, guidelines, organizational risk tolerance, and system impact level.

Actions addressed in contingency plans include orderly system degradation, system shutdown, fallback to a manual mode, alternate information flows, and operating in modes reserved for when systems are under attack. By coordinating contingency planning with incident handling activities, organizations ensure that the necessary planning activities are in place and activated in the event of an incident. Organizations consider whether continuity of operations during an incident conflicts with the capability to automatically disable the system, as specified in [IR-4\(5\)](#). Incident response planning is part of contingency planning for organizations and is addressed in the [IR](#) (Incident Response) family.

Related Controls: [CP-3](#), [CP-4](#), [CP-6](#), [CP-7](#), [CP-8](#), [CP-9](#), [CP-10](#), [CP-11](#), [CP-13](#), [IR-4](#), [IR-6](#), [IR-8](#), [IR-9](#), [MA-6](#), [MP-2](#), [MP-4](#), [MP-5](#), [PL-2](#), [PM-8](#), [PM-11](#), [SA-15](#), [SA-20](#), [SC-7](#), [SC-23](#), [SI-12](#).

Control Enhancements:

(1) CONTINGENCY PLAN | [COORDINATE WITH RELATED PLANS](#)

Coordinate contingency plan development with organizational elements responsible for related plans.

Discussion: Plans that are related to contingency plans include Business Continuity Plans, Disaster Recovery Plans, Critical Infrastructure Plans, Continuity of Operations Plans, Crisis Communications Plans, Insider Threat Implementation Plans, Data Breach Response Plans, Cyber Incident Response Plans, Breach Response Plans, and Occupant Emergency Plans.

Related Controls: None.

(2) CONTINGENCY PLAN | [CAPACITY PLANNING](#)

Conduct capacity planning so that necessary capacity for information processing, telecommunications, and environmental support exists during contingency operations.

Discussion: Capacity planning is needed because different threats can result in a reduction of the available processing, telecommunications, and support services intended to support essential mission and business functions. Organizations anticipate degraded operations during contingency operations and factor the degradation into capacity planning. For capacity planning, environmental support refers to any environmental factor for which the organization determines that it needs to provide support in a contingency situation, even if in a degraded state. Such determinations are based on an organizational assessment of risk, system categorization (impact level), and organizational risk tolerance.

Related Controls: [PE-11](#), [PE-12](#), [PE-13](#), [PE-14](#), [PE-18](#), [SC-5](#).

(3) CONTINGENCY PLAN | [RESUME MISSION AND BUSINESS FUNCTIONS](#)

Plan for the resumption of [Selection: all; essential] mission and business functions within [Assignment: organization-defined time period] of contingency plan activation.

Discussion: Organizations may choose to conduct contingency planning activities to resume mission and business functions as part of business continuity planning or as part of business impact analyses. Organizations prioritize the resumption of mission and business functions. The time period for resuming mission and business functions may be dependent on the severity and extent of the disruptions to the system and its supporting infrastructure.

Related Controls: None.

(4) CONTINGENCY PLAN | RESUME ALL MISSION AND BUSINESS FUNCTIONS

[Withdrawn: Incorporated into [CP-2\(3\)](#).]

(5) CONTINGENCY PLAN | [CONTINUE MISSION AND BUSINESS FUNCTIONS](#)

Plan for the continuance of [Selection: all; essential] mission and business functions with minimal or no loss of operational continuity and sustains that continuity until full system restoration at primary processing and/or storage sites.

Discussion: Organizations may choose to conduct the contingency planning activities to continue mission and business functions as part of business continuity planning or business impact analyses. Primary processing and/or storage sites defined by organizations as part of contingency planning may change depending on the circumstances associated with the contingency.

Related Controls: None.

(6) CONTINGENCY PLAN | [ALTERNATE PROCESSING AND STORAGE SITES](#)

Plan for the transfer of [Selection: all; essential] mission and business functions to alternate processing and/or storage sites with minimal or no loss of operational continuity and sustain that continuity through system restoration to primary processing and/or storage sites.

Discussion: Organizations may choose to conduct contingency planning activities for alternate processing and storage sites as part of business continuity planning or business impact analyses. Primary processing and/or storage sites defined by organizations as part of contingency planning may change depending on the circumstances associated with the contingency.

Related Controls: None.

(7) CONTINGENCY PLAN | [COORDINATE WITH EXTERNAL SERVICE PROVIDERS](#)

Coordinate the contingency plan with the contingency plans of external service providers to ensure that contingency requirements can be satisfied.

Discussion: When the capability of an organization to carry out its mission and business functions is dependent on external service providers, developing a comprehensive and timely contingency plan may become more challenging. When mission and business functions are dependent on external service providers, organizations coordinate contingency planning activities with the external entities to ensure that the individual plans reflect the overall contingency needs of the organization.

Related Controls: [SA-9](#).

(8) CONTINGENCY PLAN | [IDENTIFY CRITICAL ASSETS](#)

Identify critical system assets supporting [Selection: all; essential] mission and business functions.

Discussion: Organizations may choose to identify critical assets as part of criticality analysis, business continuity planning, or business impact analyses. Organizations identify critical system assets so that additional controls can be employed (beyond the controls routinely implemented) to help ensure that organizational mission and business functions can continue to be conducted during contingency operations. The identification of critical information assets also facilitates the prioritization of organizational resources. Critical system assets include technical and operational aspects. Technical aspects include system components, information technology services, information technology products, and mechanisms. Operational aspects include procedures (i.e., manually executed operations) and personnel (i.e., individuals operating technical controls and/or executing manual procedures). Organizational program protection plans can assist in identifying critical assets. If critical assets are resident within or supported by external service providers, organizations consider implementing [CP-2\(7\)](#) as a control enhancement.

Related Controls: [CM-8](#), [RA-9](#).

References: [\[SP 800-34\]](#), [\[IR 8179\]](#).

[CP-3](#) CONTINGENCY TRAINING

Control:

- a. Provide contingency training to system users consistent with assigned roles and responsibilities:
 1. Within [Assignment: organization-defined time period] of assuming a contingency role or responsibility;
 2. When required by system changes; and

3. [Assignment: organization-defined frequency] thereafter; and
- b. Review and update contingency training content [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Contingency training provided by organizations is linked to the assigned roles and responsibilities of organizational personnel to ensure that the appropriate content and level of detail is included in such training. For example, some individuals may only need to know when and where to report for duty during contingency operations and if normal duties are affected; system administrators may require additional training on how to establish systems at alternate processing and storage sites; and organizational officials may receive more specific training on how to conduct mission-essential functions in designated off-site locations and how to establish communications with other governmental entities for purposes of coordination on contingency-related activities. Training for contingency roles or responsibilities reflects the specific continuity requirements in the contingency plan. Events that may precipitate an update to contingency training content include, but are not limited to, contingency plan testing or an actual contingency (lessons learned), assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. At the discretion of the organization, participation in a contingency plan test or exercise, including lessons learned sessions subsequent to the test or exercise, may satisfy contingency plan training requirements.

Related Controls: [AT-2](#), [AT-3](#), [AT-4](#), [CP-2](#), [CP-4](#), [CP-8](#), [IR-2](#), [IR-4](#), [IR-9](#).

Control Enhancements:

(1) CONTINGENCY TRAINING | [SIMULATED EVENTS](#)

Incorporate simulated events into contingency training to facilitate effective response by personnel in crisis situations.

Discussion: The use of simulated events creates an environment for personnel to experience actual threat events, including cyber-attacks that disable websites, ransomware attacks that encrypt organizational data on servers, hurricanes that damage or destroy organizational facilities, or hardware or software failures.

Related Controls: None.

(2) CONTINGENCY TRAINING | [MECHANISMS USED IN TRAINING ENVIRONMENTS](#)

Employ mechanisms used in operations to provide a more thorough and realistic contingency training environment.

Discussion: Operational mechanisms refer to processes that have been established to accomplish an organizational goal or a system that supports a particular organizational mission or business objective. Actual mission and business processes, systems, and/or facilities may be used to generate simulated events and enhance the realism of simulated events during contingency training.

Related Controls: None.

References: [\[SP 800-50\]](#).

CP-4 CONTINGENCY PLAN TESTING

Control:

- a. Test the contingency plan for the system [Assignment: organization-defined frequency] using the following tests to determine the effectiveness of the plan and the readiness to execute the plan: [Assignment: organization-defined tests].
- b. Review the contingency plan test results; and

- c. Initiate corrective actions, if needed.

Discussion: Methods for testing contingency plans to determine the effectiveness of the plans and identify potential weaknesses include checklists, walk-through and tabletop exercises, simulations (parallel or full interrupt), and comprehensive exercises. Organizations conduct testing based on the requirements in contingency plans and include a determination of the effects on organizational operations, assets, and individuals due to contingency operations. Organizations have flexibility and discretion in the breadth, depth, and timelines of corrective actions.

Related Controls: [AT-3](#), [CP-2](#), [CP-3](#), [CP-8](#), [CP-9](#), [IR-3](#), [IR-4](#), [PL-2](#), [PM-14](#), [SR-2](#).

Control Enhancements:

(1) CONTINGENCY PLAN TESTING | [COORDINATE WITH RELATED PLANS](#)

Coordinate contingency plan testing with organizational elements responsible for related plans.

Discussion: Plans related to contingency planning for organizational systems include Business Continuity Plans, Disaster Recovery Plans, Continuity of Operations Plans, Crisis Communications Plans, Critical Infrastructure Plans, Cyber Incident Response Plans, and Occupant Emergency Plans. Coordination of contingency plan testing does not require organizations to create organizational elements to handle related plans or to align such elements with specific plans. However, it does require that if such organizational elements are responsible for related plans, organizations coordinate with those elements.

Related Controls: [IR-8](#), [PM-8](#).

(2) CONTINGENCY PLAN TESTING | [ALTERNATE PROCESSING SITE](#)

Test the contingency plan at the alternate processing site:

- (a) To familiarize contingency personnel with the facility and available resources; and**
- (b) To evaluate the capabilities of the alternate processing site to support contingency operations.**

Discussion: Conditions at the alternate processing site may be significantly different than the conditions at the primary site. Having the opportunity to visit the alternate site and experience the actual capabilities available at the site can provide valuable information on potential vulnerabilities that could affect essential organizational mission and business functions. The on-site visit can also provide an opportunity to refine the contingency plan to address the vulnerabilities discovered during testing.

Related Controls: [CP-7](#).

(3) CONTINGENCY PLAN TESTING | [AUTOMATED TESTING](#)

Test the contingency plan using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms facilitate thorough and effective testing of contingency plans by providing more complete coverage of contingency issues, selecting more realistic test scenarios and environments, and effectively stressing the system and supported mission and business functions.

Related Controls: None.

(4) CONTINGENCY PLAN TESTING | [FULL RECOVERY AND RECONSTITUTION](#)

Include a full recovery and reconstitution of the system to a known state as part of contingency plan testing.

Discussion: Recovery is executing contingency plan activities to restore organizational mission and business functions. Reconstitution takes place following recovery and includes

activities for returning systems to fully operational states. Organizations establish a known state for systems that includes system state information for hardware, software programs, and data. Preserving system state information facilitates system restart and return to the operational mode of organizations with less disruption of mission and business processes.

Related Controls: [CP-10](#), [SC-24](#).

(5) CONTINGENCY PLAN TESTING | [SELF-CHALLENGE](#)

Employ [Assignment: organization-defined mechanisms] to [Assignment: organization-defined system or system component] to disrupt and adversely affect the system or system component.

Discussion: Often, the best method of assessing system resilience is to disrupt the system in some manner. The mechanisms used by the organization could disrupt system functions or system services in many ways, including terminating or disabling critical system components, changing the configuration of system components, degrading critical functionality (e.g., restricting network bandwidth), or altering privileges. Automated, on-going, and simulated cyber-attacks and service disruptions can reveal unexpected functional dependencies and help the organization determine its ability to ensure resilience in the face of an actual cyber-attack.

Related Controls: None.

References: [\[FIPS 199\]](#), [\[SP 800-34\]](#), [\[SP 800-84\]](#), [\[SP 800-160-2\]](#).

CP-5 CONTINGENCY PLAN UPDATE

[Withdrawn: Incorporated into [CP-2](#).]

CP-6 ALTERNATE STORAGE SITE

Control:

- a. Establish an alternate storage site, including necessary agreements to permit the storage and retrieval of system backup information; and
- b. Ensure that the alternate storage site provides controls equivalent to that of the primary site.

Discussion: Alternate storage sites are geographically distinct from primary storage sites and maintain duplicate copies of information and data if the primary storage site is not available. Similarly, alternate processing sites provide processing capability if the primary processing site is not available. Geographically distributed architectures that support contingency requirements may be considered alternate storage sites. Items covered by alternate storage site agreements include environmental conditions at the alternate sites, access rules for systems and facilities, physical and environmental protection requirements, and coordination of delivery and retrieval of backup media. Alternate storage sites reflect the requirements in contingency plans so that organizations can maintain essential mission and business functions despite compromise, failure, or disruption in organizational systems.

Related Controls: [CP-2](#), [CP-7](#), [CP-8](#), [CP-9](#), [CP-10](#), [MP-4](#), [MP-5](#), [PE-3](#), [SC-36](#), [SI-13](#).

Control Enhancements:

(1) ALTERNATE STORAGE SITE | [SEPARATION FROM PRIMARY SITE](#)

Identify an alternate storage site that is sufficiently separated from the primary storage site to reduce susceptibility to the same threats.

Discussion: Threats that affect alternate storage sites are defined in organizational risk assessments and include natural disasters, structural failures, hostile attacks, and errors of

omission or commission. Organizations determine what is considered a sufficient degree of separation between primary and alternate storage sites based on the types of threats that are of concern. For threats such as hostile attacks, the degree of separation between sites is less relevant.

Related Controls: [RA-3](#).

(2) ALTERNATE STORAGE SITE | [RECOVERY TIME AND RECOVERY POINT OBJECTIVES](#)

Configure the alternate storage site to facilitate recovery operations in accordance with recovery time and recovery point objectives.

Discussion: Organizations establish recovery time and recovery point objectives as part of contingency planning. Configuration of the alternate storage site includes physical facilities and the systems supporting recovery operations that ensure accessibility and correct execution.

Related Controls: None.

(3) ALTERNATE STORAGE SITE | [ACCESSIBILITY](#)

Identify potential accessibility problems to the alternate storage site in the event of an area-wide disruption or disaster and outline explicit mitigation actions.

Discussion: Area-wide disruptions refer to those types of disruptions that are broad in geographic scope with such determinations made by organizations based on organizational assessments of risk. Explicit mitigation actions include duplicating backup information at other alternate storage sites if access problems occur at originally designated alternate sites or planning for physical access to retrieve backup information if electronic accessibility to the alternate site is disrupted.

Related Controls: [RA-3](#).

References: [\[SP 800-34\]](#).

CP-7 ALTERNATE PROCESSING SITE

Control:

- a. Establish an alternate processing site, including necessary agreements to permit the transfer and resumption of [Assignment: organization-defined system operations] for essential mission and business functions within [Assignment: organization-defined time period consistent with recovery time and recovery point objectives] when the primary processing capabilities are unavailable;
- b. Make available at the alternate processing site, the equipment and supplies required to transfer and resume operations or put contracts in place to support delivery to the site within the organization-defined time period for transfer and resumption; and
- c. Provide controls at the alternate processing site that are equivalent to those at the primary site.

Discussion: Alternate processing sites are geographically distinct from primary processing sites and provide processing capability if the primary processing site is not available. The alternate processing capability may be addressed using a physical processing site or other alternatives, such as failover to a cloud-based service provider or other internally or externally provided processing service. Geographically distributed architectures that support contingency requirements may also be considered alternate processing sites. Controls that are covered by alternate processing site agreements include the environmental conditions at alternate sites, access rules, physical and environmental protection requirements, and the coordination for the transfer and assignment of personnel. Requirements are allocated to alternate processing sites

that reflect the requirements in contingency plans to maintain essential mission and business functions despite disruption, compromise, or failure in organizational systems.

Related Controls: [CP-2](#), [CP-6](#), [CP-8](#), [CP-9](#), [CP-10](#), [MA-6](#), [PE-3](#), [PE-11](#), [PE-12](#), [PE-17](#), [SC-36](#), [SI-13](#).

Control Enhancements:

(1) ALTERNATE PROCESSING SITE | [SEPARATION FROM PRIMARY SITE](#)

Identify an alternate processing site that is sufficiently separated from the primary processing site to reduce susceptibility to the same threats.

Discussion: Threats that affect alternate processing sites are defined in organizational assessments of risk and include natural disasters, structural failures, hostile attacks, and errors of omission or commission. Organizations determine what is considered a sufficient degree of separation between primary and alternate processing sites based on the types of threats that are of concern. For threats such as hostile attacks, the degree of separation between sites is less relevant.

Related Controls: [RA-3](#).

(2) ALTERNATE PROCESSING SITE | [ACCESSIBILITY](#)

Identify potential accessibility problems to alternate processing sites in the event of an area-wide disruption or disaster and outlines explicit mitigation actions.

Discussion: Area-wide disruptions refer to those types of disruptions that are broad in geographic scope with such determinations made by organizations based on organizational assessments of risk.

Related Controls: [RA-3](#).

(3) ALTERNATE PROCESSING SITE | [PRIORITY OF SERVICE](#)

Develop alternate processing site agreements that contain priority-of-service provisions in accordance with availability requirements (including recovery time objectives).

Discussion: Priority of service agreements refer to negotiated agreements with service providers that ensure that organizations receive priority treatment consistent with their availability requirements and the availability of information resources for logical alternate processing and/or at the physical alternate processing site. Organizations establish recovery time objectives as part of contingency planning.

Related Controls: None.

(4) ALTERNATE PROCESSING SITE | [PREPARATION FOR USE](#)

Prepare the alternate processing site so that the site can serve as the operational site supporting essential mission and business functions.

Discussion: Site preparation includes establishing configuration settings for systems at the alternate processing site consistent with the requirements for such settings at the primary site and ensuring that essential supplies and logistical considerations are in place.

Related Controls: [CM-2](#), [CM-6](#), [CP-4](#).

(5) ALTERNATE PROCESSING SITE | EQUIVALENT INFORMATION SECURITY SAFEGUARDS

[Withdrawn: Incorporated into [CP-7](#).]

(6) ALTERNATE PROCESSING SITE | [INABILITY TO RETURN TO PRIMARY SITE](#)

Plan and prepare for circumstances that preclude returning to the primary processing site.

Discussion: There may be situations that preclude an organization from returning to the primary processing site such as if a natural disaster (e.g., flood or a hurricane) damaged or

destroyed a facility and it was determined that rebuilding in the same location was not prudent.

Related Controls: None.

References: [[SP 800-34](#)].

[**CP-8 TELECOMMUNICATIONS SERVICES**](#)

Control: Establish alternate telecommunications services, including necessary agreements to permit the resumption of [Assignment: organization-defined system operations] for essential mission and business functions within [Assignment: organization-defined time period] when the primary telecommunications capabilities are unavailable at either the primary or alternate processing or storage sites.

Discussion: Telecommunications services (for data and voice) for primary and alternate processing and storage sites are in scope for [CP-8](#). Alternate telecommunications services reflect the continuity requirements in contingency plans to maintain essential mission and business functions despite the loss of primary telecommunications services. Organizations may specify different time periods for primary or alternate sites. Alternate telecommunications services include additional organizational or commercial ground-based circuits or lines, network-based approaches to telecommunications, or the use of satellites. Organizations consider factors such as availability, quality of service, and access when entering into alternate telecommunications agreements.

Related Controls: [CP-2](#), [CP-6](#), [CP-7](#), [CP-11](#), [SC-7](#).

Control Enhancements:

(1) TELECOMMUNICATIONS SERVICES | [PRIORITY OF SERVICE PROVISIONS](#)

- (a) Develop primary and alternate telecommunications service agreements that contain priority-of-service provisions in accordance with availability requirements (including recovery time objectives); and**
- (b) Request Telecommunications Service Priority for all telecommunications services used for national security emergency preparedness if the primary and/or alternate telecommunications services are provided by a common carrier.**

Discussion: Organizations consider the potential mission or business impact in situations where telecommunications service providers are servicing other organizations with similar priority of service provisions. Telecommunications Service Priority (TSP) is a Federal Communications Commission (FCC) program that directs telecommunications service providers (e.g., wireline and wireless phone companies) to give preferential treatment to users enrolled in the program when they need to add new lines or have their lines restored following a disruption of service, regardless of the cause. The FCC sets the rules and policies for the TSP program, and the Department of Homeland Security manages the TSP program. The TSP program is always in effect and not contingent on a major disaster or attack taking place. Federal sponsorship is required to enroll in the TSP program.

Related Controls: None.

(2) TELECOMMUNICATIONS SERVICES | [SINGLE POINTS OF FAILURE](#)

Obtain alternate telecommunications services to reduce the likelihood of sharing a single point of failure with primary telecommunications services.

Discussion: In certain circumstances, telecommunications service providers or services may share the same physical lines, which increases the vulnerability of a single failure point. It is important to have provider transparency for the actual physical transmission capability for telecommunication services.

Related Controls: None.

(3) TELECOMMUNICATIONS SERVICES | [SEPARATION OF PRIMARY AND ALTERNATE PROVIDERS](#)

Obtain alternate telecommunications services from providers that are separated from primary service providers to reduce susceptibility to the same threats.

Discussion: Threats that affect telecommunications services are defined in organizational assessments of risk and include natural disasters, structural failures, cyber or physical attacks, and errors of omission or commission. Organizations can reduce common susceptibilities by minimizing shared infrastructure among telecommunications service providers and achieving sufficient geographic separation between services. Organizations may consider using a single service provider in situations where the service provider can provide alternate telecommunications services that meet the separation needs addressed in the risk assessment.

Related Controls: None.

(4) TELECOMMUNICATIONS SERVICES | [PROVIDER CONTINGENCY PLAN](#)

- (a) Require primary and alternate telecommunications service providers to have contingency plans;**
- (b) Review provider contingency plans to ensure that the plans meet organizational contingency requirements; and**
- (c) Obtain evidence of contingency testing and training by providers [Assignment: organization-defined frequency].**

Discussion: Reviews of provider contingency plans consider the proprietary nature of such plans. In some situations, a summary of provider contingency plans may be sufficient evidence for organizations to satisfy the review requirement. Telecommunications service providers may also participate in ongoing disaster recovery exercises in coordination with the Department of Homeland Security and state and local governments. Organizations may use these types of activities to satisfy evidentiary requirements related to service provider contingency plan reviews, testing, and training.

Related Controls: [CP-3](#), [CP-4](#).

(5) TELECOMMUNICATIONS SERVICES | [ALTERNATE TELECOMMUNICATION SERVICE TESTING](#)

Test alternate telecommunication services [Assignment: organization-defined frequency].

Discussion: Alternate telecommunications services testing is arranged through contractual agreements with service providers. The testing may occur in parallel with normal operations to ensure that there is no degradation in organizational missions or functions.

Related Controls: [CP-3](#).

References: [\[SP 800-34\]](#).

CP-9 SYSTEM BACKUP

Control:

- a. Conduct backups of user-level information contained in [Assignment: organization-defined system components] [Assignment: organization-defined frequency consistent with recovery time and recovery point objectives];
- b. Conduct backups of system-level information contained in the system [Assignment: organization-defined frequency consistent with recovery time and recovery point objectives];

- c. Conduct backups of system documentation, including security- and privacy-related documentation [*Assignment: organization-defined frequency consistent with recovery time and recovery point objectives*]; and
- d. Protect the confidentiality, integrity, and availability of backup information.

Discussion: System-level information includes system state information, operating system software, middleware, application software, and licenses. User-level information includes information other than system-level information. Mechanisms employed to protect the integrity of system backups include digital signatures and cryptographic hashes. Protection of system backup information while in transit is addressed by [MP-5](#) and [SC-8](#). System backups reflect the requirements in contingency plans as well as other organizational requirements for backing up information. Organizations may be subject to laws, executive orders, directives, regulations, or policies with requirements regarding specific categories of information (e.g., personal health information). Organizational personnel consult with the senior agency official for privacy and legal counsel regarding such requirements.

Related Controls: [CP-2](#), [CP-6](#), [CP-10](#), [MP-4](#), [MP-5](#), [SC-8](#), [SC-12](#), [SC-13](#), [SI-4](#), [SI-13](#).

Control Enhancements:

(1) SYSTEM BACKUP | [TESTING FOR RELIABILITY AND INTEGRITY](#)

Test backup information [*Assignment: organization-defined frequency*] to verify media reliability and information integrity.

Discussion: Organizations need assurance that backup information can be reliably retrieved. Reliability pertains to the systems and system components where the backup information is stored, the operations used to retrieve the information, and the integrity of the information being retrieved. Independent and specialized tests can be used for each of the aspects of reliability. For example, decrypting and transporting (or transmitting) a random sample of backup files from the alternate storage or backup site and comparing the information to the same information at the primary processing site can provide such assurance.

Related Controls: [CP-4](#).

(2) SYSTEM BACKUP | [TEST RESTORATION USING SAMPLING](#)

Use a sample of backup information in the restoration of selected system functions as part of contingency plan testing.

Discussion: Organizations need assurance that system functions can be restored correctly and can support established organizational missions. To ensure that the selected system functions are thoroughly exercised during contingency plan testing, a sample of backup information is retrieved to determine whether the functions are operating as intended. Organizations can determine the sample size for the functions and backup information based on the level of assurance needed.

Related Controls: [CP-4](#).

(3) SYSTEM BACKUP | [SEPARATE STORAGE FOR CRITICAL INFORMATION](#)

Store backup copies of [*Assignment: organization-defined critical system software and other security-related information*] in a separate facility or in a fire rated container that is not collocated with the operational system.

Discussion: Separate storage for critical information applies to all critical information regardless of the type of backup storage media. Critical system software includes operating systems, middleware, cryptographic key management systems, and intrusion detection systems. Security-related information includes inventories of system hardware, software, and firmware components. Alternate storage sites, including geographically distributed architectures, serve as separate storage facilities for organizations. Organizations may

provide separate storage by implementing automated backup processes at alternative storage sites (e.g., data centers). The General Services Administration (GSA) establishes standards and specifications for security and fire rated containers.

Related Controls: [CM-2](#), [CM-6](#), [CM-8](#).

(4) SYSTEM BACKUP | PROTECTION FROM UNAUTHORIZED MODIFICATION

[Withdrawn: Incorporated into [CP-9](#).]

(5) SYSTEM BACKUP | [TRANSFER TO ALTERNATE STORAGE SITE](#)

Transfer system backup information to the alternate storage site [Assignment: organization-defined time period and transfer rate consistent with the recovery time and recovery point objectives].

Discussion: System backup information can be transferred to alternate storage sites either electronically or by the physical shipment of storage media.

Related Controls: [CP-7](#), [MP-3](#), [MP-4](#), [MP-5](#).

(6) SYSTEM BACKUP | [REDUNDANT SECONDARY SYSTEM](#)

Conduct system backup by maintaining a redundant secondary system that is not collocated with the primary system and that can be activated without loss of information or disruption to operations.

Discussion: The effect of system backup can be achieved by maintaining a redundant secondary system that mirrors the primary system, including the replication of information. If this type of redundancy is in place and there is sufficient geographic separation between the two systems, the secondary system can also serve as the alternate processing site.

Related Controls: [CP-7](#).

(7) SYSTEM BACKUP | [DUAL AUTHORIZATION FOR DELETION OR DESTRUCTION](#)

Enforce dual authorization for the deletion or destruction of [Assignment: organization-defined backup information].

Discussion: Dual authorization ensures that deletion or destruction of backup information cannot occur unless two qualified individuals carry out the task. Individuals deleting or destroying backup information possess the skills or expertise to determine if the proposed deletion or destruction of information reflects organizational policies and procedures. Dual authorization may also be known as two-person control. To reduce the risk of collusion, organizations consider rotating dual authorization duties to other individuals.

Related Controls: [AC-3](#), [AC-5](#), [MP-2](#).

(8) SYSTEM BACKUP | [CRYPTOGRAPHIC PROTECTION](#)

Implement cryptographic mechanisms to prevent unauthorized disclosure and modification of [Assignment: organization-defined backup information].

Discussion: The selection of cryptographic mechanisms is based on the need to protect the confidentiality and integrity of backup information. The strength of mechanisms selected is commensurate with the security category or classification of the information. Cryptographic protection applies to system backup information in storage at both primary and alternate locations. Organizations that implement cryptographic mechanisms to protect information at rest also consider cryptographic key management solutions.

Related Controls: [SC-12](#), [SC-13](#), [SC-28](#).

References: [\[FIPS 140-3\]](#), [\[FIPS 186-4\]](#), [\[SP 800-34\]](#), [\[SP 800-130\]](#), [\[SP 800-152\]](#).

CP-10 SYSTEM RECOVERY AND RECONSTITUTION

Control: Provide for the recovery and reconstitution of the system to a known state within [Assignment: organization-defined time period consistent with recovery time and recovery point objectives] after a disruption, compromise, or failure.

Discussion: Recovery is executing contingency plan activities to restore organizational mission and business functions. Reconstitution takes place following recovery and includes activities for returning systems to fully operational states. Recovery and reconstitution operations reflect mission and business priorities; recovery point, recovery time, and reconstitution objectives; and organizational metrics consistent with contingency plan requirements. Reconstitution includes the deactivation of interim system capabilities that may have been needed during recovery operations. Reconstitution also includes assessments of fully restored system capabilities, reestablishment of continuous monitoring activities, system reauthorization (if required), and activities to prepare the system and organization for future disruptions, breaches, compromises, or failures. Recovery and reconstitution capabilities can include automated mechanisms and manual procedures. Organizations establish recovery time and recovery point objectives as part of contingency planning.

Related Controls: [CP-2](#), [CP-4](#), [CP-6](#), [CP-7](#), [CP-9](#), [IR-4](#), [SA-8](#), [SC-24](#), [SI-13](#).

Control Enhancements:

(1) SYSTEM RECOVERY AND RECONSTITUTION | CONTINGENCY PLAN TESTING

[Withdrawn: Incorporated into [CP-4](#).]

(2) SYSTEM RECOVERY AND RECONSTITUTION | TRANSACTION RECOVERY

Implement transaction recovery for systems that are transaction-based.

Discussion: Transaction-based systems include database management systems and transaction processing systems. Mechanisms supporting transaction recovery include transaction rollback and transaction journaling.

Related Controls: None.

(3) SYSTEM RECOVERY AND RECONSTITUTION | COMPENSATING SECURITY CONTROLS

[Withdrawn: Addressed through tailoring.]

(4) SYSTEM RECOVERY AND RECONSTITUTION | RESTORE WITHIN TIME PERIOD

Provide the capability to restore system components within [Assignment: organization-defined restoration time periods] from configuration-controlled and integrity-protected information representing a known, operational state for the components.

Discussion: Restoration of system components includes reimaging, which restores the components to known, operational states.

Related Controls: [CM-2](#), [CM-6](#).

(5) SYSTEM RECOVERY AND RECONSTITUTION | FAILOVER CAPABILITY

[Withdrawn: Incorporated into [SI-13](#).]

(6) SYSTEM RECOVERY AND RECONSTITUTION | COMPONENT PROTECTION

Protect system components used for recovery and reconstitution.

Discussion: Protection of system recovery and reconstitution components (i.e., hardware, firmware, and software) includes physical and technical controls. Backup and restoration components used for recovery and reconstitution include router tables, compilers, and other system software.

Related Controls: [AC-3](#), [AC-6](#), [MP-2](#), [MP-4](#), [PE-3](#), [PE-6](#).

References: [\[SP 800-34\]](#).

CP-11 ALTERNATE COMMUNICATIONS PROTOCOLS

Control: Provide the capability to employ [*Assignment: organization-defined alternative communications protocols*] in support of maintaining continuity of operations.

Discussion: Contingency plans and the contingency training or testing associated with those plans incorporate an alternate communications protocol capability as part of establishing resilience in organizational systems. Switching communications protocols may affect software applications and operational aspects of systems. Organizations assess the potential side effects of introducing alternate communications protocols prior to implementation.

Related Controls: [CP-2](#), [CP-8](#), [CP-13](#).

Control Enhancements: None.

References: None.

CP-12 SAFE MODE

Control: When [*Assignment: organization-defined conditions*] are detected, enter a safe mode of operation with [*Assignment: organization-defined restrictions of safe mode of operation*].

Discussion: For systems that support critical mission and business functions—including military operations, civilian space operations, nuclear power plant operations, and air traffic control operations (especially real-time operational environments)—organizations can identify certain conditions under which those systems revert to a predefined safe mode of operation. The safe mode of operation, which can be activated either automatically or manually, restricts the operations that systems can execute when those conditions are encountered. Restriction includes allowing only selected functions to execute that can be carried out under limited power or with reduced communications bandwidth.

Related Controls: [CM-2](#), [SA-8](#), [SC-24](#), [SI-13](#), [SI-17](#).

Control Enhancements: None.

References: None.

CP-13 ALTERNATIVE SECURITY MECHANISMS

Control: Employ [*Assignment: organization-defined alternative or supplemental security mechanisms*] for satisfying [*Assignment: organization-defined security functions*] when the primary means of implementing the security function is unavailable or compromised.

Discussion: Use of alternative security mechanisms supports system resiliency, contingency planning, and continuity of operations. To ensure mission and business continuity, organizations can implement alternative or supplemental security mechanisms. The mechanisms may be less effective than the primary mechanisms. However, having the capability to readily employ alternative or supplemental mechanisms enhances mission and business continuity that might otherwise be adversely impacted if operations had to be curtailed until the primary means of implementing the functions was restored. Given the cost and level of effort required to provide such alternative capabilities, the alternative or supplemental mechanisms are only applied to critical security capabilities provided by systems, system components, or system services. For example, an organization may issue one-time pads to senior executives, officials, and system administrators if multi-factor tokens—the standard means for achieving secure authentication—are compromised.

Related Controls: [CP-2](#), [CP-11](#), [SI-13](#).

Control Enhancements: None

References: None.

3.7 IDENTIFICATION AND AUTHENTICATION

[Quick link to Identification and Authentication Summary Table](#)

IA-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] identification and authentication policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the identification and authentication policy and the associated identification and authentication controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the identification and authentication policy and procedures; and
- c. Review and update the current identification and authentication:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Identification and authentication policy and procedures address the controls in the IA family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of identification and authentication policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to identification and authentication policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [AC-1](#), [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[FIPS 201-2\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-63-3\]](#), [\[SP 800-73-4\]](#), [\[SP 800-76-2\]](#), [\[SP 800-78-4\]](#), [\[SP 800-100\]](#), [\[IR 7874\]](#).

IA-2 IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS)

Control: Uniquely identify and authenticate organizational users and associate that unique identification with processes acting on behalf of those users.

Discussion: Organizations can satisfy the identification and authentication requirements by complying with the requirements in [HSPD 12]. Organizational users include employees or individuals who organizations consider to have an equivalent status to employees (e.g., contractors and guest researchers). Unique identification and authentication of users applies to all accesses other than those that are explicitly identified in AC-14 and that occur through the authorized use of group authenticators without individual authentication. Since processes execute on behalf of groups and roles, organizations may require unique identification of individuals in group accounts or for detailed accountability of individual activity.

Organizations employ passwords, physical authenticators, or biometrics to authenticate user identities or, in the case of multi-factor authentication, some combination thereof. Access to organizational systems is defined as either local access or network access. Local access is any access to organizational systems by users or processes acting on behalf of users, where access is obtained through direct connections without the use of networks. Network access is access to organizational systems by users (or processes acting on behalf of users) where access is obtained through network connections (i.e., nonlocal accesses). Remote access is a type of network access that involves communication through external networks. Internal networks include local area networks and wide area networks.

The use of encrypted virtual private networks for network connections between organization-controlled endpoints and non-organization-controlled endpoints may be treated as internal networks with respect to protecting the confidentiality and integrity of information traversing the network. Identification and authentication requirements for non-organizational users are described in IA-8.

Related Controls: [AC-2](#), [AC-3](#), [AC-4](#), [AC-14](#), [AC-17](#), [AC-18](#), [AU-1](#), [AU-6](#), [IA-4](#), [IA-5](#), [IA-8](#), [MA-4](#), [MA-5](#), [PE-2](#), [PL-4](#), [SA-4](#), [SA-8](#).

Control Enhancements:

- (1) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [MULTI-FACTOR AUTHENTICATION TO PRIVILEGED ACCOUNTS](#)

Implement multi-factor authentication for access to privileged accounts.

Discussion: Multi-factor authentication requires the use of two or more different factors to achieve authentication. The authentication factors are defined as follows: something you know (e.g., a personal identification number [PIN]), something you have (e.g., a physical authenticator such as a cryptographic private key), or something you are (e.g., a biometric). Multi-factor authentication solutions that feature physical authenticators include hardware authenticators that provide time-based or challenge-response outputs and smart cards such as the U.S. Government Personal Identity Verification (PIV) card or the Department of Defense (DoD) Common Access Card (CAC). In addition to authenticating users at the system level (i.e., at logon), organizations may employ authentication mechanisms at the application level, at their discretion, to provide increased security. Regardless of the type of access (i.e., local, network, remote), privileged accounts are authenticated using multi-factor options appropriate for the level of risk. Organizations can add additional security measures, such as additional or more rigorous authentication mechanisms, for specific types of access.

Related Controls: [AC-5](#), [AC-6](#).

- (2) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [MULTI-FACTOR AUTHENTICATION TO NON-PRIVILEGED ACCOUNTS](#)

Implement multi-factor authentication for access to non-privileged accounts.

Discussion: Multi-factor authentication requires the use of two or more different factors to achieve authentication. The authentication factors are defined as follows: something you know (e.g., a personal identification number [PIN]), something you have (e.g., a physical authenticator such as a cryptographic private key), or something you are (e.g., a biometric). Multi-factor authentication solutions that feature physical authenticators include hardware authenticators that provide time-based or challenge-response outputs and smart cards such as the U.S. Government Personal Identity Verification card or the DoD Common Access Card. In addition to authenticating users at the system level, organizations may also employ authentication mechanisms at the application level, at their discretion, to provide increased information security. Regardless of the type of access (i.e., local, network, remote), non-privileged accounts are authenticated using multi-factor options appropriate for the level of risk. Organizations can provide additional security measures, such as additional or more rigorous authentication mechanisms, for specific types of access.

Related Controls: [AC-5](#).

- (3) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | LOCAL ACCESS TO PRIVILEGED ACCOUNTS

[Withdrawn: Incorporated into [IA-2\(1\)](#).]

- (4) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | LOCAL ACCESS TO NON-PRIVILEGED ACCOUNTS

[Withdrawn: Incorporated into [IA-2\(2\)](#).]

- (5) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [INDIVIDUAL AUTHENTICATION WITH GROUP AUTHENTICATION](#)

When shared accounts or authenticators are employed, require users to be individually authenticated before granting access to the shared accounts or resources.

Discussion: Individual authentication prior to shared group authentication mitigates the risk of using group accounts or authenticators.

Related Controls: None.

- (6) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [ACCESS TO ACCOUNTS — SEPARATE DEVICE](#)

Implement multi-factor authentication for [Selection (one or more): local; network; remote] access to [Selection (one or more): privileged accounts; non-privileged accounts] such that:

- (a) **One of the factors is provided by a device separate from the system gaining access; and**
- (b) **The device meets [Assignment: organization-defined strength of mechanism requirements].**

Discussion: The purpose of requiring a device that is separate from the system to which the user is attempting to gain access for one of the factors during multi-factor authentication is to reduce the likelihood of compromising authenticators or credentials stored on the system. Adversaries may be able to compromise such authenticators or credentials and subsequently impersonate authorized users. Implementing one of the factors on a separate device (e.g., a hardware token), provides a greater strength of mechanism and an increased level of assurance in the authentication process.

Related Controls: [AC-6](#).

- (7) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | NETWORK ACCESS TO NON-PRIVILEGED ACCOUNTS — SEPARATE DEVICE

[Withdrawn: Incorporated into [IA-2\(6\)](#).]

- (8) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [ACCESS TO ACCOUNTS — REPLAY RESISTANT](#)

Implement replay-resistant authentication mechanisms for access to [Selection (one or more): privileged accounts; non-privileged accounts].

Discussion: Authentication processes resist replay attacks if it is impractical to achieve successful authentications by replaying previous authentication messages. Replay-resistant techniques include protocols that use nonces or challenges such as time synchronous or cryptographic authenticators.

Related Controls: None.

- (9) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | NETWORK ACCESS TO NON-PRIVILEGED ACCOUNTS — REPLAY RESISTANT

[Withdrawn: Incorporated into [IA-2\(8\)](#).]

- (10) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [SINGLE SIGN-ON](#)

Provide a single sign-on capability for [Assignment: organization-defined system accounts and services].

Discussion: Single sign-on enables users to log in once and gain access to multiple system resources. Organizations consider the operational efficiencies provided by single sign-on capabilities with the risk introduced by allowing access to multiple systems via a single authentication event. Single sign-on can present opportunities to improve system security, for example by providing the ability to add multi-factor authentication for applications and systems (existing and new) that may not be able to natively support multi-factor authentication.

Related Controls: None.

- (11) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | REMOTE ACCESS — SEPARATE DEVICE

[Withdrawn: Incorporated into [IA-2\(6\)](#).]

- (12) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [ACCEPTANCE OF PIV CREDENTIALS](#)

Accept and electronically verify Personal Identity Verification-compliant credentials.

Discussion: Acceptance of Personal Identity Verification (PIV)-compliant credentials applies to organizations implementing logical access control and physical access control systems. PIV-compliant credentials are those credentials issued by federal agencies that conform to FIPS Publication 201 and supporting guidance documents. The adequacy and reliability of PIV card issuers are authorized using [\[SP 800-79-2\]](#). Acceptance of PIV-compliant credentials includes derived PIV credentials, the use of which is addressed in [\[SP 800-166\]](#). The DOD Common Access Card (CAC) is an example of a PIV credential.

Related Controls: None.

- (13) IDENTIFICATION AND AUTHENTICATION (ORGANIZATIONAL USERS) | [OUT-OF-BAND AUTHENTICATION](#)

Implement the following out-of-band authentication mechanisms under [Assignment: organization-defined conditions]: [Assignment: organization-defined out-of-band authentication].

Discussion: Out-of-band authentication refers to the use of two separate communication paths to identify and authenticate users or devices to an information system. The first path (i.e., the in-band path) is used to identify and authenticate users or devices and is generally the path through which information flows. The second path (i.e., the out-of-band path) is used to independently verify the authentication and/or requested action. For example, a user authenticates via a notebook computer to a remote server to which the user desires access and requests some action of the server via that communication path. Subsequently, the server contacts the user via the user's cell phone to verify that the requested action originated from the user. The user may confirm the intended action to an individual on the telephone or provide an authentication code via the telephone. Out-of-band authentication can be used to mitigate actual or suspected "man-in-the-middle" attacks. The conditions or criteria for activation include suspicious activities, new threat indicators, elevated threat levels, or the impact or classification level of information in requested transactions.

Related Controls: [IA-10](#), [IA-11](#), [SC-37](#).

References: [\[FIPS 140-3\]](#), [\[FIPS 201-2\]](#), [\[FIPS 202\]](#), [\[SP 800-63-3\]](#), [\[SP 800-73-4\]](#), [\[SP 800-76-2\]](#), [\[SP 800-78-4\]](#), [\[SP 800-79-2\]](#), [\[SP 800-156\]](#), [\[SP 800-166\]](#), [\[IR 7539\]](#), [\[IR 7676\]](#), [\[IR 7817\]](#), [\[IR 7849\]](#), [\[IR 7870\]](#), [\[IR 7874\]](#), [\[IR 7966\]](#).

[**IA-3**](#)

DEVICE IDENTIFICATION AND AUTHENTICATION

Control: Uniquely identify and authenticate [*Assignment: organization-defined devices and/or types of devices*] before establishing a [*Selection (one or more): local; remote; network*] connection.

Discussion: Devices that require unique device-to-device identification and authentication are defined by type, device, or a combination of type and device. Organization-defined device types include devices that are not owned by the organization. Systems use shared known information (e.g., Media Access Control [MAC], Transmission Control Protocol/Internet Protocol [TCP/IP] addresses) for device identification or organizational authentication solutions (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.1x and Extensible Authentication Protocol [EAP], RADIUS server with EAP-Transport Layer Security [TLS] authentication, Kerberos) to identify and authenticate devices on local and wide area networks. Organizations determine the required strength of authentication mechanisms based on the security categories of systems and mission or business requirements. Because of the challenges of implementing device authentication on a large scale, organizations can restrict the application of the control to a limited number/type of devices based on mission or business needs.

Related Controls: [AC-17](#), [AC-18](#), [AC-19](#), [AU-6](#), [CA-3](#), [CA-9](#), [IA-4](#), [IA-5](#), [IA-9](#), [IA-11](#), [SI-4](#).

Control Enhancements:

(1) DEVICE IDENTIFICATION AND AUTHENTICATION | [CRYPTOGRAPHIC BIDIRECTIONAL AUTHENTICATION](#)

Authenticate [*Assignment: organization-defined devices and/or types of devices*] before establishing [*Selection (one or more): local; remote; network*] connection using bidirectional authentication that is cryptographically based.

Discussion: A local connection is a connection with a device that communicates without the use of a network. A network connection is a connection with a device that communicates through a network. A remote connection is a connection with a device that communicates through an external network. Bidirectional authentication provides stronger protection to validate the identity of other devices for connections that are of greater risk.

Related Controls: [SC-8](#), [SC-12](#), [SC-13](#).

(2) DEVICE IDENTIFICATION AND AUTHENTICATION | CRYPTOGRAPHIC BIDIRECTIONAL NETWORK AUTHENTICATION

[Withdrawn: Incorporated into [IA-3\(1\)](#).]

- (3) DEVICE IDENTIFICATION AND AUTHENTICATION | [DYNAMIC ADDRESS ALLOCATION](#)**
- (a) Where addresses are allocated dynamically, standardize dynamic address allocation lease information and the lease duration assigned to devices in accordance with [Assignment: organization-defined lease information and lease duration]; and**
 - (b) Audit lease information when assigned to a device.**

Discussion: The Dynamic Host Configuration Protocol (DHCP) is an example of a means by which clients can dynamically receive network address assignments.

Related Controls: [AU-2](#).

- (4) DEVICE IDENTIFICATION AND AUTHENTICATION | [DEVICE ATTESTATION](#)**

Handle device identification and authentication based on attestation by [Assignment: organization-defined configuration management process].

Discussion: Device attestation refers to the identification and authentication of a device based on its configuration and known operating state. Device attestation can be determined via a cryptographic hash of the device. 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 identification and authentication to other devices.

Related Controls: [CM-2](#), [CM-3](#), [CM-6](#).

References: None.

[IA-4](#) IDENTIFIER MANAGEMENT

Control: Manage system identifiers by:

- a. Receiving authorization from [Assignment: organization-defined personnel or roles] to assign an individual, group, role, service, or device identifier;
- b. Selecting an identifier that identifies an individual, group, role, service, or device;
- c. Assigning the identifier to the intended individual, group, role, service, or device; and
- d. Preventing reuse of identifiers for [Assignment: organization-defined time period].

Discussion: Common device identifiers include Media Access Control (MAC) addresses, Internet Protocol (IP) addresses, or device-unique token identifiers. The management of individual identifiers is not applicable to shared system accounts. Typically, individual identifiers are the usernames of the system accounts assigned to those individuals. In such instances, the account management activities of [AC-2](#) use account names provided by [IA-4](#). Identifier management also addresses individual identifiers not necessarily associated with system accounts. Preventing the reuse of identifiers implies preventing the assignment of previously used individual, group, role, service, or device identifiers to different individuals, groups, roles, services, or devices.

Related Controls: [AC-5](#), [IA-2](#), [IA-3](#), [IA-5](#), [IA-8](#), [IA-9](#), [IA-12](#), [MA-4](#), [PE-2](#), [PE-3](#), [PE-4](#), [PL-4](#), [PM-12](#), [PS-3](#), [PS-4](#), [PS-5](#), [SC-37](#).

Control Enhancements:

- (1) IDENTIFIER MANAGEMENT | [PROHIBIT ACCOUNT IDENTIFIERS AS PUBLIC IDENTIFIERS](#)**

Prohibit the use of system account identifiers that are the same as public identifiers for individual accounts.

Discussion: Prohibiting account identifiers as public identifiers applies to any publicly disclosed account identifier used for communication such as, electronic mail and instant

messaging. Prohibiting the use of systems account identifiers that are the same as some public identifier, such as the individual identifier section of an electronic mail address, makes it more difficult for adversaries to guess user identifiers. Prohibiting account identifiers as public identifiers without the implementation of other supporting controls only complicates guessing of identifiers. Additional protections are required for authenticators and credentials to protect the account.

Related Controls: [AT-2](#), [PT-7](#).

(2) IDENTIFIER MANAGEMENT | SUPERVISOR AUTHORIZATION

[Withdrawn: Incorporated into [IA-12\(1\)](#).]

(3) IDENTIFIER MANAGEMENT | MULTIPLE FORMS OF CERTIFICATION

[Withdrawn: Incorporated into [IA-12\(2\)](#).]

(4) IDENTIFIER MANAGEMENT | [IDENTIFY USER STATUS](#)

Manage individual identifiers by uniquely identifying each individual as [Assignment: organization-defined characteristic identifying individual status].

Discussion: Characteristics that identify the status of individuals include contractors, foreign nationals, and non-organizational users. Identifying the status of individuals by these characteristics provides additional information about the people with whom organizational personnel are communicating. For example, it might be useful for a government employee to know that one of the individuals on an email message is a contractor.

Related Controls: None.

(5) IDENTIFIER MANAGEMENT | [DYNAMIC MANAGEMENT](#)

Manage individual identifiers dynamically in accordance with [Assignment: organization-defined dynamic identifier policy].

Discussion: In contrast to conventional approaches to identification that presume static accounts for preregistered users, many distributed systems establish identifiers at runtime for entities that were previously unknown. When identifiers are established at runtime for previously unknown entities, organizations can anticipate and provision for the dynamic establishment of identifiers. Pre-established trust relationships and mechanisms with appropriate authorities to validate credentials and related identifiers are essential.

Related Controls: [AC-16](#).

(6) IDENTIFIER MANAGEMENT | [CROSS-ORGANIZATION MANAGEMENT](#)

Coordinate with the following external organizations for cross-organization management of identifiers: [Assignment: organization-defined external organizations].

Discussion: Cross-organization identifier management provides the capability to identify individuals, groups, roles, or devices when conducting cross-organization activities involving the processing, storage, or transmission of information.

Related Controls: [AU-16](#), [IA-2](#), [IA-5](#).

(7) IDENTIFIER MANAGEMENT | IN-PERSON REGISTRATION

[Withdrawn: Incorporated into [IA-12\(4\)](#).]

(8) IDENTIFIER MANAGEMENT | [PAIRWISE PSEUDONYMOUS IDENTIFIERS](#)

Generate pairwise pseudonymous identifiers.

Discussion: A pairwise pseudonymous identifier is an opaque unguessable subscriber identifier generated by an identity provider for use at a specific individual relying party. Generating distinct pairwise pseudonymous identifiers with no identifying information about a subscriber discourages subscriber activity tracking and profiling beyond the operational

requirements established by an organization. The pairwise pseudonymous identifiers are unique to each relying party except in situations where relying parties can show a demonstrable relationship justifying an operational need for correlation, or all parties consent to being correlated in such a manner.

Related Controls: [IA-5](#).

(9) IDENTIFIER MANAGEMENT | [ATTRIBUTE MAINTENANCE AND PROTECTION](#)

Maintain the attributes for each uniquely identified individual, device, or service in [Assignment: organization-defined protected central storage].

Discussion: For each of the entities covered in [IA-2](#), [IA-3](#), [IA-8](#), and [IA-9](#), it is important to maintain the attributes for each authenticated entity on an ongoing basis in a central (protected) store.

Related Controls: None.

References: [\[FIPS 201-2\]](#), [\[SP 800-63-3\]](#), [\[SP 800-73-4\]](#), [\[SP 800-76-2\]](#), [\[SP 800-78-4\]](#).

[IA-5 AUTHENTICATOR MANAGEMENT](#)

Control: Manage system authenticators by:

- a. Verifying, as part of the initial authenticator distribution, the identity of the individual, group, role, service, or device receiving the authenticator;
- b. Establishing initial authenticator content for any authenticators issued by the organization;
- c. Ensuring that authenticators have sufficient strength of mechanism for their intended use;
- d. Establishing and implementing administrative procedures for initial authenticator distribution, for lost or compromised or damaged authenticators, and for revoking authenticators;
- e. Changing default authenticators prior to first use;
- f. Changing or refreshing authenticators *[Assignment: organization-defined time period by authenticator type]* or when *[Assignment: organization-defined events]* occur;
- g. Protecting authenticator content from unauthorized disclosure and modification;
- h. Requiring individuals to take, and having devices implement, specific controls to protect authenticators; and
- i. Changing authenticators for group or role accounts when membership to those accounts changes.

Discussion: Authenticators include passwords, cryptographic devices, biometrics, certificates, one-time password devices, and ID badges. Device authenticators include certificates and passwords. Initial authenticator content is the actual content of the authenticator (e.g., the initial password). In contrast, the requirements for authenticator content contain specific criteria or characteristics (e.g., minimum password length). Developers may deliver system components with factory default authentication credentials (i.e., passwords) to allow for initial installation and configuration. Default authentication credentials are often well known, easily discoverable, and present a significant risk. The requirement to protect individual authenticators may be implemented via control [PL-4](#) or [PS-6](#) for authenticators in the possession of individuals and by controls [AC-3](#), [AC-6](#), and [SC-28](#) for authenticators stored in organizational systems, including passwords stored in hashed or encrypted formats or files containing encrypted or hashed passwords accessible with administrator privileges.

Systems support authenticator management by organization-defined settings and restrictions for various authenticator characteristics (e.g., minimum password length, validation time window for

time synchronous one-time tokens, and number of allowed rejections during the verification stage of biometric authentication). Actions can be taken to safeguard individual authenticators, including maintaining possession of authenticators, not sharing authenticators with others, and immediately reporting lost, stolen, or compromised authenticators. Authenticator management includes issuing and revoking authenticators for temporary access when no longer needed.

Related Controls: [AC-3](#), [AC-6](#), [CM-6](#), [IA-2](#), [IA-4](#), [IA-7](#), [IA-8](#), [IA-9](#), [MA-4](#), [PE-2](#), [PL-4](#), [SC-12](#), [SC-13](#).

Control Enhancements:

(1) AUTHENTICATOR MANAGEMENT | [PASSWORD-BASED AUTHENTICATION](#)

For password-based authentication:

- (a) **Maintain a list of commonly-used, expected, or compromised passwords and update the list [*Assignment: organization-defined frequency*] and when organizational passwords are suspected to have been compromised directly or indirectly;**
- (b) **Verify, when users create or update passwords, that the passwords are not found on the list of commonly-used, expected, or compromised passwords in IA-5(1)(a);**
- (c) **Transmit passwords only over cryptographically-protected channels;**
- (d) **Store passwords using an approved salted key derivation function, preferably using a keyed hash;**
- (e) **Require immediate selection of a new password upon account recovery;**
- (f) **Allow user selection of long passwords and passphrases, including spaces and all printable characters;**
- (g) **Employ automated tools to assist the user in selecting strong password authenticators; and**
- (h) **Enforce the following composition and complexity rules: [*Assignment: organization-defined composition and complexity rules*].**

Discussion: Password-based authentication applies to passwords regardless of whether they are used in single-factor or multi-factor authentication. Long passwords or passphrases are preferable over shorter passwords. Enforced composition rules provide marginal security benefits while decreasing usability. However, organizations may choose to establish certain rules for password generation (e.g., minimum character length for long passwords) under certain circumstances and can enforce this requirement in IA-5(1)(h). Account recovery can occur, for example, in situations when a password is forgotten. Cryptographically protected passwords include salted one-way cryptographic hashes of passwords. The list of commonly used, compromised, or expected passwords includes passwords obtained from previous breach corpuses, dictionary words, and repetitive or sequential characters. The list includes context-specific words, such as the name of the service, username, and derivatives thereof.

Related Controls: [IA-6](#).

(2) AUTHENTICATOR MANAGEMENT | [PUBLIC KEY-BASED AUTHENTICATION](#)

(a) For public key-based authentication:

- (1) **Enforce authorized access to the corresponding private key; and**
- (2) **Map the authenticated identity to the account of the individual or group; and**

(b) When public key infrastructure (PKI) is used:

- (1) **Validate certificates by constructing and verifying a certification path to an accepted trust anchor, including checking certificate status information; and**
- (2) **Implement a local cache of revocation data to support path discovery and validation.**

Discussion: Public key cryptography is a valid authentication mechanism for individuals, machines, and devices. For PKI solutions, status information for certification paths includes certificate revocation lists or certificate status protocol responses. For PIV cards, certificate validation involves the construction and verification of a certification path to the Common Policy Root trust anchor, which includes certificate policy processing. Implementing a local cache of revocation data to support path discovery and validation also supports system availability in situations where organizations are unable to access revocation information via the network.

Related Controls: [IA-3](#), [SC-17](#).

- (3) AUTHENTICATOR MANAGEMENT | IN-PERSON OR TRUSTED EXTERNAL PARTY REGISTRATION
[Withdrawn: Incorporated into [IA-12\(4\)](#).]
- (4) AUTHENTICATOR MANAGEMENT | AUTOMATED SUPPORT FOR PASSWORD STRENGTH DETERMINATION
[Withdrawn: Incorporated into [IA-5\(1\)](#).]
- (5) AUTHENTICATOR MANAGEMENT | [CHANGE AUTHENTICATORS PRIOR TO DELIVERY](#)
Require developers and installers of system components to provide unique authenticators or change default authenticators prior to delivery and installation.
Discussion: Changing authenticators prior to the delivery and installation of system components extends the requirement for organizations to change default authenticators upon system installation by requiring developers and/or installers to provide unique authenticators or change default authenticators for system components prior to delivery and/or installation. However, it typically does not apply to developers of commercial off-the-shelf information technology products. Requirements for unique authenticators can be included in acquisition documents prepared by organizations when procuring systems or system components.
Related Controls: None.
- (6) AUTHENTICATOR MANAGEMENT | [PROTECTION OF AUTHENTICATORS](#)
Protect authenticators commensurate with the security category of the information to which use of the authenticator permits access.
Discussion: For systems that contain multiple security categories of information without reliable physical or logical separation between categories, authenticators used to grant access to the systems are protected commensurate with the highest security category of information on the systems. Security categories of information are determined as part of the security categorization process.
Related Controls: [RA-2](#).
- (7) AUTHENTICATOR MANAGEMENT | [NO EMBEDDED UNENCRYPTED STATIC AUTHENTICATORS](#)
Ensure that unencrypted static authenticators are not embedded in applications or other forms of static storage.
Discussion: In addition to applications, other forms of static storage include access scripts and function keys. Organizations exercise caution when determining whether embedded or stored authenticators are in encrypted or unencrypted form. If authenticators are used in the manner stored, then those representations are considered unencrypted authenticators.
Related Controls: None.
- (8) AUTHENTICATOR MANAGEMENT | [MULTIPLE SYSTEM ACCOUNTS](#)
Implement [Assignment: organization-defined security controls] to manage the risk of compromise due to individuals having accounts on multiple systems.

Discussion: When individuals have accounts on multiple systems and use the same authenticators such as passwords, there is the risk that a compromise of one account may lead to the compromise of other accounts. Alternative approaches include having different authenticators (passwords) on all systems, employing a single sign-on or federation mechanism, or using some form of one-time passwords on all systems. Organizations can also use rules of behavior (see [PL-4](#)) and access agreements (see [PS-6](#)) to mitigate the risk of multiple system accounts.

Related Controls: [PS-6](#).

(9) AUTHENTICATOR MANAGEMENT | [FEDERATED CREDENTIAL MANAGEMENT](#)

Use the following external organizations to federate credentials: [Assignment: organization-defined external organizations].

Discussion: Federation provides organizations with the capability to authenticate individuals and devices when conducting cross-organization activities involving the processing, storage, or transmission of information. Using a specific list of approved external organizations for authentication helps to ensure that those organizations are vetted and trusted.

Related Controls: [AU-7](#), [AU-16](#).

(10) AUTHENTICATOR MANAGEMENT | [DYNAMIC CREDENTIAL BINDING](#)

Bind identities and authenticators dynamically using the following rules: [Assignment: organization-defined binding rules].

Discussion: Authentication requires some form of binding between an identity and the authenticator that is used to confirm the identity. In conventional approaches, binding is established by pre-provisioning both the identity and the authenticator to the system. For example, the binding between a username (i.e., identity) and a password (i.e., authenticator) is accomplished by provisioning the identity and authenticator as a pair in the system. New authentication techniques allow the binding between the identity and the authenticator to be implemented external to a system. For example, with smartcard credentials, the identity and authenticator are bound together on the smartcard. Using these credentials, systems can authenticate identities that have not been pre-provisioned, dynamically provisioning the identity after authentication. In these situations, organizations can anticipate the dynamic provisioning of identities. Pre-established trust relationships and mechanisms with appropriate authorities to validate identities and related credentials are essential.

Related Controls: [AU-16](#), [IA-5](#).

(11) AUTHENTICATOR MANAGEMENT | HARDWARE TOKEN-BASED AUTHENTICATION

[Withdrawn: Incorporated into [IA-2\(1\)](#) and [IA-2\(2\)](#).]

(12) AUTHENTICATOR MANAGEMENT | [BIOMETRIC AUTHENTICATION PERFORMANCE](#)

For biometric-based authentication, employ mechanisms that satisfy the following biometric quality requirements [Assignment: organization-defined biometric quality requirements].

Discussion: Unlike password-based authentication, which provides exact matches of user-input passwords to stored passwords, biometric authentication does not provide exact matches. Depending on the type of biometric and the type of collection mechanism, there is likely to be some divergence from the presented biometric and the stored biometric that serves as the basis for comparison. Matching performance is the rate at which a biometric algorithm correctly results in a match for a genuine user and rejects other users. Biometric performance requirements include the match rate, which reflects the accuracy of the biometric matching algorithm used by a system.

Related Controls: [AC-7](#).

(13) AUTHENTICATOR MANAGEMENT | [EXPIRATION OF CACHED AUTHENTICATORS](#)

Prohibit the use of cached authenticators after [Assignment: organization-defined time period].

Discussion: Cached authenticators are used to authenticate to the local machine when the network is not available. If cached authentication information is out of date, the validity of the authentication information may be questionable.

Related Controls: None.

(14) AUTHENTICATOR MANAGEMENT | [MANAGING CONTENT OF PKI TRUST STORES](#)

For PKI-based authentication, employ an organization-wide methodology for managing the content of PKI trust stores installed across all platforms, including networks, operating systems, browsers, and applications.

Discussion: An organization-wide methodology for managing the content of PKI trust stores helps improve the accuracy and currency of PKI-based authentication credentials across the organization.

Related Controls: None.

(15) AUTHENTICATOR MANAGEMENT | [GSA-APPROVED PRODUCTS AND SERVICES](#)

Use only General Services Administration-approved products and services for identity, credential, and access management.

Discussion: General Services Administration (GSA)-approved products and services are products and services that have been approved through the GSA conformance program, where applicable, and posted to the GSA Approved Products List. GSA provides guidance for teams to design and build functional and secure systems that comply with Federal Identity, Credential, and Access Management (FICAM) policies, technologies, and implementation patterns.

Related Controls: None.

(16) AUTHENTICATOR MANAGEMENT | [IN-PERSON OR TRUSTED EXTERNAL PARTY AUTHENTICATOR ISSUANCE](#)

Require that the issuance of [Assignment: organization-defined types of and/or specific authenticators] be conducted [Selection: in person; by a trusted external party] before [Assignment: organization-defined registration authority] with authorization by [Assignment: organization-defined personnel or roles].

Discussion: Issuing authenticators in person or by a trusted external party enhances and reinforces the trustworthiness of the identity proofing process.

Related Controls: [IA-12](#).

(17) AUTHENTICATOR MANAGEMENT | [PRESENTATION ATTACK DETECTION FOR BIOMETRIC AUTHENTICATORS](#)

Employ presentation attack detection mechanisms for biometric-based authentication.

Discussion: Biometric characteristics do not constitute secrets. Such characteristics can be obtained by online web accesses, taking a picture of someone with a camera phone to obtain facial images with or without their knowledge, lifting from objects that someone has touched (e.g., a latent fingerprint), or capturing a high-resolution image (e.g., an iris pattern). Presentation attack detection technologies including liveness detection, can mitigate the risk of these types of attacks by making it difficult to produce artifacts intended to defeat the biometric sensor.

Related Controls: [AC-7](#).

(18) AUTHENTICATOR MANAGEMENT | [PASSWORD MANAGERS](#)

- (a) Employ [Assignment: organization-defined password managers] to generate and manage passwords; and

- (b) Protect the passwords using [Assignment: organization-defined controls].

Discussion: For systems where static passwords are employed, it is often a challenge to ensure that the passwords are suitably complex and that the same passwords are not employed on multiple systems. A password manager is a solution to this problem as it automatically generates and stores strong and different passwords for various accounts. A potential risk of using password managers is that adversaries can target the collection of passwords generated by the password manager. Therefore, the collection of passwords requires protection including encrypting the passwords (see [IA-5\(1\)\(d\)](#)) and storing the collection offline in a token.

Related Controls: None.

References: [\[FIPS 140-3\]](#), [\[FIPS 180-4\]](#), [\[FIPS 201-2\]](#), [\[FIPS 202\]](#), [\[SP 800-63-3\]](#), [\[SP 800-73-4\]](#), [\[SP 800-76-2\]](#), [\[SP 800-78-4\]](#), [\[IR 7539\]](#), [\[IR 7817\]](#), [\[IR 7849\]](#), [\[IR 7870\]](#), [\[IR 8040\]](#).

IA-6 AUTHENTICATION FEEDBACK

Control: Obscure feedback of authentication information during the authentication process to protect the information from possible exploitation and use by unauthorized individuals.

Discussion: Authentication feedback from systems does not provide information that would allow unauthorized individuals to compromise authentication mechanisms. For some types of systems, such as desktops or notebooks with relatively large monitors, the threat (referred to as shoulder surfing) may be significant. For other types of systems, such as mobile devices with small displays, the threat may be less significant and is balanced against the increased likelihood of typographic input errors due to small keyboards. Thus, the means for obscuring authentication feedback is selected accordingly. Obscuring authentication feedback includes displaying asterisks when users type passwords into input devices or displaying feedback for a very limited time before obscuring it.

Related Controls: [AC-3](#).

Control Enhancements: None.

References: None.

IA-7 CRYPTOGRAPHIC MODULE AUTHENTICATION

Control: Implement mechanisms for authentication to a cryptographic module that meet the requirements of applicable laws, executive orders, directives, policies, regulations, standards, and guidelines for such authentication.

Discussion: Authentication mechanisms may be required within a cryptographic module to authenticate an operator accessing the module and to verify that the operator is authorized to assume the requested role and perform services within that role.

Related Controls: [AC-3](#), [IA-5](#), [SA-4](#), [SC-12](#), [SC-13](#).

Control Enhancements: None.

References: [\[FIPS 140-3\]](#).

IA-8 IDENTIFICATION AND AUTHENTICATION (NON-ORGANIZATIONAL USERS)

Control: Uniquely identify and authenticate non-organizational users or processes acting on behalf of non-organizational users.

Discussion: Non-organizational users include system users other than organizational users explicitly covered by [IA-2](#). Non-organizational users are uniquely identified and authenticated for accesses other than those explicitly identified and documented in [AC-14](#). Identification and authentication of non-organizational users accessing federal systems may be required to protect federal, proprietary, or privacy-related information (with exceptions noted for national security systems). Organizations consider many factors—including security, privacy, scalability, and practicality—when balancing the need to ensure ease of use for access to federal information and systems with the need to protect and adequately mitigate risk.

Related Controls: [AC-2](#), [AC-6](#), [AC-14](#), [AC-17](#), [AC-18](#), [AU-6](#), [IA-2](#), [IA-4](#), [IA-5](#), [IA-10](#), [IA-11](#), [MA-4](#), [RA-3](#), [SA-4](#), [SC-8](#).

Control Enhancements:

- (1) IDENTIFICATION AND AUTHENTICATION (NON-ORGANIZATIONAL USERS) | [ACCEPTANCE OF PIV CREDENTIALS FROM OTHER AGENCIES](#)

Accept and electronically verify Personal Identity Verification-compliant credentials from other federal agencies.

Discussion: Acceptance of Personal Identity Verification (PIV) credentials from other federal agencies applies to both logical and physical access control systems. PIV credentials are those credentials issued by federal agencies that conform to FIPS Publication 201 and supporting guidelines. The adequacy and reliability of PIV card issuers are addressed and authorized using [[SP 800-79-2](#)].

Related Controls: [PE-3](#).

- (2) IDENTIFICATION AND AUTHENTICATION (NON-ORGANIZATIONAL USERS) | [ACCEPTANCE OF EXTERNAL AUTHENTICATORS](#)

- (a) **Accept only external authenticators that are NIST-compliant; and**
(b) **Document and maintain a list of accepted external authenticators.**

Discussion: Acceptance of only NIST-compliant external authenticators applies to organizational systems that are accessible to the public (e.g., public-facing websites). External authenticators are issued by nonfederal government entities and are compliant with [[SP 800-63B](#)]. Approved external authenticators meet or exceed the minimum Federal Government-wide technical, security, privacy, and organizational maturity requirements. Meeting or exceeding Federal requirements allows Federal Government relying parties to trust external authenticators in connection with an authentication transaction at a specified authenticator assurance level.

Related Controls: None.

- (3) IDENTIFICATION AND AUTHENTICATION (NON-ORGANIZATIONAL USERS) | [USE OF FICAM-APPROVED PRODUCTS](#)

[Withdrawn: Incorporated into [IA-8\(2\)](#).]

- (4) IDENTIFICATION AND AUTHENTICATION (NON-ORGANIZATIONAL USERS) | [USE OF DEFINED PROFILES](#)

Conform to the following profiles for identity management [Assignment: organization-defined identity management profiles].

Discussion: Organizations define profiles for identity management based on open identity management standards. To ensure that open identity management standards are viable, robust, reliable, sustainable, and interoperable as documented, the Federal Government assesses and scopes the standards and technology implementations against applicable laws, executive orders, directives, policies, regulations, standards, and guidelines.

Related Controls: None.

(5) IDENTIFICATION AND AUTHENTICATION (NON-ORGANIZATIONAL USERS) | [ACCEPTANCE OF PIV-I CREDENTIALS](#)

Accept and verify federated or PKI credentials that meet [Assignment: organization-defined policy].

Discussion: Acceptance of PIV-I credentials can be implemented by PIV, PIV-I, and other commercial or external identity providers. The acceptance and verification of PIV-I-compliant credentials apply to both logical and physical access control systems. The acceptance and verification of PIV-I credentials address nonfederal issuers of identity cards that desire to interoperate with United States Government PIV systems and that can be trusted by Federal Government-relying parties. The X.509 certificate policy for the Federal Bridge Certification Authority (FBCA) addresses PIV-I requirements. The PIV-I card is commensurate with the PIV credentials as defined in cited references. PIV-I credentials are the credentials issued by a PIV-I provider whose PIV-I certificate policy maps to the Federal Bridge PIV-I Certificate Policy. A PIV-I provider is cross-certified with the FBCA (directly or through another PKI bridge) with policies that have been mapped and approved as meeting the requirements of the PIV-I policies defined in the FBCA certificate policy.

Related Controls: None.

(6) IDENTIFICATION AND AUTHENTICATION (NON-ORGANIZATIONAL USERS) | [DISASSOCIABILITY](#)

Implement the following measures to disassociate user attributes or identifier assertion relationships among individuals, credential service providers, and relying parties: [Assignment: organization-defined measures].

Discussion: Federated identity solutions can create increased privacy risks due to the tracking and profiling of individuals. Using identifier mapping tables or cryptographic techniques to blind credential service providers and relying parties from each other or to make identity attributes less visible to transmitting parties can reduce these privacy risks.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[FED PKI\]](#), [\[FIPS 201-2\]](#), [\[SP 800-63-3\]](#), [\[SP 800-79-2\]](#), [\[SP 800-116\]](#), [\[IR 8062\]](#).

[IA-9](#) SERVICE IDENTIFICATION AND AUTHENTICATION

Control: Uniquely identify and authenticate [Assignment: organization-defined system services and applications] before establishing communications with devices, users, or other services or applications.

Discussion: Services that may require identification and authentication include web applications using digital certificates or services or applications that query a database. Identification and authentication methods for system services and applications include information or code signing, provenance graphs, and electronic signatures that indicate the sources of services. Decisions regarding the validity of identification and authentication claims can be made by services separate from the services acting on those decisions. This can occur in distributed system architectures. In such situations, the identification and authentication decisions (instead of actual identifiers and authentication data) are provided to the services that need to act on those decisions.

Related Controls: [IA-3](#), [IA-4](#), [IA-5](#), [SC-8](#).

Control Enhancements:

(1) SERVICE IDENTIFICATION AND AUTHENTICATION | INFORMATION EXCHANGE

[Withdrawn: Incorporated into [IA-9](#).]

(2) SERVICE IDENTIFICATION AND AUTHENTICATION | TRANSMISSION OF DECISIONS

[Withdrawn: Incorporated into [IA-9](#).]

References: None.

[IA-10](#) ADAPTIVE AUTHENTICATION

Control: Require individuals accessing the system to employ [Assignment: organization-defined supplemental authentication techniques or mechanisms] under specific [Assignment: organization-defined circumstances or situations].

Discussion: Adversaries may compromise individual authentication mechanisms employed by organizations and subsequently attempt to impersonate legitimate users. To address this threat, organizations may employ specific techniques or mechanisms and establish protocols to assess suspicious behavior. Suspicious behavior may include accessing information that individuals do not typically access as part of their duties, roles, or responsibilities; accessing greater quantities of information than individuals would routinely access; or attempting to access information from suspicious network addresses. When pre-established conditions or triggers occur, organizations can require individuals to provide additional authentication information. Another potential use for adaptive authentication is to increase the strength of mechanism based on the number or types of records being accessed. Adaptive authentication does not replace and is not used to avoid the use of multi-factor authentication mechanisms but can augment implementations of multi-factor authentication.

Related Controls: [IA-2](#), [IA-8](#).

Control Enhancements: None.

References: [[SP 800-63-3](#)].

[IA-11](#) RE-AUTHENTICATION

Control: Require users to re-authenticate when [Assignment: organization-defined circumstances or situations requiring re-authentication].

Discussion: In addition to the re-authentication requirements associated with device locks, organizations may require re-authentication of individuals in certain situations, including when roles, authenticators or credentials change, when security categories of systems change, when the execution of privileged functions occurs, after a fixed time period, or periodically.

Related Controls: [AC-3](#), [AC-11](#), [IA-2](#), [IA-3](#), [IA-4](#), [IA-8](#).

Control Enhancements: None.

References: None.

[IA-12](#) IDENTITY PROOFING

Control:

- a. Identity proof users that require accounts for logical access to systems based on appropriate identity assurance level requirements as specified in applicable standards and guidelines;
- b. Resolve user identities to a unique individual; and
- c. Collect, validate, and verify identity evidence.

Discussion: Identity proofing is the process of collecting, validating, and verifying a user's identity information for the purposes of establishing credentials for accessing a system. Identity proofing is intended to mitigate threats to the registration of users and the establishment of

their accounts. Standards and guidelines specifying identity assurance levels for identity proofing include [[SP 800-63-3](#)] and [[SP 800-63A](#)]. Organizations may be subject to laws, executive orders, directives, regulations, or policies that address the collection of identity evidence. Organizational personnel consult with the senior agency official for privacy and legal counsel regarding such requirements.

Related Controls: [AC-5](#), [IA-1](#), [IA-2](#), [IA-3](#), [IA-4](#), [IA-5](#), [IA-6](#), [IA-8](#).

Control Enhancements:

(1) IDENTITY PROOFING | [SUPERVISOR AUTHORIZATION](#)

Require that the registration process to receive an account for logical access includes supervisor or sponsor authorization.

Discussion: Including supervisor or sponsor authorization as part of the registration process provides an additional level of scrutiny to ensure that the user's management chain is aware of the account, the account is essential to carry out organizational missions and functions, and the user's privileges are appropriate for the anticipated responsibilities and authorities within the organization.

Related Controls: None.

(2) IDENTITY PROOFING | [IDENTITY EVIDENCE](#)

Require evidence of individual identification be presented to the registration authority.

Discussion: Identity evidence, such as documentary evidence or a combination of documents and biometrics, reduces the likelihood of individuals using fraudulent identification to establish an identity or at least increases the work factor of potential adversaries. The forms of acceptable evidence are consistent with the risks to the systems, roles, and privileges associated with the user's account.

Related Controls: None.

(3) IDENTITY PROOFING | [IDENTITY EVIDENCE VALIDATION AND VERIFICATION](#)

Require that the presented identity evidence be validated and verified through [Assignment: organizational defined methods of validation and verification].

Discussion: Validation and verification of identity evidence increases the assurance that accounts and identifiers are being established for the correct user and authenticators are being bound to that user. Validation refers to the process of confirming that the evidence is genuine and authentic, and the data contained in the evidence is correct, current, and related to an individual. Verification confirms and establishes a linkage between the claimed identity and the actual existence of the user presenting the evidence. Acceptable methods for validating and verifying identity evidence are consistent with the risks to the systems, roles, and privileges associated with the users account.

Related Controls: None.

(4) IDENTITY PROOFING | [IN-PERSON VALIDATION AND VERIFICATION](#)

Require that the validation and verification of identity evidence be conducted in person before a designated registration authority.

Discussion: In-person proofing reduces the likelihood of fraudulent credentials being issued because it requires the physical presence of individuals, the presentation of physical identity documents, and actual face-to-face interactions with designated registration authorities.

Related Controls: None.

(5) IDENTITY PROOFING | [ADDRESS CONFIRMATION](#)

Require that a [Selection: registration code; notice of proofing] be delivered through an out-of-band channel to verify the users address (physical or digital) of record.

Discussion: To make it more difficult for adversaries to pose as legitimate users during the identity proofing process, organizations can use out-of-band methods to ensure that the individual associated with an address of record is the same individual that participated in the registration. Confirmation can take the form of a temporary enrollment code or a notice of proofing. The delivery address for these artifacts is obtained from records and not self-asserted by the user. The address can include a physical or digital address. A home address is an example of a physical address. Email addresses and telephone numbers are examples of digital addresses.

Related Controls: [IA-12](#).

(6) IDENTITY PROOFING | [ACCEPT EXTERNALLY-PROOFED IDENTITIES](#)

Accept externally-proofed identities at [Assignment: organization-defined identity assurance level].

Discussion: To limit unnecessary re-proofing of identities, particularly of non-PIV users, organizations accept proofing conducted at a commensurate level of assurance by other agencies or organizations. Proofing is consistent with organizational security policy and the identity assurance level appropriate for the system, application, or information accessed. Accepting externally-proofed identities is a fundamental component of managing federated identities across agencies and organizations.

Related Controls: [IA-3](#), [IA-4](#), [IA-5](#), [IA-8](#).

References: [\[FIPS 201-2\]](#), [\[SP 800-63-3\]](#), [\[SP 800-63A\]](#), [\[SP 800-79-2\]](#).

3.8 INCIDENT RESPONSE

[Quick link to Incident Response Summary Table](#)

IR-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] incident response policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the incident response policy and the associated incident response controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the incident response policy and procedures; and
- c. Review and update the current incident response:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Incident response policy and procedures address the controls in the IR family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of incident response policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to incident response policy and procedures include assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-50\]](#), [\[SP 800-61\]](#), [\[SP 800-83\]](#), [\[SP 800-100\]](#).

IR-2 INCIDENT RESPONSE TRAINING

Control:

- a. Provide incident response training to system users consistent with assigned roles and responsibilities:
 1. Within [Assignment: organization-defined time period] of assuming an incident response role or responsibility or acquiring system access;
 2. When required by system changes; and
 3. [Assignment: organization-defined frequency] thereafter; and
- b. Review and update incident response training content [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Incident response training is associated with the assigned roles and responsibilities of organizational personnel to ensure that the appropriate content and level of detail are included in such training. For example, users may only need to know who to call or how to recognize an incident; system administrators may require additional training on how to handle incidents; and incident responders may receive more specific training on forensics, data collection techniques, reporting, system recovery, and system restoration. Incident response training includes user training in identifying and reporting suspicious activities from external and internal sources. Incident response training for users may be provided as part of [AT-2](#) or [AT-3](#). Events that may precipitate an update to incident response training content include, but are not limited to, incident response plan testing or response to an actual incident (lessons learned), assessment or audit findings, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: [AT-2](#), [AT-3](#), [AT-4](#), [CP-3](#), [IR-3](#), [IR-4](#), [IR-8](#), [IR-9](#).

Control Enhancements:

(1) INCIDENT RESPONSE TRAINING | [SIMULATED EVENTS](#)

Incorporate simulated events into incident response training to facilitate the required response by personnel in crisis situations.

Discussion: Organizations establish requirements for responding to incidents in incident response plans. Incorporating simulated events into incident response training helps to ensure that personnel understand their individual responsibilities and what specific actions to take in crisis situations.

Related Controls: None.

(2) INCIDENT RESPONSE TRAINING | [AUTOMATED TRAINING ENVIRONMENTS](#)

Provide an incident response training environment using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms can provide a more thorough and realistic incident response training environment. This can be accomplished, for example, by providing more complete coverage of incident response issues, selecting more realistic training scenarios and environments, and stressing the response capability.

Related Controls: None.

(3) INCIDENT RESPONSE TRAINING | [BREACH](#)

Provide incident response training on how to identify and respond to a breach, including the organization's process for reporting a breach.

Discussion: For federal agencies, an incident that involves personally identifiable information is considered a breach. A breach results in the loss of control, compromise, unauthorized disclosure, unauthorized acquisition, or a similar occurrence where a person other than an authorized user accesses or potentially accesses personally identifiable information or an authorized user accesses or potentially accesses such information for other than authorized purposes. The incident response training emphasizes the obligation of individuals to report both confirmed and suspected breaches involving information in any medium or form, including paper, oral, and electronic. Incident response training includes tabletop exercises that simulate a breach. See [IR-2\(1\)](#).

Related Controls: None.

References: [\[OMB M-17-12\]](#), [\[SP 800-50\]](#).

IR-3 INCIDENT RESPONSE TESTING

Control: Test the effectiveness of the incident response capability for the system [Assignment: organization-defined frequency] using the following tests: [Assignment: organization-defined tests].

Discussion: Organizations test incident response capabilities to determine their effectiveness and identify potential weaknesses or deficiencies. Incident response testing includes the use of checklists, walk-through or tabletop exercises, and simulations (parallel or full interrupt). Incident response testing can include a determination of the effects on organizational operations and assets and individuals due to incident response. The use of qualitative and quantitative data aids in determining the effectiveness of incident response processes.

Related Controls: [CP-3](#), [CP-4](#), [IR-2](#), [IR-4](#), [IR-8](#), [PM-14](#).

Control Enhancements:

(1) INCIDENT RESPONSE TESTING | [AUTOMATED TESTING](#)

Test the incident response capability using [Assignment: organization-defined automated mechanisms].

Discussion: Organizations use automated mechanisms to more thoroughly and effectively test incident response capabilities. This can be accomplished by providing more complete coverage of incident response issues, selecting realistic test scenarios and environments, and stressing the response capability.

Related Controls: None.

(2) INCIDENT RESPONSE TESTING | [COORDINATION WITH RELATED PLANS](#)

Coordinate incident response testing with organizational elements responsible for related plans.

Discussion: Organizational plans related to incident response testing include business continuity plans, disaster recovery plans, continuity of operations plans, contingency plans, crisis communications plans, critical infrastructure plans, and occupant emergency plans.

Related Controls: None.

(3) INCIDENT RESPONSE TESTING | [CONTINUOUS IMPROVEMENT](#)

Use qualitative and quantitative data from testing to:

- (a) Determine the effectiveness of incident response processes;**
- (b) Continuously improve incident response processes; and**
- (c) Provide incident response measures and metrics that are accurate, consistent, and in a reproducible format.**

Discussion: To help incident response activities function as intended, organizations may use metrics and evaluation criteria to assess incident response programs as part of an effort to continually improve response performance. These efforts facilitate improvement in incident response efficacy and lessen the impact of incidents.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[SP 800-84\]](#), [\[SP 800-115\]](#).

IR-4 INCIDENT HANDLING

Control:

- a. Implement an incident handling capability for incidents that is consistent with the incident response plan and includes preparation, detection and analysis, containment, eradication, and recovery;
- b. Coordinate incident handling activities with contingency planning activities;
- c. Incorporate lessons learned from ongoing incident handling activities into incident response procedures, training, and testing, and implement the resulting changes accordingly; and
- d. Ensure the rigor, intensity, scope, and results of incident handling activities are comparable and predictable across the organization.

Discussion: Organizations recognize that incident response capabilities are dependent on the capabilities of organizational systems and the mission and business processes being supported by those systems. Organizations consider incident response as part of the definition, design, and development of mission and business processes and systems. Incident-related information can be obtained from a variety of sources, including audit monitoring, physical access monitoring, and network monitoring; user or administrator reports; and reported supply chain events. An effective incident handling capability includes coordination among many organizational entities (e.g., mission or business owners, system owners, authorizing officials, human resources offices, physical security offices, personnel security offices, legal departments, risk executive [function], operations personnel, procurement offices). Suspected security incidents include the receipt of suspicious email communications that can contain malicious code. Suspected supply chain incidents include the insertion of counterfeit hardware or malicious code into organizational systems or system components. For federal agencies, an incident that involves personally identifiable information is considered a breach. A breach results in unauthorized disclosure, the loss of control, unauthorized acquisition, compromise, or a similar occurrence where a person other than an authorized user accesses or potentially accesses personally identifiable information or an authorized user accesses or potentially accesses such information for other than authorized purposes.

Related Controls: [AC-19](#), [AU-6](#), [AU-7](#), [CM-6](#), [CP-2](#), [CP-3](#), [CP-4](#), [IR-2](#), [IR-3](#), [IR-5](#), [IR-6](#), [IR-8](#), [PE-6](#), [PL-2](#), [PM-12](#), [SA-8](#), [SC-5](#), [SC-7](#), [SI-3](#), [SI-4](#), [SI-7](#).

Control Enhancements:

(1) INCIDENT HANDLING | [AUTOMATED INCIDENT HANDLING PROCESSES](#)

Support the incident handling process using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms that support incident handling processes include online incident management systems and tools that support the collection of live response data, full network packet capture, and forensic analysis.

Related Controls: None.

(2) INCIDENT HANDLING | [DYNAMIC RECONFIGURATION](#)

Include the following types of dynamic reconfiguration for [Assignment: organization-defined system components] as part of the incident response capability: [Assignment: organization-defined types of dynamic reconfiguration].

Discussion: Dynamic reconfiguration includes changes to router rules, access control lists, intrusion detection or prevention system parameters, and filter rules for guards or firewalls. Organizations may perform dynamic reconfiguration of systems to stop attacks, misdirect attackers, and isolate components of systems, thus limiting the extent of the damage from breaches or compromises. Organizations include specific time frames for achieving the reconfiguration of systems in the definition of the reconfiguration capability, considering the potential need for rapid response to effectively address cyber threats.

Related Controls: [AC-2](#), [AC-4](#), [CM-2](#).

(3) INCIDENT HANDLING | [CONTINUITY OF OPERATIONS](#)

Identify [Assignment: organization-defined classes of incidents] and take the following actions in response to those incidents to ensure continuation of organizational mission and business functions: [Assignment: organization-defined actions to take in response to classes of incidents].

Discussion: Classes of incidents include malfunctions due to design or implementation errors and omissions, targeted malicious attacks, and untargeted malicious attacks. Incident response actions include orderly system degradation, system shutdown, fall back to manual mode or activation of alternative technology whereby the system operates differently, employing deceptive measures, alternate information flows, or operating in a mode that is reserved for when systems are under attack. Organizations consider whether continuity of operations requirements during an incident conflict with the capability to automatically disable the system as specified as part of [IR-4\(5\)](#).

Related Controls: None.

(4) INCIDENT HANDLING | [INFORMATION CORRELATION](#)

Correlate incident information and individual incident responses to achieve an organization-wide perspective on incident awareness and response.

Discussion: Sometimes, a threat event, such as a hostile cyber-attack, can only be observed by bringing together information from different sources, including various reports and reporting procedures established by organizations.

Related Controls: None.

(5) INCIDENT HANDLING | [AUTOMATIC DISABLING OF SYSTEM](#)

Implement a configurable capability to automatically disable the system if [Assignment: organization-defined security violations] are detected.

Discussion: Organizations consider whether the capability to automatically disable the system conflicts with continuity of operations requirements specified as part of [CP-2](#) or [IR-4\(3\)](#). Security violations include cyber-attacks that have compromised the integrity of the system or exfiltrated organizational information and serious errors in software programs that could adversely impact organizational missions or functions or jeopardize the safety of individuals.

Related Controls: None.

(6) INCIDENT HANDLING | [INSIDER THREATS](#)

Implement an incident handling capability for incidents involving insider threats.

Discussion: Explicit focus on handling incidents involving insider threats provides additional emphasis on this type of threat and the need for specific incident handling capabilities to provide appropriate and timely responses.

Related Controls: None.

(7) INCIDENT HANDLING | [INSIDER THREATS — INTRA-ORGANIZATION COORDINATION](#)

Coordinate an incident handling capability for insider threats that includes the following organizational entities [Assignment: organization-defined entities].

Discussion: Incident handling for insider threat incidents (e.g., preparation, detection and analysis, containment, eradication, and recovery) requires coordination among many organizational entities, including mission or business owners, system owners, human resources offices, procurement offices, personnel offices, physical security offices, senior agency information security officer, operations personnel, risk executive (function), senior agency official for privacy, and legal counsel. In addition, organizations may require external support from federal, state, and local law enforcement agencies.

Related Controls: None.

(8) INCIDENT HANDLING | [CORRELATION WITH EXTERNAL ORGANIZATIONS](#)

Coordinate with [Assignment: organization-defined external organizations] to correlate and share [Assignment: organization-defined incident information] to achieve a cross-organization perspective on incident awareness and more effective incident responses.

Discussion: The coordination of incident information with external organizations—including mission or business partners, military or coalition partners, customers, and developers—can provide significant benefits. Cross-organizational coordination can serve as an important risk management capability. This capability allows organizations to leverage information from a variety of sources to effectively respond to incidents and breaches that could potentially affect the organization's operations, assets, and individuals.

Related Controls: [AU-16](#), [PM-16](#).

(9) INCIDENT HANDLING | [DYNAMIC RESPONSE CAPABILITY](#)

Employ [Assignment: organization-defined dynamic response capabilities] to respond to incidents.

Discussion: The dynamic response capability addresses the timely deployment of new or replacement organizational capabilities in response to incidents. This includes capabilities implemented at the mission and business process level and at the system level.

Related Controls: None.

(10) INCIDENT HANDLING | [SUPPLY CHAIN COORDINATION](#)

Coordinate incident handling activities involving supply chain events with other organizations involved in the supply chain.

Discussion: Organizations involved in supply chain activities include product developers, system integrators, manufacturers, packagers, assemblers, distributors, vendors, and resellers. Supply chain incidents can occur anywhere through or to the supply chain and include compromises or breaches that involve primary or sub-tier providers, information technology products, system components, development processes or personnel, and distribution processes or warehousing facilities. Organizations consider including processes for protecting and sharing incident information in information exchange agreements and their obligations for reporting incidents to government oversight bodies (e.g., Federal Acquisition Security Council).

Related Controls: [CA-3](#), [MA-2](#), [SA-9](#), [SR-8](#).

(11) INCIDENT HANDLING | [INTEGRATED INCIDENT RESPONSE TEAM](#)

Establish and maintain an integrated incident response team that can be deployed to any location identified by the organization in [Assignment: organization-defined time period].

Discussion: An integrated incident response team is a team of experts that assesses, documents, and responds to incidents so that organizational systems and networks can recover quickly and implement the necessary controls to avoid future incidents. Incident response team personnel include forensic and malicious code analysts, tool developers, systems security and privacy engineers, and real-time operations personnel. The incident handling capability includes performing rapid forensic preservation of evidence and analysis of and response to intrusions. For some organizations, the incident response team can be a cross-organizational entity.

An integrated incident response team facilitates information sharing and allows organizational personnel (e.g., developers, implementers, and operators) to leverage team knowledge of the threat and implement defensive measures that enable organizations to deter intrusions more effectively. Moreover, integrated teams promote the rapid detection of intrusions, the development of appropriate mitigations, and the deployment of effective defensive measures. For example, when an intrusion is detected, the integrated team can rapidly develop an appropriate response for operators to implement, correlate the new incident with information on past intrusions, and augment ongoing cyber intelligence development. Integrated incident response teams are better able to identify adversary tactics, techniques, and procedures that are linked to the operations tempo or specific mission and business functions and to define responsive actions in a way that does not disrupt those mission and business functions. Incident response teams can be distributed within organizations to make the capability resilient.

Related Controls: [AT-3](#).

(12) INCIDENT HANDLING | [MALICIOUS CODE AND FORENSIC ANALYSIS](#)

Analyze malicious code and/or other residual artifacts remaining in the system after the incident.

Discussion: When conducted carefully in an isolated environment, analysis of malicious code and other residual artifacts of a security incident or breach can give the organization insight into adversary tactics, techniques, and procedures. It can also indicate the identity or some defining characteristics of the adversary. In addition, malicious code analysis can help the organization develop responses to future incidents.

Related Controls: None.

(13) INCIDENT HANDLING | [BEHAVIOR ANALYSIS](#)

Analyze anomalous or suspected adversarial behavior in or related to [Assignment: organization-defined environments or resources].

Discussion: If the organization maintains a deception environment, an analysis of behaviors in that environment, including resources targeted by the adversary and timing of the incident or event, can provide insight into adversarial tactics, techniques, and procedures. External to a deception environment, the analysis of anomalous adversarial behavior (e.g., changes in system performance or usage patterns) or suspected behavior (e.g., changes in searches for the location of specific resources) can give the organization such insight.

Related Controls: None.

(14) INCIDENT HANDLING | [SECURITY OPERATIONS CENTER](#)

Establish and maintain a security operations center.

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 organization staffs the SOC with skilled technical and

operational personnel (e.g., security analysts, incident response personnel, systems security engineers) and implements a combination of 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. These sources include perimeter defenses, network devices (e.g., 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 a capability.

Related Controls: None.

(15) INCIDENT HANDLING | [PUBLIC RELATIONS AND REPUTATION REPAIR](#)

- (a) Manage public relations associated with an incident; and**
- (b) Employ measures to repair the reputation of the organization.**

Discussion: It is important for an organization to have a strategy in place for addressing incidents that have been brought to the attention of the general public, have cast the organization in a negative light, or have affected the organization's constituents (e.g., partners, customers). Such publicity can be extremely harmful to the organization and affect its ability to carry out its mission and business functions. Taking proactive steps to repair the organization's reputation is an essential aspect of reestablishing the trust and confidence of its constituents.

Related Controls: None.

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[OMB M-17-12\]](#), [\[SP 800-61\]](#), [\[SP 800-86\]](#), [\[SP 800-101\]](#), [\[SP 800-150\]](#), [\[SP 800-160-2\]](#), [\[SP 800-184\]](#), [\[IR 7559\]](#).

[IR-5](#) INCIDENT MONITORING

Control: Track and document incidents.

Discussion: Documenting incidents includes maintaining records about each incident, the status of the incident, and other pertinent information necessary for forensics as well as evaluating incident details, trends, and handling. Incident information can be obtained from a variety of sources, including network monitoring, incident reports, incident response teams, user complaints, supply chain partners, audit monitoring, physical access monitoring, and user and administrator reports. [IR-4](#) provides information on the types of incidents that are appropriate for monitoring.

Related Controls: [AU-6](#), [AU-7](#), [IR-4](#), [IR-6](#), [IR-8](#), [PE-6](#), [PM-5](#), [SC-5](#), [SC-7](#), [SI-3](#), [SI-4](#), [SI-7](#).

Control Enhancements:

(1) INCIDENT MONITORING | [AUTOMATED TRACKING, DATA COLLECTION, AND ANALYSIS](#)

Track incidents and collect and analyze incident information using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms for tracking incidents and collecting and analyzing incident information include Computer Incident Response Centers or other electronic databases of incidents and network monitoring devices.

Related Controls: None.

References: [\[SP 800-61\]](#).

IR-6 INCIDENT REPORTING

Control:

- a. Require personnel to report suspected incidents to the organizational incident response capability within [Assignment: organization-defined time period]; and
- b. Report incident information to [Assignment: organization-defined authorities].

Discussion: The types of incidents reported, the content and timeliness of the reports, and the designated reporting authorities reflect applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Incident information can inform risk assessments, control effectiveness assessments, security requirements for acquisitions, and selection criteria for technology products.

Related Controls: [CM-6](#), [CP-2](#), [IR-4](#), [IR-5](#), [IR-8](#), [IR-9](#).

Control Enhancements:

(1) INCIDENT REPORTING | [AUTOMATED REPORTING](#)

Report incidents using [Assignment: organization-defined automated mechanisms].

Discussion: The recipients of incident reports are specified in [IR-6b](#). Automated reporting mechanisms include email, posting on websites (with automatic updates), and automated incident response tools and programs.

Related Controls: [IR-7](#).

(2) INCIDENT REPORTING | [VULNERABILITIES RELATED TO INCIDENTS](#)

Report system vulnerabilities associated with reported incidents to [Assignment: organization-defined personnel or roles].

Discussion: Reported incidents that uncover system vulnerabilities are analyzed by organizational personnel including system owners, mission and business owners, senior agency information security officers, senior agency officials for privacy, authorizing officials, and the risk executive (function). The analysis can serve to prioritize and initiate mitigation actions to address the discovered system vulnerability.

Related Controls: None.

(3) INCIDENT REPORTING | [SUPPLY CHAIN COORDINATION](#)

Provide incident information to the provider of the product or service and other organizations involved in the supply chain or supply chain governance for systems or system components related to the incident.

Discussion: Organizations involved in supply chain activities include product developers, system integrators, manufacturers, packagers, assemblers, distributors, vendors, and resellers. Entities that provide supply chain governance include the Federal Acquisition Security Council (FASC). Supply chain incidents include compromises or breaches that involve information technology products, system components, development processes or personnel, distribution processes, or warehousing facilities. Organizations determine the appropriate information to share and consider the value gained from informing external organizations about supply chain incidents, including the ability to improve processes or to identify the root cause of an incident.

Related Controls: [SR-8](#).

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[USCERT IR\]](#), [\[SP 800-61\]](#).

IR-7 INCIDENT RESPONSE ASSISTANCE

Control: Provide an incident response support resource, integral to the organizational incident response capability, that offers advice and assistance to users of the system for the handling and reporting of incidents.

Discussion: Incident response support resources provided by organizations include help desks, assistance groups, automated ticketing systems to open and track incident response tickets, and access to forensics services or consumer redress services, when required.

Related Controls: [AT-2](#), [AT-3](#), [IR-4](#), [IR-6](#), [IR-8](#), [PM-22](#), [PM-26](#), [SA-9](#), [SI-18](#).

Control Enhancements:

- (1) INCIDENT RESPONSE ASSISTANCE | [AUTOMATION SUPPORT FOR AVAILABILITY OF INFORMATION AND SUPPORT](#)

Increase the availability of incident response information and support using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms can provide a push or pull capability for users to obtain incident response assistance. For example, individuals may have access to a website to query the assistance capability, or the assistance capability can proactively send incident response information to users (general distribution or targeted) as part of increasing understanding of current response capabilities and support.

Related Controls: None.

- (2) INCIDENT RESPONSE ASSISTANCE | [COORDINATION WITH EXTERNAL PROVIDERS](#)

- (a) Establish a direct, cooperative relationship between its incident response capability and external providers of system protection capability; and
(b) Identify organizational incident response team members to the external providers.

Discussion: External providers of a system protection capability include the Computer Network Defense program within the U.S. Department of Defense. External providers help to protect, monitor, analyze, detect, and respond to unauthorized activity within organizational information systems and networks. It may be beneficial to have agreements in place with external providers to clarify the roles and responsibilities of each party before an incident occurs.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[IR 7559\]](#).

IR-8 INCIDENT RESPONSE PLAN

Control:

- a. Develop an incident response plan that:
 1. Provides the organization with a roadmap for implementing its incident response capability;
 2. Describes the structure and organization of the incident response capability;
 3. Provides a high-level approach for how the incident response capability fits into the overall organization;
 4. Meets the unique requirements of the organization, which relate to mission, size, structure, and functions;
 5. Defines reportable incidents;

6. Provides metrics for measuring the incident response capability within the organization;
 7. Defines the resources and management support needed to effectively maintain and mature an incident response capability;
 8. Addresses the sharing of incident information;
 9. Is reviewed and approved by [Assignment: organization-defined personnel or roles] [Assignment: organization-defined frequency]; and
 10. Explicitly designates responsibility for incident response to [Assignment: organization-defined entities, personnel, or roles].
- b. Distribute copies of the incident response plan to [Assignment: organization-defined incident response personnel (identified by name and/or by role) and organizational elements];
 - c. Update the incident response plan to address system and organizational changes or problems encountered during plan implementation, execution, or testing;
 - d. Communicate incident response plan changes to [Assignment: organization-defined incident response personnel (identified by name and/or by role) and organizational elements]; and
 - e. Protect the incident response plan from unauthorized disclosure and modification.

Discussion: It is important that organizations develop and implement a coordinated approach to incident response. Organizational mission and business functions determine the structure of incident response capabilities. As part of the incident response capabilities, organizations consider the coordination and sharing of information with external organizations, including external service providers and other organizations involved in the supply chain. For incidents involving personally identifiable information (i.e., breaches), include a process to determine whether notice to oversight organizations or affected individuals is appropriate and provide that notice accordingly.

Related Controls: [AC-2](#), [CP-2](#), [CP-4](#), [IR-4](#), [IR-7](#), [IR-9](#), [PE-6](#), [PL-2](#), [SA-15](#), [SI-12](#), [SR-8](#).

Control Enhancements:

(1) INCIDENT RESPONSE PLAN | [BREACHES](#)

Include the following in the Incident Response Plan for breaches involving personally identifiable information:

- (a) A process to determine if notice to individuals or other organizations, including oversight organizations, is needed;
- (b) An assessment process to determine the extent of the harm, embarrassment, inconvenience, or unfairness to affected individuals and any mechanisms to mitigate such harms; and
- (c) Identification of applicable privacy requirements.

Discussion: Organizations may be required by law, regulation, or policy to follow specific procedures relating to breaches, including notice to individuals, affected organizations, and oversight bodies; standards of harm; and mitigation or other specific requirements.

Related Controls: [PT-1](#), [PT-2](#), [PT-3](#), [PT-4](#), [PT-5](#), [PT-7](#).

References: [\[OMB A-130\]](#), [\[SP 800-61\]](#), [\[OMB M-17-12\]](#).

[IR-9](#) INFORMATION SPILLAGE RESPONSE

Control: Respond to information spills by:

- a. Assigning [Assignment: organization-defined personnel or roles] with responsibility for responding to information spills;

- b. Identifying the specific information involved in the system contamination;
- c. Alerting [Assignment: organization-defined personnel or roles] of the information spill using a method of communication not associated with the spill;
- d. Isolating the contaminated system or system component;
- e. Eradicating the information from the contaminated system or component;
- f. Identifying other systems or system components that may have been subsequently contaminated; and
- g. Performing the following additional actions: [Assignment: organization-defined actions].

Discussion: Information spillage refers to instances where information is placed on systems that are not authorized to process such information. Information spills occur when information that is thought to be a certain classification or impact level is transmitted to a system and subsequently is determined to be of a higher classification or impact level. At that point, corrective action is required. The nature of the response is based on the classification or impact level of the spilled information, the security capabilities of the system, the specific nature of the contaminated storage media, and the access authorizations of individuals with authorized access to the contaminated system. The methods used to communicate information about the spill after the fact do not involve methods directly associated with the actual spill to minimize the risk of further spreading the contamination before such contamination is isolated and eradicated.

Related Controls: [CP-2](#), [IR-6](#), [PM-26](#), [PM-27](#), [PT-2](#), [PT-3](#), [PT-7](#), [RA-7](#).

Control Enhancements:

(1) INFORMATION SPILLAGE RESPONSE | RESPONSIBLE PERSONNEL

[Withdrawn: Incorporated into [IR-9](#).]

(2) INFORMATION SPILLAGE RESPONSE | [TRAINING](#)

Provide information spillage response training [Assignment: organization-defined frequency].

Discussion: Organizations establish requirements for responding to information spillage incidents in incident response plans. Incident response training on a regular basis helps to ensure that organizational personnel understand their individual responsibilities and what specific actions to take when spillage incidents occur.

Related Controls: [AT-2](#), [AT-3](#), [CP-3](#), [IR-2](#).

(3) INFORMATION SPILLAGE RESPONSE | [POST-SPILL OPERATIONS](#)

Implement the following procedures to ensure that organizational personnel impacted by information spills can continue to carry out assigned tasks while contaminated systems are undergoing corrective actions: [Assignment: organization-defined procedures].

Discussion: Corrective actions for systems contaminated due to information spillages may be time-consuming. Personnel may not have access to the contaminated systems while corrective actions are being taken, which may potentially affect their ability to conduct organizational business.

Related Controls: None.

(4) INFORMATION SPILLAGE RESPONSE | [EXPOSURE TO UNAUTHORIZED PERSONNEL](#)

Employ the following controls for personnel exposed to information not within assigned access authorizations: [Assignment: organization-defined controls].

Discussion: Controls include ensuring that personnel who are exposed to spilled information are made aware of the laws, executive orders, directives, regulations, policies, standards,

and guidelines regarding the information and the restrictions imposed based on exposure to such information.

Related Controls: None.

References: None.

IR-10 INTEGRATED INFORMATION SECURITY ANALYSIS TEAM

[Withdrawn: Moved to [IR-4\(11\)](#).]

3.9 MAINTENANCE

[Quick link to Maintenance Summary Table](#)

MA-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] maintenance policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the maintenance policy and the associated maintenance controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the maintenance policy and procedures; and
- c. Review and update the current maintenance:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Maintenance policy and procedures address the controls in the MA family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of maintenance policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to maintenance policy and procedures assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

MA-2 CONTROLLED MAINTENANCE

Control:

- a. Schedule, document, and review records of maintenance, repair, and replacement on system components in accordance with manufacturer or vendor specifications and/or organizational requirements;
- b. Approve and monitor all maintenance activities, whether performed on site or remotely and whether the system or system components are serviced on site or removed to another location;
- c. Require that [Assignment: organization-defined personnel or roles] explicitly approve the removal of the system or system components from organizational facilities for off-site maintenance, repair, or replacement;
- d. Sanitize equipment to remove the following information from associated media prior to removal from organizational facilities for off-site maintenance, repair, or replacement: [Assignment: organization-defined information];
- e. Check all potentially impacted controls to verify that the controls are still functioning properly following maintenance, repair, or replacement actions; and
- f. Include the following information in organizational maintenance records: [Assignment: organization-defined information].

Discussion: Controlling system maintenance addresses the information security aspects of the system maintenance program and applies to all types of maintenance to system components conducted by local or nonlocal entities. Maintenance includes peripherals such as scanners, copiers, and printers. Information necessary for creating effective maintenance records includes the date and time of maintenance, a description of the maintenance performed, names of the individuals or group performing the maintenance, name of the escort, and system components or equipment that are removed or replaced. Organizations consider supply chain-related risks associated with replacement components for systems.

Related Controls: [CM-2](#), [CM-3](#), [CM-4](#), [CM-5](#), [CM-8](#), [MA-4](#), [MP-6](#), [PE-16](#), [SI-2](#), [SR-3](#), [SR-4](#), [SR-11](#).

Control Enhancements:

(1) CONTROLLED MAINTENANCE | RECORD CONTENT

[Withdrawn: Incorporated into [MA-2](#).]

(2) CONTROLLED MAINTENANCE | [AUTOMATED MAINTENANCE ACTIVITIES](#)

- (a) Schedule, conduct, and document maintenance, repair, and replacement actions for the system using [Assignment: organization-defined automated mechanisms]; and
- (b) Produce up-to date, accurate, and complete records of all maintenance, repair, and replacement actions requested, scheduled, in process, and completed.

Discussion: The use of automated mechanisms to manage and control system maintenance programs and activities helps to ensure the generation of timely, accurate, complete, and consistent maintenance records.

Related Controls: [MA-3](#).

References: [\[OMB A-130\]](#), [\[IR 8023\]](#).

MA-3 MAINTENANCE TOOLS

Control:

- a. Approve, control, and monitor the use of system maintenance tools; and

- b. Review previously approved system maintenance tools [*Assignment: organization-defined frequency*].

Discussion: Approving, controlling, monitoring, and reviewing maintenance tools address security-related issues associated with maintenance tools that are not within system authorization boundaries and are used specifically for diagnostic and repair actions on organizational systems. Organizations have flexibility in determining roles for the approval of maintenance tools and how that approval is documented. A periodic review of maintenance tools facilitates the withdrawal of approval for outdated, unsupported, irrelevant, or no-longer-used tools. Maintenance tools can include hardware, software, and firmware items and may be pre-installed, brought in with maintenance personnel on media, cloud-based, or downloaded from a website. Such tools can be vehicles for transporting malicious code, either intentionally or unintentionally, into a facility and subsequently into systems. Maintenance tools can include hardware and software diagnostic test equipment and packet sniffers. The hardware and software components that support maintenance and are a part of the system (including the software implementing utilities such as “ping,” “ls,” “ipconfig,” or the hardware and software implementing the monitoring port of an Ethernet switch) are not addressed by maintenance tools.

Related Controls: [MA-2](#), [PE-16](#).

Control Enhancements:

(1) MAINTENANCE TOOLS | [INSPECT TOOLS](#)

Inspect the maintenance tools used by maintenance personnel for improper or unauthorized modifications.

Discussion: Maintenance tools can be directly brought into a facility by maintenance personnel or downloaded from a vendor’s website. If, upon inspection of the maintenance tools, organizations determine that the tools have been modified in an improper manner or the tools contain malicious code, the incident is handled consistent with organizational policies and procedures for incident handling.

Related Controls: [SI-7](#).

(2) MAINTENANCE TOOLS | [INSPECT MEDIA](#)

Check media containing diagnostic and test programs for malicious code before the media are used in the system.

Discussion: If, upon inspection of media containing maintenance, diagnostic, and test programs, organizations determine that the media contains malicious code, the incident is handled consistent with organizational incident handling policies and procedures.

Related Controls: [SI-3](#).

(3) MAINTENANCE TOOLS | [PREVENT UNAUTHORIZED REMOVAL](#)

Prevent the removal of maintenance equipment containing organizational information by:

- (a) Verifying that there is no organizational information contained on the equipment;**
- (b) Sanitizing or destroying the equipment;**
- (c) Retaining the equipment within the facility; or**
- (d) Obtaining an exemption from [*Assignment: organization-defined personnel or roles*] explicitly authorizing removal of the equipment from the facility.**

Discussion: Organizational information includes all information owned by organizations and any information provided to organizations for which the organizations serve as information stewards.

Related Controls: [MP-6](#).

(4) MAINTENANCE TOOLS | [RESTRICTED TOOL USE](#)

Restrict the use of maintenance tools to authorized personnel only.

Discussion: Restricting the use of maintenance tools to only authorized personnel applies to systems that are used to carry out maintenance functions.

Related Controls: [AC-3](#), [AC-5](#), [AC-6](#).

(5) MAINTENANCE TOOLS | [EXECUTION WITH PRIVILEGE](#)

Monitor the use of maintenance tools that execute with increased privilege.

Discussion: Maintenance tools that execute with increased system privilege can result in unauthorized access to organizational information and assets that would otherwise be inaccessible.

Related Controls: [AC-3](#), [AC-6](#).

(6) MAINTENANCE TOOLS | [SOFTWARE UPDATES AND PATCHES](#)

Inspect maintenance tools to ensure the latest software updates and patches are installed.

Discussion: Maintenance tools using outdated and/or unpatched software can provide a threat vector for adversaries and result in a significant vulnerability for organizations.

Related Controls: [AC-3](#), [AC-6](#).

References: [\[SP 800-88\]](#).

MA-4 NONLOCAL MAINTENANCE

Control:

- a. Approve and monitor nonlocal maintenance and diagnostic activities;
- b. Allow the use of nonlocal maintenance and diagnostic tools only as consistent with organizational policy and documented in the security plan for the system;
- c. Employ strong authentication in the establishment of nonlocal maintenance and diagnostic sessions;
- d. Maintain records for nonlocal maintenance and diagnostic activities; and
- e. Terminate session and network connections when nonlocal maintenance is completed.

Discussion: Nonlocal maintenance and diagnostic activities are conducted by individuals who communicate through either an external or internal network. Local maintenance and diagnostic activities are carried out by individuals who are physically present at the system location and not communicating across a network connection. Authentication techniques used to establish nonlocal maintenance and diagnostic sessions reflect the network access requirements in [IA-2](#). Strong authentication requires authenticators that are resistant to replay attacks and employ multi-factor authentication. Strong authenticators include PKI where certificates are stored on a token protected by a password, passphrase, or biometric. Enforcing requirements in [MA-4](#) is accomplished, in part, by other controls. [\[SP 800-63B\]](#) provides additional guidance on strong authentication and authenticators.

Related Controls: [AC-2](#), [AC-3](#), [AC-6](#), [AC-17](#), [AU-2](#), [AU-3](#), [IA-2](#), [IA-4](#), [IA-5](#), [IA-8](#), [MA-2](#), [MA-5](#), [PL-2](#), [SC-7](#), [SC-10](#).

Control Enhancements:

(1) NONLOCAL MAINTENANCE | [LOGGING AND REVIEW](#)

- (a) Log [*Assignment: organization-defined audit events*] for nonlocal maintenance and diagnostic sessions; and

- (b) Review the audit records of the maintenance and diagnostic sessions to detect anomalous behavior.**

Discussion: Audit logging for nonlocal maintenance is enforced by [AU-2](#). Audit events are defined in [AU-2a](#).

Related Controls: [AU-6](#), [AU-12](#).

(2) NONLOCAL MAINTENANCE | DOCUMENT NONLOCAL MAINTENANCE

[Withdrawn: Incorporated into [MA-1](#) and [MA-4](#).]

(3) NONLOCAL MAINTENANCE | [COMPARABLE SECURITY AND SANITIZATION](#)

- (a) Require that nonlocal maintenance and diagnostic services be performed from a system that implements a security capability comparable to the capability implemented on the system being serviced; or**
- (b) Remove the component to be serviced from the system prior to nonlocal maintenance or diagnostic services; sanitize the component (for organizational information); and after the service is performed, inspect and sanitize the component (for potentially malicious software) before reconnecting the component to the system.**

Discussion: Comparable security capability on systems, diagnostic tools, and equipment providing maintenance services implies that the implemented controls on those systems, tools, and equipment are at least as comprehensive as the controls on the system being serviced.

Related Controls: [MP-6](#), [SI-3](#), [SI-7](#).

(4) NONLOCAL MAINTENANCE | [AUTHENTICATION AND SEPARATION OF MAINTENANCE SESSIONS](#)

Protect nonlocal maintenance sessions by:

- (a) Employing [Assignment: organization-defined authenticators that are replay resistant]; and**
- (b) Separating the maintenance sessions from other network sessions with the system by either:**
 - (1) Physically separated communications paths; or**
 - (2) Logically separated communications paths.**

Discussion: Communications paths can be logically separated using encryption.

Related Controls: None.

