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Key Practices in Cyber Supply Chain Risk Management:

Observations from Industry

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U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Institute of Standards and Technology
Walter Copan, NIST Director and Under Secretary of Commerce for Standards and Technology

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

Reports on Computer Systems Technology

The Information Technology Laboratory (ITL) at the National Institute of Standards and Technology (NIST) 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. ITL's responsibilities include the development of management, administrative, technical, and physical standards and guidelines for the cost-effective security and privacy of other than national security-related information in federal information systems.

Abstract

In today's highly connected world, all organizations rely on other organizations for critical products and services. However, today's world of globalization, while providing many benefits, has resulted in a world where organizations no longer fully control—and often do not have full visibility into—the supply ecosystems of the products that they make or the services that they deliver. With more and more businesses becoming digital, producing digital products and services, and moving their workloads to the cloud, the impact of a cybersecurity event today is greater than ever before and could include personal data loss, significant financial losses, compromise of safety, and even loss of life. Organizations can no longer protect themselves by simply securing their own infrastructures since their electronic perimeter is no longer meaningful; threat actors intentionally target the suppliers of more cyber-mature organizations to take advantage of the weakest link.

Identifying, assessing, and mitigating cyber supply chain risks is a critical capability to ensure business resilience. The multidisciplinary approach to managing these types of risks is called Cyber Supply Chain Risk Management (C-SCRM). This document provides the ever-increasing community of digital businesses to provide a set of Key Practices that any organization can use to manage cybersecurity risks associated with their supply chains. The Key Practices presented in this document can be used to implement a robust C-SCRM function at an organization of any size, scope, and complexity. These practices combine the information contained in existing C-SCRM government and industry resources with the information gathered during the 2015 and 2019 NIST research initiatives.

Keywords

best practices; cyber supply chain risk management; C-SCRM; external dependency management; information and communication technology supply chain risk management; ICT SCRM; key practices; risk management; supplier; supply chain; supply chain assurance; supply chain risk; supply chain risk assessment; supply chain risk management; supply chain security; third-party risk management.

Supplemental Content

For information about NIST's Cyber Supply Chain Risk Management Program, please visit: https://csrc.nist.gov/projects/cyber-supply-chain-risk-management/.

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Audience

All organizations rely on acquiring products and services, and most organizations also supply products and services to other organizations. Cyber Supply Chain Risk Management is an organization-wide function that encompasses multiple activities throughout the system development lifecycle. The audience for this publication is any organization, regardless of its size, scope, or complexity, wanting to manage the cybersecurity risks stemming from extended supply chains and supply ecosystems.

Note to Reviewers

NIST welcomes feedback on any part of the publication, but there is particular interest in the following:

- The Key Practices and recommendations contained in this publication are intended to be at a level high enough to apply to all types of organizations, regardless of their industry, size, or complexity, yet specific enough to be practical and usable. Are the proposed Key Practices and recommendations at the appropriate level to meet this goal? If not not, how can the document be improved?

- Are there additional Key Practices and recommendations that should be included in this publication and why? Are there Key Practices and recommendations that are currently in the publication that should not be included and why?

- Appendix B includes available government and industry resources that organizations can use to learn more more about C-SCRM. Are there other government or industry resources that should be included and, if so, which ones and why?

Call for Patent Claims

This public review includes a call for information on essential patent claims (claims whose use would be required for compliance with the guidance or requirements in this Information Technology Laboratory (ITL) draft publication). Such guidance and/or requirements may be directly stated in this ITL Publication or by reference to another publication. This call also includes disclosure, where known, of the existence of pending U.S. or foreign patent applications relating to this ITL draft publication and of any relevant unexpired U.S. or foreign patents.

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Such assurance shall indicate that the patent holder (or third party authorized to make assurances on its behalf) will include in any documents transferring ownership of patents subject to the assurance, provisions sufficient to ensure that the commitments in the assurance are binding on the transferee, and that the transferee will similarly include appropriate provisions in the event of future transfers with the goal of binding each successor-in-interest.

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Such statements should be addressed to: scrm-nist@nist.gov

Executive Summary

The National Institute of Standards of Technology (NIST) cyber supply chain risk management (C-SCRM) program was initiated in 2008 to begin the development of C-SCRM practices for non-national security systems in response to Comprehensive National Cybersecurity Initiative (CNCI) #11: Develop a multi-pronged approach for global supply chain risk management. Over the last decade, NIST has continued to develop publications and conduct further research on industry best practices for C-SCRM. This document presents Key Practices and recommendations that were developed as a result of the research conducted in 2015 and 2019, including expert interviews, development of case studies, and analysis of existing government and industry resources.