(5) NONLOCAL MAINTENANCE | [APPROVALS AND NOTIFICATIONS](#)

- (a) Require the approval of each nonlocal maintenance session by [Assignment: organization-defined personnel or roles]; and**
- (b) Notify the following personnel or roles of the date and time of planned nonlocal maintenance: [Assignment: organization-defined personnel or roles].**

Discussion: Notification may be performed by maintenance personnel. Approval of nonlocal maintenance is accomplished by personnel with sufficient information security and system knowledge to determine the appropriateness of the proposed maintenance.

Related Controls: None.

(6) NONLOCAL MAINTENANCE | [CRYPTOGRAPHIC PROTECTION](#)

Implement the following cryptographic mechanisms to protect the integrity and confidentiality of nonlocal maintenance and diagnostic communications: [Assignment: organization-defined cryptographic mechanisms].

Discussion: Failure to protect nonlocal maintenance and diagnostic communications can result in unauthorized individuals gaining access to organizational information. Unauthorized

access during remote maintenance sessions can result in a variety of hostile actions, including malicious code insertion, unauthorized changes to system parameters, and exfiltration of organizational information. Such actions can result in the loss or degradation of mission or business capabilities.

Related Controls: [SC-8](#), [SC-12](#), [SC-13](#).

(7) NONLOCAL MAINTENANCE | [DISCONNECT VERIFICATION](#)

Verify session and network connection termination after the completion of nonlocal maintenance and diagnostic sessions.

Discussion: Verifying the termination of a connection once maintenance is completed ensures that connections established during nonlocal maintenance and diagnostic sessions have been terminated and are no longer available for use.

Related Controls: [AC-12](#).

References: [\[FIPS 140-3\]](#), [\[FIPS 197\]](#), [\[FIPS 201-2\]](#), [\[SP 800-63-3\]](#), [\[SP 800-88\]](#).

[MA-5 MAINTENANCE PERSONNEL](#)

Control:

- a. Establish a process for maintenance personnel authorization and maintain a list of authorized maintenance organizations or personnel;
- b. Verify that non-escorted personnel performing maintenance on the system possess the required access authorizations; and
- c. Designate organizational personnel with required access authorizations and technical competence to supervise the maintenance activities of personnel who do not possess the required access authorizations.

Discussion: Maintenance personnel refers to individuals who perform hardware or software maintenance on organizational systems, while [PE-2](#) addresses physical access for individuals whose maintenance duties place them within the physical protection perimeter of the systems. Technical competence of supervising individuals relates to the maintenance performed on the systems, while having required access authorizations refers to maintenance on and near the systems. Individuals not previously identified as authorized maintenance personnel—such as information technology manufacturers, vendors, systems integrators, and consultants—may require privileged access to organizational systems, such as when they are required to conduct maintenance activities with little or no notice. Based on organizational assessments of risk, organizations may issue temporary credentials to these individuals. Temporary credentials may be for one-time use or for very limited time periods.

Related Controls: [AC-2](#), [AC-3](#), [AC-5](#), [AC-6](#), [IA-2](#), [IA-8](#), [MA-4](#), [MP-2](#), [PE-2](#), [PE-3](#), [PS-7](#), [RA-3](#).

Control Enhancements:

(1) MAINTENANCE PERSONNEL | [INDIVIDUALS WITHOUT APPROPRIATE ACCESS](#)

- (a) Implement procedures for the use of maintenance personnel that lack appropriate security clearances or are not U.S. citizens, that include the following requirements:**
- (1) Maintenance personnel who do not have needed access authorizations, clearances, or formal access approvals are escorted and supervised during the performance of maintenance and diagnostic activities on the system by approved organizational personnel who are fully cleared, have appropriate access authorizations, and are technically qualified; and**
 - (2) Prior to initiating maintenance or diagnostic activities by personnel who do not have needed access authorizations, clearances or formal access approvals, all**

volatile information storage components within the system are sanitized and all nonvolatile storage media are removed or physically disconnected from the system and secured; and

- (b) Develop and implement [Assignment: organization-defined alternate controls] in the event a system component cannot be sanitized, removed, or disconnected from the system.**

Discussion: Procedures for individuals who lack appropriate security clearances or who are not U.S. citizens are intended to deny visual and electronic access to classified or controlled unclassified information contained on organizational systems. Procedures for the use of maintenance personnel can be documented in security plans for the systems.

Related Controls: [MP-6](#), [PL-2](#).

(2) MAINTENANCE PERSONNEL | [SECURITY CLEARANCES FOR CLASSIFIED SYSTEMS](#)

Verify that personnel performing maintenance and diagnostic activities on a system processing, storing, or transmitting classified information possess security clearances and formal access approvals for at least the highest classification level and for compartments of information on the system.

Discussion: Personnel who conduct maintenance on organizational systems may be exposed to classified information during the course of their maintenance activities. To mitigate the inherent risk of such exposure, organizations use maintenance personnel that are cleared (i.e., possess security clearances) to the classification level of the information stored on the system.

Related Controls: [PS-3](#).

(3) MAINTENANCE PERSONNEL | [CITIZENSHIP REQUIREMENTS FOR CLASSIFIED SYSTEMS](#)

Verify that personnel performing maintenance and diagnostic activities on a system processing, storing, or transmitting classified information are U.S. citizens.

Discussion: Personnel who conduct maintenance on organizational systems may be exposed to classified information during the course of their maintenance activities. If access to classified information on organizational systems is restricted to U.S. citizens, the same restriction is applied to personnel performing maintenance on those systems.

Related Controls: [PS-3](#).

(4) MAINTENANCE PERSONNEL | [FOREIGN NATIONALS](#)

Ensure that:

- (a) Foreign nationals with appropriate security clearances are used to conduct maintenance and diagnostic activities on classified systems only when the systems are jointly owned and operated by the United States and foreign allied governments, or owned and operated solely by foreign allied governments; and**
- (b) Approvals, consents, and detailed operational conditions regarding the use of foreign nationals to conduct maintenance and diagnostic activities on classified systems are fully documented within Memoranda of Agreements.**

Discussion: Personnel who conduct maintenance and diagnostic activities on organizational systems may be exposed to classified information. If non-U.S. citizens are permitted to perform maintenance and diagnostics activities on classified systems, then additional vetting is required to ensure agreements and restrictions are not being violated.

Related Controls: [PS-3](#).

(5) MAINTENANCE PERSONNEL | [NON-SYSTEM MAINTENANCE](#)

Ensure that non-escorted personnel performing maintenance activities not directly associated with the system but in the physical proximity of the system, have required access authorizations.

Discussion: Personnel who perform maintenance activities in other capacities not directly related to the system include physical plant personnel and custodial personnel.

Related Controls: None.

References: None.

MA-6 TIMELY MAINTENANCE

Control: Obtain maintenance support and/or spare parts for [Assignment: organization-defined system components] within [Assignment: organization-defined time period] of failure.

Discussion: Organizations specify the system components that result in increased risk to organizational operations and assets, individuals, other organizations, or the Nation when the functionality provided by those components is not operational. Organizational actions to obtain maintenance support include having appropriate contracts in place.

Related Controls: [CM-8](#), [CP-2](#), [CP-7](#), [RA-7](#), [SA-15](#), [SI-13](#), [SR-2](#), [SR-3](#), [SR-4](#).

Control Enhancements:

(1) TIMELY MAINTENANCE | [PREVENTIVE MAINTENANCE](#)

Perform preventive maintenance on [Assignment: organization-defined system components] at [Assignment: organization-defined time intervals].

Discussion: Preventive maintenance includes proactive care and the servicing of system components to maintain organizational equipment and facilities in satisfactory operating condition. Such maintenance provides for the systematic inspection, tests, measurements, adjustments, parts replacement, detection, and correction of incipient failures either before they occur or before they develop into major defects. The primary goal of preventive maintenance is to avoid or mitigate the consequences of equipment failures. Preventive maintenance is designed to preserve and restore equipment reliability by replacing worn components before they fail. Methods of determining what preventive (or other) failure management policies to apply include original equipment manufacturer recommendations; statistical failure records; expert opinion; maintenance that has already been conducted on similar equipment; requirements of codes, laws, or regulations within a jurisdiction; or measured values and performance indications.

Related Controls: None.

(2) TIMELY MAINTENANCE | [PREDICTIVE MAINTENANCE](#)

Perform predictive maintenance on [Assignment: organization-defined system components] at [Assignment: organization-defined time intervals].

Discussion: Predictive maintenance evaluates the condition of equipment by performing periodic or continuous (online) equipment condition monitoring. The goal of predictive maintenance is to perform maintenance at a scheduled time when the maintenance activity is most cost-effective and before the equipment loses performance within a threshold. The predictive component of predictive maintenance stems from the objective of predicting the future trend of the equipment's condition. The predictive maintenance approach employs principles of statistical process control to determine at what point in the future maintenance activities will be appropriate. Most predictive maintenance inspections are performed while equipment is in service, thus minimizing disruption of normal system operations. Predictive maintenance can result in substantial cost savings and higher system reliability.

Related Controls: None.

(3) TIMELY MAINTENANCE | [AUTOMATED SUPPORT FOR PREDICTIVE MAINTENANCE](#)

Transfer predictive maintenance data to a maintenance management system using [Assignment: organization-defined automated mechanisms].

Discussion: A computerized maintenance management system maintains a database of information about the maintenance operations of organizations and automates the processing of equipment condition data to trigger maintenance planning, execution, and reporting.

Related Controls: None.

References: None.

[MA-7 FIELD MAINTENANCE](#)

Control: Restrict or prohibit field maintenance on [Assignment: organization-defined systems or system components] to [Assignment: organization-defined trusted maintenance facilities].

Discussion: Field maintenance is the type of maintenance conducted on a system or system component after the system or component has been deployed to a specific site (i.e., operational environment). In certain instances, field maintenance (i.e., local maintenance at the site) may not be executed with the same degree of rigor or with the same quality control checks as depot maintenance. For critical systems designated as such by the organization, it may be necessary to restrict or prohibit field maintenance at the local site and require that such maintenance be conducted in trusted facilities with additional controls.

Related Controls: [MA-2](#), [MA-4](#), [MA-5](#).

Control Enhancements: None.

References: None.

3.10 MEDIA PROTECTION

[Quick link to Media Protection Summary Table](#)

MP-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] media protection policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the media protection policy and the associated media protection controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the media protection policy and procedures; and
- c. Review and update the current media protection:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Media protection policy and procedures address the controls in the MP family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of media protection policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to media protection policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

MP-2 MEDIA ACCESS

Control: Restrict access to [Assignment: organization-defined types of digital and/or non-digital media] to [Assignment: organization-defined personnel or roles].

Discussion: System media includes digital and non-digital media. Digital media includes flash drives, diskettes, magnetic tapes, external or removable hard disk drives (e.g., solid state, magnetic), compact discs, and digital versatile discs. Non-digital media includes paper and microfilm. Denying access to patient medical records in a community hospital unless the individuals seeking access to such records are authorized healthcare providers is an example of restricting access to non-digital media. Limiting access to the design specifications stored on compact discs in the media library to individuals on the system development team is an example of restricting access to digital media.

Related Controls: [AC-19](#), [AU-9](#), [CP-2](#), [CP-9](#), [CP-10](#), [MA-5](#), [MP-4](#), [MP-6](#), [PE-2](#), [PE-3](#), [SC-12](#), [SC-13](#), [SC-34](#), [SI-12](#).

Control Enhancements:

(1) MEDIA ACCESS | AUTOMATED RESTRICTED ACCESS

[Withdrawn: Incorporated into [MP-4\(2\)](#).]

(2) MEDIA ACCESS | CRYPTOGRAPHIC PROTECTION

[Withdrawn: Incorporated into [SC-28\(1\)](#).]

References: [\[OMB A-130\]](#), [\[FIPS 199\]](#), [\[SP 800-111\]](#).

MP-3 MEDIA MARKING

Control:

- a. Mark system media indicating the distribution limitations, handling caveats, and applicable security markings (if any) of the information; and
- b. Exempt [Assignment: organization-defined types of system media] from marking if the media remain within [Assignment: organization-defined controlled areas].

Discussion: Security marking refers to the application or use of human-readable security attributes. Digital media includes diskettes, magnetic tapes, external or removable hard disk drives (e.g., solid state, magnetic), flash drives, compact discs, and digital versatile discs. Non-digital media includes paper and microfilm. Controlled unclassified information is defined by the National Archives and Records Administration along with the appropriate safeguarding and dissemination requirements for such information and is codified in [\[32 CFR 2002\]](#). Security markings are generally not required for media that contains information determined by organizations to be in the public domain or to be publicly releasable. Some organizations may require markings for public information indicating that the information is publicly releasable. System media marking reflects applicable laws, executive orders, directives, policies, regulations, standards, and guidelines.

Related Controls: [AC-16](#), [CP-9](#), [MP-5](#), [PE-22](#), [SI-12](#).

Control Enhancements: None.

References: [\[EO 13556\]](#), [\[32 CFR 2002\]](#), [\[FIPS 199\]](#).

MP-4 MEDIA STORAGE

Control:

- a. Physically control and securely store [Assignment: organization-defined types of digital and/or non-digital media] within [Assignment: organization-defined controlled areas]; and
- b. Protect system media types defined in MP-4a until the media are destroyed or sanitized using approved equipment, techniques, and procedures.

Discussion: System media includes digital and non-digital media. Digital media includes flash drives, diskettes, magnetic tapes, external or removable hard disk drives (e.g., solid state, magnetic), compact discs, and digital versatile discs. Non-digital media includes paper and microfilm. Physically controlling stored media includes conducting inventories, ensuring procedures are in place to allow individuals to check out and return media to the library, and maintaining accountability for stored media. Secure storage includes a locked drawer, desk, or cabinet or a controlled media library. The type of media storage is commensurate with the security category or classification of the information on the media. Controlled areas are spaces that provide physical and procedural controls to meet the requirements established for protecting information and systems. Fewer controls may be needed for media that contains information determined to be in the public domain, publicly releasable, or have limited adverse impacts on organizations, operations, or individuals if accessed by other than authorized personnel. In these situations, physical access controls provide adequate protection.

Related Controls: [AC-19](#), [CP-2](#), [CP-6](#), [CP-9](#), [CP-10](#), [MP-2](#), [MP-7](#), [PE-3](#), [PL-2](#), [SC-12](#), [SC-13](#), [SC-28](#), [SC-34](#), [SI-12](#).

Control Enhancements:

(1) MEDIA STORAGE | CRYPTOGRAPHIC PROTECTION

[Withdrawn: Incorporated into [SC-28\(1\)](#).]

(2) MEDIA STORAGE | AUTOMATED RESTRICTED ACCESS

Restrict access to media storage areas and log access attempts and access granted using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms include keypads, biometric readers, or card readers on the external entries to media storage areas.

Related Controls: [AC-3](#), [AU-2](#), [AU-6](#), [AU-9](#), [AU-12](#), [PE-3](#).

References: [\[FIPS 199\]](#), [\[SP 800-56A\]](#), [\[SP 800-56B\]](#), [\[SP 800-56C\]](#), [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), [\[SP 800-57-3\]](#), [\[SP 800-111\]](#).

MP-5 MEDIA TRANSPORT

Control:

- a. Protect and control [Assignment: organization-defined types of system media] during transport outside of controlled areas using [Assignment: organization-defined controls];
- b. Maintain accountability for system media during transport outside of controlled areas;
- c. Document activities associated with the transport of system media; and
- d. Restrict the activities associated with the transport of system media to authorized personnel.

Discussion: System media includes digital and non-digital media. Digital media includes flash drives, diskettes, magnetic tapes, external or removable hard disk drives (e.g., solid state and magnetic), compact discs, and digital versatile discs. Non-digital media includes microfilm and paper. Controlled areas are spaces for which organizations provide physical or procedural controls to meet requirements established for protecting information and systems. Controls to protect media during transport include cryptography and locked containers. Cryptographic

mechanisms can provide confidentiality and integrity protections depending on the mechanisms implemented. Activities associated with media transport include releasing media for transport, ensuring that media enters the appropriate transport processes, and the actual transport. Authorized transport and courier personnel may include individuals external to the organization. Maintaining accountability of media during transport includes restricting transport activities to authorized personnel and tracking and/or obtaining records of transport activities as the media moves through the transportation system to prevent and detect loss, destruction, or tampering. Organizations establish documentation requirements for activities associated with the transport of system media in accordance with organizational assessments of risk. Organizations maintain the flexibility to define record-keeping methods for the different types of media transport as part of a system of transport-related records.

Related Controls: [AC-7](#), [AC-19](#), [CP-2](#), [CP-9](#), [MP-3](#), [MP-4](#), [PE-16](#), [PL-2](#), [SC-12](#), [SC-13](#), [SC-28](#), [SC-34](#).

Control Enhancements:

(1) MEDIA TRANSPORT | PROTECTION OUTSIDE OF CONTROLLED AREAS

[Withdrawn: Incorporated into [MP-5](#).]

(2) MEDIA TRANSPORT | DOCUMENTATION OF ACTIVITIES

[Withdrawn: Incorporated into [MP-5](#).]

(3) MEDIA TRANSPORT | [CUSTODIANS](#)

Employ an identified custodian during transport of system media outside of controlled areas.

Discussion: Identified custodians provide organizations with specific points of contact during the media transport process and facilitate individual accountability. Custodial responsibilities can be transferred from one individual to another if an unambiguous custodian is identified.

Related Controls: None.

(4) MEDIA TRANSPORT | CRYPTOGRAPHIC PROTECTION

[Withdrawn: Incorporated into [SC-28\(1\)](#).]

References: [\[FIPS 199\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#).

[MP-6](#) MEDIA SANITIZATION

Control:

- a. Sanitize [*Assignment: organization-defined system media*] prior to disposal, release out of organizational control, or release for reuse using [*Assignment: organization-defined sanitization techniques and procedures*]; and
- b. Employ sanitization mechanisms with the strength and integrity commensurate with the security category or classification of the information.

Discussion: Media sanitization applies to all digital and non-digital system media subject to disposal or reuse, whether or not the media is considered removable. Examples include digital media in scanners, copiers, printers, notebook computers, workstations, network components, mobile devices, and non-digital media (e.g., paper and microfilm). The sanitization process removes information from system media such that the information cannot be retrieved or reconstructed. Sanitization techniques—including clearing, purging, cryptographic erase, de-identification of personally identifiable information, and destruction—prevent the disclosure of information to unauthorized individuals when such media is reused or released for disposal.

Organizations determine the appropriate sanitization methods, recognizing that destruction is sometimes necessary when other methods cannot be applied to media requiring sanitization.

Organizations use discretion on the employment of approved sanitization techniques and procedures for media that contains information deemed to be in the public domain or publicly releasable or information deemed to have no adverse impact on organizations or individuals if released for reuse or disposal. Sanitization of non-digital media includes destruction, removing a classified appendix from an otherwise unclassified document, or redacting selected sections or words from a document by obscuring the redacted sections or words in a manner equivalent in effectiveness to removing them from the document. NSA standards and policies control the sanitization process for media that contains classified information. NARA policies control the sanitization process for controlled unclassified information.

Related Controls: [AC-3](#), [AC-7](#), [AU-11](#), [MA-2](#), [MA-3](#), [MA-4](#), [MA-5](#), [PM-22](#), [SI-12](#), [SI-18](#), [SI-19](#), [SR-11](#).

Control Enhancements:

(1) MEDIA SANITIZATION | [REVIEW, APPROVE, TRACK, DOCUMENT, AND VERIFY](#)

Review, approve, track, document, and verify media sanitization and disposal actions.

Discussion: Organizations review and approve media to be sanitized to ensure compliance with records retention policies. Tracking and documenting actions include listing personnel who reviewed and approved sanitization and disposal actions, types of media sanitized, files stored on the media, sanitization methods used, date and time of the sanitization actions, personnel who performed the sanitization, verification actions taken and personnel who performed the verification, and the disposal actions taken. Organizations verify that the sanitization of the media was effective prior to disposal.

Related Controls: None.

(2) MEDIA SANITIZATION | [EQUIPMENT TESTING](#)

Test sanitization equipment and procedures [Assignment: organization-defined frequency] to ensure that the intended sanitization is being achieved.

Discussion: Testing of sanitization equipment and procedures may be conducted by qualified and authorized external entities, including federal agencies or external service providers.

Related Controls: None.

(3) MEDIA SANITIZATION | [NONDESTRUCTIVE TECHNIQUES](#)

Apply nondestructive sanitization techniques to portable storage devices prior to connecting such devices to the system under the following circumstances: [Assignment: organization-defined circumstances requiring sanitization of portable storage devices].

Discussion: Portable storage devices include external or removable hard disk drives (e.g., solid state, magnetic), optical discs, magnetic or optical tapes, flash memory devices, flash memory cards, and other external or removable disks. Portable storage devices can be obtained from untrustworthy sources and contain malicious code that can be inserted into or transferred to organizational systems through USB ports or other entry portals. While scanning storage devices is recommended, sanitization provides additional assurance that such devices are free of malicious code. Organizations consider nondestructive sanitization of portable storage devices when the devices are purchased from manufacturers or vendors prior to initial use or when organizations cannot maintain a positive chain of custody for the devices.

Related Controls: None.

(4) MEDIA SANITIZATION | CONTROLLED UNCLASSIFIED INFORMATION

[Withdrawn: Incorporated into [MP-6](#).]

(5) MEDIA SANITIZATION | CLASSIFIED INFORMATION

[Withdrawn: Incorporated into [MP-6](#).]

(6) MEDIA SANITIZATION | MEDIA DESTRUCTION

[Withdrawn: Incorporated into [MP-6](#).]

(7) MEDIA SANITIZATION | [DUAL AUTHORIZATION](#)

Enforce dual authorization for the sanitization of [Assignment: organization-defined system media].

Discussion: Organizations employ dual authorization to help ensure that system media sanitization cannot occur unless two technically qualified individuals conduct the designated task. Individuals who sanitize system media possess sufficient skills and expertise to determine if the proposed sanitization reflects applicable federal and organizational standards, policies, and procedures. Dual authorization also helps to ensure that sanitization occurs as intended, protecting against errors and false claims of having performed the sanitization actions. Dual authorization may also be known as two-person control. To reduce the risk of collusion, organizations consider rotating dual authorization duties to other individuals.

Related Controls: [AC-3](#), [MP-2](#).

(8) MEDIA SANITIZATION | [REMOTE PURGING OR WIPE OF INFORMATION](#)

Provide the capability to purge or wipe information from [Assignment: organization-defined systems or system components] [Selection: remotely; under the following conditions: [Assignment: organization-defined conditions]].

Discussion: Remote purging or wiping of information protects information on organizational systems and system components if systems or components are obtained by unauthorized individuals. Remote purge or wipe commands require strong authentication to help mitigate the risk of unauthorized individuals purging or wiping the system, component, or device. The purge or wipe function can be implemented in a variety of ways, including by overwriting data or information multiple times or by destroying the key necessary to decrypt encrypted data.

Related Controls: None.

References: [\[32 CFR 2002\]](#), [\[OMB A-130\]](#), [\[NARA CUI\]](#), [\[FIPS 199\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#), [\[SP 800-88\]](#), [\[SP 800-124\]](#), [\[IR 8023\]](#), [\[NSA MEDIA\]](#).

[MP-7](#) MEDIA USE

Control:

- a. [Selection: Restrict; Prohibit] the use of [Assignment: organization-defined types of system media] on [Assignment: organization-defined systems or system components] using [Assignment: organization-defined controls]; and
- b. Prohibit the use of portable storage devices in organizational systems when such devices have no identifiable owner.

Discussion: System media includes both digital and non-digital media. Digital media includes diskettes, magnetic tapes, flash drives, compact discs, digital versatile discs, and removable hard disk drives. Non-digital media includes paper and microfilm. Media use protections also apply to mobile devices with information storage capabilities. In contrast to [MP-2](#), which restricts user access to media, MP-7 restricts the use of certain types of media on systems, for example, restricting or prohibiting the use of flash drives or external hard disk drives. Organizations use technical and nontechnical controls to restrict the use of system media. Organizations may restrict the use of portable storage devices, for example, by using physical cages on workstations to prohibit access to certain external ports or disabling or removing the ability to insert, read, or

write to such devices. Organizations may also limit the use of portable storage devices to only approved devices, including devices provided by the organization, devices provided by other approved organizations, and devices that are not personally owned. Finally, organizations may restrict the use of portable storage devices based on the type of device, such as by prohibiting the use of writeable, portable storage devices and implementing this restriction by disabling or removing the capability to write to such devices. Requiring identifiable owners for storage devices reduces the risk of using such devices by allowing organizations to assign responsibility for addressing known vulnerabilities in the devices.

Related Controls: [AC-19](#), [AC-20](#), [PL-4](#), [PM-12](#), [SC-34](#), [SC-41](#).

Control Enhancements:

(1) MEDIA USE | PROHIBIT USE WITHOUT OWNER

[Withdrawn: Incorporated into [MP-7](#).]

(2) MEDIA USE | [PROHIBIT USE OF SANITIZATION-RESISTANT MEDIA](#)

Prohibit the use of sanitization-resistant media in organizational systems.

Discussion: Sanitization resistance refers to how resistant media are to non-destructive sanitization techniques with respect to the capability to purge information from media. Certain types of media do not support sanitization commands, or if supported, the interfaces are not supported in a standardized way across these devices. Sanitization-resistant media includes compact flash, embedded flash on boards and devices, solid state drives, and USB removable media.

Related Controls: [MP-6](#).

References: [\[FIPS 199\]](#), [\[SP 800-111\]](#).

MP-8 MEDIA DOWNGRADING

Control:

- a. Establish [Assignment: organization-defined system media downgrading process] that includes employing downgrading mechanisms with strength and integrity commensurate with the security category or classification of the information;
- b. Verify that the system media downgrading process is commensurate with the security category and/or classification level of the information to be removed and the access authorizations of the potential recipients of the downgraded information;
- c. Identify [Assignment: organization-defined system media requiring downgrading]; and
- d. Downgrade the identified system media using the established process.

Discussion: Media downgrading applies to digital and non-digital media subject to release outside of the organization, whether the media is considered removable or not. When applied to system media, the downgrading process removes information from the media, typically by security category or classification level, such that the information cannot be retrieved or reconstructed. Downgrading of media includes redacting information to enable wider release and distribution. Downgrading ensures that empty space on the media is devoid of information.

Related Controls: None.

Control Enhancements:

(1) MEDIA DOWNGRADING | [DOCUMENTATION OF PROCESS](#)

Document system media downgrading actions.

Discussion: Organizations can document the media downgrading process by providing information, such as the downgrading technique employed, the identification number of the downgraded media, and the identity of the individual that authorized and/or performed the downgrading action.

Related Controls: None.

(2) MEDIA DOWNGRADING | [EQUIPMENT TESTING](#)

Test downgrading equipment and procedures [Assignment: organization-defined frequency] to ensure that downgrading actions are being achieved.

Discussion: None.

Related Controls: None.

(3) MEDIA DOWNGRADING | [CONTROLLED UNCLASSIFIED INFORMATION](#)

Downgrade system media containing controlled unclassified information prior to public release.

Discussion: The downgrading of controlled unclassified information uses approved sanitization tools, techniques, and procedures.

Related Controls: None.

(4) MEDIA DOWNGRADING | [CLASSIFIED INFORMATION](#)

Downgrade system media containing classified information prior to release to individuals without required access authorizations.

Discussion: Downgrading of classified information uses approved sanitization tools, techniques, and procedures to transfer information confirmed to be unclassified from classified systems to unclassified media.

Related Controls: None.

References: [\[32 CFR 2002\]](#), [\[NSA MEDIA\]](#).

3.11 PHYSICAL AND ENVIRONMENTAL PROTECTION

[Quick link to Physical and Environmental Protection Summary Table](#)

PE-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] physical and environmental protection policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the physical and environmental protection policy and the associated physical and environmental protection controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the physical and environmental protection policy and procedures; and
- c. Review and update the current physical and environmental protection:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Physical and environmental protection policy and procedures address the controls in the PE family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of physical and environmental protection policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to physical and environmental protection policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [AT-3](#), [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

PE-2 PHYSICAL ACCESS AUTHORIZATIONS

Control:

- a. Develop, approve, and maintain a list of individuals with authorized access to the facility where the system resides;
- b. Issue authorization credentials for facility access;
- c. Review the access list detailing authorized facility access by individuals [*Assignment: organization-defined frequency*]; and
- d. Remove individuals from the facility access list when access is no longer required.

Discussion: Physical access authorizations apply to employees and visitors. Individuals with permanent physical access authorization credentials are not considered visitors. Authorization credentials include ID badges, identification cards, and smart cards. Organizations determine the strength of authorization credentials needed consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Physical access authorizations may not be necessary to access certain areas within facilities that are designated as publicly accessible.

Related Controls: [AT-3](#), [AU-9](#), [IA-4](#), [MA-5](#), [MP-2](#), [PE-3](#), [PE-4](#), [PE-5](#), [PE-8](#), [PM-12](#), [PS-3](#), [PS-4](#), [PS-5](#), [PS-6](#).

Control Enhancements:

(1) PHYSICAL ACCESS AUTHORIZATIONS | [ACCESS BY POSITION OR ROLE](#)

Authorize physical access to the facility where the system resides based on position or role.

Discussion: Role-based facility access includes access by authorized permanent and regular/routine maintenance personnel, duty officers, and emergency medical staff.

Related Controls: [AC-2](#), [AC-3](#), [AC-6](#).

(2) PHYSICAL ACCESS AUTHORIZATIONS | [TWO FORMS OF IDENTIFICATION](#)

Require two forms of identification from the following forms of identification for visitor access to the facility where the system resides: [Assignment: organization-defined list of acceptable forms of identification].

Discussion: Acceptable forms of identification include passports, REAL ID-compliant drivers' licenses, and Personal Identity Verification (PIV) cards. For gaining access to facilities using automated mechanisms, organizations may use PIV cards, key cards, PINs, and biometrics.

Related Controls: [IA-2](#), [IA-4](#), [IA-5](#).

(3) PHYSICAL ACCESS AUTHORIZATIONS | [RESTRICT UNESCORTED ACCESS](#)

Restrict unescorted access to the facility where the system resides to personnel with [Selection (one or more): security clearances for all information contained within the system; formal access authorizations for all information contained within the system; need for access to all information contained within the system; [Assignment: organization-defined physical access authorizations]].

Discussion: Individuals without required security clearances, access approvals, or need to know are escorted by individuals with appropriate physical access authorizations to ensure that information is not exposed or otherwise compromised.

Related Controls: [PS-2](#), [PS-6](#).

References: [\[FIPS 201-2\]](#), [\[SP 800-73-4\]](#), [\[SP 800-76-2\]](#), [\[SP 800-78-4\]](#).

PE-3 PHYSICAL ACCESS CONTROLControl:

- a. Enforce physical access authorizations at [Assignment: organization-defined entry and exit points to the facility where the system resides] by:
 1. Verifying individual access authorizations before granting access to the facility; and
 2. Controlling ingress and egress to the facility using [Selection (one or more): [Assignment: organization-defined physical access control systems or devices]; guards];
- b. Maintain physical access audit logs for [Assignment: organization-defined entry or exit points];
- c. Control access to areas within the facility designated as publicly accessible by implementing the following controls: [Assignment: organization-defined physical access controls];
- d. Escort visitors and control visitor activity [Assignment: organization-defined circumstances requiring visitor escorts and control of visitor activity];
- e. Secure keys, combinations, and other physical access devices;
- f. Inventory [Assignment: organization-defined physical access devices] every [Assignment: organization-defined frequency]; and
- g. Change combinations and keys [Assignment: organization-defined frequency] and/or when keys are lost, combinations are compromised, or when individuals possessing the keys or combinations are transferred or terminated.

Discussion: Physical access control applies to employees and visitors. Individuals with permanent physical access authorizations are not considered visitors. Physical access controls for publicly accessible areas may include physical access control logs/records, guards, or physical access devices and barriers to prevent movement from publicly accessible areas to non-public areas. Organizations determine the types of guards needed, including professional security staff, system users, or administrative staff. Physical access devices include keys, locks, combinations, biometric readers, and card readers. Physical access control systems comply with applicable laws, executive orders, directives, policies, regulations, standards, and guidelines. Organizations have flexibility in the types of audit logs employed. Audit logs can be procedural, automated, or some combination thereof. Physical access points can include facility access points, interior access points to systems that require supplemental access controls, or both. Components of systems may be in areas designated as publicly accessible with organizations controlling access to the components.

Related Controls: [AT-3](#), [AU-2](#), [AU-6](#), [AU-9](#), [AU-13](#), [CP-10](#), [IA-3](#), [IA-8](#), [MA-5](#), [MP-2](#), [MP-4](#), [PE-2](#), [PE-4](#), [PE-5](#), [PE-8](#), [PS-2](#), [PS-3](#), [PS-6](#), [PS-7](#), [RA-3](#), [SC-28](#), [SI-4](#), [SR-3](#).

Control Enhancements:**(1) PHYSICAL ACCESS CONTROL | [SYSTEM ACCESS](#)**

Enforce physical access authorizations to the system in addition to the physical access controls for the facility at [Assignment: organization-defined physical spaces containing one or more components of the system].

Discussion: Control of physical access to the system provides additional physical security for those areas within facilities where there is a concentration of system components.

Related Controls: None.

(2) PHYSICAL ACCESS CONTROL | [FACILITY AND SYSTEMS](#)

Perform security checks [Assignment: organization-defined frequency] at the physical perimeter of the facility or system for exfiltration of information or removal of system components.

Discussion: Organizations determine the extent, frequency, and/or randomness of security checks to adequately mitigate risk associated with exfiltration.

Related Controls: [AC-4](#), [SC-7](#).

(3) PHYSICAL ACCESS CONTROL | [CONTINUOUS GUARDS](#)

Employ guards to control [Assignment: organization-defined physical access points] to the facility where the system resides 24 hours per day, 7 days per week.

Discussion: Employing guards at selected physical access points to the facility provides a more rapid response capability for organizations. Guards also provide the opportunity for human surveillance in areas of the facility not covered by video surveillance.

Related Controls: [CP-6](#), [CP-7](#), [PE-6](#).

(4) PHYSICAL ACCESS CONTROL | [LOCKABLE CASINGS](#)

Use lockable physical casings to protect [Assignment: organization-defined system components] from unauthorized physical access.

Discussion: The greatest risk from the use of portable devices—such as smart phones, tablets, and notebook computers—is theft. Organizations can employ lockable, physical casings to reduce or eliminate the risk of equipment theft. Such casings come in a variety of sizes, from units that protect a single notebook computer to full cabinets that can protect multiple servers, computers, and peripherals. Lockable physical casings can be used in conjunction with cable locks or lockdown plates to prevent the theft of the locked casing containing the computer equipment.

Related Controls: None.

(5) PHYSICAL ACCESS CONTROL | [TAMPER PROTECTION](#)

Employ [Assignment: organization-defined anti-tamper technologies] to [Selection (one or more): detect; prevent] physical tampering or alteration of [Assignment: organization-defined hardware components] within the system.

Discussion: Organizations can implement tamper detection and prevention at selected hardware components or implement tamper detection at some components and tamper prevention at other components. Detection and prevention activities can employ many types of anti-tamper technologies, including tamper-detection seals and anti-tamper coatings. Anti-tamper programs help to detect hardware alterations through counterfeiting and other supply chain-related risks.

Related Controls: [SA-16](#), [SR-9](#), [SR-11](#).

(6) PHYSICAL ACCESS CONTROL | FACILITY PENETRATION TESTING

[Withdrawn: Incorporated into [CA-8](#).]

(7) PHYSICAL ACCESS CONTROL | [PHYSICAL BARRIERS](#)

Limit access using physical barriers.

Discussion: Physical barriers include bollards, concrete slabs, jersey walls, and hydraulic active vehicle barriers.

Related Controls: None.

(8) PHYSICAL ACCESS CONTROL | [ACCESS CONTROL VESTIBULES](#)

Employ access control vestibules at [Assignment: organization-defined locations within the facility].

Discussion: An access control vestibule is part of a physical access control system that typically provides a space between two sets of interlocking doors. Vestibules are designed to prevent unauthorized individuals from following authorized individuals into facilities with controlled access. This activity, also known as piggybacking or tailgating, results in unauthorized access to the facility. Interlocking door controllers can be used to limit the number of individuals who enter controlled access points and to provide containment areas while authorization for physical access is verified. Interlocking door controllers can be fully automated (i.e., controlling the opening and closing of the doors) or partially automated (i.e., using security guards to control the number of individuals entering the containment area).

Related Controls: None.

References: [[FIPS 201-2](#)], [[SP 800-73-4](#)], [[SP 800-76-2](#)], [[SP 800-78-4](#)], [[SP 800-116](#)].

PE-4 ACCESS CONTROL FOR TRANSMISSION

Control: Control physical access to [Assignment: organization-defined system distribution and transmission lines] within organizational facilities using [Assignment: organization-defined security controls].

Discussion: Security controls applied to system distribution and transmission lines prevent accidental damage, disruption, and physical tampering. Such controls may also be necessary to prevent eavesdropping or modification of unencrypted transmissions. Security controls used to control physical access to system distribution and transmission lines include disconnected or locked spare jacks, locked wiring closets, protection of cabling by conduit or cable trays, and wiretapping sensors.

Related Controls: [AT-3](#), [IA-4](#), [MP-2](#), [MP-4](#), [PE-2](#), [PE-3](#), [PE-5](#), [PE-9](#), [SC-7](#), [SC-8](#).

Control Enhancements: None.

References: None.

PE-5 ACCESS CONTROL FOR OUTPUT DEVICES

Control: Control physical access to output from [Assignment: organization-defined output devices] to prevent unauthorized individuals from obtaining the output.

Discussion: Controlling physical access to output devices includes placing output devices in locked rooms or other secured areas with keypad or card reader access controls and allowing access to authorized individuals only, placing output devices in locations that can be monitored by personnel, installing monitor or screen filters, and using headphones. Examples of output devices include monitors, printers, scanners, audio devices, facsimile machines, and copiers.

Related Controls: [PE-2](#), [PE-3](#), [PE-4](#), [PE-18](#).

Control Enhancements:

- (1) ACCESS CONTROL FOR OUTPUT DEVICES | ACCESS TO OUTPUT BY AUTHORIZED INDIVIDUALS
[Withdrawn: Incorporated into [PE-5](#).]

- (2) ACCESS CONTROL FOR OUTPUT DEVICES | [LINK TO INDIVIDUAL IDENTITY](#)

Link individual identity to receipt of output from output devices.

Discussion: Methods for linking individual identity to the receipt of output from output devices include installing security functionality on facsimile machines, copiers, and printers. Such functionality allows organizations to implement authentication on output devices prior to the release of output to individuals.

Related Controls: None.

(3) ACCESS CONTROL FOR OUTPUT DEVICES | MARKING OUTPUT DEVICES

[Withdrawn: Incorporated into [PE-22](#).]

References: [\[IR 8023\]](#).

PE-6 MONITORING PHYSICAL ACCESS

Control:

- a. Monitor physical access to the facility where the system resides to detect and respond to physical security incidents;
- b. Review physical access logs [*Assignment: organization-defined frequency*] and upon occurrence of [*Assignment: organization-defined events or potential indications of events*]; and
- c. Coordinate results of reviews and investigations with the organizational incident response capability.

Discussion: Physical access monitoring includes publicly accessible areas within organizational facilities. Examples of physical access monitoring include the employment of guards, video surveillance equipment (i.e., cameras), and sensor devices. Reviewing physical access logs can help identify suspicious activity, anomalous events, or potential threats. The reviews can be supported by audit logging controls, such as [AU-2](#), if the access logs are part of an automated system. Organizational incident response capabilities include investigations of physical security incidents and responses to the incidents. Incidents include security violations or suspicious physical access activities. Suspicious physical access activities include accesses outside of normal work hours, repeated accesses to areas not normally accessed, accesses for unusual lengths of time, and out-of-sequence accesses.

Related Controls: [AU-2](#), [AU-6](#), [AU-9](#), [AU-12](#), [CA-7](#), [CP-10](#), [IR-4](#), [IR-8](#).

Control Enhancements:

(1) MONITORING PHYSICAL ACCESS | [INTRUSION ALARMS AND SURVEILLANCE EQUIPMENT](#)

Monitor physical access to the facility where the system resides using physical intrusion alarms and surveillance equipment.

Discussion: Physical intrusion alarms can be employed to alert security personnel when unauthorized access to the facility is attempted. Alarm systems work in conjunction with physical barriers, physical access control systems, and security guards by triggering a response when these other forms of security have been compromised or breached. Physical intrusion alarms can include different types of sensor devices, such as motion sensors, contact sensors, and broken glass sensors. Surveillance equipment includes video cameras installed at strategic locations throughout the facility.

Related Controls: None.

(2) MONITORING PHYSICAL ACCESS | [AUTOMATED INTRUSION RECOGNITION AND RESPONSES](#)

Recognize [*Assignment: organization-defined classes or types of intrusions*] and initiate [*Assignment: organization-defined response actions*] using [*Assignment: organization-defined automated mechanisms*].

Discussion: Response actions can include notifying selected organizational personnel or law enforcement personnel. Automated mechanisms implemented to initiate response actions include system alert notifications, email and text messages, and activating door locking mechanisms. Physical access monitoring can be coordinated with intrusion detection

systems and system monitoring capabilities to provide integrated threat coverage for the organization.

Related Controls: [SI-4](#).

(3) MONITORING PHYSICAL ACCESS | [VIDEO SURVEILLANCE](#)

- (a) Employ video surveillance of [Assignment: organization-defined operational areas];**
- (b) Review video recordings [Assignment: organization-defined frequency]; and**
- (c) Retain video recordings for [Assignment: organization-defined time period].**

Discussion: Video surveillance focuses on recording activity in specified areas for the purposes of subsequent review, if circumstances so warrant. Video recordings are typically reviewed to detect anomalous events or incidents. Monitoring the surveillance video is not required, although organizations may choose to do so. There may be legal considerations when performing and retaining video surveillance, especially if such surveillance is in a public location.

Related Controls: None.

(4) MONITORING PHYSICAL ACCESS | [MONITORING PHYSICAL ACCESS TO SYSTEMS](#)

Monitor physical access to the system in addition to the physical access monitoring of the facility at [Assignment: organization-defined physical spaces containing one or more components of the system].

Discussion: Monitoring physical access to systems provides additional monitoring for those areas within facilities where there is a concentration of system components, including server rooms, media storage areas, and communications centers. Physical access monitoring can be coordinated with intrusion detection systems and system monitoring capabilities to provide comprehensive and integrated threat coverage for the organization.

Related Controls: None.

References: None.

PE-7 VISITOR CONTROL

[Withdrawn: Incorporated into [PE-2](#) and [PE-3](#).]

[PE-8](#) VISITOR ACCESS RECORDS

Control:

- a. Maintain visitor access records to the facility where the system resides for [Assignment: organization-defined time period];
- b. Review visitor access records [Assignment: organization-defined frequency]; and
- c. Report anomalies in visitor access records to [Assignment: organization-defined personnel].

Discussion: Visitor access records include the names and organizations of individuals visiting, visitor signatures, forms of identification, dates of access, entry and departure times, purpose of visits, and the names and organizations of individuals visited. Access record reviews determine if access authorizations are current and are still required to support organizational mission and business functions. Access records are not required for publicly accessible areas.

Related Controls: [PE-2](#), [PE-3](#), [PE-6](#).

Control Enhancements:

(1) VISITOR ACCESS RECORDS | [AUTOMATED RECORDS MAINTENANCE AND REVIEW](#)

Maintain and review visitor access records using [Assignment: organization-defined automated mechanisms].

Discussion: Visitor access records may be stored and maintained in a database management system that is accessible by organizational personnel. Automated access to such records facilitates record reviews on a regular basis to determine if access authorizations are current and still required to support organizational mission and business functions.

Related Controls: None.

(2) VISITOR ACCESS RECORDS | PHYSICAL ACCESS RECORDS

[Withdrawn: Incorporated into [PE-2](#).]

(3) VISITOR ACCESS RECORDS | [LIMIT PERSONALLY IDENTIFIABLE INFORMATION ELEMENTS](#)

Limit personally identifiable information contained in visitor access records to the following elements identified in the privacy risk assessment: [Assignment: organization-defined elements].

Discussion: Organizations may have requirements that specify the contents of visitor access records. Limiting personally identifiable information in visitor access records when such information is not needed for operational purposes helps reduce the level of privacy risk created by a system.

Related Controls: [RA-3](#), [SA-8](#).

References: None.

[PE-9 POWER EQUIPMENT AND CABLING](#)

Control: Protect power equipment and power cabling for the system from damage and destruction.

Discussion: Organizations determine the types of protection necessary for the power equipment and cabling employed at different locations that are both internal and external to organizational facilities and environments of operation. Types of power equipment and cabling include internal cabling and uninterruptable power sources in offices or data centers, generators and power cabling outside of buildings, and power sources for self-contained components such as satellites, vehicles, and other deployable systems.

Related Controls: [PE-4](#).

Control Enhancements:

(1) POWER EQUIPMENT AND CABLING | [REDUNDANT CABLING](#)

Employ redundant power cabling paths that are physically separated by [Assignment: organization-defined distance].

Discussion: Physically separate and redundant power cables ensure that power continues to flow in the event that one of the cables is cut or otherwise damaged.

Related Controls: None.

(2) POWER EQUIPMENT AND CABLING | [AUTOMATIC VOLTAGE CONTROLS](#)

Employ automatic voltage controls for [Assignment: organization-defined critical system components].

Discussion: Automatic voltage controls can monitor and control voltage. Such controls include voltage regulators, voltage conditioners, and voltage stabilizers.

Related Controls: None.

References: None.

PE-10 EMERGENCY SHUTOFF

Control:

- a. Provide the capability of shutting off power to [Assignment: organization-defined system or individual system components] in emergency situations;
- b. Place emergency shutoff switches or devices in [Assignment: organization-defined location by system or system component] to facilitate access for authorized personnel; and
- c. Protect emergency power shutoff capability from unauthorized activation.

Discussion: Emergency power shutoff primarily applies to organizational facilities that contain concentrations of system resources, including data centers, mainframe computer rooms, server rooms, and areas with computer-controlled machinery.

Related Controls: [PE-15](#).

Control Enhancements:

(1) EMERGENCY SHUTOFF | ACCIDENTAL AND UNAUTHORIZED ACTIVATION

[Withdrawn: Incorporated into [PE-10](#).]

References: None.

PE-11 EMERGENCY POWER

Control: Provide an uninterruptible power supply to facilitate [Selection (one or more): an orderly shutdown of the system; transition of the system to long-term alternate power] in the event of a primary power source loss.

Discussion: An uninterruptible power supply (UPS) is an electrical system or mechanism that provides emergency power when there is a failure of the main power source. A UPS is typically used to protect computers, data centers, telecommunication equipment, or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious mission or business disruption, or loss of data or information. A UPS differs from an emergency power system or backup generator in that the UPS provides near-instantaneous protection from unanticipated power interruptions from the main power source by providing energy stored in batteries, supercapacitors, or flywheels. The battery duration of a UPS is relatively short but provides sufficient time to start a standby power source, such as a backup generator, or properly shut down the system.

Related Controls: [AT-3](#), [CP-2](#), [CP-7](#).

Control Enhancements:

(1) EMERGENCY POWER | [ALTERNATE POWER SUPPLY — MINIMAL OPERATIONAL CAPABILITY](#)

Provide an alternate power supply for the system that is activated [Selection: manually; automatically] and that can maintain minimally required operational capability in the event of an extended loss of the primary power source.

Discussion: Provision of an alternate power supply with minimal operating capability can be satisfied by accessing a secondary commercial power supply or other external power supply.

Related Controls: None.

(2) EMERGENCY POWER | [ALTERNATE POWER SUPPLY — SELF-CONTAINED](#)

Provide an alternate power supply for the system that is activated [Selection: manually; automatically] and that is:

(a) Self-contained;

- (b) Not reliant on external power generation; and
- (c) Capable of maintaining [Selection: minimally required operational capability; full operational capability] in the event of an extended loss of the primary power source.

Discussion: The provision of a long-term, self-contained power supply can be satisfied by using one or more generators with sufficient capacity to meet the needs of the organization.

Related Controls: None.

References: None.

PE-12 EMERGENCY LIGHTING

Control: Employ and maintain automatic emergency lighting for the system that activates in the event of a power outage or disruption and that covers emergency exits and evacuation routes within the facility.

Discussion: The provision of emergency lighting applies primarily to organizational facilities that contain concentrations of system resources, including data centers, server rooms, and mainframe computer rooms. Emergency lighting provisions for the system are described in the contingency plan for the organization. If emergency lighting for the system fails or cannot be provided, organizations consider alternate processing sites for power-related contingencies.

Related Controls: [CP-2](#), [CP-7](#).

Control Enhancements:

(1) EMERGENCY LIGHTING | [ESSENTIAL MISSION AND BUSINESS FUNCTIONS](#)

Provide emergency lighting for all areas within the facility supporting essential mission and business functions.

Discussion: Organizations define their essential missions and functions.

Related Controls: None.

References: None.

PE-13 FIRE PROTECTION

Control: Employ and maintain fire detection and suppression systems that are supported by an independent energy source.

Discussion: The provision of fire detection and suppression systems applies primarily to organizational facilities that contain concentrations of system resources, including data centers, server rooms, and mainframe computer rooms. Fire detection and suppression systems that may require an independent energy source include sprinkler systems and smoke detectors. An independent energy source is an energy source, such as a microgrid, that is separate, or can be separated, from the energy sources providing power for the other parts of the facility.

Related Controls: [AT-3](#).

Control Enhancements:

(1) FIRE PROTECTION | [DETECTION SYSTEMS — AUTOMATIC ACTIVATION AND NOTIFICATION](#)

Employ fire detection systems that activate automatically and notify [Assignment: organization-defined personnel or roles] and [Assignment: organization-defined emergency responders] in the event of a fire.

Discussion: Organizations can identify personnel, roles, and emergency responders if individuals on the notification list need to have access authorizations or clearances (e.g., to enter to facilities where access is restricted due to the classification or impact level of

information within the facility). Notification mechanisms may require independent energy sources to ensure that the notification capability is not adversely affected by the fire.

Related Controls: None.

(2) FIRE PROTECTION | [SUPPRESSION SYSTEMS — AUTOMATIC ACTIVATION AND NOTIFICATION](#)

- (a) Employ fire suppression systems that activate automatically and notify [Assignment: organization-defined personnel or roles] and [Assignment: organization-defined emergency responders]; and**
- (b) Employ an automatic fire suppression capability when the facility is not staffed on a continuous basis.**

Discussion: Organizations can identify specific personnel, roles, and emergency responders if individuals on the notification list need to have appropriate access authorizations and/or clearances (e.g., to enter to facilities where access is restricted due to the impact level or classification of information within the facility). Notification mechanisms may require independent energy sources to ensure that the notification capability is not adversely affected by the fire.

Related Controls: None.

(3) FIRE PROTECTION | AUTOMATIC FIRE SUPPRESSION

[Withdrawn: Incorporated into [PE-13\(2\)](#).]

(4) FIRE PROTECTION | [INSPECTIONS](#)

Ensure that the facility undergoes [Assignment: organization-defined frequency] fire protection inspections by authorized and qualified inspectors and identified deficiencies are resolved within [Assignment: organization-defined time period].

Discussion: Authorized and qualified personnel within the jurisdiction of the organization include state, county, and city fire inspectors and fire marshals. Organizations provide escorts during inspections in situations where the systems that reside within the facilities contain sensitive information.

Related Controls: None.

References: None.

[PE-14 ENVIRONMENTAL CONTROLS](#)

Control:

- a. Maintain [Selection (one or more): temperature; humidity; pressure; radiation; [Assignment: organization-defined environmental control]] levels within the facility where the system resides at [Assignment: organization-defined acceptable levels]; and
- b. Monitor environmental control levels [Assignment: organization-defined frequency].

Discussion: The provision of environmental controls applies primarily to organizational facilities that contain concentrations of system resources (e.g., data centers, mainframe computer rooms, and server rooms). Insufficient environmental controls, especially in very harsh environments, can have a significant adverse impact on the availability of systems and system components that are needed to support organizational mission and business functions.

Related Controls: [AT-3](#), [CP-2](#).

Control Enhancements:

(1) ENVIRONMENTAL CONTROLS | [AUTOMATIC CONTROLS](#)

Employ the following automatic environmental controls in the facility to prevent fluctuations potentially harmful to the system: [Assignment: organization-defined automatic environmental controls].

Discussion: The implementation of automatic environmental controls provides an immediate response to environmental conditions that can damage, degrade, or destroy organizational systems or systems components.

Related Controls: None.

(2) ENVIRONMENTAL CONTROLS | [MONITORING WITH ALARMS AND NOTIFICATIONS](#)

Employ environmental control monitoring that provides an alarm or notification of changes potentially harmful to personnel or equipment to [Assignment: organization-defined personnel or roles].

Discussion: The alarm or notification may be an audible alarm or a visual message in real time to personnel or roles defined by the organization. Such alarms and notifications can help minimize harm to individuals and damage to organizational assets by facilitating a timely incident response.

Related Controls: None.

References: None.

[PE-15](#) WATER DAMAGE PROTECTION

Control: Protect the system from damage resulting from water leakage by providing master shutoff or isolation valves that are accessible, working properly, and known to key personnel.

Discussion: The provision of water damage protection primarily applies to organizational facilities that contain concentrations of system resources, including data centers, server rooms, and mainframe computer rooms. Isolation valves can be employed in addition to or in lieu of master shutoff valves to shut off water supplies in specific areas of concern without affecting entire organizations.

Related Controls: [AT-3](#), [PE-10](#).

Control Enhancements:

(1) WATER DAMAGE PROTECTION | [AUTOMATION SUPPORT](#)

Detect the presence of water near the system and alert [Assignment: organization-defined personnel or roles] using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms include notification systems, water detection sensors, and alarms.

Related Controls: None.

References: None.

[PE-16](#) DELIVERY AND REMOVAL

Control:

- a. Authorize and control [Assignment: organization-defined types of system components] entering and exiting the facility; and
- b. Maintain records of the system components.

Discussion: Enforcing authorizations for entry and exit of system components may require restricting access to delivery areas and isolating the areas from the system and media libraries.

Related Controls: [CM-3](#), [CM-8](#), [MA-2](#), [MA-3](#), [MP-5](#), [PE-20](#), [SR-2](#), [SR-3](#), [SR-4](#), [SR-6](#).

Control Enhancements: None.

References: None.

PE-17 ALTERNATE WORK SITE

Control:

- a. Determine and document the [Assignment: organization-defined alternate work sites] allowed for use by employees;
- b. Employ the following controls at alternate work sites: [Assignment: organization-defined controls];
- c. Assess the effectiveness of controls at alternate work sites; and
- d. Provide a means for employees to communicate with information security and privacy personnel in case of incidents.

Discussion: Alternate work sites include government facilities or the private residences of employees. While distinct from alternative processing sites, alternate work sites can provide readily available alternate locations during contingency operations. Organizations can define different sets of controls for specific alternate work sites or types of sites depending on the work-related activities conducted at the sites. Implementing and assessing the effectiveness of organization-defined controls and providing a means to communicate incidents at alternate work sites supports the contingency planning activities of organizations.

Related Controls: [AC-17](#), [AC-18](#), [CP-7](#).

Control Enhancements: None.

References: [\[SP 800-46\]](#).

PE-18 LOCATION OF SYSTEM COMPONENTS

Control: Position system components within the facility to minimize potential damage from [Assignment: organization-defined physical and environmental hazards] and to minimize the opportunity for unauthorized access.

Discussion: Physical and environmental hazards include floods, fires, tornadoes, earthquakes, hurricanes, terrorism, vandalism, an electromagnetic pulse, electrical interference, and other forms of incoming electromagnetic radiation. Organizations consider the location of entry points where unauthorized individuals, while not being granted access, might nonetheless be near systems. Such proximity can increase the risk of unauthorized access to organizational communications using wireless packet sniffers or microphones, or unauthorized disclosure of information.

Related Controls: [CP-2](#), [PE-5](#), [PE-19](#), [PE-20](#), [RA-3](#).

(1) LOCATION OF SYSTEM COMPONENTS | FACILITY SITE

[Withdrawn: Moved to [PE-23](#).]

References: None.

PE-19 INFORMATION LEAKAGE

Control: Protect the system from information leakage due to electromagnetic signals emanations.

Discussion: Information leakage is the intentional or unintentional release of data or information to an untrusted environment from electromagnetic signals emanations. The security categories

or classifications of systems (with respect to confidentiality), organizational security policies, and risk tolerance guide the selection of controls employed to protect systems against information leakage due to electromagnetic signals emanations.

Related Controls: [AC-18](#), [PE-18](#), [PE-20](#).

Control Enhancements:

(1) INFORMATION LEAKAGE | [NATIONAL EMISSIONS POLICIES AND PROCEDURES](#)

Protect system components, associated data communications, and networks in accordance with national Emissions Security policies and procedures based on the security category or classification of the information.

Discussion: Emissions Security (EMSEC) policies include the former TEMPEST policies.

Related Controls: None.

References: [\[FIPS 199\]](#).

[PE-20 ASSET MONITORING AND TRACKING](#)

Control: Employ [Assignment: organization-defined asset location technologies] to track and monitor the location and movement of [Assignment: organization-defined assets] within [Assignment: organization-defined controlled areas].

Discussion: Asset location technologies can help ensure that critical assets—including vehicles, equipment, and system components—remain in authorized locations. Organizations consult with the Office of the General Counsel and senior agency official for privacy regarding the deployment and use of asset location technologies to address potential privacy concerns.

Related Controls: [CM-8](#), [PE-16](#), [PM-8](#).

Control Enhancements: None.

References: None.

[PE-21 ELECTROMAGNETIC PULSE PROTECTION](#)

Control: Employ [Assignment: organization-defined protective measures] against electromagnetic pulse damage for [Assignment: organization-defined systems and system components].

Discussion: An electromagnetic pulse (EMP) is a short burst of electromagnetic energy that is spread over a range of frequencies. Such energy bursts may be natural or man-made. EMP interference may be disruptive or damaging to electronic equipment. Protective measures used to mitigate EMP risk include shielding, surge suppressors, ferro-resonant transformers, and earth grounding. EMP protection may be especially significant for systems and applications that are part of the U.S. critical infrastructure.

Related Controls: [PE-18](#), [PE-19](#).

Control Enhancements: None.

References: None.

[PE-22 COMPONENT MARKING](#)

Control: Mark [Assignment: organization-defined system hardware components] indicating the impact level or classification level of the information permitted to be processed, stored, or transmitted by the hardware component.

Discussion: Hardware components that may require marking include input and output devices. Input devices include desktop and notebook computers, keyboards, tablets, and smart phones. Output devices include printers, monitors/video displays, facsimile machines, scanners, copiers, and audio devices. Permissions controlling output to the output devices are addressed in [AC-3](#) or [AC-4](#). Components are marked to indicate the impact level or classification level of the system to which the devices are connected, or the impact level or classification level of the information permitted to be output. Security marking refers to the use of human-readable security attributes. Security labeling refers to the use of security attributes for internal system data structures. Security marking is generally not required for hardware components that process, store, or transmit information determined by organizations to be in the public domain or to be publicly releasable. However, organizations may require markings for hardware components that process, store, or transmit public information in order to indicate that such information is publicly releasable. Marking of system hardware components reflects applicable laws, executive orders, directives, policies, regulations, and standards.

Related Controls: [AC-3](#), [AC-4](#), [AC-16](#), [MP-3](#).

Control Enhancements: None.

References: [\[IR 8023\]](#).

PE-23 FACILITY LOCATION

Control:

- a. Plan the location or site of the facility where the system resides considering physical and environmental hazards; and
- b. For existing facilities, consider the physical and environmental hazards in the organizational risk management strategy.

Discussion: Physical and environmental hazards include floods, fires, tornadoes, earthquakes, hurricanes, terrorism, vandalism, an electromagnetic pulse, electrical interference, and other forms of incoming electromagnetic radiation. The location of system components within the facility is addressed in [PE-18](#).

Related Controls: [CP-2](#), [PE-18](#), [PE-19](#), [PM-8](#), [PM-9](#), [RA-3](#).

References: None.

3.12 PLANNING

[Quick link to Planning Summary Table](#)

PL-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] planning policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the planning policy and the associated planning controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the planning policy and procedures; and
- c. Review and update the current planning:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Planning policy and procedures for the controls in the PL family implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on their development. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission level or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission/business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to planning policy and procedures include, but are not limited to, assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-18\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

PL-2 SYSTEM SECURITY AND PRIVACY PLANSControl:

- a. Develop security and privacy plans for the system that:
 1. Are consistent with the organization's enterprise architecture;
 2. Explicitly define the constituent system components;
 3. Describe the operational context of the system in terms of mission and business processes;
 4. Identify the individuals that fulfill system roles and responsibilities;
 5. Identify the information types processed, stored, and transmitted by the system;
 6. Provide the security categorization of the system, including supporting rationale;
 7. Describe any specific threats to the system that are of concern to the organization;
 8. Provide the results of a privacy risk assessment for systems processing personally identifiable information;
 9. Describe the operational environment for the system and any dependencies on or connections to other systems or system components;
 10. Provide an overview of the security and privacy requirements for the system;
 11. Identify any relevant control baselines or overlays, if applicable;
 12. Describe the controls in place or planned for meeting the security and privacy requirements, including a rationale for any tailoring decisions;
 13. Include risk determinations for security and privacy architecture and design decisions;
 14. Include security- and privacy-related activities affecting the system that require planning and coordination with *[Assignment: organization-defined individuals or groups]*; and
 15. Are reviewed and approved by the authorizing official or designated representative prior to plan implementation.
- b. Distribute copies of the plans and communicate subsequent changes to the plans to *[Assignment: organization-defined personnel or roles]*;
- c. Review the plans *[Assignment: organization-defined frequency]*;
- d. Update the plans to address changes to the system and environment of operation or problems identified during plan implementation or control assessments; and
- e. Protect the plans from unauthorized disclosure and modification.

Discussion: System security and privacy plans are scoped to the system and system components within the defined authorization boundary and contain an overview of the security and privacy requirements for the system and the controls selected to satisfy the requirements. The plans describe the intended application of each selected control in the context of the system with a sufficient level of detail to correctly implement the control and to subsequently assess the effectiveness of the control. The control documentation describes how system-specific and hybrid controls are implemented and the plans and expectations regarding the functionality of the system. System security and privacy plans can also be used in the design and development of systems in support of life cycle-based security and privacy engineering processes. System security and privacy plans are living documents that are updated and adapted throughout the system development life cycle (e.g., during capability determination, analysis of alternatives, requests for proposal, and design reviews). [Section 2.1](#) describes the different types of requirements that are

relevant to organizations during the system development life cycle and the relationship between requirements and controls.

Organizations may develop a single, integrated security and privacy plan or maintain separate plans. Security and privacy plans relate security and privacy requirements to a set of controls and control enhancements. The plans describe how the controls and control enhancements meet the security and privacy requirements but do not provide detailed, technical descriptions of the design or implementation of the controls and control enhancements. Security and privacy plans contain sufficient information (including specifications of control parameter values for selection and assignment operations explicitly or by reference) to enable a design and implementation that is unambiguously compliant with the intent of the plans and subsequent determinations of risk to organizational operations and assets, individuals, other organizations, and the Nation if the plan is implemented.

Security and privacy plans need not be single documents. The plans can be a collection of various documents, including documents that already exist. Effective security and privacy plans make extensive use of references to policies, procedures, and additional documents, including design and implementation specifications where more detailed information can be obtained. The use of references helps reduce the documentation associated with security and privacy programs and maintains the security- and privacy-related information in other established management and operational areas, including enterprise architecture, system development life cycle, systems engineering, and acquisition. Security and privacy plans need not contain detailed contingency plan or incident response plan information but can instead provide—explicitly or by reference—sufficient information to define what needs to be accomplished by those plans.

Security- and privacy-related activities that may require coordination and planning with other individuals or groups within the organization include assessments, audits, inspections, hardware and software maintenance, acquisition and supply chain risk management, patch management, and contingency plan testing. Planning and coordination include emergency and nonemergency (i.e., planned or non-urgent unplanned) situations. The process defined by organizations to plan and coordinate security- and privacy-related activities can also be included in other documents, as appropriate.

Related Controls: [AC-2](#), [AC-6](#), [AC-14](#), [AC-17](#), [AC-20](#), [CA-2](#), [CA-3](#), [CA-7](#), [CM-9](#), [CM-13](#), [CP-2](#), [CP-4](#), [IR-4](#), [IR-8](#), [MA-4](#), [MA-5](#), [MP-4](#), [MP-5](#), [PL-7](#), [PL-8](#), [PL-10](#), [PL-11](#), [PM-1](#), [PM-7](#), [PM-8](#), [PM-9](#), [PM-10](#), [PM-11](#), [RA-3](#), [RA-8](#), [RA-9](#), [SA-5](#), [SA-17](#), [SA-22](#), [SI-12](#), [SR-2](#), [SR-4](#).

Control Enhancements:

- (1) SYSTEM SECURITY AND PRIVACY PLANS | CONCEPT OF OPERATIONS
[Withdrawn: Incorporated into [PL-7](#).]
- (2) SYSTEM SECURITY AND PRIVACY PLANS | FUNCTIONAL ARCHITECTURE
[Withdrawn: Incorporated into [PL-8](#).]
- (3) SYSTEM SECURITY AND PRIVACY PLANS | PLAN AND COORDINATE WITH OTHER ORGANIZATIONAL ENTITIES
[Withdrawn: Incorporated into [PL-2](#).]

References: [\[OMB A-130\]](#), [\[SP 800-18\]](#), [\[SP 800-37\]](#), [\[SP 800-160-1\]](#), [\[SP 800-160-2\]](#).

PL-3 SYSTEM SECURITY PLAN UPDATE

[Withdrawn: Incorporated into [PL-2](#).]

PL-4 RULES OF BEHAVIORControl:

- a. Establish and provide to individuals requiring access to the system, the rules that describe their responsibilities and expected behavior for information and system usage, security, and privacy;
- b. Receive a documented acknowledgment from such individuals, indicating that they have read, understand, and agree to abide by the rules of behavior, before authorizing access to information and the system;
- c. Review and update the rules of behavior [*Assignment: organization-defined frequency*]; and
- d. Require individuals who have acknowledged a previous version of the rules of behavior to read and re-acknowledge [*Selection (one or more)*: [*Assignment: organization-defined frequency*]; *when the rules are revised or updated*].

Discussion: Rules of behavior represent a type of access agreement for organizational users. Other types of access agreements include nondisclosure agreements, conflict-of-interest agreements, and acceptable use agreements (see [PS-6](#)). Organizations consider rules of behavior based on individual user roles and responsibilities and differentiate between rules that apply to privileged users and rules that apply to general users. Establishing rules of behavior for some types of non-organizational users, including individuals who receive information from federal systems, is often not feasible given the large number of such users and the limited nature of their interactions with the systems. Rules of behavior for organizational and non-organizational users can also be established in [AC-8](#). The related controls section provides a list of controls that are relevant to organizational rules of behavior. [PL-4b](#), the documented acknowledgment portion of the control, may be satisfied by the literacy training and awareness and role-based training programs conducted by organizations if such training includes rules of behavior. Documented acknowledgements for rules of behavior include electronic or physical signatures and electronic agreement check boxes or radio buttons.

Related Controls: [AC-2](#), [AC-6](#), [AC-8](#), [AC-9](#), [AC-17](#), [AC-18](#), [AC-19](#), [AC-20](#), [AT-2](#), [AT-3](#), [CM-11](#), [IA-2](#), [IA-4](#), [IA-5](#), [MP-7](#), [PS-6](#), [PS-8](#), [SA-5](#), [SI-12](#).

Control Enhancements:**(1) RULES OF BEHAVIOR | [SOCIAL MEDIA AND EXTERNAL SITE/APPLICATION USAGE RESTRICTIONS](#)****Include in the rules of behavior, restrictions on:**

- (a) **Use of social media, social networking sites, and external sites/applications;**
- (b) **Posting organizational information on public websites; and**
- (c) **Use of organization-provided identifiers (e.g., email addresses) and authentication secrets (e.g., passwords) for creating accounts on external sites/applications.**

Discussion: Social media, social networking, and external site/application usage restrictions address rules of behavior related to the use of social media, social networking, and external sites when organizational personnel are using such sites for official duties or in the conduct of official business, when organizational information is involved in social media and social networking transactions, and when personnel access social media and networking sites from organizational systems. Organizations also address specific rules that prevent unauthorized entities from obtaining non-public organizational information from social media and networking sites either directly or through inference. Non-public information includes personally identifiable information and system account information.

Related Controls: [AC-22](#), [AU-13](#).

References: [\[OMB A-130\]](#), [\[SP 800-18\]](#).

PL-5 PRIVACY IMPACT ASSESSMENT

[Withdrawn: Incorporated into [RA-8](#).]

PL-6 SECURITY-RELATED ACTIVITY PLANNING

[Withdrawn: Incorporated into [PL-2](#).]

PL-7 CONCEPT OF OPERATIONS**Control:**

- a. Develop a Concept of Operations (CONOPS) for the system describing how the organization intends to operate the system from the perspective of information security and privacy; and
- b. Review and update the CONOPS [*Assignment: organization-defined frequency*].

Discussion: The CONOPS may be included in the security or privacy plans for the system or in other system development life cycle documents. The CONOPS is a living document that requires updating throughout the system development life cycle. For example, during system design reviews, the concept of operations is checked to ensure that it remains consistent with the design for controls, the system architecture, and the operational procedures. Changes to the CONOPS are reflected in ongoing updates to the security and privacy plans, security and privacy architectures, and other organizational documents, such as procurement specifications, system development life cycle documents, and systems engineering documents.

Related Controls: [PL-2](#), [SA-2](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#).

PL-8 SECURITY AND PRIVACY ARCHITECTURES**Control:**

- a. Develop security and privacy architectures for the system that:
 1. Describe the requirements and approach to be taken for protecting the confidentiality, integrity, and availability of organizational information;
 2. Describe the requirements and approach to be taken for processing personally identifiable information to minimize privacy risk to individuals;
 3. Describe how the architectures are integrated into and support the enterprise architecture; and
 4. Describe any assumptions about, and dependencies on, external systems and services;
- b. Review and update the architectures [*Assignment: organization-defined frequency*] to reflect changes in the enterprise architecture; and
- c. Reflect planned architecture changes in security and privacy plans, Concept of Operations (CONOPS), criticality analysis, organizational procedures, and procurements and acquisitions.

Discussion: The security and privacy architectures at the system level are consistent with the organization-wide security and privacy architectures described in [PM-7](#), which are integral to and developed as part of the enterprise architecture. The architectures include an architectural description, the allocation of security and privacy functionality (including controls), security- and privacy-related information for external interfaces, information being exchanged across the interfaces, and the protection mechanisms associated with each interface. The architectures can

also include other information, such as user roles and the access privileges assigned to each role; security and privacy requirements; types of information processed, stored, and transmitted by the system; supply chain risk management requirements; restoration priorities of information and system services; and other protection needs.

[[SP 800-160-1](#)] provides guidance on the use of security architectures as part of the system development life cycle process. [[OMB M-19-03](#)] requires the use of the systems security engineering concepts described in [[SP 800-160-1](#)] for high value assets. Security and privacy architectures are reviewed and updated throughout the system development life cycle, from analysis of alternatives through review of the proposed architecture in the RFP responses to the design reviews before and during implementation (e.g., during preliminary design reviews and critical design reviews).

In today's modern computing architectures, it is becoming less common for organizations to control all information resources. There may be key dependencies on external information services and service providers. Describing such dependencies in the security and privacy architectures is necessary for developing a comprehensive mission and business protection strategy. Establishing, developing, documenting, and maintaining under configuration control a baseline configuration for organizational systems is critical to implementing and maintaining effective architectures. The development of the architectures is coordinated with the senior agency information security officer and the senior agency official for privacy to ensure that the controls needed to support security and privacy requirements are identified and effectively implemented. In many circumstances, there may be no distinction between the security and privacy architecture for a system. In other circumstances, security objectives may be adequately satisfied, but privacy objectives may only be partially satisfied by the security requirements. In these cases, consideration of the privacy requirements needed to achieve satisfaction will result in a distinct privacy architecture. The documentation, however, may simply reflect the combined architectures.

[PL-8](#) is primarily directed at organizations to ensure that architectures are developed for the system and, moreover, that the architectures are integrated with or tightly coupled to the enterprise architecture. In contrast, [SA-17](#) is primarily directed at the external information technology product and system developers and integrators. [SA-17](#), which is complementary to [PL-8](#), is selected when organizations outsource the development of systems or components to external entities and when there is a need to demonstrate consistency with the organization's enterprise architecture and security and privacy architectures.

Related Controls: [CM-2](#), [CM-6](#), [PL-2](#), [PL-7](#), [PL-9](#), [PM-5](#), [PM-7](#), [RA-9](#), [SA-3](#), [SA-5](#), [SA-8](#), [SA-17](#), [SC-7](#).

Control Enhancements:

(1) SECURITY AND PRIVACY ARCHITECTURES | [DEFENSE IN DEPTH](#)

Design the security and privacy architectures for the system using a defense-in-depth approach that:

- (a) Allocates [Assignment: organization-defined controls] to [Assignment: organization-defined locations and architectural layers]; and**
- (b) Ensures that the allocated controls operate in a coordinated and mutually reinforcing manner.**

Discussion: Organizations strategically allocate security and privacy controls in the security and privacy architectures so that adversaries must overcome multiple controls to achieve their objective. Requiring adversaries to defeat multiple controls makes it more difficult to attack information resources by increasing the work factor of the adversary; it also increases the likelihood of detection. The coordination of allocated controls is essential to ensure that an attack that involves one control does not create adverse, unintended consequences by interfering with other controls. Unintended consequences can include system lockout and

cascading alarms. The placement of controls in systems and organizations is an important activity that requires thoughtful analysis. The value of organizational assets is an important consideration in providing additional layering. Defense-in-depth architectural approaches include modularity and layering (see [SA-8\(3\)](#)), separation of system and user functionality (see [SC-2](#)), and security function isolation (see [SC-3](#)).

Related Controls: [SC-2](#), [SC-3](#), [SC-29](#), [SC-36](#).

(2) SECURITY AND PRIVACY ARCHITECTURES | [SUPPLIER DIVERSITY](#)

Require that [Assignment: organization-defined controls] allocated to [Assignment: organization-defined locations and architectural layers] are obtained from different suppliers.

Discussion: Information technology products have different strengths and weaknesses. Providing a broad spectrum of products complements the individual offerings. For example, vendors offering malicious code protection typically update their products at different times, often developing solutions for known viruses, Trojans, or worms based on their priorities and development schedules. By deploying different products at different locations, there is an increased likelihood that at least one of the products will detect the malicious code. With respect to privacy, vendors may offer products that track personally identifiable information in systems. Products may use different tracking methods. Using multiple products may result in more assurance that personally identifiable information is inventoried.

Related Controls: [SC-29](#), [SR-3](#).

References: [\[OMB A-130\]](#), [\[SP 800-160-1\]](#), [\[SP 800-160-2\]](#).

PL-9 CENTRAL MANAGEMENT

Control: Centrally manage [Assignment: organization-defined controls and related processes].

Discussion: Central management refers to organization-wide management and implementation of selected controls and processes. This includes planning, implementing, assessing, authorizing, and monitoring the organization-defined, centrally managed controls and processes. As the central management of controls is generally associated with the concept of common (inherited) controls, such management promotes and facilitates standardization of control implementations and management and the judicious use of organizational resources. Centrally managed controls and processes may also meet independence requirements for assessments in support of initial and ongoing authorizations to operate and as part of organizational continuous monitoring.

Automated tools (e.g., security information and event management tools or enterprise security monitoring and management tools) can improve the accuracy, consistency, and availability of information associated with centrally managed controls and processes. Automation can also provide data aggregation and data correlation capabilities; alerting mechanisms; and dashboards to support risk-based decision-making within the organization.

As part of the control selection processes, organizations determine the controls that may be suitable for central management based on resources and capabilities. It is not always possible to centrally manage every aspect of a control. In such cases, the control can be treated as a hybrid control with the control managed and implemented centrally or at the system level. The controls and control enhancements that are candidates for full or partial central management include but are not limited to: [AC-2\(1\)](#), [AC-2\(2\)](#), [AC-2\(3\)](#), [AC-2\(4\)](#), [AC-4\(all\)](#), [AC-17\(1\)](#), [AC-17\(2\)](#), [AC-17\(3\)](#), [AC-17\(9\)](#), [AC-18\(1\)](#), [AC-18\(3\)](#), [AC-18\(4\)](#), [AC-18\(5\)](#), [AC-19\(4\)](#), [AC-22](#), [AC-23](#), [AT-2\(1\)](#), [AT-2\(2\)](#), [AT-3\(1\)](#), [AT-3\(2\)](#), [AT-3\(3\)](#), [AT-4](#), [AU-3](#), [AU-6\(1\)](#), [AU-6\(3\)](#), [AU-6\(5\)](#), [AU-6\(6\)](#), [AU-6\(9\)](#), [AU-7\(1\)](#), [AU-7\(2\)](#), [AU-11](#), [AU-13](#), [AU-16](#), [CA-2\(1\)](#), [CA-2\(2\)](#), [CA-2\(3\)](#), [CA-3\(1\)](#), [CA-3\(2\)](#), [CA-3\(3\)](#), [CA-7\(1\)](#), [CA-9](#), [CM-2\(2\)](#), [CM-3\(1\)](#), [CM-3\(4\)](#), [CM-4](#), [CM-6](#), [CM-6\(1\)](#), [CM-7\(2\)](#), [CM-7\(4\)](#), [CM-7\(5\)](#), [CM-8\(all\)](#), [CM-9\(1\)](#), [CM-10](#), [CM-11](#), [CP-7\(all\)](#), [CP-8\(all\)](#), [SC-43](#), [SI-2](#), [SI-3](#), [SI-4\(all\)](#), [SI-7](#), [SI-8](#).

Related Controls: [PL-8](#), [PM-9](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-37\]](#).

PL-10 BASELINE SELECTION

Control: Select a control baseline for the system.

Discussion: Control baselines are predefined sets of controls specifically assembled to address the protection needs of a group, organization, or community of interest. Controls are chosen for baselines to either satisfy mandates imposed by laws, executive orders, directives, regulations, policies, standards, and guidelines or address threats common to all users of the baseline under the assumptions specific to the baseline. Baselines represent a starting point for the protection of individuals' privacy, information, and information systems with subsequent tailoring actions to manage risk in accordance with mission, business, or other constraints (see [PL-11](#)). Federal control baselines are provided in [\[SP 800-53B\]](#). The selection of a control baseline is determined by the needs of stakeholders. Stakeholder needs consider mission and business requirements as well as mandates imposed by applicable laws, executive orders, directives, policies, regulations, standards, and guidelines. For example, the control baselines in [\[SP 800-53B\]](#) are based on the requirements from [\[FISMA\]](#) and [\[PRIVACT\]](#). The requirements, along with the NIST standards and guidelines implementing the legislation, direct organizations to select one of the control baselines after the reviewing the information types and the information that is processed, stored, and transmitted on the system; analyzing the potential adverse impact of the loss or compromise of the information or system on the organization's operations and assets, individuals, other organizations, or the Nation; and considering the results from system and organizational risk assessments. [\[CNSSI 1253\]](#) provides guidance on control baselines for national security systems.

Related Controls: [PL-2](#), [PL-11](#), [RA-2](#), [RA-3](#), [SA-8](#).

Control Enhancements: None.

References: [\[FIPS 199\]](#), [\[FIPS 200\]](#), [\[SP 800-30\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-53B\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#), [\[SP 800-160-1\]](#), [\[CNSSI 1253\]](#).

PL-11 BASELINE TAILORING

Control: Tailor the selected control baseline by applying specified tailoring actions.

Discussion: The concept of tailoring allows organizations to specialize or customize a set of baseline controls by applying a defined set of tailoring actions. Tailoring actions facilitate such specialization and customization by allowing organizations to develop security and privacy plans that reflect their specific mission and business functions, the environments where their systems operate, the threats and vulnerabilities that can affect their systems, and any other conditions or situations that can impact their mission or business success. Tailoring guidance is provided in [\[SP 800-53B\]](#). Tailoring a control baseline is accomplished by identifying and designating common controls, applying scoping considerations, selecting compensating controls, assigning values to control parameters, supplementing the control baseline with additional controls as needed, and providing information for control implementation. The general tailoring actions in [\[SP 800-53B\]](#) can be supplemented with additional actions based on the needs of organizations. Tailoring actions can be applied to the baselines in [\[SP 800-53B\]](#) in accordance with the security and privacy requirements from [\[FISMA\]](#), [\[PRIVACT\]](#), and [\[OMB A-130\]](#). Alternatively, other communities of interest adopting different control baselines can apply the tailoring actions in [\[SP 800-53B\]](#) to specialize or customize the controls that represent the specific needs and concerns of those entities.

Related Controls: [PL-10](#), [RA-2](#), [RA-3](#), [RA-9](#), [SA-8](#).

Control Enhancements: None.

References: [\[FIPS 199\]](#), [\[FIPS 200\]](#), [\[SP 800-30\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-53B\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#), [\[SP 800-160-1\]](#), [\[CNSI 1253\]](#).

3.13 PROGRAM MANAGEMENT

PROGRAM MANAGEMENT CONTROLS

[FISMA], [PRIVACT], and [OMB A-130] require federal agencies to develop, implement, and provide oversight for organization-wide information security and privacy programs to help ensure the confidentiality, integrity, and availability of federal information processed, stored, and transmitted by federal information systems and to protect individual privacy. The program management (PM) controls described in this section are implemented at the organization level and not directed at individual information systems. The PM controls have been designed to facilitate organizational compliance with applicable federal laws, executive orders, directives, policies, regulations, and standards. The controls are independent of [FIPS 200] impact levels and, therefore, are not associated with the control baselines described in [SP 800-53B].

Organizations document program management controls in the information security and privacy program plans. The organization-wide information security program plan (see [PM-1](#)) and privacy program plan (see [PM-18](#)) supplement system security and privacy plans (see [PL-2](#)) developed for organizational information systems. Together, the system security and privacy plans for the individual information systems and the information security and privacy program plans cover the totality of security and privacy controls employed by the organization.

[Quick link to Program Management Summary Table](#)

[PM-1 INFORMATION SECURITY PROGRAM PLAN](#)

Control:

- a. Develop and disseminate an organization-wide information security program plan that:
 1. Provides an overview of the requirements for the security program and a description of the security program management controls and common controls in place or planned for meeting those requirements;
 2. Includes the identification and assignment of roles, responsibilities, management commitment, coordination among organizational entities, and compliance;
 3. Reflects the coordination among organizational entities responsible for information security; and
 4. Is approved by a senior official with responsibility and accountability for the risk being incurred to organizational operations (including mission, functions, image, and reputation), organizational assets, individuals, other organizations, and the Nation;
- b. Review and update the organization-wide information security program plan [*Assignment: organization-defined frequency*] and following [*Assignment: organization-defined events*]; and
- c. Protect the information security program plan from unauthorized disclosure and modification.

Discussion: An information security program plan is a formal document that provides an overview of the security requirements for an organization-wide information security program

and describes the program management controls and common controls in place or planned for meeting those requirements. An information security program plan can be represented in a single document or compilations of documents. Privacy program plans and supply chain risk management plans are addressed separately in [PM-18](#) and [SR-2](#), respectively.

An information security program plan documents implementation details about program management and common controls. The plan provides sufficient information about the controls (including specification of parameters for assignment and selection operations, explicitly or by reference) to enable implementations that are unambiguously compliant with the intent of the plan and a determination of the risk to be incurred if the plan is implemented as intended. Updates to information security program plans include organizational changes and problems identified during plan implementation or control assessments.

Program management controls may be implemented at the organization level or the mission or business process level, and are essential for managing the organization's information security program. Program management controls are distinct from common, system-specific, and hybrid controls because program management controls are independent of any particular system.

Together, the individual system security plans and the organization-wide information security program plan provide complete coverage for the security controls employed within the organization.

Common controls available for inheritance by organizational systems are documented in an appendix to the organization's information security program plan unless the controls are included in a separate security plan for a system. The organization-wide information security program plan indicates which separate security plans contain descriptions of common controls.

Events that may precipitate an update to the information security program plan include, but are not limited to, organization-wide assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: [PL-2](#), [PM-18](#), [PM-30](#), [RA-9](#), [SI-12](#), [SR-2](#).

Control Enhancements: None.

References: [\[FISMA\]](#), [\[OMB A-130\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#).

PM-2 INFORMATION SECURITY PROGRAM LEADERSHIP ROLE

Control: Appoint a senior agency information security officer with the mission and resources to coordinate, develop, implement, and maintain an organization-wide information security program.

Discussion: The senior agency information security officer is an organizational official. For federal agencies (as defined by applicable laws, executive orders, regulations, directives, policies, and standards), this official is the senior agency information security officer. Organizations may also refer to this official as the senior information security officer or chief information security officer.

Related Controls: None.

Control Enhancements: None.

References: [\[OMB M-17-25\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-181\]](#).

PM-3 INFORMATION SECURITY AND PRIVACY RESOURCES

Control:

- a. Include the resources needed to implement the information security and privacy programs in capital planning and investment requests and document all exceptions to this requirement;
- b. Prepare documentation required for addressing information security and privacy programs in capital planning and investment requests in accordance with applicable laws, executive orders, directives, policies, regulations, standards; and
- c. Make available for expenditure, the planned information security and privacy resources.

Discussion: Organizations consider establishing champions for information security and privacy and, as part of including the necessary resources, assign specialized expertise and resources as needed. Organizations may designate and empower an Investment Review Board or similar group to manage and provide oversight for the information security and privacy aspects of the capital planning and investment control process.

Related Controls: [PM-4](#), [SA-2](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#).

PM-4 PLAN OF ACTION AND MILESTONES PROCESS

Control:

- a. Implement a process to ensure that plans of action and milestones for the information security, privacy, and supply chain risk management programs and associated organizational systems:
 1. Are developed and maintained;
 2. Document the remedial information security, privacy, and supply chain risk management actions to adequately respond to risk to organizational operations and assets, individuals, other organizations, and the Nation; and
 3. Are reported in accordance with established reporting requirements.
- b. Review plans of action and milestones for consistency with the organizational risk management strategy and organization-wide priorities for risk response actions.

Discussion: The plan of action and milestones is a key organizational document and is subject to reporting requirements established by the Office of Management and Budget. Organizations develop plans of action and milestones with an organization-wide perspective, prioritizing risk response actions and ensuring consistency with the goals and objectives of the organization. Plan of action and milestones updates are based on findings from control assessments and continuous monitoring activities. There can be multiple plans of action and milestones corresponding to the information system level, mission/business process level, and organizational/governance level. While plans of action and milestones are required for federal organizations, other types of organizations can help reduce risk by documenting and tracking planned remediations. Specific guidance on plans of action and milestones at the system level is provided in [CA-5](#).

Related Controls: [CA-5](#), [CA-7](#), [PM-3](#), [RA-7](#), [SI-12](#).

Control Enhancements: None.

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[SP 800-37\]](#).

PM-5 SYSTEM INVENTORY

Control: Develop and update [Assignment: organization-defined frequency] an inventory of organizational systems.

Discussion: [OMB A-130] provides guidance on developing systems inventories and associated reporting requirements. System inventory refers to an organization-wide inventory of systems, not system components as described in CM-8.

Related Controls: None.

Control Enhancements:

(1) SYSTEM INVENTORY | INVENTORY OF PERSONALLY IDENTIFIABLE INFORMATION

Establish, maintain, and update [Assignment: organization-defined frequency] an inventory of all systems, applications, and projects that process personally identifiable information.

Discussion: An inventory of systems, applications, and projects that process personally identifiable information supports the mapping of data actions, providing individuals with privacy notices, maintaining accurate personally identifiable information, and limiting the processing of personally identifiable information when such information is not needed for operational purposes. Organizations may use this inventory to ensure that systems only process the personally identifiable information for authorized purposes and that this processing is still relevant and necessary for the purpose specified therein.

Related Controls: AC-3, CM-8, CM-12, CM-13, PL-8, PM-22, PT-3, PT-5, SI-12, SI-18.

References: [OMB A-130], [IR 8062].

PM-6 MEASURES OF PERFORMANCE

Control: Develop, monitor, and report on the results of information security and privacy measures of performance.

Discussion: Measures of performance are outcome-based metrics used by an organization to measure the effectiveness or efficiency of the information security and privacy programs and the controls employed in support of the program. To facilitate security and privacy risk management, organizations consider aligning measures of performance with the organizational risk tolerance as defined in the risk management strategy.

Related Controls: CA-7, PM-9.

Control Enhancements: None.

References: [OMB A-130], [SP 800-37], [SP 800-39], [SP 800-55], [SP 800-137].

PM-7 ENTERPRISE ARCHITECTURE

Control: Develop and maintain an enterprise architecture with consideration for information security, privacy, and the resulting risk to organizational operations and assets, individuals, other organizations, and the Nation.

Discussion: The integration of security and privacy requirements and controls into the enterprise architecture helps to ensure that security and privacy considerations are addressed throughout the system development life cycle and are explicitly related to the organization's mission and business processes. The process of security and privacy requirements integration also embeds into the enterprise architecture and the organization's security and privacy architectures consistent with the organizational risk management strategy. For PM-7, security and privacy architectures are developed at a system-of-systems level, representing all organizational

systems. For [PL-8](#), the security and privacy architectures are developed at a level that represents an individual system. The system-level architectures are consistent with the security and privacy architectures defined for the organization. Security and privacy requirements and control integration are most effectively accomplished through the rigorous application of the Risk Management Framework [[SP 800-37](#)] and supporting security standards and guidelines.

Related Controls: [AU-6](#), [PL-2](#), [PL-8](#), [PM-11](#), [RA-2](#), [SA-3](#), [SA-8](#), [SA-17](#).

Control Enhancements:

(1) ENTERPRISE ARCHITECTURE | [OFFLOADING](#)

Offload [Assignment: organization-defined non-essential functions or services] to other systems, system components, or an external provider.

Discussion: Not every function or service that a system provides is essential to organizational mission or business functions. Printing or copying is an example of a non-essential but supporting service for an organization. Whenever feasible, such supportive but non-essential functions or services are not co-located with the functions or services that support essential mission or business functions. Maintaining such functions on the same system or system component increases the attack surface of the organization's mission-essential functions or services. Moving supportive but non-essential functions to a non-critical system, system component, or external provider can also increase efficiency by putting those functions or services under the control of individuals or providers who are subject matter experts in the functions or services.

Related Controls: [SA-8](#).

References: [[OMB A-130](#)], [[SP 800-37](#)], [[SP 800-39](#)], [[SP 800-160-1](#)], [[SP 800-160-2](#)].

[PM-8 CRITICAL INFRASTRUCTURE PLAN](#)

Control: Address information security and privacy issues in the development, documentation, and updating of a critical infrastructure and key resources protection plan.

Discussion: Protection strategies are based on the prioritization of critical assets and resources. The requirement and guidance for defining critical infrastructure and key resources and for preparing an associated critical infrastructure protection plan are found in applicable laws, executive orders, directives, policies, regulations, standards, and guidelines.

Related Controls: [CP-2](#), [CP-4](#), [PE-18](#), [PL-2](#), [PM-9](#), [PM-11](#), [PM-18](#), [RA-3](#), [SI-12](#).

Control Enhancements: None.

References: [[EO 13636](#)], [[OMB A-130](#)], [[HSPD 7](#)], [[DHS NIPP](#)].

[PM-9 RISK MANAGEMENT STRATEGY](#)

Control:

- a. Develops a comprehensive strategy to manage:
 1. Security risk to organizational operations and assets, individuals, other organizations, and the Nation associated with the operation and use of organizational systems; and
 2. Privacy risk to individuals resulting from the authorized processing of personally identifiable information;
- b. Implement the risk management strategy consistently across the organization; and
- c. Review and update the risk management strategy [Assignment: organization-defined frequency] or as required, to address organizational changes.

Discussion: An organization-wide risk management strategy includes an expression of the security and privacy risk tolerance for the organization, security and privacy risk mitigation strategies, acceptable risk assessment methodologies, a process for evaluating security and privacy risk across the organization with respect to the organization's risk tolerance, and approaches for monitoring risk over time. The senior accountable official for risk management (agency head or designated official) aligns information security management processes with strategic, operational, and budgetary planning processes. The risk executive function, led by the senior accountable official for risk management, can facilitate consistent application of the risk management strategy organization-wide. The risk management strategy can be informed by security and privacy risk-related inputs from other sources, both internal and external to the organization, to ensure that the strategy is broad-based and comprehensive. The supply chain risk management strategy described in [PM-30](#) can also provide useful inputs to the organization-wide risk management strategy.

Related Controls: [AC-1](#), [AU-1](#), [AT-1](#), [CA-1](#), [CA-2](#), [CA-5](#), [CA-6](#), [CA-7](#), [CM-1](#), [CP-1](#), [IA-1](#), [IR-1](#), [MA-1](#), [MP-1](#), [PE-1](#), [PL-1](#), [PL-2](#), [PM-2](#), [PM-8](#), [PM-18](#), [PM-28](#), [PM-30](#), [PS-1](#), [PT-1](#), [PT-2](#), [PT-3](#), [RA-1](#), [RA-3](#), [RA-9](#), [SA-1](#), [SA-4](#), [SC-1](#), [SC-38](#), [SI-1](#), [SI-12](#), [SR-1](#), [SR-2](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-30\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-161\]](#), [\[IR 8023\]](#).

PM-10 AUTHORIZATION PROCESS

Control:

- a. Manage the security and privacy state of organizational systems and the environments in which those systems operate through authorization processes;
- b. Designate individuals to fulfill specific roles and responsibilities within the organizational risk management process; and
- c. Integrate the authorization processes into an organization-wide risk management program.

Discussion: Authorization processes for organizational systems and environments of operation require the implementation of an organization-wide risk management process and associated security and privacy standards and guidelines. Specific roles for risk management processes include a risk executive (function) and designated authorizing officials for each organizational system and common control provider. The authorization processes for the organization are integrated with continuous monitoring processes to facilitate ongoing understanding and acceptance of security and privacy risks to organizational operations, organizational assets, individuals, other organizations, and the Nation.

Related Controls: [CA-6](#), [CA-7](#), [PL-2](#).

Control Enhancements: None.

References: [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-181\]](#).

PM-11 MISSION AND BUSINESS PROCESS DEFINITION

Control:

- a. Define organizational mission and business processes with consideration for information security and privacy and the resulting risk to organizational operations, organizational assets, individuals, other organizations, and the Nation; and
- b. Determine information protection and personally identifiable information processing needs arising from the defined mission and business processes; and

- c. Review and revise the mission and business processes [*Assignment: organization-defined frequency*].

Discussion: Protection needs are technology-independent capabilities that are required to counter threats to organizations, individuals, systems, and the Nation through the compromise of information (i.e., loss of confidentiality, integrity, availability, or privacy). Information protection and personally identifiable information processing needs are derived from the mission and business needs defined by organizational stakeholders, the mission and business processes designed to meet those needs, and the organizational risk management strategy. Information protection and personally identifiable information processing needs determine the required controls for the organization and the systems. Inherent to defining protection and personally identifiable information processing needs is an understanding of the adverse impact that could result if a compromise or breach of information occurs. The categorization process is used to make such potential impact determinations. Privacy risks to individuals can arise from the compromise of personally identifiable information, but they can also arise as unintended consequences or a byproduct of the processing of personally identifiable information at any stage of the information life cycle. Privacy risk assessments are used to prioritize the risks that are created for individuals from system processing of personally identifiable information. These risk assessments enable the selection of the required privacy controls for the organization and systems. Mission and business process definitions and the associated protection requirements are documented in accordance with organizational policies and procedures.

Related Controls: [CP-2](#), [PL-2](#), [PM-7](#), [PM-8](#), [RA-2](#), [RA-3](#), [RA-9](#), [SA-2](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[FIPS 199\]](#), [\[SP 800-39\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#), [\[SP 800-160-1\]](#).

PM-12 INSIDER THREAT PROGRAM

Control: Implement an insider threat program that includes a cross-discipline insider threat incident handling team.

Discussion: Organizations that handle classified information are required, under Executive Order 13587 [[EO 13587](#)] and the National Insider Threat Policy [[ODNI NITP](#)], to establish insider threat programs. The same standards and guidelines that apply to insider threat programs in classified environments can also be employed effectively to improve the security of controlled unclassified and other information in non-national security systems. Insider threat programs include controls to detect and prevent malicious insider activity through the centralized integration and analysis of both technical and nontechnical information to identify potential insider threat concerns. A senior official is designated by the department or agency head as the responsible individual to implement and provide oversight for the program. In addition to the centralized integration and analysis capability, insider threat programs require organizations to prepare department or agency insider threat policies and implementation plans, conduct host-based user monitoring of individual employee activities on government-owned classified computers, provide insider threat awareness training to employees, receive access to information from offices in the department or agency for insider threat analysis, and conduct self-assessments of department or agency insider threat posture.

Insider threat programs can leverage the existence of incident handling teams that organizations may already have in place, such as computer security incident response teams. Human resources records are especially important in this effort, as there is compelling evidence to show that some types of insider crimes are often preceded by nontechnical behaviors in the workplace, including ongoing patterns of disgruntled behavior and conflicts with coworkers and other colleagues.

These precursors can guide organizational officials in more focused, targeted monitoring efforts. However, the use of human resource records could raise significant concerns for privacy. The

participation of a legal team, including consultation with the senior agency official for privacy, ensures that monitoring activities are performed in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: [AC-6](#), [AT-2](#), [AU-6](#), [AU-7](#), [AU-10](#), [AU-12](#), [AU-13](#), [CA-7](#), [IA-4](#), [IR-4](#), [MP-7](#), [PE-2](#), [PM-16](#), [PS-3](#), [PS-4](#), [PS-5](#), [PS-7](#), [PS-8](#), [SC-7](#), [SC-38](#), [SI-4](#), [PM-14](#).

Control Enhancements: None.

References: [\[EO 13587\]](#), [\[NITP12\]](#), [\[ODNI NITP\]](#).

PM-13 SECURITY AND PRIVACY WORKFORCE

Control: Establish a security and privacy workforce development and improvement program.

Discussion: Security and privacy workforce development and improvement programs include defining the knowledge, skills, and abilities needed to perform security and privacy duties and tasks; developing role-based training programs for individuals assigned security and privacy roles and responsibilities; and providing standards and guidelines for measuring and building individual qualifications for incumbents and applicants for security- and privacy-related positions. Such workforce development and improvement programs can also include security and privacy career paths to encourage security and privacy professionals to advance in the field and fill positions with greater responsibility. The programs encourage organizations to fill security- and privacy-related positions with qualified personnel. Security and privacy workforce development and improvement programs are complementary to organizational security awareness and training programs and focus on developing and institutionalizing the core security and privacy capabilities of personnel needed to protect organizational operations, assets, and individuals.

Related Controls: [AT-2](#), [AT-3](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-181\]](#).

PM-14 TESTING, TRAINING, AND MONITORING

Control:

- a. Implement a process for ensuring that organizational plans for conducting security and privacy testing, training, and monitoring activities associated with organizational systems:
 1. Are developed and maintained; and
 2. Continue to be executed; and
- b. Review testing, training, and monitoring plans for consistency with the organizational risk management strategy and organization-wide priorities for risk response actions.

Discussion: A process for organization-wide security and privacy testing, training, and monitoring helps ensure that organizations provide oversight for testing, training, and monitoring activities and that those activities are coordinated. With the growing importance of continuous monitoring programs, the implementation of information security and privacy across the three levels of the risk management hierarchy and the widespread use of common controls, organizations coordinate and consolidate the testing and monitoring activities that are routinely conducted as part of ongoing assessments supporting a variety of controls. Security and privacy training activities, while focused on individual systems and specific roles, require coordination across all organizational elements. Testing, training, and monitoring plans and activities are informed by current threat and vulnerability assessments.

Related Controls: [AT-2](#), [AT-3](#), [CA-7](#), [CP-4](#), [IR-3](#), [PM-12](#), [SI-4](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-53A\]](#), [\[SP 800-115\]](#), [\[SP 800-137\]](#).

PM-15 SECURITY AND PRIVACY GROUPS AND ASSOCIATIONS

Control: Establish and institutionalize contact with selected groups and associations within the security and privacy communities:

- a. To facilitate ongoing security and privacy education and training for organizational personnel;
- b. To maintain currency with recommended security and privacy practices, techniques, and technologies; and
- c. To share current security and privacy information, including threats, vulnerabilities, and incidents.

Discussion: Ongoing contact with security and privacy groups and associations is important in an environment of rapidly changing technologies and threats. Groups and associations include special interest groups, professional associations, forums, news groups, users' groups, and peer groups of security and privacy professionals in similar organizations. Organizations select security and privacy groups and associations based on mission and business functions. Organizations share threat, vulnerability, and incident information as well as contextual insights, compliance techniques, and privacy problems consistent with applicable laws, executive orders, directives, policies, regulations, standards, and guidelines.

Related Controls: [SA-11](#), [SI-5](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#).

PM-16 THREAT AWARENESS PROGRAM

Control: Implement a threat awareness program that includes a cross-organization information-sharing capability for threat intelligence.

Discussion: Because of the constantly changing and increasing sophistication of adversaries, especially the advanced persistent threat (APT), it may be more likely that adversaries can successfully breach or compromise organizational systems. One of the best techniques to address this concern is for organizations to share threat information, including threat events (i.e., tactics, techniques, and procedures) 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). Threat information sharing may be bilateral or multilateral. Bilateral threat sharing includes government-to-commercial and government-to-government cooperatives. Multilateral threat sharing includes organizations taking part in threat-sharing consortia. Threat information may require special agreements and protection, or it may be freely shared.

Related Controls: [IR-4](#), [PM-12](#).

Control Enhancements:

(1) THREAT AWARENESS PROGRAM | [AUTOMATED MEANS FOR SHARING THREAT INTELLIGENCE](#)

Employ automated mechanisms to maximize the effectiveness of sharing threat intelligence information.

Discussion: To maximize the effectiveness of monitoring, it is important to know what threat observables and indicators the sensors need to be searching for. By using well-

established frameworks, services, and automated tools, organizations improve their ability to rapidly share and feed the relevant threat detection signatures into monitoring tools.

Related Controls: None.

References: None.

PM-17 PROTECTING CONTROLLED UNCLASSIFIED INFORMATION ON EXTERNAL SYSTEMS

Control:

- a. Establish policy and procedures to ensure that requirements for the protection of controlled unclassified information that is processed, stored or transmitted on external systems, are implemented in accordance with applicable laws, executive orders, directives, policies, regulations, and standards; and
- b. Review and update the policy and procedures [*Assignment: organization-defined frequency*].

Discussion: Controlled unclassified information is defined by the National Archives and Records Administration along with the safeguarding and dissemination requirements for such information and is codified in [\[32 CFR 2002\]](#) and, specifically for systems external to the federal organization, [\[32 CFR 2002.14h\]](#). The policy prescribes the specific use and conditions to be implemented in accordance with organizational procedures, including via its contracting processes.

Related Controls: [CA-6](#), [PM-10](#).

Control Enhancements: None.

References: [\[32 CFR 2002\]](#), [\[SP 800-171\]](#), [\[SP 800-172\]](#), [\[NARA CUI\]](#).

PM-18 PRIVACY PROGRAM PLAN

Control:

- a. Develop and disseminate an organization-wide privacy program plan that provides an overview of the agency's privacy program, and:
 1. Includes a description of the structure of the privacy program and the resources dedicated to the privacy program;
 2. Provides an overview of the requirements for the privacy program and a description of the privacy program management controls and common controls in place or planned for meeting those requirements;
 3. Includes the role of the senior agency official for privacy and the identification and assignment of roles of other privacy officials and staff and their responsibilities;
 4. Describes management commitment, compliance, and the strategic goals and objectives of the privacy program;
 5. Reflects coordination among organizational entities responsible for the different aspects of privacy; and
 6. Is approved by a senior official with responsibility and accountability for the privacy risk being incurred to organizational operations (including mission, functions, image, and reputation), organizational assets, individuals, other organizations, and the Nation; and
- b. Update the plan [*Assignment: organization-defined frequency*] and to address changes in federal privacy laws and policy and organizational changes and problems identified during plan implementation or privacy control assessments.

Discussion: A privacy program plan is a formal document that provides an overview of an organization's privacy program, including a description of the structure of the privacy program, the resources dedicated to the privacy program, the role of the senior agency official for privacy and other privacy officials and staff, the strategic goals and objectives of the privacy program, and the program management controls and common controls in place or planned for meeting applicable privacy requirements and managing privacy risks. Privacy program plans can be represented in single documents or compilations of documents.

The senior agency official for privacy is responsible for designating which privacy controls the organization will treat as program management, common, system-specific, and hybrid controls. Privacy program plans provide sufficient information about the privacy program management and common controls (including the specification of parameters and assignment and selection operations explicitly or by reference) to enable control implementations that are unambiguously compliant with the intent of the plans and a determination of the risk incurred if the plans are implemented as intended.

Program management controls are generally implemented at the organization level and are essential for managing the organization's privacy program. Program management controls are distinct from common, system-specific, and hybrid controls because program management controls are independent of any particular information system. Together, the privacy plans for individual systems and the organization-wide privacy program plan provide complete coverage for the privacy controls employed within the organization.

Common controls are documented in an appendix to the organization's privacy program plan unless the controls are included in a separate privacy plan for a system. The organization-wide privacy program plan indicates which separate privacy plans contain descriptions of privacy controls.

Related Controls: [PM-8](#), [PM-9](#), [PM-19](#).

Control Enhancements: None.

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#).

PM-19 PRIVACY PROGRAM LEADERSHIP ROLE

Control: Appoint a senior agency official for privacy with the authority, mission, accountability, and resources to coordinate, develop, and implement, applicable privacy requirements and manage privacy risks through the organization-wide privacy program.

Discussion: The privacy officer is an organizational official. For federal agencies—as defined by applicable laws, executive orders, directives, regulations, policies, standards, and guidelines—this official is designated as the senior agency official for privacy. Organizations may also refer to this official as the chief privacy officer. The senior agency official for privacy also has roles on the data management board (see [PM-23](#)) and the data integrity board (see [PM-24](#)).

Related Controls: [PM-18](#), [PM-20](#), [PM-23](#), [PM-24](#), [PM-27](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#).

PM-20 DISSEMINATION OF PRIVACY PROGRAM INFORMATION

Control: Maintain a central resource webpage on the organization's principal public website that serves as a central source of information about the organization's privacy program and that:

- a. Ensures that the public has access to information about organizational privacy activities and can communicate with its senior agency official for privacy;

- b. Ensures that organizational privacy practices and reports are publicly available; and
- c. Employs publicly facing email addresses and/or phone lines to enable the public to provide feedback and/or direct questions to privacy offices regarding privacy practices.

Discussion: For federal agencies, the webpage is located at [www.\[agency\].gov/privacy](http://www.[agency].gov/privacy). Federal agencies include public privacy impact assessments, system of records notices, computer matching notices and agreements, [PRIVACT] exemption and implementation rules, privacy reports, privacy policies, instructions for individuals making an access or amendment request, email addresses for questions/complaints, blogs, and periodic publications.

Related Controls: [AC-3](#), [PM-19](#), [PT-5](#), [PT-6](#), [PT-7](#), [RA-8](#).

Control Enhancements:

- (1) DISSEMINATION OF PRIVACY PROGRAM INFORMATION | [PRIVACY POLICIES ON WEBSITES, APPLICATIONS, AND DIGITAL SERVICES](#)**

Develop and post privacy policies on all external-facing websites, mobile applications, and other digital services, that:

- (a) Are written in plain language and organized in a way that is easy to understand and navigate;**
- (b) Provide information needed by the public to make an informed decision about whether and how to interact with the organization; and**
- (c) Are updated whenever the organization makes a substantive change to the practices it describes and includes a time/date stamp to inform the public of the date of the most recent changes.**

Discussion: Organizations post privacy policies on all external-facing websites, mobile applications, and other digital services. Organizations post a link to the relevant privacy policy on any known, major entry points to the website, application, or digital service. In addition, organizations provide a link to the privacy policy on any webpage that collects personally identifiable information. Organizations may be subject to applicable laws, executive orders, directives, regulations, or policies that require the provision of specific information to the public. Organizational personnel consult with the senior agency official for privacy and legal counsel regarding such requirements.

Related Controls: None.

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[OMB M-17-06\]](#).

[PM-21 ACCOUNTING OF DISCLOSURES](#)

Control:

- a. Develop and maintain an accurate accounting of disclosures of personally identifiable information, including:
 1. Date, nature, and purpose of each disclosure; and
 2. Name and address, or other contact information of the individual or organization to which the disclosure was made;
- b. Retain the accounting of disclosures for the length of the time the personally identifiable information is maintained or five years after the disclosure is made, whichever is longer; and
- c. Make the accounting of disclosures available to the individual to whom the personally identifiable information relates upon request.

Discussion: The purpose of accounting of disclosures is to allow individuals to learn to whom their personally identifiable information has been disclosed, to provide a basis for subsequently advising recipients of any corrected or disputed personally identifiable information, and to provide an audit trail for subsequent reviews of organizational compliance with conditions for disclosures. For federal agencies, keeping an accounting of disclosures is required by the [PRIVACT]; agencies should consult with their senior agency official for privacy and legal counsel on this requirement and be aware of the statutory exceptions and OMB guidance relating to the provision.

Organizations can use any system for keeping notations of disclosures, if it can construct from such a system, a document listing of all disclosures along with the required information.

Automated mechanisms can be used by organizations to determine when personally identifiable information is disclosed, including commercial services that provide notifications and alerts.

Accounting of disclosures may also be used to help organizations verify compliance with applicable privacy statutes and policies governing the disclosure or dissemination of information and dissemination restrictions.

Related Controls: [AC-3](#), [AU-2](#), [PT-2](#).

Control Enhancements: None.

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#).

PM-22 PERSONALLY IDENTIFIABLE INFORMATION QUALITY MANAGEMENT

Control: Develop and document organization-wide policies and procedures for:

- a. Reviewing for the accuracy, relevance, timeliness, and completeness of personally identifiable information across the information life cycle;
- b. Correcting or deleting inaccurate or outdated personally identifiable information;
- c. Disseminating notice of corrected or deleted personally identifiable information to individuals or other appropriate entities; and
- d. Appeals of adverse decisions on correction or deletion requests.

Discussion: Personally identifiable information quality management includes steps that organizations take to confirm the accuracy and relevance of personally identifiable information throughout the information life cycle. The information life cycle includes the creation, collection, use, processing, storage, maintenance, dissemination, disclosure, and disposition of personally identifiable information. Organizational policies and procedures for personally identifiable information quality management are important because inaccurate or outdated personally identifiable information maintained by organizations may cause problems for individuals.

Organizations consider the quality of personally identifiable information involved in business functions where inaccurate information may result in adverse decisions or the denial of benefits and services, or the disclosure of the information may cause stigmatization. Correct information, in certain circumstances, can cause problems for individuals that outweigh the benefits of organizations maintaining the information. Organizations consider creating policies and procedures for the removal of such information.

The senior agency official for privacy ensures that practical means and mechanisms exist and are accessible for individuals or their authorized representatives to seek the correction or deletion of personally identifiable information. Processes for correcting or deleting data are clearly defined and publicly available. Organizations use discretion in determining whether data is to be deleted or corrected based on the scope of requests, the changes sought, and the impact of the changes. Additionally, processes include the provision of responses to individuals of decisions to deny requests for correction or deletion. The responses include the reasons for the decisions, a means

to record individual objections to the decisions, and a means of requesting reviews of the initial determinations.

Organizations notify individuals or their designated representatives when their personally identifiable information is corrected or deleted to provide transparency and confirm the completed action. Due to the complexity of data flows and storage, other entities may need to be informed of the correction or deletion. Notice supports the consistent correction and deletion of personally identifiable information across the data ecosystem.

Related Controls: [PM-23](#), [SI-18](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[OMB M-19-15\]](#), [\[SP 800-188\]](#).

PM-23 DATA GOVERNANCE BODY

Control: Establish a Data Governance Body consisting of [Assignment: organization-defined roles] with [Assignment: organization-defined responsibilities].

Discussion: A Data Governance Body can help ensure that the organization has coherent policies and the ability to balance the utility of data with security and privacy requirements. The Data Governance Body establishes policies, procedures, and standards that facilitate data governance so that data, including personally identifiable information, is effectively managed and maintained in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidance. Responsibilities can include developing and implementing guidelines that support data modeling, quality, integrity, and the de-identification needs of personally identifiable information across the information life cycle as well as reviewing and approving applications to release data outside of the organization, archiving the applications and the released data, and performing post-release monitoring to ensure that the assumptions made as part of the data release continue to be valid. Members include the chief information officer, senior agency information security officer, and senior agency official for privacy. Federal agencies are required to establish a Data Governance Body with specific roles and responsibilities in accordance with the [\[EVIDACT\]](#) and policies set forth under [\[OMB M-19-23\]](#).

Related Controls: [AT-2](#), [AT-3](#), [PM-19](#), [PM-22](#), [PM-24](#), [PT-7](#), [SI-4](#), [SI-19](#).

Control Enhancements: None.

References: [\[EVIDACT\]](#), [\[OMB A-130\]](#), [\[OMB M-19-23\]](#), [\[SP 800-188\]](#).

PM-24 DATA INTEGRITY BOARD

Control: Establish a Data Integrity Board to:

- a. Review proposals to conduct or participate in a matching program; and
- b. Conduct an annual review of all matching programs in which the agency has participated.

Discussion: A Data Integrity Board is the board of senior officials designated by the head of a federal agency and is responsible for, among other things, reviewing the agency's proposals to conduct or participate in a matching program and conducting an annual review of all matching programs in which the agency has participated. As a general matter, a matching program is a computerized comparison of records from two or more automated [\[PRIVACT\]](#) systems of records or an automated system of records and automated records maintained by a non-federal agency (or agent thereof). A matching program either pertains to Federal benefit programs or Federal personnel or payroll records. At a minimum, the Data Integrity Board includes the Inspector General of the agency, if any, and the senior agency official for privacy.

Related Controls: [AC-4](#), [PM-19](#), [PM-23](#), [PT-2](#), [PT-8](#).

Control Enhancements: None.

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[OMB A-108\]](#).

PM-25 MINIMIZATION OF PERSONALLY IDENTIFIABLE INFORMATION USED IN TESTING, TRAINING, AND RESEARCH

Control:

- a. Develop, document, and implement policies and procedures that address the use of personally identifiable information for internal testing, training, and research;
- b. Limit or minimize the amount of personally identifiable information used for internal testing, training, and research purposes;
- c. Authorize the use of personally identifiable information when such information is required for internal testing, training, and research; and
- d. Review and update policies and procedures [*Assignment: organization-defined frequency*].

Discussion: The use of personally identifiable information in testing, research, and training increases the risk of unauthorized disclosure or misuse of such information. Organizations consult with the senior agency official for privacy and/or legal counsel to ensure that the use of personally identifiable information in testing, training, and research is compatible with the original purpose for which it was collected. When possible, organizations use placeholder data to avoid exposure of personally identifiable information when conducting testing, training, and research.

Related Controls: [PM-23](#), [PT-3](#), [SA-3](#), [SA-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#).

PM-26 COMPLAINT MANAGEMENT

Control: Implement a process for receiving and responding to complaints, concerns, or questions from individuals about the organizational security and privacy practices that includes:

- a. Mechanisms that are easy to use and readily accessible by the public;
- b. All information necessary for successfully filing complaints;
- c. Tracking mechanisms to ensure all complaints received are reviewed and addressed within [*Assignment: organization-defined time period*];
- d. Acknowledgement of receipt of complaints, concerns, or questions from individuals within [*Assignment: organization-defined time period*]; and
- e. Response to complaints, concerns, or questions from individuals within [*Assignment: organization-defined time period*].