The Key Practices presented in this document can be used to implement a robust C-SCRM function at an organization of any size, scope, and complexity. These practices combine the information contained in existing C-SCRM government and industry resources with the information gathered during the 2015 and 2019 NIST research initiatives. The Key Practices are:

1. Integrate C-SCRM across the organization
2. Establish a formal program
3. Know and manage your critical suppliers
4. Understand your supply chain
5. Closely collaborate with your key suppliers
6. Include key suppliers in your resilience and improvement activities
7. Assess and monitor throughout supplier relationship
8. Plan for the full lifecycle

Each key practice includes a number of recommendations, which synthesize how these practices can be implemented from a people, process, and technology perspective. Selected key recommendations include:

- Create explicit collaborative roles, structures, and processes for supply chain, cybersecurity, product security, and physical security (and other relevant) functions.
- Integrate cybersecurity considerations into the system and product lifecycle.
- Determine supplier criticality by using industry standards and best practices.
- Mentor and coach suppliers to improve their cybersecurity practices.
- Include key suppliers in contingency planning, incident response, and disaster recovery planning and testing.
- Use third-party assessments, site visits, and formal certification to assess critical suppliers.

These and several other recommendations are mapped to each of the Key Practices to help the readers implement effective C-SCRM practices in their organizations. Readers can find additional resources for further research into C-SCRM best practices, including those specific to their industry, in Appendix B, Government and Industry Resources.

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1 Introduction

Today, organizations increasingly rely on an array of suppliers to support their critical functions. This trend has accelerated over the last decade and is expected to continue accelerating. Globalization, outsourcing, and digitization contribute to this trend. Suppliers have their own suppliers who, in turn, have their own suppliers, creating extended supply chains and entire supply ecosystems. All organizations rely on acquiring products and services, and most organizations also supply products and services to other organizations. Besides increasingly complex supply chains and cyber threat actors targeting supplier and acquirer networks, other external events such as severe weather and geopolitical unrest continue to threaten supply chains. Together, these threats increase the importance of supply chain resiliency, business continuity, and disaster recovery planning.

Many of the recent cyber breaches have been linked to supply chain risks. For example, a recent high-profile attack that took place in the second half of 2018, Operation ShadowHammer, compromised an update utility used by a global computer manufacturer[1]. The compromised software was served to users through the manufacturer's official website and is estimated to have impacted up to a million users before it was discovered. This is reminiscent of the attack by the Dragonfly group, which started in 2013 and targeted industrial control systems[2]. This group successfully inserted malware into software that was available for download through the manufacturers' websites, which resulted in companies in critical industries such as energy being impacted by this malware.

These incidents are not just isolated events. Many recent reports suggest these attacks are only increasing in frequency. An Incident Response Threat Report published in April 2019 by Carbon Black highlighted the use of "island hopping" by 50 % of attacks[3]. Island hopping is an attack that focuses on impacting not only the victim but its customers and partners, especially if these partners have network interconnections. Symantec's 2019 Security Threat Report found supply chain attacks increased by 78 % in 2018[4]. Perhaps more worrying is that a large number of these attacks appear to be successful and cause significant damage. A November 2018 study, *Data Risk in the Third-Party Ecosystem*, conducted by the Ponemon Institute found 59 % of companies surveyed experienced a data breach caused by one of their third parties[5]. A July 2018 survey conducted by Crowdstrike found software supply chains even more vulnerable with 66 % of respondents reporting a software supply chain attack, 90 % of whom faced financial impacts as a result of the attack.[6]

[1] https://securelist.com/operation-shadowhammer-a-high-profile-supply-chain-attack/90380/
[2] https://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/Dragonfly_Threat_Against_Western_Energy_Suppliers.pdf
[3] https://www.carbonblack.com/wp-content/uploads/2019/04/carbon-black-quarterly-incident-response-threat-report-april-2019.pdf
[4] https://www.symantec.com/security-center/threat-report
[5] https://www.businesswire.com/news/home/20181115005665/en/Opus-Ponemon-Institute-Announce-Results-2018-Third-Party
[6] https://www.crowdstrike.com/blog/global-survey-reveals-supply-chain-as-a-rising-and-critical-new-threat-vector/

This combination of digitization and reliance on suppliers to support critical functions creates numerous cybersecurity risks that organizations are learning to manage. Organizations have been working to address this challenge for some time, but many still struggle with recognizing the challenge, deciding how to deal with it, and getting started. For example, 90 % of respondents in the Crowdstrike survey reported that they believe they are at risk for a supply chain attack and think vetting software suppliers is a critical activity, but only 33 % actually do. Moreover, 76 % of the respondents in the Ponemon Institute study acknowledged cybersecurity incidents involving vendors are increasing, but only 46 % say managing these risks is a priority, and only 35 % rate their third-party risk management program as highly effective.