Discussion: Complaints, concerns, and questions from individuals can serve as valuable sources of input to organizations and ultimately improve operational models, uses of technology, data collection practices, and controls. Mechanisms that can be used by the public include telephone hotline, email, or web-based forms. The information necessary for successfully filing complaints includes contact information for the senior agency official for privacy or other official designated to receive complaints. Privacy complaints may also include personally identifiable information which is handled in accordance with relevant policies and processes.

Related Controls: [IR-7](#), [IR-9](#), [PM-22](#), [SI-18](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#).

PM-27 PRIVACY REPORTING

Control:

- a. Develop [Assignment: organization-defined privacy reports] and disseminate to:
 1. [Assignment: organization-defined oversight bodies] to demonstrate accountability with statutory, regulatory, and policy privacy mandates; and
 2. [Assignment: organization-defined officials] and other personnel with responsibility for monitoring privacy program compliance; and
- b. Review and update privacy reports [Assignment: organization-defined frequency].

Discussion: Through internal and external reporting, organizations promote accountability and transparency in organizational privacy operations. Reporting can also help organizations to determine progress in meeting privacy compliance requirements and privacy controls, compare performance across the federal government, discover vulnerabilities, identify gaps in policy and implementation, and identify models for success. For federal agencies, privacy reports include annual senior agency official for privacy reports to OMB, reports to Congress required by Implementing Regulations of the 9/11 Commission Act, and other public reports required by law, regulation, or policy, including internal policies of organizations. The senior agency official for privacy consults with legal counsel, where appropriate, to ensure that organizations meet all applicable privacy reporting requirements.

Related Controls: [IR-9](#), [PM-19](#).

Control Enhancements: None.

References: [\[FISMA\]](#), [\[OMB A-130\]](#), [\[OMB A-108\]](#).

PM-28 RISK FRAMING

Control:

- a. Identify and document:
 1. Assumptions affecting risk assessments, risk responses, and risk monitoring;
 2. Constraints affecting risk assessments, risk responses, and risk monitoring;
 3. Priorities and trade-offs considered by the organization for managing risk; and
 4. Organizational risk tolerance;
- b. Distribute the results of risk framing activities to [Assignment: organization-defined personnel]; and
- c. Review and update risk framing considerations [Assignment: organization-defined frequency].

Discussion: Risk framing is most effective when conducted at the organization level and in consultation with stakeholders throughout the organization including mission, business, and system owners. The assumptions, constraints, risk tolerance, priorities, and trade-offs identified as part of the risk framing process inform the risk management strategy, which in turn informs the conduct of risk assessment, risk response, and risk monitoring activities. Risk framing results are shared with organizational personnel, including mission and business owners, information

owners or stewards, system owners, authorizing officials, senior agency information security officer, senior agency official for privacy, and senior accountable official for risk management.

Related Controls: [CA-7](#), [PM-9](#), [RA-3](#), [RA-7](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-39\]](#).

PM-29 RISK MANAGEMENT PROGRAM LEADERSHIP ROLES

Control:

- a. Appoint a Senior Accountable Official for Risk Management to align organizational information security and privacy management processes with strategic, operational, and budgetary planning processes; and
- b. Establish a Risk Executive (function) to view and analyze risk from an organization-wide perspective and ensure management of risk is consistent across the organization.

Discussion: The senior accountable official for risk management leads the risk executive (function) in organization-wide risk management activities.

Related Controls: [PM-2](#), [PM-19](#).

Control Enhancements: None.

References: [\[SP 800-37\]](#), [\[SP 800-181\]](#).

PM-30 SUPPLY CHAIN RISK MANAGEMENT STRATEGY

Control:

- a. Develop an organization-wide strategy for managing supply chain risks associated with the development, acquisition, maintenance, and disposal of systems, system components, and system services;
- b. Implement the supply chain risk management strategy consistently across the organization; and
- c. Review and update the supply chain risk management strategy on *[Assignment: organization-defined frequency]* or as required, to address organizational changes.

Discussion: An organization-wide supply chain risk management strategy includes an unambiguous expression of the supply chain risk appetite and tolerance for the organization, acceptable supply chain risk mitigation strategies or controls, a process for consistently evaluating and monitoring supply chain risk, approaches for implementing and communicating the supply chain risk management strategy, and the associated roles and responsibilities. Supply chain risk management includes considerations of the security and privacy risks associated with the development, acquisition, maintenance, and disposal of systems, system components, and system services. The supply chain risk management strategy can be incorporated into the organization's overarching risk management strategy and can guide and inform supply chain policies and system-level supply chain risk management plans. In addition, the use of a risk executive function can facilitate a consistent, organization-wide application of the supply chain risk management strategy. The supply chain risk management strategy is implemented at the organization and mission/business levels, whereas the supply chain risk management plan (see [SR-2](#)) is implemented at the system level.

Related Controls: [CM-10](#), [PM-9](#), [SR-1](#), [SR-2](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-6](#), [SR-7](#), [SR-8](#), [SR-9](#), [SR-11](#).

Control Enhancements:

(1) SUPPLY CHAIN RISK MANAGEMENT STRATEGY | [SUPPLIERS OF CRITICAL OR MISSION-ESSENTIAL ITEMS](#)

Identify, prioritize, and assess suppliers of critical or mission-essential technologies, products, and services.

Discussion: The identification and prioritization of suppliers of critical or mission-essential technologies, products, and services is paramount to the mission/business success of organizations. The assessment of suppliers is conducted using supplier reviews (see [SR-6](#)) and supply chain risk assessment processes (see [RA-3\(1\)](#)). An analysis of supply chain risk can help an organization identify systems or components for which additional supply chain risk mitigations are required.

Related Controls: [RA-3](#), [SR-6](#).

References: [\[PRIVACT\]](#), [\[FASC18\]](#), [\[EO 13873\]](#), [\[41 CFR 201\]](#), [\[OMB A-130\]](#), [\[OMB M-17-06\]](#), [\[CNSSD 505\]](#), [\[ISO 27036\]](#), [\[ISO 20243\]](#), [\[SP 800-161\]](#), [\[IR 8272\]](#).

[PM-31](#) CONTINUOUS MONITORING STRATEGY

Control: Develop an organization-wide continuous monitoring strategy and implement continuous monitoring programs that include:

- a. Establishing the following organization-wide metrics to be monitored: *[Assignment: organization-defined metrics]*;
- b. Establishing *[Assignment: organization-defined frequencies]* for monitoring and *[Assignment: organization-defined frequencies]* for assessment of control effectiveness;
- c. Ongoing monitoring of organizationally-defined metrics in accordance with the continuous monitoring strategy;
- d. Correlation and analysis of information generated by control assessments and monitoring;
- e. Response actions to address results of the analysis of control assessment and monitoring information; and
- f. Reporting the security and privacy status of organizational systems to *[Assignment: organization-defined personnel or roles]* *[Assignment: organization-defined frequency]*.

Discussion: Continuous monitoring at the organization level facilitates ongoing awareness of the security and privacy posture across the organization to support organizational risk management decisions. The terms “continuous” and “ongoing” imply that organizations assess and monitor their controls and risks at a frequency sufficient to support risk-based decisions. Different types of controls may require different monitoring frequencies. The results of continuous monitoring guide and inform risk response actions by organizations. Continuous monitoring programs allow organizations to maintain the authorizations of systems and common controls in highly dynamic environments of operation with changing mission and business needs, threats, vulnerabilities, and technologies. Having access to security- and privacy-related information on a continuing basis through reports and dashboards gives organizational officials the capability to make effective, timely, and informed risk management decisions, including ongoing authorization decisions. To further facilitate security and privacy risk management, organizations consider aligning organization-defined monitoring metrics with organizational risk tolerance as defined in the risk management strategy. Monitoring requirements, including the need for monitoring, may be referenced in other controls and control enhancements such as, [AC-2g](#), [AC-2\(7\)](#), [AC-2\(12\)\(a\)](#), [AC-2\(7\)\(b\)](#), [AC-2\(7\)\(c\)](#), [AC-17\(1\)](#), [AT-4a](#), [AU-13](#), [AU-13\(1\)](#), [AU-13\(2\)](#), [CA-7](#), [CM-3f](#), [CM-6d](#), [CM-11c](#), [IR-5](#), [MA-2b](#), [MA-3a](#), [MA-4a](#), [PE-3d](#), [PE-6](#), [PE-14b](#), [PE-16](#), [PE-20](#), [PM-6](#), [PM-23](#), [PS-7e](#), [SA-9c](#), [SC-5\(3\)\(b\)](#), [SC-7a](#), [SC-7\(24\)\(b\)](#), [SC-18b](#), [SC-43b](#), [SI-4](#).

Related Controls: [AC-2](#), [AC-6](#), [AC-17](#), [AT-4](#), [AU-6](#), [AU-13](#), [CA-2](#), [CA-5](#), [CA-6](#), [CA-7](#), [CM-3](#), [CM-4](#), [CM-6](#), [CM-11](#), [IA-5](#), [IR-5](#), [MA-2](#), [MA-3](#), [MA-4](#), [PE-3](#), [PE-6](#), [PE-14](#), [PE-16](#), [PE-20](#), [PL-2](#), [PM-4](#), [PM-6](#),

[PM-9](#), [PM-10](#), [PM-12](#), [PM-14](#), [PM-23](#), [PM-28](#), [PS-7](#), [PT-7](#), [RA-3](#), [RA-5](#), [RA-7](#), [SA-9](#), [SA-11](#), [SC-5](#), [SC-7](#), [SC-18](#), [SC-38](#), [SC-43](#), [SI-3](#), [SI-4](#), [SI-12](#), [SR-2](#), [SR-4](#).

References: [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-137\]](#), [\[SP 800-137A\]](#).

PM-32 PURPOSING

Control: Analyze [Assignment: organization-defined systems or systems components] supporting mission essential services or functions to ensure that the information resources are being used consistent with their intended purpose.

Discussion: Systems are designed to support a specific mission or business function. However, over time, systems and system components may be used to support services and functions that are outside of the scope of the intended mission or business functions. This can result in exposing information resources to unintended environments and uses that can significantly increase threat exposure. In doing so, the systems are more vulnerable to compromise, which can ultimately impact the services and functions for which they were intended. This is especially impactful for mission-essential services and functions. By analyzing resource use, organizations can identify such potential exposures.

Related Controls: [CA-7](#), [PL-2](#), [RA-3](#), [RA-9](#).

Control Enhancements: None.

References: [\[SP 800-160-1\]](#), [\[SP 800-160-2\]](#).

3.14 PERSONNEL SECURITY

[Quick link to Personnel Security Summary Table](#)

PS-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] personnel security policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the personnel security policy and the associated personnel security controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the personnel security policy and procedures; and
- c. Review and update the current personnel security:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Personnel security policy and procedures for the controls in the PS family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on their development. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission level or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies reflecting the complex nature of organizations. Procedures can be established for security and privacy programs, for mission/business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to personnel security policy and procedures include, but are not limited to, assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

PS-2 POSITION RISK DESIGNATION

Control:

- a. Assign a risk designation to all organizational positions;
- b. Establish screening criteria for individuals filling those positions; and
- c. Review and update position risk designations [Assignment: organization-defined frequency].

Discussion: Position risk designations reflect Office of Personnel Management (OPM) policy and guidance. Proper position designation is the foundation of an effective and consistent suitability and personnel security program. The Position Designation System (PDS) assesses the duties and responsibilities of a position to determine the degree of potential damage to the efficiency or integrity of the service due to misconduct of an incumbent of a position and establishes the risk level of that position. The PDS assessment also determines if the duties and responsibilities of the position present the potential for position incumbents to bring about a material adverse effect on national security and the degree of that potential effect, which establishes the sensitivity level of a position. The results of the assessment determine what level of investigation is conducted for a position. Risk designations can guide and inform the types of authorizations that individuals receive when accessing organizational information and information systems. Position screening criteria include explicit information security role appointment requirements. Parts 1400 and 731 of Title 5, Code of Federal Regulations, establish the requirements for organizations to evaluate relevant covered positions for a position sensitivity and position risk designation commensurate with the duties and responsibilities of those positions.

Related Controls: [AC-5](#), [AT-3](#), [PE-2](#), [PE-3](#), [PL-2](#), [PS-3](#), [PS-6](#), [SA-5](#), [SA-21](#), [SI-12](#).

Control Enhancements: None.

References: [\[5 CFR 731\]](#), [\[SP 800-181\]](#).

PS-3 PERSONNEL SCREENING

Control:

- a. Screen individuals prior to authorizing access to the system; and
- b. Rescreen individuals in accordance with [Assignment: organization-defined conditions requiring rescreening and, where rescreening is so indicated, the frequency of rescreening].

Discussion: Personnel screening and rescreening activities reflect applicable laws, executive orders, directives, regulations, policies, standards, guidelines, and specific criteria established for the risk designations of assigned positions. Examples of personnel screening include background investigations and agency checks. Organizations may define different rescreening conditions and frequencies for personnel accessing systems based on types of information processed, stored, or transmitted by the systems.

Related Controls: [AC-2](#), [IA-4](#), [MA-5](#), [PE-2](#), [PM-12](#), [PS-2](#), [PS-6](#), [PS-7](#), [SA-21](#).

Control Enhancements:

(1) PERSONNEL SCREENING | [CLASSIFIED INFORMATION](#)

Verify that individuals accessing a system processing, storing, or transmitting classified information are cleared and indoctrinated to the highest classification level of the information to which they have access on the system.

Discussion: Classified information is the most sensitive information that the Federal Government processes, stores, or transmits. It is imperative that individuals have the requisite security clearances and system access authorizations prior to gaining access to such

information. Access authorizations are enforced by system access controls (see [AC-3](#)) and flow controls (see [AC-4](#)).

Related Controls: [AC-3](#), [AC-4](#).

(2) PERSONNEL SCREENING | [FORMAL INDOCTRINATION](#)

Verify that individuals accessing a system processing, storing, or transmitting types of classified information that require formal indoctrination, are formally indoctrinated for all the relevant types of information to which they have access on the system.

Discussion: Types of classified information that require formal indoctrination include Special Access Program (SAP), Restricted Data (RD), and Sensitive Compartmented Information (SCI).

Related Controls: [AC-3](#), [AC-4](#).

(3) PERSONNEL SCREENING | [INFORMATION REQUIRING SPECIAL PROTECTIVE MEASURES](#)

Verify that individuals accessing a system processing, storing, or transmitting information requiring special protection:

(a) Have valid access authorizations that are demonstrated by assigned official government duties; and

(b) Satisfy [Assignment: organization-defined additional personnel screening criteria].

Discussion: Organizational information that requires special protection includes controlled unclassified information. Personnel security criteria include position sensitivity background screening requirements.

Related Controls: None.

(4) PERSONNEL SCREENING | [CITIZENSHIP REQUIREMENTS](#)

Verify that individuals accessing a system processing, storing, or transmitting [Assignment: organization-defined information types] meet [Assignment: organization-defined citizenship requirements].

Discussion: None.

Related Controls: None.

References: [\[EO 13526\]](#), [\[EO 13587\]](#), [\[FIPS 199\]](#), [\[FIPS 201-2\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#), [\[SP 800-73-4\]](#), [\[SP 800-76-2\]](#), [\[SP 800-78-4\]](#).

PS-4 PERSONNEL TERMINATION

Control: Upon termination of individual employment:

- a. Disable system access within [Assignment: organization-defined time period];
- b. Terminate or revoke any authenticators and credentials associated with the individual;
- c. Conduct exit interviews that include a discussion of [Assignment: organization-defined information security topics];
- d. Retrieve all security-related organizational system-related property; and
- e. Retain access to organizational information and systems formerly controlled by terminated individual.

Discussion: System property includes hardware authentication tokens, system administration technical manuals, keys, identification cards, and building passes. Exit interviews ensure that terminated individuals understand the security constraints imposed by being former employees and that proper accountability is achieved for system-related property. Security topics at exit interviews include reminding individuals of nondisclosure agreements and potential limitations on future employment. Exit interviews may not always be possible for some individuals, including

in cases related to the unavailability of supervisors, illnesses, or job abandonment. Exit interviews are important for individuals with security clearances. The timely execution of termination actions is essential for individuals who have been terminated for cause. In certain situations, organizations consider disabling the system accounts of individuals who are being terminated prior to the individuals being notified.

Related Controls: [AC-2](#), [IA-4](#), [PE-2](#), [PM-12](#), [PS-6](#), [PS-7](#).

Control Enhancements:

(1) PERSONNEL TERMINATION | [POST-EMPLOYMENT REQUIREMENTS](#)

- (a) Notify terminated individuals of applicable, legally binding post-employment requirements for the protection of organizational information; and**
- (b) Require terminated individuals to sign an acknowledgment of post-employment requirements as part of the organizational termination process.**

Discussion: Organizations consult with the Office of the General Counsel regarding matters of post-employment requirements on terminated individuals.

Related Controls: None.

(2) PERSONNEL TERMINATION | [AUTOMATED ACTIONS](#)

Use [Assignment: organization-defined automated mechanisms] to [Selection (one or more): notify [Assignment: organization-defined personnel or roles] of individual termination actions; disable access to system resources].

Discussion: In organizations with many employees, not all personnel who need to know about termination actions receive the appropriate notifications, or if such notifications are received, they may not occur in a timely manner. Automated mechanisms can be used to send automatic alerts or notifications to organizational personnel or roles when individuals are terminated. Such automatic alerts or notifications can be conveyed in a variety of ways, including via telephone, electronic mail, text message, or websites. Automated mechanisms can also be employed to quickly and thoroughly disable access to system resources after an employee is terminated.

Related Controls: None.

References: None.

PS-5 PERSONNEL TRANSFER

Control:

- a. Review and confirm ongoing operational need for current logical and physical access authorizations to systems and facilities when individuals are reassigned or transferred to other positions within the organization;
- b. Initiate [Assignment: organization-defined transfer or reassignment actions] within [Assignment: organization-defined time period following the formal transfer action];
- c. Modify access authorization as needed to correspond with any changes in operational need due to reassignment or transfer; and
- d. Notify [Assignment: organization-defined personnel or roles] within [Assignment: organization-defined time period].

Discussion: Personnel transfer applies when reassignments or transfers of individuals are permanent or of such extended duration as to make the actions warranted. Organizations define actions appropriate for the types of reassignments or transfers, whether permanent or extended. Actions that may be required for personnel transfers or reassignments to other positions within

organizations include returning old and issuing new keys, identification cards, and building passes; closing system accounts and establishing new accounts; changing system access authorizations (i.e., privileges); and providing for access to official records to which individuals had access at previous work locations and in previous system accounts.

Related Controls: [AC-2](#), [IA-4](#), [PE-2](#), [PM-12](#), [PS-4](#), [PS-7](#).

Control Enhancements: None.

References: None.

PS-6 ACCESS AGREEMENTS

Control:

- a. Develop and document access agreements for organizational systems;
- b. Review and update the access agreements [*Assignment: organization-defined frequency*]; and
- c. Verify that individuals requiring access to organizational information and systems:
 1. Sign appropriate access agreements prior to being granted access; and
 2. Re-sign access agreements to maintain access to organizational systems when access agreements have been updated or [*Assignment: organization-defined frequency*].

Discussion: Access agreements include nondisclosure agreements, acceptable use agreements, rules of behavior, and conflict-of-interest agreements. Signed access agreements include an acknowledgement that individuals have read, understand, and agree to abide by the constraints associated with organizational systems to which access is authorized. Organizations can use electronic signatures to acknowledge access agreements unless specifically prohibited by organizational policy.

Related Controls: [AC-17](#), [PE-2](#), [PL-4](#), [PS-2](#), [PS-3](#), [PS-6](#), [PS-7](#), [PS-8](#), [SA-21](#), [SI-12](#).

Control Enhancements:

(1) ACCESS AGREEMENTS | INFORMATION REQUIRING SPECIAL PROTECTION

[Withdrawn: Incorporated into [PS-3](#).]

(2) ACCESS AGREEMENTS | [CLASSIFIED INFORMATION REQUIRING SPECIAL PROTECTION](#)

Verify that access to classified information requiring special protection is granted only to individuals who:

- (a) Have a valid access authorization that is demonstrated by assigned official government duties;
- (b) Satisfy associated personnel security criteria; and
- (c) Have read, understood, and signed a nondisclosure agreement.

Discussion: Classified information that requires special protection includes collateral information, Special Access Program (SAP) information, and Sensitive Compartmented Information (SCI). Personnel security criteria reflect applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: None.

(3) ACCESS AGREEMENTS | [POST-EMPLOYMENT REQUIREMENTS](#)

- (a) Notify individuals of applicable, legally binding post-employment requirements for protection of organizational information; and

(b) Require individuals to sign an acknowledgment of these requirements, if applicable, as part of granting initial access to covered information.

Discussion: Organizations consult with the Office of the General Counsel regarding matters of post-employment requirements on terminated individuals.

Related Controls: [PS-4](#).

References: None.

[**PS-7 EXTERNAL PERSONNEL SECURITY**](#)

Control:

- a. Establish personnel security requirements, including security roles and responsibilities for external providers;
- b. Require external providers to comply with personnel security policies and procedures established by the organization;
- c. Document personnel security requirements;
- d. Require external providers to notify [Assignment: organization-defined personnel or roles] of any personnel transfers or terminations of external personnel who possess organizational credentials and/or badges, or who have system privileges within [Assignment: organization-defined time period]; and
- e. Monitor provider compliance with personnel security requirements.

Discussion: External provider refers to organizations other than the organization operating or acquiring the system. External providers include service bureaus, contractors, and other organizations that provide system development, information technology services, testing or assessment services, outsourced applications, and network/security management. Organizations explicitly include personnel security requirements in acquisition-related documents. External providers may have personnel working at organizational facilities with credentials, badges, or system privileges issued by organizations. Notifications of external personnel changes ensure the appropriate termination of privileges and credentials. Organizations define the transfers and terminations deemed reportable by security-related characteristics that include functions, roles, and the nature of credentials or privileges associated with transferred or terminated individuals.

Related Controls: [AT-2](#), [AT-3](#), [MA-5](#), [PE-3](#), [PS-2](#), [PS-3](#), [PS-4](#), [PS-5](#), [PS-6](#), [SA-5](#), [SA-9](#), [SA-21](#).

Control Enhancements: None.

References: [\[SP 800-35\]](#), [\[SP 800-63-3\]](#).

[**PS-8 PERSONNEL SANCTIONS**](#)

Control:

- a. Employ a formal sanctions process for individuals failing to comply with established information security and privacy policies and procedures; and
- b. Notify [Assignment: organization-defined personnel or roles] within [Assignment: organization-defined time period] when a formal employee sanctions process is initiated, identifying the individual sanctioned and the reason for the sanction.

Discussion: Organizational sanctions reflect applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Sanctions processes are described in access agreements and can be included as part of general personnel policies for organizations and/or specified in security and privacy policies. Organizations consult with the Office of the General Counsel regarding matters of employee sanctions.

Related Controls: All XX-1 Controls, [PL-4](#), [PM-12](#), [PS-6](#), [PT-1](#).

Control Enhancements: None.

References: None.

[PS-9](#) POSITION DESCRIPTIONS

Control: Incorporate security and privacy roles and responsibilities into organizational position descriptions.

Discussion: Specification of security and privacy roles in individual organizational position descriptions facilitates clarity in understanding the security or privacy responsibilities associated with the roles and the role-based security and privacy training requirements for the roles.

Related Controls: None.

Control Enhancements: None.

References: [[SP 800-181](#)].

3.15 PERSONALLY IDENTIFIABLE INFORMATION PROCESSING AND TRANSPARENCY

[Quick link to Personally Identifiable Information Processing and Transparency table](#)

PT-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] personally identifiable information processing and transparency policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the personally identifiable information processing and transparency policy and the associated personally identifiable information processing and transparency controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the personally identifiable information processing and transparency policy and procedures; and
- c. Review and update the current personally identifiable information processing and transparency:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Personally identifiable information processing and transparency policy and procedures address the controls in the PT family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of personally identifiable information processing and transparency policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to personally identifiable information processing and transparency policy and procedures include assessment or audit findings, breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: None.

Control Enhancements: None.

References: [OMB A-130].

PT-2 AUTHORITY TO PROCESS PERSONALLY IDENTIFIABLE INFORMATION

Control:

- a. Determine and document the [Assignment: organization-defined authority] that permits the [Assignment: organization-defined processing] of personally identifiable information; and
- b. Restrict the [Assignment: organization-defined processing] of personally identifiable information to only that which is authorized.

Discussion: The processing of personally identifiable information is an operation or set of operations that the information system or organization performs with respect to personally identifiable information across the information life cycle. Processing includes but is not limited to creation, collection, use, processing, storage, maintenance, dissemination, disclosure, and disposal. Processing operations also include logging, generation, and transformation, as well as analysis techniques, such as data mining.

Organizations may be subject to laws, executive orders, directives, regulations, or policies that establish the organization's authority and thereby limit certain types of processing of personally identifiable information or establish other requirements related to the processing. Organizational personnel consult with the senior agency official for privacy and legal counsel regarding such authority, particularly if the organization is subject to multiple jurisdictions or sources of authority. For organizations whose processing is not determined according to legal authorities, the organization's policies and determinations govern how they process personally identifiable information. While processing of personally identifiable information may be legally permissible, privacy risks may still arise. Privacy risk assessments can identify the privacy risks associated with the authorized processing of personally identifiable information and support solutions to manage such risks.

Organizations consider applicable requirements and organizational policies to determine how to document this authority. For federal agencies, the authority to process personally identifiable information is documented in privacy policies and notices, system of records notices, privacy impact assessments, [PRIVACT] statements, computer matching agreements and notices, contracts, information sharing agreements, memoranda of understanding, and other documentation.

Organizations take steps to ensure that personally identifiable information is only processed for authorized purposes, including training organizational personnel on the authorized processing of personally identifiable information and monitoring and auditing organizational use of personally identifiable information.

Related Controls: AC-2, AC-3, CM-13, IR-9, PM-9, PM-24, PT-1, PT-3, PT-5, PT-6, RA-3, RA-8, SI-12, SI-18.

Control Enhancements:

(1) AUTHORITY TO PROCESS PERSONALLY IDENTIFIABLE INFORMATION | DATA TAGGING

Attach data tags containing [Assignment: organization-defined authorized processing] to [Assignment: organization-defined elements of personally identifiable information].

Discussion: Data tags support the tracking and enforcement of authorized processing by conveying the types of processing that are authorized along with the relevant elements of

personally identifiable information throughout the system. Data tags may also support the use of automated tools.

Related Controls: [AC-16](#), [CA-6](#), [CM-12](#), [PM-5](#), [PM-22](#), [PT-4](#), [SC-16](#), [SC-43](#), [SI-10](#), [SI-15](#), [SI-19](#).

(2) AUTHORITY TO PROCESS PERSONALLY IDENTIFIABLE INFORMATION | [AUTOMATION](#)

Manage enforcement of the authorized processing of personally identifiable information using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms augment verification that only authorized processing is occurring.

Related Controls: [CA-6](#), [CM-12](#), [PM-5](#), [PM-22](#), [PT-4](#), [SC-16](#), [SC-43](#), [SI-10](#), [SI-15](#), [SI-19](#).

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[IR 8112\]](#).

PT-3 PERSONALLY IDENTIFIABLE INFORMATION PROCESSING PURPOSES

Control:

- a. Identify and document the [Assignment: organization-defined purpose(s)] for processing personally identifiable information;
- b. Describe the purpose(s) in the public privacy notices and policies of the organization;
- c. Restrict the [Assignment: organization-defined processing] of personally identifiable information to only that which is compatible with the identified purpose(s); and
- d. Monitor changes in processing personally identifiable information and implement [Assignment: organization-defined mechanisms] to ensure that any changes are made in accordance with [Assignment: organization-defined requirements].

Discussion: Identifying and documenting the purpose for processing provides organizations with a basis for understanding why personally identifiable information may be processed. The term “process” includes every step of the information life cycle, including creation, collection, use, processing, storage, maintenance, dissemination, disclosure, and disposal. Identifying and documenting the purpose of processing is a prerequisite to enabling owners and operators of the system and individuals whose information is processed by the system to understand how the information will be processed. This enables individuals to make informed decisions about their engagement with information systems and organizations and to manage their privacy interests. Once the specific processing purpose has been identified, the purpose is described in the organization’s privacy notices, policies, and any related privacy compliance documentation, including privacy impact assessments, system of records notices, [\[PRIVACT\]](#) statements, computer matching notices, and other applicable Federal Register notices.

Organizations take steps to help ensure that personally identifiable information is processed only for identified purposes, including training organizational personnel and monitoring and auditing organizational processing of personally identifiable information.

Organizations monitor for changes in personally identifiable information processing.

Organizational personnel consult with the senior agency official for privacy and legal counsel to ensure that any new purposes that arise from changes in processing are compatible with the purpose for which the information was collected, or if the new purpose is not compatible, implement mechanisms in accordance with defined requirements to allow for the new processing, if appropriate. Mechanisms may include obtaining consent from individuals, revising privacy policies, or other measures to manage privacy risks that arise from changes in personally identifiable information processing purposes.

Related Controls: [AC-2](#), [AC-3](#), [AT-3](#), [CM-13](#), [IR-9](#), [PM-9](#), [PM-25](#), [PT-2](#), [PT-5](#), [PT-6](#), [PT-7](#), [RA-8](#), [SC-43](#), [SI-12](#), [SI-18](#).

Control Enhancements:**(1) PERSONALLY IDENTIFIABLE INFORMATION PROCESSING PURPOSES | [DATA TAGGING](#)**

Attach data tags containing the following purposes to [Assignment: organization-defined elements of personally identifiable information]: [Assignment: organization-defined processing purposes].

Discussion: Data tags support the tracking of processing purposes by conveying the purposes along with the relevant elements of personally identifiable information throughout the system. By conveying the processing purposes in a data tag along with the personally identifiable information as the information transits a system, a system owner or operator can identify whether a change in processing would be compatible with the identified and documented purposes. Data tags may also support the use of automated tools.

Related Controls: [CA-6](#), [CM-12](#), [PM-5](#), [PM-22](#), [SC-16](#), [SC-43](#), [SI-10](#), [SI-15](#), [SI-19](#).

(2) PERSONALLY IDENTIFIABLE INFORMATION PROCESSING PURPOSES | [AUTOMATION](#)

Track processing purposes of personally identifiable information using [Assignment: organization-defined automated mechanisms].

Discussion: Automated mechanisms augment tracking of the processing purposes.

Related Controls: [CA-6](#), [CM-12](#), [PM-5](#), [PM-22](#), [SC-16](#), [SC-43](#), [SI-10](#), [SI-15](#), [SI-19](#).

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[IR 8112\]](#).

PT-4 CONSENT

Control: Implement [Assignment: organization-defined tools or mechanisms] for individuals to consent to the processing of their personally identifiable information prior to its collection that facilitate individuals' informed decision-making.

Discussion: Consent allows individuals to participate in making decisions about the processing of their information and transfers some of the risk that arises from the processing of personally identifiable information from the organization to an individual. Consent may be required by applicable laws, executive orders, directives, regulations, policies, standards, or guidelines. Otherwise, when selecting consent as a control, organizations consider whether individuals can be reasonably expected to understand and accept the privacy risks that arise from their authorization. Organizations consider whether other controls may more effectively mitigate privacy risk either alone or in conjunction with consent. Organizations also consider any demographic or contextual factors that may influence the understanding or behavior of individuals with respect to the processing carried out by the system or organization. When soliciting consent from individuals, organizations consider the appropriate mechanism for obtaining consent, including the type of consent (e.g., opt-in, opt-out), how to properly authenticate and identity proof individuals and how to obtain consent through electronic means. In addition, organizations consider providing a mechanism for individuals to revoke consent once it has been provided, as appropriate. Finally, organizations consider usability factors to help individuals understand the risks being accepted when providing consent, including the use of plain language and avoiding technical jargon.

Related Controls: [AC-16](#), [PT-2](#), [PT-5](#).

Control Enhancements:**(1) CONSENT | [TAILORED CONSENT](#)**

Provide [Assignment: organization-defined mechanisms] to allow individuals to tailor processing permissions to selected elements of personally identifiable information.

Discussion: While some processing may be necessary for the basic functionality of the product or service, other processing may not. In these circumstances, organizations allow individuals to select how specific personally identifiable information elements may be processed. More tailored consent may help reduce privacy risk, increase individual satisfaction, and avoid adverse behaviors, such as abandonment of the product or service.

Related Controls: [PT-2](#).

(2) CONSENT | [JUST-IN-TIME CONSENT](#)

Present [Assignment: organization-defined consent mechanisms] to individuals at [Assignment: organization-defined frequency] and in conjunction with [Assignment: organization-defined personally identifiable information processing].

Discussion: Just-in-time consent enables individuals to participate in how their personally identifiable information is being processed at the time or in conjunction with specific types of data processing when such participation may be most useful to the individual. Individual assumptions about how personally identifiable information is being processed might not be accurate or reliable if time has passed since the individual last gave consent or the type of processing creates significant privacy risk. Organizations use discretion to determine when to use just-in-time consent and may use supporting information on demographics, focus groups, or surveys to learn more about individuals' privacy interests and concerns.

Related Controls: [PT-2](#).

(3) CONSENT | [REVOCATION](#)

Implement [Assignment: organization-defined tools or mechanisms] for individuals to revoke consent to the processing of their personally identifiable information.

Discussion: Revocation of consent enables individuals to exercise control over their initial consent decision when circumstances change. Organizations consider usability factors in enabling easy-to-use revocation capabilities.

Related Controls: [PT-2](#).

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[SP 800-63-3\]](#).

PT-5 PRIVACY NOTICE

Control: Provide notice to individuals about the processing of personally identifiable information that:

- a. Is available to individuals upon first interacting with an organization, and subsequently at [Assignment: organization-defined frequency];
- b. Is clear and easy-to-understand, expressing information about personally identifiable information processing in plain language;
- c. Identifies the authority that authorizes the processing of personally identifiable information;
- d. Identifies the purposes for which personally identifiable information is to be processed; and
- e. Includes [Assignment: organization-defined information].

Discussion: Privacy notices help inform individuals about how their personally identifiable information is being processed by the system or organization. Organizations use privacy notices to inform individuals about how, under what authority, and for what purpose their personally identifiable information is processed, as well as other information such as choices individuals might have with respect to that processing and other parties with whom information is shared. Laws, executive orders, directives, regulations, or policies may require that privacy notices include specific elements or be provided in specific formats. Federal agency personnel consult with the senior agency official for privacy and legal counsel regarding when and where to provide

privacy notices, as well as elements to include in privacy notices and required formats. In circumstances where laws or government-wide policies do not require privacy notices, organizational policies and determinations may require privacy notices and may serve as a source of the elements to include in privacy notices.

Privacy risk assessments identify the privacy risks associated with the processing of personally identifiable information and may help organizations determine appropriate elements to include in a privacy notice to manage such risks. To help individuals understand how their information is being processed, organizations write materials in plain language and avoid technical jargon.

Related Controls: [PM-20](#), [PM-22](#), [PT-2](#), [PT-3](#), [PT-4](#), [PT-7](#), [RA-3](#), [SC-42](#), [SI-18](#).

Control Enhancements:

(1) PRIVACY NOTICE | [JUST-IN-TIME NOTICE](#)

Present notice of personally identifiable information processing to individuals at a time and location where the individual provides personally identifiable information or in conjunction with a data action, or [Assignment: organization-defined frequency].

Discussion: Just-in-time notices inform individuals of how organizations process their personally identifiable information at a time when such notices may be most useful to the individuals. Individual assumptions about how personally identifiable information will be processed might not be accurate or reliable if time has passed since the organization last presented notice or the circumstances under which the individual was last provided notice have changed. A just-in-time notice can explain data actions that organizations have identified as potentially giving rise to greater privacy risk for individuals. Organizations can use a just-in-time notice to update or remind individuals about specific data actions as they occur or highlight specific changes that occurred since last presenting notice. A just-in-time notice can be used in conjunction with just-in-time consent to explain what will occur if consent is declined. Organizations use discretion to determine when to use a just-in-time notice and may use supporting information on user demographics, focus groups, or surveys to learn about users' privacy interests and concerns.

Related Controls: [PM-21](#).

(2) PRIVACY NOTICE | [PRIVACY ACT STATEMENTS](#)

Include Privacy Act statements on forms that collect information that will be maintained in a Privacy Act system of records, or provide Privacy Act statements on separate forms that can be retained by individuals.

Discussion: If a federal agency asks individuals to supply information that will become part of a system of records, the agency is required to provide a [\[PRIVACT\]](#) statement on the form used to collect the information or on a separate form that can be retained by the individual. The agency provides a [\[PRIVACT\]](#) statement in such circumstances regardless of whether the information will be collected on a paper or electronic form, on a website, on a mobile application, over the telephone, or through some other medium. This requirement ensures that the individual is provided with sufficient information about the request for information to make an informed decision on whether or not to respond.

[\[PRIVACT\]](#) statements provide formal notice to individuals of the authority that authorizes the solicitation of the information; whether providing the information is mandatory or voluntary; the principal purpose(s) for which the information is to be used; the published routine uses to which the information is subject; the effects on the individual, if any, of not providing all or any part of the information requested; and an appropriate citation and link to the relevant system of records notice. Federal agency personnel consult with the senior agency official for privacy and legal counsel regarding the notice provisions of the [\[PRIVACT\]](#).

Related Controls: [PT-6](#).

Control Enhancements: None.

References: [[PRIVACT](#)], [[OMB A-130](#)], [[OMB A-108](#)].

PT-6 SYSTEM OF RECORDS NOTICE

Control: For systems that process information that will be maintained in a Privacy Act system of records:

- a. Draft system of records notices in accordance with OMB guidance and submit new and significantly modified system of records notices to the OMB and appropriate congressional committees for advance review;
- b. Publish system of records notices in the Federal Register; and
- c. Keep system of records notices accurate, up-to-date, and scoped in accordance with policy.

Discussion: The [[PRIVACT](#)] requires that federal agencies publish a system of records notice in the Federal Register upon the establishment and/or modification of a [[PRIVACT](#)] system of records. As a general matter, a system of records notice is required when an agency maintains a group of any records under the control of the agency from which information is retrieved by the name of an individual or by some identifying number, symbol, or other identifier. The notice describes the existence and character of the system and identifies the system of records, the purpose(s) of the system, the authority for maintenance of the records, the categories of records maintained in the system, the categories of individuals about whom records are maintained, the routine uses to which the records are subject, and additional details about the system as described in [[OMB A-108](#)].

Related Controls: [AC-3](#), [PM-20](#), [PT-2](#), [PT-3](#), [PT-5](#).

Control Enhancements:

(1) SYSTEM OF RECORDS NOTICE | [ROUTINE USES](#)

Review all routine uses published in the system of records notice at [*Assignment: organization-defined frequency*] to ensure continued accuracy, and to ensure that routine uses continue to be compatible with the purpose for which the information was collected.

Discussion: A [[PRIVACT](#)] routine use is a particular kind of disclosure of a record outside of the federal agency maintaining the system of records. A routine use is an exception to the [[PRIVACT](#)] prohibition on the disclosure of a record in a system of records without the prior written consent of the individual to whom the record pertains. To qualify as a routine use, the disclosure must be for a purpose that is compatible with the purpose for which the information was originally collected. The [[PRIVACT](#)] requires agencies to describe each routine use of the records maintained in the system of records, including the categories of users of the records and the purpose of the use. Agencies may only establish routine uses by explicitly publishing them in the relevant system of records notice.

Related Controls: None.

(2) SYSTEM OF RECORDS NOTICE | [EXEMPTION RULES](#)

Review all Privacy Act exemptions claimed for the system of records at [*Assignment: organization-defined frequency*] to ensure they remain appropriate and necessary in accordance with law, that they have been promulgated as regulations, and that they are accurately described in the system of records notice.

Discussion: The [[PRIVACT](#)] includes two sets of provisions that allow federal agencies to claim exemptions from certain requirements in the statute. In certain circumstances, these provisions allow agencies to promulgate regulations to exempt a system of records from select provisions of the [[PRIVACT](#)]. At a minimum, organizations' [[PRIVACT](#)] exemption

regulations include the specific name(s) of any system(s) of records that will be exempt, the specific provisions of the [PRIVACT] from which the system(s) of records is to be exempted, the reasons for the exemption, and an explanation for why the exemption is both necessary and appropriate.

Related Controls: None.

References: [PRIVACT], [OMB A-108].

PT-7 SPECIFIC CATEGORIES OF PERSONALLY IDENTIFIABLE INFORMATION

Control: Apply [Assignment: organization-defined processing conditions] for specific categories of personally identifiable information.

Discussion: Organizations apply any conditions or protections that may be necessary for specific categories of personally identifiable information. These conditions may be required by laws, executive orders, directives, regulations, policies, standards, or guidelines. The requirements may also come from the results of privacy risk assessments that factor in contextual changes that may result in an organizational determination that a particular category of personally identifiable information is particularly sensitive or raises particular privacy risks. Organizations consult with the senior agency official for privacy and legal counsel regarding any protections that may be necessary.

Related Controls: IR-9, PT-2, PT-3, RA-3.

Control Enhancements:

(1) SPECIFIC CATEGORIES OF PERSONALLY IDENTIFIABLE INFORMATION | SOCIAL SECURITY NUMBERS

When a system processes Social Security numbers:

- (a) Eliminate unnecessary collection, maintenance, and use of Social Security numbers, and explore alternatives to their use as a personal identifier;
- (b) Do not deny any individual any right, benefit, or privilege provided by law because of such individual's refusal to disclose his or her Social Security number; and
- (c) Inform any individual who is asked to disclose his or her Social Security number whether that disclosure is mandatory or voluntary, by what statutory or other authority such number is solicited, and what uses will be made of it.

Discussion: Federal law and policy establish specific requirements for organizations' processing of Social Security numbers. Organizations take steps to eliminate unnecessary uses of Social Security numbers and other sensitive information and observe any particular requirements that apply.

Related Controls: IA-4.

(2) SPECIFIC CATEGORIES OF PERSONALLY IDENTIFIABLE INFORMATION | FIRST AMENDMENT INFORMATION

Prohibit the processing of information describing how any individual exercises rights guaranteed by the First Amendment unless expressly authorized by statute or by the individual or unless pertinent to and within the scope of an authorized law enforcement activity.

Discussion: The [PRIVACT] limits agencies' ability to process information that describes how individuals exercise rights guaranteed by the First Amendment. Organizations consult with the senior agency official for privacy and legal counsel regarding these requirements.

Related Controls: None.

References: [PRIVACT], [OMB A-130], [OMB A-108], [NARA CUI].

PT-8 COMPUTER MATCHING REQUIREMENTS

Control: When a system or organization processes information for the purpose of conducting a matching program:

- a. Obtain approval from the Data Integrity Board to conduct the matching program;
- b. Develop and enter into a computer matching agreement;
- c. Publish a matching notice in the Federal Register;
- d. Independently verify the information produced by the matching program before taking adverse action against an individual, if required; and
- e. Provide individuals with notice and an opportunity to contest the findings before taking adverse action against an individual.

Discussion: The [\[PRIVACT\]](#) establishes requirements for federal and non-federal agencies if they engage in a matching program. In general, a matching program is a computerized comparison of records from two or more automated [\[PRIVACT\]](#) systems of records or an automated system of records and automated records maintained by a non-federal agency (or agent thereof). A matching program either pertains to federal benefit programs or federal personnel or payroll records. A federal benefit match is performed to determine or verify eligibility for payments under federal benefit programs or to recoup payments or delinquent debts under federal benefit programs. A matching program involves not just the matching activity itself but also the investigative follow-up and ultimate action, if any.

Related Controls: [PM-24](#).

Control Enhancements: None.

References: [\[PRIVACT\]](#), [\[CMPPA\]](#), [\[OMB A-130\]](#), [\[OMB A-108\]](#).

3.16 RISK ASSESSMENT

[Quick link to Risk Assessment Summary Table](#)

RA-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] risk assessment policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the risk assessment policy and the associated risk assessment controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the risk assessment policy and procedures; and
- c. Review and update the current risk assessment:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Risk assessment policy and procedures address the controls in the RA family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of risk assessment policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies reflecting the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to risk assessment policy and procedures include assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#).

RA-2 SECURITY CATEGORIZATION

Control:

- a. Categorize the system and information it processes, stores, and transmits;
- b. Document the security categorization results, including supporting rationale, in the security plan for the system; and
- c. Verify that the authorizing official or authorizing official designated representative reviews and approves the security categorization decision.

Discussion: Security categories describe the potential adverse impacts or negative consequences to organizational operations, organizational assets, and individuals if organizational information and systems are compromised through a loss of confidentiality, integrity, or availability. Security categorization is also a type of asset loss characterization in systems security engineering processes that is carried out throughout the system development life cycle. Organizations can use privacy risk assessments or privacy impact assessments to better understand the potential adverse effects on individuals. [CNSSI 1253] provides additional guidance on categorization for national security systems.

Organizations conduct the security categorization process as an organization-wide activity with the direct involvement of chief information officers, senior agency information security officers, senior agency officials for privacy, system owners, mission and business owners, and information owners or stewards. Organizations consider the potential adverse impacts to other organizations and, in accordance with [USA PATRIOT] and Homeland Security Presidential Directives, potential national-level adverse impacts.

Security categorization processes facilitate the development of inventories of information assets and, along with CM-8, mappings to specific system components where information is processed, stored, or transmitted. The security categorization process is revisited throughout the system development life cycle to ensure that the security categories remain accurate and relevant.

Related Controls: [CM-8](#), [MP-4](#), [PL-2](#), [PL-10](#), [PL-11](#), [PM-7](#), [RA-3](#), [RA-5](#), [RA-7](#), [RA-8](#), [SA-8](#), [SC-7](#), [SC-38](#), [SI-12](#).

Control Enhancements:

(1) SECURITY CATEGORIZATION | [IMPACT-LEVEL PRIORITIZATION](#)

Conduct an impact-level prioritization of organizational systems to obtain additional granularity on system impact levels.

Discussion: Organizations apply the “high-water mark” concept to each system categorized in accordance with [FIPS 199], resulting in systems designated as low impact, moderate impact, or high impact. Organizations that desire additional granularity in the system impact designations for risk-based decision-making, can further partition the systems into sub-categories of the initial system categorization. For example, an impact-level prioritization on a moderate-impact system can produce three new sub-categories: low-moderate systems, moderate-moderate systems, and high-moderate systems. Impact-level prioritization and the resulting sub-categories of the system give organizations an opportunity to focus their investments related to security control selection and the tailoring of control baselines in responding to identified risks. Impact-level prioritization can also be used to determine those systems that may be of heightened interest or value to adversaries or represent a critical loss to the federal enterprise, sometimes described as high value assets. For such high value assets, organizations may be more focused on complexity, aggregation, and information exchanges. Systems with high value assets can be prioritized by partitioning high-impact systems into low-high systems, moderate-high systems, and high-high systems.

Alternatively, organizations can apply the guidance in [CNSSI 1253] for security objective-related categorization.

Related Controls: None.

References: [[FIPS 199](#)], [[FIPS 200](#)], [[SP 800-30](#)], [[SP 800-37](#)], [[SP 800-39](#)], [[SP 800-60-1](#)], [[SP 800-60-2](#)], [[SP 800-160-1](#)], [[CNSSI 1253](#)], [[NARA CUI](#)].

RA-3 RISK ASSESSMENT

Control:

- a. Conduct a risk assessment, including:
 1. Identifying threats to and vulnerabilities in the system;
 2. Determining the likelihood and magnitude of harm from unauthorized access, use, disclosure, disruption, modification, or destruction of the system, the information it processes, stores, or transmits, and any related information; and
 3. Determining the likelihood and impact of adverse effects on individuals arising from the processing of personally identifiable information;
- b. Integrate risk assessment results and risk management decisions from the organization and mission or business process perspectives with system-level risk assessments;
- c. Document risk assessment results in [*Selection: security and privacy plans; risk assessment report; Assignment: organization-defined document*]];
- d. Review risk assessment results [*Assignment: organization-defined frequency*];
- e. Disseminate risk assessment results to [*Assignment: organization-defined personnel or roles*]; and
- f. Update the risk assessment [*Assignment: organization-defined frequency*] or when there are significant changes to the system, its environment of operation, or other conditions that may impact the security or privacy state of the system.

Discussion: Risk assessments consider threats, vulnerabilities, likelihood, and impact to organizational operations and assets, individuals, other organizations, and the Nation. Risk assessments also consider risk from external parties, including contractors who operate systems on behalf of the organization, individuals who access organizational systems, service providers, and outsourcing entities.

Organizations can conduct risk assessments at all three levels in the risk management hierarchy (i.e., organization level, mission/business process level, or information system level) and at any stage in the system development life cycle. Risk assessments can also be conducted at various steps in the Risk Management Framework, including preparation, categorization, control selection, control implementation, control assessment, authorization, and control monitoring. Risk assessment is an ongoing activity carried out throughout the system development life cycle.

Risk assessments can also address information related to the system, including system design, the intended use of the system, testing results, and supply chain-related information or artifacts. Risk assessments can play an important role in control selection processes, particularly during the application of tailoring guidance and in the earliest phases of capability determination.

Related Controls: [CA-3](#), [CA-6](#), [CM-4](#), [CM-13](#), [CP-6](#), [CP-7](#), [IA-8](#), [MA-5](#), [PE-3](#), [PE-8](#), [PE-18](#), [PL-2](#), [PL-10](#), [PL-11](#), [PM-8](#), [PM-9](#), [PM-28](#), [PT-2](#), [PT-7](#), [RA-2](#), [RA-5](#), [RA-7](#), [SA-8](#), [SA-9](#), [SC-38](#), [SI-12](#).

Control Enhancements:

(1) RISK ASSESSMENT | [SUPPLY CHAIN RISK ASSESSMENT](#)

- (a) Assess supply chain risks associated with [Assignment: organization-defined systems, system components, and system services]; and
- (b) Update the supply chain risk assessment [Assignment: organization-defined frequency], when there are significant changes to the relevant supply chain, or when changes to the system, environments of operation, or other conditions may necessitate a change in the supply chain.

Discussion: Supply chain-related 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 the confidentiality, integrity, or availability of a system and its information and, therefore, can also adversely impact organizational operations (including 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.

Related Controls: [RA-2](#), [RA-9](#), [PM-17](#), [PM-30](#), [SR-2](#).

(2) RISK ASSESSMENT | [USE OF ALL-SOURCE INTELLIGENCE](#)

Use all-source intelligence to assist in the analysis of risk.

Discussion: Organizations employ all-source intelligence to inform engineering, acquisition, and risk management decisions. All-source intelligence consists of information derived from all available sources, including publicly available or open-source information, measurement and signature intelligence, human intelligence, signals intelligence, and imagery intelligence. All-source intelligence is used to analyze the risk of vulnerabilities (both intentional and unintentional) from development, manufacturing, and delivery processes, people, and the environment. The risk analysis may be performed on suppliers at multiple tiers in the supply chain sufficient to manage risks. Organizations may develop agreements to share all-source intelligence information or resulting decisions with other organizations, as appropriate.

Related Controls: None.

(3) RISK ASSESSMENT | [DYNAMIC THREAT AWARENESS](#)

Determine the current cyber threat environment on an ongoing basis using [Assignment: organization-defined means].

Discussion: The threat awareness information that is gathered feeds into the organization's information security operations to ensure that procedures are updated in response to the changing threat environment. For example, at higher threat levels, organizations may change the privilege or authentication thresholds required to perform certain operations.

Related Controls: [AT-2](#).

(4) RISK ASSESSMENT | [PREDICTIVE CYBER ANALYTICS](#)

Employ the following advanced automation and analytics capabilities to predict and identify risks to [Assignment: organization-defined systems or system components]; [Assignment: organization-defined advanced automation and analytics capabilities].

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 analytics capabilities are typically supported by artificial intelligence concepts, including machine learning. Examples include Automated Threat Discovery and Response (which includes broad-based collection, context-based analysis, and adaptive response capabilities), automated workflow operations, 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 ensure that sophisticated adversaries are not able to conceal their activities.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-161\]](#), [\[IR 8023\]](#), [\[IR 8062\]](#), [\[IR 8272\]](#).

RA-4 RISK ASSESSMENT UPDATE

[Withdrawn: Incorporated into [RA-3](#).]

RA-5 VULNERABILITY MONITORING AND SCANNING

Control:

- a. Monitor and scan for vulnerabilities in the system and hosted applications [*Assignment: organization-defined frequency and/or randomly in accordance with organization-defined process*] and when new vulnerabilities potentially affecting the system are identified and reported;
- b. Employ vulnerability monitoring tools and techniques that facilitate interoperability among tools and automate parts of the vulnerability management process by using standards for:
 1. Enumerating platforms, software flaws, and improper configurations;
 2. Formatting checklists and test procedures; and
 3. Measuring vulnerability impact;
- c. Analyze vulnerability scan reports and results from vulnerability monitoring;
- d. Remediate legitimate vulnerabilities [*Assignment: organization-defined response times*] in accordance with an organizational assessment of risk;
- e. Share information obtained from the vulnerability monitoring process and control assessments with [*Assignment: organization-defined personnel or roles*] to help eliminate similar vulnerabilities in other systems; and
- f. Employ vulnerability monitoring tools that include the capability to readily update the vulnerabilities to be scanned.

Discussion: Security categorization of information and systems guides the frequency and comprehensiveness of vulnerability monitoring (including scans). Organizations determine the required vulnerability monitoring for system components, ensuring that the potential sources of vulnerabilities—such as infrastructure components (e.g., switches, routers, guards, sensors), networked printers, scanners, and copiers—are not overlooked. The capability to readily update vulnerability monitoring tools as new vulnerabilities are discovered and announced and as new scanning methods are developed helps to ensure that new vulnerabilities are not missed by employed vulnerability monitoring tools. The vulnerability monitoring tool update process helps to ensure that potential vulnerabilities in the system are identified and addressed as quickly as possible. Vulnerability monitoring and analyses for custom software may require additional approaches, such as static analysis, dynamic analysis, binary analysis, or a hybrid of the three approaches. Organizations can use these analysis approaches in source code reviews and in a variety of tools, including web-based application scanners, static analysis tools, and binary analyzers.

Vulnerability monitoring includes scanning for patch levels; scanning for functions, ports, protocols, and services that should not be accessible to users or devices; and scanning for flow control mechanisms that are improperly configured or operating incorrectly. Vulnerability

monitoring may also include continuous vulnerability monitoring tools that use instrumentation to continuously analyze components. Instrumentation-based tools may improve accuracy and may be run throughout an organization without scanning. Vulnerability monitoring tools that facilitate interoperability include tools that are Security Content Automated Protocol (SCAP)-validated. Thus, organizations consider using scanning tools that express vulnerabilities in the Common Vulnerabilities and Exposures (CVE) naming convention and that employ the Open Vulnerability Assessment Language (OVAL) to determine the presence of vulnerabilities. Sources for vulnerability information include the Common Weakness Enumeration (CWE) listing and the National Vulnerability Database (NVD). Control assessments, such as red team exercises, provide additional sources of potential vulnerabilities for which to scan. Organizations also consider using scanning tools that express vulnerability impact by the Common Vulnerability Scoring System (CVSS).

Vulnerability monitoring includes a channel and process for receiving reports of security vulnerabilities from the public at-large. Vulnerability disclosure programs can be as simple as publishing a monitored email address or web form that can receive reports, including notification authorizing good-faith research and disclosure of security vulnerabilities. Organizations generally expect that such research is happening with or without their authorization and can use public vulnerability disclosure channels to increase the likelihood that discovered vulnerabilities are reported directly to the organization for remediation.

Organizations may also employ the use of financial incentives (also known as “bug bounties”) to further encourage external security researchers to report discovered vulnerabilities. Bug bounty programs can be tailored to the organization’s needs. Bounties can be operated indefinitely or over a defined period of time and can be offered to the general public or to a curated group. Organizations may run public and private bounties simultaneously and could choose to offer partially credentialled access to certain participants in order to evaluate security vulnerabilities from privileged vantage points.

Related Controls: [CA-2](#), [CA-7](#), [CA-8](#), [CM-2](#), [CM-4](#), [CM-6](#), [CM-8](#), [RA-2](#), [RA-3](#), [SA-11](#), [SA-15](#), [SC-38](#), [SI-2](#), [SI-3](#), [SI-4](#), [SI-7](#), [SR-11](#).

Control Enhancements:

(1) VULNERABILITY MONITORING AND SCANNING | UPDATE TOOL CAPABILITY

[Withdrawn: Incorporated into [RA-5](#).]

(2) VULNERABILITY MONITORING AND SCANNING | [UPDATE VULNERABILITIES TO BE SCANNED](#)

Update the system vulnerabilities to be scanned [Selection (one or more): [Assignment: organization-defined frequency]; prior to a new scan; when new vulnerabilities are identified and reported].

Discussion: Due to the complexity of modern software, systems, and other factors, new vulnerabilities are discovered on a regular basis. It is important that newly discovered vulnerabilities are added to the list of vulnerabilities to be scanned to ensure that the organization can take steps to mitigate those vulnerabilities in a timely manner.

Related Controls: [SI-5](#).

(3) VULNERABILITY MONITORING AND SCANNING | [BREADTH AND DEPTH OF COVERAGE](#)

Define the breadth and depth of vulnerability scanning coverage.

Discussion: The breadth of vulnerability scanning coverage can be expressed as a percentage of components within the system, by the particular types of systems, by the criticality of systems, or by the number of vulnerabilities to be checked. Conversely, the depth of vulnerability scanning coverage can be expressed as the level of the system design that the organization intends to monitor (e.g., component, module, subsystem, element).

Organizations can determine the sufficiency of vulnerability scanning coverage with regard to its risk tolerance and other factors. Scanning tools and how the tools are configured may affect the depth and coverage. Multiple scanning tools may be needed to achieve the desired depth and coverage. [SP 800-53A] provides additional information on the breadth and depth of coverage.

Related Controls: None.

(4) VULNERABILITY MONITORING AND SCANNING | [DISCOVERABLE INFORMATION](#)

Determine information about the system that is discoverable and take [Assignment: organization-defined corrective actions].

Discussion: Discoverable information includes information that adversaries could obtain without compromising or breaching the system, such as by collecting information that the system is exposing or by conducting extensive web searches. Corrective actions include notifying appropriate organizational personnel, removing designated information, or changing the system to make the designated information less relevant or attractive to adversaries. This enhancement excludes intentionally discoverable information that may be part of a decoy capability (e.g., honeypots, honeynets, or deception nets) deployed by the organization.

Related Controls: [AU-13](#), [SC-26](#).

(5) VULNERABILITY MONITORING AND SCANNING | [PRIVILEGED ACCESS](#)

Implement privileged access authorization to [Assignment: organization-defined system components] for [Assignment: organization-defined vulnerability scanning activities].

Discussion: In certain situations, the nature of the vulnerability scanning may be more intrusive, or the system component that is the subject of the scanning may contain classified or controlled unclassified information, such as personally identifiable information. Privileged access authorization to selected system components facilitates more thorough vulnerability scanning and protects the sensitive nature of such scanning.

Related Controls: None.

(6) VULNERABILITY MONITORING AND SCANNING | [AUTOMATED TREND ANALYSES](#)

Compare the results of multiple vulnerability scans using [Assignment: organization-defined automated mechanisms].

Discussion: Using automated mechanisms to analyze multiple vulnerability scans over time can help determine trends in system vulnerabilities and identify patterns of attack.

Related Controls: None.

(7) VULNERABILITY MONITORING AND SCANNING | AUTOMATED DETECTION AND NOTIFICATION OF UNAUTHORIZED COMPONENTS

[Withdrawn: Incorporated into [CM-8](#).]

(8) VULNERABILITY MONITORING AND SCANNING | [REVIEW HISTORIC AUDIT LOGS](#)

Review historic audit logs to determine if a vulnerability identified in a [Assignment: organization-defined system] has been previously exploited within an [Assignment: organization-defined time period].

Discussion: Reviewing historic audit logs to determine if a recently detected vulnerability in a system has been previously exploited by an adversary can provide important information for forensic analyses. Such analyses can help identify, for example, the extent of a previous intrusion, the trade craft employed during the attack, organizational information exfiltrated or modified, mission or business capabilities affected, and the duration of the attack.

Related Controls: [AU-6](#), [AU-11](#).

(9) VULNERABILITY MONITORING AND SCANNING | PENETRATION TESTING AND ANALYSES

[Withdrawn: Incorporated into [CA-8](#).]

(10) VULNERABILITY MONITORING AND SCANNING | [CORRELATE SCANNING INFORMATION](#)

Correlate the output from vulnerability scanning tools to determine the presence of multi-vulnerability and multi-hop attack vectors.

Discussion: An attack vector is a path or means by which an adversary can gain access to a system in order to deliver malicious code or exfiltrate information. Organizations can use attack trees to show how hostile activities by adversaries interact and combine to produce adverse impacts or negative consequences to systems and organizations. Such information, together with correlated data from vulnerability scanning tools, can provide greater clarity regarding multi-vulnerability and multi-hop attack vectors. The correlation of vulnerability scanning information is especially important when organizations are transitioning from older technologies to newer technologies (e.g., transitioning from IPv4 to IPv6 network protocols). During such transitions, some system components may inadvertently be unmanaged and create opportunities for adversary exploitation.

Related Controls: None.

(11) VULNERABILITY MONITORING AND SCANNING | [PUBLIC DISCLOSURE PROGRAM](#)

Establish a public reporting channel for receiving reports of vulnerabilities in organizational systems and system components.

Discussion: The reporting channel is publicly discoverable and contains clear language authorizing good-faith research and the disclosure of vulnerabilities to the organization. The organization does not condition its authorization on an expectation of indefinite non-disclosure to the public by the reporting entity but may request a specific time period to properly remediate the vulnerability.

Related Controls: None.

References: [\[ISO 29147\]](#), [\[SP 800-40\]](#), [\[SP 800-53A\]](#), [\[SP 800-70\]](#), [\[SP 800-115\]](#), [\[SP 800-126\]](#), [\[IR 7788\]](#), [\[IR 8011-4\]](#), [\[IR 8023\]](#).

RA-6 TECHNICAL SURVEILLANCE COUNTERMEASURES SURVEY

Control: Employ a technical surveillance countermeasures survey at [Assignment: organization-defined locations] [Selection (one or more): [Assignment: organization-defined frequency]; when the following events or indicators occur: [Assignment: organization-defined events or indicators]].

Discussion: A technical surveillance countermeasures survey is a service provided by qualified personnel to detect the presence of technical surveillance devices and hazards and to identify technical security weaknesses that could be used in the conduct of a technical penetration of the surveyed facility. Technical surveillance countermeasures surveys also provide evaluations of the technical security posture of organizations and facilities and include visual, electronic, and physical examinations of surveyed facilities, internally and externally. The surveys also provide useful input for risk assessments and information regarding organizational exposure to potential adversaries.

Related Controls: None.

Control Enhancements: None.

References: None.

RA-7 RISK RESPONSE

Control: Respond to findings from security and privacy assessments, monitoring, and audits in accordance with organizational risk tolerance.

Discussion: Organizations have many options for responding to risk including mitigating risk by implementing new controls or strengthening existing controls, accepting risk with appropriate justification or rationale, sharing or transferring risk, or avoiding risk. The risk tolerance of the organization influences risk response decisions and actions. Risk response addresses the need to determine an appropriate response to risk before generating a plan of action and milestones entry. For example, the response may be to accept risk or reject risk, or it may be possible to mitigate the risk immediately so that a plan of action and milestones entry is not needed.

However, if the risk response is to mitigate the risk, and the mitigation cannot be completed immediately, a plan of action and milestones entry is generated.

Related Controls: [CA-5](#), [IR-9](#), [PM-4](#), [PM-28](#), [RA-2](#), [RA-3](#), [SR-2](#).

Control Enhancements: None.

References: [\[FIPS 199\]](#), [\[FIPS 200\]](#), [\[SP 800-30\]](#), [\[SP 800-37\]](#), [\[SP 800-39\]](#), [\[SP 800-160-1\]](#).

RA-8 PRIVACY IMPACT ASSESSMENTS

Control: Conduct privacy impact assessments for systems, programs, or other activities before:

- a. Developing or procuring information technology that processes personally identifiable information; and
- b. Initiating a new collection of personally identifiable information that:
 1. Will be processed using information technology; and
 2. Includes personally identifiable information permitting the physical or virtual (online) contacting of a specific individual, if identical questions have been posed to, or identical reporting requirements imposed on, ten or more individuals, other than agencies, instrumentalities, or employees of the federal government.

Discussion: A privacy impact assessment is an analysis of how personally identifiable information is handled to ensure that handling conforms to applicable privacy requirements, determine the privacy risks associated with an information system or activity, and evaluate ways to mitigate privacy risks. A privacy impact assessment is both an analysis and a formal document that details the process and the outcome of the analysis.

Organizations conduct and develop a privacy impact assessment with sufficient clarity and specificity to demonstrate that the organization fully considered privacy and incorporated appropriate privacy protections from the earliest stages of the organization's activity and throughout the information life cycle. In order to conduct a meaningful privacy impact assessment, the organization's senior agency official for privacy works closely with program managers, system owners, information technology experts, security officials, counsel, and other relevant organization personnel. Moreover, a privacy impact assessment is not a time-restricted activity that is limited to a particular milestone or stage of the information system or personally identifiable information life cycles. Rather, the privacy analysis continues throughout the system and personally identifiable information life cycles. Accordingly, a privacy impact assessment is a living document that organizations update whenever changes to the information technology, changes to the organization's practices, or other factors alter the privacy risks associated with the use of such information technology.

To conduct the privacy impact assessment, organizations can use security and privacy risk assessments. Organizations may also use other related processes that may have different names,

including privacy threshold analyses. A privacy impact assessment can also serve as notice to the public regarding the organization's practices with respect to privacy. Although conducting and publishing privacy impact assessments may be required by law, organizations may develop such policies in the absence of applicable laws. For federal agencies, privacy impact assessments may be required by [EGOV]; agencies should consult with their senior agency official for privacy and legal counsel on this requirement and be aware of the statutory exceptions and OMB guidance relating to the provision.

Related Controls: [CM-4](#), [CM-9](#), [CM-13](#), [PT-2](#), [PT-3](#), [PT-5](#), [RA-1](#), [RA-2](#), [RA-3](#), [RA-7](#).

Control Enhancements: None.

References: [\[EGOV\]](#), [\[OMB A-130\]](#), [\[OMB M-03-22\]](#).

RA-9 CRITICALITY ANALYSIS

Control: Identify critical system components and functions by performing a criticality analysis for [*Assignment: organization-defined systems, system components, or system services*] at [*Assignment: organization-defined decision points in the system development life cycle*].

Discussion: Not all system components, functions, or services necessarily require significant protections. For example, criticality analysis is a key tenet of supply chain risk management and informs the prioritization of protection activities. The identification of critical system components and functions considers applicable laws, executive orders, regulations, directives, policies, standards, system functionality requirements, system and component interfaces, and system and component dependencies. Systems engineers conduct a functional decomposition of a system to identify mission-critical functions and components. The functional decomposition includes the identification of organizational missions supported by the system, decomposition into the specific functions to perform those missions, and traceability to the hardware, software, and firmware components that implement those functions, including when the functions are shared by many components within and external to the system.

The operational environment of a system or a system component may impact the criticality, including the connections to and dependencies on cyber-physical systems, devices, system-of-systems, and outsourced IT services. System components that allow unmediated access to critical system components or functions are considered critical due to the inherent vulnerabilities that such components create. Component and function criticality are assessed in terms of the impact of a component or function failure on the organizational missions that are supported by the system that contains the components and functions.

Criticality analysis is performed when an architecture or design is being developed, modified, or upgraded. If such analysis is performed early in the system development life cycle, organizations may be able to modify the system design to reduce the critical nature of these components and functions, such as by adding redundancy or alternate paths into the system design. Criticality analysis can also influence the protection measures required by development contractors. In addition to criticality analysis for systems, system components, and system services, criticality analysis of information is an important consideration. Such analysis is conducted as part of security categorization in [RA-2](#).

Related Controls: [CP-2](#), [PL-2](#), [PL-8](#), [PL-11](#), [PM-1](#), [PM-11](#), [RA-2](#), [SA-8](#), [SA-15](#), [SA-20](#), [SR-5](#).

Control Enhancements: None.

References: [\[IR 8179\]](#).

RA-10 THREAT HUNTING

Control:

- a. Establish and maintain a cyber threat hunting capability to:
 1. Search for indicators of compromise in organizational systems; and
 2. Detect, track, and disrupt threats that evade existing controls; and
- b. Employ the threat hunting capability [*Assignment: organization-defined frequency*].

Discussion: Threat hunting is an active means of cyber defense in contrast to traditional protection measures, such as firewalls, intrusion detection and prevention systems, quarantining malicious code in sandboxes, and Security Information and Event Management 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. Indications of compromise include unusual network traffic, unusual file changes, and the presence of malicious code. Threat hunting teams leverage existing threat intelligence and may create new threat intelligence, which is shared with peer organizations, Information Sharing and Analysis Organizations (ISAO), Information Sharing and Analysis Centers (ISAC), and relevant government departments and agencies.

Related Controls: [CA-2](#), [CA-7](#), [CA-8](#), [RA-3](#), [RA-5](#), [RA-6](#), [SI-4](#).

Control Enhancements: None.

References: [\[SP 800-30\]](#).

3.17 SYSTEM AND SERVICES ACQUISITION

[Quick link to System and Services Acquisition Summary Table](#)

SA-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] system and services acquisition policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the system and services acquisition policy and the associated system and services acquisition controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the system and services acquisition policy and procedures; and
- c. Review and update the current system and services acquisition:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: System and services acquisition policy and procedures address the controls in the SA family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of system and services acquisition policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to system and services acquisition policy and procedures include assessment or audit findings, security incidents or breaches, or changes in laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SA-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#), [\[SP 800-160-1\]](#).

SA-2 ALLOCATION OF RESOURCES

Control:

- a. Determine the high-level information security and privacy requirements for the system or system service in mission and business process planning;
- b. Determine, document, and allocate the resources required to protect the system or system service as part of the organizational capital planning and investment control process; and
- c. Establish a discrete line item for information security and privacy in organizational programming and budgeting documentation.

Discussion: Resource allocation for information security and privacy includes funding for system and services acquisition, sustainment, and supply chain-related risks throughout the system development life cycle.

Related Controls: [PL-7](#), [PM-3](#), [PM-11](#), [SA-9](#), [SR-3](#), [SR-5](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-37\]](#), [\[SP 800-160-1\]](#).

SA-3 SYSTEM DEVELOPMENT LIFE CYCLE

Control:

- a. Acquire, develop, and manage the system using [*Assignment: organization-defined system development life cycle*] that incorporates information security and privacy considerations;
- b. Define and document information security and privacy roles and responsibilities throughout the system development life cycle;
- c. Identify individuals having information security and privacy roles and responsibilities; and
- d. Integrate the organizational information security and privacy risk management process into system development life cycle activities.

Discussion: A system development life cycle process provides the foundation for the successful development, implementation, and operation of organizational systems. The integration of security and privacy considerations early in the system development life cycle is a foundational principle of systems security engineering and privacy engineering. To apply the required controls within the system development life cycle requires a basic understanding of information security and privacy, threats, vulnerabilities, adverse impacts, and risk to critical mission and business functions. The security engineering principles in [SA-8](#) help individuals properly design, code, and test systems and system components. Organizations include qualified personnel (e.g., senior agency information security officers, senior agency officials for privacy, security and privacy architects, and security and privacy engineers) in system development life cycle processes to ensure that established security and privacy requirements are incorporated into organizational systems. Role-based security and privacy training programs can ensure that individuals with key security and privacy roles and responsibilities have the experience, skills, and expertise to conduct assigned system development life cycle activities.

The effective integration of security and privacy requirements into enterprise architecture also helps to ensure that important security and privacy considerations are addressed throughout the system life cycle and that those considerations are directly related to organizational mission and business processes. This process also facilitates the integration of the information security and privacy architectures into the enterprise architecture, consistent with the risk management strategy of the organization. Because the system development life cycle involves multiple organizations, (e.g., external suppliers, developers, integrators, service providers), acquisition

and supply chain risk management functions and controls play significant roles in the effective management of the system during the life cycle.

Related Controls: [AT-3](#), [PL-8](#), [PM-7](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-11](#), [SA-15](#), [SA-17](#), [SA-22](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-9](#).

Control Enhancements:

(1) SYSTEM DEVELOPMENT LIFE CYCLE | [MANAGE PREPRODUCTION ENVIRONMENT](#)

Protect system preproduction environments commensurate with risk throughout the system development life cycle for the system, system component, or system service.

Discussion: The preproduction environment includes development, test, and integration environments. The program protection planning processes established by the Department of Defense are examples of managing the preproduction environment for defense contractors. Criticality analysis and the application of controls on developers also contribute to a more secure system development environment.

Related Controls: [CM-2](#), [CM-4](#), [RA-3](#), [RA-9](#), [SA-4](#).

(2) SYSTEM DEVELOPMENT LIFE CYCLE | [USE OF LIVE OR OPERATIONAL DATA](#)

- (a) Approve, document, and control the use of live data in preproduction environments for the system, system component, or system service; and**
- (b) Protect preproduction environments for the system, system component, or system service at the same impact or classification level as any live data in use within the preproduction environments.**

Discussion: Live data is also referred to as operational data. The use of live or operational data in preproduction (i.e., development, test, and integration) environments can result in significant risks to organizations. In addition, the use of personally identifiable information in testing, research, and training increases the risk of unauthorized disclosure or misuse of such information. Therefore, it is important for the organization to manage any additional risks that may result from the use of live or operational data. Organizations can minimize such risks by using test or dummy data during the design, development, and testing of systems, system components, and system services. Risk assessment techniques may be used to determine if the risk of using live or operational data is acceptable.

Related Controls: [PM-25](#), [RA-3](#).

(3) SYSTEM DEVELOPMENT LIFE CYCLE | [TECHNOLOGY REFRESH](#)

Plan for and implement a technology refresh schedule for the system throughout the system development life cycle.

Discussion: Technology refresh planning may encompass hardware, software, firmware, processes, personnel skill sets, suppliers, service providers, and facilities. The use of obsolete or nearing obsolete technology may increase the security and privacy risks associated with unsupported components, counterfeit or repurposed components, components unable to implement security or privacy requirements, slow or inoperable components, components from untrusted sources, inadvertent personnel error, or increased complexity. Technology refreshes typically occur during the operations and maintenance stage of the system development life cycle.

Related Controls: [MA-6](#).

References: [\[OMB A-130\]](#), [\[SP 800-30\]](#), [\[SP 800-37\]](#), [\[SP 800-160-1\]](#), [\[SP 800-171\]](#), [\[SP 800-172\]](#).

SA-4 ACQUISITION PROCESS

Control: Include the following requirements, descriptions, and criteria, explicitly or by reference, using [*Selection (one or more): standardized contract language; Assignment: organization-defined contract language*] in the acquisition contract for the system, system component, or system service:

- a. Security and privacy functional requirements;
- b. Strength of mechanism requirements;
- c. Security and privacy assurance requirements;
- d. Controls needed to satisfy the security and privacy requirements.
- e. Security and privacy documentation requirements;
- f. Requirements for protecting security and privacy documentation;
- g. Description of the system development environment and environment in which the system is intended to operate;
- h. Allocation of responsibility or identification of parties responsible for information security, privacy, and supply chain risk management; and
- i. Acceptance criteria.

Discussion: Security and privacy functional requirements are typically derived from the high-level security and privacy requirements described in [SA-2](#). The derived requirements include security and privacy capabilities, functions, and mechanisms. Strength requirements associated with such capabilities, functions, and mechanisms include degree of correctness, completeness, resistance to tampering or bypass, and resistance to direct attack. Assurance requirements include development processes, procedures, and methodologies as well as the evidence from development and assessment activities that provide grounds for confidence that the required functionality is implemented and possesses the required strength of mechanism. [[SP 800-160-1](#)] describes the process of requirements engineering as part of the system development life cycle.

Controls can be viewed as descriptions of the safeguards and protection capabilities appropriate for achieving the particular security and privacy objectives of the organization and for reflecting the security and privacy requirements of stakeholders. Controls are selected and implemented in order to satisfy system requirements and include developer and organizational responsibilities. Controls can include technical, administrative, and physical aspects. In some cases, the selection and implementation of a control may necessitate additional specification by the organization in the form of derived requirements or instantiated control parameter values. The derived requirements and control parameter values may be necessary to provide the appropriate level of implementation detail for controls within the system development life cycle.

Security and privacy documentation requirements address all stages of the system development life cycle. Documentation provides user and administrator guidance for the implementation and operation of controls. The level of detail required in such documentation is based on the security categorization or classification level of the system and the degree to which organizations depend on the capabilities, functions, or mechanisms to meet risk response expectations. Requirements can include mandated configuration settings that specify allowed functions, ports, protocols, and services. Acceptance criteria for systems, system components, and system services are defined in the same manner as the criteria for any organizational acquisition or procurement.

Related Controls: [CM-6](#), [CM-8](#), [PS-7](#), [SA-3](#), [SA-5](#), [SA-8](#), [SA-11](#), [SA-15](#), [SA-16](#), [SA-17](#), [SA-21](#), [SR-3](#), [SR-5](#).

Control Enhancements:

(1) ACQUISITION PROCESS | [FUNCTIONAL PROPERTIES OF CONTROLS](#)

Require the developer of the system, system component, or system service to provide a description of the functional properties of the controls to be implemented.

Discussion: Functional properties of security and privacy controls describe the functionality (i.e., security or privacy capability, functions, or mechanisms) visible at the interfaces of the controls and specifically exclude functionality and data structures internal to the operation of the controls.

Related Controls: None.

(2) ACQUISITION PROCESS | [DESIGN AND IMPLEMENTATION INFORMATION FOR CONTROLS](#)

Require the developer of the system, system component, or system service to provide design and implementation information for the controls that includes: [Selection (one or more): security-relevant external system interfaces; high-level design; low-level design; source code or hardware schematics; [Assignment: organization-defined design and implementation information]] at [Assignment: organization-defined level of detail].

Discussion: Organizations may require different levels of detail in the documentation for the design and implementation of controls in organizational systems, system components, or system services based on mission and business requirements, requirements for resiliency and trustworthiness, and requirements for analysis and testing. Systems can be partitioned into multiple subsystems. Each subsystem within the system can contain one or more modules. The high-level design for the system is expressed in terms of subsystems and the interfaces between subsystems providing security-relevant functionality. The low-level design for the system is expressed in terms of modules and the interfaces between modules providing security-relevant functionality. Design and implementation documentation can include manufacturer, version, serial number, verification hash signature, software libraries used, date of purchase or download, and the vendor or download source. Source code and hardware schematics are referred to as the implementation representation of the system.

Related Controls: None.

(3) ACQUISITION PROCESS | [DEVELOPMENT METHODS, TECHNIQUES, AND PRACTICES](#)

Require the developer of the system, system component, or system service to demonstrate the use of a system development life cycle process that includes:

- (a) [Assignment: organization-defined systems engineering methods];**
- (b) [Assignment: organization-defined [Selection (one or more): systems security; privacy] engineering methods]; and**
- (c) [Assignment: organization-defined software development methods; testing, evaluation, assessment, verification, and validation methods; and quality control processes].**

Discussion: Following a system development life cycle that includes state-of-the-practice software development methods, systems engineering methods, systems security and privacy engineering methods, and quality control processes helps to reduce the number and severity of latent errors within systems, system components, and system services. Reducing the number and severity of such errors reduces the number of vulnerabilities in those systems, components, and services. Transparency in the methods and techniques that developers select and implement for systems engineering, systems security and privacy engineering, software development, component and system assessments, and quality control processes provides an increased level of assurance in the trustworthiness of the system, system component, or system service being acquired.

Related Controls: None.

(4) ACQUISITION PROCESS | ASSIGNMENT OF COMPONENTS TO SYSTEMS

[Withdrawn: Incorporated into [CM-8\(9\)](#).]

(5) ACQUISITION PROCESS | [SYSTEM, COMPONENT, AND SERVICE CONFIGURATIONS](#)

Require the developer of the system, system component, or system service to:

- (a) Deliver the system, component, or service with [Assignment: organization-defined security configurations] implemented; and**
- (b) Use the configurations as the default for any subsequent system, component, or service reinstallation or upgrade.**

Discussion: Examples of security configurations include the U.S. Government Configuration Baseline (USGCB), Security Technical Implementation Guides (STIGs), and any limitations on functions, ports, protocols, and services. Security characteristics can include requiring that default passwords have been changed.

Related Controls: None.

(6) ACQUISITION PROCESS | [USE OF INFORMATION ASSURANCE PRODUCTS](#)

- (a) Employ only government off-the-shelf or commercial off-the-shelf information assurance and information assurance-enabled information technology products that compose an NSA-approved solution to protect classified information when the networks used to transmit the information are at a lower classification level than the information being transmitted; and**
- (b) Ensure that these products have been evaluated and/or validated by NSA or in accordance with NSA-approved procedures.**

Discussion: Commercial off-the-shelf IA or IA-enabled information technology products used to protect classified information by cryptographic means may be required to use NSA-approved key management. See [[NSA CSFC](#)].

Related Controls: [SC-8](#), [SC-12](#), [SC-13](#).

(7) ACQUISITION PROCESS | [NIAP-APPROVED PROTECTION PROFILES](#)

- (a) Limit the use of commercially provided information assurance and information assurance-enabled information technology products to those products that have been successfully evaluated against a National Information Assurance partnership (NIAP)-approved Protection Profile for a specific technology type, if such a profile exists; and**
- (b) Require, if no NIAP-approved Protection Profile exists for a specific technology type but a commercially provided information technology product relies on cryptographic functionality to enforce its security policy, that the cryptographic module is FIPS-validated or NSA-approved.**

Discussion: See [[NIAP CCEVS](#)] for additional information on NIAP. See [[NIST CMVP](#)] for additional information on FIPS-validated cryptographic modules.

Related Controls: [IA-7](#), [SC-12](#), [SC-13](#).

(8) ACQUISITION PROCESS | [CONTINUOUS MONITORING PLAN FOR CONTROLS](#)

Require the developer of the system, system component, or system service to produce a plan for continuous monitoring of control effectiveness that is consistent with the continuous monitoring program of the organization.

Discussion: The objective of continuous monitoring plans is to determine if the planned, required, and deployed controls within the system, system component, or system service continue to be effective over time based on the inevitable changes that occur. Developer continuous monitoring plans include a sufficient level of detail such that the information can be incorporated into continuous monitoring programs implemented by organizations.

Continuous monitoring plans can include the types of control assessment and monitoring

activities planned, frequency of control monitoring, and actions to be taken when controls fail or become ineffective.

Related Controls: [CA-7](#).

(9) ACQUISITION PROCESS | [FUNCTIONS, PORTS, PROTOCOLS, AND SERVICES IN USE](#)

Require the developer of the system, system component, or system service to identify the functions, ports, protocols, and services intended for organizational use.

Discussion: The identification of functions, ports, protocols, and services early in the system development life cycle (e.g., during the initial requirements definition and design stages) allows organizations to influence the design of the system, system component, or system service. This early involvement in the system development life cycle helps organizations avoid or minimize the use of functions, ports, protocols, or services that pose unnecessarily high risks and understand the trade-offs involved in blocking specific ports, protocols, or services or requiring system service providers to do so. Early identification of functions, ports, protocols, and services avoids costly retrofitting of controls after the system, component, or system service has been implemented. [SA-9](#) describes the requirements for external system services. Organizations identify which functions, ports, protocols, and services are provided from external sources.

Related Controls: [CM-7](#), [SA-9](#).

(10) ACQUISITION PROCESS | [USE OF APPROVED PIV PRODUCTS](#)

Employ only information technology products on the FIPS 201-approved products list for Personal Identity Verification (PIV) capability implemented within organizational systems.

Discussion: Products on the FIPS 201-approved products list meet NIST requirements for Personal Identity Verification (PIV) of Federal Employees and Contractors. PIV cards are used for multi-factor authentication in systems and organizations.

Related Controls: [IA-2](#), [IA-8](#), [PM-9](#).

(11) ACQUISITION PROCESS | [SYSTEM OF RECORDS](#)

Include [Assignment: organization-defined Privacy Act requirements] in the acquisition contract for the operation of a system of records on behalf of an organization to accomplish an organizational mission or function.

Discussion: When, by contract, an organization provides for the operation of a system of records to accomplish an organizational mission or function, the organization, consistent with its authority, causes the requirements of the [\[PRIVACT\]](#) to be applied to the system of records.

Related Controls: [PT-6](#).

(12) ACQUISITION PROCESS | [DATA OWNERSHIP](#)

- (a) Include organizational data ownership requirements in the acquisition contract; and**
- (b) Require all data to be removed from the contractor's system and returned to the organization within [Assignment: organization-defined time frame].**

Discussion: Contractors who operate a system that contains data owned by an organization initiating the contract have policies and procedures in place to remove the data from their systems and/or return the data in a time frame defined by the contract.

Related Controls: None.

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[ISO 15408-1\]](#), [\[ISO 15408-2\]](#), [\[ISO 15408-3\]](#), [\[ISO 29148\]](#), [\[FIPS 140-3\]](#), [\[FIPS 201-2\]](#), [\[SP 800-35\]](#), [\[SP 800-37\]](#), [\[SP 800-70\]](#), [\[SP 800-73-4\]](#), [\[SP 800-137\]](#), [\[SP 800-160-1\]](#), [\[SP 800-161\]](#), [\[IR 7539\]](#), [\[IR 7622\]](#), [\[IR 7676\]](#), [\[IR 7870\]](#), [\[IR 8062\]](#), [\[NIAP CCEVS\]](#), [\[NSA CSFC\]](#).

SA-5 SYSTEM DOCUMENTATIONControl:

- a. Obtain or develop administrator documentation for the system, system component, or system service that describes:
 1. Secure configuration, installation, and operation of the system, component, or service;
 2. Effective use and maintenance of security and privacy functions and mechanisms; and
 3. Known vulnerabilities regarding configuration and use of administrative or privileged functions;
- b. Obtain or develop user documentation for the system, system component, or system service that describes:
 1. User-accessible security and privacy functions and mechanisms and how to effectively use those functions and mechanisms;
 2. Methods for user interaction, which enables individuals to use the system, component, or service in a more secure manner and protect individual privacy; and
 3. User responsibilities in maintaining the security of the system, component, or service and privacy of individuals;
- c. Document attempts to obtain system, system component, or system service documentation when such documentation is either unavailable or nonexistent and take [Assignment: *organization-defined actions*] in response; and
- d. Distribute documentation to [Assignment: *organization-defined personnel or roles*].

Discussion: System documentation helps personnel understand the implementation and operation of controls. Organizations consider establishing specific measures to determine the quality and completeness of the content provided. System documentation may be used to support the management of supply chain risk, incident response, and other functions. Personnel or roles that require documentation include system owners, system security officers, and system administrators. Attempts to obtain documentation include contacting manufacturers or suppliers and conducting web-based searches. The inability to obtain documentation may occur due to the age of the system or component or the lack of support from developers and contractors. When documentation cannot be obtained, organizations may need to recreate the documentation if it is essential to the implementation or operation of the controls. The protection provided for the documentation is commensurate with the security category or classification of the system. Documentation that addresses system vulnerabilities may require an increased level of protection. Secure operation of the system includes initially starting the system and resuming secure system operation after a lapse in system operation.

Related Controls: [CM-4](#), [CM-6](#), [CM-7](#), [CM-8](#), [PL-2](#), [PL-4](#), [PL-8](#), [PS-2](#), [SA-3](#), [SA-4](#), [SA-8](#), [SA-9](#), [SA-10](#), [SA-11](#), [SA-15](#), [SA-16](#), [SA-17](#), [SI-12](#), [SR-3](#).

Control Enhancements:

- (1) SYSTEM DOCUMENTATION | FUNCTIONAL PROPERTIES OF SECURITY CONTROLS
[Withdrawn: Incorporated into [SA-4\(1\)](#).]
- (2) SYSTEM DOCUMENTATION | SECURITY-RELEVANT EXTERNAL SYSTEM INTERFACES
[Withdrawn: Incorporated into [SA-4\(2\)](#).]
- (3) SYSTEM DOCUMENTATION | HIGH-LEVEL DESIGN
[Withdrawn: Incorporated into [SA-4\(2\)](#).]

(4) SYSTEM DOCUMENTATION | LOW-LEVEL DESIGN

[Withdrawn: Incorporated into [SA-4\(2\)](#).]

(5) SYSTEM DOCUMENTATION | SOURCE CODE

[Withdrawn: Incorporated into [SA-4\(2\)](#).]

References: [[SP 800-160-1](#)].

SA-6 SOFTWARE USAGE RESTRICTIONS

[Withdrawn: Incorporated into [CM-10](#) and [SI-7](#).]

SA-7 USER-INSTALLED SOFTWARE

[Withdrawn: Incorporated into [CM-11](#) and [SI-7](#).]

SA-8 SECURITY AND PRIVACY ENGINEERING PRINCIPLES

Control: Apply the following systems security and privacy engineering principles in the specification, design, development, implementation, and modification of the system and system components: [Assignment: organization-defined systems security and privacy engineering principles].

Discussion: Systems security and privacy engineering principles are closely related to and implemented throughout the system development life cycle (see [SA-3](#)). Organizations can apply systems security and privacy engineering principles to new systems under development or to systems undergoing upgrades. For existing systems, organizations apply systems security and privacy engineering principles to system upgrades and modifications to the extent feasible, given the current state of hardware, software, and firmware components within those systems.

The application of systems security and privacy engineering principles helps organizations develop trustworthy, secure, and resilient systems and reduces the susceptibility to disruptions, hazards, threats, and the creation of privacy problems for individuals. Examples of system security engineering principles include: developing layered protections; establishing security and privacy policies, architecture, and controls as the foundation for design and development; incorporating security and privacy requirements into the system development life cycle; delineating physical and logical security boundaries; ensuring that developers are trained on how to build secure software; tailoring controls to meet organizational needs; and performing threat modeling to identify use cases, threat agents, attack vectors and patterns, design patterns, and compensating controls needed to mitigate risk.

Organizations that apply systems security and privacy engineering concepts and principles can facilitate the development of trustworthy, secure systems, system components, and system services; reduce risk to acceptable levels; and make informed risk management decisions. System security engineering principles can also be used to protect against certain supply chain risks, including incorporating tamper-resistant hardware into a design.

Related Controls: [PL-8](#), [PM-7](#), [RA-2](#), [RA-3](#), [RA-9](#), [SA-3](#), [SA-4](#), [SA-15](#), [SA-17](#), [SA-20](#), [SC-2](#), [SC-3](#), [SC-32](#), [SC-39](#), [SR-2](#), [SR-3](#), [SR-4](#), [SR-5](#).

Control Enhancements:

(1) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [CLEAR ABSTRACTIONS](#)

Implement the security design principle of clear abstractions.

Discussion: The principle of clear abstractions states that a system has simple, well-defined interfaces and functions that provide a consistent and intuitive view of the data and how the data is managed. The clarity, simplicity, necessity, and sufficiency of the system interfaces—

combined with a precise definition of their functional behavior—promotes ease of analysis, inspection, and testing as well as the correct and secure use of the system. The clarity of an abstraction is subjective. Examples that reflect the application of this principle include avoidance of redundant, unused interfaces; information hiding; and avoidance of semantic overloading of interfaces or their parameters. Information hiding (i.e., representation-independent programming), is a design discipline used to ensure that the internal representation of information in one system component is not visible to another system component invoking or calling the first component, such that the published abstraction is not influenced by how the data may be managed internally.

Related Controls: None.

(2) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [LEAST COMMON MECHANISM](#)

Implement the security design principle of least common mechanism in [Assignment: organization-defined systems or system components].

Discussion: The principle of least common mechanism states that the amount of mechanism common to more than one user and depended on by all users is minimized [[POPEK74](#)]. Mechanism minimization implies that different components of a system refrain from using the same mechanism to access a system resource. Every shared mechanism (especially a mechanism involving shared variables) represents a potential information path between users and is designed with care to ensure that it does not unintentionally compromise security [[SALTZER75](#)]. Implementing the principle of least common mechanism helps to reduce the adverse consequences of sharing the system state among different programs. A single program that corrupts a shared state (including shared variables) has the potential to corrupt other programs that are dependent on the state. The principle of least common mechanism also supports the principle of simplicity of design and addresses the issue of covert storage channels [[LAMPSON73](#)].

Related Controls: None.

(3) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [MODULARITY AND LAYERING](#)

Implement the security design principles of modularity and layering in [Assignment: organization-defined systems or system components].

Discussion: The principles of modularity and layering are fundamental across system engineering disciplines. Modularity and layering derived from functional decomposition are effective in managing system complexity by making it possible to comprehend the structure of the system. Modular decomposition, or refinement in system design, is challenging and resists general statements of principle. Modularity serves to isolate functions and related data structures into well-defined logical units. Layering allows the relationships of these units to be better understood so that dependencies are clear and undesired complexity can be avoided. The security design principle of modularity extends functional modularity to include considerations based on trust, trustworthiness, privilege, and security policy. Security-informed modular decomposition includes the allocation of policies to systems in a network, separation of system applications into processes with distinct address spaces, allocation of system policies to layers, and separation of processes into subjects with distinct privileges based on hardware-supported privilege domains.

Related Controls: [SC-2](#), [SC-3](#).

(4) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [PARTIALLY ORDERED DEPENDENCIES](#)

Implement the security design principle of partially ordered dependencies in [Assignment: organization-defined systems or system components].

Discussion: The principle of partially ordered dependencies states that the synchronization, calling, and other dependencies in the system are partially ordered. A fundamental concept in system design is layering, whereby the system is organized into well-defined, functionally

related modules or components. The layers are linearly ordered with respect to inter-layer dependencies, such that higher layers are dependent on lower layers. While providing functionality to higher layers, some layers can be self-contained and not dependent on lower layers. While a partial ordering of all functions in a given system may not be possible, if circular dependencies are constrained to occur within layers, the inherent problems of circularity can be more easily managed. Partially ordered dependencies and system layering contribute significantly to the simplicity and coherency of the system design. Partially ordered dependencies also facilitate system testing and analysis.

Related Controls: None.

(5) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [EFFICIENTLY MEDIATED ACCESS](#)

Implement the security design principle of efficiently mediated access in [Assignment: organization-defined systems or system components].

Discussion: The principle of efficiently mediated access states that policy enforcement mechanisms utilize the least common mechanism available while satisfying stakeholder requirements within expressed constraints. The mediation of access to system resources (i.e., CPU, memory, devices, communication ports, services, infrastructure, data, and information) is often the predominant security function of secure systems. It also enables the realization of protections for the capability provided to stakeholders by the system. Mediation of resource access can result in performance bottlenecks if the system is not designed correctly. For example, by using hardware mechanisms, efficiently mediated access can be achieved. Once access to a low-level resource such as memory has been obtained, hardware protection mechanisms can ensure that out-of-bounds access does not occur.

Related Controls: [AC-25](#).

(6) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [MINIMIZED SHARING](#)

Implement the security design principle of minimized sharing in [Assignment: organization-defined systems or system components].

Discussion: The principle of minimized sharing states that no computer resource is shared between system components (e.g., subjects, processes, functions) unless it is absolutely necessary to do so. Minimized sharing helps to simplify system design and implementation. In order to protect user-domain resources from arbitrary active entities, no resource is shared unless that sharing has been explicitly requested and granted. The need for resource sharing can be motivated by the design principle of least common mechanism in the case of internal entities or driven by stakeholder requirements. However, internal sharing is carefully designed to avoid performance and covert storage and timing channel problems. Sharing via common mechanism can increase the susceptibility of data and information to unauthorized access, disclosure, use, or modification and can adversely affect the inherent capability provided by the system. To minimize sharing induced by common mechanisms, such mechanisms can be designed to be reentrant or virtualized to preserve separation. Moreover, the use of global data to share information is carefully scrutinized. The lack of encapsulation may obfuscate relationships among the sharing entities.

Related Controls: [SC-31](#).

(7) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [REDUCED COMPLEXITY](#)

Implement the security design principle of reduced complexity in [Assignment: organization-defined systems or system components].

Discussion: The principle of reduced complexity states that the system design is as simple and small as possible. A small and simple design is more understandable, more analyzable, and less prone to error. The reduced complexity principle applies to any aspect of a system, but it has particular importance for security due to the various analyses performed to obtain evidence about the emergent security property of the system. For such analyses to be

successful, a small and simple design is essential. Application of the principle of reduced complexity contributes to the ability of system developers to understand the correctness and completeness of system security functions. It also facilitates the identification of potential vulnerabilities. The corollary of reduced complexity states that the simplicity of the system is directly related to the number of vulnerabilities it will contain; that is, simpler systems contain fewer vulnerabilities. A benefit of reduced complexity is that it is easier to understand whether the intended security policy has been captured in the system design and that fewer vulnerabilities are likely to be introduced during engineering development. An additional benefit is that any such conclusion about correctness, completeness, and the existence of vulnerabilities can be reached with a higher degree of assurance in contrast to conclusions reached in situations where the system design is inherently more complex. Transitioning from older technologies to newer technologies (e.g., transitioning from IPv4 to IPv6) may require implementing the older and newer technologies simultaneously during the transition period. This may result in a temporary increase in system complexity during the transition.

Related Controls: None.

(8) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [SECURE EVOLVABILITY](#)

Implement the security design principle of secure evolvability in [Assignment: organization-defined systems or system components].

Discussion: The principle of secure evolvability states that a system is developed to facilitate the maintenance of its security properties when there are changes to the system's structure, interfaces, interconnections (i.e., system architecture), functionality, or configuration (i.e., security policy enforcement). Changes include a new, enhanced, or upgraded system capability; maintenance and sustainment activities; and reconfiguration. Although it is not possible to plan for every aspect of system evolution, system upgrades and changes can be anticipated by analyses of mission or business strategic direction, anticipated changes in the threat environment, and anticipated maintenance and sustainment needs. It is unrealistic to expect that complex systems remain secure in contexts not envisioned during development, whether such contexts are related to the operational environment or to usage. A system may be secure in some new contexts, but there is no guarantee that its emergent behavior will always be secure. It is easier to build trustworthiness into a system from the outset, and it follows that the sustainment of system trustworthiness requires planning for change as opposed to adapting in an ad hoc or non-methodical manner. The benefits of this principle include reduced vendor life cycle costs, reduced cost of ownership, improved system security, more effective management of security risk, and less risk uncertainty.

Related Controls: [CM-3](#).

(9) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [TRUSTED COMPONENTS](#)

Implement the security design principle of trusted components in [Assignment: organization-defined systems or system components].

Discussion: The principle of trusted components states that a component is trustworthy to at least a level commensurate with the security dependencies it supports (i.e., how much it is trusted to perform its security functions by other components). This principle enables the composition of components such that trustworthiness is not inadvertently diminished and the trust is not consequently misplaced. Ultimately, this principle demands some metric by which the trust in a component and the trustworthiness of a component can be measured on the same abstract scale. The principle of trusted components is particularly relevant when considering systems and components in which there are complex chains of trust dependencies. A trust dependency is also referred to as a trust relationship and there may be chains of trust relationships.

The principle of trusted components also applies to a compound component that consists of subcomponents (e.g., a subsystem), which may have varying levels of trustworthiness. The conservative assumption is that the trustworthiness of a compound component is that of its least trustworthy subcomponent. It may be possible to provide a security engineering rationale that the trustworthiness of a particular compound component is greater than the conservative assumption. However, any such rationale reflects logical reasoning based on a clear statement of the trustworthiness objectives as well as relevant and credible evidence. The trustworthiness of a compound component is not the same as increased application of defense-in-depth layering within the component or a replication of components. Defense-in-depth techniques do not increase the trustworthiness of the whole above that of the least trustworthy component.

Related Controls: None.

(10) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [HIERARCHICAL TRUST](#)

Implement the security design principle of hierarchical trust in [Assignment: organization-defined systems or system components].

Discussion: The principle of hierarchical trust for components builds on the principle of trusted components and states that the security dependencies in a system will form a partial ordering if they preserve the principle of trusted components. The partial ordering provides the basis for trustworthiness reasoning or an assurance case (assurance argument) when composing a secure system from heterogeneously trustworthy components. To analyze a system composed of heterogeneously trustworthy components for its trustworthiness, it is essential to eliminate circular dependencies with regard to the trustworthiness. If a more trustworthy component located in a lower layer of the system were to depend on a less trustworthy component in a higher layer, this would, in effect, put the components in the same “less trustworthy” equivalence class per the principle of trusted components. Trust relationships, or chains of trust, can have various manifestations. For example, the root certificate of a certificate hierarchy is the most trusted node in the hierarchy, whereas the leaves in the hierarchy may be the least trustworthy nodes. Another example occurs in a layered high-assurance system where the security kernel (including the hardware base), which is located at the lowest layer of the system, is the most trustworthy component. The principle of hierarchical trust, however, does not prohibit the use of overly trustworthy components. There may be cases in a system of low trustworthiness where it is reasonable to employ a highly trustworthy component rather than one that is less trustworthy (e.g., due to availability or other cost-benefit driver). For such a case, any dependency of the highly trustworthy component upon a less trustworthy component does not degrade the trustworthiness of the resulting low-trust system.

Related Controls: None.

(11) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [INVERSE MODIFICATION THRESHOLD](#)

Implement the security design principle of inverse modification threshold in [Assignment: organization-defined systems or system components].

Discussion: The principle of inverse modification threshold builds on the principle of trusted components and the principle of hierarchical trust and states that the degree of protection provided to a component is commensurate with its trustworthiness. As the trust placed in a component increases, the protection against unauthorized modification of the component also increases to the same degree. Protection from unauthorized modification can come in the form of the component’s own self-protection and innate trustworthiness, or it can come from the protections afforded to the component from other elements or attributes of the security architecture (to include protections in the environment of operation).

Related Controls: None.

(12) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [HIERARCHICAL PROTECTION](#)

Implement the security design principle of hierarchical protection in [Assignment: organization-defined systems or system components].

Discussion: The principle of hierarchical protection states that a component need not be protected from more trustworthy components. In the degenerate case of the most trusted component, it protects itself from all other components. For example, if an operating system kernel is deemed the most trustworthy component in a system, then it protects itself from all untrusted applications it supports, but the applications, conversely, do not need to protect themselves from the kernel. The trustworthiness of users is a consideration for applying the principle of hierarchical protection. A trusted system need not protect itself from an equally trustworthy user, reflecting use of untrusted systems in “system high” environments where users are highly trustworthy and where other protections are put in place to bound and protect the “system high” execution environment.

Related Controls: None.

(13) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [MINIMIZED SECURITY ELEMENTS](#)

Implement the security design principle of minimized security elements in [Assignment: organization-defined systems or system components].

Discussion: The principle of minimized security elements states that the system does not have extraneous trusted components. The principle of minimized security elements has two aspects: the overall cost of security analysis and the complexity of security analysis. Trusted components are generally costlier to construct and implement, owing to the increased rigor of development processes. Trusted components require greater security analysis to qualify their trustworthiness. Thus, to reduce the cost and decrease the complexity of the security analysis, a system contains as few trustworthy components as possible. The analysis of the interaction of trusted components with other components of the system is one of the most important aspects of system security verification. If the interactions between components are unnecessarily complex, the security of the system will also be more difficult to ascertain than one whose internal trust relationships are simple and elegantly constructed. In general, fewer trusted components result in fewer internal trust relationships and a simpler system.

Related Controls: None.

(14) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [LEAST PRIVILEGE](#)

Implement the security design principle of least privilege in [Assignment: organization-defined systems or system components].

Discussion: The principle of least privilege states that each system component is allocated sufficient privileges to accomplish its specified functions but no more. Applying the principle of least privilege limits the scope of the component’s actions, which has two desirable effects: the security impact of a failure, corruption, or misuse of the component will have a minimized security impact, and the security analysis of the component will be simplified. Least privilege is a pervasive principle that is reflected in all aspects of the secure system design. Interfaces used to invoke component capability are available to only certain subsets of the user population, and component design supports a sufficiently fine granularity of privilege decomposition. For example, in the case of an audit mechanism, there may be an interface for the audit manager, who configures the audit settings; an interface for the audit operator, who ensures that audit data is safely collected and stored; and, finally, yet another interface for the audit reviewer, who only has need to view the audit data that has been collected but no need to perform operations on that data.

In addition to its manifestations at the system interface, least privilege can be used as a guiding principle for the internal structure of the system itself. One aspect of internal least privilege is to construct modules so that only the elements encapsulated by the module are

directly operated on by the functions within the module. Elements external to a module that may be affected by the module's operation are indirectly accessed through interaction (e.g., via a function call) with the module that contains those elements. Another aspect of internal least privilege is that the scope of a given module or component includes only those system elements that are necessary for its functionality and that the access modes for the elements (e.g., read, write) are minimal.

Related Controls: [AC-6](#), [CM-7](#).

(15) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | PREDICATE PERMISSION

Implement the security design principle of predicate permission in [Assignment: organization-defined systems or system components].

Discussion: The principle of predicate permission states that system designers consider requiring multiple authorized entities to provide consent before a highly critical operation or access to highly sensitive data, information, or resources is allowed to proceed. [[SALTZER75](#)] originally named predicate permission the separation of privilege. It is also equivalent to separation of duty. The division of privilege among multiple parties decreases the likelihood of abuse and provides the safeguard that no single accident, deception, or breach of trust is sufficient to enable an unrecoverable action that can lead to significantly damaging effects. The design options for such a mechanism may require simultaneous action (e.g., the firing of a nuclear weapon requires two different authorized individuals to give the correct command within a small time window) or a sequence of operations where each successive action is enabled by some prior action, but no single individual is able to enable more than one action.

Related Controls: [AC-5](#).

(16) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | SELF-RELIANT TRUSTWORTHINESS

Implement the security design principle of self-reliant trustworthiness in [Assignment: organization-defined systems or system components].

Discussion: The principle of self-reliant trustworthiness states that systems minimize their reliance on other systems for their own trustworthiness. A system is trustworthy by default, and any connection to an external entity is used to supplement its function. If a system were required to maintain a connection with another external entity in order to maintain its trustworthiness, then that system would be vulnerable to malicious and non-malicious threats that could result in the loss or degradation of that connection. The benefit of the principle of self-reliant trustworthiness is that the isolation of a system will make it less vulnerable to attack. A corollary to this principle relates to the ability of the system (or system component) to operate in isolation and then resynchronize with other components when it is rejoined with them.

Related Controls: None.

(17) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | SECURE DISTRIBUTED COMPOSITION

Implement the security design principle of secure distributed composition in [Assignment: organization-defined systems or system components].

Discussion: The principle of secure distributed composition states that the composition of distributed components that enforce the same system security policy result in a system that enforces that policy at least as well as the individual components do. Many of the design principles for secure systems deal with how components can or should interact. The need to create or enable a capability from the composition of distributed components can magnify the relevancy of these principles. In particular, the translation of security policy from a stand-alone to a distributed system or a system-of-systems can have unexpected or emergent results. Communication protocols and distributed data consistency mechanisms help to ensure consistent policy enforcement across a distributed system. To ensure a

system-wide level of assurance of correct policy enforcement, the security architecture of a distributed composite system is thoroughly analyzed.

Related Controls: None.

(18) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [TRUSTED COMMUNICATIONS CHANNELS](#)

Implement the security design principle of trusted communications channels in [Assignment: organization-defined systems or system components].

Discussion: The principle of trusted communication channels states that when composing a system where there is a potential threat to communications between components (i.e., the interconnections between components), each communication channel is trustworthy to a level commensurate with the security dependencies it supports (i.e., how much it is trusted by other components to perform its security functions). Trusted communication channels are achieved by a combination of restricting access to the communication channel (to ensure an acceptable match in the trustworthiness of the endpoints involved in the communication) and employing end-to-end protections for the data transmitted over the communication channel (to protect against interception and modification and to further increase the assurance of proper end-to-end communication).

Related Controls: [SC-8](#), [SC-12](#), [SC-13](#).

(19) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [CONTINUOUS PROTECTION](#)

Implement the security design principle of continuous protection in [Assignment: organization-defined systems or system components].

Discussion: The principle of continuous protection states that components and data used to enforce the security policy have uninterrupted protection that is consistent with the security policy and the security architecture assumptions. No assurances that the system can provide the confidentiality, integrity, availability, and privacy protections for its design capability can be made if there are gaps in the protection. Any assurances about the ability to secure a delivered capability require that data and information are continuously protected. That is, there are no periods during which data and information are left unprotected while under control of the system (i.e., during the creation, storage, processing, or communication of the data and information, as well as during system initialization, execution, failure, interruption, and shutdown). Continuous protection requires adherence to the precepts of the reference monitor concept (i.e., every request is validated by the reference monitor; the reference monitor is able to protect itself from tampering; and sufficient assurance of the correctness and completeness of the mechanism can be ascertained from analysis and testing) and the principle of secure failure and recovery (i.e., preservation of a secure state during error, fault, failure, and successful attack; preservation of a secure state during recovery to normal, degraded, or alternative operational modes).

Continuous protection also applies to systems designed to operate in varying configurations, including those that deliver full operational capability and degraded-mode configurations that deliver partial operational capability. The continuous protection principle requires that changes to the system security policies be traceable to the operational need that drives the configuration and be verifiable (i.e., it is possible to verify that the proposed changes will not put the system into an insecure state). Insufficient traceability and verification may lead to inconsistent states or protection discontinuities due to the complex or undecidable nature of the problem. The use of pre-verified configuration definitions that reflect the new security policy enables analysis to determine that a transition from old to new policies is essentially atomic and that any residual effects from the old policy are guaranteed to not conflict with the new policy. The ability to demonstrate continuous protection is rooted in the clear articulation of life cycle protection needs as stakeholder security requirements.

Related Controls: [AC-25](#).

(20) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [SECURE METADATA MANAGEMENT](#)

Implement the security design principle of secure metadata management in [Assignment: organization-defined systems or system components].

Discussion: The principle of secure metadata management states that metadata are “first class” objects with respect to security policy when the policy requires either complete protection of information or that the security subsystem be self-protecting. The principle of secure metadata management is driven by the recognition that a system, subsystem, or component cannot achieve self-protection unless it protects the data it relies on for correct execution. Data is generally not interpreted by the system that stores it. It may have semantic value (i.e., it comprises information) to users and programs that process the data. In contrast, metadata is information about data, such as a file name or the date when the file was created. Metadata is bound to the target data that it describes in a way that the system can interpret, but it need not be stored inside of or proximate to its target data. There may be metadata whose target is itself metadata (e.g., the classification level or impact level of a file name), including self-referential metadata.

The apparent secondary nature of metadata can lead to neglect of its legitimate need for protection, resulting in a violation of the security policy that includes the exfiltration of information. A particular concern associated with insufficient protections for metadata is associated with multilevel secure (MLS) systems. MLS systems mediate access by a subject to an object based on relative sensitivity levels. It follows that all subjects and objects in the scope of control of the MLS system are either directly labeled or indirectly attributed with sensitivity levels. The corollary of labeled metadata for MLS systems states that objects containing metadata are labeled. As with protection needs assessments for data, attention is given to ensure that the confidentiality and integrity protections are individually assessed, specified, and allocated to metadata, as would be done for mission, business, and system data.

Related Controls: None.

(21) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [SELF-ANALYSIS](#)

Implement the security design principle of self-analysis in [Assignment: organization-defined systems or system components].

Discussion: The principle of self-analysis states that a system component is able to assess its internal state and functionality to a limited extent at various stages of execution, and that this self-analysis capability is commensurate with the level of trustworthiness invested in the system. At the system level, self-analysis can be achieved through hierarchical assessments of trustworthiness established in a bottom-up fashion. In this approach, the lower-level components check for data integrity and correct functionality (to a limited extent) of higher-level components. For example, trusted boot sequences involve a trusted lower-level component that attests to the trustworthiness of the next higher-level components so that a transitive chain of trust can be established. At the root, a component attests to itself, which usually involves an axiomatic or environmentally enforced assumption about its integrity. Results of the self-analyses can be used to guard against externally induced errors, internal malfunction, or transient errors. By following this principle, some simple malfunctions or errors can be detected without allowing the effects of the error or malfunction to propagate outside of the component. Further, the self-test can be used to attest to the configuration of the component, detecting any potential conflicts in configuration with respect to the expected configuration.

Related Controls: [CA-7](#).

(22) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [ACCOUNTABILITY AND TRACEABILITY](#)

Implement the security design principle of accountability and traceability in [Assignment: organization-defined systems or system components].

Discussion: The principle of accountability and traceability states that it is possible to trace security-relevant actions (i.e., subject-object interactions) to the entity on whose behalf the action is being taken. The principle of accountability and traceability requires a trustworthy infrastructure that can record details about actions that affect system security (e.g., an audit subsystem). To record the details about actions, the system is able to uniquely identify the entity on whose behalf the action is being carried out and also record the relevant sequence of actions that are carried out. The accountability policy also requires that audit trail itself be protected from unauthorized access and modification. The principle of least privilege assists in tracing the actions to particular entities, as it increases the granularity of accountability. Associating specific actions with system entities, and ultimately with users, and making the audit trail secure against unauthorized access and modifications provide non-repudiation because once an action is recorded, it is not possible to change the audit trail. Another important function that accountability and traceability serves is in the routine and forensic analysis of events associated with the violation of security policy. Analysis of audit logs may provide additional information that may be helpful in determining the path or component that allowed the violation of the security policy and the actions of individuals associated with the violation of the security policy.

Related Controls: [AC-6](#), [AU-2](#), [AU-3](#), [AU-6](#), [AU-9](#), [AU-10](#), [AU-12](#), [IA-2](#), [IR-4](#).

(23) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | SECURE DEFAULTS

Implement the security design principle of secure defaults in [Assignment: organization-defined systems or system components].

Discussion: The principle of secure defaults states that the default configuration of a system (including its constituent subsystems, components, and mechanisms) reflects a restrictive and conservative enforcement of security policy. The principle of secure defaults applies to the initial (i.e., default) configuration of a system as well as to the security engineering and design of access control and other security functions that follow a “deny unless explicitly authorized” strategy. The initial configuration aspect of this principle requires that any “as shipped” configuration of a system, subsystem, or system component does not aid in the violation of the security policy and can prevent the system from operating in the default configuration for those cases where the security policy itself requires configuration by the operational user.

Restrictive defaults mean that the system will operate “as-shipped” with adequate self-protection and be able to prevent security breaches before the intended security policy and system configuration is established. In cases where the protection provided by the “as-shipped” product is inadequate, stakeholders assess the risk of using it prior to establishing a secure initial state. Adherence to the principle of secure defaults guarantees that a system is established in a secure state upon successfully completing initialization. In situations where the system fails to complete initialization, either it will perform a requested operation using secure defaults or it will not perform the operation. Refer to the principles of continuous protection and secure failure and recovery that parallel this principle to provide the ability to detect and recover from failure.

The security engineering approach to this principle states that security mechanisms deny requests unless the request is found to be well-formed and consistent with the security policy. The insecure alternative is to allow a request unless it is shown to be inconsistent with the policy. In a large system, the conditions that are satisfied to grant a request that is denied by default are often far more compact and complete than those that would need to be checked in order to deny a request that is granted by default.

Related Controls: [CM-2](#), [CM-6](#), [SA-4](#).

(24) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [SECURE FAILURE AND RECOVERY](#)

Implement the security design principle of secure failure and recovery in [Assignment: organization-defined systems or system components].

Discussion: The principle of secure failure and recovery states that neither a failure in a system function or mechanism nor any recovery action in response to failure leads to a violation of security policy. The principle of secure failure and recovery parallels the principle of continuous protection to ensure that a system is capable of detecting (within limits) actual and impending failure at any stage of its operation (i.e., initialization, normal operation, shutdown, and maintenance) and to take appropriate steps to ensure that security policies are not violated. In addition, when specified, the system is capable of recovering from impending or actual failure to resume normal, degraded, or alternative secure operations while ensuring that a secure state is maintained such that security policies are not violated.

Failure is a condition in which the behavior of a component deviates from its specified or expected behavior for an explicitly documented input. Once a failed security function is detected, the system may reconfigure itself to circumvent the failed component while maintaining security and provide all or part of the functionality of the original system, or it may completely shut itself down to prevent any further violation of security policies. For this to occur, the reconfiguration functions of the system are designed to ensure continuous enforcement of security policy during the various phases of reconfiguration.

Another technique that can be used to recover from failures is to perform a rollback to a secure state (which may be the initial state) and then either shutdown or replace the service or component that failed such that secure operations may resume. Failure of a component may or may not be detectable to the components using it. The principle of secure failure indicates that components fail in a state that denies rather than grants access. For example, a nominally “atomic” operation interrupted before completion does not violate security policy and is designed to handle interruption events by employing higher-level atomicity and rollback mechanisms (e.g., transactions). If a service is being used, its atomicity properties are well-documented and characterized so that the component availing itself of that service can detect and handle interruption events appropriately. For example, a system is designed to gracefully respond to disconnection and support resynchronization and data consistency after disconnection.

Failure protection strategies that employ replication of policy enforcement mechanisms, sometimes called defense in depth, can allow the system to continue in a secure state even when one mechanism has failed to protect the system. If the mechanisms are similar, however, the additional protection may be illusory, as the adversary can simply attack in series. Similarly, in a networked system, breaking the security on one system or service may enable an attacker to do the same on other similar replicated systems and services. By employing multiple protection mechanisms whose features are significantly different, the possibility of attack replication or repetition can be reduced. Analyses are conducted to weigh the costs and benefits of such redundancy techniques against increased resource usage and adverse effects on the overall system performance. Additional analyses are conducted as the complexity of these mechanisms increases, as could be the case for dynamic behaviors. Increased complexity generally reduces trustworthiness. When a resource cannot be continuously protected, it is critical to detect and repair any security breaches before the resource is once again used in a secure context.

Related Controls: [CP-10](#), [CP-12](#), [SC-7](#), [SC-8](#), [SC-24](#), [SI-13](#).

(25) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [ECONOMIC SECURITY](#)

Implement the security design principle of economic security in [Assignment: organization-defined systems or system components].

Discussion: The principle of economic security states that security mechanisms are not costlier than the potential damage that could occur from a security breach. This is the security-relevant form of the cost-benefit analyses used in risk management. The cost assumptions of cost-benefit analysis prevent the system designer from incorporating security mechanisms of greater strength than necessary, where strength of mechanism is proportional to cost. The principle of economic security also requires analysis of the benefits of assurance relative to the cost of that assurance in terms of the effort expended to obtain relevant and credible evidence as well as the necessary analyses to assess and draw trustworthiness and risk conclusions from the evidence.

Related Controls: [RA-3](#).

(26) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [PERFORMANCE SECURITY](#)

Implement the security design principle of performance security in [Assignment: organization-defined systems or system components].

Discussion: The principle of performance security states that security mechanisms are constructed so that they do not degrade system performance unnecessarily. Stakeholder and system design requirements for performance and security are precisely articulated and prioritized. For the system implementation to meet its design requirements and be found acceptable to stakeholders (i.e., validation against stakeholder requirements), the designers adhere to the specified constraints that capability performance needs place on protection needs. The overall impact of computationally intensive security services (e.g., cryptography) are assessed and demonstrated to pose no significant impact to higher-priority performance considerations or are deemed to provide an acceptable trade-off of performance for trustworthy protection. The trade-off considerations include less computationally intensive security services unless they are unavailable or insufficient. The insufficiency of a security service is determined by functional capability and strength of mechanism. The strength of mechanism is selected with respect to security requirements, performance-critical overhead issues (e.g., cryptographic key management), and an assessment of the capability of the threat.

The principle of performance security leads to the incorporation of features that help in the enforcement of security policy but incur minimum overhead, such as low-level hardware mechanisms upon which higher-level services can be built. Such low-level mechanisms are usually very specific, have very limited functionality, and are optimized for performance. For example, once access rights to a portion of memory is granted, many systems use hardware mechanisms to ensure that all further accesses involve the correct memory address and access mode. Application of this principle reinforces the need to design security into the system from the ground up and to incorporate simple mechanisms at the lower layers that can be used as building blocks for higher-level mechanisms.

Related Controls: [SC-12](#), [SC-13](#), [SI-2](#), [SI-7](#).

(27) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [HUMAN FACTORED SECURITY](#)

Implement the security design principle of human factored security in [Assignment: organization-defined systems or system components].

Discussion: The principle of human factored security states that the user interface for security functions and supporting services is intuitive, user-friendly, and provides feedback for user actions that affect such policy and its enforcement. The mechanisms that enforce security policy are not intrusive to the user and are designed not to degrade user efficiency. Security policy enforcement mechanisms also provide the user with meaningful, clear, and relevant feedback and warnings when insecure choices are being made. Particular attention is given to interfaces through which personnel responsible for system administration and operation configure and set up the security policies. Ideally, these personnel are able to

understand the impact of their choices. Personnel with system administrative and operational responsibilities are able to configure systems before start-up and administer them during runtime with confidence that their intent is correctly mapped to the system's mechanisms. Security services, functions, and mechanisms do not impede or unnecessarily complicate the intended use of the system. There is a trade-off between system usability and the strictness necessary for security policy enforcement. If security mechanisms are frustrating or difficult to use, then users may disable them, avoid them, or use them in ways inconsistent with the security requirements and protection needs that the mechanisms were designed to satisfy.

Related Controls: None.

(28) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [ACCEPTABLE SECURITY](#)

Implement the security design principle of acceptable security in [Assignment: organization-defined systems or system components].

Discussion: The principle of acceptable security requires that the level of privacy and performance that the system provides is consistent with the users' expectations. The perception of personal privacy may affect user behavior, morale, and effectiveness. Based on the organizational privacy policy and the system design, users should be able to restrict their actions to protect their privacy. When systems fail to provide intuitive interfaces or meet privacy and performance expectations, users may either choose to completely avoid the system or use it in ways that may be inefficient or even insecure.

Related Controls: None.

(29) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [REPEATABLE AND DOCUMENTED PROCEDURES](#)

Implement the security design principle of repeatable and documented procedures in [Assignment: organization-defined systems or system components].

Discussion: The principle of repeatable and documented procedures states that the techniques and methods employed to construct a system component permit the same component to be completely and correctly reconstructed at a later time. Repeatable and documented procedures support the development of a component that is identical to the component created earlier, which may be in widespread use. In the case of other system artifacts (e.g., documentation and testing results), repeatability supports consistency and the ability to inspect the artifacts. Repeatable and documented procedures can be introduced at various stages within the system development life cycle and contribute to the ability to evaluate assurance claims for the system. Examples include systematic procedures for code development and review, procedures for the configuration management of development tools and system artifacts, and procedures for system delivery.

Related Controls: [CM-1](#), [SA-1](#), [SA-10](#), [SA-11](#), [SA-15](#), [SA-17](#), [SC-1](#), [SI-1](#).

(30) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [PROCEDURAL RIGOR](#)

Implement the security design principle of procedural rigor in [Assignment: organization-defined systems or system components].

Discussion: The principle of procedural rigor states that the rigor of a system life cycle process is commensurate with its intended trustworthiness. Procedural rigor defines the scope, depth, and detail of the system life cycle procedures. Rigorous system life cycle procedures contribute to the assurance that the system is correct and free of unintended functionality in several ways. First, the procedures impose checks and balances on the life cycle process such that the introduction of unspecified functionality is prevented.

Second, rigorous procedures applied to systems security engineering activities that produce specifications and other system design documents contribute to the ability to understand

the system as it has been built rather than trusting that the component, as implemented, is the authoritative (and potentially misleading) specification.

Finally, modifications to an existing system component are easier when there are detailed specifications that describe its current design instead of studying source code or schematics to try to understand how it works. Procedural rigor helps ensure that security functional and assurance requirements have been satisfied, and it contributes to a better-informed basis for the determination of trustworthiness and risk posture. Procedural rigor is commensurate with the degree of assurance desired for the system. If the required trustworthiness of the system is low, a high level of procedural rigor may add unnecessary cost, whereas when high trustworthiness is critical, the cost of high procedural rigor is merited.

Related Controls: None.

(31) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [SECURE SYSTEM MODIFICATION](#)

Implement the security design principle of secure system modification in [Assignment: organization-defined systems or system components].

Discussion: The principle of secure system modification states that system modification maintains system security with respect to the security requirements and risk tolerance of stakeholders. Upgrades or modifications to systems can transform secure systems into systems that are not secure. The procedures for system modification ensure that if the system is to maintain its trustworthiness, the same rigor that was applied to its initial development is applied to any system changes. Because modifications can affect the ability of the system to maintain its secure state, a careful security analysis of the modification is needed prior to its implementation and deployment. This principle parallels the principle of secure evolvability.

Related Controls: [CM-3](#), [CM-4](#).

(32) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [SUFFICIENT DOCUMENTATION](#)

Implement the security design principle of sufficient documentation in [Assignment: organization-defined systems or system components].

Discussion: The principle of sufficient documentation states that organizational personnel with responsibilities to interact with the system are provided with adequate documentation and other information such that the personnel contribute to rather than detract from system security. Despite attempts to comply with principles such as human factored security and acceptable security, systems are inherently complex, and the design intent for the use of security mechanisms and the ramifications of the misuse or misconfiguration of security mechanisms are not always intuitively obvious. Uninformed and insufficiently trained users can introduce vulnerabilities due to errors of omission and commission. The availability of documentation and training can help to ensure a knowledgeable cadre of personnel, all of whom have a critical role in the achievement of principles such as continuous protection. Documentation is written clearly and supported by training that provides security awareness and understanding of security-relevant responsibilities.

Related Controls: [AT-2](#), [AT-3](#), [SA-5](#).

(33) SECURITY AND PRIVACY ENGINEERING PRINCIPLES | [MINIMIZATION](#)

Implement the privacy principle of minimization using [Assignment: organization-defined processes].

Discussion: The principle of minimization states that organizations should only process personally identifiable information that is directly relevant and necessary to accomplish an authorized purpose and should only maintain personally identifiable information for as long as is necessary to accomplish the purpose. Organizations have processes in place, consistent with applicable laws and policies, to implement the principle of minimization.

Related Controls: [PE-8](#), [PM-25](#), [SC-42](#), [SI-12](#).

References: [\[PRIVACT\]](#), [\[OMB A-130\]](#), [\[FIPS 199\]](#), [\[FIPS 200\]](#), [\[SP 800-37\]](#), [\[SP 800-53A\]](#), [\[SP 800-60-1\]](#), [\[SP 800-60-2\]](#), [\[SP 800-160-1\]](#), [\[IR 8062\]](#).

[SA-9](#) EXTERNAL SYSTEM SERVICES

Control:

- a. Require that providers of external system services comply with organizational security and privacy requirements and employ the following controls: *[Assignment: organization-defined controls]*;
- b. Define and document organizational oversight and user roles and responsibilities with regard to external system services; and
- c. Employ the following processes, methods, and techniques to monitor control compliance by external service providers on an ongoing basis: *[Assignment: organization-defined processes, methods, and techniques]*.

Discussion: External system services are provided by an external provider, and the organization has no direct control over the implementation of the required controls or the assessment of control effectiveness. Organizations establish relationships with external service providers in a variety of ways, including through business partnerships, contracts, interagency agreements, lines of business arrangements, licensing agreements, joint ventures, and supply chain exchanges. The responsibility for managing risks from the use of external system services remains with authorizing officials. For services external to organizations, a chain of trust requires that organizations establish and retain a certain level of confidence that each provider in the consumer-provider relationship provides adequate protection for the services rendered. The extent and nature of this chain of trust vary based on relationships between organizations and the external providers. Organizations document the basis for the trust relationships so that the relationships can be monitored. External system services documentation includes government, service providers, end user security roles and responsibilities, and service-level agreements. Service-level agreements define the expectations of performance for implemented controls, describe measurable outcomes, and identify remedies and response requirements for identified instances of noncompliance.

Related Controls: [AC-20](#), [CA-3](#), [CP-2](#), [IR-4](#), [IR-7](#), [PL-10](#), [PL-11](#), [PS-7](#), [SA-2](#), [SA-4](#), [SR-3](#), [SR-5](#).

Control Enhancements:

(1) EXTERNAL SYSTEM SERVICES | [RISK ASSESSMENTS AND ORGANIZATIONAL APPROVALS](#)

- (a) **Conduct an organizational assessment of risk prior to the acquisition or outsourcing of information security services; and**
- (b) **Verify that the acquisition or outsourcing of dedicated information security services is approved by *[Assignment: organization-defined personnel or roles]*.**

Discussion: Information security services include the operation of security devices, such as firewalls or key management services as well as incident monitoring, analysis, and response. Risks assessed can include system, mission or business, security, privacy, or supply chain risks.

Related Controls: [CA-6](#), [RA-3](#), [RA-8](#).

(2) EXTERNAL SYSTEM SERVICES | [IDENTIFICATION OF FUNCTIONS, PORTS, PROTOCOLS, AND SERVICES](#)

Require providers of the following external system services to identify the functions, ports, protocols, and other services required for the use of such services: *[Assignment: organization-defined external system services]*.

Discussion: Information from external service providers regarding the specific functions, ports, protocols, and services used in the provision of such services can be useful when the need arises to understand the trade-offs involved in restricting certain functions and services or blocking certain ports and protocols.

Related Controls: [CM-6](#), [CM-7](#).

(3) EXTERNAL SYSTEM SERVICES | [ESTABLISH AND MAINTAIN TRUST RELATIONSHIP WITH PROVIDERS](#)

Establish, document, and maintain trust relationships with external service providers based on the following requirements, properties, factors, or conditions: [Assignment: *organization-defined security and privacy requirements, properties, factors, or conditions defining acceptable trust relationships*].

Discussion: Trust relationships between organizations and external service providers reflect the degree of confidence that the risk from using external services is at an acceptable level. Trust relationships can help organizations gain increased levels of confidence that service providers are providing adequate protection for the services rendered and can also be useful when conducting incident response or when planning for upgrades or obsolescence. Trust relationships can be complicated due to the potentially large number of entities participating in the consumer-provider interactions, subordinate relationships and levels of trust, and types of interactions between the parties. In some cases, the degree of trust is based on the level of control that organizations can exert on external service providers regarding the controls necessary for the protection of the service, information, or individual privacy and the evidence brought forth as to the effectiveness of the implemented controls. The level of control is established by the terms and conditions of the contracts or service-level agreements.

Related Controls: [SR-2](#).

(4) EXTERNAL SYSTEM SERVICES | [CONSISTENT INTERESTS OF CONSUMERS AND PROVIDERS](#)

Take the following actions to verify that the interests of [Assignment: organization-defined external service providers] are consistent with and reflect organizational interests: [Assignment: organization-defined actions].

Discussion: As organizations increasingly use external service providers, it is possible that the interests of the service providers may diverge from organizational interests. In such situations, simply having the required technical, management, or operational controls in place may not be sufficient if the providers that implement and manage those controls are not operating in a manner consistent with the interests of the consuming organizations. Actions that organizations take to address such concerns include requiring background checks for selected service provider personnel; examining ownership records; employing only trustworthy service providers, such as providers with which organizations have had successful trust relationships; and conducting routine, periodic, unscheduled visits to service provider facilities.

Related Controls: None.

(5) EXTERNAL SYSTEM SERVICES | [PROCESSING, STORAGE, AND SERVICE LOCATION](#)

Restrict the location of [Selection (one or more): information processing; information or data; system services] to [Assignment: organization-defined locations] based on [Assignment: organization-defined requirements or conditions].

Discussion: The location of information processing, information and data storage, or system services can have a direct impact on the ability of organizations to successfully execute their mission and business functions. The impact occurs when external providers control the location of processing, storage, or services. The criteria that external providers use for the selection of processing, storage, or service locations may be different from the criteria that organizations use. For example, organizations may desire that data or information storage

locations be restricted to certain locations to help facilitate incident response activities in case of information security incidents or breaches. Incident response activities, including forensic analyses and after-the-fact investigations, may be adversely affected by the governing laws, policies, or protocols in the locations where processing and storage occur and/or the locations from which system services emanate.

Related Controls: [SA-5](#), [SR-4](#).

(6) EXTERNAL SYSTEM SERVICES | [ORGANIZATION-CONTROLLED CRYPTOGRAPHIC KEYS](#)

Maintain exclusive control of cryptographic keys for encrypted material stored or transmitted through an external system.

Discussion: Maintaining exclusive control of cryptographic keys in an external system prevents decryption of organizational data by external system staff. Organizational control of cryptographic keys can be implemented by encrypting and decrypting data inside the organization as data is sent to and received from the external system or by employing a component that permits encryption and decryption functions to be local to the external system but allows exclusive organizational access to the encryption keys.

Related Controls: [SC-12](#), [SC-13](#), [SI-4](#).

(7) EXTERNAL SYSTEM SERVICES | [ORGANIZATION-CONTROLLED INTEGRITY CHECKING](#)

Provide the capability to check the integrity of information while it resides in the external system.

Discussion: Storage of organizational information in an external system could limit visibility into the security status of its data. The ability of the organization to verify and validate the integrity of its stored data without transferring it out of the external system provides such visibility.

Related Controls: [SI-7](#).

(8) EXTERNAL SYSTEM SERVICES | [PROCESSING AND STORAGE LOCATION — U.S. JURISDICTION](#)

Restrict the geographic location of information processing and data storage to facilities located within in the legal jurisdictional boundary of the United States.

Discussion: The geographic location of information processing and data storage can have a direct impact on the ability of organizations to successfully execute their mission and business functions. A compromise or breach of high impact information and systems can have severe or catastrophic adverse impacts on organizational assets and operations, individuals, other organizations, and the Nation. Restricting the processing and storage of high-impact information to facilities within the legal jurisdictional boundary of the United States provides greater control over such processing and storage.

Related Controls: [SA-5](#), [SR-4](#).

References: [\[OMB A-130\]](#), [\[SP 800-35\]](#), [\[SP 800-160-1\]](#), [\[SP 800-161\]](#), [\[SP 800-171\]](#).

SA-10 DEVELOPER CONFIGURATION MANAGEMENT

Control: Require the developer of the system, system component, or system service to:

- a. Perform configuration management during system, component, or service [*Selection (one or more): design; development; implementation; operation; disposal*];
- b. Document, manage, and control the integrity of changes to [*Assignment: organization-defined configuration items under configuration management*];
- c. Implement only organization-approved changes to the system, component, or service;

- d. Document approved changes to the system, component, or service and the potential security and privacy impacts of such changes; and
- e. Track security flaws and flaw resolution within the system, component, or service and report findings to [Assignment: organization-defined personnel].

Discussion: Organizations consider the quality and completeness of configuration management activities conducted by developers as direct evidence of applying effective security controls. Controls include protecting the master copies of material used to generate security-relevant portions of the system hardware, software, and firmware from unauthorized modification or destruction. Maintaining the integrity of changes to the system, system component, or system service requires strict configuration control throughout the system development life cycle to track authorized changes and prevent unauthorized changes.

The configuration items that are placed under configuration management include the formal model; the functional, high-level, and low-level design specifications; other design data; implementation documentation; source code and hardware schematics; the current running version of the object code; tools for comparing new versions of security-relevant hardware descriptions and source code with previous versions; and test fixtures and documentation. Depending on the mission and business needs of organizations and the nature of the contractual relationships in place, developers may provide configuration management support during the operations and maintenance stage of the system development life cycle.

Related Controls: [CM-2](#), [CM-3](#), [CM-4](#), [CM-7](#), [CM-9](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-15](#), [SI-2](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-6](#).

Control Enhancements:

(1) DEVELOPER CONFIGURATION MANAGEMENT | [SOFTWARE AND FIRMWARE INTEGRITY VERIFICATION](#)

Require the developer of the system, system component, or system service to enable integrity verification of software and firmware components.

Discussion: Software and firmware integrity verification allows organizations to detect unauthorized changes to software and firmware components using developer-provided tools, techniques, and mechanisms. The integrity checking mechanisms can also address counterfeiting of software and firmware components. Organizations verify the integrity of software and firmware components, for example, through secure one-way hashes provided by developers. Delivered software and firmware components also include any updates to such components.

Related Controls: [SI-7](#), [SR-11](#).

(2) DEVELOPER CONFIGURATION MANAGEMENT | [ALTERNATIVE CONFIGURATION MANAGEMENT PROCESSES](#)

Provide an alternate configuration management process using organizational personnel in the absence of a dedicated developer configuration management team.

Discussion: Alternate configuration management processes may be required when organizations use commercial off-the-shelf information technology products. Alternate configuration management processes include organizational personnel who review and approve proposed changes to systems, system components, and system services and conduct security and privacy impact analyses prior to the implementation of changes to systems, components, or services.

Related Controls: None.

(3) DEVELOPER CONFIGURATION MANAGEMENT | [HARDWARE INTEGRITY VERIFICATION](#)

Require the developer of the system, system component, or system service to enable integrity verification of hardware components.

Discussion: Hardware integrity verification allows organizations to detect unauthorized changes to hardware components using developer-provided tools, techniques, methods, and mechanisms. Organizations may verify the integrity of hardware components with hard-to-copy labels, verifiable serial numbers provided by developers, and by requiring the use of anti-tamper technologies. Delivered hardware components also include hardware and firmware updates to such components.

Related Controls: [SI-7](#).

(4) DEVELOPER CONFIGURATION MANAGEMENT | [TRUSTED GENERATION](#)

Require the developer of the system, system component, or system service to employ tools for comparing newly generated versions of security-relevant hardware descriptions, source code, and object code with previous versions.

Discussion: The trusted generation of descriptions, source code, and object code addresses authorized changes to hardware, software, and firmware components between versions during development. The focus is on the efficacy of the configuration management process by the developer to ensure that newly generated versions of security-relevant hardware descriptions, source code, and object code continue to enforce the security policy for the system, system component, or system service. In contrast, [SA-10\(1\)](#) and [SA-10\(3\)](#) allow organizations to detect unauthorized changes to hardware, software, and firmware components using tools, techniques, or mechanisms provided by developers.

Related Controls: None.

(5) DEVELOPER CONFIGURATION MANAGEMENT | [MAPPING INTEGRITY FOR VERSION CONTROL](#)

Require the developer of the system, system component, or system service to maintain the integrity of the mapping between the master build data describing the current version of security-relevant hardware, software, and firmware and the on-site master copy of the data for the current version.

Discussion: Mapping integrity for version control addresses changes to hardware, software, and firmware components during both initial development and system development life cycle updates. Maintaining the integrity between the master copies of security-relevant hardware, software, and firmware (including designs, hardware drawings, source code) and the equivalent data in master copies in operational environments is essential to ensuring the availability of organizational systems that support critical mission and business functions.

Related Controls: None.

(6) DEVELOPER CONFIGURATION MANAGEMENT | [TRUSTED DISTRIBUTION](#)

Require the developer of the system, system component, or system service to execute procedures for ensuring that security-relevant hardware, software, and firmware updates distributed to the organization are exactly as specified by the master copies.

Discussion: The trusted distribution of security-relevant hardware, software, and firmware updates help to ensure that the updates are correct representations of the master copies maintained by the developer and have not been tampered with during distribution.

Related Controls: None.

(7) DEVELOPER CONFIGURATION MANAGEMENT | [SECURITY AND PRIVACY REPRESENTATIVES](#)

Require [Assignment: organization-defined security and privacy representatives] to be included in the [Assignment: organization-defined configuration change management and control process].

Discussion: Information security and privacy representatives can include system security officers, senior agency information security officers, senior agency officials for privacy, and system privacy officers. Representation by personnel with information security and privacy

expertise is important because changes to system configurations can have unintended side effects, some of which may be security- or privacy-relevant. Detecting such changes early in the process can help avoid unintended, negative consequences that could ultimately affect the security and privacy posture of systems. The configuration change management and control process in this control enhancement refers to the change management and control process defined by organizations in [SA-10b](#).

Related Controls: None.

References: [[FIPS 140-3](#)], [[FIPS 180-4](#)], [[FIPS 202](#)], [[SP 800-128](#)], [[SP 800-160-1](#)].

[**SA-11 DEVELOPER TESTING AND EVALUATION**](#)

Control: Require the developer of the system, system component, or system service, at all post-design stages of the system development life cycle, to:

- a. Develop and implement a plan for ongoing security and privacy control assessments;
- b. Perform [*Selection (one or more): unit; integration; system; regression*] testing/evaluation [*Assignment: organization-defined frequency*] at [*Assignment: organization-defined depth and coverage*];
- c. Produce evidence of the execution of the assessment plan and the results of the testing and evaluation;
- d. Implement a verifiable flaw remediation process; and
- e. Correct flaws identified during testing and evaluation.

Discussion: Developmental testing and evaluation confirms that the required controls are implemented correctly, operating as intended, enforcing the desired security and privacy policies, and meeting established security and privacy requirements. Security properties of systems and the privacy of individuals may be affected by the interconnection of system components or changes to those components. The interconnections or changes—including upgrading or replacing applications, operating systems, and firmware—may adversely affect previously implemented controls. Ongoing assessment during development allows for additional types of testing and evaluation that developers can conduct to reduce or eliminate potential flaws. Testing custom software applications may require approaches such as manual code review, security architecture review, and penetration testing, as well as static analysis, dynamic analysis, binary analysis, or a hybrid of the three analysis approaches.

Developers can use the analysis approaches, along with security instrumentation and fuzzing, in a variety of tools and in source code reviews. The security and privacy assessment plans include the specific activities that developers plan to carry out, including the types of analyses, testing, evaluation, and reviews of software and firmware components; the degree of rigor to be applied; the frequency of the ongoing testing and evaluation; and the types of artifacts produced during those processes. The depth of testing and evaluation refers to the rigor and level of detail associated with the assessment process. The coverage of testing and evaluation refers to the scope (i.e., number and type) of the artifacts included in the assessment process. Contracts specify the acceptance criteria for security and privacy assessment plans, flaw remediation processes, and the evidence that the plans and processes have been diligently applied. Methods for reviewing and protecting assessment plans, evidence, and documentation are commensurate with the security category or classification level of the system. Contracts may specify protection requirements for documentation.

Related Controls: [CA-2](#), [CA-7](#), [CM-4](#), [SA-3](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-15](#), [SA-17](#), [SI-2](#), [SR-5](#), [SR-6](#), [SR-7](#).

Control Enhancements:

(1) DEVELOPER TESTING AND EVALUATION | [STATIC CODE ANALYSIS](#)

Require the developer of the system, system component, or system service to employ static code analysis tools to identify common flaws and document the results of the analysis.

Discussion: Static code analysis provides a technology and methodology for security reviews and includes checking for weaknesses in the code as well as for the incorporation of libraries or other included code with known vulnerabilities or that are out-of-date and not supported. Static code analysis can be used to identify vulnerabilities and enforce secure coding practices. It is most effective when used early in the development process, when each code change can automatically be scanned for potential weaknesses. Static code analysis can provide clear remediation guidance and identify defects for developers to fix. Evidence of the correct implementation of static analysis can include aggregate defect density for critical defect types, evidence that defects were inspected by developers or security professionals, and evidence that defects were remediated. A high density of ignored findings, commonly referred to as false positives, indicates a potential problem with the analysis process or the analysis tool. In such cases, organizations weigh the validity of the evidence against evidence from other sources.

Related Controls: None.

(2) DEVELOPER TESTING AND EVALUATION | [THREAT MODELING AND VULNERABILITY ANALYSES](#)

Require the developer of the system, system component, or system service to perform threat modeling and vulnerability analyses during development and the subsequent testing and evaluation of the system, component, or service that:

- (a) Uses the following contextual information: [Assignment: organization-defined information concerning impact, environment of operations, known or assumed threats, and acceptable risk levels];**
- (b) Employs the following tools and methods: [Assignment: organization-defined tools and methods];**
- (c) Conducts the modeling and analyses at the following level of rigor: [Assignment: organization-defined breadth and depth of modeling and analyses]; and**
- (d) Produces evidence that meets the following acceptance criteria: [Assignment: organization-defined acceptance criteria].**

Discussion: Systems, system components, and system services may deviate significantly from the functional and design specifications created during the requirements and design stages of the system development life cycle. Therefore, updates to threat modeling and vulnerability analyses of those systems, system components, and system services during development and prior to delivery are critical to the effective operation of those systems, components, and services. Threat modeling and vulnerability analyses at this stage of the system development life cycle ensure that design and implementation changes have been accounted for and that vulnerabilities created because of those changes have been reviewed and mitigated.

Related controls: [PM-15](#), [RA-3](#), [RA-5](#).

(3) DEVELOPER TESTING AND EVALUATION | [INDEPENDENT VERIFICATION OF ASSESSMENT PLANS AND EVIDENCE](#)

- (a) Require an independent agent satisfying [Assignment: organization-defined independence criteria] to verify the correct implementation of the developer security and privacy assessment plans and the evidence produced during testing and evaluation; and**

(b) Verify that the independent agent is provided with sufficient information to complete the verification process or granted the authority to obtain such information.

Discussion: Independent agents have the qualifications—including the expertise, skills, training, certifications, and experience—to verify the correct implementation of developer security and privacy assessment plans.

Related Controls: [AT-3](#), [RA-5](#).

(4) DEVELOPER TESTING AND EVALUATION | [MANUAL CODE REVIEWS](#)

Require the developer of the system, system component, or system service to perform a manual code review of [Assignment: organization-defined specific code] using the following processes, procedures, and/or techniques: [Assignment: organization-defined processes, procedures, and/or techniques].

Discussion: Manual code reviews are usually reserved for the critical software and firmware components of systems. Manual code reviews are effective at identifying weaknesses that require knowledge of the application's requirements or context that, in most cases, is unavailable to automated analytic tools and techniques, such as static and dynamic analysis. The benefits of manual code review include the ability to verify access control matrices against application controls and review detailed aspects of cryptographic implementations and controls.

Related Controls: None.

(5) DEVELOPER TESTING AND EVALUATION | [PENETRATION TESTING](#)

Require the developer of the system, system component, or system service to perform penetration testing:

- (a) At the following level of rigor: [Assignment: organization-defined breadth and depth of testing]; and**
- (b) Under the following constraints: [Assignment: organization-defined constraints].**

Discussion: Penetration testing is an assessment methodology in which assessors, using all available information technology product or system documentation and working under specific constraints, attempt to circumvent the implemented security and privacy features of information technology products and systems. Useful information for assessors who conduct penetration testing includes product and system design specifications, source code, and administrator and operator manuals. Penetration testing can include white-box, gray-box, or black-box testing with analyses performed by skilled professionals who simulate adversary actions. The objective of penetration testing is to discover vulnerabilities in systems, system components, and services that result from implementation errors, configuration faults, or other operational weaknesses or deficiencies. Penetration tests can be performed in conjunction with automated and manual code reviews to provide a greater level of analysis than would ordinarily be possible. When user session information and other personally identifiable information is captured or recorded during penetration testing, such information is handled appropriately to protect privacy.

Related Controls: [CA-8](#), [PM-14](#), [PM-25](#), [PT-2](#), [SA-3](#), [SI-2](#), [SI-6](#).

(6) DEVELOPER TESTING AND EVALUATION | [ATTACK SURFACE REVIEWS](#)

Require the developer of the system, system component, or system service to perform attack surface reviews.

Discussion: Attack surfaces of systems and system components are exposed areas that make those systems more vulnerable to attacks. Attack surfaces include any accessible areas where weaknesses or deficiencies in the hardware, software, and firmware components provide opportunities for adversaries to exploit vulnerabilities. Attack surface reviews ensure that developers analyze the design and implementation changes to systems and

mitigate attack vectors generated as a result of the changes. The correction of identified flaws includes deprecation of unsafe functions.

Related Controls: [SA-15](#).

(7) DEVELOPER TESTING AND EVALUATION | [VERIFY SCOPE OF TESTING AND EVALUATION](#)

Require the developer of the system, system component, or system service to verify that the scope of testing and evaluation provides complete coverage of the required controls at the following level of rigor: [Assignment: organization-defined breadth and depth of testing and evaluation].

Discussion: Verifying that testing and evaluation provides complete coverage of required controls can be accomplished by a variety of analytic techniques ranging from informal to formal. Each of these techniques provides an increasing level of assurance that corresponds to the degree of formality of the analysis. Rigorously demonstrating control coverage at the highest levels of assurance can be achieved using formal modeling and analysis techniques, including correlation between control implementation and corresponding test cases.

Related Controls: [SA-15](#).

(8) DEVELOPER TESTING AND EVALUATION | [DYNAMIC CODE ANALYSIS](#)

Require the developer of the system, system component, or system service to employ dynamic code analysis tools to identify common flaws and document the results of the analysis.

Discussion: Dynamic code analysis provides runtime verification of software programs using tools capable of monitoring programs for memory corruption, user privilege issues, and other potential security problems. Dynamic code analysis employs runtime tools to ensure that security functionality performs in the way it was designed. A type of dynamic analysis, known as fuzz testing, induces program failures by deliberately introducing malformed or random data into software programs. Fuzz testing strategies are derived from the intended use of applications and the functional and design specifications for the applications. To understand the scope of dynamic code analysis and the assurance provided, organizations may also consider conducting code coverage analysis (i.e., checking the degree to which the code has been tested using metrics such as percent of subroutines tested or percent of program statements called during execution of the test suite) and/or concordance analysis (i.e., checking for words that are out of place in software code, such as non-English language words or derogatory terms).

Related Controls: None.

(9) DEVELOPER TESTING AND EVALUATION | [INTERACTIVE APPLICATION SECURITY TESTING](#)

Require the developer of the system, system component, or system service to employ interactive application security testing tools to identify flaws and document the results.

Discussion: Interactive (also known as instrumentation-based) application security testing is a method of detecting vulnerabilities by observing applications as they run during testing. The use of instrumentation relies on direct measurements of the actual running applications and uses access to the code, user interaction, libraries, frameworks, backend connections, and configurations to directly measure control effectiveness. When combined with analysis techniques, interactive application security testing can identify a broad range of potential vulnerabilities and confirm control effectiveness. Instrumentation-based testing works in real time and can be used continuously throughout the system development life cycle.

Related Controls: None.

References: [\[ISO 15408-3\]](#), [\[SP 800-30\]](#), [\[SP 800-53A\]](#), [\[SP 800-154\]](#), [\[SP 800-160-1\]](#).

SA-12 SUPPLY CHAIN PROTECTION

[Withdrawn: Incorporated into [SR Family](#).]

Control Enhancements:

- (1) SUPPLY CHAIN PROTECTION | ACQUISITION STRATEGIES / TOOLS / METHODS
[Withdrawn: Moved to [SR-5](#).]
- (2) SUPPLY CHAIN PROTECTION | SUPPLIER REVIEWS
[Withdrawn: Moved to [SR-6](#).]
- (3) SUPPLY CHAIN PROTECTION | TRUSTED SHIPPING AND WAREHOUSING
[Withdrawn: Incorporated into [SR-3](#).]
- (4) SUPPLY CHAIN PROTECTION | DIVERSITY OF SUPPLIERS
[Withdrawn: Moved to [SR-3\(1\)](#).]
- (5) SUPPLY CHAIN PROTECTION | LIMITATION OF HARM
[Withdrawn: Moved to [SR-3\(2\)](#).]
- (6) SUPPLY CHAIN PROTECTION | MINIMIZING PROCUREMENT TIME
[Withdrawn: Incorporated into [SR-5\(1\)](#).]
- (7) SUPPLY CHAIN PROTECTION | ASSESSMENTS PRIOR TO SELECTION / ACCEPTANCE / UPDATE
[Withdrawn: Moved to [SR-5\(2\)](#).]
- (8) SUPPLY CHAIN PROTECTION | USE OF ALL-SOURCE INTELLIGENCE
[Withdrawn: Incorporated into [RA-3\(2\)](#).]
- (9) SUPPLY CHAIN PROTECTION | OPERATIONS SECURITY
[Withdrawn: Moved to [SR-7](#).]
- (10) SUPPLY CHAIN PROTECTION | VALIDATE AS GENUINE AND NOT ALTERED
[Withdrawn: Moved to [SR-4\(3\)](#).]
- (11) SUPPLY CHAIN PROTECTION | PENETRATION TESTING / ANALYSIS OF ELEMENTS, PROCESSES, AND ACTORS
[Withdrawn: Moved to [SR-6\(1\)](#).]
- (12) SUPPLY CHAIN PROTECTION | INTER-ORGANIZATIONAL AGREEMENTS
[Withdrawn: Moved to [SR-8](#).]
- (13) SUPPLY CHAIN PROTECTION | CRITICAL INFORMATION SYSTEM COMPONENTS
[Withdrawn: Incorporated into [MA-6](#) and [RA-9](#).]
- (14) SUPPLY CHAIN PROTECTION | IDENTITY AND TRACEABILITY
[Withdrawn: Moved to [SR-4\(1\)](#) and [SR-4\(2\)](#).]
- (15) SUPPLY CHAIN PROTECTION | PROCESSES TO ADDRESS WEAKNESSES OR DEFICIENCIES
[Withdrawn: Incorporated into [SR-3](#).]

SA-13 TRUSTWORTHINESS

[Withdrawn: Incorporated into [SA-8](#).]

SA-14 CRITICALITY ANALYSIS

[Withdrawn: Incorporated into [RA-9](#).]

Control Enhancements:

(1) CRITICALITY ANALYSIS | CRITICAL COMPONENTS WITH NO VIABLE ALTERNATIVE SOURCING

[Withdrawn: Incorporated into [SA-20](#).]

SA-15 DEVELOPMENT PROCESS, STANDARDS, AND TOOLS

Control:

- a. Require the developer of the system, system component, or system service to follow a documented development process that:
 1. Explicitly addresses security and privacy requirements;
 2. Identifies the standards and tools used in the development process;
 3. Documents the specific tool options and tool configurations used in the development process; and
 4. Documents, manages, and ensures the integrity of changes to the process and/or tools used in development; and
- b. Review the development process, standards, tools, tool options, and tool configurations [Assignment: organization-defined frequency] to determine if the process, standards, tools, tool options and tool configurations selected and employed can satisfy the following security and privacy requirements: [Assignment: organization-defined security and privacy requirements].

Discussion: Development tools include programming languages and computer-aided design systems. Reviews of development processes include the use of maturity models to determine the potential effectiveness of such processes. Maintaining the integrity of changes to tools and processes facilitates effective supply chain risk assessment and mitigation. Such integrity requires configuration control throughout the system development life cycle to track authorized changes and prevent unauthorized changes.

Related Controls: [MA-6](#), [SA-3](#), [SA-4](#), [SA-8](#), [SA-10](#), [SA-11](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-6](#), [SR-9](#).

Control Enhancements:

(1) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [QUALITY METRICS](#)

Require the developer of the system, system component, or system service to:

- (a) Define quality metrics at the beginning of the development process; and
- (b) Provide evidence of meeting the quality metrics [Selection (one or more):
[Assignment: organization-defined frequency]; [Assignment: organization-defined program review milestones]; upon delivery].

Discussion: Organizations use quality metrics to establish acceptable levels of system quality. Metrics can include quality gates, which are collections of completion criteria or sufficiency standards that represent the satisfactory execution of specific phases of the system development project. For example, a quality gate may require the elimination of all compiler warnings or a determination that such warnings have no impact on the effectiveness of required security or privacy capabilities. During the execution phases of development projects, quality gates provide clear, unambiguous indications of progress. Other metrics apply to the entire development project. Metrics can include defining the severity thresholds of vulnerabilities in accordance with organizational risk tolerance, such

as requiring no known vulnerabilities in the delivered system with a Common Vulnerability Scoring System (CVSS) severity of medium or high.

Related Controls: None.

(2) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [SECURITY AND PRIVACY TRACKING TOOLS](#)

Require the developer of the system, system component, or system service to select and employ security and privacy tracking tools for use during the development process.

Discussion: System development teams select and deploy security and privacy tracking tools, including vulnerability or work item tracking systems that facilitate assignment, sorting, filtering, and tracking of completed work items or tasks associated with development processes.

Related Controls: [SA-11](#).

(3) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [CRITICALITY ANALYSIS](#)

Require the developer of the system, system component, or system service to perform a criticality analysis:

- (a) At the following decision points in the system development life cycle: [Assignment: organization-defined decision points in the system development life cycle]; and**
- (b) At the following level of rigor: [Assignment: organization-defined breadth and depth of criticality analysis].**

Discussion: Criticality analysis performed by the developer provides input to the criticality analysis performed by organizations. Developer input is essential to organizational criticality analysis because organizations may not have access to detailed design documentation for system components that are developed as commercial off-the-shelf products. Such design documentation includes functional specifications, high-level designs, low-level designs, source code, and hardware schematics. Criticality analysis is important for organizational systems that are designated as high value assets. High value assets can be moderate- or high-impact systems due to heightened adversarial interest or potential adverse effects on the federal enterprise. Developer input is especially important when organizations conduct supply chain criticality analyses.

Related Controls: [RA-9](#).

(4) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | THREAT MODELING AND VULNERABILITY ANALYSIS

[Withdrawn: Incorporated into [SA-11\(2\)](#).]

(5) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [ATTACK SURFACE REDUCTION](#)

Require the developer of the system, system component, or system service to reduce attack surfaces to [Assignment: organization-defined thresholds].

Discussion: Attack surface reduction is closely aligned with threat and vulnerability analyses and system architecture and design. Attack surface reduction is a means of reducing risk to organizations by giving attackers less opportunity to exploit weaknesses or deficiencies (i.e., potential vulnerabilities) within systems, system components, and system services. Attack surface reduction includes implementing the concept of layered defenses, applying the principles of least privilege and least functionality, applying secure software development practices, deprecating unsafe functions, reducing entry points available to unauthorized users, reducing the amount of code that executes, and eliminating application programming interfaces (APIs) that are vulnerable to attacks.

Related Controls: [AC-6](#), [CM-7](#), [RA-3](#), [SA-11](#).

(6) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [CONTINUOUS IMPROVEMENT](#)

Require the developer of the system, system component, or system service to implement an explicit process to continuously improve the development process.

Discussion: Developers of systems, system components, and system services consider the effectiveness and efficiency of their development processes for meeting quality objectives and addressing the security and privacy capabilities in current threat environments.

Related Controls: None.

(7) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [AUTOMATED VULNERABILITY ANALYSIS](#)

Require the developer of the system, system component, or system service [Assignment: organization-defined frequency] to:

- (a) Perform an automated vulnerability analysis using [Assignment: organization-defined tools];**
- (b) Determine the exploitation potential for discovered vulnerabilities;**
- (c) Determine potential risk mitigations for delivered vulnerabilities; and**
- (d) Deliver the outputs of the tools and results of the analysis to [Assignment: organization-defined personnel or roles].**

Discussion: Automated tools can be more effective at analyzing exploitable weaknesses or deficiencies in large and complex systems, prioritizing vulnerabilities by severity, and providing recommendations for risk mitigations.

Related Controls: [RA-5](#), [SA-11](#).

(8) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [REUSE OF THREAT AND VULNERABILITY INFORMATION](#)

Require the developer of the system, system component, or system service to use threat modeling and vulnerability analyses from similar systems, components, or services to inform the current development process.

Discussion: Analysis of vulnerabilities found in similar software applications can inform potential design and implementation issues for systems under development. Similar systems or system components may exist within developer organizations. Vulnerability information is available from a variety of public and private sector sources, including the NIST National Vulnerability Database.

Related Controls: None.

(9) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | USE OF LIVE DATA

[Withdrawn: Incorporated into [SA-3\(2\)](#).]

(10) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [INCIDENT RESPONSE PLAN](#)

Require the developer of the system, system component, or system service to provide, implement, and test an incident response plan.

Discussion: The incident response plan provided by developers may provide information not readily available to organizations and be incorporated into organizational incident response plans. Developer information may also be extremely helpful, such as when organizations respond to vulnerabilities in commercial off-the-shelf products.

Related Controls: [IR-8](#).

(11) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [ARCHIVE SYSTEM OR COMPONENT](#)

Require the developer of the system or system component to archive the system or component to be released or delivered together with the corresponding evidence supporting the final security and privacy review.

Discussion: Archiving system or system components requires the developer to retain key development artifacts, including hardware specifications, source code, object code, and relevant documentation from the development process that can provide a readily available configuration baseline for system and component upgrades or modifications.

Related Controls: [CM-2](#).

(12) DEVELOPMENT PROCESS, STANDARDS, AND TOOLS | [MINIMIZE PERSONALLY IDENTIFIABLE INFORMATION](#)

Require the developer of the system or system component to minimize the use of personally identifiable information in development and test environments.

Discussion: Organizations can minimize the risk to an individual's privacy by using techniques such as de-identification or synthetic data. Limiting the use of personally identifiable information in development and test environments helps reduce the level of privacy risk created by a system.

Related Controls: [PM-25](#), [SA-3](#), [SA-8](#).

References: [\[SP 800-160-1\]](#), [\[IR 8179\]](#).

[SA-16](#) DEVELOPER-PROVIDED TRAINING

Control: Require the developer of the system, system component, or system service to provide the following training on the correct use and operation of the implemented security and privacy functions, controls, and/or mechanisms: [Assignment: organization-defined training].

Discussion: Developer-provided training applies to external and internal (in-house) developers. Training personnel is essential to ensuring the effectiveness of the controls implemented within organizational systems. Types of training include web-based and computer-based training, classroom-style training, and hands-on training (including micro-training). Organizations can also request training materials from developers to conduct in-house training or offer self-training to organizational personnel. Organizations determine the type of training necessary and may require different types of training for different security and privacy functions, controls, and mechanisms.

Related Controls: [AT-2](#), [AT-3](#), [PE-3](#), [SA-4](#), [SA-5](#).

Control Enhancements: None.

References: None.

[SA-17](#) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN

Control: Require the developer of the system, system component, or system service to produce a design specification and security and privacy architecture that:

- a. Is consistent with the organization's security and privacy architecture that is an integral part of the organization's enterprise architecture;
- b. Accurately and completely describes the required security and privacy functionality, and the allocation of controls among physical and logical components; and
- c. Expresses how individual security and privacy functions, mechanisms, and services work together to provide required security and privacy capabilities and a unified approach to protection.

Discussion: Developer security and privacy architecture and design are directed at external developers, although they could also be applied to internal (in-house) development. In contrast, [PL-8](#) is directed at internal developers to ensure that organizations develop a security and privacy

architecture that is integrated with the enterprise architecture. The distinction between SA-17 and [PL-8](#) is especially important when organizations outsource the development of systems, system components, or system services and when there is a requirement to demonstrate consistency with the enterprise architecture and security and privacy architecture of the organization. [\[ISO 15408-2\]](#), [\[ISO 15408-3\]](#), and [\[SP 800-160-1\]](#) provide information on security architecture and design, including formal policy models, security-relevant components, formal and informal correspondence, conceptually simple design, and structuring for least privilege and testing.

Related Controls: [PL-2](#), [PL-8](#), [PM-7](#), [SA-3](#), [SA-4](#), [SA-8](#), [SC-7](#).

Control Enhancements:

(1) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [FORMAL POLICY MODEL](#)

Require the developer of the system, system component, or system service to:

- (a) Produce, as an integral part of the development process, a formal policy model describing the [Assignment: organization-defined elements of organizational security and privacy policy] to be enforced; and**
- (b) Prove that the formal policy model is internally consistent and sufficient to enforce the defined elements of the organizational security and privacy policy when implemented.**

Discussion: Formal models describe specific behaviors or security and privacy policies using formal languages, thus enabling the correctness of those behaviors and policies to be formally proven. Not all components of systems can be modeled. Generally, formal specifications are scoped to the behaviors or policies of interest, such as nondiscretionary access control policies. Organizations choose the formal modeling language and approach based on the nature of the behaviors and policies to be described and the available tools.

Related Controls: [AC-3](#), [AC-4](#), [AC-25](#).

(2) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [SECURITY-RELEVANT COMPONENTS](#)

Require the developer of the system, system component, or system service to:

- (a) Define security-relevant hardware, software, and firmware; and**
- (b) Provide a rationale that the definition for security-relevant hardware, software, and firmware is complete.**

Discussion: The security-relevant hardware, software, and firmware represent the portion of the system, component, or service that is trusted to perform correctly to maintain required security properties.

Related Controls: [AC-25](#), [SA-5](#).

(3) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [FORMAL CORRESPONDENCE](#)

Require the developer of the system, system component, or system service to:

- (a) Produce, as an integral part of the development process, a formal top-level specification that specifies the interfaces to security-relevant hardware, software, and firmware in terms of exceptions, error messages, and effects;**
- (b) Show via proof to the extent feasible with additional informal demonstration as necessary, that the formal top-level specification is consistent with the formal policy model;**
- (c) Show via informal demonstration, that the formal top-level specification completely covers the interfaces to security-relevant hardware, software, and firmware;**

- (d) Show that the formal top-level specification is an accurate description of the implemented security-relevant hardware, software, and firmware; and
- (e) Describe the security-relevant hardware, software, and firmware mechanisms not addressed in the formal top-level specification but strictly internal to the security-relevant hardware, software, and firmware.

Discussion: Correspondence is an important part of the assurance gained through modeling. It demonstrates that the implementation is an accurate transformation of the model, and that any additional code or implementation details that are present have no impact on the behaviors or policies being modeled. Formal methods can be used to show that the high-level security properties are satisfied by the formal system description, and that the formal system description is correctly implemented by a description of some lower level, including a hardware description. Consistency between the formal top-level specification and the formal policy models is generally not amenable to being fully proven. Therefore, a combination of formal and informal methods may be needed to demonstrate such consistency. Consistency between the formal top-level specification and the actual implementation may require the use of an informal demonstration due to limitations on the applicability of formal methods to prove that the specification accurately reflects the implementation. Hardware, software, and firmware mechanisms internal to security-relevant components include mapping registers and direct memory input and output.

Related Controls: [AC-3](#), [AC-4](#), [AC-25](#), [SA-4](#), [SA-5](#).

(4) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [INFORMAL CORRESPONDENCE](#)

Require the developer of the system, system component, or system service to:

- (a) Produce, as an integral part of the development process, an informal descriptive top-level specification that specifies the interfaces to security-relevant hardware, software, and firmware in terms of exceptions, error messages, and effects;
- (b) Show via [*Selection: informal demonstration; convincing argument with formal methods as feasible*] that the descriptive top-level specification is consistent with the formal policy model;
- (c) Show via informal demonstration, that the descriptive top-level specification completely covers the interfaces to security-relevant hardware, software, and firmware;
- (d) Show that the descriptive top-level specification is an accurate description of the interfaces to security-relevant hardware, software, and firmware; and
- (e) Describe the security-relevant hardware, software, and firmware mechanisms not addressed in the descriptive top-level specification but strictly internal to the security-relevant hardware, software, and firmware.

Discussion: Correspondence is an important part of the assurance gained through modeling. It demonstrates that the implementation is an accurate transformation of the model, and that additional code or implementation detail has no impact on the behaviors or policies being modeled. Consistency between the descriptive top-level specification (i.e., high-level/low-level design) and the formal policy model is generally not amenable to being fully proven. Therefore, a combination of formal and informal methods may be needed to show such consistency. Hardware, software, and firmware mechanisms strictly internal to security-relevant hardware, software, and firmware include mapping registers and direct memory input and output.

Related Controls: [AC-3](#), [AC-4](#), [AC-25](#), [SA-4](#), [SA-5](#).

(5) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [CONCEPTUALLY SIMPLE DESIGN](#)

Require the developer of the system, system component, or system service to:

- (a) Design and structure the security-relevant hardware, software, and firmware to use a complete, conceptually simple protection mechanism with precisely defined semantics; and
- (b) Internally structure the security-relevant hardware, software, and firmware with specific regard for this mechanism.

Discussion: The principle of reduced complexity states that the system design is as simple and small as possible (see [SA-8\(7\)](#)). A small and simple design is easier to understand and analyze and is also less prone to error (see [AC-25](#), [SA-8\(13\)](#)). The principle of reduced complexity applies to any aspect of a system, but it has particular importance for security due to the various analyses performed to obtain evidence about the emergent security property of the system. For such analyses to be successful, a small and simple design is essential. Application of the principle of reduced complexity contributes to the ability of system developers to understand the correctness and completeness of system security functions and facilitates the identification of potential vulnerabilities. The corollary of reduced complexity states that the simplicity of the system is directly related to the number of vulnerabilities it will contain. That is, simpler systems contain fewer vulnerabilities. An important benefit of reduced complexity is that it is easier to understand whether the security policy has been captured in the system design and that fewer vulnerabilities are likely to be introduced during engineering development. An additional benefit is that any such conclusion about correctness, completeness, and existence of vulnerabilities can be reached with a higher degree of assurance in contrast to conclusions reached in situations where the system design is inherently more complex.

Related Controls: [AC-25](#), [SA-8](#), [SC-3](#).

(6) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [STRUCTURE FOR TESTING](#)

Require the developer of the system, system component, or system service to structure security-relevant hardware, software, and firmware to facilitate testing.

Discussion: Applying the security design principles in [[SP 800-160-1](#)] promotes complete, consistent, and comprehensive testing and evaluation of systems, system components, and services. The thoroughness of such testing contributes to the evidence produced to generate an effective assurance case or argument as to the trustworthiness of the system, system component, or service.

Related Controls: [SA-5](#), [SA-11](#).

(7) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [STRUCTURE FOR LEAST PRIVILEGE](#)

Require the developer of the system, system component, or system service to structure security-relevant hardware, software, and firmware to facilitate controlling access with least privilege.

Discussion: The principle of least privilege states that each component is allocated sufficient privileges to accomplish its specified functions but no more (see [SA-8\(14\)](#)). Applying the principle of least privilege limits the scope of the component's actions, which has two desirable effects. First, the security impact of a failure, corruption, or misuse of the system component results in a minimized security impact. Second, the security analysis of the component is simplified. Least privilege is a pervasive principle that is reflected in all aspects of the secure system design. Interfaces used to invoke component capability are available to only certain subsets of the user population, and component design supports a sufficiently fine granularity of privilege decomposition. For example, in the case of an audit mechanism, there may be an interface for the audit manager, who configures the audit settings; an interface for the audit operator, who ensures that audit data is safely collected and stored; and, finally, yet another interface for the audit reviewer, who only has a need to view the audit data that has been collected but no need to perform operations on that data.

In addition to its manifestations at the system interface, least privilege can be used as a guiding principle for the internal structure of the system itself. One aspect of internal least privilege is to construct modules so that only the elements encapsulated by the module are directly operated upon by the functions within the module. Elements external to a module that may be affected by the module's operation are indirectly accessed through interaction (e.g., via a function call) with the module that contains those elements. Another aspect of internal least privilege is that the scope of a given module or component includes only those system elements that are necessary for its functionality, and the access modes to the elements (e.g., read, write) are minimal.

Related Controls: [AC-5](#), [AC-6](#), [SA-8](#).

(8) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [ORCHESTRATION](#)

Design [Assignment: organization-defined critical systems or system components] with coordinated behavior to implement the following capabilities: [Assignment: organization-defined capabilities, by system or component].

Discussion: Security resources that are distributed, located at different layers or in different system elements, or are implemented to support different aspects of trustworthiness can interact in unforeseen or incorrect ways. Adverse consequences can include cascading failures, interference, or coverage gaps. Coordination of the behavior of security resources (e.g., by ensuring that one patch is installed across all resources before making a configuration change that assumes that the patch is propagated) can avert such negative interactions.

Related Controls: None.

(9) DEVELOPER SECURITY AND PRIVACY ARCHITECTURE AND DESIGN | [DESIGN DIVERSITY](#)

Use different designs for [Assignment: organization-defined critical systems or system components] to satisfy a common set of requirements or to provide equivalent functionality.

Discussion: Design diversity is achieved by supplying the same requirements specification to multiple developers, each of whom is responsible for developing a variant of the system or system component that meets the requirements. Variants can be in software design, in hardware design, or in both hardware and a software design. Differences in the designs of the variants can result from developer experience (e.g., prior use of a design pattern), design style (e.g., when decomposing a required function into smaller tasks, determining what constitutes a separate task and how far to decompose tasks into sub-tasks), selection of libraries to incorporate into the variant, and the development environment (e.g., different design tools make some design patterns easier to visualize). Hardware design diversity includes making different decisions about what information to keep in analog form and what information to convert to digital form, transmitting the same information at different times, and introducing delays in sampling (temporal diversity). Design diversity is commonly used to support fault tolerance.

Related Controls: None.

References: [\[ISO 15408-2\]](#), [\[ISO 15408-3\]](#), [\[SP 800-160-1\]](#).

SA-18 TAMPER RESISTANCE AND DETECTION

[Withdrawn: Moved to [SR-9](#).]

Control Enhancements:

(1) TAMPER RESISTANCE AND DETECTION | MULTIPLE PHASES OF SYSTEM DEVELOPMENT LIFE CYCLE

[Withdrawn: Moved to [SR-9\(1\)](#).]

(2) TAMPER RESISTANCE AND DETECTION | INSPECTION OF SYSTEMS OR COMPONENTS

[Withdrawn: Moved to [SR-10](#).]

SA-19 COMPONENT AUTHENTICITY

[Withdrawn: Moved to [SR-11](#).]

Control Enhancements:

(1) COMPONENT AUTHENTICITY | ANTI-COUNTERFEIT TRAINING

[Withdrawn: Moved to [SR-11\(1\)](#).]

(2) COMPONENT AUTHENTICITY | CONFIGURATION CONTROL FOR COMPONENT SERVICE AND REPAIR

[Withdrawn: Moved to [SR-11\(2\)](#).]

(3) COMPONENT AUTHENTICITY | COMPONENT DISPOSAL

[Withdrawn: Moved to [SR-12](#).]

(4) COMPONENT AUTHENTICITY | ANTI-COUNTERFEIT SCANNING

[Withdrawn: Moved to [SR-11\(3\)](#).]

SA-20 CUSTOMIZED DEVELOPMENT OF CRITICAL COMPONENTS

Control: Reimplement or custom develop the following critical system components:

[Assignment: organization-defined critical system components].

Discussion: Organizations determine that certain system components likely cannot be trusted due to specific threats to and vulnerabilities in those components for which there are no viable security controls to adequately mitigate risk. Reimplementation or custom development of such components may satisfy requirements for higher assurance and is carried out by initiating changes to system components (including hardware, software, and firmware) such that the standard attacks by adversaries are less likely to succeed. In situations where no alternative sourcing is available and organizations choose not to reimplement or custom develop critical system components, additional controls can be employed. Controls include enhanced auditing, restrictions on source code and system utility access, and protection from deletion of system and application files.

Related Controls: [CP-2](#), [RA-9](#), [SA-8](#).

Control Enhancements: None.

References: [\[SP 800-160-1\]](#).

SA-21 DEVELOPER SCREENING

Control: Require that the developer of *[Assignment: organization-defined system, system component, or system service]*:

- a. Has appropriate access authorizations as determined by assigned *[Assignment: organization-defined official government duties]*; and
- b. Satisfies the following additional personnel screening criteria: *[Assignment: organization-defined additional personnel screening criteria]*.

Discussion: Developer screening is directed at external developers. Internal developer screening is addressed by [PS-3](#). Because the system, system component, or system service may be used in critical activities essential to the national or economic security interests of the United States, organizations have a strong interest in ensuring that developers are trustworthy. The degree of

trust required of developers may need to be consistent with that of the individuals who access the systems, system components, or system services once deployed. Authorization and personnel screening criteria include clearances, background checks, citizenship, and nationality. Developer trustworthiness may also include a review and analysis of company ownership and relationships that the company has with entities that may potentially affect the quality and reliability of the systems, components, or services being developed. Satisfying the required access authorizations and personnel screening criteria includes providing a list of all individuals who are authorized to perform development activities on the selected system, system component, or system service so that organizations can validate that the developer has satisfied the authorization and screening requirements.

Related Controls: [PS-2](#), [PS-3](#), [PS-6](#), [PS-7](#), [SA-4](#), [SR-6](#).

Control Enhancements:

(1) DEVELOPER SCREENING | VALIDATION OF SCREENING

[Withdrawn: Incorporated into [SA-21](#).]

References: None.

SA-22 UNSUPPORTED SYSTEM COMPONENTS

Control:

- a. Replace system components when support for the components is no longer available from the developer, vendor, or manufacturer; or
- b. Provide the following options for alternative sources for continued support for unsupported components [*Selection (one or more): in-house support; Assignment: organization-defined support from external providers*]].

Discussion: Support for system components includes software patches, firmware updates, replacement parts, and maintenance contracts. An example of unsupported components includes when vendors no longer provide critical software patches or product updates, which can result in an opportunity for adversaries to exploit weaknesses in the installed components. Exceptions to replacing unsupported system components include systems that provide critical mission or business capabilities where newer technologies are not available or where the systems are so isolated that installing replacement components is not an option.

Alternative sources for support address the need to provide continued support for system components that are no longer supported by the original manufacturers, developers, or vendors when such components remain essential to organizational mission and business functions. If necessary, organizations can establish in-house support by developing customized patches for critical software components or, alternatively, obtain the services of external providers who provide ongoing support for the designated unsupported components through contractual relationships. Such contractual relationships can include open-source software value-added vendors. The increased risk of using unsupported system components can be mitigated, for example, by prohibiting the connection of such components to public or uncontrolled networks, or implementing other forms of isolation.

Related Controls: [PL-2](#), [SA-3](#).

Control Enhancements:

(1) UNSUPPORTED SYSTEM COMPONENTS | ALTERNATIVE SOURCES FOR CONTINUED SUPPORT

[Withdrawn: Incorporated into [SA-22](#).]

References: None.

SA-23 SPECIALIZATION

Control: Employ [*Selection (one or more): design; modification; augmentation; reconfiguration*] on [*Assignment: organization-defined systems or system components*] supporting mission essential services or functions to increase the trustworthiness in those systems or components.

Discussion: It is often necessary for a system or system component that supports mission-essential services or functions to be enhanced to maximize the trustworthiness of the resource. Sometimes this enhancement is done at the design level. In other instances, it is done post-design, either through modifications of the system in question or by augmenting the system with additional components. For example, supplemental authentication or non-repudiation functions may be added to the system to enhance the identity of critical resources to other resources that depend on the organization-defined resources.

Related Controls: [RA-9](#), [SA-8](#).

Control Enhancements: None.

References: [\[SP 800-160-1\]](#), [\[SP 800-160-2\]](#).

3.18 SYSTEM AND COMMUNICATIONS PROTECTION

[Quick link to System and Communications Protection Summary Table](#)

SC-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] system and communications protection policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the system and communications protection policy and the associated system and communications protection controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the system and communications protection policy and procedures; and
- c. Review and update the current system and communications protection:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: System and communications protection policy and procedures address the controls in the SC family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of system and communications protection policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to system and communications protection policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SA-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-100\]](#).

SC-2 SEPARATION OF SYSTEM AND USER FUNCTIONALITY

Control: Separate user functionality, including user interface services, from system management functionality.

Discussion: System management functionality includes functions that are necessary to administer databases, network components, workstations, or servers. These functions typically require privileged user access. The separation of user functions from system management functions is physical or logical. Organizations may separate system management functions from user functions by using different computers, instances of operating systems, central processing units, or network addresses; by employing virtualization techniques; or some combination of these or other methods. Separation of system management functions from user functions includes web administrative interfaces that employ separate authentication methods for users of any other system resources. Separation of system and user functions may include isolating administrative interfaces on different domains and with additional access controls. The separation of system and user functionality can be achieved by applying the systems security engineering design principles in [SA-8](#), including [SA-8\(1\)](#), [SA-8\(3\)](#), [SA-8\(4\)](#), [SA-8\(10\)](#), [SA-8\(12\)](#), [SA-8\(13\)](#), [SA-8\(14\)](#), and [SA-8\(18\)](#).

Related Controls: [AC-6](#), [SA-4](#), [SA-8](#), [SC-3](#), [SC-7](#), [SC-22](#), [SC-32](#), [SC-39](#).

Control Enhancements:

(1) SEPARATION OF SYSTEM AND USER FUNCTIONALITY | [INTERFACES FOR NON-PRIVILEGED USERS](#)

Prevent the presentation of system management functionality at interfaces to non-privileged users.

Discussion: Preventing the presentation of system management functionality at interfaces to non-privileged users ensures that system administration options, including administrator privileges, are not available to the general user population. Restricting user access also prohibits the use of the grey-out option commonly used to eliminate accessibility to such information. One potential solution is to withhold system administration options until users establish sessions with administrator privileges.

Related Controls: [AC-3](#).

(2) SEPARATION OF SYSTEM AND USER FUNCTIONALITY | [DISASSOCIABILITY](#)

Store state information from applications and software separately.

Discussion: If a system is compromised, storing applications and software separately from state information about users' interactions with an application may better protect individuals' privacy.

Related Controls: None.

References: None.

SC-3 SECURITY FUNCTION ISOLATION

Control: Isolate security functions from nonsecurity functions.

Discussion: Security functions are isolated from nonsecurity functions by means of an isolation boundary implemented within a system via partitions and domains. The isolation boundary controls access to and protects the integrity of the hardware, software, and firmware that perform system security functions. Systems implement code separation in many ways, such as through the provision of security kernels via processor rings or processor modes. For non-kernel code, security function isolation is often achieved through file system protections that protect the code on disk and address space protections that protect executing code. Systems can restrict access to security functions using access control mechanisms and by implementing least privilege

capabilities. While the ideal is for all code within the defined security function isolation boundary to only contain security-relevant code, it is sometimes necessary to include nonsecurity functions as an exception. The isolation of security functions from nonsecurity functions can be achieved by applying the systems security engineering design principles in [SA-8](#), including [SA-8\(1\)](#), [SA-8\(3\)](#), [SA-8\(4\)](#), [SA-8\(10\)](#), [SA-8\(12\)](#), [SA-8\(13\)](#), [SA-8\(14\)](#), and [SA-8\(18\)](#).

Related Controls: [AC-3](#), [AC-6](#), [AC-25](#), [CM-2](#), [CM-4](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-15](#), [SA-17](#), [SC-2](#), [SC-7](#), [SC-32](#), [SC-39](#), [SI-16](#).

Control Enhancements:

(1) SECURITY FUNCTION ISOLATION | [HARDWARE SEPARATION](#)

Employ hardware separation mechanisms to implement security function isolation.

Discussion: Hardware separation mechanisms include hardware ring architectures that are implemented within microprocessors and hardware-enforced address segmentation used to support logically distinct storage objects with separate attributes (i.e., readable, writeable).

Related Controls: None.

(2) SECURITY FUNCTION ISOLATION | [ACCESS AND FLOW CONTROL FUNCTIONS](#)

Isolate security functions enforcing access and information flow control from nonsecurity functions and from other security functions.

Discussion: Security function isolation occurs because of implementation. The functions can still be scanned and monitored. Security functions that are potentially isolated from access and flow control enforcement functions include auditing, intrusion detection, and malicious code protection functions.

Related Controls: None.

(3) SECURITY FUNCTION ISOLATION | [MINIMIZE NONSECURITY FUNCTIONALITY](#)

Minimize the number of nonsecurity functions included within the isolation boundary containing security functions.

Discussion: Where it is not feasible to achieve strict isolation of nonsecurity functions from security functions, it is necessary to take actions to minimize nonsecurity-relevant functions within the security function boundary. Nonsecurity functions contained within the isolation boundary are considered security-relevant because errors or malicious code in the software can directly impact the security functions of systems. The fundamental design objective is that the specific portions of systems that provide information security are of minimal size and complexity. Minimizing the number of nonsecurity functions in the security-relevant system components allows designers and implementers to focus only on those functions which are necessary to provide the desired security capability (typically access enforcement). By minimizing the nonsecurity functions within the isolation boundaries, the amount of code that is trusted to enforce security policies is significantly reduced, thus contributing to understandability.

Related Controls: None.

(4) SECURITY FUNCTION ISOLATION | [MODULE COUPLING AND COHESIVENESS](#)

Implement security functions as largely independent modules that maximize internal cohesiveness within modules and minimize coupling between modules.

Discussion: The reduction of inter-module interactions helps to constrain security functions and manage complexity. The concepts of coupling and cohesion are important with respect to modularity in software design. Coupling refers to the dependencies that one module has on other modules. Cohesion refers to the relationship between functions within a module. Best practices in software engineering and systems security engineering rely on layering,

minimization, and modular decomposition to reduce and manage complexity. This produces software modules that are highly cohesive and loosely coupled.

Related Controls: None.

(5) SECURITY FUNCTION ISOLATION | [LAYERED STRUCTURES](#)

Implement security functions as a layered structure minimizing interactions between layers of the design and avoiding any dependence by lower layers on the functionality or correctness of higher layers.

Discussion: The implementation of layered structures with minimized interactions among security functions and non-looping layers (i.e., lower-layer functions do not depend on higher-layer functions) enables the isolation of security functions and the management of complexity.

Related Controls: None.

References: None.

[SC-4](#) INFORMATION IN SHARED SYSTEM RESOURCES

Control: Prevent unauthorized and unintended information transfer via shared system resources.

Discussion: Preventing unauthorized and unintended information transfer via shared system resources stops information produced by the actions of prior users or roles (or the actions of processes acting on behalf of prior users or roles) from being available to current users or roles (or current processes acting on behalf of current users or roles) that obtain access to shared system resources after those resources have been released back to the system. Information in shared system resources also applies to encrypted representations of information. In other contexts, control of information in shared system resources is referred to as object reuse and residual information protection. Information in shared system resources does not address information remanence, which refers to the residual representation of data that has been nominally deleted; covert channels (including storage and timing channels), where shared system resources are manipulated to violate information flow restrictions; or components within systems for which there are only single users or roles.

Related Controls: [AC-3](#), [AC-4](#), [SA-8](#).

Control Enhancements:

(1) INFORMATION IN SHARED SYSTEM RESOURCES | SECURITY LEVELS

[Withdrawn: Incorporated into [SC-4](#).]

(2) INFORMATION IN SHARED SYSTEM RESOURCES | [MULTILEVEL OR PERIODS PROCESSING](#)

Prevent unauthorized information transfer via shared resources in accordance with [Assignment: organization-defined procedures] when system processing explicitly switches between different information classification levels or security categories.

Discussion: Changes in processing levels can occur during multilevel or periods processing with information at different classification levels or security categories. It can also occur during serial reuse of hardware components at different classification levels. Organization-defined procedures can include approved sanitization processes for electronically stored information.

Related Controls: None.

References: None.

SC-5 DENIAL-OF-SERVICE PROTECTIONControl:

- a. [Selection: Protect against; Limit] the effects of the following types of denial-of-service events: [Assignment: organization-defined types of denial-of-service events]; and
- b. Employ the following controls to achieve the denial-of-service objective: [Assignment: organization-defined controls by type of denial-of-service event].

Discussion: Denial-of-service events may occur due to a variety of internal and external causes, such as an attack by an adversary or a lack of planning to support organizational needs with respect to capacity and bandwidth. Such attacks can occur across a wide range of network protocols (e.g., IPv4, IPv6). A variety of technologies are available to limit or eliminate the origination and effects of denial-of-service events. For example, boundary protection devices can filter certain types of packets to protect system components on internal networks from being directly affected by or the source of denial-of-service attacks. Employing increased network capacity and bandwidth combined with service redundancy also reduces the susceptibility to denial-of-service events.

Related Controls: [CP-2](#), [IR-4](#), [SC-6](#), [SC-7](#), [SC-40](#).

Control Enhancements:**(1) DENIAL-OF-SERVICE PROTECTION | [RESTRICT ABILITY TO ATTACK OTHER SYSTEMS](#)**

Restrict the ability of individuals to launch the following denial-of-service attacks against other systems: [Assignment: organization-defined denial-of-service attacks].

Discussion: Restricting the ability of individuals to launch denial-of-service attacks requires the mechanisms commonly used for such attacks to be unavailable. Individuals of concern include hostile insiders or external adversaries who have breached or compromised the system and are using it to launch a denial-of-service attack. Organizations can restrict the ability of individuals to connect and transmit arbitrary information on the transport medium (i.e., wired networks, wireless networks, spoofed Internet protocol packets). Organizations can also limit the ability of individuals to use excessive system resources. Protection against individuals having the ability to launch denial-of-service attacks may be implemented on specific systems or boundary devices that prohibit egress to potential target systems.

Related Controls: None.

(2) DENIAL-OF-SERVICE PROTECTION | [CAPACITY, BANDWIDTH, AND REDUNDANCY](#)

Manage capacity, bandwidth, or other redundancy to limit the effects of information flooding denial-of-service attacks.

Discussion: Managing capacity ensures that sufficient capacity is available to counter flooding attacks. Managing capacity includes establishing selected usage priorities, quotas, partitioning, or load balancing.

Related Controls: None.

(3) DENIAL-OF-SERVICE PROTECTION | [DETECTION AND MONITORING](#)

- (a) **Employ the following monitoring tools to detect indicators of denial-of-service attacks against, or launched from, the system: [Assignment: organization-defined monitoring tools]; and**
- (b) **Monitor the following system resources to determine if sufficient resources exist to prevent effective denial-of-service attacks: [Assignment: organization-defined system resources].**

Discussion: Organizations consider the utilization and capacity of system resources when managing risk associated with a denial of service due to malicious attacks. Denial-of-service attacks can originate from external or internal sources. System resources that are sensitive to denial of service include physical disk storage, memory, and CPU cycles. Techniques used to prevent denial-of-service attacks related to storage utilization and capacity include instituting disk quotas, configuring systems to automatically alert administrators when specific storage capacity thresholds are reached, using file compression technologies to maximize available storage space, and imposing separate partitions for system and user data.

Related Controls: [CA-7](#), [SI-4](#).

References: [\[SP 800-189\]](#).

SC-6 RESOURCE AVAILABILITY

Control: Protect the availability of resources by allocating [Assignment: organization-defined resources] by [Selection (one or more): priority; quota; [Assignment: organization-defined controls]].

Discussion: Priority protection prevents lower-priority processes from delaying or interfering with the system that services higher-priority processes. Quotas prevent users or processes from obtaining more than predetermined amounts of resources.

Related Controls: [SC-5](#).

Control Enhancements: None.

References: [\[OMB M-08-05\]](#), [\[DHS TIC\]](#).

SC-7 BOUNDARY PROTECTION

Control:

- a. Monitor and control communications at the external managed interfaces to the system and at key internal managed interfaces within the system;
- b. Implement subnetworks for publicly accessible system components that are [Selection: physically; logically] separated from internal organizational networks; and
- c. Connect to external networks or systems only through managed interfaces consisting of boundary protection devices arranged in accordance with an organizational security and privacy architecture.

Discussion: Managed interfaces include gateways, routers, firewalls, guards, network-based malicious code analysis, virtualization systems, or encrypted tunnels implemented within a security architecture. Subnetworks that are physically or logically separated from internal networks are referred to as demilitarized zones or DMZs. Restricting or prohibiting interfaces within organizational systems includes restricting external web traffic to designated web servers within managed interfaces, prohibiting external traffic that appears to be spoofing internal addresses, and prohibiting internal traffic that appears to be spoofing external addresses. [\[SP 800-189\]](#) provides additional information on source address validation techniques to prevent ingress and egress of traffic with spoofed addresses. Commercial telecommunications services are provided by network components and consolidated management systems shared by customers. These services may also include third party-provided access lines and other service elements. Such services may represent sources of increased risk despite contract security provisions. Boundary protection may be implemented as a common control for all or part of an organizational network such that the boundary to be protected is greater than a system-specific boundary (i.e., an authorization boundary).

Related Controls: [AC-4](#), [AC-17](#), [AC-18](#), [AC-19](#), [AC-20](#), [AU-13](#), [CA-3](#), [CM-2](#), [CM-4](#), [CM-7](#), [CM-10](#), [CP-8](#), [CP-10](#), [IR-4](#), [MA-4](#), [PE-3](#), [PL-8](#), [PM-12](#), [SA-8](#), [SA-17](#), [SC-5](#), [SC-26](#), [SC-32](#), [SC-35](#), [SC-43](#).

Control Enhancements:

(1) BOUNDARY PROTECTION | PHYSICALLY SEPARATED SUBNETWORKS

[Withdrawn: Incorporated into [SC-7](#).]

(2) BOUNDARY PROTECTION | PUBLIC ACCESS

[Withdrawn: Incorporated into [SC-7](#).]

(3) BOUNDARY PROTECTION | [ACCESS POINTS](#)

Limit the number of external network connections to the system.

Discussion: Limiting the number of external network connections facilitates monitoring of inbound and outbound communications traffic. The Trusted Internet Connection [[DHS TIC](#)] initiative is an example of a federal guideline that requires limits on the number of external network connections. Limiting the number of external network connections to the system is important during transition periods from older to newer technologies (e.g., transitioning from IPv4 to IPv6 network protocols). Such transitions may require implementing the older and newer technologies simultaneously during the transition period and thus increase the number of access points to the system.

Related Controls: None.

(4) BOUNDARY PROTECTION | [EXTERNAL TELECOMMUNICATIONS SERVICES](#)

- (a) Implement a managed interface for each external telecommunication service;**
- (b) Establish a traffic flow policy for each managed interface;**
- (c) Protect the confidentiality and integrity of the information being transmitted across each interface;**
- (d) Document each exception to the traffic flow policy with a supporting mission or business need and duration of that need;**
- (e) Review exceptions to the traffic flow policy [*Assignment: organization-defined frequency*] and remove exceptions that are no longer supported by an explicit mission or business need;**
- (f) Prevent unauthorized exchange of control plane traffic with external networks;**
- (g) Publish information to enable remote networks to detect unauthorized control plane traffic from internal networks; and**
- (h) Filter unauthorized control plane traffic from external networks.**

Discussion: External telecommunications services can provide data and/or voice communications services. Examples of control plane traffic include Border Gateway Protocol (BGP) routing, Domain Name System (DNS), and management protocols. See [[SP 800-189](#)] for additional information on the use of the resource public key infrastructure (RPKI) to protect BGP routes and detect unauthorized BGP announcements.

Related Controls: [AC-3](#), [SC-8](#), [SC-20](#), [SC-21](#), [SC-22](#).

(5) BOUNDARY PROTECTION | [DENY BY DEFAULT — ALLOW BY EXCEPTION](#)

Deny network communications traffic by default and allow network communications traffic by exception [Selection (one or more): at managed interfaces; for [Assignment: organization-defined systems]].

Discussion: Denying by default and allowing by exception applies to inbound and outbound network communications traffic. A deny-all, permit-by-exception network communications traffic policy ensures that only those system connections that are essential and approved are

allowed. Deny by default, allow by exception also applies to a system that is connected to an external system.

Related Controls: None.

(6) BOUNDARY PROTECTION | RESPONSE TO RECOGNIZED FAILURES

[Withdrawn: Incorporated into [SC-7\(18\)](#).]

(7) BOUNDARY PROTECTION | [SPLIT TUNNELING FOR REMOTE DEVICES](#)

Prevent split tunneling for remote devices connecting to organizational systems unless the split tunnel is securely provisioned using [Assignment: organization-defined safeguards].

Discussion: Split tunneling is the process of allowing a remote user or device to establish a non-remote connection with a system and simultaneously communicate via some other connection to a resource in an external network. This method of network access enables a user to access remote devices and simultaneously, access uncontrolled networks. Split tunneling might be desirable by remote users to communicate with local system resources, such as printers or file servers. However, split tunneling can facilitate unauthorized external connections, making the system vulnerable to attack and to exfiltration of organizational information. Split tunneling can be prevented by disabling configuration settings that allow such capability in remote devices and by preventing those configuration settings from being configurable by users. Prevention can also be achieved by the detection of split tunneling (or of configuration settings that allow split tunneling) in the remote device, and by prohibiting the connection if the remote device is using split tunneling. A virtual private network (VPN) can be used to securely provision a split tunnel. A securely provisioned VPN includes locking connectivity to exclusive, managed, and named environments, or to a specific set of pre-approved addresses, without user control.

Related Controls: None.

(8) BOUNDARY PROTECTION | [ROUTE TRAFFIC TO AUTHENTICATED PROXY SERVERS](#)

Route [Assignment: organization-defined internal communications traffic] to [Assignment: organization-defined external networks] through authenticated proxy servers at managed interfaces.

Discussion: External networks are networks outside of organizational control. A proxy server is a server (i.e., system or application) that acts as an intermediary for clients requesting system resources from non-organizational or other organizational servers. System resources that may be requested include files, connections, web pages, or services. Client requests established through a connection to a proxy server are assessed to manage complexity and provide additional protection by limiting direct connectivity. Web content filtering devices are one of the most common proxy servers that provide access to the Internet. Proxy servers can support the logging of Transmission Control Protocol sessions and the blocking of specific Uniform Resource Locators, Internet Protocol addresses, and domain names. Web proxies can be configured with organization-defined lists of authorized and unauthorized websites. Note that proxy servers may inhibit the use of virtual private networks (VPNs) and create the potential for “man-in-the-middle” attacks (depending on the implementation).

Related Controls: [AC-3](#).

(9) BOUNDARY PROTECTION | [RESTRICT THREATENING OUTGOING COMMUNICATIONS TRAFFIC](#)

- (a) Detect and deny outgoing communications traffic posing a threat to external systems; and**
- (b) Audit the identity of internal users associated with denied communications.**

Discussion: Detecting outgoing communications traffic from internal actions that may pose threats to external systems is known as extrusion detection. Extrusion detection is carried out within the system at managed interfaces. Extrusion detection includes the analysis of

incoming and outgoing communications traffic while searching for indications of internal threats to the security of external systems. Internal threats to external systems include traffic indicative of denial-of-service attacks, traffic with spoofed source addresses, and traffic that contains malicious code. Organizations have criteria to determine, update, and manage identified threats related to extrusion detection.

Related Controls: [AU-2](#), [AU-6](#), [SC-5](#), [SC-38](#), [SC-44](#), [SI-3](#), [SI-4](#).

(10) BOUNDARY PROTECTION | [PREVENT EXFILTRATION](#)

(a) Prevent the exfiltration of information; and

(b) Conduct exfiltration tests [Assignment: organization-defined frequency].

Discussion: Prevention of exfiltration applies to both the intentional and unintentional exfiltration of information. Techniques used to prevent the exfiltration of information from systems may be implemented at internal endpoints, external boundaries, and across managed interfaces and include adherence to protocol formats, monitoring for beaconing activity from systems, disconnecting external network interfaces except when explicitly needed, employing traffic profile analysis to detect deviations from the volume and types of traffic expected, call backs to command and control centers, conducting penetration testing, monitoring for steganography, disassembling and reassembling packet headers, and using data loss and data leakage prevention tools. Devices that enforce strict adherence to protocol formats include deep packet inspection firewalls and Extensible Markup Language (XML) gateways. The devices verify adherence to protocol formats and specifications at the application layer and identify vulnerabilities that cannot be detected by devices that operate at the network or transport layers. The prevention of exfiltration is similar to data loss prevention or data leakage prevention and is closely associated with cross-domain solutions and system guards that enforce information flow requirements.

Related Controls: [AC-2](#), [CA-8](#), [SI-3](#).

(11) BOUNDARY PROTECTION | [RESTRICT INCOMING COMMUNICATIONS TRAFFIC](#)

Only allow incoming communications from [Assignment: organization-defined authorized sources] to be routed to [Assignment: organization-defined authorized destinations].

Discussion: General source address validation techniques are applied to restrict the use of illegal and unallocated source addresses as well as source addresses that should only be used within the system. The restriction of incoming communications traffic provides determinations that source and destination address pairs represent authorized or allowed communications. Determinations can be based on several factors, including the presence of such address pairs in the lists of authorized or allowed communications, the absence of such address pairs in lists of unauthorized or disallowed pairs, or meeting more general rules for authorized or allowed source and destination pairs. Strong authentication of network addresses is not possible without the use of explicit security protocols, and thus, addresses can often be spoofed. Further, identity-based incoming traffic restriction methods can be employed, including router access control lists and firewall rules.

Related Controls: [AC-3](#).

(12) BOUNDARY PROTECTION | [HOST-BASED PROTECTION](#)

Implement [Assignment: organization-defined host-based boundary protection mechanisms] at [Assignment: organization-defined system components].

Discussion: Host-based boundary protection mechanisms include host-based firewalls. System components that employ host-based boundary protection mechanisms include servers, workstations, notebook computers, and mobile devices.

Related Controls: None.

(13) BOUNDARY PROTECTION | ISOLATION OF SECURITY TOOLS, MECHANISMS, AND SUPPORT COMPONENTS

Isolate [Assignment: organization-defined information security tools, mechanisms, and support components] from other internal system components by implementing physically separate subnetworks with managed interfaces to other components of the system.

Discussion: Physically separate subnetworks with managed interfaces are useful in isolating computer network defenses from critical operational processing networks to prevent adversaries from discovering the analysis and forensics techniques employed by organizations.

Related Controls: [SC-2](#), [SC-3](#).

(14) BOUNDARY PROTECTION | PROTECT AGAINST UNAUTHORIZED PHYSICAL CONNECTIONS

Protect against unauthorized physical connections at [Assignment: organization-defined managed interfaces].

Discussion: Systems that operate at different security categories or classification levels may share common physical and environmental controls, since the systems may share space within the same facilities. In practice, it is possible that these separate systems may share common equipment rooms, wiring closets, and cable distribution paths. Protection against unauthorized physical connections can be achieved by using clearly identified and physically separated cable trays, connection frames, and patch panels for each side of managed interfaces with physical access controls that enforce limited authorized access to these items.

Related Controls: [PE-4](#), [PE-19](#).

(15) BOUNDARY PROTECTION | NETWORKED PRIVILEGED ACCESSES

Route networked, privileged accesses through a dedicated, managed interface for purposes of access control and auditing.

Discussion: Privileged access provides greater accessibility to system functions, including security functions. Adversaries attempt to gain privileged access to systems through remote access to cause adverse mission or business impacts, such as by exfiltrating information or bringing down a critical system capability. Routing networked, privileged access requests through a dedicated, managed interface further restricts privileged access for increased access control and auditing.

Related Controls: [AC-2](#), [AC-3](#), [AU-2](#), [SI-4](#).

(16) BOUNDARY PROTECTION | PREVENT DISCOVERY OF SYSTEM COMPONENTS

Prevent the discovery of specific system components that represent a managed interface.

Discussion: Preventing the discovery of system components representing a managed interface helps protect network addresses of those components from discovery through common tools and techniques used to identify devices on networks. Network addresses are not available for discovery and require prior knowledge for access. Preventing the discovery of components and devices can be accomplished by not publishing network addresses, using network address translation, or not entering the addresses in domain name systems.

Another prevention technique is to periodically change network addresses.

Related Controls: None.

(17) BOUNDARY PROTECTION | AUTOMATED ENFORCEMENT OF PROTOCOL FORMATS

Enforce adherence to protocol formats.

Discussion: System components that enforce protocol formats include deep packet inspection firewalls and XML gateways. The components verify adherence to protocol

formats and specifications at the application layer and identify vulnerabilities that cannot be detected by devices operating at the network or transport layers.

Related Controls: [SC-4](#).

(18) BOUNDARY PROTECTION | [FAIL SECURE](#)

Prevent systems from entering unsecure states in the event of an operational failure of a boundary protection device.

Discussion: Fail secure is a condition achieved by employing mechanisms to ensure that in the event of operational failures of boundary protection devices at managed interfaces, systems do not enter into unsecure states where intended security properties no longer hold. Managed interfaces include routers, firewalls, and application gateways that reside on protected subnetworks (commonly referred to as demilitarized zones). Failures of boundary protection devices cannot lead to or cause information external to the devices to enter the devices nor can failures permit unauthorized information releases.

Related Controls: [CP-2](#), [CP-12](#), [SC-24](#).

(19) BOUNDARY PROTECTION | [BLOCK COMMUNICATION FROM NON-ORGANIZATIONALLY CONFIGURED HOSTS](#)

Block inbound and outbound communications traffic between [Assignment: organization-defined communication clients] that are independently configured by end users and external service providers.

Discussion: Communication clients independently configured by end users and external service providers include instant messaging clients and video conferencing software and applications. Traffic blocking does not apply to communication clients that are configured by organizations to perform authorized functions.

Related Controls: None.

(20) BOUNDARY PROTECTION | [DYNAMIC ISOLATION AND SEGREGATION](#)

Provide the capability to dynamically isolate [Assignment: organization-defined system components] from other system components.

Discussion: The capability to dynamically isolate certain internal system components is useful when it is necessary to partition or separate system components of questionable origin from components that possess greater trustworthiness. Component isolation reduces the attack surface of organizational systems. Isolating selected system components can also limit the damage from successful attacks when such attacks occur.

Related Controls: None.

(21) BOUNDARY PROTECTION | [ISOLATION OF SYSTEM COMPONENTS](#)

Employ boundary protection mechanisms to isolate [Assignment: organization-defined system components] supporting [Assignment: organization-defined missions and/or business functions].

Discussion: Organizations can isolate system components that perform different mission or business functions. Such isolation limits unauthorized information flows among system components and provides the opportunity to deploy greater levels of protection for selected system components. Isolating system components with boundary protection mechanisms provides the capability for increased protection of individual system components and to more effectively control information flows between those components. Isolating system components provides enhanced protection that limits the potential harm from hostile cyber-attacks and errors. The degree of isolation varies depending upon the mechanisms chosen. Boundary protection mechanisms include routers, gateways, and firewalls that separate system components into physically separate networks or subnetworks; cross-domain devices

that separate subnetworks; virtualization techniques; and the encryption of information flows among system components using distinct encryption keys.

Related Controls: [CA-9](#).

(22) BOUNDARY PROTECTION | [SEPARATE SUBNETS FOR CONNECTING TO DIFFERENT SECURITY DOMAINS](#)

Implement separate network addresses to connect to systems in different security domains.

Discussion: The decomposition of systems into subnetworks (i.e., subnets) helps to provide the appropriate level of protection for network connections to different security domains that contain information with different security categories or classification levels.

Related Controls: None.

(23) BOUNDARY PROTECTION | [DISABLE SENDER FEEDBACK ON PROTOCOL VALIDATION FAILURE](#)

Disable feedback to senders on protocol format validation failure.

Discussion: Disabling feedback to senders when there is a failure in protocol validation format prevents adversaries from obtaining information that would otherwise be unavailable.

Related Controls: None.

(24) BOUNDARY PROTECTION | [PERSONALLY IDENTIFIABLE INFORMATION](#)

For systems that process personally identifiable information:

- (a) Apply the following processing rules to data elements of personally identifiable information: [Assignment: organization-defined processing rules];**
- (b) Monitor for permitted processing at the external interfaces to the system and at key internal boundaries within the system;**
- (c) Document each processing exception; and**
- (d) Review and remove exceptions that are no longer supported.**

Discussion: Managing the processing of personally identifiable information is an important aspect of protecting an individual's privacy. Applying, monitoring for, and documenting exceptions to processing rules ensure that personally identifiable information is processed only in accordance with established privacy requirements.

Related Controls: [PT-2](#), [SI-15](#).

(25) BOUNDARY PROTECTION | [UNCLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS](#)

Prohibit the direct connection of [Assignment: organization-defined unclassified national security system] to an external network without the use of [Assignment: organization-defined boundary protection device].

Discussion: A direct connection is a dedicated physical or virtual connection between two or more systems. Organizations typically do not have complete control over external networks, including the Internet. Boundary protection devices (e.g., firewalls, gateways, and routers) mediate communications and information flows between unclassified national security systems and external networks.

Related Controls: None.

(26) BOUNDARY PROTECTION | [CLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS](#)

Prohibit the direct connection of a classified national security system to an external network without the use of [Assignment: organization-defined boundary protection device].

Discussion: A direct connection is a dedicated physical or virtual connection between two or more systems. Organizations typically do not have complete control over external networks,

including the Internet. Boundary protection devices (e.g., firewalls, gateways, and routers) mediate communications and information flows between classified national security systems and external networks. In addition, approved boundary protection devices (typically managed interface or cross-domain systems) provide information flow enforcement from systems to external networks.

Related Controls: None.

(27) BOUNDARY PROTECTION | [UNCLASSIFIED NON-NATIONAL SECURITY SYSTEM CONNECTIONS](#)

Prohibit the direct connection of [Assignment: organization-defined unclassified non-national security system] to an external network without the use of [Assignment: organization-defined boundary protection device].

Discussion: A direct connection is a dedicated physical or virtual connection between two or more systems. Organizations typically do not have complete control over external networks, including the Internet. Boundary protection devices (e.g., firewalls, gateways, and routers) mediate communications and information flows between unclassified non-national security systems and external networks.

Related Controls: None.

(28) BOUNDARY PROTECTION | [CONNECTIONS TO PUBLIC NETWORKS](#)

Prohibit the direct connection of [Assignment: organization-defined system] to a public network.

Discussion: A direct connection is a dedicated physical or virtual connection between two or more systems. A public network is a network accessible to the public, including the Internet and organizational extranets with public access.

Related Controls: None.

(29) BOUNDARY PROTECTION | [SEPARATE SUBNETS TO ISOLATE FUNCTIONS](#)

Implement [Selection: physically; logically] separate subnetworks to isolate the following critical system components and functions: [Assignment: organization-defined critical system components and functions].

Discussion: Separating critical system components and functions from other noncritical system components and functions through separate subnetworks may be necessary to reduce susceptibility to a catastrophic or debilitating breach or compromise that results in system failure. For example, physically separating the command and control function from the in-flight entertainment function through separate subnetworks in a commercial aircraft provides an increased level of assurance in the trustworthiness of critical system functions.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[FIPS 199\]](#), [\[SP 800-37\]](#), [\[SP 800-41\]](#), [\[SP 800-77\]](#), [\[SP 800-189\]](#).

SC-8

TRANSMISSION CONFIDENTIALITY AND INTEGRITY

Control: Protect the [Selection (one or more): confidentiality; integrity] of transmitted information.

Discussion: Protecting the confidentiality and integrity of transmitted information applies to internal and external networks as well as any system components that can transmit information, including servers, notebook computers, desktop computers, mobile devices, printers, copiers, scanners, facsimile machines, and radios. Unprotected communication paths are exposed to the possibility of interception and modification. Protecting the confidentiality and integrity of information can be accomplished by physical or logical means. Physical protection can be achieved by using protected distribution systems. A protected distribution system is a wireline or fiber-optics telecommunications system that includes terminals and adequate electromagnetic,

acoustical, electrical, and physical controls to permit its use for the unencrypted transmission of classified information. Logical protection can be achieved by employing encryption techniques.

Organizations that rely on commercial providers who offer transmission services as commodity services rather than as fully dedicated services may find it difficult to obtain the necessary assurances regarding the implementation of needed controls for transmission confidentiality and integrity. In such situations, organizations determine what types of confidentiality or integrity services are available in standard, commercial telecommunications service packages. If it is not feasible to obtain the necessary controls and assurances of control effectiveness through appropriate contracting vehicles, organizations can implement appropriate compensating controls.

Related Controls: [AC-17](#), [AC-18](#), [AU-10](#), [IA-3](#), [IA-8](#), [IA-9](#), [MA-4](#), [PE-4](#), [SA-4](#), [SA-8](#), [SC-7](#), [SC-16](#), [SC-20](#), [SC-23](#), [SC-28](#).

Control Enhancements:

(1) TRANSMISSION CONFIDENTIALITY AND INTEGRITY | [CRYPTOGRAPHIC PROTECTION](#)

Implement cryptographic mechanisms to [Selection (one or more): prevent unauthorized disclosure of information; detect changes to information] during transmission.

Discussion: Encryption protects information from unauthorized disclosure and modification during transmission. Cryptographic mechanisms that protect the confidentiality and integrity of information during transmission include TLS and IPSec. Cryptographic mechanisms used to protect information integrity include cryptographic hash functions that have applications in digital signatures, checksums, and message authentication codes.

Related Controls: [SC-12](#), [SC-13](#).

(2) TRANSMISSION CONFIDENTIALITY AND INTEGRITY | [PRE- AND POST-TRANSMISSION HANDLING](#)

Maintain the [Selection (one or more): confidentiality; integrity] of information during preparation for transmission and during reception.

Discussion: Information can be unintentionally or maliciously disclosed or modified during preparation for transmission or during reception, including during aggregation, at protocol transformation points, and during packing and unpacking. Such unauthorized disclosures or modifications compromise the confidentiality or integrity of the information.

Related Controls: None.

(3) TRANSMISSION CONFIDENTIALITY AND INTEGRITY | [CRYPTOGRAPHIC PROTECTION FOR MESSAGE EXTERNALS](#)

Implement cryptographic mechanisms to protect message externals unless otherwise protected by [Assignment: organization-defined alternative physical controls].

Discussion: Cryptographic protection for message externals addresses protection from the unauthorized disclosure of information. Message externals include message headers and routing information. Cryptographic protection prevents the exploitation of message externals and applies to internal and external networks or links that may be visible to individuals who are not authorized users. Header and routing information is sometimes transmitted in clear text (i.e., unencrypted) because the information is not identified by organizations as having significant value or because encrypting the information can result in lower network performance or higher costs. Alternative physical controls include protected distribution systems.

Related Controls: [SC-12](#), [SC-13](#).

(4) TRANSMISSION CONFIDENTIALITY AND INTEGRITY | [CONCEAL OR RANDOMIZE COMMUNICATIONS](#)

Implement cryptographic mechanisms to conceal or randomize communication patterns unless otherwise protected by [Assignment: organization-defined alternative physical controls].

Discussion: Concealing or randomizing communication patterns addresses protection from unauthorized disclosure of information. Communication patterns include frequency, periods, predictability, and amount. Changes to communications patterns can reveal information with intelligence value, especially when combined with other available information related to the mission and business functions of the organization. Concealing or randomizing communications prevents the derivation of intelligence based on communications patterns and applies to both internal and external networks or links that may be visible to individuals who are not authorized users. Encrypting the links and transmitting in continuous, fixed, or random patterns prevents the derivation of intelligence from the system communications patterns. Alternative physical controls include protected distribution systems.

Related Controls: [SC-12](#), [SC-13](#).

(5) TRANSMISSION CONFIDENTIALITY AND INTEGRITY | [PROTECTED DISTRIBUTION SYSTEM](#)

Implement [Assignment: organization-defined protected distribution system] to [Selection (one or more): prevent unauthorized disclosure of information; detect changes to information] during transmission.

Discussion: The purpose of a protected distribution system is to deter, detect, and/or make difficult physical access to the communication lines that carry national security information.

Related Controls: None.

References: [\[FIPS 140-3\]](#), [\[FIPS 197\]](#), [\[SP 800-52\]](#), [\[SP 800-77\]](#), [\[SP 800-81-2\]](#), [\[SP 800-113\]](#), [\[SP 800-177\]](#), [\[IR 8023\]](#).

SC-9 TRANSMISSION CONFIDENTIALITY

[Withdrawn: Incorporated into [SC-8](#).]

[SC-10 NETWORK DISCONNECT](#)

Control: Terminate the network connection associated with a communications session at the end of the session or after [Assignment: organization-defined time period] of inactivity.

Discussion: Network disconnect applies to internal and external networks. Terminating network connections associated with specific communications sessions includes de-allocating TCP/IP address or port pairs at the operating system level and de-allocating the networking assignments at the application level if multiple application sessions are using a single operating system-level network connection. Periods of inactivity may be established by organizations and include time periods by type of network access or for specific network accesses.

Related Controls: [AC-17](#), [SC-23](#).

Control Enhancements: None.

References: None.

[SC-11 TRUSTED PATH](#)

Control:

- a. Provide a [Selection: physically; logically] isolated trusted communications path for communications between the user and the trusted components of the system; and

- b. Permit users to invoke the trusted communications path for communications between the user and the following security functions of the system, including at a minimum, authentication and re-authentication: [Assignment: organization-defined security functions].

Discussion: Trusted paths are mechanisms by which users can communicate (using input devices such as keyboards) directly with the security functions of systems with the requisite assurance to support security policies. Trusted path mechanisms can only be activated by users or the security functions of organizational systems. User responses that occur via trusted paths are protected from modification by and disclosure to untrusted applications. Organizations employ trusted paths for trustworthy, high-assurance connections between security functions of systems and users, including during system logons. The original implementations of trusted paths employed an out-of-band signal to initiate the path, such as using the <BREAK> key, which does not transmit characters that can be spoofed. In later implementations, a key combination that could not be hijacked was used (e.g., the <CTRL> + <ALT> + keys). Such key combinations, however, are platform-specific and may not provide a trusted path implementation in every case. The enforcement of trusted communications paths is provided by a specific implementation that meets the reference monitor concept.

Related Controls: [AC-16](#), [AC-25](#), [SC-12](#), [SC-23](#).

Control Enhancements:

(1) TRUSTED PATH | [IRREFUTABLE COMMUNICATIONS PATH](#)

- (a) Provide a trusted communications path that is irrefutably distinguishable from other communications paths; and
- (b) Initiate the trusted communications path for communications between the [Assignment: organization-defined security functions] of the system and the user.

Discussion: An irrefutable communications path permits the system to initiate a trusted path, which necessitates that the user can unmistakably recognize the source of the communication as a trusted system component. For example, the trusted path may appear in an area of the display that other applications cannot access or be based on the presence of an identifier that cannot be spoofed.

Related Controls: None.

References: [\[OMB A-130\]](#).

[SC-12 CRYPTOGRAPHIC KEY ESTABLISHMENT AND MANAGEMENT](#)

Control: Establish and manage cryptographic keys when cryptography is employed within the system in accordance with the following key management requirements: [Assignment: organization-defined requirements for key generation, distribution, storage, access, and destruction].

Discussion: Cryptographic key management and establishment can be performed using manual procedures or automated mechanisms with supporting manual procedures. Organizations define key management requirements in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines and specify appropriate options, parameters, and levels. Organizations manage trust stores to ensure that only approved trust anchors are part of such trust stores. This includes certificates with visibility external to organizational systems and certificates related to the internal operations of systems. [\[NIST CMVP\]](#) and [\[NIST CAVP\]](#) provide additional information on validated cryptographic modules and algorithms that can be used in cryptographic key management and establishment.

Related Controls: [AC-17](#), [AU-9](#), [AU-10](#), [CM-3](#), [IA-3](#), [IA-7](#), [SA-4](#), [SA-8](#), [SA-9](#), [SC-8](#), [SC-11](#), [SC-12](#), [SC-13](#), [SC-17](#), [SC-20](#), [SC-37](#), [SC-40](#), [SI-3](#), [SI-7](#).

Control Enhancements:

- (1) CRYPTOGRAPHIC KEY ESTABLISHMENT AND MANAGEMENT | [AVAILABILITY](#)**
Maintain availability of information in the event of the loss of cryptographic keys by users.
Discussion: Escrowing of encryption keys is a common practice for ensuring availability in the event of key loss. A forgotten passphrase is an example of losing a cryptographic key.
Related Controls: None.
- (2) CRYPTOGRAPHIC KEY ESTABLISHMENT AND MANAGEMENT | [SYMMETRIC KEYS](#)**
Produce, control, and distribute symmetric cryptographic keys using [Selection: NIST FIPS-validated; NSA-approved] key management technology and processes.
Discussion: [\[SP 800-56A\]](#), [\[SP 800-56B\]](#), and [\[SP 800-56C\]](#) provide guidance on cryptographic key establishment schemes and key derivation methods. [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), and [\[SP 800-57-3\]](#) provide guidance on cryptographic key management.
Related Controls: None.
- (3) CRYPTOGRAPHIC KEY ESTABLISHMENT AND MANAGEMENT | [ASYMMETRIC KEYS](#)**
Produce, control, and distribute asymmetric cryptographic keys using [Selection: NSA-approved key management technology and processes; prepositioned keying material; DoD-approved or DoD-issued Medium Assurance PKI certificates; DoD-approved or DoD-issued Medium Hardware Assurance PKI certificates and hardware security tokens that protect the user's private key; certificates issued in accordance with organization-defined requirements].
Discussion: [\[SP 800-56A\]](#), [\[SP 800-56B\]](#), and [\[SP 800-56C\]](#) provide guidance on cryptographic key establishment schemes and key derivation methods. [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), and [\[SP 800-57-3\]](#) provide guidance on cryptographic key management.
Related Controls: None.
- (4) CRYPTOGRAPHIC KEY ESTABLISHMENT AND MANAGEMENT | PKI CERTIFICATES**
[Withdrawn: Incorporated into [SC-12\(3\)](#).]
- (5) CRYPTOGRAPHIC KEY ESTABLISHMENT AND MANAGEMENT | PKI CERTIFICATES / HARDWARE TOKENS**
[Withdrawn: Incorporated into [SC-12\(3\)](#).]
- (6) CRYPTOGRAPHIC KEY ESTABLISHMENT AND MANAGEMENT | [PHYSICAL CONTROL OF KEYS](#)**
Maintain physical control of cryptographic keys when stored information is encrypted by external service providers.
Discussion: For organizations that use external service providers (e.g., cloud service or data center providers), physical control of cryptographic keys provides additional assurance that information stored by such external providers is not subject to unauthorized disclosure or modification.
Related Controls: None.
- References:** [\[FIPS 140-3\]](#), [\[SP 800-56A\]](#), [\[SP 800-56B\]](#), [\[SP 800-56C\]](#), [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), [\[SP 800-57-3\]](#), [\[SP 800-63-3\]](#), [\[IR 7956\]](#), [\[IR 7966\]](#).

SC-13 CRYPTOGRAPHIC PROTECTION**Control:**

- Determine the [Assignment: organization-defined cryptographic uses]; and

- b. Implement the following types of cryptography required for each specified cryptographic use: [Assignment: organization-defined types of cryptography for each specified cryptographic use].

Discussion: Cryptography can be employed to support a variety of security solutions, including the protection of classified information and controlled unclassified information, the provision and implementation of digital signatures, and the enforcement of information separation when authorized individuals have the necessary clearances but lack the necessary formal access approvals. Cryptography can also be used to support random number and hash generation. Generally applicable cryptographic standards include FIPS-validated cryptography and NSA-approved cryptography. For example, organizations that need to protect classified information may specify the use of NSA-approved cryptography. Organizations that need to provision and implement digital signatures may specify the use of FIPS-validated cryptography. Cryptography is implemented in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: [AC-2](#), [AC-3](#), [AC-7](#), [AC-17](#), [AC-18](#), [AC-19](#), [AU-9](#), [AU-10](#), [CM-11](#), [CP-9](#), [IA-3](#), [IA-5](#), [IA-7](#), [MA-4](#), [MP-2](#), [MP-4](#), [MP-5](#), [SA-4](#), [SA-8](#), [SA-9](#), [SC-8](#), [SC-12](#), [SC-20](#), [SC-23](#), [SC-28](#), [SC-40](#), [SI-3](#), [SI-7](#).

Control Enhancements: None.

(1) CRYPTOGRAPHIC PROTECTION | FIPS-VALIDATED CRYPTOGRAPHY

[Withdrawn: Incorporated into [SC-13](#).]

(2) CRYPTOGRAPHIC PROTECTION | NSA-APPROVED CRYPTOGRAPHY

[Withdrawn: Incorporated into [SC-13](#).]

(3) CRYPTOGRAPHIC PROTECTION | INDIVIDUALS WITHOUT FORMAL ACCESS APPROVALS

[Withdrawn: Incorporated into [SC-13](#).]

(4) CRYPTOGRAPHIC PROTECTION | DIGITAL SIGNATURES

[Withdrawn: Incorporated into [SC-13](#).]

References: [\[FIPS 140-3\]](#).

SC-14 PUBLIC ACCESS PROTECTIONS

[Withdrawn: Incorporated into [AC-2](#), [AC-3](#), [AC-5](#), [AC-6](#), [SI-3](#), [SI-4](#), [SI-5](#), [SI-7](#), and [SI-10](#).]

SC-15 COLLABORATIVE COMPUTING DEVICES AND APPLICATIONS

Control:

- a. Prohibit remote activation of collaborative computing devices and applications with the following exceptions: [Assignment: organization-defined exceptions where remote activation is to be allowed]; and
- b. Provide an explicit indication of use to users physically present at the devices.

Discussion: Collaborative computing devices and applications include remote meeting devices and applications, networked white boards, cameras, and microphones. The explicit indication of use includes signals to users when collaborative computing devices and applications are activated.

Related Controls: [AC-21](#), [SC-42](#).

Control Enhancements:

(1) COLLABORATIVE COMPUTING DEVICES | [PHYSICAL OR LOGICAL DISCONNECT](#)

Provide [Selection (one or more): physical; logical] disconnect of collaborative computing devices in a manner that supports ease of use.

Discussion: Failing to disconnect from collaborative computing devices can result in subsequent compromises of organizational information. Providing easy methods to disconnect from such devices after a collaborative computing session ensures that participants carry out the disconnect activity without having to go through complex and tedious procedures. Disconnect from collaborative computing devices can be manual or automatic.

Related Controls: None.

(2) COLLABORATIVE COMPUTING DEVICES | BLOCKING INBOUND AND OUTBOUND COMMUNICATIONS TRAFFIC

[Withdrawn: Incorporated into [SC-7](#).]

(3) COLLABORATIVE COMPUTING DEVICES | [DISABLING AND REMOVAL IN SECURE WORK AREAS](#)

Disable or remove collaborative computing devices and applications from [Assignment: organization-defined systems or system components] in [Assignment: organization-defined secure work areas].

Discussion: Failing to disable or remove collaborative computing devices and applications from systems or system components can result in compromises of information, including eavesdropping on conversations. A Sensitive Compartmented Information Facility (SCIF) is an example of a secure work area.

Related Controls: None.

(4) COLLABORATIVE COMPUTING DEVICES | [EXPLICITLY INDICATE CURRENT PARTICIPANTS](#)

Provide an explicit indication of current participants in [Assignment: organization-defined online meetings and teleconferences].

Discussion: Explicitly indicating current participants prevents unauthorized individuals from participating in collaborative computing sessions without the explicit knowledge of other participants.

Related Controls: None.

References: None.

SC-16 TRANSMISSION OF SECURITY AND PRIVACY ATTRIBUTES

Control: Associate [Assignment: organization-defined security and privacy attributes] with information exchanged between systems and between system components.

Discussion: Security and privacy attributes can be explicitly or implicitly associated with the information contained in organizational systems or system components. Attributes are abstractions that represent the basic properties or characteristics of an entity with respect to protecting information or the management of personally identifiable information. Attributes are typically associated with internal data structures, including records, buffers, and files within the system. Security and privacy attributes are used to implement access control and information flow control policies; reflect special dissemination, management, or distribution instructions, including permitted uses of personally identifiable information; or support other aspects of the information security and privacy policies. Privacy attributes may be used independently or in conjunction with security attributes.

Related Controls: [AC-3](#), [AC-4](#), [AC-16](#).

Control Enhancements:

(1) TRANSMISSION OF SECURITY AND PRIVACY ATTRIBUTES | [INTEGRITY VERIFICATION](#)

Verify the integrity of transmitted security and privacy attributes.

Discussion: Part of verifying the integrity of transmitted information is ensuring that security and privacy attributes that are associated with such information have not been modified in an unauthorized manner. Unauthorized modification of security or privacy attributes can result in a loss of integrity for transmitted information.

Related Controls: [AU-10](#), [SC-8](#).

(2) TRANSMISSION OF SECURITY AND PRIVACY ATTRIBUTES | [ANTI-SPOOFING MECHANISMS](#)

Implement anti-spoofing mechanisms to prevent adversaries from falsifying the security attributes indicating the successful application of the security process.

Discussion: Some attack vectors operate by altering the security attributes of an information system to intentionally and maliciously implement an insufficient level of security within the system. The alteration of attributes leads organizations to believe that a greater number of security functions are in place and operational than have actually been implemented.

Related Controls: [SI-3](#), [SI-4](#), [SI-7](#).

(3) TRANSMISSION OF SECURITY AND PRIVACY ATTRIBUTES | [CRYPTOGRAPHIC BINDING](#)

Implement [Assignment: organization-defined mechanisms or techniques] to bind security and privacy attributes to transmitted information.

Discussion: Cryptographic mechanisms and techniques can provide strong security and privacy attribute binding to transmitted information to help ensure the integrity of such information.

Related Controls: [AC-16](#), [SC-12](#), [SC-13](#).

References: [\[OMB A-130\]](#).

SC-17 PUBLIC KEY INFRASTRUCTURE CERTIFICATES

Control:

- a. Issue public key certificates under an [Assignment: organization-defined certificate policy] or obtain public key certificates from an approved service provider; and
- b. Include only approved trust anchors in trust stores or certificate stores managed by the organization.

Discussion: Public key infrastructure (PKI) certificates are certificates with visibility external to organizational systems and certificates related to the internal operations of systems, such as application-specific time services. In cryptographic systems with a hierarchical structure, a trust anchor is an authoritative source (i.e., a certificate authority) for which trust is assumed and not derived. A root certificate for a PKI system is an example of a trust anchor. A trust store or certificate store maintains a list of trusted root certificates.

Related Controls: [AU-10](#), [IA-5](#), [SC-12](#).

Control Enhancements: None.

References: [\[SP 800-32\]](#), [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), [\[SP 800-57-3\]](#), [\[SP 800-63-3\]](#).

SC-18 MOBILE CODE

Control:

- a. Define acceptable and unacceptable mobile code and mobile code technologies; and
- b. Authorize, monitor, and control the use of mobile code within the system.

Discussion: Mobile code includes any program, application, or content that can be transmitted across a network (e.g., embedded in an email, document, or website) and executed on a remote system. Decisions regarding the use of mobile code within organizational systems are based on the potential for the code to cause damage to the systems if used maliciously. Mobile code technologies include Java applets, JavaScript, HTML5, WebGL, and VBScript. Usage restrictions and implementation guidelines apply to both the selection and use of mobile code installed on servers and mobile code downloaded and executed on individual workstations and devices, including notebook computers and smart phones. Mobile code policy and procedures address specific actions taken to prevent the development, acquisition, and introduction of unacceptable mobile code within organizational systems, including requiring mobile code to be digitally signed by a trusted source.

Related Controls: [AU-2](#), [AU-12](#), [CM-2](#), [CM-6](#), [SI-3](#).

Control Enhancements:

(1) MOBILE CODE | [IDENTIFY UNACCEPTABLE CODE AND TAKE CORRECTIVE ACTIONS](#)

Identify [*Assignment: organization-defined unacceptable mobile code*] and take [*Assignment: organization-defined corrective actions*].

Discussion: Corrective actions when unacceptable mobile code is detected include blocking, quarantine, or alerting administrators. Blocking includes preventing the transmission of word processing files with embedded macros when such macros have been determined to be unacceptable mobile code.

Related Controls: None.

(2) MOBILE CODE | [ACQUISITION, DEVELOPMENT, AND USE](#)

Verify that the acquisition, development, and use of mobile code to be deployed in the system meets [*Assignment: organization-defined mobile code requirements*].

Discussion: None.

Related Controls: None.

(3) MOBILE CODE | [PREVENT DOWNLOADING AND EXECUTION](#)

Prevent the download and execution of [*Assignment: organization-defined unacceptable mobile code*].

Discussion: None.

Related Controls: None.

(4) MOBILE CODE | [PREVENT AUTOMATIC EXECUTION](#)

Prevent the automatic execution of mobile code in [*Assignment: organization-defined software applications*] and enforce [*Assignment: organization-defined actions*] prior to executing the code.

Discussion: Actions enforced before executing mobile code include prompting users prior to opening email attachments or clicking on web links. Preventing the automatic execution of mobile code includes disabling auto-execute features on system components that employ portable storage devices, such as compact discs, digital versatile discs, and universal serial bus devices.

Related Controls: None.

(5) MOBILE CODE | [ALLOW EXECUTION ONLY IN CONFINED ENVIRONMENTS](#)

Allow execution of permitted mobile code only in confined virtual machine environments.

Discussion: Permitting the execution of mobile code only in confined virtual machine environments helps prevent the introduction of malicious code into other systems and system components.

Related Controls: [SC-44](#), [SI-7](#).