The National Institute of Standards and Technology (NIST) has been researching this challenge and issuing publications on this topic for over 10 years. NIST publications on this topic include:

- NISTIR 7622, *Notional Supply Chain Risk Management Practices for Federal Information Systems*, 2012 [NISTIR 7622]
- NIST Special Publication (SP) 800-161, *Supply Chain Risk Management Practices for Federal Information Systems and Organizations*, 2015 [SP 800-161]
- Draft NIST SP 800-53, Revision 5, *Security and Privacy Controls for Federal Information Systems and Organizations*, 2017 [SP 800-53]
    - Relevant control groups include:
        - Supply Chain Risk Management (SA-12),
        - Supply Chain Risk Management Plan (PM-31),
        - Integrated Situational Awareness (SI-4(17)),
        - Component Authenticity (SA-19),
        - Tamper Resistance and Detection (SA-18),
        - External System Services (SA-9),
        - Acquisition Process (SA-4),
        - Supply Chain Risk Assessment (RA-3(1)),
        - Criticality Analysis (RA-9),
        - Supply Chain Risk Management Plan (PM-31),
        - Incident Handling – Supply Chain Coordination (IR-4(10)),
        - Incident Reporting – Supply Chain Coordination (IR-6(3)),
        - Adequate Supply (MA-6(4)), and
        - Tampering Protection (PE-3(5))
- Case studies, briefing papers and other resources on the NIST Cyber Supply Chain Risk Management site [NIST C-SCRM][7]:
    - Case Studies: Best Practices in Cyber Supply Chain Risk Management, 2015
    - Best Practices in Vendor Selection and Management
    - Business Case for Cyber Supply Chain Risk Management

[7] The case studies and briefing papers are linked from https://csrc.nist.gov/projects/cyber-supply-chain-risk-management/key-practices.

- Organizational Strategies for Cyber Supply Chain Risk Management
- Cyber Supply Chain Standards Mapping and Roadmap
- Cyber Supply Chain Best Practices

Today, the discipline of addressing cybersecurity risks stemming from extended supply chains and supply ecosystems is known as Cyber Supply Chain Risk Management (C-SCRM). It is an overarching function that includes concepts such as third-party risk management and external dependency management.

This document provides a starting point for those organizations that need to begin addressing the challenge of C-SCRM. It provides a basic set of C-SCRM Key Practices that capture processes, practices, and tools adopted by industry. These Key Practices are based on a set of industry case studies conducted in 2015 and 2019, prior NIST initiatives, and a number of standards and industry best practice documents. Once an organization has implemented the basic Key Practices contained in this document, additional, more extensive standards, guidelines, and best practices can be applied.

1.1 Purpose and Scope

This document provides a set of C-SCRM Key Practices that can be used by any organization. It provides guidance as to what these high-level concepts mean, why they are important, and some characteristics and examples of corresponding Key Practices. This document also provides recommendations for how organizations can put the Key Practices into use. This document concludes with a list of references that organizations can use to get more guidance on C-SCRM.[8]

1.2 Background

In 2014-2015, NIST conducted a series of interviews on the topic of current C-SCRM practices. The industries surveyed ranged from telecommunications to utilities, industrial manufacturing, health, and information technology. The results of these interviews were published in 2015 in a series of case studies which identified a number of useful cyber supply chain risk management practices deployed by the surveyed organizations: supply chain risk councils to bring together key players; vendor risk assessment tools; supply chain resiliency tools, such as databases of suppliers; track-and-trace tools; and a master security requirements specification.[9]

Since these case studies were published, the C-SCRM problem set and the discipline itself evolved, warranting a new look at emergent practices. Ever more companies produce smart electronics, offer their products and services online, and integrate smart electronics into their products and infrastructures. The Internet of Things (IoT) and Industrial Internet of Things (IIoT) exponentially increase the need to manage cybersecurity risks associated with extended supply ecosystems. The increased use of these and other connected devices broadens the attack surface,

[8] It should be noted that this document does not provide a complete set of practices that would apply to every circumstance.
[9] Best Practices in Cyber Supply Chain Risk Management (https://csrc.nist.gov/projects/cyber-supply-chain-risk-management/key-practices)

with the devices attacking both the companies that make them and the devices, systems, and networks to which they are connected.