References: [[SP 800-28](#)].

SC-19 VOICE OVER INTERNET PROTOCOL

[Withdrawn: Technology-specific; addressed as any other technology or protocol.]

SC-20 SECURE NAME/ADDRESS RESOLUTION SERVICE (AUTHORITATIVE SOURCE)

Control:

- a. Provide additional data origin authentication and integrity verification artifacts along with the authoritative name resolution data the system returns in response to external name/address resolution queries; and
- b. Provide the means to indicate the security status of child zones and (if the child supports secure resolution services) to enable verification of a chain of trust among parent and child domains, when operating as part of a distributed, hierarchical namespace.

Discussion: Providing authoritative source information enables external clients, including remote Internet clients, to obtain origin authentication and integrity verification assurances for the host/service name to network address resolution information obtained through the service. Systems that provide name and address resolution services include domain name system (DNS) servers. Additional artifacts include DNS Security Extensions (DNSSEC) digital signatures and cryptographic keys. Authoritative data includes DNS resource records. The means for indicating the security status of child zones include the use of delegation signer resource records in the DNS. Systems that use technologies other than the DNS to map between host and service names and network addresses provide other means to assure the authenticity and integrity of response data.

Related Controls: [AU-10](#), [SC-8](#), [SC-12](#), [SC-13](#), [SC-21](#), [SC-22](#).

Control Enhancements:

- (1) SECURE NAME/ADDRESS RESOLUTION SERVICE (AUTHORITATIVE SOURCE) | CHILD SUBSPACES
[Withdrawn: Incorporated into [SC-20](#).]

- (2) SECURE NAME/ADDRESS RESOLUTION SERVICE (AUTHORITATIVE SOURCE) | [DATA ORIGIN AND INTEGRITY](#)

Provide data origin and integrity protection artifacts for internal name/address resolution queries.

Discussion: None.

Related Controls: None.

References: [[FIPS 140-3](#)], [[FIPS 186-4](#)], [[SP 800-81-2](#)].

SC-21 SECURE NAME/ADDRESS RESOLUTION SERVICE (RECURSIVE OR CACHING RESOLVER)

Control: Request and perform data origin authentication and data integrity verification on the name/address resolution responses the system receives from authoritative sources.

Discussion: Each client of name resolution services either performs this validation on its own or has authenticated channels to trusted validation providers. Systems that provide name and

address resolution services for local clients include recursive resolving or caching domain name system (DNS) servers. DNS client resolvers either perform validation of DNSSEC signatures, or clients use authenticated channels to recursive resolvers that perform such validations. Systems that use technologies other than the DNS to map between host and service names and network addresses provide some other means to enable clients to verify the authenticity and integrity of response data.

Related Controls: [SC-20](#), [SC-22](#).

Control Enhancements: None.

- (1) SECURE NAME/ADDRESS RESOLUTION SERVICE (RECURSIVE OR CACHING RESOLVER) | DATA ORIGIN AND INTEGRITY**

[Withdrawn: Incorporated into [SC-21](#).]

References: [[SP 800-81-2](#)].

[SC-22 ARCHITECTURE AND PROVISIONING FOR NAME/ADDRESS RESOLUTION SERVICE](#)

Control: Ensure the systems that collectively provide name/address resolution service for an organization are fault-tolerant and implement internal and external role separation.

Discussion: Systems that provide name and address resolution services include domain name system (DNS) servers. To eliminate single points of failure in systems and enhance redundancy, organizations employ at least two authoritative domain name system servers—one configured as the primary server and the other configured as the secondary server. Additionally, organizations typically deploy the servers in two geographically separated network subnetworks (i.e., not located in the same physical facility). For role separation, DNS servers with internal roles only process name and address resolution requests from within organizations (i.e., from internal clients). DNS servers with external roles only process name and address resolution information requests from clients external to organizations (i.e., on external networks, including the Internet). Organizations specify clients that can access authoritative DNS servers in certain roles (e.g., by address ranges and explicit lists).

Related Controls: [SC-2](#), [SC-20](#), [SC-21](#), [SC-24](#).

Control Enhancements: None.

References: [[SP 800-81-2](#)].

[SC-23 SESSION AUTHENTICITY](#)

Control: Protect the authenticity of communications sessions.

Discussion: Protecting session authenticity addresses communications protection at the session level, not at the packet level. Such protection establishes grounds for confidence at both ends of communications sessions in the ongoing identities of other parties and the validity of transmitted information. Authenticity protection includes protecting against “man-in-the-middle” attacks, session hijacking, and the insertion of false information into sessions.

Related Controls: [AU-10](#), [SC-8](#), [SC-10](#), [SC-11](#).

Control Enhancements:

- (1) SESSION AUTHENTICITY | [INVALIDATE SESSION IDENTIFIERS AT LOGOUT](#)**

Invalidate session identifiers upon user logout or other session termination.

Discussion: Invalidating session identifiers at logout curtails the ability of adversaries to capture and continue to employ previously valid session IDs.

Related Controls: None.

- (2) SESSION AUTHENTICITY | USER-INITIATED LOGOUTS AND MESSAGE DISPLAYS
[Withdrawn: Incorporated into [AC-12\(1\)](#).]
- (3) SESSION AUTHENTICITY | [UNIQUE SYSTEM-GENERATED SESSION IDENTIFIERS](#)
Generate a unique session identifier for each session with [Assignment: organization-defined randomness requirements] and recognize only session identifiers that are system-generated.
Discussion: Generating unique session identifiers curtails the ability of adversaries to reuse previously valid session IDs. Employing the concept of randomness in the generation of unique session identifiers protects against brute-force attacks to determine future session identifiers.
Related Controls: [AC-10](#), [SC-12](#), [SC-13](#).
- (4) SESSION AUTHENTICITY | UNIQUE SESSION IDENTIFIERS WITH RANDOMIZATION
[Withdrawn: Incorporated into [SC-23\(3\)](#).]
- (5) SESSION AUTHENTICITY | [ALLOWED CERTIFICATE AUTHORITIES](#)
Only allow the use of [Assignment: organization-defined certificate authorities] for verification of the establishment of protected sessions.
Discussion: Reliance on certificate authorities for the establishment of secure sessions includes the use of Transport Layer Security (TLS) certificates. These certificates, after verification by their respective certificate authorities, facilitate the establishment of protected sessions between web clients and web servers.
Related Controls: [SC-12](#), [SC-13](#).
References: [\[SP 800-52\]](#), [\[SP 800-77\]](#), [\[SP 800-95\]](#), [\[SP 800-113\]](#).

[SC-24 FAIL IN KNOWN STATE](#)

Control: Fail to a [Assignment: organization-defined known system state] for the following failures on the indicated components while preserving [Assignment: organization-defined system state information] in failure: [Assignment: list of organization-defined types of system failures on organization-defined system components].

Discussion: Failure in a known state addresses security concerns in accordance with the mission and business needs of organizations. Failure in a known state prevents the loss of confidentiality, integrity, or availability of information in the event of failures of organizational systems or system components. Failure in a known safe state helps to prevent systems from failing to a state that may cause injury to individuals or destruction to property. Preserving system state information facilitates system restart and return to the operational mode with less disruption of mission and business processes.

Related Controls: [CP-2](#), [CP-4](#), [CP-10](#), [CP-12](#), [SA-8](#), [SC-7](#), [SC-22](#), [SI-13](#).

Control Enhancements: None.

References: None.

[SC-25 THIN NODES](#)

Control: Employ minimal functionality and information storage on the following system components: [Assignment: organization-defined system components].

Discussion: The deployment of system components with minimal functionality reduces the need to secure every endpoint and may reduce the exposure of information, systems, and services to attacks. Reduced or minimal functionality includes diskless nodes and thin client technologies.

Related Controls: [SC-30](#), [SC-44](#).

Control Enhancements: None.

References: None.

SC-26 DECOYS

Control: Include components within organizational systems specifically designed to be the target of malicious attacks for detecting, deflecting, and analyzing such attacks.

Discussion: Decoys (i.e., honeypots, honeynets, or deception nets) are established to attract adversaries and deflect attacks away from the operational systems that support organizational mission and business functions. Use of decoys requires some supporting isolation measures to ensure that any deflected malicious code does not infect organizational systems. Depending on the specific usage of the decoy, consultation with the Office of the General Counsel before deployment may be needed.

Related Controls: [RA-5](#), [SC-7](#), [SC-30](#), [SC-35](#), [SC-44](#), [SI-3](#), [SI-4](#).

Control Enhancements: None.

(1) DECOYS | DETECTION OF MALICIOUS CODE

[Withdrawn: Incorporated into [SC-35](#).]

References: None.

SC-27 PLATFORM-INDEPENDENT APPLICATIONS

Control: Include within organizational systems the following platform independent applications: [Assignment: organization-defined platform-independent applications].

Discussion: Platforms are combinations of hardware, firmware, and software components used to execute software applications. Platforms include operating systems, the underlying computer architectures, or both. Platform-independent applications are applications with the capability to execute on multiple platforms. Such applications promote portability and reconstitution on different platforms. Application portability and the ability to reconstitute on different platforms increase the availability of mission-essential functions within organizations in situations where systems with specific operating systems are under attack.

Related Controls: [SC-29](#).

Control Enhancements: None.

References: None.

SC-28 PROTECTION OF INFORMATION AT REST

Control: Protect the [Selection (one or more): confidentiality; integrity] of the following information at rest: [Assignment: organization-defined information at rest].

Discussion: Information at rest refers to the state of information when it is not in process or in transit and is located on system components. Such components include internal or external hard disk drives, storage area network devices, or databases. However, the focus of protecting information at rest is not on the type of storage device or frequency of access but rather on the state of the information. Information at rest addresses the confidentiality and integrity of

information and covers user information and system information. System-related information that requires protection includes configurations or rule sets for firewalls, intrusion detection and prevention systems, filtering routers, and authentication information. Organizations may employ different mechanisms to achieve confidentiality and integrity protections, including the use of cryptographic mechanisms and file share scanning. Integrity protection can be achieved, for example, by implementing write-once-read-many (WORM) technologies. When adequate protection of information at rest cannot otherwise be achieved, organizations may employ other controls, including frequent scanning to identify malicious code at rest and secure offline storage in lieu of online storage.

Related Controls: [AC-3](#), [AC-4](#), [AC-6](#), [AC-19](#), [CA-7](#), [CM-3](#), [CM-5](#), [CM-6](#), [CP-9](#), [MP-4](#), [MP-5](#), [PE-3](#), [SC-8](#), [SC-12](#), [SC-13](#), [SC-34](#), [SI-3](#), [SI-7](#), [SI-16](#).

Control Enhancements:

(1) PROTECTION OF INFORMATION AT REST | [CRYPTOGRAPHIC PROTECTION](#)

Implement cryptographic mechanisms to prevent unauthorized disclosure and modification of the following information at rest on [Assignment: organization-defined system components or media]: [Assignment: organization-defined information].

Discussion: The selection of cryptographic mechanisms is based on the need to protect the confidentiality and integrity of organizational information. The strength of mechanism is commensurate with the security category or classification of the information. Organizations have the flexibility to encrypt information on system components or media or encrypt data structures, including files, records, or fields.

Related Controls: [AC-19](#), [SC-12](#), [SC-13](#).

(2) PROTECTION OF INFORMATION AT REST | [OFFLINE STORAGE](#)

Remove the following information from online storage and store offline in a secure location: [Assignment: organization-defined information].

Discussion: Removing organizational information from online storage to offline storage eliminates the possibility of individuals gaining unauthorized access to the information through a network. Therefore, organizations may choose to move information to offline storage in lieu of protecting such information in online storage.

Related Controls: None.

(3) PROTECTION OF INFORMATION AT REST | [CRYPTOGRAPHIC KEYS](#)

Provide protected storage for cryptographic keys [Selection: [Assignment: organization-defined safeguards]; hardware-protected key store].

Discussion: A Trusted Platform Module (TPM) is an example of a hardware-protected data store that can be used to protect cryptographic keys.

Related Controls: [SC-12](#), [SC-13](#).

References: [\[OMB A-130\]](#), [\[SP 800-56A\]](#), [\[SP 800-56B\]](#), [\[SP 800-56C\]](#), [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), [\[SP 800-57-3\]](#), [\[SP 800-111\]](#), [\[SP 800-124\]](#).

[SC-29](#) HETEROGENEITY

Control: Employ a diverse set of information technologies for the following system components in the implementation of the system: [Assignment: organization-defined system components].

Discussion: Increasing the diversity of information technologies 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 in information technologies also reduces the likelihood that the means

adversaries use to compromise one system component will be effective against other system components, thus further increasing the adversary work factor to successfully complete planned attacks. An increase in diversity may add complexity and management overhead that could ultimately lead to mistakes and unauthorized configurations.

Related Controls: [AU-9](#), [PL-8](#), [SC-27](#), [SC-30](#), [SR-3](#).

Control Enhancements:

(1) HETEROGENEITY | [VIRTUALIZATION TECHNIQUES](#)

Employ virtualization techniques to support the deployment of a diversity of operating systems and applications that are changed [Assignment: organization-defined frequency].

Discussion: While frequent changes to operating systems and applications can pose significant configuration management challenges, the changes can result in an increased work factor for adversaries to conduct successful attacks. Changing virtual operating systems or applications, as opposed to changing actual operating systems or applications, provides virtual changes that impede attacker success while reducing configuration management efforts. Virtualization techniques can assist in isolating untrustworthy software or software of dubious provenance into confined execution environments.

Related Controls: None.

References: None.

SC-30 CONCEALMENT AND MISDIRECTION

Control: Employ the following concealment and misdirection techniques for [Assignment: organization-defined systems] at [Assignment: organization-defined time periods] to confuse and mislead adversaries: [Assignment: organization-defined concealment and misdirection techniques].

Discussion: Concealment and misdirection techniques can significantly reduce the targeting capabilities of adversaries (i.e., window of opportunity and available attack surface) to initiate and complete attacks. For example, virtualization techniques provide organizations with the ability to disguise systems, potentially reducing the likelihood of successful attacks without the cost of having multiple platforms. The increased use of concealment and misdirection techniques and methods—including randomness, uncertainty, and virtualization—may sufficiently confuse and mislead adversaries and subsequently increase the risk of discovery and/or exposing tradecraft. Concealment and misdirection techniques may provide additional time to perform core mission and business functions. The implementation of concealment and misdirection techniques may add to the complexity and management overhead required for the system.

Related Controls: [AC-6](#), [SC-25](#), [SC-26](#), [SC-29](#), [SC-44](#), [SI-14](#).

Control Enhancements:

(1) CONCEALMENT AND MISDIRECTION | [VIRTUALIZATION TECHNIQUES](#)

[Withdrawn: Incorporated into [SC-29\(1\)](#).]

(2) CONCEALMENT AND MISDIRECTION | [RANDOMNESS](#)

Employ [Assignment: organization-defined techniques] to introduce randomness into organizational operations and assets.

Discussion: Randomness introduces increased levels of uncertainty for adversaries regarding the actions that organizations take to defend their systems against attacks. Such actions may impede the ability of adversaries to correctly target information resources of organizations that support critical missions or business functions. Uncertainty may also cause adversaries to hesitate before initiating or continuing attacks. Misdirection techniques that involve

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.

Related Controls: None.

(3) CONCEALMENT AND MISDIRECTION | [CHANGE PROCESSING AND STORAGE LOCATIONS](#)

**Change the location of [Assignment: organization-defined processing and/or storage]
[Selection: [Assignment: organization-defined time frequency]; at random time intervals].**

Discussion: Adversaries target critical mission and business functions and the systems that support those mission and business functions while also trying to minimize the exposure of their existence and tradecraft. The static, homogeneous, and deterministic nature of organizational systems targeted by adversaries make such systems more susceptible to attacks with less adversary cost and effort to be successful. 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, storage) that support critical mission and business functions. Changing the locations of processing activities and/or storage sites introduces a degree of uncertainty into the targeting activities of adversaries. The targeting uncertainty increases the work factor of adversaries and makes compromises or breaches of the organizational systems more difficult and time-consuming. It also increases the chances that adversaries may inadvertently disclose certain aspects of their tradecraft while attempting to locate critical organizational resources.

Related Controls: None.

(4) CONCEALMENT AND MISDIRECTION | [MISLEADING INFORMATION](#)

Employ realistic, but misleading information in [Assignment: organization-defined system components] about its security state or posture.

Discussion: Employing misleading information is intended to confuse potential adversaries regarding the nature and extent of controls deployed by organizations. Thus, adversaries may employ incorrect and ineffective attack techniques. One technique for misleading adversaries is for organizations to place misleading information regarding the specific controls deployed in external systems that are known to be targeted by adversaries. Another technique is the use of deception nets that mimic actual aspects of organizational systems but use, for example, out-of-date software configurations.

Related Controls: None.

(5) CONCEALMENT AND MISDIRECTION | [CONCEALMENT OF SYSTEM COMPONENTS](#)

Employ the following techniques to hide or conceal [Assignment: organization-defined system components]: [Assignment: organization-defined techniques].

Discussion: By hiding, disguising, or concealing critical system components, organizations may be able to decrease the probability that adversaries target and successfully compromise those assets. Potential means to hide, disguise, or conceal system components include the configuration of routers or the use of encryption or virtualization techniques.

Related Controls: None.

References: None.

SC-31 COVERT CHANNEL ANALYSIS

Control:

- a. Perform a covert channel analysis to identify those aspects of communications within the system that are potential avenues for covert [*Selection (one or more): storage; timing*] channels; and
- b. Estimate the maximum bandwidth of those channels.

Discussion: Developers are in the best position to identify potential areas within systems that might lead to covert channels. Covert channel analysis is a meaningful activity when there is the potential for unauthorized information flows across security domains, such as in the case of systems that contain export-controlled information and have connections to external networks (i.e., networks that are not controlled by organizations). Covert channel analysis is also useful for multilevel secure systems, multiple security level systems, and cross-domain systems.

Related Controls: [AC-3](#), [AC-4](#), [SA-8](#), [SI-11](#).

Control Enhancements:

(1) COVERT CHANNEL ANALYSIS | [TEST COVERT CHANNELS FOR EXPLOITABILITY](#)

Test a subset of the identified covert channels to determine the channels that are exploitable.

Discussion: None.

Related Controls: None.

(2) COVERT CHANNEL ANALYSIS | [MAXIMUM BANDWIDTH](#)

Reduce the maximum bandwidth for identified covert [*Selection (one or more): storage; timing*] channels to [*Assignment: organization-defined values*].

Discussion: The complete elimination of covert channels, especially covert timing channels, is usually not possible without significant performance impacts.

Related Controls: None.

(3) COVERT CHANNEL ANALYSIS | [MEASURE BANDWIDTH IN OPERATIONAL ENVIRONMENTS](#)

Measure the bandwidth of [*Assignment: organization-defined subset of identified covert channels*] in the operational environment of the system.

Discussion: Measuring covert channel bandwidth in specified operational environments helps organizations determine how much information can be covertly leaked before such leakage adversely affects mission or business functions. Covert channel bandwidth may be significantly different when measured in settings that are independent of the specific environments of operation, including laboratories or system development environments.

Related Controls: None.

References: None.

[SC-32](#) SYSTEM PARTITIONING

Control: Partition the system into [*Assignment: organization-defined system components*] residing in separate [*Selection: physical; logical*] domains or environments based on [*Assignment: organization-defined circumstances for physical or logical separation of components*].

Discussion: System partitioning is part of a defense-in-depth protection strategy. Organizations determine the degree of physical separation of system components. Physical separation options include physically distinct components in separate racks in the same room, critical components in separate rooms, and geographical separation of critical components. Security categorization can guide the selection of candidates for domain partitioning. Managed interfaces restrict or prohibit network access and information flow among partitioned system components.

Related Controls: [AC-4](#), [AC-6](#), [SA-8](#), [SC-2](#), [SC-3](#), [SC-7](#), [SC-36](#).

Control Enhancements:**(1) SYSTEM PARTITIONING | [SEPARATE PHYSICAL DOMAINS FOR PRIVILEGED FUNCTIONS](#)****Partition privileged functions into separate physical domains.**

Discussion: Privileged functions that operate in a single physical domain may represent a single point of failure if that domain becomes compromised or experiences a denial of service.

Related Controls: None.

References: [\[FIPS 199\]](#), [\[IR 8179\]](#).

SC-33 TRANSMISSION PREPARATION INTEGRITY

[Withdrawn: Incorporated into [SC-8](#).]

SC-34 NON-MODIFIABLE EXECUTABLE PROGRAMS

Control: For [Assignment: organization-defined system components], load and execute:

- a. The operating environment from hardware-enforced, read-only media; and
- b. The following applications from hardware-enforced, read-only media: [Assignment: organization-defined applications].

Discussion: The operating environment for a system contains the code that hosts applications, including operating systems, executives, or virtual machine monitors (i.e., hypervisors). It can also include certain applications that run directly on hardware platforms. Hardware-enforced, read-only media include Compact Disc-Recordable (CD-R) and Digital Versatile Disc-Recordable (DVD-R) disk drives as well as one-time, programmable, read-only memory. The use of non-modifiable storage ensures the integrity of software from the point of creation of the read-only image. The use of reprogrammable, read-only memory can be accepted as read-only media provided that integrity can be adequately protected from the point of initial writing to the insertion of the memory into the system, and there are reliable hardware protections against reprogramming the memory while installed in organizational systems.

Related Controls: [AC-3](#), [SI-7](#), [SI-14](#).

Control Enhancements:**(1) NON-MODIFIABLE EXECUTABLE PROGRAMS | [NO WRITABLE STORAGE](#)**

Employ [Assignment: organization-defined system components] with no writeable storage that is persistent across component restart or power on/off.

Discussion: Disallowing writeable storage eliminates the possibility of malicious code insertion via persistent, writeable storage within the designated system components. The restriction applies to fixed and removable storage, with the latter being addressed either directly or as specific restrictions imposed through access controls for mobile devices.

Related Controls: [AC-19](#), [MP-7](#).

(2) NON-MODIFIABLE EXECUTABLE PROGRAMS | [INTEGRITY PROTECTION ON READ-ONLY MEDIA](#)

Protect the integrity of information prior to storage on read-only media and control the media after such information has been recorded onto the media.

Discussion: Controls prevent the substitution of media into systems or the reprogramming of programmable read-only media prior to installation into the systems. Integrity protection controls include a combination of prevention, detection, and response.

Related Controls: [CM-3](#), [CM-5](#), [CM-9](#), [MP-2](#), [MP-4](#), [MP-5](#), [SC-28](#), [SI-3](#).

(3) NON-MODIFIABLE EXECUTABLE PROGRAMS | HARDWARE-BASED PROTECTION

[Withdrawn: Moved to [SC-51](#).]

SC-35 EXTERNAL MALICIOUS CODE IDENTIFICATION

Control: Include system components that proactively seek to identify network-based malicious code or malicious websites.

Discussion: External malicious code identification differs from decoys in [SC-26](#) in that the components actively probe networks, including the Internet, in search of malicious code contained on external websites. Like decoys, the use of external malicious code identification techniques requires some supporting isolation measures to ensure that any malicious code discovered during the search and subsequently executed does not infect organizational systems. Virtualization is a common technique for achieving such isolation.

Related Controls: [SC-7](#), [SC-26](#), [SC-44](#), [SI-3](#), [SI-4](#).

Control Enhancements: None.

References: None.

SC-36 DISTRIBUTED PROCESSING AND STORAGE

Control: Distribute the following processing and storage components across multiple [*Selection: physical locations; logical domains*]: [*Assignment: organization-defined processing and storage components*].

Discussion: Distributing processing and storage across multiple physical locations or logical domains provides a degree of redundancy or overlap for organizations. The redundancy and overlap increase the work factor of adversaries to adversely impact organizational operations, assets, and individuals. The use of distributed processing and storage does not assume a single primary processing or storage location. Therefore, it allows for parallel processing and storage.

Related Controls: [CP-6](#), [CP-7](#), [PL-8](#), [SC-32](#).

Control Enhancements:

(1) DISTRIBUTED PROCESSING AND STORAGE | [POLLING TECHNIQUES](#)

- (a) **Employ polling techniques to identify potential faults, errors, or compromises to the following processing and storage components: [*Assignment: organization-defined distributed processing and storage components*]; and**
- (b) **Take the following actions in response to identified faults, errors, or compromises: [*Assignment: organization-defined actions*].**

Discussion: Distributed processing and/or storage may be used to reduce opportunities for adversaries to compromise the confidentiality, integrity, or availability of organizational information and systems. However, the distribution of processing and storage components does not prevent adversaries from compromising one or more of the components. Polling compares the processing results and/or storage content from the distributed components and subsequently votes on the outcomes. Polling identifies potential faults, compromises, or errors in the distributed processing and storage components.

Related Controls: [SI-4](#).

(2) DISTRIBUTED PROCESSING AND STORAGE | [SYNCHRONIZATION](#)

Synchronize the following duplicate systems or system components: [*Assignment: organization-defined duplicate systems or system components*].

Discussion: [SC-36](#) and [CP-9\(6\)](#) require the duplication of systems or system components in distributed locations. The synchronization of duplicated and redundant services and data helps to ensure that information contained in the distributed locations can be used in the mission or business functions of organizations, as needed.

Related Controls: [CP-9](#).

References: [\[SP 800-160-2\]](#).

SC-37 OUT-OF-BAND CHANNELS

Control: Employ the following out-of-band channels for the physical delivery or electronic transmission of [Assignment: organization-defined information, system components, or devices] to [Assignment: organization-defined individuals or systems]: [Assignment: organization-defined out-of-band channels].

Discussion: Out-of-band channels include local, non-network accesses to systems; network paths physically separate from network paths used for operational traffic; or non-electronic paths, such as the U.S. Postal Service. The use of out-of-band channels is contrasted with the use of in-band channels (i.e., the same channels) that carry routine operational traffic. Out-of-band channels do not have the same vulnerability or exposure as in-band channels. Therefore, the confidentiality, integrity, or availability compromises of in-band channels will not compromise or adversely affect the out-of-band channels. Organizations may employ out-of-band channels in the delivery or transmission of organizational items, including authenticators and credentials; cryptographic key management information; system and data backups; configuration management changes for hardware, firmware, or software; security updates; maintenance information; and malicious code protection updates.

Related Controls: [AC-2](#), [CM-3](#), [CM-5](#), [CM-7](#), [IA-2](#), [IA-4](#), [IA-5](#), [MA-4](#), [SC-12](#), [SI-3](#), [SI-4](#), [SI-7](#).

Control Enhancements:

(1) OUT-OF-BAND CHANNELS | [ENSURE DELIVERY AND TRANSMISSION](#)

Employ [Assignment: organization-defined controls] to ensure that only [Assignment: organization-defined individuals or systems] receive the following information, system components, or devices: [Assignment: organization-defined information, system components, or devices].

Discussion: Techniques employed by organizations to ensure that only designated systems or individuals receive certain information, system components, or devices include sending authenticators via an approved courier service but requiring recipients to show some form of government-issued photographic identification as a condition of receipt.

Related Controls: None.

References: [\[SP 800-57-1\]](#), [\[SP 800-57-2\]](#), [\[SP 800-57-3\]](#).

SC-38 OPERATIONS SECURITY

Control: Employ the following operations security controls to protect key organizational information throughout the system development life cycle: [Assignment: organization-defined operations security controls].

Discussion: Operations security (OPSEC) is a systematic process by which potential adversaries can be denied information about the capabilities and intentions of organizations by identifying, controlling, and protecting generally unclassified information that specifically relates to the planning and execution of sensitive organizational activities. The OPSEC process involves five steps: identification of critical information, analysis of threats, analysis of vulnerabilities, assessment of risks, and the application of appropriate countermeasures. OPSEC controls are

applied to organizational systems and the environments in which those systems operate. OPSEC controls protect the confidentiality of information, including limiting the sharing of information with suppliers, potential suppliers, and other non-organizational elements and individuals. Information critical to organizational mission and business functions includes user identities, element uses, suppliers, supply chain processes, functional requirements, security requirements, system design specifications, testing and evaluation protocols, and security control implementation details.

Related Controls: [CA-2](#), [CA-7](#), [PL-1](#), [PM-9](#), [PM-12](#), [RA-2](#), [RA-3](#), [RA-5](#), [SC-7](#), [SR-3](#), [SR-7](#).

Control Enhancements: None.

References: None.

SC-39 PROCESS ISOLATION

Control: Maintain a separate execution domain for each executing system process.

Discussion: Systems can maintain separate execution domains for each executing process by assigning each process a separate address space. Each system process has a distinct address space so that communication between processes is performed in a manner controlled through the security functions, and one process cannot modify the executing code of another process. Maintaining separate execution domains for executing processes can be achieved, for example, by implementing separate address spaces. Process isolation technologies, including sandboxing or virtualization, logically separate software and firmware from other software, firmware, and data. Process isolation helps limit the access of potentially untrusted software to other system resources. The capability to maintain separate execution domains is available in commercial operating systems that employ multi-state processor technologies.

Related Controls: [AC-3](#), [AC-4](#), [AC-6](#), [AC-25](#), [SA-8](#), [SC-2](#), [SC-3](#), [SI-16](#).

Control Enhancements:

(1) PROCESS ISOLATION | [HARDWARE SEPARATION](#)

Implement hardware separation mechanisms to facilitate process isolation.

Discussion: Hardware-based separation of system processes is generally less susceptible to compromise than software-based separation, thus providing greater assurance that the separation will be enforced. Hardware separation mechanisms include hardware memory management.

Related Controls: None.

(2) PROCESS ISOLATION | [SEPARATE EXECUTION DOMAIN PER THREAD](#)

Maintain a separate execution domain for each thread in [Assignment: organization-defined multi-threaded processing].

Discussion: None.

Related Controls: None.

References: [\[SP 800-160-1\]](#).

SC-40 WIRELESS LINK PROTECTION

Control: Protect external and internal [Assignment: organization-defined wireless links] from the following signal parameter attacks: [Assignment: organization-defined types of signal parameter attacks or references to sources for such attacks].

Discussion: Wireless link protection applies to internal and external wireless communication links that may be visible to individuals who are not authorized system users. Adversaries can

exploit the signal parameters of wireless links if such links are not adequately protected. There are many ways to exploit the signal parameters of wireless links to gain intelligence, deny service, or spoof system users. Protection of wireless links reduces the impact of attacks that are unique to wireless systems. If organizations rely on commercial service providers for transmission services as commodity items rather than as fully dedicated services, it may not be possible to implement wireless link protections to the extent necessary to meet organizational security requirements.

Related Controls: [AC-18](#), [SC-5](#).

Control Enhancements:

(1) WIRELESS LINK PROTECTION | [ELECTROMAGNETIC INTERFERENCE](#)

Implement cryptographic mechanisms that achieve [Assignment: organization-defined level of protection] against the effects of intentional electromagnetic interference.

Discussion: The implementation of cryptographic mechanisms for electromagnetic interference protects systems against intentional jamming that might deny or impair communications by ensuring that wireless spread spectrum waveforms used to provide anti-jam protection are not predictable by unauthorized individuals. The implementation of cryptographic mechanisms may also coincidentally mitigate the effects of unintentional jamming due to interference from legitimate transmitters that share the same spectrum. Mission requirements, projected threats, concept of operations, and laws, executive orders, directives, regulations, policies, and standards determine levels of wireless link availability, cryptography needed, and performance.

Related Controls: [PE-21](#), [SC-12](#), [SC-13](#).

(2) WIRELESS LINK PROTECTION | [REDUCE DETECTION POTENTIAL](#)

Implement cryptographic mechanisms to reduce the detection potential of wireless links to [Assignment: organization-defined level of reduction].

Discussion: The implementation of cryptographic mechanisms to reduce detection potential is used for covert communications and to protect wireless transmitters from geo-location. It also ensures that the spread spectrum waveforms used to achieve a low probability of detection are not predictable by unauthorized individuals. Mission requirements, projected threats, concept of operations, and applicable laws, executive orders, directives, regulations, policies, and standards determine the levels to which wireless links are undetectable.

Related Controls: [SC-12](#), [SC-13](#).

(3) WIRELESS LINK PROTECTION | [IMITATIVE OR MANIPULATIVE COMMUNICATIONS DECEPTION](#)

Implement cryptographic mechanisms to identify and reject wireless transmissions that are deliberate attempts to achieve imitative or manipulative communications deception based on signal parameters.

Discussion: The implementation of cryptographic mechanisms to identify and reject imitative or manipulative communications ensures that the signal parameters of wireless transmissions are not predictable by unauthorized individuals. Such unpredictability reduces the probability of imitative or manipulative communications deception based on signal parameters alone.

Related Controls: [SC-12](#), [SC-13](#), [SI-4](#).

(4) WIRELESS LINK PROTECTION | [SIGNAL PARAMETER IDENTIFICATION](#)

Implement cryptographic mechanisms to prevent the identification of [Assignment: organization-defined wireless transmitters] by using the transmitter signal parameters.

Discussion: The implementation of cryptographic mechanisms to prevent the identification of wireless transmitters protects against the unique identification of wireless transmitters

for the purposes of intelligence exploitation by ensuring that anti-fingerprinting alterations to signal parameters are not predictable by unauthorized individuals. It also provides anonymity when required. Radio fingerprinting techniques identify the unique signal parameters of transmitters to fingerprint such transmitters for purposes of tracking and mission or user identification.

Related Controls: [SC-12](#), [SC-13](#).

References: None.

SC-41 PORT AND I/O DEVICE ACCESS

Control: [Selection: Physically; Logically] disable or remove [Assignment: organization-defined connection ports or input/output devices] on the following systems or system components: [Assignment: organization-defined systems or system components].

Discussion: Connection ports include Universal Serial Bus (USB), Thunderbolt, and Firewire (IEEE 1394). Input/output (I/O) devices include compact disc and digital versatile disc drives. Disabling or removing such connection ports and I/O devices helps prevent the exfiltration of information from systems and the introduction of malicious code from those ports or devices. Physically disabling or removing ports and/or devices is the stronger action.

Related Controls: [AC-20](#), [MP-7](#).

Control Enhancements: None.

References: None.

SC-42 SENSOR CAPABILITY AND DATA

Control:

- a. Prohibit [Selection (one or more): the use of devices possessing [Assignment: organization-defined environmental sensing capabilities] in [Assignment: organization-defined facilities, areas, or systems]; the remote activation of environmental sensing capabilities on organizational systems or system components with the following exceptions: [Assignment: organization-defined exceptions where remote activation of sensors is allowed]]; and
- b. Provide an explicit indication of sensor use to [Assignment: organization-defined group of users].

Discussion: Sensor capability and data applies to types of systems or system components characterized as mobile devices, such as cellular telephones, smart phones, and tablets. Mobile devices often include sensors that can collect and record data regarding the environment where the system is in use. Sensors that are embedded within mobile devices include microphones, cameras, Global Positioning System (GPS) mechanisms, and accelerometers. While the sensors on mobile devices provide an important function, if activated covertly, such devices can potentially provide a means for adversaries to learn valuable information about individuals and organizations. For example, remotely activating the GPS function on a mobile device could provide an adversary with the ability to track the movements of an individual. Organizations may prohibit individuals from bringing cellular telephones or digital cameras into certain designated facilities or controlled areas within facilities where classified information is stored or sensitive conversations are taking place.

Related Controls: [SC-15](#).

Control Enhancements:

(1) SENSOR CAPABILITY AND DATA | [REPORTING TO AUTHORIZED INDIVIDUALS OR ROLES](#)

Verify that the system is configured so that data or information collected by the [Assignment: organization-defined sensors] is only reported to authorized individuals or roles.

Discussion: In situations where sensors are activated by authorized individuals, it is still possible that the data or information collected by the sensors will be sent to unauthorized entities.

Related Controls: None.

(2) SENSOR CAPABILITY AND DATA | [AUTHORIZED USE](#)

Employ the following measures so that data or information collected by [Assignment: organization-defined sensors] is only used for authorized purposes: [Assignment: organization-defined measures].

Discussion: Information collected by sensors for a specific authorized purpose could be misused for some unauthorized purpose. For example, GPS sensors that are used to support traffic navigation could be misused to track the movements of individuals. Measures to mitigate such activities include additional training to help ensure that authorized individuals do not abuse their authority and, in the case where sensor data is maintained by external parties, contractual restrictions on the use of such data.

Related Controls: [PT-2](#).

(3) SENSOR CAPABILITY AND DATA | PROHIBIT USE OF DEVICES

[Withdrawn: Incorporated into [SC-42](#).]

(4) SENSOR CAPABILITY AND DATA | [NOTICE OF COLLECTION](#)

Employ the following measures to facilitate an individual's awareness that personally identifiable information is being collected by [Assignment: organization-defined sensors]: [Assignment: organization-defined measures].

Discussion: Awareness that organizational sensors are collecting data enables individuals to more effectively engage in managing their privacy. Measures can include conventional written notices and sensor configurations that make individuals directly or indirectly aware through other devices that the sensor is collecting information. The usability and efficacy of the notice are important considerations.

Related Controls: [PT-1](#), [PT-4](#), [PT-5](#).

(5) SENSOR CAPABILITY AND DATA | [COLLECTION MINIMIZATION](#)

Employ [Assignment: organization-defined sensors] that are configured to minimize the collection of information about individuals that is not needed.

Discussion: Although policies to control for authorized use can be applied to information once it is collected, minimizing the collection of information that is not needed mitigates privacy risk at the system entry point and mitigates the risk of policy control failures. Sensor configurations include the obscuring of human features, such as blurring or pixelating flesh tones.

Related Controls: [SA-8](#), [SI-12](#).

References: [\[OMB A-130\]](#), [\[SP 800-124\]](#).

SC-43 USAGE RESTRICTIONS

Control:

- a. Establish usage restrictions and implementation guidelines for the following system components: [Assignment: organization-defined system components]; and

- b. Authorize, monitor, and control the use of such components within the system.

Discussion: Usage restrictions apply to all system components including but not limited to mobile code, mobile devices, wireless access, and wired and wireless peripheral components (e.g., copiers, printers, scanners, optical devices, and other similar technologies). The usage restrictions and implementation guidelines are based on the potential for system components to cause damage to the system and help to ensure that only authorized system use occurs.

Related Controls: [AC-18](#), [AC-19](#), [CM-6](#), [SC-7](#), [SC-18](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-124\]](#).

SC-44 DETONATION CHAMBERS

Control: Employ a detonation chamber capability within [Assignment: organization-defined system, system component, or location].

Discussion: Detonation chambers, also known as dynamic execution environments, allow organizations to open email attachments, execute untrusted or suspicious applications, and execute Universal Resource Locator requests in the safety of an isolated environment or a virtualized sandbox. Protected and isolated execution environments provide a means of determining whether the associated attachments or applications contain malicious code. While related to the concept of deception nets, the employment of detonation chambers is not intended to maintain a long-term environment in which adversaries can operate and their actions can be observed. Rather, detonation chambers are intended to quickly identify malicious code and either reduce the likelihood that the code is propagated to user environments of operation or prevent such propagation completely.

Related Controls: [SC-7](#), [SC-18](#), [SC-25](#), [SC-26](#), [SC-30](#), [SC-35](#), [SC-39](#), [SI-3](#), [SI-7](#).

Control Enhancements: None.

References: [\[SP 800-177\]](#).

SC-45 SYSTEM TIME SYNCHRONIZATION

Control: Synchronize system clocks within and between systems and system components.

Discussion: Time synchronization of system clocks is essential for the correct execution of many system services, including identification and authentication processes that involve certificates and time-of-day restrictions as part of access control. Denial of service or failure to deny expired credentials may result without properly synchronized clocks within and between systems and system components. Time is commonly expressed in Coordinated Universal Time (UTC), a modern continuation of Greenwich Mean Time (GMT), or local time with an offset from UTC. The granularity of time measurements refers to the degree of synchronization between system clocks and reference clocks, such as clocks synchronizing within hundreds of milliseconds or tens of milliseconds. Organizations may define different time granularities for system components. Time service can be critical to other security capabilities—such as access control and identification and authentication—depending on the nature of the mechanisms used to support the capabilities.

Related Controls: [AC-3](#), [AU-8](#), [IA-2](#), [IA-8](#).

Control Enhancements:

(1) SYSTEM TIME SYNCHRONIZATION | [SYNCHRONIZATION WITH AUTHORITATIVE TIME SOURCE](#)

(a) Compare the internal system clocks [Assignment: organization-defined frequency] with [Assignment: organization-defined authoritative time source]; and

- (b) Synchronize the internal system clocks to the authoritative time source when the time difference is greater than [Assignment: organization-defined time period].**

Discussion: Synchronization of internal system clocks with an authoritative source provides uniformity of time stamps for systems with multiple system clocks and systems connected over a network.

Related Controls: None.

(2) SYSTEM TIME SYNCHRONIZATION | [SECONDARY AUTHORITATIVE TIME SOURCE](#)

- (a) Identify a secondary authoritative time source that is in a different geographic region than the primary authoritative time source; and**
- (b) Synchronize the internal system clocks to the secondary authoritative time source if the primary authoritative time source is unavailable.**

Discussion: It may be necessary to employ geolocation information to determine that the secondary authoritative time source is in a different geographic region.

Related Controls: None.

References: [[IETF 5905](#)].

[SC-46 CROSS DOMAIN POLICY ENFORCEMENT](#)

Control: Implement a policy enforcement mechanism [*Selection: physically; logically*] between the physical and/or network interfaces for the connecting security domains.

Discussion: For logical policy enforcement mechanisms, organizations avoid creating a logical path between interfaces to prevent the ability to bypass the policy enforcement mechanism. For physical policy enforcement mechanisms, the robustness of physical isolation afforded by the physical implementation of policy enforcement to preclude the presence of logical covert channels penetrating the security domain may be needed. Contact ncdsmo@nsa.gov for more information.

Related Controls: [AC-4](#), [SC-7](#).

Control Enhancements: None.

References: [[SP 800-160-1](#)].

[SC-47 ALTERNATE COMMUNICATIONS PATHS](#)

Control: Establish [Assignment: organization-defined alternate communications paths] for system operations organizational command and control.

Discussion: An incident, whether adversarial- or nonadversarial-based, can disrupt established communications paths used for system operations and organizational command and control. Alternate communications paths reduce the risk of all communications paths being affected by the same incident. To compound the problem, the inability of organizational officials to obtain timely information about disruptions or to provide timely direction to operational elements after a communications path incident, can impact the ability of the organization to respond to such incidents in a timely manner. Establishing alternate communications paths for command and control purposes, including designating alternative decision makers if primary decision makers are unavailable and establishing the extent and limitations of their actions, can greatly facilitate the organization's ability to continue to operate and take appropriate actions during an incident.

Related Controls: [CP-2](#), [CP-8](#).

Control Enhancements: None.

References: [[SP 800-34](#)], [[SP 800-61](#)], [[SP 800-160-2](#)].

SC-48 SENSOR RELOCATION

Control: Relocate [Assignment: organization-defined sensors and monitoring capabilities] to [Assignment: organization-defined locations] under the following conditions or circumstances: [Assignment: organization-defined conditions or circumstances].

Discussion: Adversaries may take various paths and use different approaches as they move laterally through an organization (including its systems) to reach their target or as they attempt to exfiltrate information from the organization. The organization often only has a limited set of monitoring and detection capabilities, and they may be focused on the critical or likely infiltration or exfiltration paths. By using communications paths that the organization typically does not monitor, the adversary can increase its chances of achieving its desired goals. By relocating its sensors or monitoring capabilities to new locations, the organization can impede the adversary's ability to achieve its goals. The relocation of the sensors or monitoring capabilities might be done based on threat information that the organization has acquired or randomly to confuse the adversary and make its lateral transition through the system or organization more challenging.

Related Controls: [AU-2](#), [SC-7](#), [SI-4](#).

Control Enhancements:

(1) SENSOR RELOCATION | [DYNAMIC RELOCATION OF SENSORS OR MONITORING CAPABILITIES](#)

Dynamically relocate [Assignment: organization-defined sensors and monitoring capabilities] to [Assignment: organization-defined locations] under the following conditions or circumstances: [Assignment: organization-defined conditions or circumstances].

Discussion: None.

Related Controls: None.

References: [\[SP 800-160-2\]](#).

SC-49 HARDWARE-ENFORCED SEPARATION AND POLICY ENFORCEMENT

Control: Implement hardware-enforced separation and policy enforcement mechanisms between [Assignment: organization-defined security domains].

Discussion: System owners may require additional strength of mechanism and robustness to ensure domain separation and policy enforcement for specific types of threats and environments of operation. Hardware-enforced separation and policy enforcement provide greater strength of mechanism than software-enforced separation and policy enforcement.

Related Controls: [AC-4](#), [SA-8](#), [SC-50](#).

Control Enhancements: None.

References: [\[SP 800-160-1\]](#).

SC-50 SOFTWARE-ENFORCED SEPARATION AND POLICY ENFORCEMENT

Control: Implement software-enforced separation and policy enforcement mechanisms between [Assignment: organization-defined security domains].

Discussion: System owners may require additional strength of mechanism to ensure domain separation and policy enforcement for specific types of threats and environments of operation.

Related Controls: [AC-3](#), [AC-4](#), [SA-8](#), [SC-2](#), [SC-3](#), [SC-49](#).

Control Enhancements: None.

References: [\[SP 800-160-1\]](#).

SC-51 HARDWARE-BASED PROTECTIONControl:

- a. Employ hardware-based, write-protect for [Assignment: organization-defined system firmware components]; and
- b. Implement specific procedures for [Assignment: organization-defined authorized individuals] to manually disable hardware write-protect for firmware modifications and re-enable the write-protect prior to returning to operational mode.

Discussion: None.Related Controls: None.Control Enhancements: None.References: None.

3.19 SYSTEM AND INFORMATION INTEGRITY

[Quick link to System and Information Integrity Summary Table](#)

SI-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] system and information integrity policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the system and information integrity policy and the associated system and information integrity controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the system and information integrity policy and procedures; and
- c. Review and update the current system and information integrity:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: System and information integrity policy and procedures address the controls in the SI family that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of system and information integrity policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to system and information integrity policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PS-8](#), [SA-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-12\]](#), [\[SP 800-100\]](#).

SI-2 FLAW REMEDIATIONControl:

- a. Identify, report, and correct system flaws;
- b. Test software and firmware updates related to flaw remediation for effectiveness and potential side effects before installation;
- c. Install security-relevant software and firmware updates within [Assignment: organization-defined time period] of the release of the updates; and
- d. Incorporate flaw remediation into the organizational configuration management process.

Discussion: The need to remediate system flaws applies to all types of software and firmware. Organizations identify systems affected by software flaws, including potential vulnerabilities resulting from those flaws, and report this information to designated organizational personnel with information security and privacy responsibilities. Security-relevant updates include patches, service packs, and malicious code signatures. Organizations also address flaws discovered during assessments, continuous monitoring, incident response activities, and system error handling. By incorporating flaw remediation into configuration management processes, required remediation actions can be tracked and verified.

Organization-defined time periods for updating security-relevant software and firmware may vary based on a variety of risk factors, including the security category of the system, the criticality of the update (i.e., severity of the vulnerability related to the discovered flaw), the organizational risk tolerance, the mission supported by the system, or the threat environment. Some types of flaw remediation may require more testing than other types. Organizations determine the type of testing needed for the specific type of flaw remediation activity under consideration and the types of changes that are to be configuration-managed. In some situations, organizations may determine that the testing of software or firmware updates is not necessary or practical, such as when implementing simple malicious code signature updates. In testing decisions, organizations consider whether security-relevant software or firmware updates are obtained from authorized sources with appropriate digital signatures.

Related Controls: [CA-5](#), [CM-3](#), [CM-4](#), [CM-5](#), [CM-6](#), [CM-8](#), [MA-2](#), [RA-5](#), [SA-8](#), [SA-10](#), [SA-11](#), [SI-3](#), [SI-5](#), [SI-7](#), [SI-11](#).

Control Enhancements:**(1) FLAW REMEDIATION | CENTRAL MANAGEMENT**

[Withdrawn: Incorporated into [PL-9](#).]

(2) FLAW REMEDIATION | [AUTOMATED FLAW REMEDIATION STATUS](#)

Determine if system components have applicable security-relevant software and firmware updates installed using [Assignment: organization-defined automated mechanisms]
[Assignment: organization-defined frequency].

Discussion: Automated mechanisms can track and determine the status of known flaws for system components.

Related Controls: [CA-7](#), [SI-4](#).

(3) FLAW REMEDIATION | [TIME TO REMEDIATE FLAWS AND BENCHMARKS FOR CORRECTIVE ACTIONS](#)

(a) Measure the time between flaw identification and flaw remediation; and

(b) Establish the following benchmarks for taking corrective actions: [Assignment: organization-defined benchmarks].

Discussion: Organizations determine the time it takes on average to correct system flaws after such flaws have been identified and subsequently establish organizational benchmarks

(i.e., time frames) for taking corrective actions. Benchmarks can be established by the type of flaw or the severity of the potential vulnerability if the flaw can be exploited.

Related Controls: None.

(4) FLAW REMEDIATION | [AUTOMATED PATCH MANAGEMENT TOOLS](#)

Employ automated patch management tools to facilitate flaw remediation to the following system components: [Assignment: organization-defined system components].

Discussion: Using automated tools to support patch management helps to ensure the timeliness and completeness of system patching operations.

Related Controls: None.

(5) FLAW REMEDIATION | [AUTOMATIC SOFTWARE AND FIRMWARE UPDATES](#)

Install [Assignment: organization-defined security-relevant software and firmware updates] automatically to [Assignment: organization-defined system components].

Discussion: Due to system integrity and availability concerns, organizations consider the methodology used to carry out automatic updates. Organizations balance the need to ensure that the updates are installed as soon as possible with the need to maintain configuration management and control with any mission or operational impacts that automatic updates might impose.

Related Controls: None.

(6) FLAW REMEDIATION | [REMOVAL OF PREVIOUS VERSIONS OF SOFTWARE AND FIRMWARE](#)

Remove previous versions of [Assignment: organization-defined software and firmware components] after updated versions have been installed.

Discussion: Previous versions of software or firmware components that are not removed from the system after updates have been installed may be exploited by adversaries. Some products may automatically remove previous versions of software and firmware from the system.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[FIPS 140-3\]](#), [\[FIPS 186-4\]](#), [\[SP 800-39\]](#), [\[SP 800-40\]](#), [\[SP 800-128\]](#), [\[IR 7788\]](#).

SI-3 MALICIOUS CODE PROTECTION

Control:

- a. Implement [Selection (one or more): signature based; non-signature based] malicious code protection mechanisms at system entry and exit points to detect and eradicate malicious code;
- b. Automatically update malicious code protection mechanisms as new releases are available in accordance with organizational configuration management policy and procedures;
- c. Configure malicious code protection mechanisms to:
 1. Perform periodic scans of the system [Assignment: organization-defined frequency] and real-time scans of files from external sources at [Selection (one or more): endpoint; network entry and exit points] as the files are downloaded, opened, or executed in accordance with organizational policy; and
 2. [Selection (one or more): block malicious code; quarantine malicious code; take [Assignment: organization-defined action]]; and send alert to [Assignment: organization-defined personnel or roles] in response to malicious code detection; and

- d. Address the receipt of false positives during malicious code detection and eradication and the resulting potential impact on the availability of the system.

Discussion: System entry and exit points include firewalls, remote access servers, workstations, electronic mail servers, web servers, proxy servers, notebook computers, and mobile devices. Malicious code includes viruses, worms, Trojan horses, and spyware. Malicious code can also be encoded in various formats contained within compressed or hidden files or hidden in files using techniques such as steganography. Malicious code can be inserted into systems in a variety of ways, including by electronic mail, the world-wide web, and portable storage devices. Malicious code insertions occur through the exploitation of system vulnerabilities. A variety of technologies and methods exist to limit or eliminate the effects of malicious code.

Malicious code protection mechanisms include both signature- and nonsignature-based technologies. Nonsignature-based detection mechanisms include artificial intelligence techniques that use heuristics to detect, analyze, and describe the characteristics or behavior of malicious code and to provide controls against such code for which signatures do not yet exist or for which existing signatures may not be effective. Malicious code for which active signatures do not yet exist or may be ineffective includes polymorphic malicious code (i.e., code that changes signatures when it replicates). Nonsignature-based mechanisms also include reputation-based technologies. In addition to the above technologies, pervasive configuration management, comprehensive software integrity controls, and anti-exploitation software may be effective in preventing the execution of unauthorized code. Malicious code may be present in commercial off-the-shelf software as well as custom-built software and could include logic bombs, backdoors, and other types of attacks that could affect organizational mission and business functions.

In situations where malicious code cannot be detected by detection methods or technologies, organizations rely on other types of controls, including secure coding practices, configuration management and control, trusted procurement processes, and monitoring practices to ensure that software does not perform functions other than the functions intended. Organizations may determine that, in response to the detection of malicious code, different actions may be warranted. For example, organizations can define actions in response to malicious code detection during periodic scans, the detection of malicious downloads, or the detection of maliciousness when attempting to open or execute files.

Related Controls: [AC-4](#), [AC-19](#), [CM-3](#), [CM-8](#), [IR-4](#), [MA-3](#), [MA-4](#), [PL-9](#), [RA-5](#), [SC-7](#), [SC-23](#), [SC-26](#), [SC-28](#), [SC-44](#), [SI-2](#), [SI-4](#), [SI-7](#), [SI-8](#), [SI-15](#).

Control Enhancements:

(1) MALICIOUS CODE PROTECTION | CENTRAL MANAGEMENT

[Withdrawn: Incorporated into [PL-9](#).]

(2) MALICIOUS CODE PROTECTION | AUTOMATIC UPDATES

[Withdrawn: Incorporated into [SI-3](#).]

(3) MALICIOUS CODE PROTECTION | NON-PRIVILEGED USERS

[Withdrawn: Incorporated into [AC-6\(10\)](#).]

(4) MALICIOUS CODE PROTECTION | [UPDATES ONLY BY PRIVILEGED USERS](#)

Update malicious code protection mechanisms only when directed by a privileged user.

Discussion: Protection mechanisms for malicious code are typically categorized as security-related software and, as such, are only updated by organizational personnel with appropriate access privileges.

Related Controls: [CM-5](#).

(5) MALICIOUS CODE PROTECTION | PORTABLE STORAGE DEVICES

[Withdrawn: Incorporated into [MP-7](#).]

- (6) MALICIOUS CODE PROTECTION | [TESTING AND VERIFICATION](#)
- (a) **Test malicious code protection mechanisms** [*Assignment: organization-defined frequency*] by introducing known benign code into the system; and
- (b) **Verify that the detection of the code and the associated incident reporting occur.**
- Discussion: None.
- Related Controls: [CA-2](#), [CA-7](#), [RA-5](#).
- (7) MALICIOUS CODE PROTECTION | NONSIGNATURE-BASED DETECTION
- [Withdrawn: Incorporated into [SI-3](#).]
- (8) MALICIOUS CODE PROTECTION | [DETECT UNAUTHORIZED COMMANDS](#)
- (a) **Detect the following unauthorized operating system commands through the kernel application programming interface** on [*Assignment: organization-defined system hardware components*]: [*Assignment: organization-defined unauthorized operating system commands*]; and
- (b) **[Selection (one or more): issue a warning; audit the command execution; prevent the execution of the command].**
- Discussion: Detecting unauthorized commands can be applied to critical interfaces other than kernel-based interfaces, including interfaces with virtual machines and privileged applications. Unauthorized operating system commands include commands for kernel functions from system processes that are not trusted to initiate such commands as well as commands for kernel functions that are suspicious even though commands of that type are reasonable for processes to initiate. Organizations can define the malicious commands to be detected by a combination of command types, command classes, or specific instances of commands. Organizations can also define hardware components by component type, component, component location in the network, or a combination thereof. Organizations may select different actions for different types, classes, or instances of malicious commands.
- Related Controls: [AU-2](#), [AU-6](#), [AU-12](#).
- (9) MALICIOUS CODE PROTECTION | AUTHENTICATE REMOTE COMMANDS
- [Withdrawn: Moved to [AC-17\(10\)](#).]
- (10) MALICIOUS CODE PROTECTION | [MALICIOUS CODE ANALYSIS](#)
- (a) **Employ the following tools and techniques to analyze the characteristics and behavior of malicious code:** [*Assignment: organization-defined tools and techniques*]; and
- (b) **Incorporate the results from malicious code analysis into organizational incident response and flaw remediation processes.**
- Discussion: The use of malicious code analysis tools provides organizations with a more in-depth understanding of adversary tradecraft (i.e., tactics, techniques, and procedures) and the functionality and purpose of specific instances of malicious code. Understanding the characteristics of malicious code facilitates effective organizational responses to current and future threats. Organizations can conduct malicious code analyses by employing reverse engineering techniques or by monitoring the behavior of executing code.
- Related Controls: None.
- References: [\[SP 800-83\]](#), [\[SP 800-125B\]](#), [\[SP 800-177\]](#).

SI-4 SYSTEM MONITORING

Control:

- a. Monitor the system to detect:
 1. Attacks and indicators of potential attacks in accordance with the following monitoring objectives: [Assignment: organization-defined monitoring objectives]; and
 2. Unauthorized local, network, and remote connections;
- b. Identify unauthorized use of the system through the following techniques and methods: [Assignment: organization-defined techniques and methods];
- c. Invoke internal monitoring capabilities or deploy monitoring devices:
 1. Strategically within the system to collect organization-determined essential information; and
 2. At ad hoc locations within the system to track specific types of transactions of interest to the organization;
- d. Analyze detected events and anomalies;
- e. Adjust the level of system monitoring activity when there is a change in risk to organizational operations and assets, individuals, other organizations, or the Nation;
- f. Obtain legal opinion regarding system monitoring activities; and
- g. Provide [Assignment: organization-defined system monitoring information] to [Assignment: organization-defined personnel or roles] [Selection (one or more): as needed; [Assignment: organization-defined frequency]].

Discussion: System monitoring includes external and internal monitoring. External monitoring includes the observation of events occurring at external interfaces to the system. Internal monitoring includes the observation of events occurring within the system. Organizations monitor systems by observing audit activities in real time or by observing other system aspects such as access patterns, characteristics of access, and other actions. The monitoring objectives guide and inform the determination of the events. System monitoring capabilities are achieved through a variety of tools and techniques, including intrusion detection and prevention systems, malicious code protection software, scanning tools, audit record monitoring software, and network monitoring software.

Depending on the security architecture, the distribution and configuration of monitoring devices may impact throughput at key internal and external boundaries as well as at other locations across a network due to the introduction of network throughput latency. If throughput management is needed, such devices are strategically located and deployed as part of an established organization-wide security architecture. Strategic locations for monitoring devices include selected perimeter locations and near key servers and server farms that support critical applications. Monitoring devices are typically employed at the managed interfaces associated with controls [SC-7](#) and [AC-17](#). The information collected is a function of the organizational monitoring objectives and the capability of systems to support such objectives. Specific types of transactions of interest include Hypertext Transfer Protocol (HTTP) traffic that bypasses HTTP proxies. System monitoring is an integral part of organizational continuous monitoring and incident response programs, and output from system monitoring serves as input to those programs. System monitoring requirements, including the need for specific types of system monitoring, may be referenced in other controls (e.g., [AC-2g](#), [AC-2\(7\)](#), [AC-2\(12\)\(a\)](#), [AC-17\(1\)](#), [AU-13](#), [AU-13\(1\)](#), [AU-13\(2\)](#), [CM-3f](#), [CM-6d](#), [MA-3a](#), [MA-4a](#), [SC-5\(3\)\(b\)](#), [SC-7a](#), [SC-7\(24\)\(b\)](#), [SC-18b](#), [SC-43b](#)). Adjustments to levels of system monitoring are based on law enforcement information, intelligence information, or other sources of information. The legality of system monitoring activities is based on applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: [AC-2](#), [AC-3](#), [AC-4](#), [AC-8](#), [AC-17](#), [AU-2](#), [AU-6](#), [AU-7](#), [AU-9](#), [AU-12](#), [AU-13](#), [AU-14](#), [CA-7](#), [CM-3](#), [CM-6](#), [CM-8](#), [CM-11](#), [IA-10](#), [IR-4](#), [MA-3](#), [MA-4](#), [PL-9](#), [PM-12](#), [RA-5](#), [RA-10](#), [SC-5](#), [SC-7](#), [SC-18](#), [SC-26](#), [SC-31](#), [SC-35](#), [SC-36](#), [SC-37](#), [SC-43](#), [SI-3](#), [SI-6](#), [SI-7](#), [SR-9](#), [SR-10](#).

Control Enhancements:

(1) SYSTEM MONITORING | [SYSTEM-WIDE INTRUSION DETECTION SYSTEM](#)

Connect and configure individual intrusion detection tools into a system-wide intrusion detection system.

Discussion: Linking individual intrusion detection tools into a system-wide intrusion detection system provides additional coverage and effective detection capabilities. The information contained in one intrusion detection tool can be shared widely across the organization, making the system-wide detection capability more robust and powerful.

Related Controls: None.

(2) SYSTEM MONITORING | [AUTOMATED TOOLS AND MECHANISMS FOR REAL-TIME ANALYSIS](#)

Employ automated tools and mechanisms to support near real-time analysis of events.

Discussion: Automated tools and mechanisms include host-based, network-based, transport-based, or storage-based event monitoring tools and mechanisms or security information and event management (SIEM) technologies that provide real-time analysis of alerts and notifications generated by organizational systems. Automated monitoring techniques can create unintended privacy risks because automated controls may connect to external or otherwise unrelated systems. The matching of records between these systems may create linkages with unintended consequences. Organizations assess and document these risks in their privacy impact assessment and make determinations that are in alignment with their privacy program plan.

Related Controls: [PM-23](#), [PM-25](#).

(3) SYSTEM MONITORING | [AUTOMATED TOOL AND MECHANISM INTEGRATION](#)

Employ automated tools and mechanisms to integrate intrusion detection tools and mechanisms into access control and flow control mechanisms.

Discussion: Using automated tools and mechanisms to integrate intrusion detection tools and mechanisms into access and flow control mechanisms facilitates a rapid response to attacks by enabling the reconfiguration of mechanisms in support of attack isolation and elimination.

Related Controls: [PM-23](#), [PM-25](#).

(4) SYSTEM MONITORING | [INBOUND AND OUTBOUND COMMUNICATIONS TRAFFIC](#)

(a) Determine criteria for unusual or unauthorized activities or conditions for inbound and outbound communications traffic;

(b) Monitor inbound and outbound communications traffic [Assignment: organization-defined frequency] for [Assignment: organization-defined unusual or unauthorized activities or conditions].

Discussion: Unusual or unauthorized activities or conditions related to system inbound and outbound communications traffic includes internal traffic that indicates the presence of malicious code or unauthorized use of legitimate code or credentials within organizational systems or propagating among system components, signaling to external systems, and the unauthorized exporting of information. Evidence of malicious code or unauthorized use of legitimate code or credentials is used to identify potentially compromised systems or system components.

Related Controls: None.

(5) SYSTEM MONITORING | [SYSTEM-GENERATED ALERTS](#)

Alert [Assignment: organization-defined personnel or roles] when the following system-generated indications of compromise or potential compromise occur: [Assignment: organization-defined compromise indicators].

Discussion: Alerts may be generated from a variety of sources, including audit records or inputs from malicious code protection mechanisms, intrusion detection or prevention mechanisms, or boundary protection devices such as firewalls, gateways, and routers. Alerts can be automated and may be transmitted telephonically, by electronic mail messages, or by text messaging. Organizational personnel on the alert notification list can include system administrators, mission or business owners, system owners, information owners/stewards, senior agency information security officers, senior agency officials for privacy, system security officers, or privacy officers. In contrast to alerts generated by the system, alerts generated by organizations in [SI-4\(12\)](#) focus on information sources external to the system, such as suspicious activity reports and reports on potential insider threats.

Related Controls: [AU-4](#), [AU-5](#), [PE-6](#).

(6) SYSTEM MONITORING | RESTRICT NON-PRIVILEGED USERS

[Withdrawn: Incorporated into [AC-6\(10\)](#).]

(7) SYSTEM MONITORING | [AUTOMATED RESPONSE TO SUSPICIOUS EVENTS](#)

- (a) Notify [Assignment: organization-defined incident response personnel (identified by name and/or by role)] of detected suspicious events; and**
- (b) Take the following actions upon detection: [Assignment: organization-defined least-disruptive actions to terminate suspicious events].**

Discussion: Least-disruptive actions include initiating requests for human responses.

Related Controls: None.

(8) SYSTEM MONITORING | PROTECTION OF MONITORING INFORMATION

[Withdrawn: Incorporated into [SI-4](#).]

(9) SYSTEM MONITORING | [TESTING OF MONITORING TOOLS AND MECHANISMS](#)

Test intrusion-monitoring tools and mechanisms [Assignment: organization-defined frequency].

Discussion: Testing intrusion-monitoring tools and mechanisms is necessary to ensure that the tools and mechanisms are operating correctly and continue to satisfy the monitoring objectives of organizations. The frequency and depth of testing depends on the types of tools and mechanisms used by organizations and the methods of deployment.

Related Controls: None.

(10) SYSTEM MONITORING | [VISIBILITY OF ENCRYPTED COMMUNICATIONS](#)

Make provisions so that [Assignment: organization-defined encrypted communications traffic] is visible to [Assignment: organization-defined system monitoring tools and mechanisms].

Discussion: Organizations balance the need to encrypt communications traffic to protect data confidentiality with the need to maintain visibility into such traffic from a monitoring perspective. Organizations determine whether the visibility requirement applies to internal encrypted traffic, encrypted traffic intended for external destinations, or a subset of the traffic types.

Related Controls: None.

(11) SYSTEM MONITORING | [ANALYZE COMMUNICATIONS TRAFFIC ANOMALIES](#)

Analyze outbound communications traffic at the external interfaces to the system and selected [Assignment: organization-defined interior points within the system] to discover anomalies.

Discussion: Organization-defined interior points include subnetworks and subsystems. Anomalies within organizational systems include large file transfers, long-time persistent connections, attempts to access information from unexpected locations, the use of unusual protocols and ports, the use of unmonitored network protocols (e.g., IPv6 usage during IPv4 transition), and attempted communications with suspected malicious external addresses.

Related Controls: None.

(12) SYSTEM MONITORING | [AUTOMATED ORGANIZATION-GENERATED ALERTS](#)

Alert [Assignment: organization-defined personnel or roles] using [Assignment: organization-defined automated mechanisms] when the following indications of inappropriate or unusual activities with security or privacy implications occur: [Assignment: organization-defined activities that trigger alerts].

Discussion: Organizational personnel on the system alert notification list include system administrators, mission or business owners, system owners, senior agency information security officer, senior agency official for privacy, system security officers, or privacy officers. Automated organization-generated alerts are the security alerts generated by organizations and transmitted using automated means. The sources for organization-generated alerts are focused on other entities such as suspicious activity reports and reports on potential insider threats. In contrast to alerts generated by the organization, alerts generated by the system in [SI-4\(5\)](#) focus on information sources that are internal to the systems, such as audit records.

Related Controls: None.

(13) SYSTEM MONITORING | [ANALYZE TRAFFIC AND EVENT PATTERNS](#)

- (a) Analyze communications traffic and event patterns for the system;**
- (b) Develop profiles representing common traffic and event patterns; and**
- (c) Use the traffic and event profiles in tuning system-monitoring devices.**

Discussion: Identifying and understanding common communications traffic and event patterns help organizations provide useful information to system monitoring devices to more effectively identify suspicious or anomalous traffic and events when they occur. Such information can help reduce the number of false positives and false negatives during system monitoring.

Related Controls: None.

(14) SYSTEM MONITORING | [WIRELESS INTRUSION DETECTION](#)

Employ a wireless intrusion detection system to identify rogue wireless devices and to detect attack attempts and potential compromises or breaches to the system.

Discussion: Wireless signals may radiate beyond organizational facilities. Organizations proactively search for unauthorized wireless connections, including the conduct of thorough scans for unauthorized wireless access points. Wireless scans are not limited to those areas within facilities containing systems but also include areas outside of facilities to verify that unauthorized wireless access points are not connected to organizational systems.

Related Controls: [AC-18](#), [IA-3](#).

(15) SYSTEM MONITORING | [WIRELESS TO WIRELINE COMMUNICATIONS](#)

Employ an intrusion detection system to monitor wireless communications traffic as the traffic passes from wireless to wireline networks.

Discussion: Wireless networks are inherently less secure than wired networks. For example, wireless networks are more susceptible to eavesdroppers or traffic analysis than wireline networks. When wireless to wireline communications exist, the wireless network could become a port of entry into the wired network. Given the greater facility of unauthorized network access via wireless access points compared to unauthorized wired network access from within the physical boundaries of the system, additional monitoring of transitioning traffic between wireless and wired networks may be necessary to detect malicious activities. Employing intrusion detection systems to monitor wireless communications traffic helps to ensure that the traffic does not contain malicious code prior to transitioning to the wireline network.

Related Controls: [AC-18](#).

(16) SYSTEM MONITORING | [CORRELATE MONITORING INFORMATION](#)

Correlate information from monitoring tools and mechanisms employed throughout the system.

Discussion: Correlating information from different system monitoring tools and mechanisms can provide a more comprehensive view of system activity. Correlating system monitoring tools and mechanisms that typically work in isolation—including malicious code protection software, host monitoring, and network monitoring—can provide an organization-wide monitoring view and may reveal otherwise unseen attack patterns. Understanding the capabilities and limitations of diverse monitoring tools and mechanisms and how to maximize the use of information generated by those tools and mechanisms can help organizations develop, operate, and maintain effective monitoring programs. The correlation of monitoring information is especially important during the transition from older to newer technologies (e.g., transitioning from IPv4 to IPv6 network protocols).

Related Controls: [AU-6](#).

(17) SYSTEM MONITORING | [INTEGRATED SITUATIONAL AWARENESS](#)

Correlate information from monitoring physical, cyber, and supply chain activities to achieve integrated, organization-wide situational awareness.

Discussion: Correlating monitoring information from a more diverse set of information sources helps to achieve integrated situational awareness. Integrated situational awareness from a combination of physical, cyber, and supply chain monitoring activities enhances the capability of organizations to more quickly detect sophisticated attacks and investigate the methods and techniques employed to carry out such attacks. In contrast to [SI-4\(16\)](#), which correlates the various cyber monitoring information, integrated situational awareness is intended to correlate monitoring beyond the cyber domain. Correlation of monitoring information from multiple activities may help reveal attacks on organizations that are operating across multiple attack vectors.

Related Controls: [AU-16](#), [PE-6](#), [SR-2](#), [SR-4](#), [SR-6](#).

(18) SYSTEM MONITORING | [ANALYZE TRAFFIC AND COVERT EXFILTRATION](#)

Analyze outbound communications traffic at external interfaces to the system and at the following interior points to detect covert exfiltration of information: [Assignment: organization-defined interior points within the system].

Discussion: Organization-defined interior points include subnetworks and subsystems. Covert means that can be used to exfiltrate information include steganography.

Related Controls: None.

(19) SYSTEM MONITORING | [RISK FOR INDIVIDUALS](#)

Implement [Assignment: organization-defined additional monitoring] of individuals who have been identified by [Assignment: organization-defined sources] as posing an increased level of risk.

Discussion: Indications of increased risk from individuals can be obtained from different sources, including personnel records, intelligence agencies, law enforcement organizations, and other sources. The monitoring of individuals is coordinated with the management, legal, security, privacy, and human resource officials who conduct such monitoring. Monitoring is conducted in accordance with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines.

Related Controls: None.

(20) SYSTEM MONITORING | [PRIVILEGED USERS](#)

Implement the following additional monitoring of privileged users: [Assignment: organization-defined additional monitoring].

Discussion: Privileged users have access to more sensitive information, including security-related information, than the general user population. Access to such information means that privileged users can potentially do greater damage to systems and organizations than non-privileged users. Therefore, implementing additional monitoring on privileged users helps to ensure that organizations can identify malicious activity at the earliest possible time and take appropriate actions.

Related Controls: [AC-18](#).

(21) SYSTEM MONITORING | [PROBATIONARY PERIODS](#)

Implement the following additional monitoring of individuals during [Assignment: organization-defined probationary period]: [Assignment: organization-defined additional monitoring].

Discussion: During probationary periods, employees do not have permanent employment status within organizations. Without such status or access to information that is resident on the system, additional monitoring can help identify any potentially malicious activity or inappropriate behavior.

Related Controls: [AC-18](#).

(22) SYSTEM MONITORING | [UNAUTHORIZED NETWORK SERVICES](#)

- (a) Detect network services that have not been authorized or approved by [Assignment: organization-defined authorization or approval processes]; and**
- (b) [Selection (one or more): Audit; Alert [Assignment: organization-defined personnel or roles]] when detected.**

Discussion: Unauthorized or unapproved network services include services in service-oriented architectures that lack organizational verification or validation and may therefore be unreliable or serve as malicious rogues for valid services.

Related Controls: [CM-7](#).

(23) SYSTEM MONITORING | [HOST-BASED DEVICES](#)

Implement the following host-based monitoring mechanisms at [Assignment: organization-defined system components]: [Assignment: organization-defined host-based monitoring mechanisms].

Discussion: Host-based monitoring collects information about the host (or system in which it resides). System components in which host-based monitoring can be implemented include servers, notebook computers, and mobile devices. Organizations may consider employing host-based monitoring mechanisms from multiple product developers or vendors.

Related Controls: [AC-18](#), [AC-19](#).

(24) SYSTEM MONITORING | [INDICATORS OF COMPROMISE](#)

Discover, collect, and distribute to [Assignment: organization-defined personnel or roles], indicators of compromise provided by [Assignment: organization-defined sources].

Discussion: Indicators of compromise (IOC) are forensic artifacts from intrusions that are identified on organizational systems at the host or network level. IOCs provide valuable information on systems that have been compromised. IOCs can include the creation of registry key values. IOCs for network traffic include Universal Resource Locator or protocol elements that indicate malicious code command and control servers. The rapid distribution and adoption of IOCs can improve information security by reducing the time that systems and organizations are vulnerable to the same exploit or attack. Threat indicators, signatures, tactics, techniques, procedures, and other indicators of compromise may be available via government and non-government cooperatives, including the Forum of Incident Response and Security Teams, the United States Computer Emergency Readiness Team, the Defense Industrial Base Cybersecurity Information Sharing Program, and the CERT Coordination Center.

Related Controls: [AC-18](#).

(25) SYSTEM MONITORING | [OPTIMIZE NETWORK TRAFFIC ANALYSIS](#)

Provide visibility into network traffic at external and key internal system interfaces to optimize the effectiveness of monitoring devices.

Discussion: Encrypted traffic, asymmetric routing architectures, capacity and latency limitations, and transitioning from older to newer technologies (e.g., IPv4 to IPv6 network protocol transition) may result in blind spots for organizations when analyzing network traffic. Collecting, decrypting, pre-processing, and distributing only relevant traffic to monitoring devices can streamline the efficiency and use of devices and optimize traffic analysis.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[FIPS 140-3\]](#), [\[SP 800-61\]](#), [\[SP 800-83\]](#), [\[SP 800-92\]](#), [\[SP 800-94\]](#), [\[SP 800-137\]](#).

SI-5 SECURITY ALERTS, ADVISORIES, AND DIRECTIVES

Control:

- a. Receive system security alerts, advisories, and directives from [Assignment: organization-defined external organizations] on an ongoing basis;
- b. Generate internal security alerts, advisories, and directives as deemed necessary;
- c. Disseminate security alerts, advisories, and directives to: [Selection (one or more): [Assignment: organization-defined personnel or roles]; [Assignment: organization-defined elements within the organization]; [Assignment: organization-defined external organizations]]; and
- d. Implement security directives in accordance with established time frames, or notify the issuing organization of the degree of noncompliance.

Discussion: The Cybersecurity and Infrastructure Security Agency (CISA) generates security alerts and advisories to maintain situational awareness throughout the Federal Government. Security directives are issued by OMB or other designated organizations with the responsibility and authority to issue such directives. Compliance with security directives is essential due to the critical nature of many of these directives and the potential (immediate) adverse effects on organizational operations and assets, individuals, other organizations, and the Nation should the directives not be implemented in a timely manner. External organizations include supply chain

partners, external mission or business partners, external service providers, and other peer or supporting organizations.

Related Controls: [PM-15](#), [RA-5](#), [SI-2](#).

Control Enhancements:

(1) SECURITY ALERTS, ADVISORIES, AND DIRECTIVES | [AUTOMATED ALERTS AND ADVISORIES](#)

Broadcast security alert and advisory information throughout the organization using [Assignment: organization-defined automated mechanisms].

Discussion: The significant number of changes to organizational systems and environments of operation requires the dissemination of security-related information to a variety of organizational entities that have a direct interest in the success of organizational mission and business functions. Based on information provided by security alerts and advisories, changes may be required at one or more of the three levels related to the management of risk, including the governance level, mission and business process level, and the information system level.

Related Controls: None.

References: [\[SP 800-40\]](#).

SI-6 SECURITY AND PRIVACY FUNCTION VERIFICATION

Control:

- a. Verify the correct operation of [Assignment: organization-defined security and privacy functions];
- b. Perform the verification of the functions specified in SI-6a [Selection (one or more): *[Assignment: organization-defined system transitional states]; upon command by user with appropriate privilege; [Assignment: organization-defined frequency]*];
- c. Alert [Assignment: organization-defined personnel or roles] to failed security and privacy verification tests; and
- d. [Selection (one or more): *Shut the system down; Restart the system; [Assignment: organization-defined alternative action(s)]*] when anomalies are discovered.

Discussion: Transitional states for systems include system startup, restart, shutdown, and abort. System notifications include hardware indicator lights, electronic alerts to system administrators, and messages to local computer consoles. In contrast to security function verification, privacy function verification ensures that privacy functions operate as expected and are approved by the senior agency official for privacy or that privacy attributes are applied or used as expected.

Related Controls: [CA-7](#), [CM-4](#), [CM-6](#), [SI-7](#).

Control Enhancements:

**(1) SECURITY AND PRIVACY FUNCTION VERIFICATION | NOTIFICATION OF FAILED SECURITY TESTS
[Withdrawn: Incorporated into [SI-6](#).]**

(2) SECURITY AND PRIVACY FUNCTION VERIFICATION | [AUTOMATION SUPPORT FOR DISTRIBUTED TESTING](#)

Implement automated mechanisms to support the management of distributed security and privacy function testing.

Discussion: The use of automated mechanisms to support the management of distributed function testing helps to ensure the integrity, timeliness, completeness, and efficacy of such testing.

Related Controls: [SI-2](#).

(3) SECURITY AND PRIVACY FUNCTION VERIFICATION | [REPORT VERIFICATION RESULTS](#)

Report the results of security and privacy function verification to [Assignment: organization-defined personnel or roles].

Discussion: Organizational personnel with potential interest in the results of the verification of security and privacy functions include systems security officers, senior agency information security officers, and senior agency officials for privacy.

Related Controls: [SI-4](#), [SR-4](#), [SR-5](#).

References: [\[OMB A-130\]](#).

[SI-7 SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY](#)

Control:

- a. Employ integrity verification tools to detect unauthorized changes to the following software, firmware, and information: [Assignment: organization-defined software, firmware, and information]; and
- b. Take the following actions when unauthorized changes to the software, firmware, and information are detected: [Assignment: organization-defined actions].

Discussion: Unauthorized changes to software, firmware, and information can occur due to errors or malicious activity. Software includes operating systems (with key internal components, such as kernels or drivers), middleware, and applications. Firmware interfaces include Unified Extensible Firmware Interface (UEFI) and Basic Input/Output System (BIOS). Information includes personally identifiable information and metadata that contains security and privacy attributes associated with information. Integrity-checking mechanisms—including parity checks, cyclical redundancy checks, cryptographic hashes, and associated tools—can automatically monitor the integrity of systems and hosted applications.

Related Controls: [AC-4](#), [CM-3](#), [CM-7](#), [CM-8](#), [MA-3](#), [MA-4](#), [RA-5](#), [SA-8](#), [SA-9](#), [SA-10](#), [SC-8](#), [SC-12](#), [SC-13](#), [SC-28](#), [SC-37](#), [SI-3](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-6](#), [SR-9](#), [SR-10](#), [SR-11](#).

Control Enhancements:

(1) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [INTEGRITY CHECKS](#)

Perform an integrity check of [Assignment: organization-defined software, firmware, and information] [Selection (one or more): at startup; at [Assignment: organization-defined transitional states or security-relevant events]; [Assignment: organization-defined frequency]].

Discussion: Security-relevant events include the identification of new threats to which organizational systems are susceptible and the installation of new hardware, software, or firmware. Transitional states include system startup, restart, shutdown, and abort.

Related Controls: None.

(2) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [AUTOMATED NOTIFICATIONS OF INTEGRITY VIOLATIONS](#)

Employ automated tools that provide notification to [Assignment: organization-defined personnel or roles] upon discovering discrepancies during integrity verification.

Discussion: The employment of automated tools to report system and information integrity violations and to notify organizational personnel in a timely matter is essential to effective risk response. Personnel with an interest in system and information integrity violations include mission and business owners, system owners, senior agency information security official, senior agency official for privacy, system administrators, software developers, systems integrators, information security officers, and privacy officers.

Related Controls: None.

(3) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [CENTRALLY MANAGED INTEGRITY TOOLS](#)

Employ centrally managed integrity verification tools.

Discussion: Centrally managed integrity verification tools provides greater consistency in the application of such tools and can facilitate more comprehensive coverage of integrity verification actions.

Related Controls: [AU-3](#), [SI-2](#), [SI-8](#).

(4) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | TAMPER-EVIDENT PACKAGING

[Withdrawn: Incorporated into [SR-9](#).]

(5) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [AUTOMATED RESPONSE TO INTEGRITY VIOLATIONS](#)

Automatically [Selection (one or more): shut the system down; restart the system; implement [Assignment: organization-defined controls]] when integrity violations are discovered.

Discussion: Organizations may define different integrity-checking responses by type of information, specific information, or a combination of both. Types of information include firmware, software, and user data. Specific information includes boot firmware for certain types of machines. The automatic implementation of controls within organizational systems includes reversing the changes, halting the system, or triggering audit alerts when unauthorized modifications to critical security files occur.

Related Controls: None.

(6) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [CRYPTOGRAPHIC PROTECTION](#)

Implement cryptographic mechanisms to detect unauthorized changes to software, firmware, and information.

Discussion: Cryptographic mechanisms used to protect integrity 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. Organizations that employ cryptographic mechanisms also consider cryptographic key management solutions.

Related Controls: [SC-12](#), [SC-13](#).

(7) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [INTEGRATION OF DETECTION AND RESPONSE](#)

Incorporate the detection of the following unauthorized changes into the organizational incident response capability: [Assignment: organization-defined security-relevant changes to the system].

Discussion: Integrating detection and response helps to ensure that detected events are tracked, monitored, corrected, and available for historical purposes. Maintaining historical records is important for being able to identify and discern adversary actions over an extended time period and for possible legal actions. Security-relevant changes include

unauthorized changes to established configuration settings or the unauthorized elevation of system privileges.

Related Controls: [AU-2](#), [AU-6](#), [IR-4](#), [IR-5](#), [SI-4](#).

(8) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [AUDITING CAPABILITY FOR SIGNIFICANT EVENTS](#)

Upon detection of a potential integrity violation, provide the capability to audit the event and initiate the following actions: [Selection (one or more): generate an audit record; alert current user; alert [Assignment: organization-defined personnel or roles]; [Assignment: organization-defined other actions]].

Discussion: Organizations select response actions based on types of software, specific software, or information for which there are potential integrity violations.

Related Controls: [AU-2](#), [AU-6](#), [AU-12](#).

(9) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [VERIFY BOOT PROCESS](#)

Verify the integrity of the boot process of the following system components: [Assignment: organization-defined system components].

Discussion: Ensuring the integrity of boot processes is critical to starting system components in known, trustworthy states. Integrity verification mechanisms provide a level of assurance that only trusted code is executed during boot processes.

Related Controls: [SI-6](#).

(10) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [PROTECTION OF BOOT FIRMWARE](#)

Implement the following mechanisms to protect the integrity of boot firmware in [Assignment: organization-defined system components]: [Assignment: organization-defined mechanisms].

Discussion: Unauthorized modifications to boot firmware may indicate a sophisticated, targeted attack. These types of targeted attacks can result in a permanent denial of service or a persistent malicious code presence. These situations can occur if the firmware is corrupted or if the malicious code is embedded within the firmware. System components can protect the integrity of boot firmware in organizational systems by verifying the integrity and authenticity of all updates to the firmware prior to applying changes to the system component and preventing unauthorized processes from modifying the boot firmware.

Related Controls: [SI-6](#).

(11) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | CONFINED ENVIRONMENTS WITH LIMITED PRIVILEGES

[Withdrawn: Moved to [CM-7\(6\)](#).]

(12) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [INTEGRITY VERIFICATION](#)

Require that the integrity of the following user-installed software be verified prior to execution: [Assignment: organization-defined user-installed software].

Discussion: Organizations verify the integrity of user-installed software prior to execution to reduce the likelihood of executing malicious code or programs that contains errors from unauthorized modifications. Organizations consider the practicality of approaches to verifying software integrity, including the availability of trustworthy checksums from software developers and vendors.

Related Controls: [CM-11](#).

(13) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | CODE EXECUTION IN PROTECTED ENVIRONMENTS

[Withdrawn: Moved to [CM-7\(7\)](#).]

(14) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | BINARY OR MACHINE EXECUTABLE CODE
[Withdrawn: Moved to [CM-7\(8\)](#).]

(15) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [CODE AUTHENTICATION](#)

Implement cryptographic mechanisms to authenticate the following software or firmware components prior to installation: [Assignment: organization-defined software or firmware components].

Discussion: Cryptographic authentication includes verifying that software or firmware components have been digitally signed using certificates recognized and approved by organizations. Code signing is an effective method to protect against malicious code. Organizations that employ cryptographic mechanisms also consider cryptographic key management solutions.

Related Controls: [CM-5](#), [SC-12](#), [SC-13](#).

(16) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [TIME LIMIT ON PROCESS EXECUTION WITHOUT SUPERVISION](#)

Prohibit processes from executing without supervision for more than [Assignment: organization-defined time period].

Discussion: Placing a time limit on process execution without supervision is intended to apply to processes for which typical or normal execution periods can be determined and situations in which organizations exceed such periods. Supervision includes timers on operating systems, automated responses, and manual oversight and response when system process anomalies occur.

Related Controls: None.

(17) SOFTWARE, FIRMWARE, AND INFORMATION INTEGRITY | [RUNTIME APPLICATION SELF-PROTECTION](#)

Implement [Assignment: organization-defined controls] for application self-protection at runtime.

Discussion: Runtime application self-protection employs runtime instrumentation to detect and block the exploitation of software vulnerabilities by taking advantage of information from the software in execution. Runtime exploit prevention differs from traditional perimeter-based protections such as guards and firewalls which can only detect and block attacks by using network information without contextual awareness. Runtime application self-protection technology can reduce the susceptibility of software to attacks by monitoring its inputs and blocking those inputs that could allow attacks. It can also help protect the runtime environment from unwanted changes and tampering. When a threat is detected, runtime application self-protection technology can prevent exploitation and take other actions (e.g., sending a warning message to the user, terminating the user's session, terminating the application, or sending an alert to organizational personnel). Runtime application self-protection solutions can be deployed in either a monitor or protection mode.

Related Controls: [SI-16](#).

References: [\[OMB A-130\]](#), [\[FIPS 140-3\]](#), [\[FIPS 180-4\]](#), [\[FIPS 186-4\]](#), [\[FIPS 202\]](#), [\[SP 800-70\]](#), [\[SP 800-147\]](#).

SI-8 SPAM PROTECTION

Control:

- a. Employ spam protection mechanisms at system entry and exit points to detect and act on unsolicited messages; and
- b. Update spam protection mechanisms when new releases are available in accordance with organizational configuration management policy and procedures.

Discussion: System entry and exit points include firewalls, remote-access servers, electronic mail servers, web servers, proxy servers, workstations, notebook computers, and mobile devices. Spam can be transported by different means, including email, email attachments, and web accesses. Spam protection mechanisms include signature definitions.

Related Controls: [PL-9](#), [SC-5](#), [SC-7](#), [SC-38](#), [SI-3](#), [SI-4](#).

Control Enhancements:

(1) SPAM PROTECTION | CENTRAL MANAGEMENT

[Withdrawn: Incorporated into [PL-9](#).]

(2) SPAM PROTECTION | [AUTOMATIC UPDATES](#)

Automatically update spam protection mechanisms [Assignment: organization-defined frequency].

Discussion: Using automated mechanisms to update spam protection mechanisms helps to ensure that updates occur on a regular basis and provide the latest content and protection capabilities.

Related Controls: None.

(3) SPAM PROTECTION | [CONTINUOUS LEARNING CAPABILITY](#)

Implement spam protection mechanisms with a learning capability to more effectively identify legitimate communications traffic.

Discussion: Learning mechanisms include Bayesian filters that respond to user inputs that identify specific traffic as spam or legitimate by updating algorithm parameters and thereby more accurately separating types of traffic.

Related Controls: None.

References: [\[SP 800-45\]](#), [\[SP 800-177\]](#).

SI-9 INFORMATION INPUT RESTRICTIONS

[Withdrawn: Incorporated into [AC-2](#), [AC-3](#), [AC-5](#), and [AC-6](#).]

SI-10 INFORMATION INPUT VALIDATION

Control: Check the validity of the following information inputs: [Assignment: organization-defined information inputs to the system].

Discussion: Checking the valid syntax and semantics of system inputs—including character set, length, numerical range, and acceptable values—verifies that inputs match specified definitions for format and content. For example, if the organization specifies that numerical values between 1-100 are the only acceptable inputs for a field in a given application, inputs of “387,” “abc,” or “%K%” are invalid inputs and are not accepted as input to the system. Valid inputs are likely to vary from field to field within a software application. Applications typically follow well-defined protocols that use structured messages (i.e., commands or queries) to communicate between software modules or system components. Structured messages can contain raw or unstructured data interspersed with metadata or control information. If software applications use attacker-supplied inputs to construct structured messages without properly encoding such messages, then the attacker could insert malicious commands or special characters that can cause the data

to be interpreted as control information or metadata. Consequently, the module or component that receives the corrupted output will perform the wrong operations or otherwise interpret the data incorrectly. Prescreening inputs prior to passing them to interpreters prevents the content from being unintentionally interpreted as commands. Input validation ensures accurate and correct inputs and prevents attacks such as cross-site scripting and a variety of injection attacks.

Related Controls: None.

Control Enhancements:

(1) INFORMATION INPUT VALIDATION | [MANUAL OVERRIDE CAPABILITY](#)

- (a) Provide a manual override capability for input validation of the following information inputs: [Assignment: organization-defined inputs defined in the base control (SI-10)];**
- (b) Restrict the use of the manual override capability to only [Assignment: organization-defined authorized individuals]; and**
- (c) Audit the use of the manual override capability.**

Discussion: In certain situations, such as during events that are defined in contingency plans, a manual override capability for input validation may be needed. Manual overrides are used only in limited circumstances and with the inputs defined by the organization.

Related Controls: [AC-3](#), [AU-2](#), [AU-12](#).

(2) INFORMATION INPUT VALIDATION | [REVIEW AND RESOLVE ERRORS](#)

Review and resolve input validation errors within [Assignment: organization-defined time period].

Discussion: Resolution of input validation errors includes correcting systemic causes of errors and resubmitting transactions with corrected input. Input validation errors are those related to the information inputs defined by the organization in the base control ([SI-10](#)).

Related Controls: None.

(3) INFORMATION INPUT VALIDATION | [PREDICTABLE BEHAVIOR](#)

Verify that the system behaves in a predictable and documented manner when invalid inputs are received.

Discussion: A common vulnerability in organizational systems is unpredictable behavior when invalid inputs are received. Verification of system predictability helps ensure that the system behaves as expected when invalid inputs are received. This occurs by specifying system responses that allow the system to transition to known states without adverse, unintended side effects. The invalid inputs are those related to the information inputs defined by the organization in the base control ([SI-10](#)).

Related Controls: None.

(4) INFORMATION INPUT VALIDATION | [TIMING INTERACTIONS](#)

Account for timing interactions among system components in determining appropriate responses for invalid inputs.

Discussion: In addressing invalid system inputs received across protocol interfaces, timing interactions become relevant, where one protocol needs to consider the impact of the error response on other protocols in the protocol stack. For example, 802.11 standard wireless network protocols do not interact well with Transmission Control Protocols (TCP) when packets are dropped (which could be due to invalid packet input). TCP assumes packet losses are due to congestion, while packets lost over 802.11 links are typically dropped due to noise or collisions on the link. If TCP makes a congestion response, it takes the wrong action in response to a collision event. Adversaries may be able to use what appear to be acceptable individual behaviors of the protocols in concert to achieve adverse effects through suitable

construction of invalid input. The invalid inputs are those related to the information inputs defined by the organization in the base control ([SI-10](#)).

Related Controls: None.

(5) INFORMATION INPUT VALIDATION | [RESTRICT INPUTS TO TRUSTED SOURCES AND APPROVED FORMATS](#)

Restrict the use of information inputs to [Assignment: organization-defined trusted sources] and/or [Assignment: organization-defined formats].

Discussion: Restricting the use of inputs to trusted sources and in trusted formats applies the concept of authorized or permitted software to information inputs. Specifying known trusted sources for information inputs and acceptable formats for such inputs can reduce the probability of malicious activity. The information inputs are those defined by the organization in the base control ([SI-10](#)).

Related Controls: [AC-3](#), [AC-6](#).

(6) INFORMATION INPUT VALIDATION | [INJECTION PREVENTION](#)

Prevent untrusted data injections.

Discussion: Untrusted data injections may be prevented using a parameterized interface or output escaping (output encoding). Parameterized interfaces separate data from code so that injections of malicious or unintended data cannot change the semantics of commands being sent. Output escaping uses specified characters to inform the interpreter's parser whether data is trusted. Prevention of untrusted data injections are with respect to the information inputs defined by the organization in the base control ([SI-10](#)).

Related Controls: [AC-3](#), [AC-6](#).

References: [\[OMB A-130\]](#).

SI-11 ERROR HANDLING

Control:

- a. Generate error messages that provide information necessary for corrective actions without revealing information that could be exploited; and
- b. Reveal error messages only to [Assignment: organization-defined personnel or roles].

Discussion: Organizations consider the structure and content of error messages. The extent to which systems can handle error conditions is guided and informed by organizational policy and operational requirements. Exploitable information includes stack traces and implementation details; erroneous logon attempts with passwords mistakenly entered as the username; mission or business information that can be derived from, if not stated explicitly by, the information recorded; and personally identifiable information, such as account numbers, social security numbers, and credit card numbers. Error messages may also provide a covert channel for transmitting information.

Related Controls: [AU-2](#), [AU-3](#), [SC-31](#), [SI-2](#), [SI-15](#).

Control Enhancements: None.

References: None.

SI-12 INFORMATION MANAGEMENT AND RETENTION

Control: Manage and retain information within the system and information output from the system in accordance with applicable laws, executive orders, directives, regulations, policies, standards, guidelines and operational requirements.

Discussion: Information management and retention requirements cover the full life cycle of information, in some cases extending beyond system disposal. Information to be retained may also include policies, procedures, plans, reports, data output from control implementation, and other types of administrative information. The National Archives and Records Administration (NARA) provides federal policy and guidance on records retention and schedules. If organizations have a records management office, consider coordinating with records management personnel. Records produced from the output of implemented controls that may require management and retention include, but are not limited to: All XX-1, [AC-6\(9\)](#), [AT-4](#), [AU-12](#), [CA-2](#), [CA-3](#), [CA-5](#), [CA-6](#), [CA-7](#), [CA-8](#), [CA-9](#), [CM-2](#), [CM-3](#), [CM-4](#), [CM-6](#), [CM-8](#), [CM-9](#), [CM-12](#), [CM-13](#), [CP-2](#), [IR-6](#), [IR-8](#), [MA-2](#), [MA-4](#), [PE-2](#), [PE-8](#), [PE-16](#), [PE-17](#), [PL-2](#), [PL-4](#), [PL-7](#), [PL-8](#), [PM-5](#), [PM-8](#), [PM-9](#), [PM-18](#), [PM-21](#), [PM-27](#), [PM-28](#), [PM-30](#), [PM-31](#), [PS-2](#), [PS-6](#), [PS-7](#), [PT-2](#), [PT-3](#), [PT-7](#), [RA-2](#), [RA-3](#), [RA-5](#), [RA-8](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-10](#), [SI-4](#), [SR-2](#), [SR-4](#), [SR-8](#).

Related Controls: All XX-1 Controls, [AC-16](#), [AU-5](#), [AU-11](#), [CA-2](#), [CA-3](#), [CA-5](#), [CA-6](#), [CA-7](#), [CA-9](#), [CM-5](#), [CM-9](#), [CP-2](#), [IR-8](#), [MP-2](#), [MP-3](#), [MP-4](#), [MP-6](#), [PL-2](#), [PL-4](#), [PM-4](#), [PM-8](#), [PM-9](#), [PS-2](#), [PS-6](#), [PT-2](#), [PT-3](#), [RA-2](#), [RA-3](#), [SA-5](#), [SA-8](#), [SR-2](#).

Control Enhancements:

(1) INFORMATION MANAGEMENT AND RETENTION | [LIMIT PERSONALLY IDENTIFIABLE INFORMATION ELEMENTS](#)

Limit personally identifiable information being processed in the information life cycle to the following elements of personally identifiable information: [Assignment: organization-defined elements of personally identifiable information].

Discussion: Limiting the use of personally identifiable information throughout the information life cycle when the information is not needed for operational purposes helps to reduce the level of privacy risk created by a system. The information life cycle includes information creation, collection, use, processing, storage, maintenance, dissemination, disclosure, and disposition. Risk assessments as well as applicable laws, regulations, and policies can provide useful inputs to determining which elements of personally identifiable information may create risk.

Related Controls: [PM-25](#).

(2) INFORMATION MANAGEMENT AND RETENTION | [MINIMIZE PERSONALLY IDENTIFIABLE INFORMATION IN TESTING, TRAINING, AND RESEARCH](#)

Use the following techniques to minimize the use of personally identifiable information for research, testing, or training: [Assignment: organization-defined techniques].

Discussion: Organizations can minimize the risk to an individual's privacy by employing techniques such as de-identification or synthetic data. Limiting the use of personally identifiable information throughout the information life cycle when the information is not needed for research, testing, or training helps reduce the level of privacy risk created by a system. Risk assessments as well as applicable laws, regulations, and policies can provide useful inputs to determining the techniques to use and when to use them.

Related Controls: [PM-22](#), [PM-25](#), [SI-19](#).

(3) INFORMATION MANAGEMENT AND RETENTION | [INFORMATION DISPOSAL](#)

Use the following techniques to dispose of, destroy, or erase information following the retention period: [Assignment: organization-defined techniques].

Discussion: Organizations can minimize both security and privacy risks by disposing of information when it is no longer needed. The disposal or destruction of information applies to originals as well as copies and archived records, including system logs that may contain personally identifiable information.

Related Controls: None.

References: [[USC 2901](#)], [[OMB A-130](#)].

SI-13 PREDICTABLE FAILURE PREVENTION

Control:

- a. Determine mean time to failure (MTTF) for the following system components in specific environments of operation: [Assignment: organization-defined system components]; and
- b. Provide substitute system components and a means to exchange active and standby components in accordance with the following criteria: [Assignment: organization-defined MTTF substitution criteria].

Discussion: While MTTF is primarily a reliability issue, predictable failure prevention is intended to address potential failures of system components that provide security capabilities. Failure rates reflect installation-specific consideration rather than the industry-average. Organizations define the criteria for the substitution of system components based on the MTTF value with consideration for the potential harm from component failures. The transfer of responsibilities between active and standby components does not compromise safety, operational readiness, or security capabilities. The preservation of system state variables is also critical to help ensure a successful transfer process. Standby components remain available at all times except for maintenance issues or recovery failures in progress.

Related Controls: [CP-2](#), [CP-10](#), [CP-13](#), [MA-2](#), [MA-6](#), [SA-8](#), [SC-6](#).

Control Enhancements:

(1) PREDICTABLE FAILURE PREVENTION | [TRANSFERRING COMPONENT RESPONSIBILITIES](#)

Take system components out of service by transferring component responsibilities to substitute components no later than [Assignment: organization-defined fraction or percentage] of mean time to failure.

Discussion: Transferring primary system component responsibilities to other substitute components prior to primary component failure is important to reduce the risk of degraded or debilitated mission or business functions. Making such transfers based on a percentage of mean time to failure allows organizations to be proactive based on their risk tolerance. However, the premature replacement of system components can result in the increased cost of system operations.

Related Controls: None.

(2) PREDICTABLE FAILURE PREVENTION | TIME LIMIT ON PROCESS EXECUTION WITHOUT SUPERVISION

[Withdrawn: Incorporated into [SI-7\(16\)](#).]

(3) PREDICTABLE FAILURE PREVENTION | [MANUAL TRANSFER BETWEEN COMPONENTS](#)

Manually initiate transfers between active and standby system components when the use of the active component reaches [Assignment: organization-defined percentage] of the mean time to failure.

Discussion: For example, if the MTTF for a system component is 100 days and the MTTF percentage defined by the organization is 90 percent, the manual transfer would occur after 90 days.

Related Controls: None.

(4) PREDICTABLE FAILURE PREVENTION | [STANDBY COMPONENT INSTALLATION AND NOTIFICATION](#)

If system component failures are detected:

- (a) Ensure that the standby components are successfully and transparently installed within [Assignment: organization-defined time period]; and
- (b) [Selection (one or more): Activate [Assignment: organization-defined alarm]; Automatically shut down the system; [Assignment: organization-defined action]].

Discussion: Automatic or manual transfer of components from standby to active mode can occur upon the detection of component failures.

Related Controls: None.

(5) PREDICTABLE FAILURE PREVENTION | [FAILOVER CAPABILITY](#)

Provide [Selection: real-time; near real-time] [Assignment: organization-defined failover capability] for the system.

Discussion: Failover refers to the automatic switchover to an alternate system upon the failure of the primary system. Failover capability includes incorporating mirrored system operations at alternate processing sites or periodic data mirroring at regular intervals defined by the recovery time periods of organizations.

Related Controls: [CP-6](#), [CP-7](#), [CP-9](#).

References: None.

SI-14 NON-PERSISTENCE

Control: Implement non-persistent [Assignment: organization-defined system components and services] that are initiated in a known state and terminated [Selection (one or more): upon end of session of use; periodically at [Assignment: organization-defined frequency]].

Discussion: Implementation of non-persistent components and services mitigates risk from advanced persistent threats (APTs) by reducing the targeting capability of adversaries (i.e., window of opportunity and available attack surface) to initiate and complete attacks. By implementing the concept of non-persistence for selected system components, organizations can provide a trusted, known state computing resource for a specific time period that does not give adversaries sufficient time to exploit vulnerabilities in organizational systems or operating environments. Since the APT is a high-end, sophisticated threat with regard to capability, intent, and targeting, organizations assume that over an extended period, a percentage of attacks will be successful. Non-persistent system components and services are activated as required using protected information and terminated periodically or at the end of sessions. Non-persistence increases the work factor of adversaries attempting to compromise or breach organizational systems.

Non-persistence can be achieved by refreshing system components, periodically reimaging components, or 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 exploit optimum windows of vulnerabilities.

Related Controls: [SC-30](#), [SC-34](#), [SI-21](#).

Control Enhancements:

(1) NON-PERSISTENCE | [REFRESH FROM TRUSTED SOURCES](#)

Obtain software and data employed during system component and service refreshes from the following trusted sources: [Assignment: organization-defined trusted sources].

Discussion: Trusted sources include software and data from write-once, read-only media or from selected offline secure storage facilities.

Related Controls: None.

(2) NON-PERSISTENCE | [NON-PERSISTENT INFORMATION](#)

(a) [Selection: Refresh [Assignment: organization-defined information] [Assignment: organization-defined frequency]; Generate [Assignment: organization-defined information] on demand]; and

(b) Delete information when no longer needed.

Discussion: Retaining information longer than is needed makes the information a potential target for advanced adversaries searching for high value assets to compromise through unauthorized disclosure, unauthorized modification, or exfiltration. For system-related information, unnecessary retention provides advanced adversaries information that can assist in their reconnaissance and lateral movement through the system.

Related Controls: None.

(3) NON-PERSISTENCE | [NON-PERSISTENT CONNECTIVITY](#)

Establish connections to the system on demand and terminate connections after [Selection: completion of a request; a period of non-use].

Discussion: Persistent connections to systems can provide advanced adversaries with paths to move laterally through systems and potentially position themselves closer to high value assets. Limiting the availability of such connections impedes the adversary's ability to move freely through organizational systems.

Related Controls: [SC-10](#).

References: None.

[SI-15 INFORMATION OUTPUT FILTERING](#)

Control: Validate information output from the following software programs and/or applications to ensure that the information is consistent with the expected content: [Assignment: organization-defined software programs and/or applications].

Discussion: Certain types of attacks, including SQL injections, produce output results that are unexpected or inconsistent with the output results that would be expected from software programs or applications. Information output filtering focuses on detecting extraneous content, preventing such extraneous content from being displayed, and then alerting monitoring tools that anomalous behavior has been discovered.

Related Controls: [SI-3](#), [SI-4](#), [SI-11](#).

Control Enhancements: None.

References: None.

[SI-16 MEMORY PROTECTION](#)

Control: Implement the following controls to protect the system memory from unauthorized code execution: [Assignment: organization-defined controls].

Discussion: Some adversaries launch attacks with the intent of executing code in non-executable regions of memory or in memory locations that are prohibited. Controls employed to protect memory include data execution prevention and address space layout randomization. Data

execution prevention controls can either be hardware-enforced or software-enforced with hardware enforcement providing the greater strength of mechanism.

Related Controls: [AC-25](#), [SC-3](#), [SI-7](#).

Control Enhancements: None.

References: None.

SI-17 FAIL-SAFE PROCEDURES

Control: Implement the indicated fail-safe procedures when the indicated failures occur:

[Assignment: organization-defined list of failure conditions and associated fail-safe procedures].

Discussion: Failure conditions include the loss of communications among critical system components or between system components and operational facilities. Fail-safe procedures include alerting operator personnel and providing specific instructions on subsequent steps to take. Subsequent steps may include doing nothing, reestablishing system settings, shutting down processes, restarting the system, or contacting designated organizational personnel.

Related Controls: [CP-12](#), [CP-13](#), [SC-24](#), [SI-13](#).

Control Enhancements: None.

References: None.

SI-18 PERSONALLY IDENTIFIABLE INFORMATION QUALITY OPERATIONS

Control:

- a. Check the accuracy, relevance, timeliness, and completeness of personally identifiable information across the information life cycle *[Assignment: organization-defined frequency]*; and
- b. Correct or delete inaccurate or outdated personally identifiable information.

Discussion: Personally identifiable information quality operations include the steps that organizations take to confirm the accuracy and relevance of personally identifiable information throughout the information life cycle. The information life cycle includes the creation, collection, use, processing, storage, maintenance, dissemination, disclosure, and disposal of personally identifiable information. Personally identifiable information quality operations include editing and validating addresses as they are collected or entered into systems using automated address verification look-up application programming interfaces. Checking personally identifiable information quality includes the tracking of updates or changes to data over time, which enables organizations to know how and what personally identifiable information was changed should erroneous information be identified. The measures taken to protect personally identifiable information quality are based on the nature and context of the personally identifiable information, how it is to be used, how it was obtained, and the potential de-identification methods employed. The measures taken to validate the accuracy of personally identifiable information used to make determinations about the rights, benefits, or privileges of individuals covered under federal programs may be more comprehensive than the measures used to validate personally identifiable information used for less sensitive purposes.

Related Controls: [PM-22](#), [PM-24](#), [PT-2](#), [SI-4](#).

Control Enhancements:

(1) PERSONALLY IDENTIFIABLE INFORMATION QUALITY OPERATIONS | [AUTOMATION SUPPORT](#)

Correct or delete personally identifiable information that is inaccurate or outdated, incorrectly determined regarding impact, or incorrectly de-identified using [Assignment: organization-defined automated mechanisms].

Discussion: The use of automated mechanisms to improve data quality may inadvertently create privacy risks. Automated tools may connect to external or otherwise unrelated systems, and the matching of records between these systems may create linkages with unintended consequences. Organizations assess and document these risks in their privacy impact assessments and make determinations that are in alignment with their privacy program plans.

As data is obtained and used across the information life cycle, it is important to confirm the accuracy and relevance of personally identifiable information. Automated mechanisms can augment existing data quality processes and procedures and enable an organization to better identify and manage personally identifiable information in large-scale systems. For example, automated tools can greatly improve efforts to consistently normalize data or identify malformed data. Automated tools can also be used to improve the auditing of data and detect errors that may incorrectly alter personally identifiable information or incorrectly associate such information with the wrong individual. Automated capabilities backstop processes and procedures at-scale and enable more fine-grained detection and correction of data quality errors.

Related Controls: [PM-18](#), [RA-8](#).

(2) PERSONALLY IDENTIFIABLE INFORMATION QUALITY OPERATIONS | [DATA TAGS](#)

Employ data tags to automate the correction or deletion of personally identifiable information across the information life cycle within organizational systems.

Discussion: Data tagging personally identifiable information includes tags that note processing permissions, authority to process, de-identification, impact level, information life cycle stage, and retention or last updated dates. Employing data tags for personally identifiable information can support the use of automation tools to correct or delete relevant personally identifiable information.

Related Controls: [AC-3](#), [AC-16](#), [SC-16](#).

(3) PERSONALLY IDENTIFIABLE INFORMATION QUALITY OPERATIONS | [COLLECTION](#)

Collect personally identifiable information directly from the individual.

Discussion: Individuals or their designated representatives can be sources of correct personally identifiable information. Organizations consider contextual factors that may incentivize individuals to provide correct data versus false data. Additional steps may be necessary to validate collected information based on the nature and context of the personally identifiable information, how it is to be used, and how it was obtained. The measures taken to validate the accuracy of personally identifiable information used to make determinations about the rights, benefits, or privileges of individuals under federal programs may be more comprehensive than the measures taken to validate less sensitive personally identifiable information.

Related Controls: None.

(4) PERSONALLY IDENTIFIABLE INFORMATION QUALITY OPERATIONS | [INDIVIDUAL REQUESTS](#)

Correct or delete personally identifiable information upon request by individuals or their designated representatives.

Discussion: Inaccurate personally identifiable information maintained by organizations may cause problems for individuals, especially in those business functions where inaccurate information may result in inappropriate decisions or the denial of benefits and services to individuals. Even correct information, in certain circumstances, can cause problems for

individuals that outweigh the benefits of an organization maintaining the information. Organizations use discretion when determining if personally identifiable information is to be corrected or deleted based on the scope of requests, the changes sought, the impact of the changes, and laws, regulations, and policies. Organizational personnel consult with the senior agency official for privacy and legal counsel regarding appropriate instances of correction or deletion.

Related Controls: None.

(5) PERSONALLY IDENTIFIABLE INFORMATION QUALITY OPERATIONS | [NOTICE OF CORRECTION OR DELETION](#)

Notify [Assignment: organization-defined recipients of personally identifiable information] and individuals that the personally identifiable information has been corrected or deleted.

Discussion: When personally identifiable information is corrected or deleted, organizations take steps to ensure that all authorized recipients of such information, and the individual with whom the information is associated or their designated representatives, are informed of the corrected or deleted information.

Related Controls: None.

References: [\[OMB M-19-15\]](#), [\[SP 800-188\]](#), [\[IR 8112\]](#).

SI-19 DE-IDENTIFICATION

Control:

- a. Remove the following elements of personally identifiable information from datasets: *[Assignment: organization-defined elements of personally identifiable information]*; and
- b. Evaluate *[Assignment: organization-defined frequency]* for effectiveness of de-identification.

Discussion: De-identification is the general term for the process of removing the association between a set of identifying data and the data subject. Many datasets contain information about individuals that can be used to distinguish or trace an individual's identity, such as name, social security number, date and place of birth, mother's maiden name, or biometric records. Datasets may also contain other information that is linked or linkable to an individual, such as medical, educational, financial, and employment information. Personally identifiable information is removed from datasets by trained individuals when such information is not (or no longer) necessary to satisfy the requirements envisioned for the data. For example, if the dataset is only used to produce aggregate statistics, the identifiers that are not needed for producing those statistics are removed. Removing identifiers improves privacy protection since information that is removed cannot be inadvertently disclosed or improperly used. Organizations may be subject to specific de-identification definitions or methods under applicable laws, regulations, or policies. Re-identification is a residual risk with de-identified data. Re-identification attacks can vary, including combining new datasets or other improvements in data analytics. Maintaining awareness of potential attacks and evaluating for the effectiveness of the de-identification over time support the management of this residual risk.

Related Controls: [MP-6](#), [PM-22](#), [PM-23](#), [PM-24](#), [RA-2](#), [SI-12](#).

Control Enhancements:

(1) DE-IDENTIFICATION | [COLLECTION](#)

De-identify the dataset upon collection by not collecting personally identifiable information.

Discussion: If a data source contains personally identifiable information but the information will not be used, the dataset can be de-identified when it is created by not collecting the

data elements that contain the personally identifiable information. For example, if an organization does not intend to use the social security number of an applicant, then application forms do not ask for a social security number.

Related Controls: None.

(2) DE-IDENTIFICATION | [ARCHIVING](#)

Prohibit archiving of personally identifiable information elements if those elements in a dataset will not be needed after the dataset is archived.

Discussion: Datasets can be archived for many reasons. The envisioned purposes for the archived dataset are specified, and if personally identifiable information elements are not required, the elements are not archived. For example, social security numbers may have been collected for record linkage, but the archived dataset may include the required elements from the linked records. In this case, it is not necessary to archive the social security numbers.

Related Controls: None.

(3) DE-IDENTIFICATION | [RELEASE](#)

Remove personally identifiable information elements from a dataset prior to its release if those elements in the dataset do not need to be part of the data release.

Discussion: Prior to releasing a dataset, a data custodian considers the intended uses of the dataset and determines if it is necessary to release personally identifiable information. If the personally identifiable information is not necessary, the information can be removed using de-identification techniques.

Related Controls: None.

(4) DE-IDENTIFICATION | [REMOVAL, MASKING, ENCRYPTION, HASHING, OR REPLACEMENT OF DIRECT IDENTIFIERS](#)

Remove, mask, encrypt, hash, or replace direct identifiers in a dataset.

Discussion: There are many possible processes for removing direct identifiers from a dataset. Columns in a dataset that contain a direct identifier can be removed. In masking, the direct identifier is transformed into a repeating character, such as XXXXXX or 999999. Identifiers can be encrypted or hashed so that the linked records remain linked. In the case of encryption or hashing, algorithms are employed that require the use of a key, including the Advanced Encryption Standard or a Hash-based Message Authentication Code.

Implementations may use the same key for all identifiers or use a different key for each identifier. Using a different key for each identifier provides a higher degree of security and privacy. Identifiers can alternatively be replaced with a keyword, including transforming “George Washington” to “PATIENT” or replacing it with a surrogate value, such as transforming “George Washington” to “Abraham Polk.”

Related Controls: [SC-12](#), [SC-13](#).

(5) DE-IDENTIFICATION | [STATISTICAL DISCLOSURE CONTROL](#)

Manipulate numerical data, contingency tables, and statistical findings so that no individual or organization is identifiable in the results of the analysis.

Discussion: Many types of statistical analyses can result in the disclosure of information about individuals even if only summary information is provided. For example, if a school that publishes a monthly table with the number of minority students enrolled, reports that it has 10-19 such students in January, and subsequently reports that it has 20-29 such students in March, then it can be inferred that the student who enrolled in February was a minority.

Related Controls: None.

(6) DE-IDENTIFICATION | [DIFFERENTIAL PRIVACY](#)

Prevent disclosure of personally identifiable information by adding non-deterministic noise to the results of mathematical operations before the results are reported.

Discussion: The mathematical definition for differential privacy holds that the result of a dataset analysis should be approximately the same before and after the addition or removal of a single data record (which is assumed to be the data from a single individual). In its most basic form, differential privacy applies only to online query systems. However, it can also be used to produce machine-learning statistical classifiers and synthetic data. Differential privacy comes at the cost of decreased accuracy of results, forcing organizations to quantify the trade-off between privacy protection and the overall accuracy, usefulness, and utility of the de-identified dataset. Non-deterministic noise can include adding small, random values to the results of mathematical operations in dataset analysis.

Related Controls: [SC-12](#), [SC-13](#).

(7) DE-IDENTIFICATION | [VALIDATED ALGORITHMS AND SOFTWARE](#)

Perform de-identification using validated algorithms and software that is validated to implement the algorithms.

Discussion: Algorithms that appear to remove personally identifiable information from a dataset may in fact leave information that is personally identifiable or data that is re-identifiable. Software that is claimed to implement a validated algorithm may contain bugs or implement a different algorithm. Software may de-identify one type of data, such as integers, but not de-identify another type of data, such as floating point numbers. For these reasons, de-identification is performed using algorithms and software that are validated.

Related Controls: None.

(8) DE-IDENTIFICATION | [MOTIVATED INTRUDER](#)

Perform a motivated intruder test on the de-identified dataset to determine if the identified data remains or if the de-identified data can be re-identified.

Discussion: A motivated intruder test is a test in which an individual or group takes a data release and specified resources and attempts to re-identify one or more individuals in the de-identified dataset. Such tests specify the amount of inside knowledge, computational resources, financial resources, data, and skills that intruders possess to conduct the tests. A motivated intruder test can determine if the de-identification is insufficient. It can also be a useful diagnostic tool to assess if de-identification is likely to be sufficient. However, the test alone cannot prove that de-identification is sufficient.

Related Controls: None.

References: [\[OMB A-130\]](#), [\[SP 800-188\]](#).

[SI-20](#) TAINTING

Control: Embed data or capabilities in the following systems or system components to determine if organizational data has been exfiltrated or improperly removed from the organization: *[Assignment: organization-defined systems or system components]*.

Discussion: Many cyber-attacks target organizational information, or information that the organization holds on behalf of other entities (e.g., personally identifiable information), and exfiltrate that data. In addition, insider attacks and erroneous user procedures can remove information from the system that is in violation of the organizational policies. Tainting approaches can range from passive to active. A passive tainting approach can be as simple as adding false email names and addresses to an internal database. If the organization receives email at one of the false email addresses, it knows that the database has been compromised. Moreover, the organization knows that the email was sent by an unauthorized entity, so any

packets it includes potentially contain malicious code, and that the unauthorized entity may have potentially obtained a copy of the database. Another tainting approach can include embedding false data or steganographic data in files to enable the data to be found via open-source analysis. Finally, an active tainting approach can include embedding software in the data that is able to “call home,” thereby alerting the organization to its “capture,” and possibly its location, and the path by which it was exfiltrated or removed.

Related Controls: [AU-13](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-160-2\]](#).

SI-21 INFORMATION REFRESH

Control: Refresh [Assignment: organization-defined information] at [Assignment: organization-defined frequencies] or generate the information on demand and delete the information when no longer needed.

Discussion: Retaining information for longer than it is needed makes it an increasingly valuable and enticing target for adversaries. Keeping information available for the minimum period of time needed to support organizational missions or business functions reduces the opportunity for adversaries to compromise, capture, and exfiltrate that information.

Related Controls: [SI-14](#).

Control Enhancements: None.

References: [\[OMB A-130\]](#), [\[SP 800-160-2\]](#).

SI-22 INFORMATION DIVERSITY

Control:

- a. Identify the following alternative sources of information for [Assignment: organization-defined essential functions and services]: [Assignment: organization-defined alternative information sources]; and
- b. Use an alternative information source for the execution of essential functions or services on [Assignment: organization-defined systems or system components] when the primary source of information is corrupted or unavailable.

Discussion: Actions taken by a system service or a function are often driven by the information it receives. Corruption, fabrication, modification, or deletion of that information could impact the ability of the service function to properly carry out its intended actions. By having multiple sources of input, the service or function can continue operation if one source is corrupted or no longer available. It is possible that the alternative sources of information may be less precise or less accurate than the primary source of information. But having such sub-optimal information sources may still provide a sufficient level of quality that the essential service or function can be carried out, even in a degraded or debilitated manner.

Related Controls: None.

Control Enhancements: None.

References: [\[SP 800-160-2\]](#).

SI-23 INFORMATION FRAGMENTATION

Control: Based on [Assignment: organization-defined circumstances]:

- a. Fragment the following information: [Assignment: organization-defined information]; and
- b. Distribute the fragmented information across the following systems or system components: [Assignment organization-defined systems or system components].

Discussion: One objective of the advanced persistent threat is to exfiltrate valuable information. Once exfiltrated, there is generally no way for the organization to recover the lost information. Therefore, organizations may consider dividing the information into disparate elements and distributing those elements across multiple systems or system components and locations. Such actions will increase the adversary's work factor to capture and exfiltrate the desired information and, in so doing, increase the probability of detection. The fragmentation of information impacts the organization's ability to access the information in a timely manner. The extent of the fragmentation is dictated by the impact or classification level (and value) of the information, threat intelligence information received, and whether data tainting is used (i.e., data tainting-derived information about the exfiltration of some information could result in the fragmentation of the remaining information).

Related Controls: None.

Control Enhancements: None.

References: [\[SP 800-160-2\]](#).

3.20 SUPPLY CHAIN RISK MANAGEMENT

[Quick link to Supply Chain Risk Management Summary Table](#)

SR-1 POLICY AND PROCEDURES

Control:

- a. Develop, document, and disseminate to [Assignment: organization-defined personnel or roles]:
 1. [Selection (one or more): Organization-level; Mission/business process-level; System-level] supply chain risk management policy that:
 - (a) Addresses purpose, scope, roles, responsibilities, management commitment, coordination among organizational entities, and compliance; and
 - (b) Is consistent with applicable laws, executive orders, directives, regulations, policies, standards, and guidelines; and
 2. Procedures to facilitate the implementation of the supply chain risk management policy and the associated supply chain risk management controls;
- b. Designate an [Assignment: organization-defined official] to manage the development, documentation, and dissemination of the supply chain risk management policy and procedures; and
- c. Review and update the current supply chain risk management:
 1. Policy [Assignment: organization-defined frequency] and following [Assignment: organization-defined events]; and
 2. Procedures [Assignment: organization-defined frequency] and following [Assignment: organization-defined events].

Discussion: Supply chain risk management policy and procedures address the controls in the SR family as well as supply chain-related controls in other families that are implemented within systems and organizations. The risk management strategy is an important factor in establishing such policies and procedures. Policies and procedures contribute to security and privacy assurance. Therefore, it is important that security and privacy programs collaborate on the development of supply chain risk management policy and procedures. Security and privacy program policies and procedures at the organization level are preferable, in general, and may obviate the need for mission- or system-specific policies and procedures. The policy can be included as part of the general security and privacy policy or be represented by multiple policies that reflect the complex nature of organizations. Procedures can be established for security and privacy programs, for mission or business processes, and for systems, if needed. Procedures describe how the policies or controls are implemented and can be directed at the individual or role that is the object of the procedure. Procedures can be documented in system security and privacy plans or in one or more separate documents. Events that may precipitate an update to supply chain risk management policy and procedures include assessment or audit findings, security incidents or breaches, or changes in applicable laws, executive orders, directives, regulations, policies, standards, and guidelines. Simply restating controls does not constitute an organizational policy or procedure.

Related Controls: [PM-9](#), [PM-30](#), [PS-8](#), [SI-12](#).

Control Enhancements: None.

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[EO 13873\]](#), [\[CNSSD 505\]](#), [\[SP 800-12\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP 800-100\]](#), [\[SP 800-161\]](#).

SR-2 SUPPLY CHAIN RISK MANAGEMENT PLAN

Control:

- a. Develop a plan for managing supply chain risks associated with the research and development, design, manufacturing, acquisition, delivery, integration, operations and maintenance, and disposal of the following systems, system components or system services: *[Assignment: organization-defined systems, system components, or system services]*;
- b. Review and update the supply chain risk management plan *[Assignment: organization-defined frequency]* or as required, to address threat, organizational or environmental changes; and
- c. Protect the supply chain risk management plan from unauthorized disclosure and modification.

Discussion: The dependence on products, systems, and services from external providers, as well as the nature of the relationships with those providers, present an increasing level of risk to an organization. Threat actions that may increase security or privacy risks include unauthorized production, the insertion or use of counterfeits, tampering, theft, insertion of malicious software and hardware, and 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 that requires a coordinated effort across an organization to build trust relationships and communicate with internal and external stakeholders. Supply chain risk management (SCRM) activities include identifying and assessing risks, determining appropriate risk response actions, developing SCRM plans to document response actions, and monitoring performance against plans. The SCRM plan (at the system-level) is implementation specific, providing policy implementation, requirements, constraints and implications. It can either be stand-alone, or incorporated into system security and privacy plans. The SCRM plan addresses managing, implementation, and monitoring of SCRM controls and the development/sustainment of systems across the SDLC to support mission and business functions.

Because supply chains can differ significantly across and within organizations, SCRM plans are tailored to the individual program, organizational, and operational contexts. Tailored SCRM plans provide the basis for determining whether a technology, service, system component, or system is fit for purpose, and as such, the controls need to be tailored accordingly. Tailored SCRM plans help organizations focus their resources on the most critical mission and business functions based on mission and business requirements and their risk environment. Supply chain risk management plans include an expression of the supply chain risk tolerance for the organization, acceptable supply chain risk mitigation strategies or controls, a process for consistently evaluating and monitoring supply chain risk, approaches for implementing and communicating the plan, a description of and justification for supply chain risk mitigation measures taken, and associated roles and responsibilities. Finally, supply chain risk management plans address requirements for developing trustworthy, secure, privacy-protective, 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 (see [SA-8](#)).

Related Controls: [CA-2](#), [CP-4](#), [IR-4](#), [MA-2](#), [MA-6](#), [PE-16](#), [PL-2](#), [PM-9](#), [PM-30](#), [RA-3](#), [RA-7](#), [SA-8](#), [SI-4](#).

Control Enhancements:

- (1) SUPPLY CHAIN RISK MANAGEMENT PLAN | [ESTABLISH SCRM TEAM](#)**

Establish a supply chain risk management team consisting of [Assignment: organization-defined personnel, roles, and responsibilities] to lead and support the following SCRM activities: [Assignment: organization-defined supply chain risk management activities].

Discussion: To implement supply chain risk management plans, organizations establish a coordinated, team-based approach to identify and assess supply chain risks and manage these risks by using programmatic and technical mitigation techniques. The team approach enables organizations to conduct an analysis of their supply chain, communicate with internal and external partners or stakeholders, and gain broad consensus regarding the appropriate resources for SCRM. The SCRM team consists of organizational personnel with diverse roles and responsibilities for leading and supporting SCRM activities, including risk executive, information technology, contracting, information security, privacy, mission or business, legal, supply chain and logistics, acquisition, business continuity, and other relevant functions. Members of the SCRM team are involved in various aspects of the SDLC and, collectively, have an awareness of and provide expertise in acquisition processes, legal practices, vulnerabilities, threats, and attack vectors, as well as an understanding of the technical aspects and dependencies of systems. The SCRM team can be an extension of the security and privacy risk management processes or be included as part of an organizational risk management team.

Related Controls: None.

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[EO 13873\]](#), [\[CNSSD 505\]](#), [\[SP 800-30\]](#), [\[SP 800-39\]](#), [\[SP-800-160-1\]](#), [\[SP 800-161\]](#), [\[SP 800-181\]](#), [\[IR 7622\]](#), [\[IR 8272\]](#).

SR-3 SUPPLY CHAIN CONTROLS AND PROCESSES

Control:

- a. Establish a process or processes to identify and address weaknesses or deficiencies in the supply chain elements and processes of [Assignment: organization-defined system or system component] in coordination with [Assignment: organization-defined supply chain personnel];
- b. Employ the following controls to protect against supply chain risks to the system, system component, or system service and to limit the harm or consequences from supply chain-related events: [Assignment: organization-defined supply chain controls]; and
- c. Document the selected and implemented supply chain processes and controls in [Selection: security and privacy plans; supply chain risk management plan; [Assignment: organization-defined document]].

Discussion: Supply chain elements include organizations, entities, or tools employed for the research and development, design, manufacturing, acquisition, delivery, integration, operations and maintenance, and disposal of systems and system components. Supply chain processes include hardware, software, and firmware development processes; shipping and handling procedures; personnel security and physical security programs; configuration management tools, techniques, and measures to maintain provenance; or other programs, processes, or procedures associated with the development, acquisition, maintenance and disposal of systems and system components. Supply chain elements and processes may be provided by organizations, system integrators, or external providers. Weaknesses or deficiencies in supply chain elements or processes represent potential vulnerabilities that can be exploited by adversaries to cause harm to the organization and affect its ability to carry out its core missions or business functions. Supply chain personnel are individuals with roles and responsibilities in the supply chain.

Related Controls: [CA-2](#), [MA-2](#), [MA-6](#), [PE-3](#), [PE-16](#), [PL-8](#), [PM-30](#), [SA-2](#), [SA-3](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-9](#), [SA-10](#), [SA-15](#), [SC-7](#), [SC-29](#), [SC-30](#), [SC-38](#), [SI-7](#), [SR-6](#), [SR-9](#), [SR-11](#).

Control Enhancements:

(1) SUPPLY CHAIN CONTROLS AND PROCESSES | [DIVERSE SUPPLY BASE](#)

Employ a diverse set of sources for the following system components and services:
[Assignment: organization-defined system components and services].

Discussion: Diversifying the supply of systems, system components, and services can reduce the probability that adversaries will successfully identify and target the supply chain and can reduce the impact of a supply chain event or compromise. Identifying multiple suppliers for replacement components can reduce the probability that the replacement component will become unavailable. Employing a diverse set of developers or logistics service providers can reduce the impact of a natural disaster or other supply chain event. Organizations consider designing the system to include diverse materials and components.

Related Controls: None.

(2) SUPPLY CHAIN PROTECTION CONTROLS AND PROCESSES | [LIMITATION OF HARM](#)

Employ the following controls to limit harm from potential adversaries identifying and targeting the organizational supply chain: [Assignment: organization-defined controls].

Discussion: Controls that can be implemented to reduce the probability of adversaries successfully identifying and targeting the supply chain include avoiding the purchase of custom or non-standardized configurations, employing approved vendor lists with standing reputations in industry, following pre-agreed maintenance schedules and update and patch delivery mechanisms, maintaining a contingency plan in case of a supply chain event, using procurement carve-outs that provide exclusions to commitments or obligations, using diverse delivery routes, and minimizing the time between purchase decisions and delivery.

Related Controls: None.

(3) SUPPLY CHAIN PROTECTION CONTROLS AND PROCESSES | [SUB-TIER FLOW DOWN](#)

Ensure that the controls included in the contracts of prime contractors are also included in the contracts of subcontractors.

Discussion: To manage supply chain risk effectively and holistically, it is important that organizations ensure that supply chain risk management controls are included at all tiers in the supply chain. This includes ensuring that Tier 1 (prime) contractors have implemented processes to facilitate the “flow down” of supply chain risk management controls to sub-tier contractors. The controls subject to flow down are identified in [SR-3b](#).

Related Controls: [SR-5](#), [SR-8](#).

References: [[FASC18](#)], [[41 CFR 201](#)], [[EO 13873](#)], [[ISO 20243](#)], [[SP 800-30](#)], [[SP 800-161](#)], [[IR 7622](#)].

SR-4 PROVENANCE

Control: Document, monitor, and maintain valid provenance of the following systems, system components, and associated data: [Assignment: organization-defined systems, system components, and associated data].

Discussion: Every system and system component has a point of origin and may be changed throughout its existence. Provenance is the chronology of the origin, development, ownership, location, and changes to a system or system component and associated data. It may also include personnel and processes used to interact with or make modifications to the system, component, or associated data. Organizations consider developing procedures (see [SR-1](#)) for allocating responsibilities for the creation, maintenance, and monitoring of provenance for systems and system components; transferring provenance documentation and responsibility between organizations; and preventing and monitoring for unauthorized changes to the provenance records. Organizations have methods to document, monitor, and maintain valid provenance baselines for systems, system components, and related data. These actions help track, assess,

and document any changes to the provenance, including changes in supply chain elements or configuration, and help ensure non-repudiation of provenance information and the provenance change records. Provenance considerations are addressed throughout the system development life cycle and incorporated into contracts and other arrangements, as appropriate.

Related Controls: [CM-8](#), [MA-2](#), [MA-6](#), [RA-9](#), [SA-3](#), [SA-8](#), [SI-4](#).

Control Enhancements:

(1) PROVENANCE | [IDENTITY](#)

Establish and maintain unique identification of the following supply chain elements, processes, and personnel associated with the identified system and critical system components: [Assignment: organization-defined supply chain elements, processes, and personnel associated with organization-defined systems and critical system components].

Discussion: Knowing who and what is in the supply chains of organizations is critical to gaining visibility into supply chain activities. Visibility into supply chain activities is also important for monitoring and identifying high-risk events and activities. Without reasonable visibility into supply chain elements, processes, and personnel, it is very difficult for organizations to understand and manage risk and reduce their susceptibility to adverse events. Supply chain elements include organizations, entities, or tools used for the research and development, design, manufacturing, acquisition, delivery, integration, operations, maintenance, and disposal of systems and system components. Supply chain processes include development processes for hardware, software, and firmware; shipping and handling procedures; configuration management tools, techniques, and measures to maintain provenance; personnel and physical security programs; or other programs, processes, or procedures associated with the production and distribution of supply chain elements. Supply chain personnel are individuals with specific roles and responsibilities related to the secure the research and development, design, manufacturing, acquisition, delivery, integration, operations and maintenance, and disposal of a system or system component. Identification methods are sufficient to support an investigation in case of a supply chain change (e.g. if a supply company is purchased), compromise, or event.

Related Controls: [IA-2](#), [IA-8](#), [PE-16](#).

(2) PROVENANCE | [TRACK AND TRACE](#)

Establish and maintain unique identification of the following systems and critical system components for tracking through the supply chain: [Assignment: organization-defined systems and critical system components].

Discussion: Tracking the unique identification of systems and system components during development and transport activities provides a foundational identity structure for the establishment and maintenance of provenance. For example, system components may be labeled using serial numbers or tagged using radio-frequency identification tags. Labels and tags can help provide better visibility into the provenance of a system or system component. A system or system component may have more than one unique identifier. Identification methods are sufficient to support a forensic investigation after a supply chain compromise or event.

Related Controls: [IA-2](#), [IA-8](#), [PE-16](#), [PL-2](#).

(3) PROVENANCE | [VALIDATE AS GENUINE AND NOT ALTERED](#)

Employ the following controls to validate that the system or system component received is genuine and has not been altered: [Assignment: organization-defined controls].

Discussion: For many systems and system components, especially hardware, there are technical means to determine if the items are genuine or have been altered, including optical and nanotechnology tagging, physically unclonable functions, side-channel analysis,

cryptographic hash verifications or digital signatures, and visible anti-tamper labels or stickers. Controls can also include monitoring for out of specification performance, which can be an indicator of tampering or counterfeits. Organizations may leverage supplier and contractor processes for validating that a system or component is genuine and has not been altered and for replacing a suspect system or component. Some indications of tampering may be visible and addressable before accepting delivery, such as inconsistent packaging, broken seals, and incorrect labels. When a system or system component is suspected of being altered or counterfeit, the supplier, contractor, or original equipment manufacturer may be able to replace the item or provide a forensic capability to determine the origin of the counterfeit or altered item. Organizations can provide training to personnel on how to identify suspicious system or component deliveries.

Related Controls: [AT-3](#), [SR-9](#), [SR-10](#), [SR-11](#).

(4) PROVENANCE | [SUPPLY CHAIN INTEGRITY — PEDIGREE](#)

Employ [Assignment: organization-defined controls] and conduct [Assignment: organization-defined analysis] to ensure the integrity of the system and system components by validating the internal composition and provenance of critical or mission-essential technologies, products, and services.

Discussion: Authoritative information regarding the internal composition of system components and the provenance of technology, products, and services provides a strong basis for trust. The validation of the internal composition and provenance of technologies, products, and services is referred to as the pedigree. For microelectronics, this includes material composition of components. For software this includes the composition of open-source and proprietary code, including the version of the component at a given point in time. Pedigrees increase the assurance that the claims suppliers assert about the internal composition and provenance of the products, services, and technologies they provide are valid. The validation of the internal composition and provenance can be achieved by various evidentiary artifacts or records that manufacturers and suppliers produce during the research and development, design, manufacturing, acquisition, delivery, integration, operations and maintenance, and disposal of technology, products, and services. Evidentiary artifacts include, but are not limited to, software identification (SWID) tags, software component inventory, the manufacturers' declarations of platform attributes (e.g., serial numbers, hardware component inventory), and measurements (e.g., firmware hashes) that are tightly bound to the hardware itself.

Related Controls: [RA-3](#).

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[EO 13873\]](#), [\[ISO 27036\]](#), [\[ISO 20243\]](#), [\[SP 800-160-1\]](#), [\[SP 800-161\]](#), [\[IR 7622\]](#), [\[IR 8112\]](#), [\[IR 8272\]](#).

SR-5

ACQUISITION STRATEGIES, TOOLS, AND METHODS

Control: Employ the following acquisition strategies, contract tools, and procurement methods to protect against, identify, and mitigate supply chain risks: *[Assignment: organization-defined acquisition strategies, contract tools, and procurement methods]*.

Discussion: The use of the acquisition process provides an important vehicle to protect the supply chain. There are many useful tools and techniques available, including obscuring the end use of a system or system component, using blind or filtered buys, requiring tamper-evident packaging, or using trusted or controlled distribution. The results from a supply chain risk assessment can guide and inform the strategies, tools, and methods that are most applicable to the situation. Tools and techniques may provide protections against unauthorized production, theft, tampering, insertion of counterfeits, insertion of malicious software or backdoors, and poor development practices throughout the system development life cycle. Organizations also

consider providing incentives for suppliers who implement controls, promote transparency into their processes and security and privacy practices, provide contract language that addresses the prohibition of tainted or counterfeit components, and restrict purchases from untrustworthy suppliers. Organizations consider providing training, education, and awareness programs for personnel regarding supply chain risk, available mitigation strategies, and when the programs should be employed. Methods for reviewing and protecting development plans, documentation, and evidence are commensurate with the security and privacy requirements of the organization. Contracts may specify documentation protection requirements.

Related Controls: [AT-3](#), [SA-2](#), [SA-3](#), [SA-4](#), [SA-5](#), [SA-8](#), [SA-9](#), [SA-10](#), [SA-15](#), [SR-6](#), [SR-9](#), [SR-10](#), [SR-11](#).

Control Enhancements:

(1) ACQUISITION STRATEGIES, TOOLS, AND METHODS | [ADEQUATE SUPPLY](#)

Employ the following controls to ensure an adequate supply of [Assignment: organization-defined critical system components]: [Assignment: organization-defined controls].

Discussion: Adversaries can attempt to impede organizational operations by disrupting the supply of critical system components or corrupting supplier operations. Organizations may track systems and component mean time to failure to mitigate the loss of temporary or permanent system function. Controls to ensure that adequate supplies of critical system components include the use of multiple suppliers throughout the supply chain for the identified critical components, stockpiling spare components to ensure operation during mission-critical times, and the identification of functionally identical or similar components that may be used, if necessary.

Related Controls: [RA-9](#).

(2) ACQUISITION STRATEGIES, TOOLS, AND METHODS | [ASSESSMENTS PRIOR TO SELECTION, ACCEPTANCE, MODIFICATION, OR UPDATE](#)

Assess the system, system component, or system service prior to selection, acceptance, modification, or update.

Discussion: Organizational personnel or independent, external entities conduct assessments of systems, components, products, tools, and services to uncover evidence of tampering, unintentional and intentional vulnerabilities, or evidence of non-compliance with supply chain controls. These include malicious code, malicious processes, defective software, backdoors, and counterfeits. Assessments can include evaluations; design proposal reviews; visual or physical inspection; static and dynamic analyses; visual, x-ray, or magnetic particle inspections; simulations; white, gray, or black box testing; fuzz testing; stress testing; and penetration testing (see [SR-6\(1\)](#)). Evidence generated during assessments is documented for follow-on actions by organizations. The evidence generated during the organizational or independent assessments of supply chain elements may be used to improve supply chain processes and inform the supply chain risk management process. The evidence can be leveraged in follow-on assessments. Evidence and other documentation may be shared in accordance with organizational agreements.

Related Controls: [CA-8](#), [RA-5](#), [SA-11](#), [SI-7](#).

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[EO 13873\]](#), [\[ISO 27036\]](#), [\[ISO 20243\]](#), [\[SP 800-30\]](#), [\[SP 800-161\]](#), [\[IR 7622\]](#), [\[IR 8272\]](#).

SR-6 SUPPLIER ASSESSMENTS AND REVIEWS

Control: Assess and review the supply chain-related risks associated with suppliers or contractors and the system, system component, or system service they provide [Assignment: organization-defined frequency].

Discussion: An assessment and review of supplier risk includes security and supply chain risk management processes, foreign ownership, control or influence (FOCI), and the ability of the supplier to effectively assess subordinate second-tier and third-tier suppliers and contractors. The reviews may be conducted by the organization or by an independent third party. The reviews consider documented processes, documented controls, all-source intelligence, and publicly available information related to the supplier or contractor. Organizations can use open-source information to monitor for indications of stolen information, poor development and quality control practices, information spillage, or counterfeits. In some cases, it may be appropriate or required to share assessment and review results with other organizations in accordance with any applicable rules, policies, or inter-organizational agreements or contracts.

Related Controls: [SR-3](#), [SR-5](#).

Control Enhancements:

(1) SUPPLIER ASSESSMENTS AND REVIEWS | [TESTING AND ANALYSIS](#)

Employ [Selection (one or more): organizational analysis; independent third-party analysis; organizational testing; independent third-party testing] of the following supply chain elements, processes, and actors associated with the system, system component, or system service: [Assignment: organization-defined supply chain elements, processes, and actors].

Discussion: Relationships between entities and procedures within the supply chain, including development and delivery, are considered. Supply chain elements include organizations, entities, or tools that are used for the research and development, design, manufacturing, acquisition, delivery, integration, operations, maintenance, and disposal of systems, system components, or system services. Supply chain processes include supply chain risk management programs; SCRM strategies and implementation plans; personnel and physical security programs; hardware, software, and firmware development processes; configuration management tools, techniques, and measures to maintain provenance; shipping and handling procedures; and programs, processes, or procedures associated with the production and distribution of supply chain elements. Supply chain actors are individuals with specific roles and responsibilities in the supply chain. The evidence generated and collected during analyses and testing of supply chain elements, processes, and actors is documented and used to inform organizational risk management activities and decisions.

Related Controls: [CA-8](#), [SI-4](#).

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[EO 13873\]](#), [\[ISO 27036\]](#), [\[ISO 20243\]](#), [\[FIPS 140-3\]](#), [\[FIPS 180-4\]](#), [\[FIPS 186-4\]](#), [\[FIPS 202\]](#), [\[SP 800-30\]](#), [\[SP 800-161\]](#), [\[IR 7622\]](#), [\[IR 8272\]](#).

[SR-7](#)

SUPPLY CHAIN OPERATIONS SECURITY

Control: Employ the following Operations Security (OPSEC) controls to protect supply chain-related information for the system, system component, or system service: [Assignment: organization-defined Operations Security (OPSEC) controls].

Discussion: Supply chain OPSEC expands the scope of OPSEC to include suppliers and potential suppliers. OPSEC is a process that includes identifying critical information, analyzing friendly actions related to operations and other activities to identify actions that can be observed by potential adversaries, determining indicators that potential adversaries might obtain that could be interpreted or pieced together to derive information in sufficient time to cause harm to organizations, implementing safeguards or countermeasures to eliminate or reduce exploitable vulnerabilities and risk to an acceptable level, and considering how aggregated information may expose users or specific uses of the supply chain. Supply chain information includes user identities; uses for systems, system components, and system services; supplier identities; security and privacy requirements; system and component configurations; supplier processes; design specifications; and testing and evaluation results. Supply chain OPSEC may require

organizations to withhold mission or business information from suppliers and may include the use of intermediaries to hide the end use or users of systems, system components, or system services.

Related Controls: [SC-38](#).

Control Enhancements: None.

References: [\[EO 13873\]](#), [\[SP 800-30\]](#), [\[ISO 27036\]](#), [\[SP 800-161\]](#), [\[IR 7622\]](#).

SR-8 NOTIFICATION AGREEMENTS

Control: Establish agreements and procedures with entities involved in the supply chain for the system, system component, or system service for the [Selection (one or more): notification of supply chain compromises; results of assessments or audits; Assignment: organization-defined information]].

Discussion: The establishment of agreements and procedures facilitates communications among supply chain entities. Early notification of compromises and potential compromises in the supply chain that can potentially adversely affect or have adversely affected organizational systems or system components is essential for organizations to effectively respond to such incidents. The results of assessments or audits may include open-source information that contributed to a decision or result and could be used to help the supply chain entity resolve a concern or improve its processes.

Related Controls: [IR-4](#), [IR-6](#), [IR-8](#).

Control Enhancements: None.

References: [\[FASC18\]](#), [\[41 CFR 201\]](#), [\[EO 13873\]](#), [\[ISO 27036\]](#), [\[SP 800-30\]](#), [\[SP 800-161\]](#), [\[IR 7622\]](#).

SR-9 TAMPER RESISTANCE AND DETECTION

Control: Implement a tamper protection program for the system, system component, or system service.

Discussion: Anti-tamper technologies, tools, and techniques provide a level of protection for systems, system components, and services against many threats, including reverse engineering, modification, and substitution. Strong identification combined with tamper resistance and/or tamper detection is essential to protecting systems and components during distribution and when in use.

Related Controls: [PE-3](#), [PM-30](#), [SA-15](#), [SI-4](#), [SI-7](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-10](#), [SR-11](#).

Control Enhancements:

(1) TAMPER RESISTANCE AND DETECTION | [MULTIPLE STAGES OF SYSTEM DEVELOPMENT LIFE CYCLE](#)

Employ anti-tamper technologies, tools, and techniques throughout the system development life cycle.

Discussion: The system development life cycle includes research and development, design, manufacturing, acquisition, delivery, integration, operations and maintenance, and disposal. Organizations use a combination of hardware and software techniques for tamper resistance and detection. Organizations use obfuscation and self-checking to make reverse engineering and modifications more difficult, time-consuming, and expensive for adversaries. The customization of systems and system components can make substitutions easier to detect and therefore limit damage.

Related Controls: [SA-3](#).

References: [\[ISO 20243\]](#).

SR-10 INSPECTION OF SYSTEMS OR COMPONENTS

Control: Inspect the following systems or system components [*Selection (one or more)*: at random; at [*Assignment: organization-defined frequency*], upon [*Assignment: organization-defined indications of need for inspection*]] to detect tampering: [*Assignment: organization-defined systems or system components*].

Discussion: The inspection of systems or systems components for tamper resistance and detection addresses physical and logical tampering and is applied to systems and system components removed from organization-controlled areas. Indications of a need for inspection include changes in packaging, specifications, factory location, or entity in which the part is purchased, and when individuals return from travel to high-risk locations.

Related Controls: [AT-3](#), [PM-30](#), [SI-4](#), [SI-7](#), [SR-3](#), [SR-4](#), [SR-5](#), [SR-9](#), [SR-11](#).

References: [\[ISO 20243\]](#).

SR-11 COMPONENT AUTHENTICITY

Control:

- a. Develop and implement anti-counterfeit policy and procedures that include the means to detect and prevent counterfeit components from entering the system; and
- b. Report counterfeit system components to [*Selection (one or more)*: *source of counterfeit component*; [*Assignment: organization-defined external reporting organizations*]]; [*Assignment: organization-defined personnel or roles*]].

Discussion: Sources of counterfeit components include manufacturers, developers, vendors, and contractors. Anti-counterfeiting policies and procedures support tamper resistance and provide a level of protection against the introduction of malicious code. External reporting organizations include CISA.

Related Controls: [PE-3](#), [SA-4](#), [SI-7](#), [SR-9](#), [SR-10](#).

Control Enhancements:

(1) COMPONENT AUTHENTICITY | [ANTI-COUNTERFEIT TRAINING](#)

Train [*Assignment: organization-defined personnel or roles*] to detect counterfeit system components (including hardware, software, and firmware).

Discussion: None.

Related Controls: [AT-3](#).

(2) COMPONENT AUTHENTICITY | [CONFIGURATION CONTROL FOR COMPONENT SERVICE AND REPAIR](#)

Maintain configuration control over the following system components awaiting service or repair and serviced or repaired components awaiting return to service: [*Assignment: organization-defined system components*].

Discussion: None.

Related Controls: [CM-3](#), [MA-2](#), [MA-4](#), [SA-10](#).

(3) COMPONENT AUTHENTICITY | [ANTI-COUNTERFEIT SCANNING](#)

Scan for counterfeit system components [*Assignment: organization-defined frequency*].

Discussion: The type of component determines the type of scanning to be conducted (e.g., web application scanning if the component is a web application).

Related Controls: [RA-5](#).

References: [\[ISO 20243\]](#).

SR-12 COMPONENT DISPOSAL

Control: Dispose of [Assignment: organization-defined data, documentation, tools, or system components] using the following techniques and methods: [Assignment: organization-defined techniques and methods].

Discussion: Data, documentation, tools, or system components can be disposed of at any time during the system development life cycle (not only in the disposal or retirement phase of the life cycle). For example, disposal can occur during research and development, design, prototyping, or operations/maintenance and include methods such as disk cleaning, removal of cryptographic keys, partial reuse of components. Opportunities for compromise during disposal affect physical and logical data, including system documentation in paper-based or digital files; shipping and delivery documentation; memory sticks with software code; or complete routers or servers that include permanent media, which contain sensitive or proprietary information. Additionally, proper disposal of system components helps to prevent such components from entering the gray market.

Related Controls: [MP-6](#).

References: None.

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³⁴ The references cited in this appendix are those external publications that directly support the FISMA and Privacy Projects at NIST. Additional NIST standards, guidelines, and interagency reports are also cited throughout this publication, including in the references section of the applicable controls in [Chapter Three](#). Direct links to the NIST website are provided to obtain access to those publications.

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<http://www.csl.sri.com/users/neumann/chats4.pdf>
- [NSA CSFC] National Security Agency, *Commercial Solutions for Classified Program (CSfC)*.
<https://www.nsa.gov/resources/everyone/csfc>
- [NSA MEDIA] National Security Agency, *Media Destruction Guidance*.
<https://www.nsa.gov/resources/everyone/media-destruction>

- [ODNI CTF] Office of the Director of National Intelligence (ODNI) Cyber Threat Framework.
<https://www.dni.gov/index.php/cyber-threat-framework>
- [POPEK74] G. Popek, *The Principle of Kernel Design*, in 1974 NCC, AFIPS Cong. Proc., Vol. 43, pp. 977-978.
- [SALTZER75] J. Saltzer and M. Schroeder, *The Protection of Information in Computer Systems*, in Proceedings of the IEEE 63(9), September 1975, pp. 1278-1308.
- [SP 800-53 RES] NIST Special Publication 800-53, Revision 5 Resource Center.
<https://csrc.nist.gov/publications/detail/sp/800-53/rev-5/final>
- [USGCB] National Institute of Standards and Technology (2020) *United States Government Configuration Baseline*. Available at
<https://csrc.nist.gov/projects/united-states-government-configuration-baseline>

APPENDIX A

GLOSSARY

COMMON TERMS AND DEFINITIONS

Appendix A provides definitions for terminology used in NIST Special Publication 800-53. Sources for terms used in this publication are cited as applicable. Where no citation is noted, the source of the definition is Special Publication 800-53.

access control

[[FIPS 201-2](#)]

The process of granting or denying specific requests for obtaining and using information and related information processing services; and to enter specific physical facilities (e.g., Federal buildings, military establishments, and border crossing entrances).

adequate security

[[OMB A-130](#)]

Security protections commensurate with the risk resulting from the unauthorized access, use, disclosure, disruption, modification, or destruction of information. This includes ensuring that information hosted on behalf of an agency and information systems and applications used by the agency operate effectively and provide appropriate confidentiality, integrity, and availability protections through the application of cost-effective security controls.

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 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.

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. See *executive agency*.

all-source intelligence

[[DODTERMS](#)]

Intelligence products and/or organizations and activities that incorporate all sources of information, most frequently including human resources intelligence, imagery intelligence, measurement and signature intelligence, signals intelligence, and open-source data in the production of finished intelligence.

application [SP 800-37]	A software program hosted by an information system.
assessment	See <i>control assessment</i> or <i>risk assessment</i> .
assessment plan	The objectives for the security and privacy control assessments and a detailed roadmap of how to conduct such assessments.
assessor	The individual, group, or organization responsible for conducting a security or privacy control assessment.
assignment operation	A control parameter that allows an organization to assign a specific, organization-defined value to the control or control enhancement (e.g., assigning a list of roles to be notified or a value for the frequency of testing). See <i>organization-defined control parameters</i> and <i>selection operation</i> .
assurance [ISO/IEC 15026, Adapted]	Grounds for justified confidence that a [security or privacy] claim has been or will be achieved. <i>Note 1:</i> Assurance is typically obtained relative to a set of specific claims. The scope and focus of such claims may vary (e.g., security claims, safety claims) and the claims themselves may be interrelated. <i>Note 2:</i> Assurance is obtained through techniques and methods that generate credible evidence to substantiate claims.
attack surface	The set of points on the boundary of a system, a system component, or an environment where an attacker can try to enter, cause an effect on, or extract data from, that system, component, or environment.
audit [CNSSI 4009]	Independent review and examination of records and activities to assess the adequacy of system controls, to ensure compliance with established policies and operational procedures.
audit log [CNSSI 4009]	A chronological record of system activities, including records of system accesses and operations performed in a given period.
audit record	An individual entry in an audit log related to an audited event.
audit record reduction	A process that manipulates collected audit information and organizes it into a summary format that is more meaningful to analysts.
audit trail	A chronological record that reconstructs and examines the sequence of activities surrounding or leading to a specific operation, procedure, or event in a security-relevant transaction from inception to result.
authentication [FIPS 200]	Verifying the identity of a user, process, or device, often as a prerequisite to allowing access to resources in a system.

authenticator	Something that the claimant possesses and controls (typically a cryptographic module or password) that is used to authenticate the claimant's identity. This was previously referred to as a token.
authenticity	The property of being genuine and being able to be verified and trusted; confidence in the validity of a transmission, message, or message originator. See <i>authentication</i> .
authorization [CNSSI 4009]	Access privileges granted to a user, program, or process or the act of granting those privileges.
authorization boundary [OMB A-130]	All components of an information system to be authorized for operation by an authorizing official. This excludes separately authorized systems to which the information system is connected.
authorization to operate [OMB A-130]	The official management decision given by a senior Federal official or officials to authorize operation of an information system and to explicitly accept the risk to agency operations (including mission, functions, image, or reputation), agency assets, individuals, other organizations, and the Nation based on the implementation of an agreed-upon set of security and privacy controls. Authorization also applies to common controls inherited by agency information systems.
authorizing official [OMB A-130]	A senior Federal official or executive with the authority to authorize (i.e., assume responsibility for) the operation of an information system or the use of a designated set of common controls at an acceptable level of risk to agency operations (including mission, functions, image, or reputation), agency assets, individuals, other organizations, and the Nation.
availability [FISMA]	Ensuring timely and reliable access to and use of information.
baseline	See <i>control baseline</i> .
baseline configuration [SP 800-128, Adapted]	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.
boundary [CNSSI 4009]	Physical or logical perimeter of a system. See also <i>authorization boundary</i> and <i>interface</i> .
boundary protection	Monitoring and control of communications at the external interface to a system to prevent and detect malicious and other unauthorized communications using boundary protection devices.

boundary protection device	A device (e.g., gateway, router, firewall, guard, or encrypted tunnel) that facilitates the adjudication of different system security policies for connected systems or provides boundary protection. The boundary may be the authorization boundary for a system, the organizational network boundary, or a logical boundary defined by the organization.
breach [OMB M-17-12]	The loss of control, compromise, unauthorized disclosure, unauthorized acquisition, or any similar occurrence where: a person other than an authorized user accesses or potentially accesses personally identifiable information; or an authorized user accesses personally identifiable information for another than authorized purpose.
breadth [SP 800-53A]	An attribute associated with an assessment method that addresses the scope or coverage of the assessment objects included with the assessment.
capability	A combination of mutually reinforcing security and/or privacy controls implemented by technical, physical, and procedural means. Such controls are typically selected to achieve a common information security- or privacy-related purpose.
central management	The organization-wide management and implementation of selected security and privacy controls and related processes. Central management includes planning, implementing, assessing, authorizing, and monitoring the organization-defined, centrally managed security and privacy controls and processes.
checksum [IETF 4949]	A value that (a) is computed by a function that is dependent on the contents of a data object and (b) is stored or transmitted together with the object, for detecting changes in the data.
chief information officer [OMB A-130]	The senior official that provides advice and other assistance to the head of the agency and other senior management personnel of the agency to ensure that IT is acquired and information resources are managed for the agency in a manner that achieves the agency's strategic goals and information resources management goals; and is responsible for ensuring agency compliance with, and prompt, efficient, and effective implementation of, the information policies and information resources management responsibilities, including the reduction of information collection burdens on the public.
chief information security officer	See <i>senior agency information security officer</i> .
classified information	See classified national security information.
classified national security information [EO 13526]	Information that has been determined pursuant to Executive Order (E.O.) 13526 or any predecessor order to require protection against unauthorized disclosure and is marked to indicate its classified status when in documentary form.

commodity service	A system service provided by a commercial service provider to a large and diverse set of consumers. The organization acquiring or receiving the commodity service possesses limited visibility into the management structure and operations of the provider, and while the organization may be able to negotiate service-level agreements, the organization is typically not able to require that the provider implement specific security or privacy controls.
common carrier	A telecommunications company that holds itself out to the public for hire to provide communications transmission services.
common control [OMB A-130]	A security or privacy control that is inherited by multiple information systems or programs.
common control provider [SP 800-37]	An organizational official responsible for the development, implementation, assessment, and monitoring of common controls (i.e., security or privacy controls inheritable by systems).
common criteria [CNSSI 4009]	Governing document that provides a comprehensive, rigorous method for specifying security function and assurance requirements for products and systems.
common secure configuration [SP 800-128]	A recognized standardized and established benchmark that stipulates specific secure configuration settings for a given information technology platform.
compensating controls	The security and privacy controls employed in lieu of the controls in the baselines described in NIST Special Publication 800-53B that provide equivalent or comparable protection for a system or organization.
component	See <i>system component</i> .
confidentiality [FISMA]	Preserving authorized restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information.
configuration control [SP 800-128]	Process for controlling modifications to hardware, firmware, software, and documentation to protect the system against improper modifications before, during, and after system implementation.
configuration item [SP 800-128]	An aggregation of system components that is designated for configuration management and treated as a single entity in the configuration management process.
configuration management [SP 800-128]	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 [SP 800-128]	The set of parameters that can be changed in hardware, software, or firmware that affect the security posture and/or functionality of the system.
continuous monitoring [SP 800-137]	Maintaining ongoing awareness to support organizational risk decisions.
control	See <i>security control</i> or <i>privacy control</i> .
control assessment [SP 800-37]	The testing or evaluation of the controls in an information system or an organization 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 or privacy requirements for the system or the organization.
control assessor	See <i>assessor</i> .
control baseline [SP 800-53B]	Predefined sets of controls specifically assembled to address the protection needs of groups, organizations, or communities of interest. See <i>privacy control baseline</i> or <i>security control baseline</i> .
control effectiveness	A measure of whether a security or privacy control contributes to the reduction of information security or privacy risk.
control enhancement	Augmentation of a security or privacy control to build in additional but related functionality to the control, increase the strength of the control, or add assurance to the control.
control inheritance	A situation in which a system or application receives protection from security or privacy controls (or portions of controls) that are developed, implemented, assessed, authorized, and monitored by entities other than those responsible for the system or application; entities either internal or external to the organization where the system or application resides. See <i>common control</i> .
control parameter	See <i>organization-defined control parameter</i> .
controlled area	Any area or space for which an organization has confidence that the physical and procedural protections provided are sufficient to meet the requirements established for protecting the information and/or information system.
controlled interface	An interface to a system with a set of mechanisms that enforces the security policies and controls the flow of information between connected systems.

controlled unclassified information [32 CFR 2002]	Information that the Government creates or possesses, or that an entity creates or possesses for or on behalf of the Government, that a law, regulation, or Government-wide policy requires or permits an agency to handle using safeguarding or dissemination controls. However, CUI does not include classified information or information a non-executive branch entity possesses and maintains in its own systems that did not come from, or was not created or possessed by or for, an executive branch agency or an entity acting for an agency.
counterfeit [SP 800-161]	An unauthorized copy or substitute that has been identified, marked, and/or altered by a source other than the item's legally authorized source and has been misrepresented to be an authorized item of the legally authorized source.
countermeasures [FIPS 200]	Actions, devices, procedures, techniques, or other measures that reduce the vulnerability of a system. Synonymous with security controls and safeguards.
covert channel [CNSSI 4009]	An unintended or unauthorized intra-system channel that enables two cooperating entities to transfer information in a way that violates the system's security policy but does not exceed the entities' access authorizations.
covert channel analysis [CNSSI 4009]	Determination of the extent to which the security policy model and subsequent lower-level program descriptions may allow unauthorized access to information.
covert storage channel [CNSSI 4009]	A system feature that enables one system entity to signal information to another entity by directly or indirectly writing to a storage location that is later directly or indirectly read by the second entity.
covert timing channel [CNSSI 4009, Adapted]	A system feature that enables one system entity to signal information to another by modulating its own use of a system resource in such a way as to affect system response time observed by the second entity.
credential [SP 800-63-3]	An object or data structure that authoritatively binds an identity, via an identifier or identifiers, and (optionally) additional attributes, to at least one authenticator possessed and controlled by a subscriber.
critical infrastructure [USA PATRIOT]	Systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.
cross domain solution [CNSSI 1253]	A form of controlled interface that provides the ability to manually and/or automatically access and/or transfer information between different security domains.

cryptographic module [FIPS 140-3]	The set of hardware, software, and/or firmware that implements Approved security functions (including cryptographic algorithms and key generation) and is contained within the cryptographic boundary.
cybersecurity [OMB A-130]	Prevention of damage to, protection of, and restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communication, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and nonrepudiation.
cyberspace [CNSSI 4009]	The interdependent network of information technology infrastructures that includes the Internet, telecommunications networks, computer systems, and embedded processors and controllers in critical industries.
data action [IR 8062]	A system operation that processes personally identifiable information.
data mining	An analytical process that attempts to find correlations or patterns in large data sets for the purpose of data or knowledge discovery.
de-identification [ISO 25237]	General term for any process of removing the association between a set of identifying data and the data subject.
defense in breadth [CNSSI 4009]	A planned, systematic set of multidisciplinary activities that seek to identify, manage, and reduce risk of exploitable vulnerabilities at every stage of the system, network, or subcomponent life cycle, including system, network, or product design and development; manufacturing; packaging; assembly; system integration; distribution; operations; maintenance; and retirement.
defense in depth	An information security strategy that integrates people, technology, and operations capabilities to establish variable barriers across multiple layers and missions of the organization.
depth [SP 800-53A]	An attribute associated with an assessment method that addresses the rigor and level of detail associated with the application of the method.
developer	A general term that includes developers or manufacturers of systems, system components, or system services; systems integrators; vendors; and product resellers. The development of systems, components, or services can occur internally within organizations or through external entities.
digital media	A form of electronic media where data is stored in digital (as opposed to analog) form.

discretionary access control	An access control policy that is enforced over all subjects and objects in a system where the policy specifies that a subject that has been granted access to information can do one or more of the following: pass the information to other subjects or objects; grant its privileges to other subjects; change the security attributes of subjects, objects, systems, or system components; choose the security attributes to be associated with newly-created or revised objects; or change the rules governing access control. Mandatory access controls restrict this capability.
disassociability [IR 8062]	Enabling the processing of personally identifiable information or events without association to individuals or devices beyond the operational requirements of the system.
domain	An environment or context that includes a set of system resources and a set of system entities that have the right to access the resources as defined by a common security policy, security model, or security architecture. See <i>security domain</i> .
enterprise [CNSSI 4009]	An organization with a defined mission/goal and a defined boundary, using systems to execute that mission, and with responsibility for managing its own risks and performance. An enterprise may consist of all or some of the following business aspects: acquisition, program management, human resources, financial management, security, and systems, information and mission management. See <i>organization</i> .
enterprise architecture [OMB A-130]	A strategic information asset base, which defines the mission; the information necessary to perform the mission; the technologies necessary to perform the mission; and the transitional processes for implementing new technologies in response to changing mission needs; and includes a baseline architecture; a target architecture; and a sequencing plan.
environment of operation [OMB A-130]	The physical surroundings in which an information system processes, stores, and transmits information.
event [SP 800-61, Adapted]	Any observable occurrence in a system.
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.
exfiltration	The unauthorized transfer of information from a system.
external system (or component)	A system or component of a system that is used by but is not a part of an organizational system and for which the organization has no direct control over the implementation of required security and privacy controls or the assessment of control effectiveness.

external system service	A system service that is provided by an external service provider and for which the organization has no direct control over the implementation of required security and privacy controls or the assessment of control effectiveness.
external system service provider	A provider of external system services to an organization through a variety of consumer-producer relationships, including joint ventures, business partnerships, outsourcing arrangements (i.e., through contracts, interagency agreements, lines of business arrangements), licensing agreements, and/or supply chain exchanges.
external network	A network not controlled by the organization.
failover	The capability to switch over automatically (typically without human intervention or warning) to a redundant or standby system upon the failure or abnormal termination of the previously active system.
federal information system [OMB A-130]	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.
FIPS-validated cryptography	A cryptographic module validated by the Cryptographic Module Validation Program (CMVP) to meet requirements specified in FIPS Publication 140-3 (as amended). As a prerequisite to CMVP validation, the cryptographic module is required to employ a cryptographic algorithm implementation that has successfully passed validation testing by the Cryptographic Algorithm Validation Program (CAVP). See <i>NSA-approved cryptography</i> .
firmware [CNSSI 4009]	Computer programs and data stored in hardware - typically in read-only memory (ROM) or programmable read-only memory (PROM) - such that the programs and data cannot be dynamically written or modified during execution of the programs. See <i>hardware</i> and <i>software</i> .
hardware [CNSSI 4009]	The material physical components of a system. See <i>software</i> and <i>firmware</i> .
high-impact system [FIPS 200]	A system in which at least one security objective (i.e., confidentiality, integrity, or availability) is assigned a FIPS Publication 199 potential impact value of high.
hybrid control [OMB A-130]	A security or privacy control that is implemented for an information system in part as a common control and in part as a system-specific control.
identifier [FIPS 201-2]	Unique data used to represent a person's identity and associated attributes. A name or a card number are examples of identifiers. A unique label used by a system to indicate a specific entity, object, or group.

impact	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.
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 [FISMA]	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 control system [SP 800-82]	General term that encompasses several types of control systems, including supervisory control and data acquisition (SCADA) systems, distributed control systems (DCS), and other control system configurations such as programmable logic controllers (PLC) found in the industrial sectors and critical infrastructures. An industrial control system consists of combinations of control components (e.g., electrical, mechanical, hydraulic, pneumatic) that act together to achieve an industrial objective (e.g., manufacturing, transportation of matter or energy).
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	Controls to ensure that information transfers within a system or organization are not made in violation of the security policy.
information leakage	The intentional or unintentional release of information to an untrusted environment.
information owner [SP 800-37]	Official with statutory or operational authority for specified information and responsibility for establishing the controls for its generation, collection, processing, dissemination, and disposal.
information resources [OMB A-130]	Information and related resources, such as personnel, equipment, funds, and information technology.
information security [OMB A-130]	The protection of information and systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to provide confidentiality, integrity, and availability.
information security architecture [OMB A-130]	An embedded, integral part of the enterprise architecture that describes the structure and behavior of the enterprise security processes, security systems, personnel and organizational subunits, showing their alignment with the enterprise's mission and strategic plans.

information security policy [CNSSI 4009]	Aggregate of directives, regulations, rules, and practices that prescribes how an organization manages, protects, and distributes information.
information security program plan [OMB A-130]	Formal document that provides an overview of the security requirements for an organization-wide information security program and describes the program management controls and common controls in place or planned for meeting those requirements.
information security risk [SP 800-30]	The risk to organizational operations (including mission, functions, image, reputation), organizational assets, individuals, other organizations, and the Nation due to the potential for unauthorized access, use, disclosure, disruption, modification, or destruction of information and/or systems.
information steward [SP 800-37]	An agency official with statutory or operational authority for specified information and responsibility for establishing the controls for its generation, collection, processing, dissemination, and disposal.
information system [USC 3502]	A discrete set of information resources organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information.
information technology [USC 11101]	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.
information technology product	See <i>system component</i> .

information type [FIPS 199]	A specific category of information (e.g., privacy, medical, proprietary, financial, investigative, contractor-sensitive, security management) defined by an organization or in some instances, by a specific law, Executive Order, directive, policy, or regulation.
insider [CNSSI 4009, Adapted]	Any person with authorized access to any organizational resource, to include personnel, facilities, information, equipment, networks, or systems.
insider threat [CNSSI 4009, Adapted]	The threat that an insider will use her/his authorized access, wittingly or unwittingly, to do harm to the security of organizational operations and assets, individuals, other organizations, and the Nation. This threat can include damage through espionage, terrorism, unauthorized disclosure of national security information, or through the loss or degradation of organizational resources or capabilities.
insider threat program [CNSSI 4009, Adapted]	A coordinated collection of capabilities authorized by the organization and used to deter, detect, and mitigate the unauthorized disclosure of information.
interface [CNSSI 4009]	Common boundary between independent systems or modules where interactions take place.
integrity [FISMA]	Guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity.
internal network	A network where the establishment, maintenance, and provisioning of security controls are under the direct control of organizational employees or contractors. Cryptographic encapsulation or similar security technology implemented between organization-controlled endpoints provides the same effect (at least regarding confidentiality and integrity). An internal network is typically organization-owned yet may be organization-controlled while not being organization-owned.
label	See <i>security label</i> .
least privilege [CNSSI 4009]	The principle that a security architecture is designed so that each entity is granted the minimum system resources and authorizations that the entity needs to perform its function.
local access	Access to an organizational system by a user (or process acting on behalf of a user) communicating through a direct connection without the use of a network.

logical access control system	An automated system that controls an individual's ability to access one or more computer system resources, such as a workstation, network, application, or database. A logical access control system requires the validation of an individual's identity through some mechanism, such as a PIN, card, biometric, or other token. It has the capability to assign different access privileges to different individuals depending on their roles and responsibilities in an organization.
low-impact system [FIPS 200]	A system in which all three security objectives (i.e., confidentiality, integrity, and availability) are assigned a FIPS Publication 199 potential impact value of low.
malicious code	Software or firmware intended to perform an unauthorized process that will have adverse impacts 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.
managed interface	An interface within a system that provides boundary protection capabilities using automated mechanisms or devices.
mandatory access control	An access control policy that is uniformly enforced across all subjects and objects within a system. A subject that has been granted access to information is constrained from: passing the information to unauthorized subjects or objects; granting its privileges to other subjects; changing one or more security attributes on subjects, objects, the system, or system components; choosing the security attributes to be associated with newly created or modified objects; or changing the rules for governing access control. Organization-defined subjects may explicitly be granted organization-defined privileges (i.e., they are trusted subjects) such that they are not limited by some or all of the above constraints. Mandatory access control is considered a type of nondiscretionary access control.
marking	See <i>security marking</i> .
matching agreement [OMB A-108]	A written agreement between a recipient agency and a source agency (or a non-Federal agency) that is required by the Privacy Act for parties engaging in a matching program.
media [FIPS 200]	Physical devices or writing surfaces including magnetic tapes, optical disks, magnetic disks, Large-Scale Integration memory chips, and printouts (but excluding display media) onto which information is recorded, stored, or printed within a system.
metadata	Information that describes the characteristics of data, including structural metadata that describes data structures (i.e., data format, syntax, semantics) and descriptive metadata that describes data contents (i.e., security labels).

mobile code	Software programs or parts of programs obtained from remote systems, transmitted across a network, and executed on a local system without explicit installation or execution by the recipient.
mobile code technologies	Software technologies that provide the mechanisms for the production and use of mobile code.
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 data storage; and is powered on for extended periods of time with a self-contained power source. Mobile devices may also include voice communication capabilities, on-board sensors that allow the device to capture (e.g., photograph, video, record, or determine location) information, and/or built-in features for synchronizing local data with remote locations. Examples include smart phones, tablets, and e-readers.
moderate-impact system [FIPS 200]	A system in which at least one security objective (i.e., confidentiality, integrity, or availability) is assigned a FIPS Publication 199 potential impact value of moderate and no security objective is assigned a potential impact value of high.
multi-factor authentication [SP 800-63-3]	An authentication system or an authenticator that requires more than one authentication factor for successful authentication. Multi-factor authentication can be performed using a single authenticator that provides more than one factor or by a combination of authenticators that provide different factors. The three authentication factors are something you know, something you have, and something you are. See <i>authenticator</i> .
multilevel security [CNSSI 4009]	Concept of processing information with different classifications and categories that simultaneously permits access by users with different security clearances and denies access to users who lack authorization.
multiple security levels [CNSSI 4009]	Capability of a system that is trusted to contain, and maintain separation between, resources (particularly stored data) of different security domains.

national security system [OMB A-130]	Any system (including any telecommunications system) used or operated by an agency or by a contractor of an agency, or other organization on behalf of an agency—(i) the function, operation, or use of which involves intelligence activities; involves cryptologic activities related to national security; involves command and control of military forces; involves equipment that is an integral part of a weapon or weapons system; or is critical to the direct fulfillment of military or intelligence missions (excluding a system that is to be used for routine administrative and business applications, for example, payroll, finance, logistics, and personnel management applications); or (ii) is protected at all times by procedures established for information that have been specifically authorized under criteria established by an Executive Order or an Act of Congress to be kept classified in the interest of national defense or foreign policy.
network	A system implemented with a collection of connected 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, including a local area network, a wide area network, and the Internet.
nonce [SP 800-63-3]	A value used in security protocols that is never repeated with the same key. For example, nonces used as challenges in challenge-response authentication protocols are not repeated until the authentication keys are changed. Otherwise, there is a possibility of a replay attack.
nondiscretionary access control	See <i>mandatory access control</i> .
nonlocal maintenance	Maintenance activities conducted by individuals who communicate through either an internal or external network.
non-organizational user	A user who is not an organizational user (including public users).
non-repudiation	Protection against an individual who falsely denies having performed a certain action and provides the capability to determine whether an individual took a certain action, such as creating information, sending a message, approving information, or receiving a message.
NSA-approved cryptography	Cryptography that consists of an approved algorithm, an implementation that has been approved for the protection of classified information and/or controlled unclassified information in a specific environment, and a supporting key management infrastructure.

object	Passive system-related entity, including devices, files, records, tables, processes, programs, and domains that contain or receive information. Access to an object (by a subject) implies access to the information it contains. See <i>subject</i> .
operations security [CNSSI 4009]	Systematic and proven process by which potential adversaries can be denied information about capabilities and intentions by identifying, controlling, and protecting generally unclassified evidence of the planning and execution of sensitive activities. The process involves five steps: identification of critical information, analysis of threats, analysis of vulnerabilities, assessment of risks, and application of appropriate countermeasures.
organization [FIPS 200, Adapted]	An entity of any size, complexity, or positioning within an organizational structure, including federal agencies, private enterprises, academic institutions, state, local, or tribal governments, or as appropriate, any of their operational elements.
organization-defined control parameter	The variable part of a control or control enhancement that is instantiated by an organization during the tailoring process by either assigning an organization-defined value or selecting a value from a predefined list provided as part of the control or control enhancement. See <i>assignment operation</i> and <i>selection operation</i> .
organizational user	An organizational employee or an individual whom the organization deems to have equivalent status of an employee, including a contractor, guest researcher, or individual detailed from another organization. Policies and procedures for granting the equivalent status of employees to individuals may include need-to-know, relationship to the organization, and citizenship.
overlay [OMB A-130]	A specification of security or privacy controls, control enhancements, supplemental guidance, and other supporting information employed during the tailoring process, that is intended to complement (and further refine) security control baselines. The overlay specification may be more stringent or less stringent than the original security control baseline specification and can be applied to multiple information systems. See <i>tailoring</i> .
parameter	See <i>organization-defined control parameter</i> .
penetration testing	A test methodology in which assessors, typically working under specific constraints, attempt to circumvent or defeat the security features of a system.

periods processing	A mode of system operation in which information of different sensitivities is processed at distinctly different times by the same system with the system being properly purged or sanitized between periods.
personally identifiable information [OMB A-130]	Information that can be used to distinguish or trace an individual's identity, either alone or when combined with other information that is linked or linkable to a specific individual.
personally identifiable information processing [ISO/IEC 29100, Adapted]	An operation or set of operations performed upon personally identifiable information that can include, but is not limited to, the collection, retention, logging, generation, transformation, use, disclosure, transfer, and disposal of personally identifiable information.
personally identifiable information processing permissions	The requirements for how personally identifiable information can be processed or the conditions under which personally identifiable information can be processed.
personnel security	The discipline of assessing the conduct, integrity, judgment, loyalty, reliability, and stability of individuals for duties and responsibilities that require trustworthiness.
physical access control system [SP 800-116]	An electronic system that controls the ability of people or vehicles to enter a protected area by means of authentication and authorization at access control points.
plan of action and milestones	A document that identifies tasks that need to be accomplished. It details resources required to accomplish the elements of the plan, milestones for meeting the tasks, and the scheduled completion dates for the milestones.
portable storage device	A system component that can communicate with and be added to or removed from a system or network and that is limited to data storage—including text, video, audio or image data—as its primary function (e.g., optical discs, external or removable hard drives, external or removable solid-state disk drives, magnetic or optical tapes, flash memory devices, flash memory cards, and other external or removable disks).
potential impact [FIPS 199]	The loss of confidentiality, integrity, or availability could be expected to have a limited adverse effect (FIPS Publication 199 low); a serious adverse effect (FIPS Publication 199 moderate); or a severe or catastrophic adverse effect (FIPS Publication 199 high) on organizational operations, organizational assets, or individuals.
privacy architecture [SP 800-37]	An embedded, integral part of the enterprise architecture that describes the structure and behavior for an enterprise's privacy protection processes, technical measures, personnel and organizational sub-units, showing their alignment with the enterprise's mission and strategic plans.

privacy control [OMB A-130]	The administrative, technical, and physical safeguards employed within an agency to ensure compliance with applicable privacy requirements and manage privacy risks.
privacy control baseline	The set of privacy controls selected based on the privacy selection criteria that provide a starting point for the tailoring process.
privacy domain	A domain that implements a privacy policy.
privacy impact assessment [OMB A-130]	An analysis of how information is handled to ensure handling conforms to applicable legal, regulatory, and policy requirements regarding privacy; to determine the risks and effects of creating, collecting, using, processing, storing, maintaining, disseminating, disclosing, and disposing of information in identifiable form in an electronic information system; and to examine and evaluate protections and alternate processes for handling information to mitigate potential privacy concerns. A privacy impact assessment is both an analysis and a formal document detailing the process and the outcome of the analysis.
privacy plan [OMB A-130]	A formal document that details the privacy controls selected for an information system or environment of operation that are in place or planned for meeting applicable privacy requirements and managing privacy risks, details how the controls have been implemented, and describes the methodologies and metrics that will be used to assess the controls.
privacy program plan [OMB A-130]	A formal document that provides an overview of an agency's privacy program, including a description of the structure of the privacy program, the resources dedicated to the privacy program, the role of the Senior Agency Official for Privacy and other privacy officials and staff, the strategic goals and objectives of the privacy program, and the program management controls and common controls in place or planned for meeting applicable privacy requirements and managing privacy risks.
privileged account	A system account with the authorizations of a privileged user.
privileged command	A human-initiated command executed on a system that involves the control, monitoring, or administration of the system, including security functions and associated security-relevant information.
privileged user [CNSSI 4009]	A user that is authorized (and therefore, trusted) to perform security-relevant functions that ordinary users are not authorized to perform.

protected distribution system [CNSSI 4009]	Wire line or fiber optic system that includes adequate safeguards and/or countermeasures (e.g., acoustic, electric, electromagnetic, and physical) to permit its use for the transmission of unencrypted information through an area of lesser classification or control.
provenance	The chronology of the origin, development, ownership, location, and changes to a system or system component and associated data. It may also include the personnel and processes used to interact with or make modifications to the system, component, or associated data.
public key infrastructure [CNSSI 4009]	The architecture, organization, techniques, practices, and procedures that collectively support the implementation and operation of a certificate-based public key cryptographic system. Framework established to issue, maintain, and revoke public key certificates.
purge [SP 800-88]	A method of sanitization that applies physical or logical techniques that render target data recovery infeasible using state of the art laboratory techniques.
reciprocity [SP 800-37]	Agreement among participating organizations to accept each other's security assessments to reuse system resources and/or to accept each other's assessed security posture to share information.
records [OMB A-130]	All recorded information, regardless of form or characteristics, made or received by a Federal agency under Federal law or in connection with the transaction of public business and preserved or appropriate for preservation by that agency or its legitimate successor as evidence of the organization, functions, policies, decisions, procedures, operations, or other activities of the United States Government or because of the informational value of data in them.
red team exercise	An exercise, reflecting real-world conditions that is conducted as a simulated adversarial attempt to compromise organizational missions or business processes and to provide a comprehensive assessment of the security capabilities of an organization and its systems.
reference monitor	A set of design requirements on a reference validation mechanism that, as a key component of an operating system, enforces an access control policy over all subjects and objects. A reference validation mechanism is always invoked (i.e., complete mediation), tamperproof, and small enough to be subject to analysis and tests, the completeness of which can be assured (i.e., verifiable).

regrader [CNSSI 4009]	A trusted process explicitly authorized to re-classify and re-label data in accordance with a defined policy exception. Untrusted or unauthorized processes are such actions by the security policy.
remote access	Access to an organizational system by a user (or a process acting on behalf of a user) communicating through an external network.
remote maintenance	Maintenance activities conducted by individuals communicating through an external network.
replay attack [SP 800-63-3]	An attack in which the Attacker is able to replay previously captured messages (between a legitimate Claimant and a Verifier) to masquerade as that Claimant to the Verifier or vice versa.
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.
resilience [OMB A-130]	The ability of an information system to operate under adverse conditions or stress, even if in a degraded or debilitated state, while maintaining essential operational capabilities, and to recover to an effective operational posture in a time frame consistent with mission needs.
restricted data [ATOM54]	All data concerning (i) design, manufacture, or utilization of atomic weapons; (ii) the production of special nuclear material; or (iii) the use of special nuclear material in the production of energy, but shall not include data declassified or removed from the Restricted Data category pursuant to Section 142 [of the Atomic Energy Act of 1954].
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 800-39] [IR 8062, adapted]	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.
	Risk management includes threat and vulnerability analyses as well as analyses of adverse effects on individuals arising from information processing and considers mitigations provided by security and privacy controls planned or in place. Synonymous with <i>risk analysis</i> .

risk executive (function) [SP 800-37]	An individual or group within an organization that helps to ensure that security risk-related considerations for individual systems, to include the authorization decisions for those systems, are viewed from an organization-wide perspective with regard to the overall strategic goals and objectives of the organization in carrying out its mission and business functions; and managing risk from individual systems is consistent across the organization, reflects organizational risk tolerance, and is considered along with other organizational risks affecting mission or business success.
risk management [OMB A-130]	The program and supporting processes to manage risk to agency operations (including mission, functions, image, reputation), agency assets, individuals, other organizations, and the Nation, and includes: establishing the context for risk-related activities; assessing risk; responding to risk once determined; and monitoring risk over time.
risk mitigation [CNSSI 4009]	Prioritizing, evaluating, and implementing the appropriate risk-reducing controls/countermeasures recommended from the risk management process.
risk response [OMB A-130]	Accepting, avoiding, mitigating, sharing, or transferring risk to agency operations, agency assets, individuals, other organizations, or the Nation.
risk tolerance [SP 800-39]	The level of risk or the degree of uncertainty that is acceptable to an organization.
role-based access control	Access control based on user roles (i.e., a collection of access authorizations that a user receives based on an explicit or implicit assumption of a given role). Role permissions may be inherited through a role hierarchy and typically reflect the permissions needed to perform defined functions within an organization. A given role may apply to a single individual or to several individuals.
runtime	The period during which a computer program is executing.
sanitization [SP 800-88]	A process to render access to target data on the media infeasible for a given level of effort. Clear, purge, and destroy are actions that can be taken to sanitize media.
scoping considerations	A part of tailoring guidance that provides organizations with specific considerations on the applicability and implementation of security and privacy controls in the control baselines. Considerations include policy or regulatory, technology, physical infrastructure, system component allocation, public access, scalability, common control, operational or environmental, and security objective.

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 attribute	An abstraction that represents the basic properties or characteristics of an entity with respect to safeguarding information. Typically associated with internal data structures—including records, buffers, and files within the system—and used to enable the implementation of access control and flow control policies; reflect special dissemination, handling or distribution instructions; or support other aspects of the information security policy.
security categorization	The process of determining the security category for information or a system. Security categorization methodologies are described in CNSS Instruction 1253 for national security systems and in FIPS Publication 199 for other than national security systems. See <i>security category</i> .
security category [OMB A-130]	The characterization of information or an information system based on an assessment of the potential impact that a loss of confidentiality, integrity, or availability of such information or information system would have on agency operations, agency assets, individuals, other organizations, and the Nation.
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 baseline [OMB A-130]	The set of minimum security controls defined for a low-impact, moderate-impact, or high-impact information system.
security domain [CNSSI 4009]	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 information 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.
security impact analysis [SP 800-128]	The analysis conducted by qualified staff within an organization to determine the extent to which changes to the system affect the security posture of the system.

security kernel [CNSSI 4009]	Hardware, firmware, and software elements of a trusted computing base implementing the reference monitor concept. Security kernel must mediate all accesses, be protected from modification, and be verifiable as correct.
security label	The means used to associate a set of security attributes with a specific information object as part of the data structure for that object.
security marking	The means used to associate a set of security attributes with objects in a human-readable form in order to enable organizational, process-based enforcement of information security policies.
security objective [FIPS 199]	Confidentiality, integrity, or availability.
security plan	A formal document that provides an overview of the security requirements for an information system or an information security program and describes the security controls in place or planned for meeting those requirements. The system security plan describes the system components that are included within the system, the environment in which the system operates, how the security requirements are implemented, and the relationships with or connections to other systems. <i>See system security plan.</i>
security policy [SP 800-160-1 adapted]	A set of criteria for the provision of security services. A set of rules that governs all aspects of security-relevant system and system component behavior.
security policy filter	A hardware and/or software component that performs one or more of the following functions: content verification to ensure the data type of the submitted content; content inspection to analyze the submitted content and verify that complies with a defined policy; malicious content checker that evaluates the content for malicious code; suspicious activity checker that evaluates or executes the content in a safe manner, such as in a sandbox or detonation chamber and monitors for suspicious activity; or content sanitization, cleansing, and transformation, which modifies the submitted content to comply with a defined policy.

security requirement [FIPS 200, Adapted]	A requirement levied on an information system or an organization that is derived from applicable laws, executive orders, directives, regulations, policies, standards, procedures, or mission/business needs to ensure the confidentiality, integrity, and availability of information that is being processed, stored, or transmitted. <i>Note:</i> Security requirements can be used in a variety of contexts from high-level policy-related activities to low-level implementation-related activities in system development and engineering disciplines.
security service [SP 800-160-1]	A security capability or function provided by an entity that supports one or more security objectives.
security-relevant information	Information within the system that can potentially impact the operation of security functions or the provision of security services in a manner that could result in failure to enforce the system security policy or maintain isolation of code and data.
selection operation	A control parameter that allows an organization to select a value from a list of predefined values provided as part of the control or control enhancement (e.g., selecting to either restrict an action or prohibit an action). See <i>assignment operation</i> and <i>organization-defined control parameter</i> .
senior agency information security officer	Official responsible for carrying out the Chief Information Officer responsibilities under FISMA and serving as the Chief Information Officer's primary liaison to the agency's authorizing officials, information system owners, and information system security officers. <i>Note:</i> Organizations subordinate to federal agencies may use the term <i>senior information security officer</i> or <i>chief information security officer</i> to denote individuals who fill positions with similar responsibilities to senior agency information security officers.
senior agency official for privacy [OMB A-130]	Senior official, designated by the head of each agency, who has agency-wide responsibility for privacy, including implementation of privacy protections; compliance with Federal laws, regulations, and policies relating to privacy; management of privacy risks at the agency; and a central policy-making role in the agency's development and evaluation of legislative, regulatory, and other policy proposals.
senior information security officer	See <i>senior agency information security officer</i> .
sensitive compartmented information [CNSSI 4009]	Classified information concerning or derived from intelligence sources, methods, or analytical processes, which is required to be handled within formal access control systems established by the Director of National Intelligence.

service-oriented architecture	A set of principles and methodologies for designing and developing software in the form of interoperable services. These services are well-defined business functions that are built as software components (i.e., discrete pieces of code and/or data structures) that can be reused for different purposes.
shared control	A security or privacy control that is implemented for an information system in part as a common control and in part as a system-specific control. See <i>hybrid control</i> .
software [CNSSI 4009]	Computer programs and associated data that may be dynamically written or modified during execution.
spam	The abuse of electronic messaging systems to indiscriminately send unsolicited bulk messages.
special access program [CNSSI 4009]	A program established for a specific class of classified information that imposes safeguarding and access requirements that exceed those normally required for information at the same classification level.
split tunneling	The process of allowing a remote user or device to establish a non-remote connection with a system and simultaneously communicate via some other connection to a resource in an external network. This method of network access enables a user to access remote devices, and simultaneously, access uncontrolled networks.
spyware	Software that is secretly or surreptitiously installed into an information system to gather information on individuals or organizations without their knowledge; a type of malicious code.
subject	An individual, process, or device that causes information to flow among objects or change to the system state. Also see <i>object</i> .
subsystem	A major subdivision or component of an information system consisting of information, information technology, and personnel that performs one or more specific functions.
supplier	Organization or individual that enters into an agreement with the acquirer or integrator for the supply of a product or service. This includes all suppliers in the supply chain, developers or manufacturers of systems, system components, or system services; systems integrators; vendors; product resellers; and third party partners.
supply chain	Linked set of resources and processes between and among multiple tiers of organizations, each of which is an acquirer, that begins with the sourcing of products and services and extends through their life cycle.

supply chain element	Organizations, entities, or tools employed for the research and development, design, manufacturing, acquisition, delivery, integration, operations and maintenance, and disposal of systems and system components.
supply chain risk	The potential for harm or compromise that arises as a result of security risks from suppliers, their supply chains, and their products or services. Supply chain risks include exposures, threats, and vulnerabilities associated with the products and services traversing the supply chain as well as the exposures, threats, and vulnerabilities to the supply chain.
supply chain risk assessment	A systematic examination of supply chain risks, likelihoods of their occurrence, and potential impacts.
supply chain risk management	A systematic process for managing cyber supply chain risk exposures, threats, and vulnerabilities throughout the supply chain and developing risk response strategies to the risks presented by the supplier, the supplied products and services, or the supply chain.
system [CNSSI 4009]	<p>Any organized assembly of resources and procedures united and regulated by interaction or interdependence to accomplish a set of specific functions.</p> <p><i>Note:</i> Systems also include specialized systems such as industrial control systems, telephone switching and private branch exchange (PBX) systems, and environmental control systems.</p>
[ISO 15288]	<p>Combination of interacting elements organized to achieve one or more stated purposes.</p> <p><i>Note 1:</i> There are many types of systems. Examples include: general and special-purpose information systems; command, control, and communication systems; crypto modules; central processing unit and graphics processor boards; industrial control systems; flight control systems; weapons, targeting, and fire control systems; medical devices and treatment systems; financial, banking, and merchandising transaction systems; and social networking systems.</p> <p><i>Note 2:</i> The interacting elements in the definition of system include hardware, software, data, humans, processes, facilities, materials, and naturally occurring physical entities.</p> <p><i>Note 3:</i> System-of-systems is included in the definition of system.</p>
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 of records [USC 552]	A group of any records under the control of any agency from which information is retrieved by the name of the individual or by some identifying number, symbol, or other identifying particular assigned to the individual.
system of records notice [OMB A-108]	The notice(s) published by an agency in the <i>Federal Register</i> upon the establishment and/or modification of a system of records describing the existence and character of the system.

system owner (or program manager)	Official responsible for the overall procurement, development, integration, modification, operation, and maintenance of a system.
system security officer [SP 800-37]	Individual with assigned responsibility for maintaining the appropriate operational security posture for a system or program.
system security plan	See <i>security plan</i> .
system service	A capability provided by a system that facilitates information processing, storage, or transmission.
system-related security risk [SP 800-30]	Risk that arises through the loss of confidentiality, integrity, or availability of information or systems and that considers impacts to the organization (including assets, mission, functions, image, or reputation), individuals, other organizations, and the Nation. See <i>risk</i> .
system-specific control [OMB A-130]	A security or privacy control for an information system that is implemented at the system level and is not inherited by any other information system.
systems engineering [SP 800-160-1]	An engineering discipline whose responsibility is creating and executing an interdisciplinary process to ensure that the customer and all other stakeholder needs are satisfied in a high-quality, trustworthy, cost-efficient, and schedule-compliant manner throughout a system's entire life cycle.
systems security engineering [SP 800-160-1]	A specialty engineering field strongly related to systems engineering. It applies scientific, engineering, and information assurance principles to deliver trustworthy systems that satisfy stakeholder requirements within their established risk tolerance.
tailored control baseline	A set of controls that result from the application of tailoring guidance to a control baseline. See <i>tailoring</i> .
tailoring	The process by which security control baselines are modified by identifying and designating common controls, applying scoping considerations on the applicability and implementation of baseline controls, selecting compensating security controls, assigning specific values to organization-defined security control parameters, supplementing baselines with additional security controls or control enhancements, and providing additional specification information for control implementation.
tampering [CNSSI 4009]	An intentional but unauthorized act resulting in the modification of a system, components of systems, its intended behavior, or data.

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 assessment [CNSSI 4009]	Formal description and evaluation of threat to an information system.
threat modeling [SP 800-154]	A form of risk assessment that models aspects of the attack and defense sides of a logical entity, such as a piece of data, an application, a host, a system, or an environment.
threat source [FIPS 200]	The intent and method targeted at the intentional exploitation of a vulnerability or a situation and method that may accidentally trigger a vulnerability. See <i>threat agent</i> .
transmission [CNSSI 4009]	The state that exists when information is being electronically sent from one location to one or more other locations.
trusted path	A mechanism by which a user (through an input device) can communicate directly with the security functions of the system with the necessary confidence to support the system security policy. This mechanism can only be activated by the user or the security functions of the system and cannot be imitated by untrusted software.
trustworthiness [CNSSI 4009]	The attribute of a person or enterprise that provides confidence to others of the qualifications, capabilities, and reliability of that entity to perform specific tasks and fulfill assigned responsibilities.
trustworthiness (system)	The degree to which an information system (including the information technology components that are used to build the system) can be expected to preserve the confidentiality, integrity, and availability of the information being processed, stored, or transmitted by the system across the full range of threats. A trustworthy information system is believed to operate within defined levels of risk despite the environmental disruptions, human errors, structural failures, and purposeful attacks that are expected to occur in its environment of operation.
user	Individual, or (system) process acting on behalf of an individual, authorized to access a system. See <i>organizational user</i> and <i>non-organizational user</i> .
virtual private network [CNSSI 4009]	Protected information system link utilizing tunneling, security controls, and endpoint address translation giving the impression of a dedicated line.

vulnerability [SP 800-30]	Weakness in an information system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat source.
vulnerability analysis	See <i>vulnerability assessment</i> .
vulnerability assessment [CNSSI 4009]	Systematic examination of an information system or product to determine the adequacy of security measures, identify security deficiencies, provide data from which to predict the effectiveness of proposed security measures, and confirm the adequacy of such measures after implementation.

APPENDIX B

ACRONYMS

COMMON ABBREVIATIONS

ABAC	Attribute-Based Access Control
API	Application Programming Interface
APT	Advanced Persistent Threat
BGP	Border Gateway Protocol
BIOS	Basic Input/Output System
CA	Certificate Authority/Certificate Authorities
CAC	Common Access Card
CAVP	Cryptographic Algorithm Validation Program
CD	Compact Disc
CD-R	Compact Disc-Recordable
CIPSEA	Confidential Information Protection and Statistical Efficiency Act
CIRT	Computer Incident Response Team
CISA	Cybersecurity and Infrastructure Security Agency
CMVP	Cryptographic Module Validation Program
CNSSD	Committee on National Security Systems Directive
CNSSI	Committee on National Security Systems Instruction
CNSSP	Committee on National Security Systems Policy
CONOPS	Concept of Operations
CUI	Controlled Unclassified Information
CVE	Common Vulnerabilities and Exposures
CVSS	Common Vulnerability Scoring System
CWE	Common Weakness Enumeration
DHCP	Dynamic Host Configuration Protocol
DMZ	Demilitarized Zone
DNS	Domain Name System
DNSSEC	Domain Name System Security Extensions
DoD	Department of Defense
DSB	Defense Science Board
DVD	Digital Versatile Disc

DVD-R	Digital Versatile Disc-Recordable
EAP	Extensible Authentication Protocol
EMP	Electromagnetic Pulse
EMSEC	Emissions Security
FASC	Federal Acquisition Security Council
FBCA	Federal Bridge Certification Authority
FCC	Federal Communications Commission
FICAM	Federal Identity, Credential, and Access Management
FIPPs	Fair Information Practice Principles
FIPS	Federal Information Processing Standards
FISMA	Federal Information Security Modernization Act
FOCI	Foreign Ownership, Control, or Influence
FOIA	Freedom of Information Act
FTP	File Transfer Protocol
GMT	Greenwich Mean Time
GPS	Global Positioning System
GSA	General Services Administration
HSPD	Homeland Security Presidential Directive
HTTP	Hypertext Transfer Protocol
ICS	Industrial Control System
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
IOC	Indicators of Compromise
IoT	Internet of Things
IP	Internet Protocol
IR	Interagency Report or Internal Report
ISAC	Information Sharing and Analysis Centers
ISAO	Information Sharing and Analysis Organizations
IT	Information Technology
ITL	Information Technology Laboratory
MAC	Media Access Control
MLS	Multilevel Secure
MTTF	Mean Time To Failure

NARA	National Archives and Records Administration
NATO	North Atlantic Treaty Organization
NDA	Non-Disclosure Agreement
NIAP	National Information Assurance Partnership
NICE	National Initiative for Cybersecurity Education
NIST	National Institute of Standards and Technology
NOFORN	Not Releasable to Foreign Nationals
NSA	National Security Agency
NVD	National Vulnerability Database
ODNI	Office of the Director of National Intelligence
OMB	Office of Management and Budget
OPM	Office of Personnel Management
OPSEC	Operation Security
OVAL	Open Vulnerability and Assessment Language
PDF	Portable Document Format
PDS	Position Designation System
PII	Personally Identifiable Information
PIN	Personal Identification Number
PIV	Personal Identity Verification
PIV-I	Personal Identity Verification-Interoperable
PKI	Public Key Infrastructure
RBAC	Role-Based Access Control
RD	Restricted Data
RFID	Radio-Frequency Identification
RFP	Request For Proposal
RPKI	Resource Public Key Infrastructure
SAP	Special Access Program
SCAP	Security Content Automation Protocol
SCI	Sensitive Compartmented Information
SCIF	Sensitive Compartmented Information Facility
SCRM	Supply Chain Risk Management
SDLC	System Development Life Cycle
SIEM	Security Information and Event Management

SME	Subject Matter Expert
SMTP	Simple Mail Transfer Protocol
SOC	Security Operations Center
SP	Special Publication
STIG	Security Technical Implementation Guide
SWID	Software Identification
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TIC	Trusted Internet Connections
TLS	Transport Layer Security
TPM	Trusted Platform Module
TSP	Telecommunications Service Priority
UEFI	Unified Extensible Firmware Interface
UPS	Uninterruptible Power Supply
USGCB	United States Government Configuration Baseline
USB	Universal Serial Bus
UTC	Coordinated Universal Time
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WORM	Write-Once, Read-Many
XML	Extensible Markup Language

APPENDIX C

CONTROL SUMMARIES

IMPLEMENTATION, WITHDRAWAL, AND ASSURANCE DESIGNATIONS

Tables C-1 through C-20 provide a summary of the security and privacy controls and control enhancements in [Chapter Three](#). Each table focuses on a different control family.

- A control or control enhancement that has been withdrawn from the control catalog is indicated by a “W” and an explanation of the control or control enhancement disposition in light gray text.
- A control or control enhancement that is typically implemented by an information system through technical means is indicated by an “S” in the *implemented by* column.
- A control or control enhancement that is typically implemented by an organization (i.e., by an individual through nontechnical means) is indicated by an “O” in the *implemented by* column.³⁵
- A control or control enhancement that can be implemented by an organization, a system, or a combination of the two is indicated by an “O/S.”
- A control or control enhancement marked with a “v” in the *assurance* column indicates the control or control enhancement contributes to the grounds for confidence that a security or privacy claim has been or will be achieved.³⁶

Each control and control enhancement in Tables C-1 through C-20 is hyperlinked to the text for that control and control enhancement in [Chapter Three](#).

Families of controls contain base controls and control enhancements, which are directly related to their base controls. Control enhancements either add functionality or specificity to a base control or increase the strength of a base control. In both cases, control enhancements are used in systems and environments of operation that require greater protection than provided by the base control. This increased protection is required due to the potential adverse organizational or individual impacts or when organizations require additions to the base control functionality or assurance based on organizational assessments of risk. The use of control enhancements **always** requires the use of the base control.

The families are arranged in alphabetical order, while the controls and control enhancements within each family are arranged in numerical order. The alphabetical or numerical order of the families, controls, and control enhancements does **not** imply any type of prioritization, level of importance, or order in which the controls or control enhancements are to be implemented.

³⁵ The indication that a certain control or control enhancement is implemented by a *system* or by an *organization* in Tables C-1 through C-20 is notional. Organizations have the flexibility to implement their selected controls and control enhancements in the most cost-effective and efficient manner while simultaneously complying with the intent of the controls or control enhancements. In certain situations, a control or control enhancement may be implemented by the system, the organization, or a combination of the two entities.

³⁶ Assurance is a critical aspect in determining the trustworthiness of systems. Assurance is the measure of confidence that the security and privacy functions, features, practices, policies, procedures, mechanisms, and architecture of organizational systems accurately mediate and enforce established security and privacy policies.

TABLE C-1: ACCESS CONTROL FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
AC-1	Policy and Procedures	O	✓
AC-2	Account Management	O	
AC-2(1)	AUTOMATED SYSTEM ACCOUNT MANAGEMENT	O	
AC-2(2)	AUTOMATED TEMPORARY AND EMERGENCY ACCOUNT MANAGEMENT	S	
AC-2(3)	DISABLE ACCOUNTS	S	
AC-2(4)	AUTOMATED AUDIT ACTIONS	S	
AC-2(5)	INACTIVITY LOGOUT	O/S	
AC-2(6)	DYNAMIC PRIVILEGE MANAGEMENT	S	
AC-2(7)	PRIVILEGED USER ACCOUNTS	O	
AC-2(8)	DYNAMIC ACCOUNT MANAGEMENT	S	
AC-2(9)	RESTRICTIONS ON USE OF SHARED AND GROUP ACCOUNTS	O	
AC-2(10)	SHARED AND GROUP ACCOUNT CREDENTIAL CHANGE	W: Incorporated into AC-2k.	
AC-2(11)	USAGE CONDITIONS	S	
AC-2(12)	ACCOUNT MONITORING FOR ATYPICAL USAGE	O/S	
AC-2(13)	DISABLE ACCOUNTS FOR HIGH-RISK INDIVIDUALS	O	
AC-3	Access Enforcement	S	
AC-3(1)	RESTRICTED ACCESS TO PRIVILEGED FUNCTIONS	W: Incorporated into AC-6.	
AC-3(2)	DUAL AUTHORIZATION	S	
AC-3(3)	MANDATORY ACCESS CONTROL	S	
AC-3(4)	DISCRETIONARY ACCESS CONTROL	S	
AC-3(5)	SECURITY-RELEVANT INFORMATION	S	
AC-3(6)	PROTECTION OF USER AND SYSTEM INFORMATION	W: Incorporated into MP-4 and SC-28.	
AC-3(7)	ROLE-BASED ACCESS CONTROL	O/S	
AC-3(8)	REVOCATION OF ACCESS AUTHORIZATIONS	O/S	
AC-3(9)	CONTROLLED RELEASE	O/S	
AC-3(10)	AUDITED OVERRIDE OF ACCESS CONTROL MECHANISMS	O	
AC-3(11)	RESTRICT ACCESS TO SPECIFIC INFORMATION TYPES	S	
AC-3(12)	ASSERT AND ENFORCE APPLICATION ACCESS	S	
AC-3(13)	ATTRIBUTE-BASED ACCESS CONTROL	S	
AC-3(14)	INDIVIDUAL ACCESS	S	
AC-3(15)	DISCRETIONARY AND MANDATORY ACCESS CONTROL	S	
AC-4	Information Flow Enforcement	S	
AC-4(1)	OBJECT SECURITY AND PRIVACY ATTRIBUTES	S	
AC-4(2)	PROCESSING DOMAINS	S	
AC-4(3)	DYNAMIC INFORMATION FLOW CONTROL	S	
AC-4(4)	FLOW CONTROL OF ENCRYPTED INFORMATION	S	
AC-4(5)	EMBEDDED DATA TYPES	S	
AC-4(6)	METADATA	S	
AC-4(7)	ONE-WAY FLOW MECHANISMS	S	
AC-4(8)	SECURITY AND PRIVACY POLICY FILTERS	S	
AC-4(9)	HUMAN REVIEWS	O/S	
AC-4(10)	ENABLE AND DISABLE SECURITY OR PRIVACY POLICY FILTERS	S	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
AC-4(11)	CONFIGURATION OF SECURITY OR PRIVACY POLICY FILTERS	S	
AC-4(12)	DATA TYPE IDENTIFIERS	S	
AC-4(13)	DECOMPOSITION INTO POLICY-RELEVANT SUBCOMPONENTS	S	
AC-4(14)	SECURITY OR PRIVACY POLICY FILTER CONSTRAINTS	S	
AC-4(15)	DETECTION OF UNSANCTIONED INFORMATION	S	
AC-4(16)	INFORMATION TRANSFERS ON INTERCONNECTED SYSTEMS	W: Incorporated into AC-4.	
AC-4(17)	DOMAIN AUTHENTICATION	S	
AC-4(18)	SECURITY ATTRIBUTE BINDING	W: Incorporated into AC-16.	
AC-4(19)	VALIDATION OF METADATA	S	
AC-4(20)	APPROVED SOLUTIONS	O	
AC-4(21)	PHYSICAL OR LOGICAL SEPARATION OF INFORMATION FLOWS	O/S	
AC-4(22)	ACCESS ONLY	S	
AC-4(23)	MODIFY NON-RELEASEABLE INFORMATION	O/S	
AC-4(24)	INTERNAL NORMALIZED FORMAT	S	
AC-4(25)	DATA SANITIZATION	S	
AC-4(26)	AUDIT FILTERING ACTIONS	O/S	
AC-4(27)	REDUNDANT/INDEPENDENT FILTERING MECHANISMS	S	
AC-4(28)	LINEAR FILTER PIPELINES	S	
AC-4(29)	FILTER ORCHESTRATION ENGINES	O/S	
AC-4(30)	FILTER MECHANISMS USING MULTIPLE PROCESSES	S	
AC-4(31)	FAILED CONTENT TRANSFER PREVENTION	S	
AC-4(32)	PROCESS REQUIREMENTS FOR INFORMATION TRANSFER	S	
AC-5	Separation of Duties	O	
AC-6	Least Privilege	O	
AC-6(1)	AUTHORIZE ACCESS TO SECURITY FUNCTIONS	O	
AC-6(2)	NON-PRIVILEGED ACCESS FOR NONSECURITY FUNCTIONS	O	
AC-6(3)	NETWORK ACCESS TO PRIVILEGED COMMANDS	O	
AC-6(4)	SEPARATE PROCESSING DOMAINS	O/S	
AC-6(5)	PRIVILEGED ACCOUNTS	O	
AC-6(6)	PRIVILEGED ACCESS BY NON-ORGANIZATIONAL USERS	O	
AC-6(7)	REVIEW OF USER PRIVILEGES	O	
AC-6(8)	PRIVILEGE LEVELS FOR CODE EXECUTION	S	
AC-6(9)	LOG USE OF PRIVILEGED FUNCTIONS	S	
AC-6(10)	PROHIBIT NON-PRIVILEGED USERS FROM EXECUTING PRIVILEGED FUNCTIONS	S	
AC-7	Unsuccessful Logon Attempts	S	
AC-7(1)	AUTOMATIC ACCOUNT LOCK	W: Incorporated into AC-7.	
AC-7(2)	PURGE OR WIPE MOBILE DEVICE	S	
AC-7(3)	BIOMETRIC ATTEMPT LIMITING	O	
AC-7(4)	USE OF ALTERNATE AUTHENTICATION FACTOR	O/S	
AC-8	System Use Notification	O/S	
AC-9	Previous Logon Notification	S	
AC-9(1)	UNSUCCESSFUL LOGONS	S	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>AC-9(2)</u>	SUCCESSFUL AND UNSUCCESSFUL LOGONS	S	
<u>AC-9(3)</u>	NOTIFICATION OF ACCOUNT CHANGES	S	
<u>AC-9(4)</u>	ADDITIONAL LOGON INFORMATION	S	
<u>AC-10</u>	Concurrent Session Control	S	
<u>AC-11</u>	Device Lock	S	
<u>AC-11(1)</u>	PATTERN-HIDING DISPLAYS	S	
<u>AC-12</u>	Session Termination	S	
<u>AC-12(1)</u>	USER-INITIATED LOGOUTS	o/s	
<u>AC-12(2)</u>	TERMINATION MESSAGE	S	
<u>AC-12(3)</u>	TIMEOUT WARNING MESSAGE	S	
<u>AC-13</u>	Supervision and Review-Access Control	W: Incorporated into AC-2 and AU-6.	
<u>AC-14</u>	Permitted Actions without Identification or Authentication	O	
<u>AC-14(1)</u>	NECESSARY USES	W: Incorporated into AC-14.	
<u>AC-15</u>	Automated Marking	W: Incorporated into MP-3.	
<u>AC-16</u>	Security and Privacy Attributes	O	
<u>AC-16(1)</u>	DYNAMIC ATTRIBUTE ASSOCIATION	S	
<u>AC-16(2)</u>	ATTRIBUTE VALUE CHANGES BY AUTHORIZED INDIVIDUALS	S	
<u>AC-16(3)</u>	MAINTENANCE OF ATTRIBUTE ASSOCIATIONS BY SYSTEM	S	
<u>AC-16(4)</u>	ASSOCIATION OF ATTRIBUTES BY AUTHORIZED INDIVIDUALS	S	
<u>AC-16(5)</u>	ATTRIBUTE DISPLAYS ON OBJECTS TO BE OUTPUT	S	
<u>AC-16(6)</u>	MAINTENANCE OF ATTRIBUTE ASSOCIATION	O	
<u>AC-16(7)</u>	CONSISTENT ATTRIBUTE INTERPRETATION	O	
<u>AC-16(8)</u>	ASSOCIATION TECHNIQUES AND TECHNOLOGIES	S	
<u>AC-16(9)</u>	ATTRIBUTE REASSIGNMENT — REGARDING MECHANISMS	O	
<u>AC-16(10)</u>	ATTRIBUTE CONFIGURATION BY AUTHORIZED INDIVIDUALS	O	
<u>AC-17</u>	Remote Access	O	
<u>AC-17(1)</u>	MONITORING AND CONTROL	o/s	
<u>AC-17(2)</u>	PROTECTION OF CONFIDENTIALITY AND INTEGRITY USING ENCRYPTION	S	
<u>AC-17(3)</u>	MANAGED ACCESS CONTROL POINTS	S	
<u>AC-17(4)</u>	PRIVILEGED COMMANDS AND ACCESS	O	
<u>AC-17(5)</u>	MONITORING FOR UNAUTHORIZED CONNECTIONS	W: Incorporated into SI-4.	
<u>AC-17(6)</u>	PROTECTION OF MECHANISM INFORMATION	O	
<u>AC-17(7)</u>	ADDITIONAL PROTECTION FOR SECURITY FUNCTION ACCESS	W: Incorporated into AC-3(10).	
<u>AC-17(8)</u>	DISABLE NONSECURE NETWORK PROTOCOLS	W: Incorporated into CM-7.	
<u>AC-17(9)</u>	DISCONNECT OR DISABLE ACCESS	O	
<u>AC-17(10)</u>	AUTHENTICATE REMOTE COMMANDS	S	
<u>AC-18</u>	Wireless Access	O	
<u>AC-18(1)</u>	AUTHENTICATION AND ENCRYPTION	S	
<u>AC-18(2)</u>	MONITORING UNAUTHORIZED CONNECTIONS	W: Incorporated into SI-4.	
<u>AC-18(3)</u>	DISABLE WIRELESS NETWORKING	o/s	
<u>AC-18(4)</u>	RESTRICT CONFIGURATIONS BY USERS	O	
<u>AC-18(5)</u>	ANTENNAS AND TRANSMISSION POWER LEVELS	O	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>AC-19</u>	Access Control for Mobile Devices	O	
AC-19(1)	USE OF WRITABLE AND PORTABLE STORAGE DEVICES	W: Incorporated into MP-7.	
AC-19(2)	USE OF PERSONALLY OWNED PORTABLE STORAGE DEVICES	W: Incorporated into MP-7.	
AC-19(3)	USE OF PORTABLE STORAGE DEVICES WITH NO IDENTIFIABLE OWNER	W: Incorporated into MP-7.	
<u>AC-19(4)</u>	RESTRICTIONS FOR CLASSIFIED INFORMATION	O	
<u>AC-19(5)</u>	FULL DEVICE OR CONTAINER-BASED ENCRYPTION	O	
<u>AC-20</u>	Use of External Systems	O	
<u>AC-20(1)</u>	LIMITS ON AUTHORIZED USE	O	
<u>AC-20(2)</u>	PORTABLE STORAGE DEVICES — RESTRICTED USE	O	
<u>AC-20(3)</u>	NON-ORGANIZATIONALLY OWNED SYSTEMS — RESTRICTED USE	O	
<u>AC-20(4)</u>	NETWORK ACCESSIBLE STORAGE DEVICES — PROHIBITED USE	O	
<u>AC-20(5)</u>	PORTABLE STORAGE DEVICES — PROHIBITED USE	O	
<u>AC-21</u>	Information Sharing	O	
<u>AC-21(1)</u>	AUTOMATED DECISION SUPPORT	S	
<u>AC-21(2)</u>	INFORMATION SEARCH AND RETRIEVAL	S	
<u>AC-22</u>	Publicly Accessible Content	O	
<u>AC-23</u>	Data Mining Protection	O	
<u>AC-24</u>	Access Control Decisions	O	
<u>AC-24(1)</u>	TRANSMIT ACCESS AUTHORIZATION INFORMATION	S	
<u>AC-24(2)</u>	NO USER OR PROCESS IDENTITY	S	
<u>AC-25</u>	Reference Monitor	S	V

TABLE C-2: AWARENESS AND TRAINING FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>AT-1</u>	Policy and Procedures	O	✓
<u>AT-2</u>	Literacy Training and Awareness	O	✓
<u>AT-2(1)</u>	PRACTICAL EXERCISES	O	✓
<u>AT-2(2)</u>	INSIDER THREAT	O	✓
<u>AT-2(3)</u>	SOCIAL ENGINEERING AND MINING	O	✓
<u>AT-2(4)</u>	SUSPICIOUS COMMUNICATIONS AND ANOMALOUS SYSTEM BEHAVIOR	O	✓
<u>AT-2(5)</u>	ADVANCED PERSISTENT THREAT	O	✓
<u>AT-2(6)</u>	CYBER THREAT ENVIRONMENT	O	✓
<u>AT-3</u>	Role-Based Training	O	✓
<u>AT-3(1)</u>	ENVIRONMENTAL CONTROLS	O	✓
<u>AT-3(2)</u>	PHYSICAL SECURITY CONTROLS	O	✓
<u>AT-3(3)</u>	PRACTICAL EXERCISES	O	✓
<u>AT-3(4)</u>	SUSPICIOUS COMMUNICATIONS AND ANOMALOUS SYSTEM BEHAVIOR	W: Incorporated into AT-2(4).	
<u>AT-3(5)</u>	PROCESSING PERSONALLY IDENTIFIABLE INFORMATION	O	✓
<u>AT-4</u>	Training Records	O	✓
<u>AT-5</u>	Contacts with Security Groups and Associations	W: Incorporated into PM-15.	
<u>AT-6</u>	Training Feedback	O	✓

TABLE C-3: AUDIT AND ACCOUNTABILITY FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>AU-1</u>	Policy and Procedures	O	✓
<u>AU-2</u>	Event Logging	O	
AU-2(1)	COMPIRATION OF AUDIT RECORDS FROM MULTIPLE SOURCES	W: Incorporated into AU-12.	
AU-2(2)	SELECTION OF AUDIT EVENTS BY COMPONENT	W: Incorporated into AU-12.	
AU-2(3)	REVIEWS AND UPDATES	W: Incorporated into AU-2.	
AU-2(4)	PRIVILEGED FUNCTIONS	W: Incorporated into AC-6(9).	
<u>AU-3</u>	Content of Audit Records	S	
<u>AU-3(1)</u>	ADDITIONAL AUDIT INFORMATION	S	
AU-3(2)	CENTRALIZED MANAGEMENT OF PLANNED AUDIT RECORD CONTENT	W: Incorporated into PL-9.	
<u>AU-3(3)</u>	LIMIT PERSONALLY IDENTIFIABLE INFORMATION ELEMENTS	O	
<u>AU-4</u>	Audit Log Storage Capacity	O/S	
<u>AU-4(1)</u>	TRANSFER TO ALTERNATE STORAGE	O/S	
<u>AU-5</u>	Response to Audit Logging Process Failures	S	
<u>AU-5(1)</u>	STORAGE CAPACITY WARNING	S	
<u>AU-5(2)</u>	REAL-TIME ALERTS	S	
<u>AU-5(3)</u>	CONFIGURABLE TRAFFIC VOLUME THRESHOLDS	S	
<u>AU-5(4)</u>	SHUTDOWN ON FAILURE	S	
<u>AU-5(5)</u>	ALTERNATE AUDIT LOGGING CAPABILITY	O	
<u>AU-6</u>	Audit Record Review, Analysis, and Reporting	O	✓
<u>AU-6(1)</u>	AUTOMATED PROCESS INTEGRATION	O	✓
AU-6(2)	AUTOMATED SECURITY ALERTS	W: Incorporated into SI-4.	
<u>AU-6(3)</u>	CORRELATE AUDIT RECORD REPOSITORIES	O	✓
<u>AU-6(4)</u>	CENTRAL REVIEW AND ANALYSIS	S	✓
<u>AU-6(5)</u>	INTEGRATED ANALYSIS OF AUDIT RECORDS	O	✓
<u>AU-6(6)</u>	CORRELATION WITH PHYSICAL MONITORING	O	✓
<u>AU-6(7)</u>	PERMITTED ACTIONS	O	✓
<u>AU-6(8)</u>	FULL TEXT ANALYSIS OF PRIVILEGED COMMANDS	O	✓
<u>AU-6(9)</u>	CORRELATION WITH INFORMATION FROM NONTECHNICAL SOURCES	O	✓
AU-6(10)	AUDIT LEVEL ADJUSTMENT	W: Incorporated into AU-6.	
<u>AU-7</u>	Audit Record Reduction and Report Generation	S	✓
<u>AU-7(1)</u>	AUTOMATIC PROCESSING	S	✓
AU-7(2)	AUTOMATIC SORT AND SEARCH	W: Incorporated into AU-7(1).	
<u>AU-8</u>	Time Stamps	S	
AU-8(1)	SYNCHRONIZATION WITH AUTHORITATIVE TIME SOURCE	W: Moved to SC-45(1).	
AU-8(2)	SECONDARY AUTHORITATIVE TIME SOURCE	W: Moved to SC-45(2).	
<u>AU-9</u>	Protection of Audit Information	S	
<u>AU-9(1)</u>	HARDWARE WRITE-ONCE MEDIA	S	
<u>AU-9(2)</u>	STORE ON SEPARATE PHYSICAL SYSTEMS OR COMPONENTS	S	
<u>AU-9(3)</u>	CRYPTOGRAPHIC PROTECTION	S	
<u>AU-9(4)</u>	ACCESS BY SUBSET OF PRIVILEGED USERS	O	
<u>AU-9(5)</u>	DUAL AUTHORIZATION	O/S	
<u>AU-9(6)</u>	READ-ONLY ACCESS	O/S	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
AU-9(7)	STORE ON COMPONENT WITH DIFFERENT OPERATING SYSTEM	O	
AU-10	Non-repudiation	S	✓
AU-10(1)	ASSOCIATION OF IDENTITIES	S	✓
AU-10(2)	VALIDATE BINDING OF INFORMATION PRODUCER IDENTITY	S	✓
AU-10(3)	CHAIN OF CUSTODY	O/S	✓
AU-10(4)	VALIDATE BINDING OF INFORMATION REVIEWER IDENTITY	S	✓
AU-10(5)	DIGITAL SIGNATURES	W: Incorporated into SI-7.	
AU-11	Audit Record Retention	O	
AU-11(1)	LONG-TERM RETRIEVAL CAPABILITY	O	✓
AU-12	Audit Record Generation	S	
AU-12(1)	SYSTEM-WIDE AND TIME-CORRELATED AUDIT TRAIL	S	
AU-12(2)	STANDARDIZED FORMATS	S	
AU-12(3)	CHANGES BY AUTHORIZED INDIVIDUALS	S	
AU-12(4)	QUERY PARAMETER AUDITS OF PERSONALLY IDENTIFIABLE INFORMATION	S	
AU-13	Monitoring for Information Disclosure	O	✓
AU-13(1)	USE OF AUTOMATED TOOLS	O/S	✓
AU-13(2)	REVIEW OF MONITORED SITES	O	✓
AU-13(3)	UNAUTHORIZED REPLICATION OF INFORMATION	O/S	✓
AU-14	Session Audit	S	✓
AU-14(1)	SYSTEM START-UP	S	✓
AU-14(2)	CAPTURE AND RECORD CONTENT	W: Incorporated into AU-14.	
AU-14(3)	REMOTE VIEWING AND LISTENING	S	✓
AU-15	Alternate Audit Logging Capability	W: Moved to AU-5(5).	
AU-16	Cross-Organizational Audit Logging	O	
AU-16(1)	IDENTITY PRESERVATION	O	
AU-16(2)	SHARING OF AUDIT INFORMATION	O	
AU-16(3)	DISASSOCIABILITY	O	

TABLE C-4: ASSESSMENT, AUTHORIZATION, AND MONITORING FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
CA-1	Policy and Procedures	O	✓
CA-2	Control Assessments	O	✓
CA-2(1)	INDEPENDENT ASSESSORS	O	✓
CA-2(2)	SPECIALIZED ASSESSMENTS	O	✓
CA-2(3)	LEVERAGING RESULTS FROM EXTERNAL ORGANIZATIONS	O	✓
CA-3	Information Exchange	O	✓
CA-3(1)	UNCLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS	W: Moved to SC-7(25).	
CA-3(2)	CLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS	W: Moved to SC-7(26).	
CA-3(3)	UNCLASSIFIED NON-NATIONAL SECURITY SYSTEM CONNECTIONS	W: Moved to SC-7(27).	
CA-3(4)	CONNECTIONS TO PUBLIC NETWORKS	W: Moved to SC-7(28).	
CA-3(5)	RESTRICTIONS ON EXTERNAL SYSTEM CONNECTIONS	W: Incorporated into SC-7(5).	
CA-3(6)	TRANSFER AUTHORIZATIONS	O/S	✓
CA-3(7)	TRANSITIVE INFORMATION EXCHANGES	O/S	✓
CA-4	Security Certification	W: Incorporated into CA-2.	
CA-5	Plan of Action and Milestones	O	✓
CA-5(1)	AUTOMATION SUPPORT FOR ACCURACY AND CURRENCY	O	✓
CA-6	Authorization	O	✓
CA-6(1)	JOINT AUTHORIZATION — INTRA-ORGANIZATION	O	✓
CA-6(2)	JOINT AUTHORIZATION — INTER-ORGANIZATION	O	✓
CA-7	Continuous Monitoring	O	✓
CA-7(1)	INDEPENDENT ASSESSMENT	O	✓
CA-7(2)	TYPES OF ASSESSMENTS	W: Incorporated into CA-2.	
CA-7(3)	TREND ANALYSES	O	✓
CA-7(4)	RISK MONITORING	O/S	✓
CA-7(5)	CONSISTENCY ANALYSIS	O	✓
CA-7(6)	AUTOMATION SUPPORT FOR MONITORING	O/S	✓
CA-8	Penetration Testing	O	✓
CA-8(1)	INDEPENDENT PENETRATION TESTING AGENT OR TEAM	O	✓
CA-8(2)	RED TEAM EXERCISES	O	✓
CA-8(3)	FACILITY PENETRATION TESTING	O	✓
CA-9	Internal System Connections	O	✓
CA-9(1)	COMPLIANCE CHECKS	O/S	✓

TABLE C-5: CONFIGURATION MANAGEMENT FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>CM-1</u>	Policy and Procedures	O	✓
<u>CM-2</u>	Baseline Configuration	O	✓
<u>CM-2(1)</u>	REVIEWS AND UPDATES	W: Incorporated into CM-2.	
<u>CM-2(2)</u>	AUTOMATION SUPPORT FOR ACCURACY AND CURRENCY	O	✓
<u>CM-2(3)</u>	RETENTION OF PREVIOUS CONFIGURATIONS	O	✓
<u>CM-2(4)</u>	UNAUTHORIZED SOFTWARE	W: Incorporated into CM-7.	
<u>CM-2(5)</u>	AUTHORIZED SOFTWARE	W: Incorporated into CM-7.	
<u>CM-2(6)</u>	DEVELOPMENT AND TEST ENVIRONMENTS	O	✓
<u>CM-2(7)</u>	CONFIGURE SYSTEMS AND COMPONENTS FOR HIGH-RISK AREAS	O	✓
<u>CM-3</u>	Configuration Change Control	O	✓
<u>CM-3(1)</u>	AUTOMATED DOCUMENTATION, NOTIFICATION, AND PROHIBITION OF CHANGES	O	✓
<u>CM-3(2)</u>	TESTING, VALIDATION, AND DOCUMENTATION OF CHANGES	O	✓
<u>CM-3(3)</u>	AUTOMATED CHANGE IMPLEMENTATION	O	
<u>CM-3(4)</u>	SECURITY AND PRIVACY REPRESENTATIVES	O	
<u>CM-3(5)</u>	AUTOMATED SECURITY RESPONSE	S	
<u>CM-3(6)</u>	CRYPTOGRAPHY MANAGEMENT	O	
<u>CM-3(7)</u>	REVIEW SYSTEM CHANGES	O	
<u>CM-3(8)</u>	PREVENT OR RESTRICT CONFIGURATION CHANGES	S	
<u>CM-4</u>	Impact Analyses	O	✓
<u>CM-4(1)</u>	SEPARATE TEST ENVIRONMENTS	O	✓
<u>CM-4(2)</u>	VERIFICATION OF CONTROLS	O	✓
<u>CM-5</u>	Access Restrictions for Change	O	
<u>CM-5(1)</u>	AUTOMATED ACCESS ENFORCEMENT AND AUDIT RECORDS	S	
<u>CM-5(2)</u>	REVIEW SYSTEM CHANGES	W: Incorporated into CM-3(7).	
<u>CM-5(3)</u>	SIGNED COMPONENTS	W: Moved to CM-14.	
<u>CM-5(4)</u>	DUAL AUTHORIZATION	O/S	
<u>CM-5(5)</u>	PRIVILEGE LIMITATION FOR PRODUCTION AND OPERATION	O	
<u>CM-5(6)</u>	LIMIT LIBRARY PRIVILEGES	O/S	
<u>CM-5(7)</u>	AUTOMATIC IMPLEMENTATION OF SECURITY SAFEGUARDS	W: Incorporated into SI-7.	
<u>CM-6</u>	Configuration Settings	O/S	
<u>CM-6(1)</u>	AUTOMATED MANAGEMENT, APPLICATION, AND VERIFICATION	O	
<u>CM-6(2)</u>	RESPOND TO UNAUTHORIZED CHANGES	O	
<u>CM-6(3)</u>	UNAUTHORIZED CHANGE DETECTION	W: Incorporated into SI-7.	
<u>CM-6(4)</u>	CONFORMANCE DEMONSTRATION	W: Incorporated into CM-4.	
<u>CM-7</u>	Least Functionality	O/S	
<u>CM-7(1)</u>	PERIODIC REVIEW	O/S	
<u>CM-7(2)</u>	PREPARE PROGRAM EXECUTION	S	
<u>CM-7(3)</u>	REGISTRATION COMPLIANCE	O	
<u>CM-7(4)</u>	UNAUTHORIZED SOFTWARE — DENY-BY-EXCEPTION	O/S	
<u>CM-7(5)</u>	AUTHORIZED SOFTWARE — ALLOW-BY-EXCEPTION	O/S	
<u>CM-7(6)</u>	CONFINED ENVIRONMENTS WITH LIMITED PRIVILEGES	O	✓

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>CM-7(7)</u>	CODE EXECUTION IN PROTECTED ENVIRONMENTS	o/s	✓
<u>CM-7(8)</u>	BINARY OR MACHINE EXECUTABLE CODE	o/s	✓
<u>CM-7(9)</u>	PROHIBITING THE USE OF UNAUTHORIZED HARDWARE	o/s	✓
CM-8	System Component Inventory	o	✓
<u>CM-8(1)</u>	UPDATES DURING INSTALLATION AND REMOVAL	o	✓
<u>CM-8(2)</u>	AUTOMATED MAINTENANCE	o	✓
<u>CM-8(3)</u>	AUTOMATED UNAUTHORIZED COMPONENT DETECTION	o	✓
<u>CM-8(4)</u>	ACCOUNTABILITY INFORMATION	o	✓
<u>CM-8(5)</u>	NO DUPLICATE ACCOUNTING OF COMPONENTS	W: Incorporated into CM-8.	
<u>CM-8(6)</u>	ASSESSED CONFIGURATIONS AND APPROVED DEVIATIONS	o	✓
<u>CM-8(7)</u>	CENTRALIZED REPOSITORY	o	✓
<u>CM-8(8)</u>	AUTOMATED LOCATION TRACKING	o	✓
<u>CM-8(9)</u>	ASSIGNMENT OF COMPONENTS TO SYSTEMS	o	✓
CM-9	Configuration Management Plan	o	
<u>CM-9(1)</u>	ASSIGNMENT OF RESPONSIBILITY	o	
CM-10	Software Usage Restrictions	o	
<u>CM-10(1)</u>	OPEN-SOURCE SOFTWARE	o	
CM-11	User-Installed Software	o	
<u>CM-11(1)</u>	ALERTS FOR UNAUTHORIZED INSTALLATIONS	W: Incorporated into CM-8(3).	
<u>CM-11(2)</u>	SOFTWARE INSTALLATION WITH PRIVILEGED STATUS	s	
<u>CM-11(3)</u>	AUTOMATED ENFORCEMENT AND MONITORING	s	✓
CM-12	Information Location	o	✓
<u>CM-12(1)</u>	AUTOMATED TOOLS TO SUPPORT INFORMATION LOCATION	o	✓
CM-13	Data Action Mapping	o	
<u>CM-14</u>	Signed Components	o/s	✓

TABLE C-6: CONTINGENCY PLANNING FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
CP-1	Policy and Procedures	O	✓
CP-2	Contingency Plan	O	
CP-2(1)	COORDINATE WITH RELATED PLANS	O	
CP-2(2)	CAPACITY PLANNING	O	
CP-2(3)	RESUME MISSION AND BUSINESS FUNCTIONS	O	
CP-2(4)	RESUME ALL MISSION AND BUSINESS FUNCTIONS	W: Incorporated into CP-2(3).	
CP-2(5)	CONTINUE MISSION AND BUSINESS FUNCTIONS	O	
CP-2(6)	ALTERNATE PROCESSING AND STORAGE SITES	O	
CP-2(7)	COORDINATE WITH EXTERNAL SERVICE PROVIDERS	O	
CP-2(8)	IDENTIFY CRITICAL ASSETS	O	
CP-3	Contingency Training	O	✓
CP-3(1)	SIMULATED EVENTS	O	✓
CP-3(2)	MECHANISMS USED IN TRAINING ENVIRONMENTS	O	✓
CP-4	Contingency Plan Testing	O	✓
CP-4(1)	COORDINATE WITH RELATED PLANS	O	✓
CP-4(2)	ALTERNATE PROCESSING SITE	O	✓
CP-4(3)	AUTOMATED TESTING	O	✓
CP-4(4)	FULL RECOVERY AND RECONSTITUTION	O	✓
CP-4(5)	SELF-CHALLENGE	O/S	✓
CP-5	Contingency Plan Update	W: Incorporated into CP-2.	
CP-6	Alternate Storage Site	O	
CP-6(1)	SEPARATION FROM PRIMARY SITE	O	
CP-6(2)	RECOVERY TIME AND RECOVERY POINT OBJECTIVES	O	
CP-6(3)	ACCESSIBILITY	O	
CP-7	Alternate Processing Site	O	
CP-7(1)	SEPARATION FROM PRIMARY SITE	O	
CP-7(2)	ACCESSIBILITY	O	
CP-7(3)	PRIORITY OF SERVICE	O	
CP-7(4)	PREPARATION FOR USE	O	
CP-7(5)	EQUIVALENT INFORMATION SECURITY SAFEGUARDS	W: Incorporated into CP-7.	
CP-7(6)	INABILITY TO RETURN TO PRIMARY SITE	O	
CP-8	Telecommunications Services	O	
CP-8(1)	PRIORITY OF SERVICE PROVISIONS	O	
CP-8(2)	SINGLE POINTS OF FAILURE	O	
CP-8(3)	SEPARATION OF PRIMARY AND ALTERNATE PROVIDERS	O	
CP-8(4)	PROVIDER CONTINGENCY PLAN	O	
CP-8(5)	ALTERNATE TELECOMMUNICATION SERVICE TESTING	O	
CP-9	System Backup	O	
CP-9(1)	TESTING FOR RELIABILITY AND INTEGRITY	O	
CP-9(2)	TEST RESTORATION USING SAMPLING	O	
CP-9(3)	SEPARATE STORAGE FOR CRITICAL INFORMATION	O	
CP-9(4)	PROTECTION FROM UNAUTHORIZED MODIFICATION	W: Incorporated into CP-9.	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>CP-9(5)</u>	TRANSFER TO ALTERNATE STORAGE SITE	O	
<u>CP-9(6)</u>	REDUNDANT SECONDARY SYSTEM	O	
<u>CP-9(7)</u>	DUAL AUTHORIZATION FOR DELETION OR DESTRUCTION	O	
<u>CP-9(8)</u>	CRYPTOGRAPHIC PROTECTION	O	
<u>CP-10</u>	System Recovery and Reconstitution	O	
<u>CP-10(1)</u>	CONTINGENCY PLAN TESTING	W: Incorporated into CP-4.	
<u>CP-10(2)</u>	TRANSACTION RECOVERY	O	
<u>CP-10(3)</u>	COMPENSATING SECURITY CONTROLS	W: Addressed through tailoring.	
<u>CP-10(4)</u>	RESTORE WITHIN TIME PERIOD	O	
<u>CP-10(5)</u>	FAILOVER CAPABILITY	W: Incorporated into SI-13.	
<u>CP-10(6)</u>	COMPONENT PROTECTION	O	
<u>CP-11</u>	Alternate Communications Protocols	O	
<u>CP-12</u>	Safe Mode	S	✓
<u>CP-13</u>	Alternative Security Mechanisms	O/S	

TABLE C-7: IDENTIFICATION AND AUTHENTICATION FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
IA-1	Policy and Procedures	O	✓
IA-2	Identification and Authentication (Organizational Users)	O/S	
IA-2(1)	MULTI-FACTOR AUTHENTICATION TO PRIVILEGED ACCOUNTS	S	
IA-2(2)	MULTI-FACTOR AUTHENTICATION TO NON-PRIVILEGED ACCOUNTS	S	
IA-2(3)	LOCAL ACCESS TO PRIVILEGED ACCOUNTS	W: Incorporated into IA-2(1).	
IA-2(4)	LOCAL ACCESS TO NON-PRIVILEGED ACCOUNTS	W: Incorporated into IA-2(2).	
IA-2(5)	INDIVIDUAL AUTHENTICATION WITH GROUP AUTHENTICATION	O/S	
IA-2(6)	ACCESS TO ACCOUNTS — SEPARATE DEVICE	S	
IA-2(7)	NETWORK ACCESS TO NON-PRIVILEGED ACCOUNTS — SEPARATE DEVICE	W: Incorporated into IA-2(6).	
IA-2(8)	ACCESS TO ACCOUNTS — REPLAY RESISTANT	S	
IA-2(9)	NETWORK ACCESS TO NON-PRIVILEGED ACCOUNTS — REPLAY RESISTANT	W: Incorporated into IA-2(8).	
IA-2(10)	SINGLE SIGN-ON	S	
IA-2(11)	REMOTE ACCESS — SEPARATE DEVICE	W: Incorporated into IA-2(6).	
IA-2(12)	ACCEPTANCE OF PIV CREDENTIALS	S	
IA-2(13)	OUT-OF-BAND AUTHENTICATION	S	
IA-3	Device Identification and Authentication	S	
IA-3(1)	CRYPTOGRAPHIC BIDIRECTIONAL AUTHENTICATION	S	
IA-3(2)	CRYPTOGRAPHIC BIDIRECTIONAL NETWORK AUTHENTICATION	W: Incorporated into IA-3(1).	
IA-3(3)	DYNAMIC ADDRESS ALLOCATION	O	
IA-3(4)	DEVICE ATTESTATION	O	
IA-4	Identifier Management	O	
IA-4(1)	PROHIBIT ACCOUNT IDENTIFIERS AS PUBLIC IDENTIFIERS	O	
IA-4(2)	SUPERVISOR AUTHORIZATION	W: Incorporated into IA-12(1).	
IA-4(3)	MULTIPLE FORMS OF CERTIFICATION	W: Incorporated into IA-12(2).	
IA-4(4)	IDENTIFY USER STATUS	O	
IA-4(5)	DYNAMIC MANAGEMENT	S	
IA-4(6)	CROSS-ORGANIZATION MANAGEMENT	O	
IA-4(7)	IN-PERSON REGISTRATION	W: Incorporated into IA-12(4).	
IA-4(8)	PAIRWISE PSEUDONYMOUS IDENTIFIERS	O	
IA-4(9)	ATTRIBUTE MAINTENANCE AND PROTECTION	O/S	
IA-5	Authenticator Management	O/S	
IA-5(1)	PASSWORD-BASED AUTHENTICATION	O/S	
IA-5(2)	PUBLIC KEY-BASED AUTHENTICATION	S	
IA-5(3)	IN-PERSON OR TRUSTED EXTERNAL PARTY REGISTRATION	W: Incorporated into IA-12(4).	
IA-5(4)	AUTOMATED SUPPORT FOR PASSWORD STRENGTH DETERMINATION	W: Incorporated into IA-5(1).	
IA-5(5)	CHANGE AUTHENTICATORS PRIOR TO DELIVERY	O	
IA-5(6)	PROTECTION OF AUTHENTICATORS	O	
IA-5(7)	NO EMBEDDED UNENCRYPTED STATIC AUTHENTICATORS	O	
IA-5(8)	MULTIPLE SYSTEM ACCOUNTS	O	
IA-5(9)	FEDERATED CREDENTIAL MANAGEMENT	O	
IA-5(10)	DYNAMIC CREDENTIAL BINDING	S	
IA-5(11)	HARDWARE TOKEN-BASED AUTHENTICATION	W: Incorporated into IA-2(1) and IA-2(2).	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>IA-5(12)</u>	BIOMETRIC AUTHENTICATION PERFORMANCE	S	
<u>IA-5(13)</u>	EXPIRATION OF CACHED AUTHENTICATORS	S	
<u>IA-5(14)</u>	MANAGING CONTENT OF PKI TRUST STORES	O	
<u>IA-5(15)</u>	GSA-APPROVED PRODUCTS AND SERVICES	O	
<u>IA-5(16)</u>	IN-PERSON OR TRUSTED EXTERNAL PARTY AUTHENTICATOR ISSUANCE	O	
<u>IA-5(17)</u>	PRESENTATION ATTACK DETECTION FOR BIOMETRIC AUTHENTICATORS	S	
<u>IA-5(18)</u>	PASSWORD MANAGERS	S	
IA-6	Authentication Feedback	S	
IA-7	Cryptographic Module Authentication	S	
IA-8	Identification and Authentication (Non-Organizational Users)	S	
<u>IA-8(1)</u>	ACCEPTANCE OF PIV CREDENTIALS FROM OTHER AGENCIES	S	
<u>IA-8(2)</u>	ACCEPTANCE OF EXTERNAL AUTHENTICATORS	S	
<u>IA-8(3)</u>	USE OF FICAM-APPROVED PRODUCTS	W: Incorporated into IA-8(2).	
<u>IA-8(4)</u>	USE OF DEFINED PROFILES	S	
<u>IA-8(5)</u>	ACCEPTANCE OF PIV-I CREDENTIALS	S	
<u>IA-8(6)</u>	DISASSOCIABILITY	O	
IA-9	Service Identification and Authentication	O/S	
IA-9(1)	INFORMATION EXCHANGE	W: Incorporated into IA-9.	
IA-9(2)	TRANSMISSION OF DECISIONS	W: Incorporated into IA-9.	
<u>IA-10</u>	Adaptive Authentication	O	
<u>IA-11</u>	Re-authentication	O/S	
<u>IA-12</u>	Identity Proofing	O	
<u>IA-12(1)</u>	SUPERVISOR AUTHORIZATION	O	
<u>IA-12(2)</u>	IDENTITY EVIDENCE	O	
<u>IA-12(3)</u>	IDENTITY EVIDENCE VALIDATION AND VERIFICATION	O	
<u>IA-12(4)</u>	IN-PERSON VALIDATION AND VERIFICATION	O	
<u>IA-12(5)</u>	ADDRESS CONFIRMATION	O	
<u>IA-12(6)</u>	ACCEPT EXTERNALLY-PROOFED IDENTITIES	O	

TABLE C-8: INCIDENT RESPONSE FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
IR-1	Policy and Procedures	O	✓
IR-2	Incident Response Training	O	✓
IR-2(1)	SIMULATED EVENTS	O	✓
IR-2(2)	AUTOMATED TRAINING ENVIRONMENTS	O	✓
IR-2(3)	BREACH	O	✓
IR-3	Incident Response Testing	O	✓
IR-3(1)	AUTOMATED TESTING	O	✓
IR-3(2)	COORDINATION WITH RELATED PLANS	O	✓
IR-3(3)	CONTINUOUS IMPROVEMENT	O	✓
IR-4	Incident Handling	O	
IR-4(1)	AUTOMATED INCIDENT HANDLING PROCESSES	O	
IR-4(2)	DYNAMIC RECONFIGURATION	O	
IR-4(3)	CONTINUITY OF OPERATIONS	O	
IR-4(4)	INFORMATION CORRELATION	O	
IR-4(5)	AUTOMATIC DISABLING OF SYSTEM	O/S	
IR-4(6)	INSIDER THREATS	O	
IR-4(7)	INSIDER THREATS — INTRA-ORGANIZATION COORDINATION	O	
IR-4(8)	CORRELATION WITH EXTERNAL ORGANIZATIONS	O	
IR-4(9)	DYNAMIC RESPONSE CAPABILITY	O	
IR-4(10)	SUPPLY CHAIN COORDINATION	O	
IR-4(11)	INTEGRATED INCIDENT RESPONSE TEAM	O	
IR-4(12)	MALICIOUS CODE AND FORENSIC ANALYSIS	O	
IR-4(13)	BEHAVIOR ANALYSIS	O	
IR-4(14)	SECURITY OPERATIONS CENTER	O/S	
IR-4(15)	PUBLIC RELATIONS AND REPUTATION REPAIR	O	
IR-5	Incident Monitoring	O	✓
IR-5(1)	AUTOMATED TRACKING, DATA COLLECTION, AND ANALYSIS	O	✓
IR-6	Incident Reporting	O	
IR-6(1)	AUTOMATED REPORTING	O	
IR-6(2)	VULNERABILITIES RELATED TO INCIDENTS	O	
IR-6(3)	SUPPLY CHAIN COORDINATION	O	
IR-7	Incident Response Assistance	O	
IR-7(1)	AUTOMATION SUPPORT FOR AVAILABILITY OF INFORMATION AND SUPPORT	O	
IR-7(2)	COORDINATION WITH EXTERNAL PROVIDERS	O	
IR-8	Incident Response Plan	O	
IR-8(1)	BREACHES	O	
IR-9	Information Spillage Response	O	
IR-9(1)	RESPONSIBLE PERSONNEL	W: Incorporated into IR-9.	
IR-9(2)	TRAINING	O	
IR-9(3)	POST-SPILL OPERATIONS	O	
IR-9(4)	EXPOSURE TO UNAUTHORIZED PERSONNEL	O	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
IR-10	Integrated Information Security Analysis Team	W: Moved to IR-4(11).	