In 2018, NIST initiated a set of new, second-generation case studies with the purpose of surveying how the C-SCRM practices evolved and whether new practices emerged. These second-generation case studies were analyzed with the first set of case studies, NIST C-SCRM publications, and numerous industry C-SCRM standards and best practice documents. The results of this analysis revealed that many of the established practices are still relevant, and no practices identified in earlier efforts have been deemed obsolete or retired. This document summarizes the results of this analysis into a set of C-SCRM Key Practices and provides specific recommendations for how to implement them.

2 Problem Definition

Supply chain management is an established discipline that has become one of the key capabilities for enabling globalization and increasing economic growth in many parts of the world. With globalization, the rate at which critical services and functions were outsourced also increased to take advantage of business efficiencies. These trends resulted in a world where an organization no longer fully controls—and often does not have full visibility into—the supply ecosystems of the products that it makes or the services that it delivers.

Cybersecurity risks associated with this loss of control can be significant. They range from unknown provenance of hardware or software that supports organization's digital functions to subcontractors and consultants having access to its critical data. This phenomenon is referred to as cybersecurity aspects of C-SCRM. Over the last decade, C-SCRM evolved from a narrow focus on information and communication technology (ICT) supply chains to covering any cybersecurity-related supply chain risk. Today, it encompasses an increasing array of digital products and services that continues to grow with the expanding role of cyber space in the daily life of individuals and in how business is conducted. With more and more businesses becoming digital, producing digital products and services, and moving their workloads to the cloud, the impact of a cybersecurity event today is greater than ever before and could include personal data loss, significant financial losses, compromise of safety, and even loss of life. Threat actors intentionally target third parties of more cyber-mature organizations to take advantage of the weakest link. Organizations can no longer protect themselves by simply securing their own infrastructures since their electronic perimeter is no longer meaningful.

While cybersecurity risks associated with extended supply chains and supply ecosystems are significant, those risks are not well understood by many organizations that are expanding their use of digital technologies to support critical functions or creating digital products for their customers. In today's digital economy, identifying, assessing, and mitigating cyber supply chain risks is a critical capability to ensure business resiliency. A number of standards, guidance, and best practices documents have been written on the topic of C-SCRM. This document targets the ever-increasing community of digital businesses to provide a set of Key Practices that any organization can use to manage cybersecurity risks associated with their supply chains.

In today's highly connected world, all organizations rely on other organizations for critical products and services. Many organizations also supply products and services to other organizations. This document will use the terms "acquirers" and "suppliers" to make a distinction between these two roles.

3 Key Practices for C-SCRM

The C-SCRM Key Practices in this section blend the information contained in existing C-SCRM government and industry resources with the information gathered during the 2019 NIST case studies initiative. Collectively, the Key Practices identify established and emerging practices that have anecdotally proven to be effective, explain why they have been effective, and list tools that are most useful for identifying, defining, and communicating cyber supply chain risks. These Key Practices are:

1. Integrate C-SCRM across the organization
2. Establish a formal program
3. Know and manage your critical suppliers
4. Understand your supply chain
5. Closely collaborate with your key suppliers
6. Include key suppliers in your resilience and improvement activities
7. Assess and monitor throughout the supplier relationship
8. Plan for the full lifecycle

3.1 Integrate C-SCRM across the organization

A number of organizations have established Supply Chain Risk Councils (or Supply Chain Leadership Risk Councils) that include executives from supply chain/procurement, information technology, cybersecurity, operations, legal, enterprise risk management, and other functional and business leaders, depending on the organization's business and structure. These Councils proactively review relevant risks and risk mitigation plans, set priorities, direct sharing of best practices throughout the enterprise, and pilot initiatives. They also result in informal networks of leaders that facilitate trust and accountability in complex business environments. The benefit of Councils is the shared risk decision-making that ensures all perspectives are addressed.