TABLE C-9: MAINTENANCE FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
MA-1	Policy and Procedures	O	✓
MA-2	Controlled Maintenance	O	
MA-2(1)	RECORD CONTENT	W: Incorporated into MA-2.	
MA-2(2)	AUTOMATED MAINTENANCE ACTIVITIES	O	
MA-3	Maintenance Tools	O	
MA-3(1)	INSPECT TOOLS	O	
MA-3(2)	INSPECT MEDIA	O	
MA-3(3)	PREVENT UNAUTHORIZED REMOVAL	O	
MA-3(4)	RESTRICTED TOOL USE	O/S	
MA-3(5)	EXECUTION WITH PRIVILEGE	O/S	
MA-3(6)	SOFTWARE UPDATES AND PATCHES	O/S	
MA-4	Nonlocal Maintenance	O	
MA-4(1)	LOGGING AND REVIEW	O	
MA-4(2)	DOCUMENT NONLOCAL MAINTENANCE	W: Incorporated into MA-1 and MA-4.	
MA-4(3)	COMPARABLE SECURITY AND SANITIZATION	O	
MA-4(4)	AUTHENTICATION AND SEPARATION OF MAINTENANCE SESSIONS	O	
MA-4(5)	APPROVALS AND NOTIFICATIONS	O	
MA-4(6)	CRYPTOGRAPHIC PROTECTION	O/S	
MA-4(7)	DISCONNECT VERIFICATION	S	
MA-5	Maintenance Personnel	O	
MA-5(1)	INDIVIDUALS WITHOUT APPROPRIATE ACCESS	O	
MA-5(2)	SECURITY CLEARANCES FOR CLASSIFIED SYSTEMS	O	
MA-5(3)	CITIZENSHIP REQUIREMENTS FOR CLASSIFIED SYSTEMS	O	
MA-5(4)	FOREIGN NATIONALS	O	
MA-5(5)	NON-SYSTEM MAINTENANCE	O	
MA-6	Timely Maintenance	O	
MA-6(1)	PREVENTIVE MAINTENANCE	O	
MA-6(2)	PREDICTIVE MAINTENANCE	O	
MA-6(3)	AUTOMATED SUPPORT FOR PREDICTIVE MAINTENANCE	O	
MA-7	Field Maintenance	O	

TABLE C-10: MEDIA PROTECTION FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>MP-1</u>	Policy and Procedures	O	✓
<u>MP-2</u>	Media Access	O	
MP-2(1)	AUTOMATED RESTRICTED ACCESS	W: Incorporated into MP-4(2).	
MP-2(2)	CRYPTOGRAPHIC PROTECTION	W: Incorporated into SC-28(1).	
<u>MP-3</u>	Media Marking	O	
<u>MP-4</u>	Media Storage	O	
MP-4(1)	CRYPTOGRAPHIC PROTECTION	W: Incorporated into SC-28(1).	
<u>MP-4(2)</u>	AUTOMATED RESTRICTED ACCESS	O	
<u>MP-5</u>	Media Transport	O	
MP-5(1)	PROTECTION OUTSIDE OF CONTROLLED AREAS	W: Incorporated into MP-5.	
MP-5(2)	DOCUMENTATION OF ACTIVITIES	W: Incorporated into MP-5.	
<u>MP-5(3)</u>	CUSTODIANS	O	
MP-5(4)	CRYPTOGRAPHIC PROTECTION	W: Incorporated into SC-28(1).	
<u>MP-6</u>	Media Sanitization	O	
<u>MP-6(1)</u>	REVIEW, APPROVE, TRACK, DOCUMENT, AND VERIFY	O	
<u>MP-6(2)</u>	EQUIPMENT TESTING	O	
<u>MP-6(3)</u>	NONDESTRUCTIVE TECHNIQUES	O	
MP-6(4)	CONTROLLED UNCLASSIFIED INFORMATION	W: Incorporated into MP-6.	
MP-6(5)	CLASSIFIED INFORMATION	W: Incorporated into MP-6.	
MP-6(6)	MEDIA DESTRUCTION	W: Incorporated into MP-6.	
<u>MP-6(7)</u>	DUAL AUTHORIZATION	O	
<u>MP-6(8)</u>	REMOTE PURGING OR WIPE OF INFORMATION	O	
<u>MP-7</u>	Media Use	O	
MP-7(1)	PROHIBIT USE WITHOUT OWNER	W: Incorporated into MP-7.	
<u>MP-7(2)</u>	PROHIBIT USE OF SANITIZATION-RESISTANT MEDIA	O	
<u>MP-8</u>	Media Downgrading	O	
<u>MP-8(1)</u>	DOCUMENTATION OF PROCESS	O	
<u>MP-8(2)</u>	EQUIPMENT TESTING	O	
<u>MP-8(3)</u>	CONTROLLED UNCLASSIFIED INFORMATION	O	
<u>MP-8(4)</u>	CLASSIFIED INFORMATION	O	

TABLE C-11: PHYSICAL AND ENVIRONMENTAL PROTECTION FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
PE-1	Policy and Procedures	O	✓
PE-2	Physical Access Authorizations	O	
PE-2(1)	ACCESS BY POSITION AND ROLE	O	
PE-2(2)	TWO FORMS OF IDENTIFICATION	O	
PE-2(3)	RESTRICT UNESCORTED ACCESS	O	
PE-3	Physical Access Control	O	
PE-3(1)	SYSTEM ACCESS	O	
PE-3(2)	FACILITY AND SYSTEMS	O	
PE-3(3)	CONTINUOUS GUARDS	O	
PE-3(4)	LOCKABLE CASINGS	O	
PE-3(5)	TAMPER PROTECTION	O	
PE-3(6)	FACILITY PENETRATION TESTING	W: Incorporated into CA-8.	
PE-3(7)	PHYSICAL BARRIERS	O	
PE-3(8)	ACCESS CONTROL VESTIBULES	O	
PE-4	Access Control for Transmission	O	
PE-5	Access Control for Output Devices	O	
PE-5(1)	ACCESS TO OUTPUT BY AUTHORIZED INDIVIDUALS	W: Incorporated into PE-5.	
PE-5(2)	LINK TO INDIVIDUAL IDENTITY	S	
PE-5(3)	MARKING OUTPUT DEVICES	W: Incorporated into PE-22.	
PE-6	Monitoring Physical Access	O	✓
PE-6(1)	INTRUSION ALARMS AND SURVEILLANCE EQUIPMENT	O	✓
PE-6(2)	AUTOMATED INTRUSION RECOGNITION AND RESPONSES	O	✓
PE-6(3)	VIDEO SURVEILLANCE	O	✓
PE-6(4)	MONITORING PHYSICAL ACCESS TO SYSTEMS	O	✓
PE-7	Visitor Control	W: Incorporated into PE-2 and PE-3.	
PE-8	Visitor Access Records	O	✓
PE-8(1)	AUTOMATED RECORDS MAINTENANCE AND REVIEW	O	
PE-8(2)	PHYSICAL ACCESS RECORDS	W: Incorporated into PE-2.	
PE-8(3)	LIMIT PERSONALLY IDENTIFIABLE INFORMATION ELEMENTS	O	
PE-9	Power Equipment and Cabling	O	
PE-9(1)	REDUNDANT CABLING	O	
PE-9(2)	AUTOMATIC VOLTAGE CONTROLS	O	
PE-10	Emergency Shutoff	O	
PE-10(1)	ACCIDENTAL AND UNAUTHORIZED ACTIVATION	W: Incorporated into PE-10.	
PE-11	Emergency Power	O	
PE-11(1)	ALTERNATE POWER SUPPLY — MINIMAL OPERATIONAL CAPABILITY	O	
PE-11(2)	ALTERNATE POWER SUPPLY — SELF-CONTAINED	O	
PE-12	Emergency Lighting	O	
PE-12(1)	ESSENTIAL MISSION AND BUSINESS FUNCTIONS	O	
PE-13	Fire Protection	O	
PE-13(1)	DETECTION SYSTEMS — AUTOMATIC ACTIVATION AND NOTIFICATION	O	
PE-13(2)	SUPPRESSION SYSTEMS — AUTOMATIC ACTIVATION AND NOTIFICATION	O	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
PE-13(3)	AUTOMATIC FIRE SUPPRESSION	W: Incorporated into PE-13(2).	
<u>PE-13(4)</u>	INSPECTIONS	O	
<u>PE-14</u>	Environmental Controls	O	
<u>PE-14(1)</u>	AUTOMATIC CONTROLS	O	
<u>PE-14(2)</u>	MONITORING WITH ALARMS AND NOTIFICATIONS	O	
<u>PE-15</u>	Water Damage Protection	O	
<u>PE-15(1)</u>	AUTOMATION SUPPORT	O	
<u>PE-16</u>	Delivery and Removal	O	
<u>PE-17</u>	Alternate Work Site	O	
<u>PE-18</u>	Location of System Components	O	
PE-18(1)	FACILITY SITE	W: Moved to PE-23.	
<u>PE-19</u>	Information Leakage	O	
<u>PE-19(1)</u>	NATIONAL EMISSIONS POLICIES AND PROCEDURES	O	
<u>PE-20</u>	Asset Monitoring and Tracking	O	
<u>PE-21</u>	Electromagnetic Pulse Protection	O	
<u>PE-22</u>	Component Marking	O	
<u>PE-23</u>	Facility Location	O	

TABLE C-12: PLANNING FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
PL-1	Policy and Procedures	O	✓
PL-2	System Security and Privacy Plans	O	✓
PL-2(1)	CONCEPT OF OPERATIONS	W: Incorporated into PL-7.	
PL-2(2)	FUNCTIONAL ARCHITECTURE	W: Incorporated into PL-8.	
PL-2(3)	PLAN AND COORDINATE WITH OTHER ORGANIZATIONAL ENTITIES	W: Incorporated into PL-2.	
PL-3	System Security Plan Update	W: Incorporated into PL-2.	
PL-4	Rules of Behavior	O	✓
PL-4(1)	SOCIAL MEDIA AND EXTERNAL SITE/APPLICATION USAGE RESTRICTIONS	O	✓
PL-5	Privacy Impact Assessment	W: Incorporated into RA-8.	
PL-6	Security-Related Activity Planning	W: Incorporated into PL-2.	
PL-7	Concept of Operations	O	
PL-8	Security and Privacy Architectures	O	✓
PL-8(1)	DEFENSE IN DEPTH	O	✓
PL-8(2)	SUPPLIER DIVERSITY	O	✓
PL-9	Central Management	O	✓
PL-10	Baseline Selection	O	
PL-11	Baseline Tailoring	O	

TABLE C-13: PROGRAM MANAGEMENT FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
PM-1	Information Security Program Plan	o	
PM-2	Information Security Program Leadership Role	o	
PM-3	Information Security and Privacy Resources	o	
PM-4	Plan of Action and Milestones Process	o	
PM-5	System Inventory	o	
PM-5(1)	INVENTORY OF PERSONALLY IDENTIFIABLE INFORMATION	o	
PM-6	Measures of Performance	o	✓
PM-7	Enterprise Architecture	o	
PM-7(1)	OFFLOADING	o	
PM-8	Critical Infrastructure Plan	o	
PM-9	Risk Management Strategy	o	✓
PM-10	Authorization Process	o	✓
PM-11	Mission and Business Process Definition	o	
PM-12	Insider Threat Program	o	✓
PM-13	Security and Privacy Workforce	o	
PM-14	Testing, Training, and Monitoring	o	✓
PM-15	Security and Privacy Groups and Associations	o	
PM-16	Threat Awareness Program	o	✓
PM-16(1)	AUTOMATED MEANS FOR SHARING THREAT INTELLIGENCE	o	✓
PM-17	Protecting Controlled Unclassified Information on External Systems	o	✓
PM-18	Privacy Program Plan	o	
PM-19	Privacy Program Leadership Role	o	
PM-20	Dissemination of Privacy Program Information	o	
PM-20(1)	PRIVACY POLICIES ON WEBSITES, APPLICATIONS, AND DIGITAL SERVICES	o	✓
PM-21	Accounting of Disclosures	o	
PM-22	Personally Identifiable Information Quality Management	o	✓
PM-23	Data Governance Body	o	✓
PM-24	Data Integrity Board	o	✓
PM-25	Minimization of Personally Identifiable Information Used in Testing, Training, and Research	o	
PM-26	Complaint Management	o	
PM-27	Privacy Reporting	o	
PM-28	Risk Framing	o	✓
PM-29	Risk Management Program Leadership Roles	o	
PM-30	Supply Chain Risk Management Strategy	o	✓
PM-30(1)	SUPPLIERS OF CRITICAL OR MISSION-ESSENTIAL ITEMS	o	✓
PM-31	Continuous Monitoring Strategy	o	
PM-32	Purposing	o	✓

TABLE C-14: PERSONNEL SECURITY FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>PS-1</u>	Policy and Procedures	o	✓
<u>PS-2</u>	Position Risk Designation	o	
<u>PS-3</u>	Personnel Screening	o	
<u>PS-3(1)</u>	CLASSIFIED INFORMATION	o	
<u>PS-3(2)</u>	FORMAL INDOCTRINATION	o	
<u>PS-3(3)</u>	INFORMATION REQUIRING SPECIAL PROTECTION MEASURES	o	
<u>PS-3(4)</u>	CITIZENSHIP REQUIREMENTS	o	
<u>PS-4</u>	Personnel Termination	o	
<u>PS-4(1)</u>	POST-EMPLOYMENT REQUIREMENTS	o	
<u>PS-4(2)</u>	AUTOMATED ACTIONS	o	
<u>PS-5</u>	Personnel Transfer	o	
<u>PS-6</u>	Access Agreements	o	✓
PS-6(1)	INFORMATION REQUIRING SPECIAL PROTECTION	W: Incorporated into PS-3.	
<u>PS-6(2)</u>	CLASSIFIED INFORMATION REQUIRING SPECIAL PROTECTION	o	✓
<u>PS-6(3)</u>	POST-EMPLOYMENT REQUIREMENTS	o	✓
<u>PS-7</u>	External Personnel Security	o	✓
<u>PS-8</u>	Personnel Sanctions	o	
<u>PS-9</u>	Position Descriptions	o	

TABLE C-15: PERSONALLY IDENTIFIABLE INFORMATION PROCESSING AND TRANSPARENCY FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>PT-1</u>	Policy and Procedures	O	✓
<u>PT-2</u>	Authority to Process Personally Identifiable Information	O	✓
<u>PT-2(1)</u>	DATA TAGGING	S	✓
<u>PT-2(2)</u>	AUTOMATION	O	✓
<u>PT-3</u>	Personally Identifiable Information Processing Purposes	O	
<u>PT-3(1)</u>	DATA TAGGING	S	✓
<u>PT-3(2)</u>	AUTOMATION	O	✓
<u>PT-4</u>	Consent	O	
<u>PT-4(1)</u>	TAILORED CONSENT	O	
<u>PT-4(2)</u>	JUST-IN-TIME CONSENT	O	
<u>PT-4(3)</u>	REVOCATION	O	
<u>PT-5</u>	Privacy Notice	O	
<u>PT-5(1)</u>	JUST-IN-TIME NOTICE	O	
<u>PT-5(2)</u>	PRIVACY ACT STATEMENTS	O	
<u>PT-6</u>	System of Records Notice	O	
<u>PT-6(1)</u>	ROUTINE USES	O	
<u>PT-6(2)</u>	EXEMPTION RULES	O	
<u>PT-7</u>	Specific Categories of Personally Identifiable Information	O	
<u>PT-7(1)</u>	SOCIAL SECURITY NUMBERS	O	
<u>PT-7(2)</u>	FIRST AMENDMENT INFORMATION	O	
<u>PT-8</u>	Computer Matching Requirements	O	

TABLE C-16: RISK ASSESSMENT FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
RA-1	Policy and Procedures	O	✓
RA-2	Security Categorization	O	
RA-2(1)	IMPACT-LEVEL PRIORITIZATION	O	
RA-3	Risk Assessment	O	✓
RA-3(1)	SUPPLY CHAIN RISK ASSESSMENT	O	✓
RA-3(2)	USE OF ALL-SOURCE INTELLIGENCE	O	✓
RA-3(3)	DYNAMIC THREAT AWARENESS	O	✓
RA-3(4)	PREDICTIVE CYBER ANALYTICS	O	✓
RA-4	Risk Assessment Update	W: Incorporated into RA-3.	
RA-5	Vulnerability Monitoring and Scanning	O	✓
RA-5(1)	UPDATE TOOL CAPABILITY	W: Incorporated into RA-5.	
RA-5(2)	UPDATE VULNERABILITIES TO BE SCANNED	O	✓
RA-5(3)	BREADTH AND DEPTH OF COVERAGE	O	✓
RA-5(4)	DISCOVERABLE INFORMATION	O	✓
RA-5(5)	PRIVILEGED ACCESS	O	✓
RA-5(6)	AUTOMATED TREND ANALYSES	O	✓
RA-5(7)	AUTOMATED DETECTION AND NOTIFICATION OF UNAUTHORIZED COMPONENTS	W: Incorporated into CM-8.	
RA-5(8)	REVIEW HISTORIC AUDIT LOGS	O	✓
RA-5(9)	PENETRATION TESTING AND ANALYSES	W: Incorporated into CA-8.	
RA-5(10)	CORRELATE SCANNING INFORMATION	O	✓
RA-5(11)	PUBLIC DISCLOSURE PROGRAM	O	✓
RA-6	Technical Surveillance Countermeasures Survey	O	✓
RA-7	Risk Response	O	✓
RA-8	Privacy Impact Assessments	O	✓
RA-9	Criticality Analysis	O	
RA-10	Threat Hunting	O/S	✓

TABLE C-17: SYSTEM AND SERVICES ACQUISITION FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
SA-1	Policy and Procedures	O	✓
SA-2	Allocation of Resources	O	✓
SA-3	System Development Life Cycle	O	✓
SA-3(1)	MANAGE PREPRODUCTION ENVIRONMENT	O	✓
SA-3(2)	USE OF LIVE OR OPERATIONAL DATA	O	✓
SA-3(3)	TECHNOLOGY REFRESH	O	✓
SA-4	Acquisition Process	O	✓
SA-4(1)	FUNCTIONAL PROPERTIES OF CONTROLS	O	✓
SA-4(2)	DESIGN AND IMPLEMENTATION INFORMATION FOR CONTROLS	O	✓
SA-4(3)	DEVELOPMENT METHODS, TECHNIQUES, AND PRACTICES	O	✓
SA-4(4)	ASSIGNMENT OF COMPONENTS TO SYSTEMS	W: Incorporated into CM-8(9).	
SA-4(5)	SYSTEM, COMPONENT, AND SERVICE CONFIGURATIONS	O	✓
SA-4(6)	USE OF INFORMATION ASSURANCE PRODUCTS	O	✓
SA-4(7)	NIAP-APPROVED PROTECTION PROFILES	O	✓
SA-4(8)	CONTINUOUS MONITORING PLAN FOR CONTROLS	O	✓
SA-4(9)	FUNCTIONS, PORTS, PROTOCOLS, AND SERVICES IN USE	O	✓
SA-4(10)	USE OF APPROVED PIV PRODUCTS	O	✓
SA-4(11)	SYSTEM OF RECORDS	O	✓
SA-4(12)	DATA OWNERSHIP	O	✓
SA-5	System Documentation	O	✓
SA-5(1)	FUNCTIONAL PROPERTIES OF SECURITY CONTROLS	W: Incorporated into SA-4(1).	
SA-5(2)	SECURITY-RELEVANT EXTERNAL SYSTEM INTERFACES	W: Incorporated into SA-4(2).	
SA-5(3)	HIGH-LEVEL DESIGN	W: Incorporated into SA-4(2).	
SA-5(4)	LOW-LEVEL DESIGN	W: Incorporated into SA-4(2).	
SA-5(5)	SOURCE CODE	W: Incorporated into SA-4(2).	
SA-6	Software Usage Restrictions	W: Incorporated into CM-10 and SI-7.	
SA-7	User-Installed Software	W: Incorporated into CM-11 and SI-7.	
SA-8	Security and Privacy Engineering Principles	O	✓
SA-8(1)	CLEAR ABSTRACTIONS	O/S	✓
SA-8(2)	LEAST COMMON MECHANISM	O/S	✓
SA-8(3)	MODULARITY AND LAYERING	O/S	✓
SA-8(4)	PARTIALLY ORDERED DEPENDENCIES	O/S	✓
SA-8(5)	EFFICIENTLY MEDIATED ACCESS	O/S	✓
SA-8(6)	MINIMIZED SHARING	O/S	✓
SA-8(7)	REDUCED COMPLEXITY	O/S	✓
SA-8(8)	SECURE EVOLVABILITY	O/S	✓
SA-8(9)	TRUSTED COMPONENTS	O/S	✓
SA-8(10)	HIERARCHICAL TRUST	O/S	✓
SA-8(11)	INVERSE MODIFICATION THRESHOLD	O/S	✓
SA-8(12)	HIERARCHICAL PROTECTION	O/S	✓
SA-8(13)	MINIMIZED SECURITY ELEMENTS	O/S	✓
SA-8(14)	LEAST PRIVILEGE	O/S	✓

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SA-8(15)</u>	PREDICATE PERMISSION	o/s	✓
<u>SA-8(16)</u>	SELF-RELIANT TRUSTWORTHINESS	o/s	✓
<u>SA-8(17)</u>	SECURE DISTRIBUTED COMPOSITION	o/s	✓
<u>SA-8(18)</u>	TRUSTED COMMUNICATIONS CHANNELS	o/s	✓
<u>SA-8(19)</u>	CONTINUOUS PROTECTION	o/s	✓
<u>SA-8(20)</u>	SECURE METADATA MANAGEMENT	o/s	✓
<u>SA-8(21)</u>	SELF-ANALYSIS	o/s	✓
<u>SA-8(22)</u>	ACCOUNTABILITY AND TRACEABILITY	o/s	✓
<u>SA-8(23)</u>	SECURE DEFAULTS	o/s	✓
<u>SA-8(24)</u>	SECURE FAILURE AND RECOVERY	o/s	✓
<u>SA-8(25)</u>	ECONOMIC SECURITY	o/s	✓
<u>SA-8(26)</u>	PERFORMANCE SECURITY	o/s	✓
<u>SA-8(27)</u>	HUMAN FACTORED SECURITY	o/s	✓
<u>SA-8(28)</u>	ACCEPTABLE SECURITY	o/s	✓
<u>SA-8(29)</u>	REPEATABLE AND DOCUMENTED PROCEDURES	o/s	✓
<u>SA-8(30)</u>	PROCEDURAL RIGOR	o/s	✓
<u>SA-8(31)</u>	SECURE SYSTEM MODIFICATION	o/s	✓
<u>SA-8(32)</u>	SUFFICIENT DOCUMENTATION	o/s	✓
<u>SA-8(33)</u>	MINIMIZATION	o/s	✓
SA-9	External System Services	o	✓
<u>SA-9(1)</u>	RISK ASSESSMENTS AND ORGANIZATIONAL APPROVALS	o	✓
<u>SA-9(2)</u>	IDENTIFICATION OF FUNCTIONS, PORTS, PROTOCOLS, AND SERVICES	o	✓
<u>SA-9(3)</u>	ESTABLISH AND MAINTAIN TRUST RELATIONSHIP WITH PROVIDERS	o	✓
<u>SA-9(4)</u>	CONSISTENT INTERESTS OF CONSUMERS AND PROVIDERS	o	✓
<u>SA-9(5)</u>	PROCESSING, STORAGE, AND SERVICE LOCATION	o	✓
<u>SA-9(6)</u>	ORGANIZATION-CONTROLLED CRYPTOGRAPHIC KEYS	o	✓
<u>SA-9(7)</u>	ORGANIZATION-CONTROLLED INTEGRITY CHECKING	o	✓
<u>SA-9(8)</u>	PROCESSING AND STORAGE LOCATION — U.S. JURISDICTION	o	✓
SA-10	Developer Configuration Management	o	✓
<u>SA-10(1)</u>	SOFTWARE AND FIRMWARE INTEGRITY VERIFICATION	o	✓
<u>SA-10(2)</u>	ALTERNATIVE CONFIGURATION MANAGEMENT PROCESSES	o	✓
<u>SA-10(3)</u>	HARDWARE INTEGRITY VERIFICATION	o	✓
<u>SA-10(4)</u>	TRUSTED GENERATION	o	✓
<u>SA-10(5)</u>	MAPPING INTEGRITY FOR VERSION CONTROL	o	✓
<u>SA-10(6)</u>	TRUSTED DISTRIBUTION	o	✓
<u>SA-10(7)</u>	SECURITY AND PRIVACY REPRESENTATIVES	o	✓
SA-11	Developer Testing and Evaluation	o	✓
<u>SA-11(1)</u>	STATIC CODE ANALYSIS	o	✓
<u>SA-11(2)</u>	THREAT MODELING AND VULNERABILITY ANALYSES	o	✓
<u>SA-11(3)</u>	INDEPENDENT VERIFICATION OF ASSESSMENT PLANS AND EVIDENCE	o	✓
<u>SA-11(4)</u>	MANUAL CODE REVIEWS	o	✓
<u>SA-11(5)</u>	PENETRATION TESTING	o	✓
<u>SA-11(6)</u>	ATTACK SURFACE REVIEWS	o	✓

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SA-11(7)</u>	VERIFY SCOPE OF TESTING AND EVALUATION	O	✓
<u>SA-11(8)</u>	DYNAMIC CODE ANALYSIS	O	✓
<u>SA-11(9)</u>	INTERACTIVE APPLICATION SECURITY TESTING	O	✓
SA-12	Supply Chain Protection	W: Moved to SR Family.	
SA-12(1)	ACQUISITION STRATEGIES, TOOLS, AND METHODS	W: Moved to SR-5.	
SA-12(2)	SUPPLIER REVIEWS	W: Moved to SR-6.	
SA-12(3)	TRUSTED SHIPPING AND WAREHOUSING	W: Incorporated into SR-3.	
SA-12(4)	DIVERSITY OF SUPPLIERS	W: Moved to SR-3(1).	
SA-12(5)	LIMITATION OF HARM	W: Moved to SR-3(2).	
SA-12(6)	MINIMIZING PROCUREMENT TIME	W: Incorporated into SR-5(1).	
SA-12(7)	ASSESSMENTS PRIOR TO SELECTION / ACCEPTANCE / UPDATE	W: Moved to SR-5(2).	
SA-12(8)	USE OF ALL-SOURCE INTELLIGENCE	W: Incorporated into RA-3(2).	
SA-12(9)	OPERATIONS SECURITY	W: Moved to SR-7.	
SA-12(10)	VALIDATE AS GENUINE AND NOT ALTERED	W: Moved to SR-4(3).	
SA-12(11)	PENETRATION TESTING / ANALYSIS OF ELEMENTS, PROCESSES, AND ACTORS	W: Moved to SR-6(1).	
SA-12(12)	INTER-ORGANIZATIONAL AGREEMENTS	W: Moved to SR-8.	
SA-12(13)	CRITICAL INFORMATION SYSTEM COMPONENTS	W: Incorporated into MA-6 and RA-9.	
SA-12(14)	IDENTITY AND TRACEABILITY	W: Moved to SR-4(1) and SR-4(2).	
SA-12(15)	PROCESSES TO ADDRESS WEAKNESSES OR DEFICIENCIES	W: Incorporated into SR-3.	
SA-13	Trustworthiness	W: Incorporated into SA-8.	
SA-14	Criticality Analysis	W: Incorporated into RA-9.	
SA-14(1)	CRITICAL COMPONENTS WITH NO Viable ALTERNATIVE SOURCING	W: Incorporated into SA-20.	
SA-15	Development Process, Standards, and Tools	O	✓
<u>SA-15(1)</u>	QUALITY METRICS	O	✓
<u>SA-15(2)</u>	SECURITY AND PRIVACY TRACKING TOOLS	O	✓
<u>SA-15(3)</u>	CRITICALITY ANALYSIS	O	✓
<u>SA-15(4)</u>	THREAT MODELING AND VULNERABILITY ANALYSIS	W: Incorporated into SA-11(2).	
<u>SA-15(5)</u>	ATTACK SURFACE REDUCTION	O	✓
<u>SA-15(6)</u>	CONTINUOUS IMPROVEMENT	O	✓
<u>SA-15(7)</u>	AUTOMATED VULNERABILITY ANALYSIS	O	✓
<u>SA-15(8)</u>	REUSE OF THREAT AND VULNERABILITY INFORMATION	O	✓
<u>SA-15(9)</u>	USE OF LIVE DATA	W: Incorporated into SA-3(2).	
<u>SA-15(10)</u>	INCIDENT RESPONSE PLAN	O	✓
<u>SA-15(11)</u>	ARCHIVE SYSTEM OR COMPONENT	O	✓
<u>SA-15(12)</u>	MINIMIZE PERSONALLY IDENTIFIABLE INFORMATION	O	✓
SA-16	Developer-Provided Training	O	✓
SA-17	Developer Security and Privacy Architecture and Design	O	✓
<u>SA-17(1)</u>	FORMAL POLICY MODEL	O	✓
<u>SA-17(2)</u>	SECURITY-RELEVANT COMPONENTS	O	✓
<u>SA-17(3)</u>	FORMAL CORRESPONDENCE	O	✓
<u>SA-17(4)</u>	INFORMAL CORRESPONDENCE	O	✓
<u>SA-17(5)</u>	CONCEPTUALLY SIMPLE DESIGN	O	✓

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SA-17(6)</u>	STRUCTURE FOR TESTING	O	✓
<u>SA-17(7)</u>	STRUCTURE FOR LEAST PRIVILEGE	O	✓
<u>SA-17(8)</u>	ORCHESTRATION	O	✓
<u>SA-17(9)</u>	DESIGN DIVERSITY	O	✓
<u>SA-18</u>	Tamper Resistance and Detection	W: Moved to SR-9.	
<u>SA-18(1)</u>	MULTIPLE PHASES OF SYSTEM DEVELOPMENT LIFE CYCLE	W: Moved to SR-9(1).	
<u>SA-18(2)</u>	INSPECTION OF SYSTEMS OR COMPONENTS	W: Moved to SR-10.	
<u>SA-19</u>	Component Authenticity	W: Moved to SR-11.	
<u>SA-19(1)</u>	ANTI-COUNTERFEIT TRAINING	W: Moved to SR-11(1).	
<u>SA-19(2)</u>	CONFIGURATION CONTROL FOR COMPONENT SERVICE AND REPAIR	W: Moved to SR-11(2).	
<u>SA-19(3)</u>	COMPONENT DISPOSAL	W: Moved to SR-12.	
<u>SA-19(4)</u>	ANTI-COUNTERFEIT SCANNING	W: Moved to SR-11(3).	
<u>SA-20</u>	Customized Development of Critical Components	O	✓
<u>SA-21</u>	Developer Screening	O	✓
<u>SA-21(1)</u>	VALIDATION OF SCREENING	W: Incorporated into SA-21.	
<u>SA-22</u>	Unsupported System Components	O	✓
<u>SA-22(1)</u>	ALTERNATIVE SOURCES FOR CONTINUED SUPPORT	W: Incorporated into SA-22.	
<u>SA-23</u>	Specialization	O	✓

TABLE C-18: SYSTEM AND COMMUNICATIONS PROTECTION FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
SC-1	Policy and Procedures	O	✓
SC-2	Separation of System and User Functionality	S	✓
SC-2(1)	INTERFACES FOR NON-PRIVILEGED USERS	S	✓
SC-2(2)	DISASSOCIABILITY	S	✓
SC-3	Security Function Isolation	S	✓
SC-3(1)	HARDWARE SEPARATION	S	✓
SC-3(2)	ACCESS AND FLOW CONTROL FUNCTIONS	S	✓
SC-3(3)	MINIMIZE NONSECURITY FUNCTIONALITY	O/S	✓
SC-3(4)	MODULE COUPLING AND COHESIVENESS	O/S	✓
SC-3(5)	LAYERED STRUCTURES	O/S	✓
SC-4	Information in Shared System Resources	S	
SC-4(1)	SECURITY LEVELS	W: Incorporated into SC-4.	
SC-4(2)	MULTILEVEL OR PERIODS PROCESSING	S	
SC-5	Denial-of-Service Protection	S	
SC-5(1)	RESTRICT ABILITY TO ATTACK OTHER SYSTEMS	S	
SC-5(2)	CAPACITY, BANDWIDTH, AND REDUNDANCY	S	
SC-5(3)	DETECTION AND MONITORING	S	
SC-6	Resource Availability	S	✓
SC-7	Boundary Protection	S	
SC-7(1)	PHYSICALLY SEPARATED SUBNETWORKS	W: Incorporated into SC-7.	
SC-7(2)	PUBLIC ACCESS	W: Incorporated into SC-7.	
SC-7(3)	ACCESS POINTS	S	
SC-7(4)	EXTERNAL TELECOMMUNICATIONS SERVICES	O	
SC-7(5)	DENY BY DEFAULT — ALLOW BY EXCEPTION	S	
SC-7(6)	RESPONSE TO RECOGNIZED FAILURES	W: Incorporated into SC-7(18).	
SC-7(7)	SPLIT TUNNELING FOR REMOTE DEVICES	S	
SC-7(8)	ROUTE TRAFFIC TO AUTHENTICATED PROXY SERVERS	S	
SC-7(9)	RESTRICT THREATENING OUTGOING COMMUNICATIONS TRAFFIC	S	
SC-7(10)	PREVENT EXFILTRATION	S	
SC-7(11)	RESTRICT INCOMING COMMUNICATIONS TRAFFIC	S	
SC-7(12)	HOST-BASED PROTECTION	S	
SC-7(13)	ISOLATION OF SECURITY TOOLS, MECHANISMS, AND SUPPORT COMPONENTS	S	
SC-7(14)	PROTECT AGAINST UNAUTHORIZED PHYSICAL CONNECTIONS	S	
SC-7(15)	NETWORKED PRIVILEGED ACCESSES	S	
SC-7(16)	PREVENT DISCOVERY OF SYSTEM COMPONENTS	S	
SC-7(17)	AUTOMATED ENFORCEMENT OF PROTOCOL FORMATS	S	
SC-7(18)	FAIL SECURE	S	✓
SC-7(19)	BLOCK COMMUNICATION FROM NON-ORGANIZATIONALLY CONFIGURED HOSTS	S	
SC-7(20)	DYNAMIC ISOLATION AND SEGREGATION	S	
SC-7(21)	ISOLATION OF SYSTEM COMPONENTS	O/S	✓

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SC-7(22)</u>	SEPARATE SUBNETS FOR CONNECTING TO DIFFERENT SECURITY DOMAINS	S	✓
<u>SC-7(23)</u>	DISABLE SENDER FEEDBACK ON PROTOCOL VALIDATION FAILURE	S	
<u>SC-7(24)</u>	PERSONALLY IDENTIFIABLE INFORMATION	o/s	
<u>SC-7(25)</u>	UNCLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS	O	
<u>SC-7(26)</u>	CLASSIFIED NATIONAL SECURITY SYSTEM CONNECTIONS	O	
<u>SC-7(27)</u>	UNCLASSIFIED NON-NATIONAL SECURITY SYSTEM CONNECTIONS	O	
<u>SC-7(28)</u>	CONNECTIONS TO PUBLIC NETWORKS	O	
<u>SC-7(29)</u>	SEPARATE SUBNETS TO ISOLATE FUNCTIONS	S	
SC-8	Transmission Confidentiality and Integrity	S	
<u>SC-8(1)</u>	CRYPTOGRAPHIC PROTECTION	S	
<u>SC-8(2)</u>	PRE- AND POST-TRANSMISSION HANDLING	S	
<u>SC-8(3)</u>	CRYPTOGRAPHIC PROTECTION FOR MESSAGE EXTERNALS	S	
<u>SC-8(4)</u>	CONCEAL OR RANDOMIZE COMMUNICATIONS	S	
<u>SC-8(5)</u>	PROTECTED DISTRIBUTION SYSTEM	S	
SC-9	Transmission Confidentiality	W: Incorporated into SC-8.	
SC-10	Network Disconnect	S	
<u>SC-11</u>	Trusted Path	S	✓
<u>SC-11(1)</u>	IRREFUTABLE COMMUNICATIONS PATH	S	✓
SC-12	Cryptographic Key Establishment and Management	o/s	
<u>SC-12(1)</u>	AVAILABILITY	o/s	
<u>SC-12(2)</u>	SYMMETRIC KEYS	o/s	
<u>SC-12(3)</u>	ASYMMETRIC KEYS	o/s	
SC-12(4)	PKI CERTIFICATES	W: Incorporated into SC-12(3).	
SC-12(5)	PKI CERTIFICATES / HARDWARE TOKENS	W: Incorporated into SC-12(3).	
<u>SC-12(6)</u>	PHYSICAL CONTROL OF KEYS	o/s	
SC-13	Cryptographic Protection	S	
SC-13(1)	FIPS-VALIDATED CRYPTOGRAPHY	W: Incorporated into SC-13.	
SC-13(2)	NSA-APPROVED CRYPTOGRAPHY	W: Incorporated into SC-13.	
SC-13(3)	INDIVIDUALS WITHOUT FORMAL ACCESS APPROVALS	W: Incorporated into SC-13.	
SC-13(4)	DIGITAL SIGNATURES	W: Incorporated into SC-13.	
SC-14	Public Access Protections	W: Incorporated into AC-2, AC-3, AC-5, SI-3, SI-4, SI-5, SI-7, and SI-10.	
SC-15	Collaborative Computing Devices and Applications	S	
<u>SC-15(1)</u>	PHYSICAL OR LOGICAL DISCONNECT	S	
SC-15(2)	BLOCKING INBOUND AND OUTBOUND COMMUNICATIONS TRAFFIC	W: Incorporated into SC-7.	
<u>SC-15(3)</u>	DISABLING AND REMOVAL IN SECURE WORK AREAS	O	
<u>SC-15(4)</u>	EXPLICITLY INDICATE CURRENT PARTICIPANTS	S	
SC-16	Transmission of Security and Privacy Attributes	S	
<u>SC-16(1)</u>	INTEGRITY VERIFICATION	S	
<u>SC-16(2)</u>	ANTI-SPOOFING MECHANISMS	S	
<u>SC-16(3)</u>	CRYPTOGRAPHIC BINDING	S	
SC-17	Public Key Infrastructure Certificates	o/s	
SC-18	Mobile Code	O	
<u>SC-18(1)</u>	IDENTIFY UNACCEPTABLE CODE AND TAKE CORRECTIVE ACTIONS	S	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SC-18(2)</u>	ACQUISITION, DEVELOPMENT, AND USE	O	
<u>SC-18(3)</u>	PREVENT DOWNLOADING AND EXECUTION	S	
<u>SC-18(4)</u>	PREVENT AUTOMATIC EXECUTION	S	
<u>SC-18(5)</u>	ALLOW EXECUTION ONLY IN CONFINED ENVIRONMENTS	S	
<u>SC-19</u>	Voice over Internet Protocol	W: Technology-specific; addressed as any other technology or protocol.	
<u>SC-20</u>	Secure Name/Address Resolution Service (Authoritative Source)	S	
<u>SC-20(1)</u>	CHILD SUBSPACES	W: Incorporated into SC-20.	
<u>SC-20(2)</u>	DATA ORIGIN AND INTEGRITY	S	
<u>SC-21</u>	Secure Name/Address Resolution Service (Recursive or Caching Resolver)	S	
<u>SC-21(1)</u>	DATA ORIGIN AND INTEGRITY	W: Incorporated into SC-21.	
<u>SC-22</u>	Architecture and Provisioning for Name/Address Resolution Service	S	
<u>SC-23</u>	Session Authenticity	S	
<u>SC-23(1)</u>	INVALIDATE SESSION IDENTIFIERS AT LOGOUT	S	
<u>SC-23(2)</u>	USER-INITIATED LOGOUTS AND MESSAGE DISPLAYS	W: Incorporated into AC-12(1).	
<u>SC-23(3)</u>	UNIQUE SYSTEM-GENERATED SESSION IDENTIFIERS	S	
<u>SC-23(4)</u>	UNIQUE SESSION IDENTIFIERS WITH RANDOMIZATION	W: Incorporated into SC-23(3).	
<u>SC-23(5)</u>	ALLOWED CERTIFICATE AUTHORITIES	S	
<u>SC-24</u>	Fail in Known State	S	✓
<u>SC-25</u>	Thin Nodes	S	
<u>SC-26</u>	Decoys	S	
<u>SC-26(1)</u>	DETECTION OF MALICIOUS CODE	W: Incorporated into SC-35.	
<u>SC-27</u>	Platform-Independent Applications	S	
<u>SC-28</u>	Protection of Information at Rest	S	
<u>SC-28(1)</u>	CRYPTOGRAPHIC PROTECTION	S	
<u>SC-28(2)</u>	OFFLINE STORAGE	O	
<u>SC-28(3)</u>	CRYPTOGRAPHIC KEYS	O/S	
<u>SC-29</u>	Heterogeneity	O	✓
<u>SC-29(1)</u>	VIRTUALIZATION TECHNIQUES	O	✓
<u>SC-30</u>	Concealment and Misdirection	O	✓
<u>SC-30(1)</u>	VIRTUALIZATION TECHNIQUES	W: Incorporated into SC-29(1).	
<u>SC-30(2)</u>	RANDOMNESS	O	✓
<u>SC-30(3)</u>	CHANGE PROCESSING AND STORAGE LOCATIONS	O	✓
<u>SC-30(4)</u>	MISLEADING INFORMATION	O	✓
<u>SC-30(5)</u>	CONCEALMENT OF SYSTEM COMPONENTS	O	✓
<u>SC-31</u>	Covert Channel Analysis	O	✓
<u>SC-31(1)</u>	TEST COVERT CHANNELS FOR EXPLOITABILITY	O	✓
<u>SC-31(2)</u>	MAXIMUM BANDWIDTH	O	✓
<u>SC-31(3)</u>	MEASURE BANDWIDTH IN OPERATIONAL ENVIRONMENTS	O	✓
<u>SC-32</u>	System Partitioning	O/S	✓
<u>SC-32(1)</u>	SEPARATE PHYSICAL DOMAINS FOR PRIVILEGED FUNCTIONS	O/S	✓

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
SC-33	Transmission Preparation Integrity	W: Incorporated into SC-8.	
SC-34	Non-Modifiable Executable Programs	S	✓
SC-34(1)	NO WRITABLE STORAGE	O	✓
SC-34(2)	INTEGRITY PROTECTION AND READ-ONLY MEDIA	O	✓
SC-34(3)	HARDWARE-BASED PROTECTION	W: Moved to SC-51.	
SC-35	External Malicious Code Identification	S	
SC-36	Distributed Processing and Storage	O	✓
SC-36(1)	POLLING TECHNIQUES	O	✓
SC-36(2)	SYNCHRONIZATION	O	✓
SC-37	Out-of-Band Channels	O	✓
SC-37(1)	ENSURE DELIVERY AND TRANSMISSION	O	✓
SC-38	Operations Security	O	✓
SC-39	Process Isolation	S	✓
SC-39(1)	HARDWARE SEPARATION	S	✓
SC-39(2)	SEPARATE EXECUTION DOMAIN PER THREAD	S	✓
SC-40	Wireless Link Protection	S	
SC-40(1)	ELECTROMAGNETIC INTERFERENCE	S	
SC-40(2)	REDUCE DETECTION POTENTIAL	S	
SC-40(3)	IMITATIVE OR MANIPULATIVE COMMUNICATIONS DECEPTION	S	
SC-40(4)	SIGNAL PARAMETER IDENTIFICATION	S	
SC-41	Port and I/O Device Access	O/S	
SC-42	Sensor Capability and Data	S	
SC-42(1)	REPORTING TO AUTHORIZED INDIVIDUALS OR ROLES	O	
SC-42(2)	AUTHORIZED USE	O	
SC-42(3)	PROHIBIT USE OF DEVICES	W: Incorporated into SC-42.	
SC-42(4)	NOTICE OF COLLECTION	O	
SC-42(5)	COLLECTION MINIMIZATION	O	
SC-43	Usage Restrictions	O/S	
SC-44	Detonation Chambers	S	
SC-45	System Time Synchronization	S	
SC-45(1)	SYNCHRONIZATION WITH AUTHORITATIVE TIME SOURCE	S	
SC-45(2)	SECONDARY AUTHORITATIVE TIME SOURCE	S	
SC-46	Cross Domain Policy Enforcement	S	
SC-47	Alternate Communications Paths	O/S	
SC-48	Sensor Relocation	O/S	
SC-48(1)	DYNAMIC RELOCATION OF SENSORS OR MONITORING CAPABILITIES	O/S	
SC-49	Hardware-Enforced Separation and Policy Enforcement	O/S	✓
SC-50	Software-Enforced Separation and Policy Enforcement	O/S	✓
SC-51	Hardware-Based Protection	O/S	✓

TABLE C-19: SYSTEM AND INFORMATION INTEGRITY FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SI-1</u>	Policy and Procedures	O	✓
<u>SI-2</u>	Flaw Remediation	O	
SI-2(1)	CENTRAL MANAGEMENT	W: Incorporated into PL-9.	
<u>SI-2(2)</u>	AUTOMATED FLAW REMEDIATION STATUS	O	
<u>SI-2(3)</u>	TIME TO REMEDIATE FLAWS AND BENCHMARKS FOR CORRECTIVE ACTIONS	O	
<u>SI-2(4)</u>	AUTOMATED PATCH MANAGEMENT TOOLS	o/s	
<u>SI-2(5)</u>	AUTOMATIC SOFTWARE AND FIRMWARE UPDATES	o/s	
<u>SI-2(6)</u>	REMOVAL OF PREVIOUS VERSIONS OF SOFTWARE AND FIRMWARE	o/s	
<u>SI-3</u>	Malicious Code Protection	o/s	
SI-3(1)	CENTRAL MANAGEMENT	W: Incorporated into PL-9.	
SI-3(2)	AUTOMATIC UPDATES	W: Incorporated into SI-3.	
SI-3(3)	NON-PRIVILEGED USERS	W: Incorporated into AC-6(10).	
<u>SI-3(4)</u>	UPDATES ONLY BY PRIVILEGED USERS	o/s	
SI-3(5)	PORTABLE STORAGE DEVICES	W: Incorporated into MP-7.	
<u>SI-3(6)</u>	TESTING AND VERIFICATION	O	
SI-3(7)	NONSIGNATURE-BASED DETECTION	W: Incorporated into SI-3.	
<u>SI-3(8)</u>	DETECT UNAUTHORIZED COMMANDS	S	
SI-3(9)	AUTHENTICATE REMOTE COMMANDS	W: Moved to AC-17(10).	
<u>SI-3(10)</u>	MALICIOUS CODE ANALYSIS	O	
<u>SI-4</u>	System Monitoring	o/s	✓
<u>SI-4(1)</u>	SYSTEM-WIDE INTRUSION DETECTION SYSTEM	o/s	✓
<u>SI-4(2)</u>	AUTOMATED TOOLS AND MECHANISMS FOR REAL-TIME ANALYSIS	S	✓
<u>SI-4(3)</u>	AUTOMATED TOOL AND MECHANISM INTEGRATION	S	✓
<u>SI-4(4)</u>	INBOUND AND OUTBOUND COMMUNICATIONS TRAFFIC	S	✓
<u>SI-4(5)</u>	SYSTEM-GENERATED ALERTS	S	✓
SI-4(6)	RESTRICT NON-PRIVILEGED USERS	W: Incorporated into AC-6(10).	
<u>SI-4(7)</u>	AUTOMATED RESPONSE TO SUSPICIOUS EVENTS	S	✓
SI-4(8)	PROTECTION OF MONITORING INFORMATION	W: Incorporated into SI-4.	
<u>SI-4(9)</u>	TESTING OF MONITORING TOOLS AND MECHANISMS	O	✓
<u>SI-4(10)</u>	VISIBILITY OF ENCRYPTED COMMUNICATIONS	O	✓
<u>SI-4(11)</u>	ANALYZE COMMUNICATIONS TRAFFIC ANOMALIES	o/s	✓
<u>SI-4(12)</u>	AUTOMATED ORGANIZATION-GENERATED ALERTS	o/s	✓
<u>SI-4(13)</u>	ANALYZE TRAFFIC AND EVENT PATTERNS	o/s	✓
<u>SI-4(14)</u>	WIRELESS INTRUSION DETECTION	S	✓
<u>SI-4(15)</u>	WIRELESS TO WIRELINE COMMUNICATIONS	S	✓
<u>SI-4(16)</u>	CORRELATE MONITORING INFORMATION	o/s	✓
<u>SI-4(17)</u>	INTEGRATED SITUATIONAL AWARENESS	O	✓
<u>SI-4(18)</u>	ANALYZE TRAFFIC AND COVERT EXFILTRATION	o/s	✓
<u>SI-4(19)</u>	RISK FOR INDIVIDUALS	O	✓
<u>SI-4(20)</u>	PRIVILEGED USERS	S	✓
<u>SI-4(21)</u>	PROBATIONARY PERIODS	O	✓

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SI-4(22)</u>	UNAUTHORIZED NETWORK SERVICES	S	✓
<u>SI-4(23)</u>	HOST-BASED DEVICES	O	✓
<u>SI-4(24)</u>	INDICATORS OF COMPROMISE	S	✓
<u>SI-4(25)</u>	OPTIMIZE NETWORK TRAFFIC ANALYSIS	S	✓
<u>SI-5</u>	Security Alerts, Advisories, and Directives	O	✓
<u>SI-5(1)</u>	AUTOMATED ALERTS AND ADVISORIES	O	✓
<u>SI-6</u>	Security and Privacy Function Verification	S	✓
<u>SI-6(1)</u>	NOTIFICATION OF FAILED SECURITY TESTS	W: Incorporated into SI-6.	
<u>SI-6(2)</u>	AUTOMATION SUPPORT FOR DISTRIBUTED TESTING	S	
<u>SI-6(3)</u>	REPORT VERIFICATION RESULTS	O	
<u>SI-7</u>	Software, Firmware, and Information Integrity	o/s	✓
<u>SI-7(1)</u>	INTEGRITY CHECKS	S	✓
<u>SI-7(2)</u>	AUTOMATED NOTIFICATIONS OF INTEGRITY VIOLATIONS	S	✓
<u>SI-7(3)</u>	CENTRALLY MANAGED INTEGRITY TOOLS	O	✓
<u>SI-7(4)</u>	TAMPER-EVIDENT PACKAGING	W: Incorporated into SR-9.	
<u>SI-7(5)</u>	AUTOMATED RESPONSE TO INTEGRITY VIOLATIONS	S	✓
<u>SI-7(6)</u>	CRYPTOGRAPHIC PROTECTION	S	✓
<u>SI-7(7)</u>	INTEGRATION OF DETECTION AND RESPONSE	O	✓
<u>SI-7(8)</u>	AUDITING CAPABILITY FOR SIGNIFICANT EVENTS	S	✓
<u>SI-7(9)</u>	VERIFY BOOT PROCESS	S	✓
<u>SI-7(10)</u>	PROTECTION OF BOOT FIRMWARE	S	✓
<u>SI-7(11)</u>	CONFINED ENVIRONMENTS WITH LIMITED PRIVILEGES	W: Moved to CM-7(6).	
<u>SI-7(12)</u>	INTEGRITY VERIFICATION	o/s	✓
<u>SI-7(13)</u>	CODE EXECUTION IN PROTECTED ENVIRONMENTS	W: Moved to CM-7(7).	
<u>SI-7(14)</u>	BINARY OR MACHINE EXECUTABLE CODE	W: Moved to CM-7(8).	
<u>SI-7(15)</u>	CODE AUTHENTICATION	S	✓
<u>SI-7(16)</u>	TIME LIMIT ON PROCESS EXECUTION WITHOUT SUPERVISION	O	✓
<u>SI-7(17)</u>	RUNTIME APPLICATION SELF-PROTECTION	o/s	✓
<u>SI-8</u>	Spam Protection	O	
<u>SI-8(1)</u>	CENTRAL MANAGEMENT	W: Incorporated into PL-9.	
<u>SI-8(2)</u>	AUTOMATIC UPDATES	S	
<u>SI-8(3)</u>	CONTINUOUS LEARNING CAPABILITY	S	
<u>SI-9</u>	Information Input Restrictions	W: Incorporated into AC-2, AC-3, AC-5, and AC-6.	
<u>SI-10</u>	Information Input Validation	S	✓
<u>SI-10(1)</u>	MANUAL OVERRIDE CAPABILITY	o/s	✓
<u>SI-10(2)</u>	REVIEW AND RESOLVE ERRORS	O	✓
<u>SI-10(3)</u>	PREDICTABLE BEHAVIOR	o/s	✓
<u>SI-10(4)</u>	TIMING INTERACTIONS	S	✓
<u>SI-10(5)</u>	RESTRICT INPUTS TO TRUSTED SOURCES AND APPROVED FORMATS	S	✓
<u>SI-10(6)</u>	INJECTION PREVENTION	S	✓
<u>SI-11</u>	Error Handling	S	
<u>SI-12</u>	Information Management and Retention	O	
<u>SI-12(1)</u>	LIMIT PERSONALLY IDENTIFIABLE INFORMATION ELEMENTS	O	

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SI-12(2)</u>	MINIMIZE PERSONALLY IDENTIFIABLE INFORMATION IN TESTING, TRAINING, AND RESEARCH	O	
<u>SI-12(3)</u>	INFORMATION DISPOSAL	O	
<u>SI-13</u>	Predictable Failure Prevention	O	✓
<u>SI-13(1)</u>	TRANSFERRING COMPONENT RESPONSIBILITIES	O	✓
<u>SI-13(2)</u>	TIME LIMIT ON PROCESS EXECUTION WITHOUT SUPERVISION	W: Incorporated into SI-7(16).	
<u>SI-13(3)</u>	MANUAL TRANSFER BETWEEN COMPONENTS	O	✓
<u>SI-13(4)</u>	STANDBY COMPONENT INSTALLATION AND NOTIFICATION	o/s	✓
<u>SI-13(5)</u>	FAILOVER CAPABILITY	O	✓
<u>SI-14</u>	Non-Persistence	O	✓
<u>SI-14(1)</u>	REFRESH FROM TRUSTED SOURCES	O	✓
<u>SI-14(2)</u>	NON-PERSISTENT INFORMATION	O	✓
<u>SI-14(3)</u>	NON-PERSISTENT CONNECTIVITY	O	✓
<u>SI-15</u>	Information Output Filtering	S	✓
<u>SI-16</u>	Memory Protection	S	✓
<u>SI-17</u>	Fail-Safe Procedures	S	✓
<u>SI-18</u>	Personally Identifiable Information Quality Operations	o/s	
<u>SI-18(1)</u>	AUTOMATION SUPPORT	o/s	
<u>SI-18(2)</u>	DATA TAGS	o/s	
<u>SI-18(3)</u>	COLLECTION	o/s	
<u>SI-18(4)</u>	INDIVIDUAL REQUESTS	o/s	
<u>SI-18(5)</u>	NOTICE OF CORRECTION OR DELETION	o/s	
<u>SI-19</u>	De-Identification	o/s	
<u>SI-19(1)</u>	COLLECTION	o/s	
<u>SI-19(2)</u>	ARCHIVING	o/s	
<u>SI-19(3)</u>	RELEASE	o/s	
<u>SI-19(4)</u>	REMOVAL, MASKING, ENCRYPTION, HASHING, OR REPLACEMENT OF DIRECT IDENTIFIERS	S	
<u>SI-19(5)</u>	STATISTICAL DISCLOSURE CONTROL	o/s	
<u>SI-19(6)</u>	DIFFERENTIAL PRIVACY	o/s	
<u>SI-19(7)</u>	VALIDATED ALGORITHMS AND SOFTWARE	O	
<u>SI-19(8)</u>	MOTIVATED INTRUDER	o/s	
<u>SI-20</u>	Tainting	o/s	✓
<u>SI-21</u>	Information Refresh	o/s	✓
<u>SI-22</u>	Information Diversity	o/s	✓
<u>SI-23</u>	Information Fragmentation	o/s	✓

TABLE C-20: SUPPLY CHAIN RISK MANAGEMENT FAMILY

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	IMPLEMENTED BY	ASSURANCE
<u>SR-1</u>	Policy and Procedures	O	✓
<u>SR-2</u>	Supply Chain Risk Management Plan	O	✓
<u>SR-2(1)</u>	ESTABLISH SCRM TEAM	O	✓
<u>SR-3</u>	Supply Chain Controls and Processes	O/S	✓
<u>SR-3(1)</u>	DIVERSE SUPPLY BASE	O	✓
<u>SR-3(2)</u>	LIMITATION OF HARM	O	✓
<u>SR-3(3)</u>	SUB-TIER FLOW DOWN	O	✓
<u>SR-4</u>	Provenance	O	✓
<u>SR-4(1)</u>	IDENTITY	O	✓
<u>SR-4(2)</u>	TRACK AND TRACE	O	✓
<u>SR-4(3)</u>	VALIDATE AS GENUINE AND NOT ALTERED	O	✓
<u>SR-4(4)</u>	SUPPLY CHAIN INTEGRITY — PEDIGREE	O	✓
<u>SR-5</u>	Acquisition Strategies, Tools, and Methods	O	✓
<u>SR-5(1)</u>	ADEQUATE SUPPLY	O	✓
<u>SR-5(2)</u>	ASSESSMENTS PRIOR TO SELECTION, ACCEPTANCE, MODIFICATION, OR UPDATE	O	✓
<u>SR-6</u>	Supplier Assessments and Reviews	O	✓
<u>SR-6(1)</u>	TESTING AND ANALYSIS	O	✓
<u>SR-7</u>	Supply Chain Operations Security	O	✓
<u>SR-8</u>	Notification Agreements	O	✓
<u>SR-9</u>	Tamper Resistance and Detection	O	✓
<u>SR-9(1)</u>	MULTIPLE STAGES OF SYSTEM DEVELOPMENT LIFE CYCLE	O	✓
<u>SR-10</u>	Inspection of Systems or Components	O	✓
<u>SR-11</u>	Component Authenticity	O	✓
<u>SR-11(1)</u>	ANTI-COUNTERFEIT TRAINING	O	✓
<u>SR-11(2)</u>	CONFIGURATION CONTROL FOR COMPONENT SERVICE AND REPAIR	O	✓
<u>SR-11(3)</u>	ANTI-COUNTERFEIT SCANNING	O	✓
<u>SR-12</u>	Component Disposal	O	✓



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Reports on Computer Systems Technology

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Abstract

Computer security incident response has become an important component of information technology (IT) programs. Because performing incident response effectively is a complex undertaking, establishing a successful incident response capability requires substantial planning and resources. This publication assists organizations in establishing computer security incident response capabilities and handling incidents efficiently and effectively. This publication provides guidelines for incident handling, particularly for analyzing incident-related data and determining the appropriate response to each incident. The guidelines can be followed independently of particular hardware platforms, operating systems, protocols, or applications.

Keywords

computer security incident; incident handling; incident response; information security

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Table of Contents

Executive Summary	1
1. Introduction	4
1.1 Authority	4
1.2 Purpose and Scope	4
1.3 Audience	4
1.4 Document Structure	4
2. Organizing a Computer Security Incident Response Capability.....	6
2.1 Events and Incidents	6
2.2 Need for Incident Response	6
2.3 Incident Response Policy, Plan, and Procedure Creation.....	7
2.3.1 Policy Elements.....	7
2.3.2 Plan Elements.....	8
2.3.3 Procedure Elements.....	8
2.3.4 Sharing Information With Outside Parties.....	9
2.4 Incident Response Team Structure	13
2.4.1 Team Models	13
2.4.2 Team Model Selection.....	14
2.4.3 Incident Response Personnel.....	16
2.4.4 Dependencies within Organizations	17
2.5 Incident Response Team Services	18
2.6 Recommendations	19
3. Handling an Incident	21
3.1 Preparation.....	21
3.1.1 Preparing to Handle Incidents	21
3.1.2 Preventing Incidents.....	23
3.2 Detection and Analysis	25
3.2.1 Attack Vectors.....	25
3.2.2 Signs of an Incident.....	26
3.2.3 Sources of Precursors and Indicators.....	27
3.2.4 Incident Analysis	28
3.2.5 Incident Documentation.....	30
3.2.6 Incident Prioritization.....	32
3.2.7 Incident Notification.....	33
3.3 Containment, Eradication, and Recovery.....	35
3.3.1 Choosing a Containment Strategy.....	35
3.3.2 Evidence Gathering and Handling	36
3.3.3 Identifying the Attacking Hosts	37
3.3.4 Eradication and Recovery	37
3.4 Post-Incident Activity	38
3.4.1 Lessons Learned.....	38
3.4.2 Using Collected Incident Data	39
3.4.3 Evidence Retention	41
3.5 Incident Handling Checklist	42
3.6 Recommendations	42
4. Coordination and Information Sharing	45

4.1	Coordination.....	45
4.1.1	Coordination Relationships	46
4.1.2	Sharing Agreements and Reporting Requirements	47
4.2	Information Sharing Techniques.....	48
4.2.1	Ad Hoc	48
4.2.2	Partially Automated	48
4.2.3	Security Considerations	49
4.3	Granular Information Sharing	49
4.3.1	Business Impact Information	49
4.3.2	Technical Information	50
4.4	Recommendations	51

List of Appendices

Appendix A— Incident Handling Scenarios.....	52
A.1 Scenario Questions	52
A.2 Scenarios	53
Appendix B— Incident-Related Data Elements.....	58
B.1 Basic Data Elements	58
B.2 Incident Handler Data Elements	59
Appendix C— Glossary	60
Appendix D— Acronyms	61
Appendix E— Resources.....	63
Appendix F— Frequently Asked Questions	65
Appendix G— Crisis Handling Steps.....	68
Appendix H— Change Log	69

List of Figures

Figure 2-1. Communications with Outside Parties.....	10
Figure 3-1. Incident Response Life Cycle.....	21
Figure 3-2. Incident Response Life Cycle (Detection and Analysis).....	25
Figure 3-3. Incident Response Life Cycle (Containment, Eradication, and Recovery)	35
Figure 3-4. Incident Response Life Cycle (Post-Incident Activity)	38
Figure 4-1. Incident Response Coordination	46

List of Tables

Table 3-1. Common Sources of Precursors and Indicators	27
Table 3-2. Functional Impact Categories.....	33
Table 3-3. Information Impact Categories	33
Table 3-4. Recoverability Effort Categories	33
Table 3-5. Incident Handling Checklist	42
Table 4-1. Coordination Relationships	47

Executive Summary

Computer security incident response has become an important component of information technology (IT) programs. Cybersecurity-related attacks have become not only more numerous and diverse but also more damaging and disruptive. New types of security-related incidents emerge frequently. Preventive activities based on the results of risk assessments can lower the number of incidents, but not all incidents can be prevented. An incident response capability is therefore necessary for rapidly detecting incidents, minimizing loss and destruction, mitigating the weaknesses that were exploited, and restoring IT services. To that end, this publication provides guidelines for incident handling, particularly for analyzing incident-related data and determining the appropriate response to each incident. The guidelines can be followed independently of particular hardware platforms, operating systems, protocols, or applications.

Because performing incident response effectively is a complex undertaking, establishing a successful incident response capability requires substantial planning and resources. Continually monitoring for attacks is essential. Establishing clear procedures for prioritizing the handling of incidents is critical, as is implementing effective methods of collecting, analyzing, and reporting data. It is also vital to build relationships and establish suitable means of communication with other internal groups (e.g., human resources, legal) and with external groups (e.g., other incident response teams, law enforcement).

This publication assists organizations in establishing computer security incident response capabilities and handling incidents efficiently and effectively. This revision of the publication, Revision 2, updates material throughout the publication to reflect the changes in attacks and incidents. Understanding threats and identifying modern attacks in their early stages is key to preventing subsequent compromises, and proactively sharing information among organizations regarding the signs of these attacks is an increasingly effective way to identify them.

Implementing the following requirements and recommendations should facilitate efficient and effective incident response for Federal departments and agencies.

Organizations must create, provision, and operate a formal incident response capability. Federal law requires Federal agencies to report incidents to the United States Computer Emergency Readiness Team (US-CERT) office within the Department of Homeland Security (DHS).

The Federal Information Security Management Act (FISMA) requires Federal agencies to establish incident response capabilities. Each Federal civilian agency must designate a primary and secondary point of contact (POC) with US-CERT and report all incidents consistent with the agency's incident response policy. Each agency is responsible for determining how to fulfill these requirements.

Establishing an incident response capability should include the following actions:

- Creating an incident response policy and plan
- Developing procedures for performing incident handling and reporting
- Setting guidelines for communicating with outside parties regarding incidents
- Selecting a team structure and staffing model
- Establishing relationships and lines of communication between the incident response team and other groups, both internal (e.g., legal department) and external (e.g., law enforcement agencies)
- Determining what services the incident response team should provide

- Staffing and training the incident response team.

Organizations should reduce the frequency of incidents by effectively securing networks, systems, and applications.

Preventing problems is often less costly and more effective than reacting to them after they occur. Thus, incident prevention is an important complement to an incident response capability. If security controls are insufficient, high volumes of incidents may occur. This could overwhelm the resources and capacity for response, which would result in delayed or incomplete recovery and possibly more extensive damage and longer periods of service and data unavailability. Incident handling can be performed more effectively if organizations complement their incident response capability with adequate resources to actively maintain the security of networks, systems, and applications. This includes training IT staff on complying with the organization's security standards and making users aware of policies and procedures regarding appropriate use of networks, systems, and applications.

Organizations should document their guidelines for interactions with other organizations regarding incidents.

During incident handling, the organization will need to communicate with outside parties, such as other incident response teams, law enforcement, the media, vendors, and victim organizations. Because these communications often need to occur quickly, organizations should predetermine communication guidelines so that only the appropriate information is shared with the right parties.

Organizations should be generally prepared to handle any incident but should focus on being prepared to handle incidents that use common attack vectors.

Incidents can occur in countless ways, so it is infeasible to develop step-by-step instructions for handling every incident. This publication defines several types of incidents, based on common attack vectors; these categories are not intended to provide definitive classification for incidents, but rather to be used as a basis for defining more specific handling procedures. Different types of incidents merit different response strategies. The attack vectors are:

- **External/Removable Media:** An attack executed from removable media (e.g., flash drive, CD) or a peripheral device.
- **Attrition:** An attack that employs brute force methods to compromise, degrade, or destroy systems, networks, or services.
- **Web:** An attack executed from a website or web-based application.
- **Email:** An attack executed via an email message or attachment.
- **Improper Usage:** Any incident resulting from violation of an organization's acceptable usage policies by an authorized user, excluding the above categories.
- **Loss or Theft of Equipment:** The loss or theft of a computing device or media used by the organization, such as a laptop or smartphone.
- **Other:** An attack that does not fit into any of the other categories.

Organizations should emphasize the importance of incident detection and analysis throughout the organization.

In an organization, millions of possible signs of incidents may occur each day, recorded mainly by logging and computer security software. Automation is needed to perform an initial analysis of the data and select events of interest for human review. Event correlation software can be of great value in automating the analysis process. However, the effectiveness of the process depends on the quality of the data that goes into it. Organizations should establish logging standards and procedures to ensure that adequate information is collected by logs and security software and that the data is reviewed regularly.

Organizations should create written guidelines for prioritizing incidents.

Prioritizing the handling of individual incidents is a critical decision point in the incident response process. Effective information sharing can help an organization identify situations that are of greater severity and demand immediate attention. Incidents should be prioritized based on the relevant factors, such as the functional impact of the incident (e.g., current and likely future negative impact to business functions), the information impact of the incident (e.g., effect on the confidentiality, integrity, and availability of the organization's information), and the recoverability from the incident (e.g., the time and types of resources that must be spent on recovering from the incident).

Organizations should use the lessons learned process to gain value from incidents.

After a major incident has been handled, the organization should hold a lessons learned meeting to review the effectiveness of the incident handling process and identify necessary improvements to existing security controls and practices. Lessons learned meetings can also be held periodically for lesser incidents as time and resources permit. The information accumulated from all lessons learned meetings should be used to identify and correct systemic weaknesses and deficiencies in policies and procedures. Follow-up reports generated for each resolved incident can be important not only for evidentiary purposes but also for reference in handling future incidents and in training new team members.

1. Introduction

1.1 Authority

The National Institute of Standards and Technology (NIST) developed this document in furtherance of its statutory responsibilities under the Federal Information Security Management Act (FISMA) of 2002, Public Law 107-347.

NIST is responsible for developing standards and guidelines, including minimum requirements, for providing adequate information security for all agency operations and assets, but such standards and guidelines shall not apply to national security systems. This guideline is consistent with the requirements of the Office of Management and Budget (OMB) Circular A-130, Section 8b(3), "Securing Agency Information Systems," as analyzed in A-130, Appendix IV: Analysis of Key Sections. Supplemental information is provided in A-130, Appendix III.

This guideline has been prepared for use by Federal agencies. It may be used by nongovernmental organizations on a voluntary basis and is not subject to copyright, though attribution is desired.

Nothing in this document should be taken to contradict standards and guidelines made mandatory and binding on Federal agencies by the Secretary of Commerce under statutory authority, nor should these guidelines be interpreted as altering or superseding the existing authorities of the Secretary of Commerce, Director of the OMB, or any other Federal official.

1.2 Purpose and Scope

This publication seeks to assist organizations in mitigating the risks from computer security incidents by providing practical guidelines on responding to incidents effectively and efficiently. It includes guidelines on establishing an effective incident response program, but the primary focus of the document is detecting, analyzing, prioritizing, and handling incidents. Organizations are encouraged to tailor the recommended guidelines and solutions to meet their specific security and mission requirements.

1.3 Audience

This document has been created for computer security incident response teams (CSIRTs), system and network administrators, security staff, technical support staff, chief information security officers (CISOs), chief information officers (CIOs), computer security program managers, and others who are responsible for preparing for, or responding to, security incidents.

1.4 Document Structure

The remainder of this document is organized into the following sections and appendices:

- Section 2 discusses the need for incident response, outlines possible incident response team structures, and highlights other groups within an organization that may participate in incident handling.
- Section 3 reviews the basic incident handling steps and provides advice for performing incident handling more effectively, particularly incident detection and analysis.
- Section 4 examines the need for incident response coordination and information sharing.

- Appendix A contains incident response scenarios and questions for use in incident response tabletop discussions.
- Appendix B provides lists of suggested data fields to collect for each incident.
- Appendices C and D contain a glossary and acronym list, respectively.
- Appendix E identifies resources that may be useful in planning and performing incident response.
- Appendix F covers frequently asked questions about incident response.
- Appendix G lists the major steps to follow when handling a computer security incident-related crisis.
- Appendix H contains a change log listing significant changes since the previous revision.

2. Organizing a Computer Security Incident Response Capability

Organizing an effective computer security incident response capability (CSIRC) involves several major decisions and actions. One of the first considerations should be to create an organization-specific definition of the term “incident” so that the scope of the term is clear. The organization should decide what services the incident response team should provide, consider which team structures and models can provide those services, and select and implement one or more incident response teams. Incident response plan, policy, and procedure creation is an important part of establishing a team, so that incident response is performed effectively, efficiently, and consistently, and so that the team is empowered to do what needs to be done. The plan, policies, and procedures should reflect the team’s interactions with other teams within the organization as well as with outside parties, such as law enforcement, the media, and other incident response organizations. This section provides not only guidelines that should be helpful to organizations that are establishing incident response capabilities, but also advice on maintaining and enhancing existing capabilities.

2.1 Events and Incidents

An *event* is any observable occurrence in a system or network. Events include a user connecting to a file share, a server receiving a request for a web page, a user sending email, and a firewall blocking a connection attempt. *Adverse events* are events with a negative consequence, such as system crashes, packet floods, unauthorized use of system privileges, unauthorized access to sensitive data, and execution of malware that destroys data. This guide addresses only adverse events that are computer security-related, not those caused by natural disasters, power failures, etc.

A *computer security incident* is a violation or imminent threat of violation¹ of computer security policies, acceptable use policies, or standard security practices. Examples of incidents² are:

- An attacker commands a botnet to send high volumes of connection requests to a web server, causing it to crash.
- Users are tricked into opening a “quarterly report” sent via email that is actually malware; running the tool has infected their computers and established connections with an external host.
- An attacker obtains sensitive data and threatens that the details will be released publicly if the organization does not pay a designated sum of money.
- A user provides or exposes sensitive information to others through peer-to-peer file sharing services.

2.2 Need for Incident Response

Attacks frequently compromise personal and business data, and it is critical to respond quickly and effectively when security breaches occur. The concept of computer security incident response has become widely accepted and implemented. One of the benefits of having an incident response capability is that it supports responding to incidents systematically (i.e., following a consistent incident handling methodology) so that the appropriate actions are taken. Incident response helps personnel to minimize loss or theft of information and disruption of services caused by incidents. Another benefit of incident response is the ability to use information gained during incident handling to better prepare for handling

¹ An “imminent threat of violation” refers to a situation in which the organization has a factual basis for believing that a specific incident is about to occur. For example, the antivirus software maintainers may receive a bulletin from the software vendor, warning them of new malware that is rapidly spreading across the Internet.

² For the remainder of this document, the terms “incident” and “computer security incident” are interchangeable.

future incidents and to provide stronger protection for systems and data. An incident response capability also helps with dealing properly with legal issues that may arise during incidents.

Besides the business reasons to establish an incident response capability, Federal departments and agencies must comply with law, regulations, and policy directing a coordinated, effective defense against information security threats. Chief among these are the following:

- OMB's Circular No. A-130, Appendix III,³ released in 2000, which directs Federal agencies to "ensure that there is a capability to provide help to users when a security incident occurs in the system and to share information concerning common vulnerabilities and threats. This capability shall share information with other organizations ... and should assist the agency in pursuing appropriate legal action, consistent with Department of Justice guidance."
- FISMA (from 2002),⁴ which requires agencies to have "procedures for detecting, reporting, and responding to security incidents" and establishes a centralized Federal information security incident center, in part to:
 - "Provide timely technical assistance to operators of agency information systems ... including guidance on detecting and handling information security incidents ..."
 - Compile and analyze information about incidents that threaten information security ...
 - Inform operators of agency information systems about current and potential information security threats, and vulnerabilities"
- Federal Information Processing Standards (FIPS) 200, *Minimum Security Requirements for Federal Information and Information Systems*⁵, March 2006, which specifies minimum security requirements for Federal information and information systems, including incident response. The specific requirements are defined in NIST Special Publication (SP) 800-53, *Recommended Security Controls for Federal Information Systems and Organizations*.
- OMB Memorandum M-07-16, *Safeguarding Against and Responding to the Breach of Personally Identifiable Information*⁶, May 2007, which provides guidance on reporting security incidents that involve PII.

2.3 Incident Response Policy, Plan, and Procedure Creation

This section discusses policies, plans, and procedures related to incident response, with an emphasis on interactions with outside parties.

2.3.1 Policy Elements

Policy governing incident response is highly individualized to the organization. However, most policies include the same key elements:

- Statement of management commitment
- Purpose and objectives of the policy

³ <http://www.whitehouse.gov/omb/circulars/a130/a130trans4.html>

⁴ <http://csrc.nist.gov/drivers/documents/FISMA-final.pdf>

⁵ <http://csrc.nist.gov/publications/PubsFIPS.html>

⁶ <http://www.whitehouse.gov/omb/memoranda/fy2007/m07-16.pdf>

- Scope of the policy (to whom and what it applies and under what circumstances)
- Definition of computer security incidents and related terms
- Organizational structure and definition of roles, responsibilities, and levels of authority; should include the authority of the incident response team to confiscate or disconnect equipment and to monitor suspicious activity, the requirements for reporting certain types of incidents, the requirements and guidelines for external communications and information sharing (e.g., what can be shared with whom, when, and over what channels), and the handoff and escalation points in the incident management process
- Prioritization or severity ratings of incidents
- Performance measures (as discussed in Section 3.4.2)
- Reporting and contact forms.

2.3.2 Plan Elements

Organizations should have a formal, focused, and coordinated approach to responding to incidents, including an incident response plan that provides the roadmap for implementing the incident response capability. Each organization needs a plan that meets its unique requirements, which relates to the organization's mission, size, structure, and functions. The plan should lay out the necessary resources and management support. The incident response plan should include the following elements:

- Mission
- Strategies and goals
- Senior management approval
- Organizational approach to incident response
- How the incident response team will communicate with the rest of the organization and with other organizations
- Metrics for measuring the incident response capability and its effectiveness
- Roadmap for maturing the incident response capability
- How the program fits into the overall organization.

The organization's mission, strategies, and goals for incident response should help in determining the structure of its incident response capability. The incident response program structure should also be discussed within the plan. Section 2.4.1 discusses the types of structures.

Once an organization develops a plan and gains management approval, the organization should implement the plan and review it at least annually to ensure the organization is following the roadmap for maturing the capability and fulfilling their goals for incident response.

2.3.3 Procedure Elements

Procedures should be based on the incident response policy and plan. Standard operating procedures (SOPs) are a delineation of the specific technical processes, techniques, checklists, and forms used by the incident response team. SOPs should be reasonably comprehensive and detailed to ensure that the

priorities of the organization are reflected in response operations. In addition, following standardized responses should minimize errors, particularly those that might be caused by stressful incident handling situations. SOPs should be tested to validate their accuracy and usefulness, then distributed to all team members. Training should be provided for SOP users; the SOP documents can be used as an instructional tool. Suggested SOP elements are presented throughout Section 3.

2.3.4 Sharing Information With Outside Parties

Organizations often need to communicate with outside parties regarding an incident, and they should do so whenever appropriate, such as contacting law enforcement, fielding media inquiries, and seeking external expertise. Another example is discussing incidents with other involved parties, such as Internet service providers (ISPs), the vendor of vulnerable software, or other incident response teams.

Organizations may also proactively share relevant incident indicator information with peers to improve detection and analysis of incidents. The incident response team should discuss information sharing with the organization's public affairs office, legal department, and management before an incident occurs to establish policies and procedures regarding information sharing. Otherwise, sensitive information regarding incidents may be provided to unauthorized parties, potentially leading to additional disruption and financial loss. The team should document all contacts and communications with outside parties for liability and evidentiary purposes.

The following sections provide guidelines on communicating with several types of outside parties, as depicted in Figure 2-1. The double-headed arrows indicate that either party may initiate communications. See Section 4 for additional information on communicating with outside parties, and see Section 2.4 for a discussion of communications involving incident response outsourcers.

**Figure 2-1. Communications with Outside Parties**

2.3.4.1 The Media

The incident handling team should establish media communications procedures that comply with the organization's policies on media interaction and information disclosure.⁷ For discussing incidents with the media, organizations often find it beneficial to designate a single point of contact (POC) and at least one backup contact. The following actions are recommended for preparing these designated contacts and should also be considered for preparing others who may be communicating with the media:

- Conduct training sessions on interacting with the media regarding incidents, which should include the importance of not revealing sensitive information, such as technical details of countermeasures that could assist other attackers, and the positive aspects of communicating important information to the public fully and effectively.
- Establish procedures to brief media contacts on the issues and sensitivities regarding a particular incident before discussing it with the media.

⁷ For example, an organization may want members of its public affairs office and legal department to participate in all incident discussions with the media.

- Maintain a statement of the current status of the incident so that communications with the media are consistent and up-to-date.
- Remind all staff of the general procedures for handling media inquiries.
- Hold mock interviews and press conferences during incident handling exercises. The following are examples of questions to ask the media contact:
 - Who attacked you? Why?
 - When did it happen? How did it happen? Did this happen because you have poor security practices?
 - How widespread is this incident? What steps are you taking to determine what happened and to prevent future occurrences?
 - What is the impact of this incident? Was any personally identifiable information (PII) exposed? What is the estimated cost of this incident?

2.3.4.2 Law Enforcement

One reason that many security-related incidents do not result in convictions is that some organizations do not properly contact law enforcement. Several levels of law enforcement are available to investigate incidents: for example, within the United States, Federal investigatory agencies (e.g., the Federal Bureau of Investigation [FBI] and the U.S. Secret Service), district attorney offices, state law enforcement, and local (e.g., county) law enforcement. Law enforcement agencies in other countries may also be involved, such as for attacks launched from or directed at locations outside the US. In addition, agencies have an Office of Inspector General (OIG) for investigation of violation of the law within each agency. The incident response team should become acquainted with its various law enforcement representatives before an incident occurs to discuss conditions under which incidents should be reported to them, how the reporting should be performed, what evidence should be collected, and how it should be collected.

Law enforcement should be contacted through designated individuals in a manner consistent with the requirements of the law and the organization’s procedures. Many organizations prefer to appoint one incident response team member as the primary POC with law enforcement. This person should be familiar with the reporting procedures for all relevant law enforcement agencies and well prepared to recommend which agency, if any, should be contacted. Note that the organization typically should not contact multiple agencies because doing so might result in jurisdictional conflicts. The incident response team should understand what the potential jurisdictional issues are (e.g., physical location—an organization based in one state has a server located in a second state attacked from a system in a third state, being used remotely by an attacker in a fourth state).

2.3.4.3 Incident Reporting Organizations

FISMA requires Federal agencies to report incidents to the United States Computer Emergency Readiness Team (US-CERT),⁸ which is a governmentwide incident response organization that assists Federal civilian agencies in their incident handling efforts. US-CERT does not replace existing agency response teams; rather, it augments the efforts of Federal civilian agencies by serving as a focal point for dealing with incidents. US-CERT analyzes the agency-provided information to identify trends and indicators of attacks; these are easier to discern when reviewing data from many organizations than when reviewing the data of a single organization.

⁸ <http://www.us-cert.gov/>

Each agency must designate a primary and secondary POC with US-CERT and report all incidents consistent with the agency’s incident response policy. Organizations should create a policy that states who is designated to report incidents and how the incidents should be reported. Requirements, categories, and timeframes for reporting incidents to US-CERT are on the US-CERT website.⁹ All Federal agencies must ensure that their incident response procedures adhere to US-CERT’s reporting requirements and that the procedures are followed properly.

All organizations are encouraged to report incidents to their appropriate CSIRTs. If an organization does not have its own CSIRT to contact, it can report incidents to other organizations, including Information Sharing and Analysis Centers (ISACs). One of the functions of these industry-specific private sector groups is to share important computer security-related information among their members. Several ISACs have been formed for industry sectors such as Communications, Electric Sector, Financial Services, Information Technology, and Research and Education.¹⁰

2.3.4.4 Other Outside Parties

An organization may want to discuss incidents with other groups, including those listed below. When reaching out to these external parties, an organization may want to work through US-CERT or its ISAC, as a “trusted introducer” to broker the relationship. It is likely that others are experiencing similar issues, and the trusted introducer can ensure that any such patterns are identified and taken into consideration.

- **Organization’s ISP.** An organization may need assistance from its ISP in blocking a major network-based attack or tracing its origin.
- **Owners of Attacking Addresses.** If attacks are originating from an external organization’s IP address space, incident handlers may want to talk to the designated security contacts for the organization to alert them to the activity or to ask them to collect evidence. It is highly recommended to coordinate such communications with US-CERT or an ISAC.
- **Software Vendors.** Incident handlers may want to speak to a software vendor about suspicious activity. This contact could include questions regarding the significance of certain log entries or known false positives for certain intrusion detection signatures, where minimal information regarding the incident may need to be revealed. More information may need to be provided in some cases—for example, if a server appears to have been compromised through an unknown software vulnerability. Software vendors may also provide information on known threats (e.g., new attacks) to help organizations understand the current threat environment.
- **Other Incident Response Teams.** An organization may experience an incident that is similar to ones handled by other teams; proactively sharing information can facilitate more effective and efficient incident handling (e.g., providing advance warning, increasing preparedness, developing situational awareness). Groups such as the Forum of Incident Response and Security Teams (FIRST)¹¹, the Government Forum of Incident Response and Security Teams (GFIRST)¹², and the Anti-Phishing Working Group (APWG)¹³ are not incident response teams, but they promote information sharing among incident response teams.
- **Affected External Parties.** An incident may affect external parties directly—for example, an outside organization may contact the organization and claim that one of the organization’s users is attacking

⁹ <http://www.us-cert.gov/federal/reportingRequirements.html>

¹⁰ See the National Council of ISACs website at <http://www.isaccouncil.org/> for a list of ISACs.

¹¹ <http://www.first.org/>

¹² GFIRST is specifically for Federal departments and agencies. (<http://www.us-cert.gov/federal/gfirst.html>)

¹³ <http://www.antiphishing.org/>

it. Another way in which external parties may be affected is if an attacker gains access to sensitive information regarding them, such as credit card information. In some jurisdictions, organizations are required to notify all parties that are affected by such an incident. Regardless of the circumstances, it is preferable for the organization to notify affected external parties of an incident before the media or other external organizations do so. Handlers should be careful to give out only appropriate information—the affected parties may request details about internal investigations that should not be revealed publicly.

OMB Memorandum M-07-16, *Safeguarding Against and Responding to the Breach of Personally Identifiable Information*, requires Federal agencies to develop and implement a breach notification policy for personally identifiable information (PII).¹⁴ Incident handlers should understand how their incident handling actions should differ when a PII breach is suspected to have occurred, such as notifying additional parties or notifying parties within a shorter timeframe. Specific recommendations for PII breach notification policies are presented in OMB Memorandum M-07-16. Also, the National Conference of State Legislatures has a list of state security breach notification laws.¹⁵

2.4 Incident Response Team Structure

An incident response team should be available for anyone who discovers or suspects that an incident involving the organization has occurred. One or more team members, depending on the magnitude of the incident and availability of personnel, will then handle the incident. The incident handlers analyze the incident data, determine the impact of the incident, and act appropriately to limit the damage and restore normal services. The incident response team's success depends on the participation and cooperation of individuals throughout the organization. This section identifies such individuals, discusses incident response team models, and provides advice on selecting an appropriate model.

2.4.1 Team Models

Possible structures for an incident response team include the following:

- **Central Incident Response Team.** A single incident response team handles incidents throughout the organization. This model is effective for small organizations and for organizations with minimal geographic diversity in terms of computing resources.
- **Distributed Incident Response Teams.** The organization has multiple incident response teams, each responsible for a particular logical or physical segment of the organization. This model is effective for large organizations (e.g., one team per division) and for organizations with major computing resources at distant locations (e.g., one team per geographic region, one team per major facility). However, the teams should be part of a single coordinated entity so that the incident response process is consistent across the organization and information is shared among teams. This is particularly important because multiple teams may see components of the same incident or may handle similar incidents.
- **Coordinating Team.** An incident response team provides advice to other teams without having authority over those teams—for example, a departmentwide team may assist individual agencies' teams. This model can be thought of as a CSIRT for CSIRTs. Because the focus of this document is

¹⁴ <http://www.whitehouse.gov/omb/memoranda/fy2007/m07-16.pdf>

¹⁵ <http://www.ncsl.org/default.aspx?tabid=13489>

central and distributed CSIRTs, the coordinating team model is not addressed in detail in this document.¹⁶

Incident response teams can also use any of three staffing models:

- **Employees.** The organization performs all of its incident response work, with limited technical and administrative support from contractors.
- **Partially Outsourced.** The organization outsources portions of its incident response work. Section 2.4.2 discusses the major factors that should be considered with outsourcing. Although incident response duties can be divided among the organization and one or more outsourcers in many ways, a few arrangements have become commonplace:
 - The most prevalent arrangement is for the organization to outsource 24-hours-a-day, 7-days-a-week (24/7) monitoring of intrusion detection sensors, firewalls, and other security devices to an offsite managed security services provider (MSSP). The MSSP identifies and analyzes suspicious activity and reports each detected incident to the organization's incident response team.
 - Some organizations perform basic incident response work in-house and call on contractors to assist with handling incidents, particularly those that are more serious or widespread.
- **Fully Outsourced.** The organization completely outsources its incident response work, typically to an onsite contractor. This model is most likely to be used when the organization needs a full-time, onsite incident response team but does not have enough available, qualified employees. It is assumed that the organization will have employees supervising and overseeing the outsourcer's work.

2.4.2 Team Model Selection

When selecting appropriate structure and staffing models for an incident response team, organizations should consider the following factors:

- **The Need for 24/7 Availability.** Most organizations need incident response staff to be available 24/7. This typically means that incident handlers can be contacted by phone, but it can also mean that an onsite presence is required. Real-time availability is the best for incident response because the longer an incident lasts, the more potential there is for damage and loss. Real-time contact is often needed when working with other organizations—for example, tracing an attack back to its source.
- **Full-Time Versus Part-Time Team Members.** Organizations with limited funding, staffing, or incident response needs may have only part-time incident response team members, serving as more of a virtual incident response team. In this case, the incident response team can be thought of as a volunteer fire department. When an emergency occurs, the team members are contacted rapidly, and those who can assist do so. An existing group such as the IT help desk can act as a first POC for incident reporting. The help desk members can be trained to perform the initial investigation and data gathering and then alert the incident response team if it appears that a serious incident has occurred.
- **Employee Morale.** Incident response work is very stressful, as are the on-call responsibilities of most team members. This combination makes it easy for incident response team members to become overly stressed. Many organizations will also struggle to find willing, available, experienced, and properly skilled people to participate, particularly in 24-hour support. Segregating roles, particularly

¹⁶ Information about the Coordinating team model, as well as extensive information on other team models, is available in a CERT®/CC document titled *Organizational Models for Computer Security Incident Response Teams (CSIRTs)* (<http://www.cert.org/archive/pdf/03hb001.pdf>).

reducing the amount of administrative work that team members are responsible for performing, can be a significant boost to morale.

- **Cost.** Cost is a major factor, especially if employees are required to be onsite 24/7. Organizations may fail to include incident response-specific costs in budgets, such as sufficient funding for training and maintaining skills. Because the incident response team works with so many facets of IT, its members need much broader knowledge than most IT staff members. They must also understand how to use the tools of incident response, such as digital forensics software. Other costs that may be overlooked are physical security for the team's work areas and communications mechanisms.
- **Staff Expertise.** Incident handling requires specialized knowledge and experience in several technical areas; the breadth and depth of knowledge required varies based on the severity of the organization's risks. Outsourcers may possess deeper knowledge of intrusion detection, forensics, vulnerabilities, exploits, and other aspects of security than employees of the organization. Also, MSSPs may be able to correlate events among customers so that they can identify new threats more quickly than any individual customer could. However, technical staff members within the organization usually have much better knowledge of the organization's environment than an outsourcer would, which can be beneficial in identifying false positives associated with organization-specific behavior and the criticality of targets. Section 2.4.3 contains additional information on recommended team member skills.

When considering outsourcing, organizations should keep these issues in mind:

- **Current and Future Quality of Work.** Organizations should consider not only the current quality (breadth and depth) of the outsourcer's work, but also efforts to ensure the quality of future work—for example, minimizing turnover and burnout and providing a solid training program for new employees. Organizations should think about how they could objectively assess the quality of the outsourcer's work.
- **Division of Responsibilities.** Organizations are often unwilling to give an outsourcer authority to make operational decisions for the environment (e.g., disconnecting a web server). It is important to document the appropriate actions for these decision points. For example, one partially outsourced model addresses this issue by having the outsourcer provide incident data to the organization's internal team, along with recommendations for further handling the incident. The internal team ultimately makes the operational decisions, with the outsourcer continuing to provide support as needed.
- **Sensitive Information Revealed to the Contractor.** Dividing incident response responsibilities and restricting access to sensitive information can limit this. For example, a contractor may determine what user ID was used in an incident (e.g., ID 123456) but not know what person is associated with the user ID. Employees can then take over the investigation. Non-disclosure agreements (NDAs) are one possible option for protecting the disclosure of sensitive information.
- **Lack of Organization-Specific Knowledge.** Accurate analysis and prioritization of incidents are dependent on specific knowledge of the organization's environment. The organization should provide the outsourcer regularly updated documents that define what incidents it is concerned about, which resources are critical, and what the level of response should be under various sets of circumstances. The organization should also report all changes and updates made to its IT infrastructure, network configuration, and systems. Otherwise, the contractor has to make a best guess as to how each incident should be handled, inevitably leading to mishandled incidents and frustration on both sides. Lack of organization-specific knowledge can also be a problem when incident response is not outsourced if communications are weak among teams or if the organization simply does not collect the necessary information.

- **Lack of Correlation.** Correlation among multiple data sources is very important. If the intrusion detection system records an attempted attack against a web server, but the outsourcer has no access to the server's logs, it may be unable to determine whether the attack was successful. To be efficient, the outsourcer will require administrative privileges to critical systems and security device logs remotely over a secure channel. This will increase administration costs, introduce additional access entry points, and increase the risk of unauthorized disclosure of sensitive information.
- **Handling Incidents at Multiple Locations.** Effective incident response work often requires a physical presence at the organization's facilities. If the outsourcer is offsite, consider where the outsourcer is located, how quickly it can have an incident response team at any facility, and how much this will cost. Consider onsite visits; perhaps there are certain facilities or areas where the outsourcer should not be permitted to work.
- **Maintaining Incident Response Skills In-House.** Organizations that completely outsource incident response should strive to maintain basic incident response skills in-house. Situations may arise in which the outsourcer is unavailable, so the organization should be prepared to perform its own incident handling. The organization's technical staff must also be able to understand the significance, technical implications, and impact of the outsourcer's recommendations.

2.4.3 Incident Response Personnel

A single employee, with one or more designated alternates, should be in charge of incident response. In a fully outsourced model, this person oversees and evaluates the outsourcer's work. All other models generally have a team manager and one or more deputies who assumes authority in the absence of the team manager. The managers typically perform a variety of tasks, including acting as a liaison with upper management and other teams and organizations, defusing crisis situations, and ensuring that the team has the necessary personnel, resources, and skills. Managers should be technically adept and have excellent communication skills, particularly an ability to communicate to a range of audiences. Managers are ultimately responsible for ensuring that incident response activities are performed properly.

In addition to the team manager and deputy, some teams also have a technical lead—a person with strong technical skills and incident response experience who assumes oversight of and final responsibility for the quality of the team's technical work. The position of technical lead should not be confused with the position of incident lead. Larger teams often assign an incident lead as the primary POC for handling a specific incident; the incident lead is held accountable for the incident's handling. Depending on the size of the incident response team and the magnitude of the incident, the incident lead may not actually perform any actual incident handling, but rather coordinate the handlers' activities, gather information from the handlers, provide incident updates to other groups, and ensure that the team's needs are met.

Members of the incident response team should have excellent technical skills, such as system administration, network administration, programming, technical support, or intrusion detection. Every team member should have good problem solving skills and critical thinking abilities. It is not necessary for every team member to be a technical expert—to a large degree, practical and funding considerations will dictate this—but having at least one highly proficient person in each major area of technology (e.g., commonly attacked operating systems and applications) is a necessity. It may also be helpful to have some team members specialize in particular technical areas, such as network intrusion detection, malware analysis, or forensics. It is also often helpful to temporarily bring in technical specialists that aren't normally part of the team.

It is important to counteract staff burnout by providing opportunities for learning and growth. Suggestions for building and maintaining skills are as follows:

- Budget enough funding to maintain, enhance, and expand proficiency in technical areas and security disciplines, as well as less technical topics such as the legal aspects of incident response. This should include sending staff to conferences and encouraging or otherwise incentivizing participation in conferences, ensuring the availability of technical references that promote deeper technical understanding, and occasionally bringing in outside experts (e.g., contractors) with deep technical knowledge in needed areas as funding permits.
- Give team members opportunities to perform other tasks, such as creating educational materials, conducting security awareness workshops, and performing research.
- Consider rotating staff members in and out of the incident response team, and participate in exchanges in which team members temporarily trade places with others (e.g., network administrators) to gain new technical skills.
- Maintain sufficient staffing so that team members can have uninterrupted time off work (e.g., vacations).
- Create a mentoring program to enable senior technical staff to help less experienced staff learn incident handling.
- Develop incident handling scenarios and have the team members discuss how they would handle them. Appendix A contains a set of scenarios and a list of questions to be used during scenario discussions.

Incident response team members should have other skills in addition to technical expertise. Teamwork skills are of fundamental importance because cooperation and coordination are necessary for successful incident response. Every team member should also have good communication skills. Speaking skills are important because the team will interact with a wide variety of people, and writing skills are important when team members are preparing advisories and procedures. Although not everyone within a team needs to have strong writing and speaking skills, at least a few people within every team should possess them so the team can represent itself well in front of others.

2.4.4 Dependencies within Organizations

It is important to identify other groups within the organization that may need to participate in incident handling so that their cooperation can be solicited before it is needed. Every incident response team relies on the expertise, judgment, and abilities of others, including:

- **Management.** Management establishes incident response policy, budget, and staffing. Ultimately, management is held responsible for coordinating incident response among various stakeholders, minimizing damage, and reporting to Congress, OMB, the General Accounting Office (GAO), and other parties.
- **Information Assurance.** Information security staff members may be needed during certain stages of incident handling (prevention, containment, eradication, and recovery)—for example, to alter network security controls (e.g., firewall rulesets).
- **IT Support.** IT technical experts (e.g., system and network administrators) not only have the needed skills to assist but also usually have the best understanding of the technology they manage on a daily basis. This understanding can ensure that the appropriate actions are taken for the affected system, such as whether to disconnect an attacked system.

- **Legal Department.** Legal experts should review incident response plans, policies, and procedures to ensure their compliance with law and Federal guidance, including the right to privacy. In addition, the guidance of the general counsel or legal department should be sought if there is reason to believe that an incident may have legal ramifications, including evidence collection, prosecution of a suspect, or a lawsuit, or if there may be a need for a memorandum of understanding (MOU) or other binding agreements involving liability limitations for information sharing.
- **Public Affairs and Media Relations.** Depending on the nature and impact of an incident, a need may exist to inform the media and, by extension, the public.
- **Human Resources.** If an employee is suspected of causing an incident, the human resources department may be involved—for example, in assisting with disciplinary proceedings.
- **Business Continuity Planning.** Organizations should ensure that incident response policies and procedures and business continuity processes are in sync. Computer security incidents undermine the business resilience of an organization. Business continuity planning professionals should be made aware of incidents and their impacts so they can fine-tune business impact assessments, risk assessments, and continuity of operations plans. Further, because business continuity planners have extensive expertise in minimizing operational disruption during severe circumstances, they may be valuable in planning responses to certain situations, such as denial of service (DoS) conditions.
- **Physical Security and Facilities Management.** Some computer security incidents occur through breaches of physical security or involve coordinated logical and physical attacks. The incident response team also may need access to facilities during incident handling—for example, to acquire a compromised workstation from a locked office.

2.5 Incident Response Team Services

The main focus of an incident response team is performing incident response, but it is fairly rare for a team to perform incident response only. The following are examples of other services a team might offer:

- **Intrusion Detection.** The first tier of an incident response team often assumes responsibility for intrusion detection.¹⁷ The team generally benefits because it should be poised to analyze incidents more quickly and accurately, based on the knowledge it gains of intrusion detection technologies.
- **Advisory Distribution.** A team may issue advisories within the organization regarding new vulnerabilities and threats.¹⁸ Automated methods should be used whenever appropriate to disseminate information; for example, the National Vulnerability Database (NVD) provides information via XML and RSS feeds when new vulnerabilities are added to it.¹⁹ Advisories are often most necessary when new threats are emerging, such as a high-profile social or political event (e.g., celebrity wedding) that attackers are likely to leverage in their social engineering. Only one group within the organization should distribute computer security advisories to avoid duplicated effort and conflicting information.
- **Education and Awareness.** Education and awareness are resource multipliers—the more the users and technical staff know about detecting, reporting, and responding to incidents, the less drain there

¹⁷ See NIST SP 800-94, *Guide to Intrusion Detection and Prevention Systems (IDPS)* for more information on IDPS technologies. It is available at <http://csrc.nist.gov/publications/PubsSPs.html#800-94>.

¹⁸ Teams should word advisories so that they do not blame any person or organization for security issues. Teams should meet with legal advisors to discuss the possible need for a disclaimer in advisories, stating that the team and organization has no liability in regard to the accuracy of the advisory. This is most pertinent when advisories may be sent to contractors, vendors, and other nonemployees who are users of the organization's computing resources.

¹⁹ <http://nvd.nist.gov/>

should be on the incident response team. This information can be communicated through many means: workshops, websites, newsletters, posters, and even stickers on monitors and laptops.

- **Information Sharing.** Incident response teams often participate in information sharing groups, such as ISACs or regional partnerships. Accordingly, incident response teams often manage the organization's incident information sharing efforts, such as aggregating information related to incidents and effectively sharing that information with other organizations, as well as ensuring that pertinent information is shared within the enterprise.

2.6 Recommendations

The key recommendations presented in this section for organizing a computer security incident handling capability are summarized below.

- **Establish a formal incident response capability.** Organizations should be prepared to respond quickly and effectively when computer security defenses are breached. FISMA requires Federal agencies to establish incident response capabilities.
- **Create an incident response policy.** The incident response policy is the foundation of the incident response program. It defines which events are considered incidents, establishes the organizational structure for incident response, defines roles and responsibilities, and lists the requirements for reporting incidents, among other items.
- **Develop an incident response plan based on the incident response policy.** The incident response plan provides a roadmap for implementing an incident response program based on the organization's policy. The plan indicates both short- and long-term goals for the program, including metrics for measuring the program. The incident response plan should also indicate how often incident handlers should be trained and the requirements for incident handlers.
- **Develop incident response procedures.** The incident response procedures provide detailed steps for responding to an incident. The procedures should cover all the phases of the incident response process. The procedures should be based on the incident response policy and plan.
- **Establish policies and procedures regarding incident-related information sharing.** The organization should communicate appropriate incident details with outside parties, such as the media, law enforcement agencies, and incident reporting organizations. The incident response team should discuss this with the organization's public affairs office, legal department, and management to establish policies and procedures regarding information sharing. The team should comply with existing organization policy on interacting with the media and other outside parties.
- **Provide pertinent information on incidents to the appropriate organization.** Federal civilian agencies are required to report incidents to US-CERT; other organizations can contact US-CERT and/or their ISAC. Reporting is beneficial because US-CERT and the ISACs use the reported data to provide information to the reporting parties regarding new threats and incident trends.
- **Consider the relevant factors when selecting an incident response team model.** Organizations should carefully weigh the advantages and disadvantages of each possible team structure model and staffing model in the context of the organization's needs and available resources.
- **Select people with appropriate skills for the incident response team.** The credibility and proficiency of the team depend to a large extent on the technical skills and critical thinking abilities of its members. Critical technical skills include system administration, network administration, programming, technical support, and intrusion detection. Teamwork and communications skills are

also needed for effective incident handling. Necessary training should be provided to all team members.

- **Identify other groups within the organization that may need to participate in incident handling.** Every incident response team relies on the expertise, judgment, and abilities of other teams, including management, information assurance, IT support, legal, public affairs, and facilities management.
- **Determine which services the team should offer.** Although the main focus of the team is incident response, most teams perform additional functions. Examples include monitoring intrusion detection sensors, distributing security advisories, and educating users on security.

3. Handling an Incident

The incident response process has several phases. The initial phase involves establishing and training an incident response team, and acquiring the necessary tools and resources. During preparation, the organization also attempts to limit the number of incidents that will occur by selecting and implementing a set of controls based on the results of risk assessments. However, residual risk will inevitably persist after controls are implemented. Detection of security breaches is thus necessary to alert the organization whenever incidents occur. In keeping with the severity of the incident, the organization can mitigate the impact of the incident by containing it and ultimately recovering from it. During this phase, activity often cycles back to detection and analysis—for example, to see if additional hosts are infected by malware while eradicating a malware incident. After the incident is adequately handled, the organization issues a report that details the cause and cost of the incident and the steps the organization should take to prevent future incidents. This section describes the major phases of the incident response process—preparation, detection and analysis, containment, eradication and recovery, and post-incident activity—in detail. Figure 3-1 illustrates the incident response life cycle.

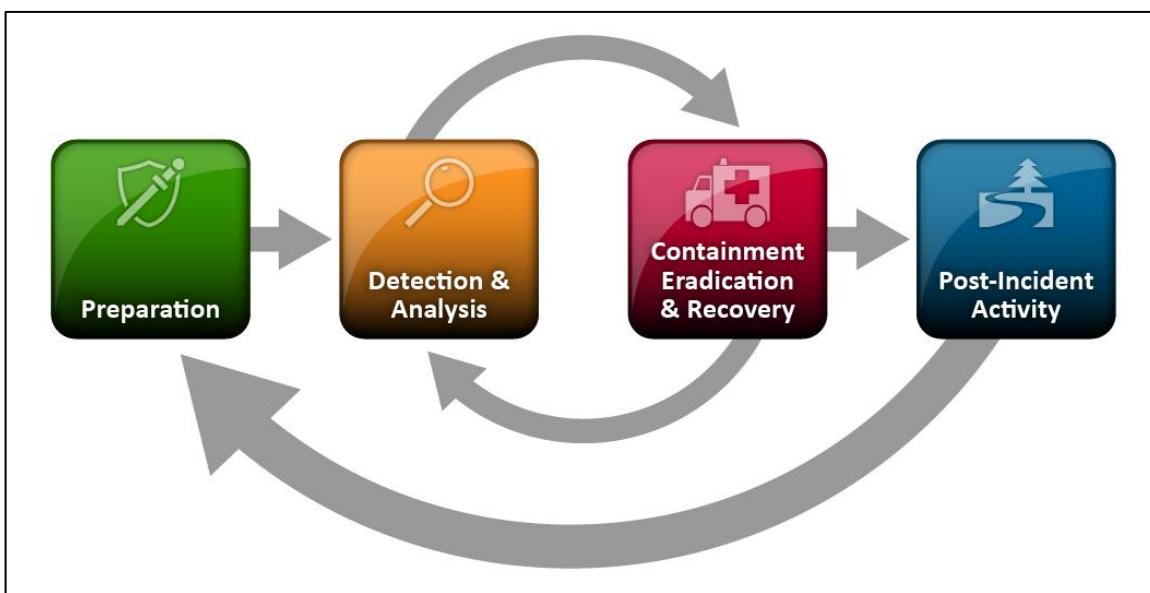


Figure 3-1. Incident Response Life Cycle

3.1 Preparation

Incident response methodologies typically emphasize preparation—not only establishing an incident response capability so that the organization is ready to respond to incidents, but also preventing incidents by ensuring that systems, networks, and applications are sufficiently secure. Although the incident response team is not typically responsible for incident prevention, it is fundamental to the success of incident response programs. This section provides basic advice on preparing to handle incidents and on preventing incidents.

3.1.1 Preparing to Handle Incidents

The lists below provide examples of tools and resources available that may be of value during incident handling. These lists are intended to be a starting point for discussions about which tools and resources an organization's incident handlers need. For example, smartphones are one way to have resilient emergency

communication and coordination mechanisms. An organization should have multiple (separate and different) communication and coordination mechanisms in case of failure of one mechanism.

Incident Handler Communications and Facilities:

- **Contact information** for team members and others within and outside the organization (primary and backup contacts), such as law enforcement and other incident response teams; information may include phone numbers, email addresses, public encryption keys (in accordance with the encryption software described below), and instructions for verifying the contact's identity
- **On-call information** for other teams within the organization, including escalation information
- **Incident reporting mechanisms**, such as phone numbers, email addresses, online forms, and secure instant messaging systems that users can use to report suspected incidents; at least one mechanism should permit people to report incidents anonymously
- **Issue tracking system** for tracking incident information, status, etc.
- **Smartphones** to be carried by team members for off-hour support and onsite communications
- **Encryption software** to be used for communications among team members, within the organization and with external parties; for Federal agencies, software must use a FIPS-validated encryption algorithm²⁰
- **War room** for central communication and coordination; if a permanent war room is not necessary or practical, the team should create a procedure for procuring a temporary war room when needed
- **Secure storage facility** for securing evidence and other sensitive materials

Incident Analysis Hardware and Software:

- **Digital forensic workstations**²¹ and/or **backup devices** to create disk images, preserve log files, and save other relevant incident data
- **Laptops** for activities such as analyzing data, sniffing packets, and writing reports
- **Spare workstations, servers, and networking equipment, or the virtualized equivalents**, which may be used for many purposes, such as restoring backups and trying out malware
- **Blank removable media**
- **Portable printer** to print copies of log files and other evidence from non-networked systems
- **Packet sniffers and protocol analyzers** to capture and analyze network traffic
- **Digital forensic software** to analyze disk images
- **Removable media** with trusted versions of programs to be used to gather evidence from systems
- **Evidence gathering accessories**, including hard-bound notebooks, digital cameras, audio recorders, chain of custody forms, evidence storage bags and tags, and evidence tape, to preserve evidence for possible legal actions

²⁰ FIPS 140-2, *Security Requirements for Cryptographic Modules*, <http://csrc.nist.gov/publications/PubsFIPS.html>.

²¹ A digital forensic workstation is specially designed to assist incident handlers in acquiring and analyzing data. These workstations typically contain a set of removable hard drives that can be used for evidence storage.

Incident Analysis Resources:

- **Port lists**, including commonly used ports and Trojan horse ports
- **Documentation** for OSs, applications, protocols, and intrusion detection and antivirus products
- **Network diagrams and lists of critical assets**, such as database servers
- **Current baselines** of expected network, system, and application activity
- **Cryptographic hashes** of critical files²² to speed incident analysis, verification, and eradication

Incident Mitigation Software:

- **Access to images** of clean OS and application installations for restoration and recovery purposes

Many incident response teams create a *jump kit*, which is a portable case that contains materials that may be needed during an investigation. The jump kit should be ready to go at all times. Jump kits contain many of the same items listed in the bulleted lists above. For example, each jump kit typically includes a laptop, loaded with appropriate software (e.g., packet sniffers, digital forensics). Other important materials include backup devices, blank media, and basic networking equipment and cables. Because the purpose of having a jump kit is to facilitate faster responses, the team should avoid borrowing items from the jump kit.

Each incident handler should have access to at least two computing devices (e.g., laptops). One, such as the one from the jump kit, should be used to perform packet sniffing, malware analysis, and all other actions that risk contaminating the laptop that performs them. This laptop should be scrubbed and all software reinstalled before it is used for another incident. Note that because this laptop is special purpose, it is likely to use software other than the standard enterprise tools and configurations, and whenever possible the incident handlers should be allowed to specify basic technical requirements for these special-purpose investigative laptops. In addition to an investigative laptop, each incident handler should also have a standard laptop, smart phone, or other computing device for writing reports, reading email, and performing other duties unrelated to the hands-on incident analysis.

Exercises involving simulated incidents can also be very useful for preparing staff for incident handling; see NIST SP 800-84 for more information on exercises²³ and Appendix A for sample exercise scenarios.

3.1.2 Preventing Incidents

Keeping the number of incidents reasonably low is very important to protect the business processes of the organization. If security controls are insufficient, higher volumes of incidents may occur, overwhelming the incident response team. This can lead to slow and incomplete responses, which translate to a larger negative business impact (e.g., more extensive damage, longer periods of service and data unavailability).

It is outside the scope of this document to provide specific advice on securing networks, systems, and applications. Although incident response teams are generally not responsible for securing resources, they can be advocates of sound security practices. An incident response team may be able to identify problems that the organization is otherwise not aware of; the team can play a key role in risk assessment and training by identifying gaps. Other documents already provide advice on general security concepts and

²² The National Software Reference Library (NSRL) Project maintains records of hashes of various files, including operating system, application, and graphic image files. The hashes can be downloaded from <http://www.nsrl.nist.gov/>.

²³ *Guide to Test, Training, and Exercise Programs for IT Plans and Capabilities*, <http://csrc.nist.gov/publications/PubsSPs.html#800-84>

operating system and application-specific guidelines.²⁴ The following text, however, provides a brief overview of some of the main recommended practices for securing networks, systems, and applications:

- **Risk Assessments.** Periodic risk assessments of systems and applications should determine what risks are posed by combinations of threats and vulnerabilities.²⁵ This should include understanding the applicable threats, including organization-specific threats. Each risk should be prioritized, and the risks can be mitigated, transferred, or accepted until a reasonable overall level of risk is reached. Another benefit of conducting risk assessments regularly is that critical resources are identified, allowing staff to emphasize monitoring and response activities for those resources.²⁶
- **Host Security.** All hosts should be hardened appropriately using standard configurations. In addition to keeping each host properly patched, hosts should be configured to follow the principle of least privilege—granting users only the privileges necessary for performing their authorized tasks. Hosts should have auditing enabled and should log significant security-related events. The security of hosts and their configurations should be continuously monitored.²⁷ Many organizations use Security Content Automation Protocol (SCAP)²⁸ expressed operating system and application configuration checklists to assist in securing hosts consistently and effectively.²⁹
- **Network Security.** The network perimeter should be configured to deny all activity that is not expressly permitted. This includes securing all connection points, such as virtual private networks (VPNs) and dedicated connections to other organizations.
- **Malware Prevention.** Software to detect and stop malware should be deployed throughout the organization. Malware protection should be deployed at the host level (e.g., server and workstation operating systems), the application server level (e.g., email server, web proxies), and the application client level (e.g., email clients, instant messaging clients).³⁰
- **User Awareness and Training.** Users should be made aware of policies and procedures regarding appropriate use of networks, systems, and applications. Applicable lessons learned from previous incidents should also be shared with users so they can see how their actions could affect the organization. Improving user awareness regarding incidents should reduce the frequency of incidents. IT staff should be trained so that they can maintain their networks, systems, and applications in accordance with the organization’s security standards.

²⁴ <http://csrc.nist.gov/publications/PubsSPs.html> provides links to the NIST Special Publications on computer security, which include documents on operating system and application security baselines.

²⁵ Guidelines on risk assessment are available in NIST SP 800-30, *Guide for Conducting Risk Assessments*, at <http://csrc.nist.gov/publications/PubsSPs.html#800-30-Rev1>.

²⁶ Information on identifying critical resources is discussed in FIPS 199, *Standards for Security Categorization of Federal Information and Information Systems*, at <http://csrc.nist.gov/publications/PubsFIPS.html>.

²⁷ For more information on continuous monitoring, see NIST SP 800-137, *Information Security Continuous Monitoring for Federal Information Systems and Organizations* (<http://csrc.nist.gov/publications/PubsSPs.html#800-137>).

²⁸ More information on SCAP is available from NIST SP 800-117 Revision 1, *Guide to Adopting and Using the Security Content Automation Protocol (SCAP) Version 1.2* (<http://csrc.nist.gov/publications/PubsSPs.html#800-117>).

²⁹ NIST hosts a security checklists repository at <http://checklists.nist.gov/>.

³⁰ More information on malware prevention is available from NIST SP 800-83, *Guide to Malware Incident Prevention and Handling* (<http://csrc.nist.gov/publications/PubsSPs.html#800-83>).

3.2 Detection and Analysis

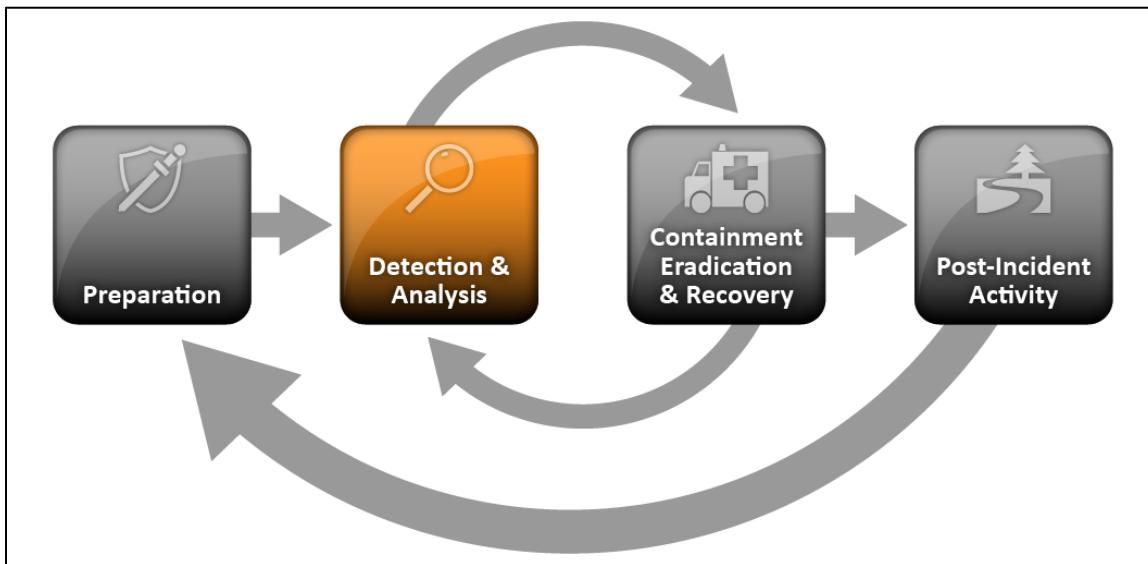


Figure 3-2. Incident Response Life Cycle (Detection and Analysis)

3.2.1 Attack Vectors

Incidents can occur in countless ways, so it is infeasible to develop step-by-step instructions for handling every incident. Organizations should be generally prepared to handle any incident but should focus on being prepared to handle incidents that use common attack vectors. Different types of incidents merit different response strategies. The attack vectors listed below are not intended to provide definitive classification for incidents; rather, they simply list common methods of attack, which can be used as a basis for defining more specific handling procedures.

- **External/Removable Media:** An attack executed from removable media or a peripheral device—for example, malicious code spreading onto a system from an infected USB flash drive.
- **Attrition:** An attack that employs brute force methods to compromise, degrade, or destroy systems, networks, or services (e.g., a DDoS intended to impair or deny access to a service or application; a brute force attack against an authentication mechanism, such as passwords, CAPTCHAS, or digital signatures).
- **Web:** An attack executed from a website or web-based application—for example, a cross-site scripting attack used to steal credentials or a redirect to a site that exploits a browser vulnerability and installs malware.
- **Email:** An attack executed via an email message or attachment—for example, exploit code disguised as an attached document or a link to a malicious website in the body of an email message.
- **Impersonation:** An attack involving replacement of something benign with something malicious—for example, spoofing, man in the middle attacks, rogue wireless access points, and SQL injection attacks all involve impersonation.
- **Improper Usage:** Any incident resulting from violation of an organization's acceptable usage policies by an authorized user, excluding the above categories; for example, a user installs file sharing software, leading to the loss of sensitive data; or a user performs illegal activities on a system.

- **Loss or Theft of Equipment:** The loss or theft of a computing device or media used by the organization, such as a laptop, smartphone, or authentication token.
- **Other:** An attack that does not fit into any of the other categories.

This section focuses on recommended practices for handling any type of incident. It is outside the scope of this publication to give specific advice based on the attack vectors; such guidelines would be provided in separate publications addressing other incident handling topics, such as NIST SP 800-83 on malware incident prevention and handling.

3.2.2 Signs of an Incident

For many organizations, the most challenging part of the incident response process is accurately detecting and assessing possible incidents—determining whether an incident has occurred and, if so, the type, extent, and magnitude of the problem. What makes this so challenging is a combination of three factors:

- Incidents may be detected through many different means, with varying levels of detail and fidelity. Automated detection capabilities include network-based and host-based IDPSs, antivirus software, and log analyzers. Incidents may also be detected through manual means, such as problems reported by users. Some incidents have overt signs that can be easily detected, whereas others are almost impossible to detect.
- The volume of potential signs of incidents is typically high—for example, it is not uncommon for an organization to receive thousands or even millions of intrusion detection sensor alerts per day. (See Section 3.2.4 for information on analyzing such alerts.)
- Deep, specialized technical knowledge and extensive experience are necessary for proper and efficient analysis of incident-related data.

Signs of an incident fall into one of two categories: precursors and indicators. A *precursor* is a sign that an incident may occur in the future. An *indicator* is a sign that an incident may have occurred or may be occurring now.

Most attacks do not have any identifiable or detectable precursors from the target’s perspective. If precursors are detected, the organization may have an opportunity to prevent the incident by altering its security posture to save a target from attack. At a minimum, the organization could monitor activity involving the target more closely. Examples of precursors are:

- Web server log entries that show the usage of a vulnerability scanner
- An announcement of a new exploit that targets a vulnerability of the organization’s mail server
- A threat from a group stating that the group will attack the organization.

While precursors are relatively rare, indicators are all too common. Too many types of indicators exist to exhaustively list them, but some examples are listed below:

- A network intrusion detection sensor alerts when a buffer overflow attempt occurs against a database server.
- Antivirus software alerts when it detects that a host is infected with malware.
- A system administrator sees a filename with unusual characters.
- A host records an auditing configuration change in its log.

- An application logs multiple failed login attempts from an unfamiliar remote system.
- An email administrator sees a large number of bounced emails with suspicious content.
- A network administrator notices an unusual deviation from typical network traffic flows.

3.2.3 Sources of Precursors and Indicators

Precursors and indicators are identified using many different sources, with the most common being computer security software alerts, logs, publicly available information, and people. Table 3-2 lists common sources of precursors and indicators for each category.

Table 3-1. Common Sources of Precursors and Indicators

Source	Description
Alerts	
IDPSs	IDPS products identify suspicious events and record pertinent data regarding them, including the date and time the attack was detected, the type of attack, the source and destination IP addresses, and the username (if applicable and known). Most IDPS products use attack signatures to identify malicious activity; the signatures must be kept up to date so that the newest attacks can be detected. IDPS software often produces <i>false positives</i> —alerts that indicate malicious activity is occurring, when in fact there has been none. Analysts should manually validate IDPS alerts either by closely reviewing the recorded supporting data or by getting related data from other sources. ³¹
SIEMs	Security Information and Event Management (SIEM) products are similar to IDPS products, but they generate alerts based on analysis of log data (see below).
Antivirus and antispam software	Antivirus software detects various forms of malware, generates alerts, and prevents the malware from infecting hosts. Current antivirus products are effective at stopping many instances of malware if their signatures are kept up to date. Antispam software is used to detect spam and prevent it from reaching users' mailboxes. Spam may contain malware, phishing attacks, and other malicious content, so alerts from antispam software may indicate attack attempts.
File integrity checking software	File integrity checking software can detect changes made to important files during incidents. It uses a hashing algorithm to obtain a cryptographic checksum for each designated file. If the file is altered and the checksum is recalculated, an extremely high probability exists that the new checksum will not match the old checksum. By regularly recalculating checksums and comparing them with previous values, changes to files can be detected.
Third-party monitoring services	Third parties offer a variety of subscription-based and free monitoring services. An example is fraud detection services that will notify an organization if its IP addresses, domain names, etc. are associated with current incident activity involving other organizations. There are also free real-time blacklists with similar information. Another example of a third-party monitoring service is a CSIRC notification list; these lists are often available only to other incident response teams.
Logs	
Operating system, service and application logs	Logs from operating systems, services, and applications (particularly audit-related data) are frequently of great value when an incident occurs, such as recording which accounts were accessed and what actions were performed. Organizations should require a baseline level of logging on all systems and a higher baseline level on critical systems. Logs can be used for analysis by correlating event information. Depending on the event information, an alert can be generated to indicate an incident. Section 3.2.4 discusses the value of centralized logging.
Network device logs	Logs from network devices such as firewalls and routers are not typically a primary source of precursors or indicators. Although these devices are usually configured to log blocked connection attempts, they provide little information about the nature of the activity. Still, they can be valuable in identifying network trends and in correlating events detected by other devices.

³¹ See NIST SP 800-94, *Guide to Intrusion Detection and Prevention Systems*, for additional information on IDPS products. It is available at <http://csrc.nist.gov/publications/PubsSPs.html#800-94>.

Source	Description
Network flows	A network flow is a particular communication session occurring between hosts. Routers and other networking devices can provide network flow information, which can be used to find anomalous network activity caused by malware, data exfiltration, and other malicious acts. There are many standards for flow data formats, including NetFlow, sFlow, and IPFIX.
Publicly Available Information	
Information on new vulnerabilities and exploits	Keeping up with new vulnerabilities and exploits can prevent some incidents from occurring and assist in detecting and analyzing new attacks. The National Vulnerability Database (NVD) contains information on vulnerabilities. ³² Organizations such as US-CERT ³³ and CERT®/CC periodically provide threat update information through briefings, web postings, and mailing lists.
People	
People from within the organization	Users, system administrators, network administrators, security staff, and others from within the organization may report signs of incidents. It is important to validate all such reports. One approach is to ask people who provide such information how confident they are of the accuracy of the information. Recording this estimate along with the information provided can help considerably during incident analysis, particularly when conflicting data is discovered.
People from other organizations	Reports of incidents that originate externally should be taken seriously. For example, the organization might be contacted by a party claiming a system at the organization is attacking its systems. External users may also report other indicators, such as a defaced web page or an unavailable service. Other incident response teams also may report incidents. It is important to have mechanisms in place for external parties to report indicators and for trained staff to monitor those mechanisms carefully; this may be as simple as setting up a phone number and email address, configured to forward messages to the help desk.

3.2.4 Incident Analysis

Incident detection and analysis would be easy if every precursor or indicator were guaranteed to be accurate; unfortunately, this is not the case. For example, user-provided indicators such as a complaint of a server being unavailable are often incorrect. Intrusion detection systems may produce false positives—incorrect indicators. These examples demonstrate what makes incident detection and analysis so difficult: each indicator ideally should be evaluated to determine if it is legitimate. Making matters worse, the total number of indicators may be thousands or millions a day. Finding the real security incidents that occurred out of all the indicators can be a daunting task.

Even if an indicator is accurate, it does not necessarily mean that an incident has occurred. Some indicators, such as a server crash or modification of critical files, could happen for several reasons other than a security incident, including human error. Given the occurrence of indicators, however, it is reasonable to suspect that an incident might be occurring and to act accordingly. Determining whether a particular event is actually an incident is sometimes a matter of judgment. It may be necessary to collaborate with other technical and information security personnel to make a decision. In many instances, a situation should be handled the same way regardless of whether it is security related. For example, if an organization is losing Internet connectivity every 12 hours and no one knows the cause, the staff would want to resolve the problem just as quickly and would use the same resources to diagnose the problem, regardless of its cause.

Some incidents are easy to detect, such as an obviously defaced web page. However, many incidents are not associated with such clear symptoms. Small signs such as one change in one system configuration file may be the only indicators that an incident has occurred. In incident handling, detection may be the most difficult task. Incident handlers are responsible for analyzing ambiguous, contradictory, and incomplete symptoms to determine what has happened. Although technical solutions exist that can make detection

³² <http://nvd.nist.gov/>

³³ <http://www.us-cert.gov/cas/signup.html>

easier, the best remedy is to build a team of highly experienced and proficient staff members who can analyze the precursors and indicators effectively and efficiently and take appropriate actions. Without a well-trained and capable staff, incident detection and analysis will be conducted inefficiently, and costly mistakes will be made.

The incident response team should work quickly to analyze and validate each incident, following a pre-defined process and documenting each step taken. When the team believes that an incident has occurred, the team should rapidly perform an initial analysis to determine the incident's scope, such as which networks, systems, or applications are affected; who or what originated the incident; and how the incident is occurring (e.g., what tools or attack methods are being used, what vulnerabilities are being exploited). The initial analysis should provide enough information for the team to prioritize subsequent activities, such as containment of the incident and deeper analysis of the effects of the incident.

Performing the initial analysis and validation is challenging. The following are recommendations for making incident analysis easier and more effective:

- **Profile Networks and Systems.** *Profiling* is measuring the characteristics of expected activity so that changes to it can be more easily identified. Examples of profiling are running file integrity checking software on hosts to derive checksums for critical files and monitoring network bandwidth usage to determine what the average and peak usage levels are on various days and times. In practice, it is difficult to detect incidents accurately using most profiling techniques; organizations should use profiling as one of several detection and analysis techniques.
- **Understand Normal Behaviors.** Incident response team members should study networks, systems, and applications to understand what their normal behavior is so that abnormal behavior can be recognized more easily. No incident handler will have a comprehensive knowledge of all behavior throughout the environment, but handlers should know which experts could fill in the gaps. One way to gain this knowledge is through reviewing log entries and security alerts. This may be tedious if filtering is not used to condense the logs to a reasonable size. As handlers become more familiar with the logs and alerts, they should be able to focus on unexplained entries, which are usually more important to investigate. Conducting frequent log reviews should keep the knowledge fresh, and the analyst should be able to notice trends and changes over time. The reviews also give the analyst an indication of the reliability of each source.
- **Create a Log Retention Policy.** Information regarding an incident may be recorded in several places, such as firewall, IDPS, and application logs. Creating and implementing a log retention policy that specifies how long log data should be maintained may be extremely helpful in analysis because older log entries may show reconnaissance activity or previous instances of similar attacks. Another reason for retaining logs is that incidents may not be discovered until days, weeks, or even months later. The length of time to maintain log data is dependent on several factors, including the organization's data retention policies and the volume of data. See NIST SP 800-92, *Guide to Computer Security Log Management* for additional recommendations related to logging.³⁴
- **Perform Event Correlation.** Evidence of an incident may be captured in several logs that each contain different types of data—a firewall log may have the source IP address that was used, whereas an application log may contain a username. A network IDPS may detect that an attack was launched against a particular host, but it may not know if the attack was successful. The analyst may need to examine the host's logs to determine that information. Correlating events among multiple indicator sources can be invaluable in validating whether a particular incident occurred.

³⁴ <http://csrc.nist.gov/publications/PubsSPs.html#800-92>

- **Keep All Host Clocks Synchronized.** Protocols such as the Network Time Protocol (NTP) synchronize clocks among hosts.³⁵ Event correlation will be more complicated if the devices reporting events have inconsistent clock settings. From an evidentiary standpoint, it is preferable to have consistent timestamps in logs—for example, to have three logs that show an attack occurred at 12:07:01 a.m., rather than logs that list the attack as occurring at 12:07:01, 12:10:35, and 11:07:06.
- **Maintain and Use a Knowledge Base of Information.** The knowledge base should include information that handlers need for referencing quickly during incident analysis. Although it is possible to build a knowledge base with a complex structure, a simple approach can be effective. Text documents, spreadsheets, and relatively simple databases provide effective, flexible, and searchable mechanisms for sharing data among team members. The knowledge base should also contain a variety of information, including explanations of the significance and validity of precursors and indicators, such as IDPS alerts, operating system log entries, and application error codes.
- **Use Internet Search Engines for Research.** Internet search engines can help analysts find information on unusual activity. For example, an analyst may see some unusual connection attempts targeting TCP port 22912. Performing a search on the terms “TCP,” “port,” and “22912” may return some hits that contain logs of similar activity or even an explanation of the significance of the port number. Note that separate workstations should be used for research to minimize the risk to the organization from conducting these searches.
- **Run Packet Sniffers to Collect Additional Data.** Sometimes the indicators do not record enough detail to permit the handler to understand what is occurring. If an incident is occurring over a network, the fastest way to collect the necessary data may be to have a packet sniffer capture network traffic. Configuring the sniffer to record traffic that matches specified criteria should keep the volume of data manageable and minimize the inadvertent capture of other information. Because of privacy concerns, some organizations may require incident handlers to request and receive permission before using packet sniffers.
- **Filter the Data.** There is simply not enough time to review and analyze all the indicators; at minimum the most suspicious activity should be investigated. One effective strategy is to filter out categories of indicators that tend to be insignificant. Another filtering strategy is to show only the categories of indicators that are of the highest significance; however, this approach carries substantial risk because new malicious activity may not fall into one of the chosen indicator categories.
- **Seek Assistance from Others.** Occasionally, the team will be unable to determine the full cause and nature of an incident. If the team lacks sufficient information to contain and eradicate the incident, then it should consult with internal resources (e.g., information security staff) and external resources (e.g., US-CERT, other CSIRTs, contractors with incident response expertise). It is important to accurately determine the cause of each incident so that it can be fully contained and the exploited vulnerabilities can be mitigated to prevent similar incidents from occurring.

3.2.5 Incident Documentation

An incident response team that suspects that an incident has occurred should immediately start recording all facts regarding the incident.³⁶ A logbook is an effective and simple medium for this,³⁷ but laptops,

³⁵ More information on NTP is available at <http://www.ntp.org/>.

³⁶ Incident handlers should log only the facts regarding the incident, not personal opinions or conclusions. Subjective material should be presented in incident reports, not recorded as evidence.

³⁷ If a logbook is used, it is preferable that the logbook is bound and that the incident handlers number the pages, write in ink, and leave the logbook intact (i.e., do not rip out any pages).

audio recorders, and digital cameras can also serve this purpose.³⁸ Documenting system events, conversations, and observed changes in files can lead to a more efficient, more systematic, and less error-prone handling of the problem. Every step taken from the time the incident was detected to its final resolution should be documented and timestamped. Every document regarding the incident should be dated and signed by the incident handler. Information of this nature can also be used as evidence in a court of law if legal prosecution is pursued. Whenever possible, handlers should work in teams of at least two: one person can record and log events while the other person performs the technical tasks. Section 3.3.2 presents more information about evidence.³⁹

The incident response team should maintain records about the status of incidents, along with other pertinent information.⁴⁰ Using an application or a database, such as an issue tracking system, helps ensure that incidents are handled and resolved in a timely manner. The issue tracking system should contain information on the following:

- The current status of the incident (new, in progress, forwarded for investigation, resolved, etc.)
- A summary of the incident
- Indicators related to the incident
- Other incidents related to this incident
- Actions taken by all incident handlers on this incident
- Chain of custody, if applicable
- Impact assessments related to the incident
- Contact information for other involved parties (e.g., system owners, system administrators)
- A list of evidence gathered during the incident investigation
- Comments from incident handlers
- Next steps to be taken (e.g., rebuild the host, upgrade an application).⁴¹

The incident response team should safeguard incident data and restrict access to it because it often contains sensitive information—for example, data on exploited vulnerabilities, recent security breaches, and users that may have performed inappropriate actions. For example, only authorized personnel should have access to the incident database. Incident communications (e.g., emails) and documents should be encrypted or otherwise protected so that only authorized personnel can read them.

³⁸ Consider the admissibility of evidence collected with a device before using it. For example, any devices that are potential sources of evidence should not themselves be used to record other evidence.

³⁹ NIST SP 800-86, *Guide to Integrating Forensic Techniques Into Incident Response*, provides detailed information on establishing a forensic capability, including the development of policies and procedures.

⁴⁰ Appendix B contains a suggested list of data elements to collect when incidents are reported. Also, the CERT®/CC document *State of the Practice of Computer Security Incident Response Teams (CSIRTs)* provides several sample incident reporting forms. The document is available at <http://www.cert.org/archive/pdf/03tr001.pdf>.

⁴¹ The Trans-European Research and Education Networking Association (TERENA) has developed RFC 3067, *TERENA's Incident Object Description and Exchange Format Requirements* (<http://www.ietf.org/rfc/rfc3067.txt>). The document provides recommendations for what information should be collected for each incident. The IETF Extended Incident Handling (inch) Working Group (<http://www.cert.org/ietf/inch/inch.html>) created an RFC that expands on TERENA's work—RFC 5070, *Incident Object Description Exchange Format* (<http://www.ietf.org/rfc/rfc5070.txt>).

3.2.6 Incident Prioritization

Prioritizing the handling of the incident is perhaps the most critical decision point in the incident handling process. Incidents should not be handled on a first-come, first-served basis as a result of resource limitations. Instead, handling should be prioritized based on the relevant factors, such as the following:

- **Functional Impact of the Incident.** Incidents targeting IT systems typically impact the business functionality that those systems provide, resulting in some type of negative impact to the users of those systems. Incident handlers should consider how the incident will impact the existing functionality of the affected systems. Incident handlers should consider not only the current functional impact of the incident, but also the likely future functional impact of the incident if it is not immediately contained.
- **Information Impact of the Incident.** Incidents may affect the confidentiality, integrity, and availability of the organization's information. For example, a malicious agent may exfiltrate sensitive information. Incident handlers should consider how this information exfiltration will impact the organization's overall mission. An incident that results in the exfiltration of sensitive information may also affect other organizations if any of the data pertained to a partner organization.
- **Recoverability from the Incident.** The size of the incident and the type of resources it affects will determine the amount of time and resources that must be spent on recovering from that incident. In some instances it is not possible to recover from an incident (e.g., if the confidentiality of sensitive information has been compromised) and it would not make sense to spend limited resources on an elongated incident handling cycle, unless that effort was directed at ensuring that a similar incident did not occur in the future. In other cases, an incident may require far more resources to handle than what an organization has available. Incident handlers should consider the effort necessary to actually recover from an incident and carefully weigh that against the value the recovery effort will create and any requirements related to incident handling.

Combining the functional impact to the organization's systems and the impact to the organization's information determines the business impact of the incident—for example, a distributed denial of service attack against a public web server may temporarily reduce the functionality for users attempting to access the server, whereas unauthorized root-level access to a public web server may result in the exfiltration of personally identifiable information (PII), which could have a long-lasting impact on the organization's reputation.

The recoverability from the incident determines the possible responses that the team may take when handling the incident. An incident with a high functional impact and low effort to recover from is an ideal candidate for immediate action from the team. However, some incidents may not have smooth recovery paths and may need to be queued for a more strategic-level response—for example, an incident that results in an attacker exfiltrating and publicly posting gigabytes of sensitive data has no easy recovery path since the data is already exposed; in this case the team may transfer part of the responsibility for handling the data exfiltration incident to a more strategic-level team that develops strategy for preventing future breaches and creates an outreach plan for alerting those individuals or organizations whose data was exfiltrated. The team should prioritize the response to each incident based on its estimate of the business impact caused by the incident and the estimated efforts required to recover from the incident.

An organization can best quantify the effect of its own incidents because of its situational awareness. Table 3-2 provides examples of functional impact categories that an organization might use for rating its own incidents. Rating incidents can be helpful in prioritizing limited resources.

Table 3-2. Functional Impact Categories

Category	Definition
None	No effect to the organization's ability to provide all services to all users
Low	Minimal effect; the organization can still provide all critical services to all users but has lost efficiency
Medium	Organization has lost the ability to provide a critical service to a subset of system users
High	Organization is no longer able to provide some critical services to any users

Table 3-3 provides examples of possible information impact categories that describe the extent of information compromise that occurred during the incident. In this table, with the exception of the ‘None’ value, the categories are not mutually exclusive and the organization could choose more than one.

Table 3-3. Information Impact Categories

Category	Definition
None	No information was exfiltrated, changed, deleted, or otherwise compromised
Privacy Breach	Sensitive personally identifiable information (PII) of taxpayers, employees, beneficiaries, etc. was accessed or exfiltrated
Proprietary Breach	Unclassified proprietary information, such as protected critical infrastructure information (PCII), was accessed or exfiltrated
Integrity Loss	Sensitive or proprietary information was changed or deleted

Table 3-4 shows examples of recoverability effort categories that reflect the level of and type of resources required to recover from the incident.

Table 3-4. Recoverability Effort Categories

Category	Definition
Regular	Time to recovery is predictable with existing resources
Supplemented	Time to recovery is predictable with additional resources
Extended	Time to recovery is unpredictable; additional resources and outside help are needed
Not Recoverable	Recovery from the incident is not possible (e.g., sensitive data exfiltrated and posted publicly); launch investigation

Organizations should also establish an escalation process for those instances when the team does not respond to an incident within the designated time. This can happen for many reasons: for example, cell phones may fail or people may have personal emergencies. The escalation process should state how long a person should wait for a response and what to do if no response occurs. Generally, the first step is to duplicate the initial contact. After waiting for a brief time—perhaps 15 minutes—the caller should escalate the incident to a higher level, such as the incident response team manager. If that person does not respond within a certain time, then the incident should be escalated again to a higher level of management. This process should be repeated until someone responds.

3.2.7 Incident Notification

When an incident is analyzed and prioritized, the incident response team needs to notify the appropriate individuals so that all who need to be involved will play their roles. Incident response policies should

include provisions concerning incident reporting—at a minimum, what must be reported to whom and at what times (e.g., initial notification, regular status updates). The exact reporting requirements vary among organizations, but parties that are typically notified include:

- CIO
- Head of information security
- Local information security officer
- Other incident response teams within the organization
- External incident response teams (if appropriate)
- System owner
- Human resources (for cases involving employees, such as harassment through email)
- Public affairs (for incidents that may generate publicity)
- Legal department (for incidents with potential legal ramifications)
- US-CERT (required for Federal agencies and systems operated on behalf of the Federal government; see Section 2.3.4.3)
- Law enforcement (if appropriate)

During incident handling, the team may need to provide status updates to certain parties, even in some cases the entire organization. The team should plan and prepare several communication methods, including out-of-band methods (e.g., in person, paper), and select the methods that are appropriate for a particular incident. Possible communication methods include:

- Email
- Website (internal, external, or portal)
- Telephone calls
- In person (e.g., daily briefings)
- Voice mailbox greeting (e.g., set up a separate voice mailbox for incident updates, and update the greeting message to reflect the current incident status; use the help desk's voice mail greeting)
- Paper (e.g., post notices on bulletin boards and doors, hand out notices at all entrance points).

3.3 Containment, Eradication, and Recovery

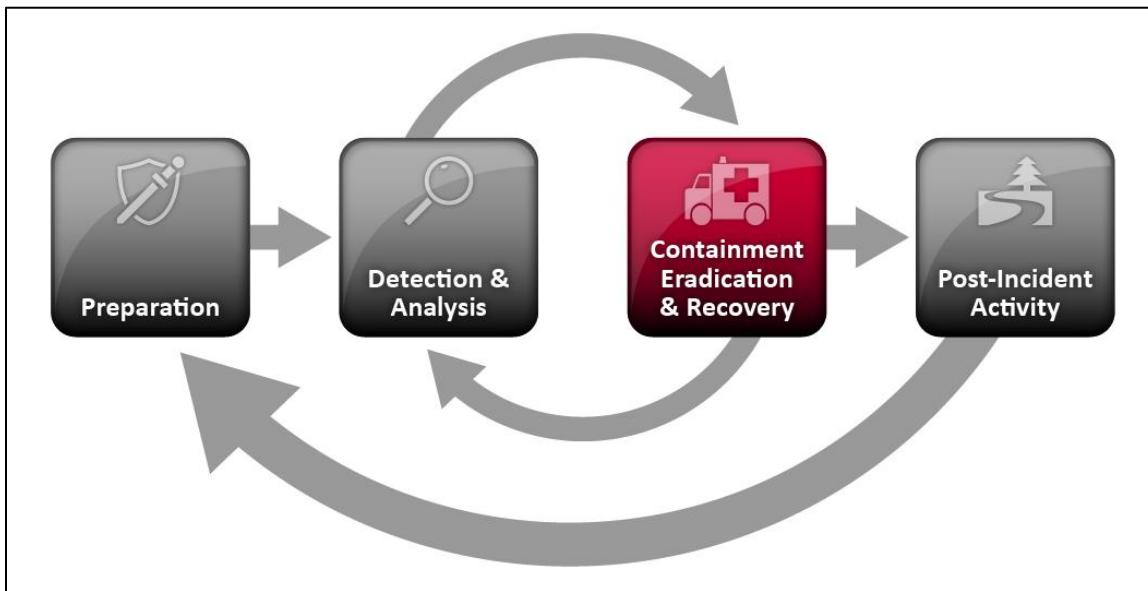


Figure 3-3. Incident Response Life Cycle (Containment, Eradication, and Recovery)

3.3.1 Choosing a Containment Strategy

Containment is important before an incident overwhelms resources or increases damage. Most incidents require containment, so that is an important consideration early in the course of handling each incident. Containment provides time for developing a tailored remediation strategy. An essential part of containment is decision-making (e.g., shut down a system, disconnect it from a network, disable certain functions). Such decisions are much easier to make if there are predetermined strategies and procedures for containing the incident. Organizations should define acceptable risks in dealing with incidents and develop strategies accordingly.

Containment strategies vary based on the type of incident. For example, the strategy for containing an email-borne malware infection is quite different from that of a network-based DDoS attack. Organizations should create separate containment strategies for each major incident type, with criteria documented clearly to facilitate decision-making. Criteria for determining the appropriate strategy include:

- Potential damage to and theft of resources
- Need for evidence preservation
- Service availability (e.g., network connectivity, services provided to external parties)
- Time and resources needed to implement the strategy
- Effectiveness of the strategy (e.g., partial containment, full containment)
- Duration of the solution (e.g., emergency workaround to be removed in four hours, temporary workaround to be removed in two weeks, permanent solution).

In certain cases, some organizations redirect the attacker to a sandbox (a form of containment) so that they can monitor the attacker's activity, usually to gather additional evidence. The incident response team should discuss this strategy with its legal department to determine if it is feasible. Ways of monitoring an

attacker's activity other than sandboxing should not be used; if an organization knows that a system has been compromised and allows the compromise to continue, it may be liable if the attacker uses the compromised system to attack other systems. The delayed containment strategy is dangerous because an attacker could escalate unauthorized access or compromise other systems.

Another potential issue regarding containment is that some attacks may cause additional damage when they are contained. For example, a compromised host may run a malicious process that pings another host periodically. When the incident handler attempts to contain the incident by disconnecting the compromised host from the network, the subsequent pings will fail. As a result of the failure, the malicious process may overwrite or encrypt all the data on the host's hard drive. Handlers should not assume that just because a host has been disconnected from the network, further damage to the host has been prevented.

3.3.2 Evidence Gathering and Handling

Although the primary reason for gathering evidence during an incident is to resolve the incident, it may also be needed for legal proceedings.⁴² In such cases, it is important to clearly document how all evidence, including compromised systems, has been preserved.⁴³ Evidence should be collected according to procedures that meet all applicable laws and regulations that have been developed from previous discussions with legal staff and appropriate law enforcement agencies so that any evidence can be admissible in court.⁴⁴ In addition, evidence should be accounted for at all times; whenever evidence is transferred from person to person, chain of custody forms should detail the transfer and include each party's signature. A detailed log should be kept for all evidence, including the following:

- Identifying information (e.g., the location, serial number, model number, hostname, media access control (MAC) addresses, and IP addresses of a computer)
- Name, title, and phone number of each individual who collected or handled the evidence during the investigation
- Time and date (including time zone) of each occurrence of evidence handling
- Locations where the evidence was stored.

Collecting evidence from computing resources presents some challenges. It is generally desirable to acquire evidence from a system of interest as soon as one suspects that an incident may have occurred. Many incidents cause a dynamic chain of events to occur; an initial system snapshot may do more good in identifying the problem and its source than most other actions that can be taken at this stage. From an evidentiary standpoint, it is much better to get a snapshot of the system as-is rather than doing so after incident handlers, system administrators, and others have inadvertently altered the state of the machine during the investigation. Users and system administrators should be made aware of the steps that they should take to preserve evidence. See NIST SP 800-86, *Guide to Integrating Forensic Techniques into Incident Response*, for additional information on preserving evidence.

⁴² NIST SP 800-86, *Guide to Integrating Forensic Techniques into Incident Response*, provides detailed information on establishing a forensic capability. It focuses on forensic techniques for PCs, but much of the material is applicable to other systems. The document can be found at <http://csrc.nist.gov/publications/PubsSPs.html#800-86>.

⁴³ Evidence gathering and handling is not typically performed for every incident that occurs—for example, most malware incidents do not merit evidence acquisition. In many organizations, digital forensics is not needed for most incidents.

⁴⁴ *Searching and Seizing Computers and Obtaining Electronic Evidence in Criminal Investigations*, from the Computer Crime and Intellectual Property Section (CCIPS) of the Department of Justice, provides legal guidance on evidence gathering. The document is available at <http://www.cybercrime.gov/ssmanual/index.html>.

3.3.3 Identifying the Attacking Hosts

During incident handling, system owners and others sometimes want to or need to identify the attacking host or hosts. Although this information can be important, incident handlers should generally stay focused on containment, eradication, and recovery. Identifying an attacking host can be a time-consuming and futile process that can prevent a team from achieving its primary goal—minimizing the business impact. The following items describe the most commonly performed activities for attacking host identification:

- **Validating the Attacking Host’s IP Address.** New incident handlers often focus on the attacking host’s IP address. The handler may attempt to validate that the address was not spoofed by verifying connectivity to it; however, this simply indicates that a host at that address does or does not respond to the requests. A failure to respond does not mean the address is not real—for example, a host may be configured to ignore pings and traceroutes. Also, the attacker may have received a dynamic address that has already been reassigned to someone else.
- **Researching the Attacking Host through Search Engines.** Performing an Internet search using the apparent source IP address of an attack may lead to more information on the attack—for example, a mailing list message regarding a similar attack.
- **Using Incident Databases.** Several groups collect and consolidate incident data from various organizations into incident databases. This information sharing may take place in many forms, such as trackers and real-time blacklists. The organization can also check its own knowledge base or issue tracking system for related activity.
- **Monitoring Possible Attacker Communication Channels.** Incident handlers can monitor communication channels that may be used by an attacking host. For example, many bots use IRC as their primary means of communication. Also, attackers may congregate on certain IRC channels to brag about their compromises and share information. However, incident handlers should treat any such information that they acquire only as a potential lead, not as fact.

3.3.4 Eradication and Recovery

After an incident has been contained, eradication may be necessary to eliminate components of the incident, such as deleting malware and disabling breached user accounts, as well as identifying and mitigating all vulnerabilities that were exploited. During eradication, it is important to identify all affected hosts within the organization so that they can be remediated. For some incidents, eradication is either not necessary or is performed during recovery.

In recovery, administrators restore systems to normal operation, confirm that the systems are functioning normally, and (if applicable) remediate vulnerabilities to prevent similar incidents. Recovery may involve such actions as restoring systems from clean backups, rebuilding systems from scratch, replacing compromised files with clean versions, installing patches, changing passwords, and tightening network perimeter security (e.g., firewall rulesets, boundary router access control lists). Higher levels of system logging or network monitoring are often part of the recovery process. Once a resource is successfully attacked, it is often attacked again, or other resources within the organization are attacked in a similar manner.

Eradication and recovery should be done in a phased approach so that remediation steps are prioritized. For large-scale incidents, recovery may take months; the intent of the early phases should be to increase the overall security with relatively quick (days to weeks) high value changes to prevent future incidents. The later phases should focus on longer-term changes (e.g., infrastructure changes) and ongoing work to keep the enterprise as secure as possible.

Because eradication and recovery actions are typically OS or application-specific, detailed recommendations and advice regarding them are outside the scope of this document.

3.4 Post-Incident Activity

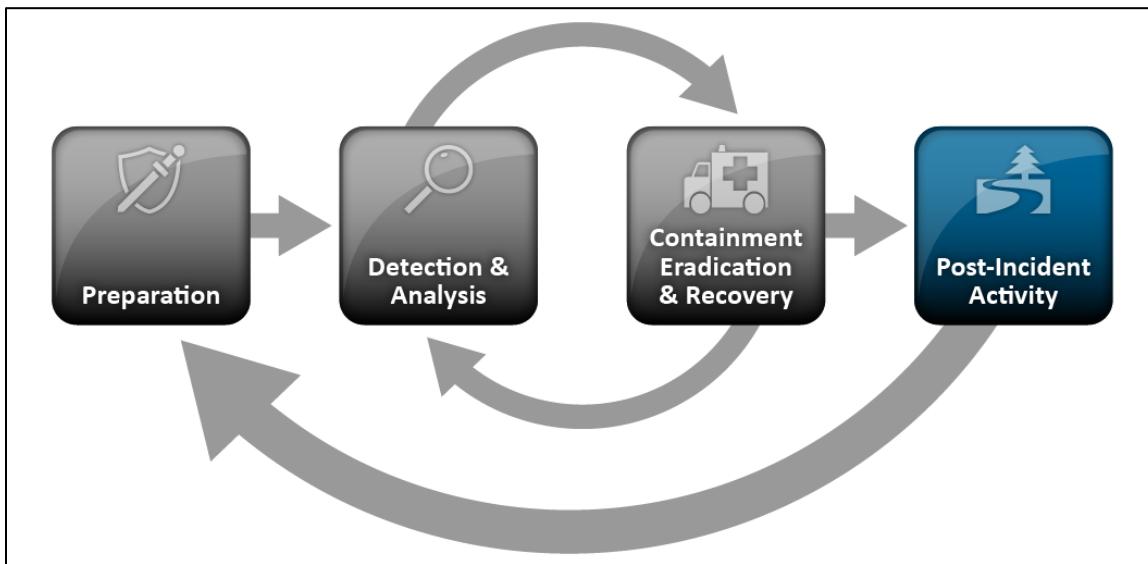


Figure 3-4. Incident Response Life Cycle (Post-Incident Activity)

3.4.1 Lessons Learned

One of the most important parts of incident response is also the most often omitted: learning and improving. Each incident response team should evolve to reflect new threats, improved technology, and lessons learned. Holding a “lessons learned” meeting with all involved parties after a major incident, and optionally periodically after lesser incidents as resources permit, can be extremely helpful in improving security measures and the incident handling process itself. Multiple incidents can be covered in a single lessons learned meeting. This meeting provides a chance to achieve closure with respect to an incident by reviewing what occurred, what was done to intervene, and how well intervention worked. The meeting should be held within several days of the end of the incident. Questions to be answered in the meeting include:

- Exactly what happened, and at what times?
- How well did staff and management perform in dealing with the incident? Were the documented procedures followed? Were they adequate?
- What information was needed sooner?
- Were any steps or actions taken that might have inhibited the recovery?
- What would the staff and management do differently the next time a similar incident occurs?
- How could information sharing with other organizations have been improved?
- What corrective actions can prevent similar incidents in the future?
- What precursors or indicators should be watched for in the future to detect similar incidents?

- What additional tools or resources are needed to detect, analyze, and mitigate future incidents?

Small incidents need limited post-incident analysis, with the exception of incidents performed through new attack methods that are of widespread concern and interest. After serious attacks have occurred, it is usually worthwhile to hold post-mortem meetings that cross team and organizational boundaries to provide a mechanism for information sharing. The primary consideration in holding such meetings is ensuring that the right people are involved. Not only is it important to invite people who have been involved in the incident that is being analyzed, but also it is wise to consider who should be invited for the purpose of facilitating future cooperation.

The success of such meetings also depends on the agenda. Collecting input about expectations and needs (including suggested topics to cover) from participants before the meeting increases the likelihood that the participants' needs will be met. In addition, establishing rules of order before or during the start of a meeting can minimize confusion and discord. Having one or more moderators who are skilled in group facilitation can yield a high payoff. Finally, it is also important to document the major points of agreement and action items and to communicate them to parties who could not attend the meeting.

Lessons learned meetings provide other benefits. Reports from these meetings are good material for training new team members by showing them how more experienced team members respond to incidents. Updating incident response policies and procedures is another important part of the lessons learned process. Post-mortem analysis of the way an incident was handled will often reveal a missing step or an inaccuracy in a procedure, providing impetus for change. Because of the changing nature of information technology and changes in personnel, the incident response team should review all related documentation and procedures for handling incidents at designated intervals.

Another important post-incident activity is creating a follow-up report for each incident, which can be quite valuable for future use. The report provides a reference that can be used to assist in handling similar incidents. Creating a formal chronology of events (including timestamped information such as log data from systems) is important for legal reasons, as is creating a monetary estimate of the amount of damage the incident caused. This estimate may become the basis for subsequent prosecution activity by entities such as the U.S. Attorney General's office. Follow-up reports should be kept for a period of time as specified in record retention policies.⁴⁵

3.4.2 Using Collected Incident Data

Lessons learned activities should produce a set of objective and subjective data regarding each incident. Over time, the collected incident data should be useful in several capacities. The data, particularly the total hours of involvement and the cost, may be used to justify additional funding of the incident response team. A study of incident characteristics may indicate systemic security weaknesses and threats, as well as changes in incident trends. This data can be put back into the risk assessment process, ultimately leading to the selection and implementation of additional controls. Another good use of the data is measuring the success of the incident response team. If incident data is collected and stored properly, it should provide several measures of the success (or at least the activities) of the incident response team. Incident data can also be collected to determine if a change to incident response capabilities causes a corresponding change in the team's performance (e.g., improvements in efficiency, reductions in costs). Furthermore, organizations that are required to report incident information will need to collect the

⁴⁵ General Records Schedule (GRS) 24, *Information Technology Operations and Management Records*, specifies that "computer security incident handling, reporting and follow-up records" should be destroyed "3 years after all necessary follow-up actions have been completed." GRS 24 is available from the National Archives and Records Administration at <http://www.archives.gov/records-mgmt/grs/grs24.html>.

necessary data to meet their requirements. See Section 4 for additional information on sharing incident data with other organizations.

Organizations should focus on collecting data that is actionable, rather than collecting data simply because it is available. For example, counting the number of precursor port scans that occur each week and producing a chart at the end of the year that shows port scans increased by eight percent is not very helpful and may be quite time-consuming. Absolute numbers are not informative—understanding how they represent threats to the business processes of the organization is what matters. Organizations should decide what incident data to collect based on reporting requirements and on the expected return on investment from the data (e.g., identifying a new threat and mitigating the related vulnerabilities before they can be exploited.) Possible metrics for incident-related data include:

- **Number of Incidents Handled.⁴⁶** Handling more incidents is not necessarily better—for example, the number of incidents handled may decrease because of better network and host security controls, not because of negligence by the incident response team. The number of incidents handled is best taken as a measure of the relative amount of work that the incident response team had to perform, not as a measure of the quality of the team, unless it is considered in the context of other measures that collectively give an indication of work quality. It is more effective to produce separate incident counts for each incident category. Subcategories also can be used to provide more information. For example, a growing number of incidents performed by insiders could prompt stronger policy provisions concerning background investigations for personnel and misuse of computing resources and stronger security controls on internal networks (e.g., deploying intrusion detection software to more internal networks and hosts).
- **Time Per Incident.** For each incident, time can be measured in several ways:
 - Total amount of labor spent working on the incident
 - Elapsed time from the beginning of the incident to incident discovery, to the initial impact assessment, and to each stage of the incident handling process (e.g., containment, recovery)
 - How long it took the incident response team to respond to the initial report of the incident
 - How long it took to report the incident to management and, if necessary, appropriate external entities (e.g., US-CERT).
- **Objective Assessment of Each Incident.** The response to an incident that has been resolved can be analyzed to determine how effective it was. The following are examples of performing an objective assessment of an incident:
 - Reviewing logs, forms, reports, and other incident documentation for adherence to established incident response policies and procedures
 - Identifying which precursors and indicators of the incident were recorded to determine how effectively the incident was logged and identified
 - Determining if the incident caused damage before it was detected

⁴⁶ Metrics such as the number of incidents handled are generally not of value in a comparison of multiple organizations because each organization is likely to have defined key terms differently. For example, most organizations define “incident” in terms of their own policies and practices, and what one organization considers a single incident may be considered multiple incidents by others. More specific metrics, such as the number of port scans, are also of little value in organizational comparisons. For example, it is highly unlikely that different security systems, such as network intrusion detection sensors, would all use the same criteria in labeling activity as a port scan.

- Determining if the actual cause of the incident was identified, and identifying the vector of attack, the vulnerabilities exploited, and the characteristics of the targeted or victimized systems, networks, and applications
 - Determining if the incident is a recurrence of a previous incident
 - Calculating the estimated monetary damage from the incident (e.g., information and critical business processes negatively affected by the incident)
 - Measuring the difference between the initial impact assessment and the final impact assessment (see Section 3.2.6)
 - Identifying which measures, if any, could have prevented the incident.
- **Subjective Assessment of Each Incident.** Incident response team members may be asked to assess their own performance, as well as that of other team members and of the entire team. Another valuable source of input is the owner of a resource that was attacked, in order to determine if the owner thinks the incident was handled efficiently and if the outcome was satisfactory.

Besides using these metrics to measure the team's success, organizations may also find it useful to periodically audit their incident response programs. Audits will identify problems and deficiencies that can then be corrected. At a minimum, an incident response audit should evaluate the following items against applicable regulations, policies, and generally accepted practices:

- Incident response policies, plans, and procedures
- Tools and resources
- Team model and structure
- Incident handler training and education
- Incident documentation and reports
- The measures of success discussed earlier in this section.

3.4.3 Evidence Retention

Organizations should establish policy for how long evidence from an incident should be retained. Most organizations choose to retain all evidence for months or years after the incident ends. The following factors should be considered during the policy creation:

- **Prosecution.** If it is possible that the attacker will be prosecuted, evidence may need to be retained until all legal actions have been completed. In some cases, this may take several years. Furthermore, evidence that seems insignificant now may become more important in the future. For example, if an attacker is able to use knowledge gathered in one attack to perform a more severe attack later, evidence from the first attack may be key to explaining how the second attack was accomplished.
- **Data Retention.** Most organizations have data retention policies that state how long certain types of data may be kept. For example, an organization may state that email messages should be retained for only 180 days. If a disk image contains thousands of emails, the organization may not want the image to be kept for more than 180 days unless it is absolutely necessary. As discussed in Section 3.4.2, General Records Schedule (GRS) 24 specifies that incident handling records should be kept for three years.

- **Cost.** Original hardware (e.g., hard drives, compromised systems) that is stored as evidence, as well as hard drives and removable media that are used to hold disk images, are generally individually inexpensive. However, if an organization stores many such components for years, the cost can be substantial. The organization also must retain functional computers that can use the stored hardware and media.

3.5 Incident Handling Checklist

The checklist in Table 3-5 provides the major steps to be performed in the handling of an incident. Note that the actual steps performed may vary based on the type of incident and the nature of individual incidents. For example, if the handler knows exactly what has happened based on analysis of indicators (Step 1.1), there may be no need to perform Steps 1.2 or 1.3 to further research the activity. The checklist provides guidelines to handlers on the major steps that should be performed; it does not dictate the exact sequence of steps that should always be followed.

Table 3-5. Incident Handling Checklist

	Action	Completed
Detection and Analysis		
1.	Determine whether an incident has occurred	
1.1	Analyze the precursors and indicators	
1.2	Look for correlating information	
1.3	Perform research (e.g., search engines, knowledge base)	
1.4	As soon as the handler believes an incident has occurred, begin documenting the investigation and gathering evidence	
2.	Prioritize handling the incident based on the relevant factors (functional impact, information impact, recoverability effort, etc.)	
3.	Report the incident to the appropriate internal personnel and external organizations	
Containment, Eradication, and Recovery		
4.	Acquire, preserve, secure, and document evidence	
5.	Contain the incident	
6.	Eradicate the incident	
6.1	Identify and mitigate all vulnerabilities that were exploited	
6.2	Remove malware, inappropriate materials, and other components	
6.3	If more affected hosts are discovered (e.g., new malware infections), repeat the Detection and Analysis steps (1.1, 1.2) to identify all other affected hosts, then contain (5) and eradicate (6) the incident for them	
7.	Recover from the incident	
7.1	Return affected systems to an operationally ready state	
7.2	Confirm that the affected systems are functioning normally	
7.3	If necessary, implement additional monitoring to look for future related activity	
Post-Incident Activity		
8.	Create a follow-up report	
9.	Hold a lessons learned meeting (mandatory for major incidents, optional otherwise)	

3.6 Recommendations

The key recommendations presented in this section for handling incidents are summarized below.

- **Acquire tools and resources that may be of value during incident handling.** The team will be more efficient at handling incidents if various tools and resources are already available to them. Examples include contact lists, encryption software, network diagrams, backup devices, digital forensic software, and port lists.
- **Prevent incidents from occurring by ensuring that networks, systems, and applications are sufficiently secure.** Preventing incidents is beneficial to the organization and also reduces the workload of the incident response team. Performing periodic risk assessments and reducing the identified risks to an acceptable level are effective in reducing the number of incidents. Awareness of security policies and procedures by users, IT staff, and management is also very important.
- **Identify precursors and indicators through alerts generated by several types of security software.** Intrusion detection and prevention systems, antivirus software, and file integrity checking software are valuable for detecting signs of incidents. Each type of software may detect incidents that the other types of software cannot, so the use of several types of computer security software is highly recommended. Third-party monitoring services can also be helpful.
- **Establish mechanisms for outside parties to report incidents.** Outside parties may want to report incidents to the organization—for example, they may believe that one of the organization's users is attacking them. Organizations should publish a phone number and email address that outside parties can use to report such incidents.
- **Require a baseline level of logging and auditing on all systems, and a higher baseline level on all critical systems.** Logs from operating systems, services, and applications frequently provide value during incident analysis, particularly if auditing was enabled. The logs can provide information such as which accounts were accessed and what actions were performed.
- **Profile networks and systems.** Profiling measures the characteristics of expected activity levels so that changes in patterns can be more easily identified. If the profiling process is automated, deviations from expected activity levels can be detected and reported to administrators quickly, leading to faster detection of incidents and operational issues.
- **Understand the normal behaviors of networks, systems, and applications.** Team members who understand normal behavior should be able to recognize abnormal behavior more easily. This knowledge can best be gained by reviewing log entries and security alerts; the handlers should become familiar with the typical data and can investigate the unusual entries to gain more knowledge.
- **Create a log retention policy.** Information regarding an incident may be recorded in several places. Creating and implementing a log retention policy that specifies how long log data should be maintained may be extremely helpful in analysis because older log entries may show reconnaissance activity or previous instances of similar attacks.
- **Perform event correlation.** Evidence of an incident may be captured in several logs. Correlating events among multiple sources can be invaluable in collecting all the available information for an incident and validating whether the incident occurred.
- **Keep all host clocks synchronized.** If the devices reporting events have inconsistent clock settings, event correlation will be more complicated. Clock discrepancies may also cause issues from an evidentiary standpoint.
- **Maintain and use a knowledge base of information.** Handlers need to reference information quickly during incident analysis; a centralized knowledge base provides a consistent, maintainable source of information. The knowledge base should include general information, such as data on precursors and indicators of previous incidents.

- **Start recording all information as soon as the team suspects that an incident has occurred.** Every step taken, from the time the incident was detected to its final resolution, should be documented and timestamped. Information of this nature can serve as evidence in a court of law if legal prosecution is pursued. Recording the steps performed can also lead to a more efficient, systematic, and less error-prone handling of the problem.
- **Safeguard incident data.** It often contains sensitive information regarding such things as vulnerabilities, security breaches, and users that may have performed inappropriate actions. The team should ensure that access to incident data is restricted properly, both logically and physically.
- **Prioritize handling of the incidents based on the relevant factors.** Because of resource limitations, incidents should not be handled on a first-come, first-served basis. Instead, organizations should establish written guidelines that outline how quickly the team must respond to the incident and what actions should be performed, based on relevant factors such as the functional and information impact of the incident, and the likely recoverability from the incident. This saves time for the incident handlers and provides a justification to management and system owners for their actions. Organizations should also establish an escalation process for those instances when the team does not respond to an incident within the designated time.
- **Include provisions regarding incident reporting in the organization's incident response policy.** Organizations should specify which incidents must be reported, when they must be reported, and to whom. The parties most commonly notified are the CIO, head of information security, local information security officer, other incident response teams within the organization, and system owners.
- **Establish strategies and procedures for containing incidents.** It is important to contain incidents quickly and effectively to limit their business impact. Organizations should define acceptable risks in containing incidents and develop strategies and procedures accordingly. Containment strategies should vary based on the type of incident.
- **Follow established procedures for evidence gathering and handling.** The team should clearly document how all evidence has been preserved. Evidence should be accounted for at all times. The team should meet with legal staff and law enforcement agencies to discuss evidence handling, then develop procedures based on those discussions.
- **Capture volatile data from systems as evidence.** This includes lists of network connections, processes, login sessions, open files, network interface configurations, and the contents of memory. Running carefully chosen commands from trusted media can collect the necessary information without damaging the system's evidence.
- **Obtain system snapshots through full forensic disk images, not file system backups.** Disk images should be made to sanitized write-protectable or write-once media. This process is superior to a file system backup for investigatory and evidentiary purposes. Imaging is also valuable in that it is much safer to analyze an image than it is to perform analysis on the original system because the analysis may inadvertently alter the original.
- **Hold lessons learned meetings after major incidents.** Lessons learned meetings are extremely helpful in improving security measures and the incident handling process itself.

4. Coordination and Information Sharing

The nature of contemporary threats and attacks makes it more important than ever for organizations to work together during incident response. Organizations should ensure that they effectively coordinate portions of their incident response activities with appropriate partners. The most important aspect of incident response coordination is information sharing, where different organizations share threat, attack, and vulnerability information with each other so that each organization's knowledge benefits the other. Incident information sharing is frequently mutually beneficial because the same threats and attacks often affect multiple organizations simultaneously.

As mentioned in Section 2, coordinating and sharing information with partner organizations can strengthen the organization's ability to effectively respond to IT incidents. For example, if an organization identifies some behavior on its network that seems suspicious and sends information about the event to a set of trusted partners, someone else in that network may have already seen similar behavior and be able to respond with additional details about the suspicious activity, including signatures, other indicators to look for, or suggested remediation actions. Collaboration with the trusted partner can enable an organization to respond to the incident more quickly and efficiently than an organization operating in isolation.

This increase in efficiency for standard incident response techniques is not the only incentive for cross-organization coordination and information sharing. Another incentive for information sharing is the ability to respond to incidents using techniques that may not be available to a single organization, especially if that organization is small to medium size. For example, a small organization that identifies a particularly complex instance of malware on its network may not have the in-house resources to fully analyze the malware and determine its effect on the system. In this case, the organization may be able to leverage a trusted information sharing network to effectively outsource the analysis of this malware to third party resources that have the adequate technical capabilities to perform the malware analysis.

This section of the document highlights coordination and information sharing. Section 4.1 presents an overview of incident response coordination and focuses on the need for cross-organization coordination to supplement organization incident response processes. Section 4.2 discusses techniques for information sharing across organizations, and Section 4.3 examines how to restrict what information is shared or not shared with other organizations.

4.1 Coordination

As discussed in Section 2.3.4, an organization may need to interact with several types of external organizations in the course of conducting incident response activities. Examples of these organizations include other incident response teams, law enforcement agencies, Internet service providers, and constituents and customers. An organization's incident response team should plan its incident coordination with those parties before incidents occur to ensure that all parties know their roles and that effective lines of communication are established. Figure 4-1 provides a sample view into an organization performing coordination at every phase of the incident response lifecycle, highlighting that coordination is valuable throughout the lifecycle.

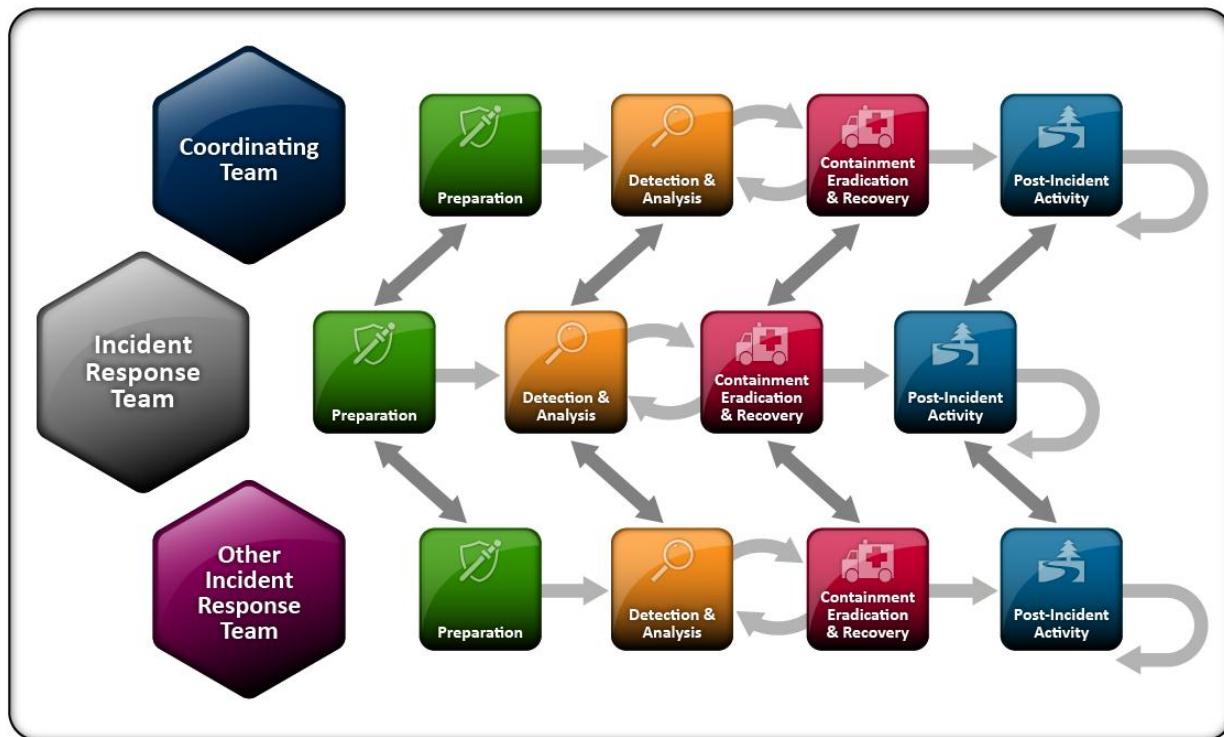


Figure 4-1. Incident Response Coordination

4.1.1 Coordination Relationships

An incident response team within an organization may participate in different types of coordination arrangements, depending on the type of organization with which it is coordinating. For example, the team members responsible for the technical details of incident response may coordinate with operational colleagues at partner organizations to share strategies for mitigating an attack spanning multiple organizations. Alternatively, during the same incident, the incident response team manager may coordinate with ISACs to satisfy necessary reporting requirements and seek advice and additional resources for successfully responding to the incident. Table 4-1 provides some examples of coordination relationships that may exist when collaborating with outside organizations.

Table 4-1. Coordination Relationships

Category	Definition	Information Shared
Team-to-team	Team-to-team relationships exist whenever technical incident responders in different organizations collaborate with their peers during any phase of the incident handling life cycle. The organizations participating in this type of relationship are usually peers without any authority over each other and choose to share information, pool resources, and reuse knowledge to solve problems common to both teams.	The information most frequently shared in team-to-team relationships is tactical and technical (e.g., technical indicators of compromise, suggested remediation actions) but may also include other types of information (plans, procedures, lessons learned) if conducted as part of the Preparation phase.
Team-to-coordinating team	Team-to-coordinating team relationships exist between an organizational incident response team and a separate organization that acts as a central point for coordinated incident response and management such as US-CERT or an ISAC. This type of relationship may include some degree of required reporting from the member organizations by the coordinating body, as well as the expectation that the coordinating team will disseminate timely and useful information to participating member organizations.	Teams and coordinating teams frequently share tactical, technical information as well as information regarding threats, vulnerabilities, and risks to the community served by the coordinating team. The coordinating team may also need specific impact information about incidents in order to help make decisions on where to focus its resources and attention.
Coordinating team-to-coordinating team	Relationships between multiple coordinating teams such as US-CERT and the ISACs exist to share information relating to cross-cutting incidents which may affect multiple communities. The coordinating teams act on behalf of their respective community member organizations to share information on the nature and scope of cross-cutting incidents and reusable mitigation strategies to assist in inter-community response.	The type of information shared by coordinating teams with their counterparts often consists of periodical summaries during “steady state” operations, punctuated by the exchange of tactical, technical details, response plans, and impact or risk assessment information during coordinated incident response activities.

Organizations may find it challenging to build the relationships needed for coordination. Good places to start building a community include the industry sector that the organization belongs to and the geographic region where the organization operates. An organization’s incident response team can try to form relationships with other teams (at the team-to-team level) within its own industry sector and region, or join established bodies within the industry sector that already facilitate information sharing. Another consideration for building relationships is that some relationships are mandatory and others voluntary; for example, team-to-coordinating team relationships are often mandatory, while team-to-team relationships are usually voluntary. Organizations pursue voluntary relationships because they fulfill mutual self-interests. Mandatory relationships are usually defined by a regulatory body within the industry or by another entity.

4.1.2 Sharing Agreements and Reporting Requirements

Organizations trying to share information with external organizations should consult with their legal department before initiating any coordination efforts. There may be contracts or other agreements that need to be put into place before discussions occur. An example is a nondisclosure agreement (NDA) to protect the confidentiality of the organization’s most sensitive information. Organizations should also consider any existing requirements for reporting, such as sharing incident information with an ISAC or reporting incidents to a higher-level CIRT.

4.2 Information Sharing Techniques

Information sharing is a key element of enabling coordination across organizations. Even the smallest organizations need to be able to share incident information with peers and partners in order to deal with many incidents effectively. Organizations should perform such information sharing throughout the incident response life cycle and not wait until an incident has been fully resolved before sharing details of it with others. Section 4.3 discusses the types of incident information that organizations may or may not want to share with others.

This section focuses on techniques for information sharing. Section 4.2.1 looks at ad hoc methods, while Section 4.2.2 examines partially automated methods. Finally, Section 4.2.3 discusses security considerations related to information sharing.

4.2.1 Ad Hoc

Most incident information sharing has traditionally occurred through ad hoc methods, such as email, instant messaging clients, and phone. Ad hoc information sharing mechanisms normally rely on an individual employee's connections with employees in incident response teams of partner organizations. The employee uses these connections to manually share information with peers and coordinate with them to construct strategies for responding to an incident. Depending on the size of the organization, these ad hoc techniques may be the most cost-effective way of sharing information with partner organizations. However, due to the informal nature of ad hoc information sharing, it is not possible to guarantee that the information sharing processes will always operate. For example, if a particularly well-connected employee resigns from an incident response team, that team may temporarily lose the majority of information sharing channels it relies on to effectively coordinate with outside organizations.

Ad hoc information sharing methods are also largely unstandardized in terms of what information is communicated and how that communication occurs. Because of the lack of standardization, they tend to require manual intervention and to be more resource-intensive to process than the alternative, partially automated methods. Whenever possible an organization should attempt to formalize its information sharing strategies through formal agreements with partner organizations and technical mechanisms that will help to partially automate the sharing of information.

4.2.2 Partially Automated

Organizations should attempt to automate as much of the information sharing process as possible to make cross-organizational coordination efficient and cost effective. In reality, it will not be possible to fully automate the sharing of all incident information, nor will it be desirable due to security and trust considerations. Organizations should attempt to achieve a balance of automated information sharing overlaid with human-centric processes for managing the information flow.

When engineering automated information sharing solutions, organizations should first consider what types of information they will communicate with partners. The organization may want to construct a formal data dictionary enumerating all entities and relationships between entities that they will wish to share. Once the organization understands the types of information they will share, it is necessary to construct formal, machine-processable models to capture this information. Wherever possible, an organization should use existing data exchange standards for representing the information they need to

share.⁴⁷ The organization should work with its partner organizations when deciding on the data exchange models to ensure that the standards selected are compatible with the partner organization's incident response systems. When selecting existing data exchange models, organizations may prefer to select multiple models that model different aspects of the incident response domain and then leverage these models in a modular fashion, communicating only the information needed at a specific decision point in the life cycle. Appendix E provides a non-exhaustive list of existing standards defining data exchange models that are applicable to the incident response domain.

In addition to selecting the data exchange models for sharing incident information, an organization must also work with its partner organizations to agree on the technical transport mechanisms for enabling the information exchange to occur in an automated fashion. These transport mechanisms include, at a minimum, the transport protocol for exchanging the information, the architectural model for communicating with an information resource, and the applicable ports and domain names for accessing an information resource in a particular organization. For example, a group of partner organizations may decide to exchange incident information using a Representational State Transfer (REST) architecture to exchange IODEF/Real-Time Inter-Network Defense (RID) data over Hypertext Transfer Protocol Secure (HTTPS) on port 4590 of a specific domain name within each organization's DMZ.

4.2.3 Security Considerations

There are several security considerations that incident response teams should consider when planning their information sharing. One is being able to designate who can see which pieces of incident information (e.g., protection of sensitive information). It may also be necessary to perform data sanitization or scrubbing to remove sensitive pieces of data from the incident information without disturbing the information on precursors, indicators, and other technical information. See Section 4.3 for more information on granular information sharing. The incident response team should also ensure that the necessary measures are taken to protect information shared with the team by other organizations.

There are also many legal issues to consider regarding data sharing. See Section 4.1.2 for additional information.

4.3 Granular Information Sharing

Organizations need to balance the benefits of information sharing with the drawbacks of sharing sensitive information, ideally sharing the necessary information and only the necessary information with the appropriate parties. Organizations can think of their incident information as being comprised of two types of information: business impact and technical. Business impact information is often shared in the context of a team-to-coordinating-team relationship as defined in Section 4.1.1, while technical information is often shared within all three types of coordination relationships. This section discusses both types of information and provides recommendations for performing granular information sharing.

4.3.1 Business Impact Information

Business impact information involves how the incident is affecting the organization in terms of mission impact, financial impact, etc. Such information, at least at a summary level, is often reported to higher-level coordinating incident response teams to communicate an estimate of the damage caused by the incident. Coordinating response teams may need this impact information to make decisions regarding the

⁴⁷ According to the National Technology Transfer and Advancement Act (NTTAA), “all Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies”. See <http://standards.gov/nttaa.cfm> for more details.

degree of assistance to provide to the reporting organization. A coordinating team may also use this information to make decisions relative to how a specific incident will affect other organizations in the community they represent.

Coordinating teams may require member organizations to report on some degree of business impact information. For example, a coordinating team may require a member organization to report impact information using the categories defined in Section 3.2.6. In this case, for a hypothetical incident an organization would report that it has a functional impact of *medium*, an information impact of *none*, and will require *extended* recoverability time. This high-level information would alert the coordinating team that the member organization requires some level of additional resources to recover from the incident. The coordinating team could then pursue additional communication with the member organization to determine how many resources are required as well as the type of resources based on the technical information provided about the incident.

Business impact information is only useful for reporting to organizations that have some interest in ensuring the mission of the organization experiencing the incident. In many cases, incident response teams should avoid sharing business impact information with outside organizations unless there is a clear value proposition or formal reporting requirements. When sharing information with peer and partner organizations, incident response teams should focus on exchanging technical information as outlined in Section 4.3.2.

4.3.2 Technical Information

There are many different types of technical indicators signifying the occurrence of an incident within an organization. These indicators originate from the variety of technical information associated with incidents, such as the hostnames and IP addresses of attacking hosts, samples of malware, precursors and indicators of similar incidents, and types of vulnerabilities exploited in an incident. Section 3.2.2 provides an overview of how organizations should collect and utilize these indicators to help identify an incident that is in progress. In addition, Section 3.2.3 provides a listing of common sources of incident indicator data.

While organizations gain value from collecting their own internal indicators, they may gain additional value from analyzing indicators received from partner organizations and sharing internal indicators for external analysis and use. If the organization receives external indicator data pertaining to an incident they have not seen, they can use that indicator data to identify the incident as it begins to occur. Similarly, an organization may use external indicator data to detect an ongoing incident that it was not aware of due to the lack of internal resources to capture the specific indicator data. Organizations may also benefit from sharing their internal indicator data with external organizations. For example, if they share technical information pertaining to an incident they are experiencing, a partner organization may respond with a suggested remediation strategy for handling that incident.

Organizations should share as much of this information as possible; however, there may be both security and liability reasons why an organization would not want to reveal the details of an exploited vulnerability. External indicators, such as the general characteristics of attacks and the identity of attacking hosts, are usually safe to share with others. Organizations should consider which types of technical information should or should not be shared with various parties, and then endeavor to share as much of the appropriate information as possible with other organizations.

Technical indicator data is useful when it allows an organization to identify an actual incident. However, not all indicator data received from external sources will pertain to the organization receiving it. In some

cases, this external data will generate false positives within the receiving organization's network and may cause resources to be spent on nonexistent problems.

Organizations participating in incident information sharing should have staff skilled in taking technical indicator information from sharing communities and disseminating that information throughout the enterprise, preferably in an automated way. Organizations should also attempt to ensure that they only share an indicator for which they have a relatively high level of confidence that it signifies an actual incident.

4.4 Recommendations

The key recommendations presented in this section for handling incidents are summarized below.

- **Plan incident coordination with external parties before incidents occur.** Examples of external parties include other incident response teams, law enforcement agencies, Internet service providers, and constituents and customers. This planning helps ensure that all parties know their roles and that effective lines of communication are established.
- **Consult with the legal department before initiating any coordination efforts.** There may be contracts or other agreements that need to be put into place before discussions occur.
- **Perform incident information sharing throughout the incident response life cycle.** Information sharing is a key element of enabling coordination across organizations. Organizations should not wait until an incident has been fully resolved before sharing details of it with others.
- **Attempt to automate as much of the information sharing process as possible.** This makes cross-organizational coordination efficient and cost effective. Organizations should attempt to achieve a balance of automated information sharing overlaid with human-centric processes for managing the information flow.
- **Balance the benefits of information sharing with the drawbacks of sharing sensitive information.** Ideally organizations should share the necessary information and only the necessary information with the appropriate parties. Business impact information is often shared in a team-to-coordinating team relationship, while technical information is often shared within all types of coordination relationships. When sharing information with peer and partner organizations, incident response teams should focus on exchanging technical information.
- **Share as much of the appropriate incident information as possible with other organizations.** Organizations should consider which types of technical information should or should not be shared with various parties. For example, external indicators, such as the general characteristics of attacks and the identity of attacking hosts, are usually safe to share with others, but there may be both security and liability reasons why an organization would not want to reveal the details of an exploited vulnerability.

Appendix A—Incident Handling Scenarios

Incident handling scenarios provide an inexpensive and effective way to build incident response skills and identify potential issues with incident response processes. The incident response team or team members are presented with a scenario and a list of related questions. The team then discusses each question and determines the most likely answer. The goal is to determine what the team would really do and to compare that with policies, procedures, and generally recommended practices to identify discrepancies or deficiencies. For example, the answer to one question may indicate that the response would be delayed because the team lacks a piece of software or because another team does not provide off-hours support.

The questions listed below are applicable to almost any scenario. Each question is followed by a reference to the related section(s) of the document. After the questions are scenarios, each of which is followed by additional incident-specific questions. Organizations are strongly encouraged to adapt these questions and scenarios for use in their own incident response exercises.⁴⁸

A.1 Scenario Questions

Preparation:

1. Would the organization consider this activity to be an incident? If so, which of the organization's policies does this activity violate? (*Section 2.1*)
2. What measures are in place to attempt to prevent this type of incident from occurring or to limit its impact? (*Section 3.1.2*)

Detection and Analysis:

1. What precursors of the incident, if any, might the organization detect? Would any precursors cause the organization to take action before the incident occurred? (*Sections 3.2.2, 3.2.3*)
2. What indicators of the incident might the organization detect? Which indicators would cause someone to think that an incident might have occurred? (*Sections 3.2.2, 3.2.3*)
3. What additional tools might be needed to detect this particular incident? (*Section 3.2.3*)
4. How would the incident response team analyze and validate this incident? What personnel would be involved in the analysis and validation process? (*Section 3.2.4*)
5. To which people and groups within the organization would the team report the incident? (*Section 3.2.7*)
6. How would the team prioritize the handling of this incident? (*Section 3.2.6*)

Containment, Eradication, and Recovery:

1. What strategy should the organization take to contain the incident? Why is this strategy preferable to others? (*Section 3.3.1*)
2. What could happen if the incident were not contained? (*Section 3.3.1*)
3. What additional tools might be needed to respond to this particular incident? (*Sections 3.3.1, 3.3.4*)
4. Which personnel would be involved in the containment, eradication, and/or recovery processes? (*Sections 3.3.1, 3.3.4*)

⁴⁸ For additional information on exercises, see NIST SP 800-84, *Guide to Test, Training, and Exercise Programs for IT Plans and Capabilities*, which is available at <http://csrc.nist.gov/publications/PubsSPs.html#800-84>.

5. What sources of evidence, if any, should the organization acquire? How would the evidence be acquired? Where would it be stored? How long should it be retained? (*Sections 3.2.5, 3.3.2, 3.4.3*)

Post-Incident Activity:

1. Who would attend the lessons learned meeting regarding this incident? (*Section 3.4.1*)
2. What could be done to prevent similar incidents from occurring in the future? (*Section 3.1.2*)
3. What could be done to improve detection of similar incidents? (*Section 3.1.2*)

General Questions:

1. How many incident response team members would participate in handling this incident? (*Section 2.4.3*)
2. Besides the incident response team, what groups within the organization would be involved in handling this incident? (*Section 2.4.4*)
3. To which external parties would the team report the incident? When would each report occur? How would each report be made? What information would you report or not report, and why? (*Section 2.3.2*)
4. What other communications with external parties may occur? (*Section 2.3.2*)
5. What tools and resources would the team use in handling this incident? (*Section 3.1.1*)
6. What aspects of the handling would have been different if the incident had occurred at a different day and time (on-hours versus off-hours)? (*Section 2.4.2*)
7. What aspects of the handling would have been different if the incident had occurred at a different physical location (onsite versus offsite)? (*Section 2.4.2*)

A.2 Scenarios

Scenario 1: Domain Name System (DNS) Server Denial of Service (DoS)

On a Saturday afternoon, external users start having problems accessing the organization's public websites. Over the next hour, the problem worsens to the point where nearly every access attempt fails. Meanwhile, a member of the organization's networking staff responds to alerts from an Internet border router and determines that the organization's Internet bandwidth is being consumed by an unusually large volume of User Datagram Protocol (UDP) packets to and from both the organization's public DNS servers. Analysis of the traffic shows that the DNS servers are receiving high volumes of requests from a single external IP address. Also, all the DNS requests from that address come from the same source port.

The following are additional questions for this scenario:

1. Whom should the organization contact regarding the external IP address in question?
2. Suppose that after the initial containment measures were put in place, the network administrators detected that nine internal hosts were also attempting the same unusual requests to the DNS server. How would that affect the handling of this incident?
3. Suppose that two of the nine internal hosts disconnected from the network before their system owners were identified. How would the system owners be identified?

Scenario 2: Worm and Distributed Denial of Service (DDoS) Agent Infestation

On a Tuesday morning, a new worm is released; it spreads itself through removable media, and it can copy itself to open Windows shares. When the worm infects a host, it installs a DDoS agent. The

organization has already incurred widespread infections before antivirus signatures become available several hours after the worm started to spread.

The following are additional questions for this scenario:

1. How would the incident response team identify all infected hosts?
2. How would the organization attempt to prevent the worm from entering the organization before antivirus signatures were released?
3. How would the organization attempt to prevent the worm from being spread by infected hosts before antivirus signatures were released?
4. Would the organization attempt to patch all vulnerable machines? If so, how would this be done?
5. How would the handling of this incident change if infected hosts that had received the DDoS agent had been configured to attack another organization's website the next morning?
6. How would the handling of this incident change if one or more of the infected hosts contained sensitive personally identifiable information regarding the organization's employees?
7. How would the incident response team keep the organization's users informed about the status of the incident?
8. What additional measures would the team perform for hosts that are not currently connected to the network (e.g., staff members on vacation, offsite employees who connect occasionally)?

Scenario 3: Stolen Documents

On a Monday morning, the organization's legal department receives a call from the Federal Bureau of Investigation (FBI) regarding some suspicious activity involving the organization's systems. Later that day, an FBI agent meets with members of management and the legal department to discuss the activity. The FBI has been investigating activity involving public posting of sensitive government documents, and some of the documents reportedly belong to the organization. The agent asks for the organization's assistance, and management asks for the incident response team's assistance in acquiring the necessary evidence to determine if these documents are legitimate or not and how they might have been leaked.

The following are additional questions for this scenario:

1. From what sources might the incident response team gather evidence?
2. What would the team do to keep the investigation confidential?
3. How would the handling of this incident change if the team identified an internal host responsible for the leaks?
4. How would the handling of this incident change if the team found a rootkit installed on the internal host responsible for the leaks?

Scenario 4: Compromised Database Server

On a Tuesday night, a database administrator performs some off-hours maintenance on several production database servers. The administrator notices some unfamiliar and unusual directory names on one of the servers. After reviewing the directory listings and viewing some of the files, the administrator concludes that the server has been attacked and calls the incident response team for assistance. The team's investigation determines that the attacker successfully gained root access to the server six weeks ago.

The following are additional questions for this scenario:

1. What sources might the team use to determine when the compromise had occurred?

2. How would the handling of this incident change if the team found that the database server had been running a packet sniffer and capturing passwords from the network?
3. How would the handling of this incident change if the team found that the server was running a process that would copy a database containing sensitive customer information (including personally identifiable information) each night and transfer it to an external address?
4. How would the handling of this incident change if the team discovered a rootkit on the server?

Scenario 5: Unknown Exfiltration

On a Sunday night, one of the organization's network intrusion detection sensors alerts on anomalous outbound network activity involving large file transfers. The intrusion analyst reviews the alerts; it appears that thousands of .RAR files are being copied from an internal host to an external host, and the external host is located in another country. The analyst contacts the incident response team so that it can investigate the activity further. The team is unable to see what the .RAR files hold because their contents are encrypted. Analysis of the internal host containing the .RAR files shows signs of a bot installation.

The following are additional questions for this scenario:

1. How would the team determine what was most likely inside the .RAR files? Which other teams might assist the incident response team?
2. If the incident response team determined that the initial compromise had been performed through a wireless network card in the internal host, how would the team further investigate this activity?
3. If the incident response team determined that the internal host was being used to stage sensitive files from other hosts within the enterprise, how would the team further investigate this activity?

Scenario 6: Unauthorized Access to Payroll Records

On a Wednesday evening, the organization's physical security team receives a call from a payroll administrator who saw an unknown person leave her office, run down the hallway, and exit the building. The administrator had left her workstation unlocked and unattended for only a few minutes. The payroll program is still logged in and on the main menu, as it was when she left it, but the administrator notices that the mouse appears to have been moved. The incident response team has been asked to acquire evidence related to the incident and to determine what actions were performed.

The following are additional questions for this scenario:

1. How would the team determine what actions had been performed?
2. How would the handling of this incident differ if the payroll administrator had recognized the person leaving her office as a former payroll department employee?
3. How would the handling of this incident differ if the team had reason to believe that the person was a current employee?
4. How would the handling of this incident differ if the physical security team determined that the person had used social engineering techniques to gain physical access to the building?
5. How would the handling of this incident differ if logs from the previous week showed an unusually large number of failed remote login attempts using the payroll administrator's user ID?
6. How would the handling of this incident differ if the incident response team discovered that a keystroke logger was installed on the computer two weeks earlier?

Scenario 7: Disappearing Host

On a Thursday afternoon, a network intrusion detection sensor records vulnerability scanning activity directed at internal hosts that is being generated by an internal IP address. Because the intrusion detection analyst is unaware of any authorized, scheduled vulnerability scanning activity, she reports the activity to the incident response team. When the team begins the analysis, it discovers that the activity has stopped and that there is no longer a host using the IP address.

The following are additional questions for this scenario:

1. What data sources might contain information regarding the identity of the vulnerability scanning host?
2. How would the team identify who had been performing the vulnerability scans?
3. How would the handling of this incident differ if the vulnerability scanning were directed at the organization's most critical hosts?
4. How would the handling of this incident differ if the vulnerability scanning were directed at external hosts?
5. How would the handling of this incident differ if the internal IP address was associated with the organization's wireless guest network?
6. How would the handling of this incident differ if the physical security staff discovered that someone had broken into the facility half an hour before the vulnerability scanning occurred?

Scenario 8: Telecommuting Compromise

On a Saturday night, network intrusion detection software records an inbound connection originating from a watchlist IP address. The intrusion detection analyst determines that the connection is being made to the organization's VPN server and contacts the incident response team. The team reviews the intrusion detection, firewall, and VPN server logs and identifies the user ID that was authenticated for the session and the name of the user associated with the user ID.

The following are additional questions for this scenario:

1. What should the team's next step be (e.g., calling the user at home, disabling the user ID, disconnecting the VPN session)? Why should this step be performed first? What step should be performed second?
2. How would the handling of this incident differ if the external IP address belonged to an open proxy?
3. How would the handling of this incident differ if the ID had been used to initiate VPN connections from several external IP addresses without the knowledge of the user?
4. Suppose that the identified user's computer had become compromised by a game containing a Trojan horse that was downloaded by a family member. How would this affect the team's analysis of the incident? How would this affect evidence gathering and handling? What should the team do in terms of eradicating the incident from the user's computer?
5. Suppose that the user installed antivirus software and determined that the Trojan horse had included a keystroke logger. How would this affect the handling of the incident? How would this affect the handling of the incident if the user were a system administrator? How would this affect the handling of the incident if the user were a high-ranking executive in the organization?

Scenario 9: Anonymous Threat

On a Thursday afternoon, the organization's physical security team receives a call from an IT manager, reporting that two of her employees just received anonymous threats against the organization's systems. Based on an investigation, the physical security team believes that the threats should be taken seriously and notifies the appropriate internal teams, including the incident response team, of the threats.

The following are additional questions for this scenario:

1. What should the incident response team do differently, if anything, in response to the notification of the threats?
2. What impact could heightened physical security controls have on the team's responses to incidents?

Scenario 10: Peer-to-Peer File Sharing

The organization prohibits the use of peer-to-peer file sharing services. The organization's network intrusion detection sensors have signatures enabled that can detect the usage of several popular peer-to-peer file sharing services. On a Monday evening, an intrusion detection analyst notices that several file sharing alerts have occurred during the past three hours, all involving the same internal IP address.

1. What factors should be used to prioritize the handling of this incident (e.g., the apparent content of the files that are being shared)?
2. What privacy considerations may impact the handling of this incident?
3. How would the handling of this incident differ if the computer performing peer-to-peer file sharing also contains sensitive personally identifiable information?

Scenario 11: Unknown Wireless Access Point

On a Monday morning, the organization's help desk receives calls from three users on the same floor of a building who state that they are having problems with their wireless access. A network administrator who is asked to assist in resolving the problem brings a laptop with wireless access to the users' floor. As he views his wireless networking configuration, he notices that there is a new access point listed as being available. He checks with his teammates and determines that this access point was not deployed by his team, so that it is most likely a rogue access point that was established without permission.

1. What should be the first major step in handling this incident (e.g., physically finding the rogue access point, logically attaching to the access point)?
2. What is the fastest way to locate the access point? What is the most covert way to locate the access point?
3. How would the handling of this incident differ if the access point had been deployed by an external party (e.g., contractor) temporarily working at the organization's office?
4. How would the handling of this incident differ if an intrusion detection analyst reported signs of suspicious activity involving some of the workstations on the same floor of the building?
5. How would the handling of this incident differ if the access point had been removed while the team was still attempting to physically locate it?

Appendix B—Incident-Related Data Elements

Organizations should identify a standard set of incident-related data elements to be collected for each incident. This effort will not only facilitate more effective and consistent incident handling, but also assist the organization in meeting applicable incident reporting requirements. The organization should designate a set of basic elements (e.g., incident reporter’s name, phone number, and location) to be collected when the incident is reported and an additional set of elements to be collected by the incident handlers during their response. The two sets of elements would be the basis for the incident reporting database, previously discussed in Section 3.2.5. The lists below provide suggestions of what information to collect for incidents and are not intended to be comprehensive. Each organization should create its own list of elements based on several factors, including its incident response team model and structure and its definition of the term “incident.”

B.1 Basic Data Elements

- Contact Information for the Incident Reporter and Handler
 - Name
 - Role
 - Organizational unit (e.g., agency, department, division, team) and affiliation
 - Email address
 - Phone number
 - Location (e.g., mailing address, office room number)
- Incident Details
 - Status change date/timestamps (including time zone): when the incident started, when the incident was discovered/detected, when the incident was reported, when the incident was resolved/ended, etc.
 - Physical location of the incident (e.g., city, state)
 - Current status of the incident (e.g., ongoing attack)
 - Source/cause of the incident (if known), including hostnames and IP addresses
 - Description of the incident (e.g., how it was detected, what occurred)
 - Description of affected resources (e.g., networks, hosts, applications, data), including systems’ hostnames, IP addresses, and function
 - If known, incident category, vectors of attack associated with the incident, and indicators related to the incident (traffic patterns, registry keys, etc.)
 - Prioritization factors (functional impact, information impact, recoverability, etc.)
 - Mitigating factors (e.g., stolen laptop containing sensitive data was using full disk encryption)
 - Response actions performed (e.g., shut off host, disconnected host from network)
 - Other organizations contacted (e.g., software vendor)
- General Comments

B.2 Incident Handler Data Elements

- Current Status of the Incident Response
- Summary of the Incident
- Incident Handling Actions
 - Log of actions taken by all handlers
 - Contact information for all involved parties
 - List of evidence gathered
- Incident Handler Comments
- Cause of the Incident (e.g., misconfigured application, unpatched host)
- Cost of the Incident
- Business Impact of the Incident⁴⁹

⁴⁹ The business impact of the incident could either be a description of the incident's effect (e.g., accounting department unable to perform tasks for two days) or an impact category based on the cost (e.g., a "major" incident has a cost of over \$100,000).

Appendix C—Glossary

Selected terms used in the publication are defined below.

Baselining: Monitoring resources to determine typical utilization patterns so that significant deviations can be detected.

Computer Security Incident: See “incident.”

Computer Security Incident Response Team (CSIRT): A capability set up for the purpose of assisting in responding to computer security-related incidents; also called a Computer Incident Response Team (CIRT) or a CIRC (Computer Incident Response Center, Computer Incident Response Capability).

Event: Any observable occurrence in a network or system.

False Positive: An alert that incorrectly indicates that malicious activity is occurring.

Incident: A violation or imminent threat of violation of computer security policies, acceptable use policies, or standard security practices.

Incident Handling: The mitigation of violations of security policies and recommended practices.

Incident Response: See “incident handling.”

Indicator: A sign that an incident may have occurred or may be currently occurring.

Intrusion Detection and Prevention System (IDPS): Software that automates the process of monitoring the events occurring in a computer system or network and analyzing them for signs of possible incidents and attempting to stop detected possible incidents.

Malware: A virus, worm, Trojan horse, or other code-based malicious entity that successfully infects a host.

Precursor: A sign that an attacker may be preparing to cause an incident.

Profiling: Measuring the characteristics of expected activity so that changes to it can be more easily identified.

Signature: A recognizable, distinguishing pattern associated with an attack, such as a binary string in a virus or a particular set of keystrokes used to gain unauthorized access to a system.

Social Engineering: An attempt to trick someone into revealing information (e.g., a password) that can be used to attack systems or networks.

Threat: The potential source of an adverse event.

Vulnerability: A weakness in a system, application, or network that is subject to exploitation or misuse.

Appendix D—Acronyms

Selected acronyms used in the publication are defined below.

CCIPS	Computer Crime and Intellectual Property Section
CERIAS	Center for Education and Research in Information Assurance and Security
CERT®/CC	CERT® Coordination Center
CIO	Chief Information Officer
CIRC	Computer Incident Response Capability
CIRC	Computer Incident Response Center
CIRT	Computer Incident Response Team
CISO	Chief Information Security Officer
CSIRC	Computer Security Incident Response Capability
CSIRT	Computer Security Incident Response Team
DDoS	Distributed Denial of Service
DHS	Department of Homeland Security
DNS	Domain Name System
Dos	Denial of Service
FAQ	Frequently Asked Questions
FBI	Federal Bureau of Investigation
FIPS	Federal Information Processing Standards
FIRST	Forum of Incident Response and Security Teams
FISMA	Federal Information Security Management Act
GAO	General Accountability Office
GFIRST	Government Forum of Incident Response and Security Teams
GRS	General Records Schedule
HTTP	HyperText Transfer Protocol
IANA	Internet Assigned Numbers Authority
IDPS	Intrusion Detection and Prevention System
IETF	Internet Engineering Task Force
IP	Internet Protocol
IR	Interagency Report
IRC	Internet Relay Chat
ISAC	Information Sharing and Analysis Center
ISP	Internet Service Provider
IT	Information Technology
ITL	Information Technology Laboratory
MAC	Media Access Control
MOU	Memorandum of Understanding
MSSP	Managed Security Services Provider
NAT	Network Address Translation
NDA	Non-Disclosure Agreement
NIST	National Institute of Standards and Technology
NSRL	National Software Reference Library
NTP	Network Time Protocol
NVD	National Vulnerability Database
OIG	Office of Inspector General
OMB	Office of Management and Budget
OS	Operating System
PII	Personally Identifiable Information
PIN	Personal Identification Number

POC	Point of Contact
REN-ISAC	Research and Education Networking Information Sharing and Analysis Center
RFC	Request for Comment
RID	Real-Time Inter-Network Defense
SIEM	Security Information and Event Management
SLA	Service Level Agreement
SOP	Standard Operating Procedure
SP	Special Publication
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TERENA	Trans-European Research and Education Networking Association
UDP	User Datagram Protocol
URL	Uniform Resource Locator
US-CERT	United States Computer Emergency Readiness Team
VPN	Virtual Private Network

Appendix E—Resources

The lists below provide examples of resources that may be helpful in establishing and maintaining an incident response capability.

Incident Response Organizations

Organization	URL
Anti-Phishing Working Group (APWG)	http://www.antiphishing.org/
Computer Crime and Intellectual Property Section (CCIPS), U.S. Department of Justice	http://www.cybercrime.gov/
CERT® Coordination Center, Carnegie Mellon University (CERT®/CC)	http://www.cert.org/
European Network and Information Security Agency (ENISA)	http://www.enisa.europa.eu/activities/cert
Forum of Incident Response and Security Teams (FIRST)	http://www.first.org/
Government Forum of Incident Response and Security Teams (GFIRST)	http://www.us-cert.gov/federal/gfirst.html
High Technology Crime Investigation Association (HTCIA)	http://www.htcia.org/
InfraGard	http://www.infragard.net/
Internet Storm Center (ISC)	http://isc.sans.edu/
National Council of ISACs	http://www.isaccouncil.org/
United States Computer Emergency Response Team (US-CERT)	http://www.us-cert.gov/

NIST Publications

Resource Name	URL
NIST SP 800-53 Revision 3, <i>Recommended Security Controls for Federal Information Systems and Organizations</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-53
NIST SP 800-83, <i>Guide to Malware Incident Prevention and Handling</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-83
NIST SP 800-84, <i>Guide to Test, Training, and Exercise Programs for IT Plans and Capabilities</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-84
NIST SP 800-86, <i>Guide to Integrating Forensic Techniques into Incident Response</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-86
NIST SP 800-92, <i>Guide to Computer Security Log Management</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-92
NIST SP 800-94, <i>Guide to Intrusion Detection and Prevention Systems (IDPS)</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-94
NIST SP 800-115, <i>Technical Guide to Information Security Testing and Assessment</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-115
NIST SP 800-128, <i>Guide for Security-Focused Configuration Management of Information Systems</i>	http://csrc.nist.gov/publications/PubsSPs.html#800-128

Data Exchange Specifications Applicable to Incident Handling

Title	Description	Additional Information
AI	Asset Identification	http://csrc.nist.gov/publications/PubsNISTIRs.html#NIST-IR-7693
ARF	Asset Results Format	http://csrc.nist.gov/publications/PubsNISTIRs.html#NIST-IR-7694
CAPEC	Common Attack Pattern Enumeration and Classification	http://capec.mitre.org/
CCE	Common Configuration Enumeration	http://cce.mitre.org/
CEE	Common Event Expression	http://cee.mitre.org/
CPE	Common Platform Enumeration	http://cpe.mitre.org/
CVE	Common Vulnerabilities and Exposures	http://cve.mitre.org/
CVSS	Common Vulnerability Scoring System	http://www.first.org/cvss/cvss-guide
CWE	Common Weakness Enumeration	http://cwe.mitre.org/
CybOX	Cyber Observable eXpression	http://cybox.mitre.org/
MAEC	Malware Attribute Enumeration and Characterization	http://maec.mitre.org/
OCIL	Open Checklist Interactive Language	http://csrc.nist.gov/publications/PubsNISTIRs.html#NIST-IR-7692
OVAL	Open Vulnerability Assessment Language	http://oval.mitre.org/
RFC 4765	Intrusion Detection Message Exchange Format (IDMEF)	http://www.ietf.org/rfc/rfc4765.txt
RFC 5070	Incident Object Description Exchange Format (IODEF)	http://www.ietf.org/rfc/rfc5070.txt
RFC 5901	Extensions to the IODEF for Reporting Phishing	http://www.ietf.org/rfc/rfc5901.txt
RFC 5941	Sharing Transaction Fraud Data	http://www.ietf.org/rfc/rfc5941.txt
RFC 6545	Real-time Inter-network Defense (RID)	http://www.ietf.org/rfc/rfc6545.txt
RFC 6546	Transport of Real-time Inter-network Defense (RID) Messages over HTTP/TLS	http://www.ietf.org/rfc/rfc6546.txt
SCAP	Security Content Automation Protocol	http://csrc.nist.gov/publications/PubsSPs.html#SP-800-126-Rev.%202
XCCDF	Extensible Configuration Checklist Description Format	http://csrc.nist.gov/publications/PubsNISTIRs.html#NIST-IR-7275-r4

Appendix F—Frequently Asked Questions

Users, system administrators, information security staff members, and others within organizations may have questions about incident response. The following are frequently asked questions (FAQ). Organizations are encouraged to customize this FAQ and make it available to their user community.

1. What is an incident?

In general, an incident is a violation of computer security policies, acceptable use policies, or standard computer security practices. Examples of incidents are:

- An attacker commands a botnet to send high volumes of connection requests to one of an organization’s web servers, causing it to crash.
- Users are tricked into opening a “quarterly report” sent via email that is actually malware; running the tool has infected their computers and established connections with an external host.
- A perpetrator obtains unauthorized access to sensitive data and threatens to release the details to the press if the organization does not pay a designated sum of money.
- A user provides illegal copies of software to others through peer-to-peer file sharing services.

2. What is incident handling?

Incident handling is the process of detecting and analyzing incidents and limiting the incident’s effect. For example, if an attacker breaks into a system through the Internet, the incident handling process should detect the security breach. Incident handlers will then analyze the data and determine how serious the attack is. The incident will be prioritized, and the incident handlers will take action to ensure that the progress of the incident is halted and that the affected systems return to normal operation as soon as possible.

3. What is incident response?

The terms “incident handling” and “incident response” are synonymous in this document.⁵⁰

4. What is an incident response team?

An incident response team (also known as a Computer Security Incident Response Team [CSIRT]) is responsible for providing incident response services to part or all of an organization. The team receives information on possible incidents, investigates them, and takes action to ensure that the damage caused by the incidents is minimized.

5. What services does the incident response team provide?

The particular services that incident response teams offer vary widely among organizations. Besides performing incident handling, most teams also assume responsibility for intrusion detection system monitoring and management. A team may also distribute advisories regarding new threats, and educate users and IT staff on their roles in incident prevention and handling.

6. To whom should incidents be reported?

Organizations should establish clear points of contact (POC) for reporting incidents internally. Some organizations will structure their incident response capability so that all incidents are reported directly to the incident response team, whereas others will use existing support

⁵⁰ Definitions of “incident handling” and “incident response” vary widely. For example, CERT®/CC uses “incident handling” to refer to the overall process of incident detection, reporting, analysis, and response, whereas “incident response” refers specifically to incident containment, recovery, and notification of others. See http://www.cert.org/csirts/csirt_faq.html for more information.

structures, such as the IT help desk, for an initial POC. The organization should recognize that external parties, such as other incident response teams, would report some incidents. Federal agencies are required under the law to report all incidents to the United States Computer Emergency Readiness Team (US-CERT). All organizations are encouraged to report incidents to their appropriate Computer Security Incident Response Teams (CSIRTs). If an organization does not have its own CSIRT to contact, it can report incidents to other organizations, including Information Sharing and Analysis Centers (ISACs).

7. How are incidents reported?

Most organizations have multiple methods for reporting an incident. Different reporting methods may be preferable as a result of variations in the skills of the person reporting the activity, the urgency of the incident, and the sensitivity of the incident. A phone number should be established to report emergencies. An email address may be provided for informal incident reporting, whereas a web-based form may be useful in formal incident reporting. Sensitive information can be provided to the team by using a public key published by the team to encrypt the material.

8. What information should be provided when reporting an incident?

The more precise the information is, the better. For example, if a workstation appears to have been infected by malware, the incident report should include as much of the following data as practical:

- The user’s name, user ID, and contact information (e.g., phone number, email address)
- The workstation’s location, model number, serial number, hostname, and IP address
- The date and time that the incident occurred
- A step-by-step explanation of what happened, including what was done to the workstation after the infection was discovered. This explanation should be detailed, including the exact wording of messages, such as those displayed by the malware or by antivirus software alerts.

9. How quickly does the incident response team respond to an incident report?

The response time depends on several factors, such as the type of incident, the criticality of the resources and data that are affected, the severity of the incident, existing Service Level Agreements (SLA) for affected resources, the time and day of the week, and other incidents that the team is handling. Generally, the highest priority is handling incidents that are likely to cause the most damage to the organization or to other organizations.

10. When should a person involved with an incident contact law enforcement?

Communications with law enforcement agencies should be initiated by the incident response team members, the chief information officer (CIO), or other designated official—users, system administrators, system owners, and other involved parties should not initiate contact.

11. What should someone do who discovers that a system has been attacked?

The person should immediately stop using the system and contact the incident response team. The person may need to assist in the initial handling of the incident—for instance, physically monitoring the system until incident handlers arrive to protect evidence on the system.

12. What should someone do who is contacted by the media regarding an incident?

A person may answer the media’s questions in accordance with the organization’s policy regarding incidents and outside parties. If the person is not qualified to represent the organization in terms of discussing the incident, the person should make no comment regarding the incident,

other than to refer the caller to the organization's public affairs office. This will allow the public affairs office to provide accurate and consistent information to the media and the public.

Appendix G—Crisis Handling Steps

This is a list of the major steps that should be performed when a technical professional believes that a serious incident has occurred and the organization does not have an incident response capability available. This serves as a basic reference of what to do for someone who is faced with a crisis and does not have time to read through this entire document.

1. **Document everything.** This effort includes every action that is performed, every piece of evidence, and every conversation with users, system owners, and others regarding the incident.
2. **Find a coworker who can provide assistance.** Handling the incident will be much easier if two or more people work together. For example, one person can perform actions while the other documents them.
3. **Analyze the evidence to confirm that an incident has occurred.** Perform additional research as necessary (e.g., Internet search engines, software documentation) to better understand the evidence. Reach out to other technical professionals within the organization for additional help.
4. **Notify the appropriate people within the organization.** This should include the chief information officer (CIO), the head of information security, and the local security manager. Use discretion when discussing details of an incident with others; tell only the people who need to know and use communication mechanisms that are reasonably secure. (If the attacker has compromised email services, do not send emails about the incident.)
5. **Notify US-CERT and/or other external organizations** for assistance in dealing with the incident.
6. **Stop the incident if it is still in progress.** The most common way to do this is to disconnect affected systems from the network. In some cases, firewall and router configurations may need to be modified to stop network traffic that is part of an incident, such as a denial of service (DoS) attack.
7. **Preserve evidence from the incident.** Make backups (preferably disk image backups, not file system backups) of affected systems. Make copies of log files that contain evidence related to the incident.
8. **Wipe out all effects of the incident.** This effort includes malware infections, inappropriate materials (e.g., pirated software), Trojan horse files, and any other changes made to systems by incidents. If a system has been fully compromised, rebuild it from scratch or restore it from a known good backup.
9. **Identify and mitigate all vulnerabilities that were exploited.** The incident may have occurred by taking advantage of vulnerabilities in operating systems or applications. It is critical to identify such vulnerabilities and eliminate or otherwise mitigate them so that the incident does not recur.
10. **Confirm that operations have been restored to normal.** Make sure that data, applications, and other services affected by the incident have been returned to normal operations.
11. **Create a final report.** This report should detail the incident handling process. It also should provide an executive summary of what happened and how a formal incident response capability would have helped to handle the situation, mitigate the risk, and limit the damage more quickly.

Appendix H—Change Log

Revision 2 Draft 1—January 2012

Editorial:

- Tightened writing throughout publication
- Made minor formatting changes throughout publication

Technical Changes:

- Expanded material on information sharing (throughout Section 2)
- Updated incident reporting organization listings (Section 2.3.4.3)
- Updated list of common incident response team services (Section 2.5)
- Revised the incident response life cycle diagrams (throughout Section 3)
- Revamped the list of attack vectors (Section 3.2.1)
- Revamped the factors for incident handling prioritization (Section 3.2.6)
- Changed focus from identifying the attacker to identifying the attacking host (Section 3.3.3)
- Expanded the list of possible incident metrics (Section 3.4.2)
- Updated the incident handling scenarios to reflect current threats (old Appendix B, new Appendix A)
- Made minor updates to incident-related data field suggestions (old Appendix C, new Appendix B)
- Updated all of the tools and resources listings (old Appendix G, new Appendix E)
- Updated the Frequently Asked Questions and the Crisis Handling Steps to reflect changes made elsewhere in the publication (old Appendices H and I, new Appendices F and G)

Deletions:

- Removed duplicate material on forensics, pointed readers to SP 800-86 for the same information (Section 3.3.2)
- Deleted material specific to the old incident categories (Sections 4 through 8)
- Deleted the duplicate list of recommendations (old Appendix A)
- Deleted print resources list (old Appendix F)
- Deleted federal agency incident reporting categories (old Appendix J)

Revision 2 Final—August 2012

Editorial:

- Made minor revisions throughout publication

Technical Changes:

- Added information sharing as a team service (Section 2.5)
- Converted Table 3-1 into bulleted lists (Section 3.1.1)
- Added a mention of exercises (Section 3.1.1)
- Revised the attack vectors (formerly incident categories) (Section 3.2.1)

- Added SIEMs, network flows as common sources of precursors and indicators (Section 3.2.3)
- Expanded discussion of eradication and recovery (Section 3.3.4)
- Added a section on coordination and information sharing (Section 4)
- Added a table of data exchange specifications applicable to incident handling (Appendix E)