Collaborative C-SCRM is not limited to the executive suite. Mature C-SCRM programs facilitate closer collaboration between cybersecurity, product security, physical security, enterprise risk management, and, of course, supply chain/procurement. Specifically, the level of integration of supply chain, cybersecurity, product security, and physical security increases with C-SCRM practice maturity. More mature companies have explicit roles that bridge these functions and also integrate them with corporate risk management. Such internal alignment facilitates the efficiency and effectiveness of delivering products and services while appropriately managing C-SCRM risks. For example, these integrated functions share information, metrics, and program objectives to reduce C-SCRM risks. This often results in a more nuanced and comprehensive understanding of cybersecurity risks by business executives, as well as better strategic decisions that take C-SCRM into consideration.

3.2 Establish a formal program

A formal C-SCRM program ensures organizational accountability for managing cyber supply chain risks. Mature organizations have formal programs with established governance, policies and procedures, processes, and tools.

It should be noted that smaller organizations may not need the level of maturity and structure required by larger organizations. For example, a small manufacturing organization may not need as many formal processes as a large technology company. The following is a list of high-level characteristics of a formal C-SCRM program which organizations can use as a starting point for consideration:

- Increased Board involvement for establishing C-SCRM as a top business priority and to ensure proper oversight
- Clear governance of C-SCRM activities that includes cross-organizational roles and responsibilities with clear definitions and designation/distribution of these roles among enterprise risk management, supply chain, cybersecurity, product management and product security (if applicable), and other relevant functions appropriate for the organization's business
- Standards-based policies and procedures that provide guidance to different business units detailing their C-SCRM activities
- Same policies used internally and with suppliers
- Integration of cybersecurity considerations into the system and product development lifecycle
- Use of cross-functional teams to address specific enterprise-wide risks
- Clear definition of roles of individuals responsible for cybersecurity aspects of supplier relationships (which may be different than those responsible for procurement activities with specific suppliers)
- Establishment of centers of excellence to identify and manage best practices
- A set of measures of success used to facilitate decision-making, accountability, and improvement
- Approved supplier lists
- Use of Bill of Materials (BOM) for third-party components
- Prioritization of suppliers based on their criticality
- Establishment of a known set of security requirements or controls for all suppliers, especially robust security requirements for critical suppliers to be used in procurement, sometimes known as master specifications
- Service-level agreements (SLA) with suppliers stating the requirements for adhering to the organization's cybersecurity policy and any controls required of the supplier
- Shared supplier questionnaires across like organizations, such as within the same critical infrastructure sector
- Propagating acquirer's security requirements to suppliers' suppliers
- Ensuring that suppliers have only the access they need in terms of data, capability/functionality, infrastructure; bounding this access by specific time frames during which suppliers need it
- Provision of organization-wide training for all relevant stakeholders within the organization, such as supply chain, legal, product development, and procurement; this training may also be extended to key suppliers
- Identification of alternative sources of critical components to ensure uninterrupted production and delivery of products

- Secure requirements guiding disposal of hardware that contains regulated data (e.g., PII) or otherwise sensitive information (e.g., intellectual property)
- Protocols for securely terminating supplier relationships to ensure that all hardware containing acquirer's data has been properly disposed of and that the risks of data leakage have been minimized

3.3 Know and manage your critical suppliers

Critical suppliers are those suppliers which, if disrupted, would create a negative business impact on the organization. Identifying such suppliers requires organizations to first identify and prioritize critical assets, systems, processes, and data, and then identify suppliers that either have access to or provide infrastructure for critical assets, systems, processes, and data.

Several criteria can be used to determine supplier criticality:

- Revenue contribution of suppliers
- Whether a supplier processes critical data belonging to the acquirer, such as regulated data (e.g., PII, PHI) or intellectual property
- Whether a supplier has access to the acquirer's system and network infrastructure
- Whether a supplier can become an attack vector by being compromised and allowing threat actors access to the acquirer
- For technology companies, whether a supplier can become an attack vector for the technology company's products or services delivered to customers

There is a number of NIST and industry resources that can be used to identify critical suppliers:

- NIST has made available a free tool that helps identify the impact of suppliers to the organization; NISTIR 8272 describes the tool and how to use it [NISTIR 8272].
- NISTIR 8179, *Criticality Analysis Process Model*, provides a comprehensive methodology for determining project and product criticality that can be used as an input in determining supplier criticality [NISTIR 8179].
- The Business Impact Analysis (BIA) described in NIST SP 800-34, Rev. 1 can also be used to determine supplier criticality [SP 800-34].
- The Business Continuity Planning booklet published by FFIEC (Federal Financial Institutions Examination Council) provides a process and list of considerations that can be adapted to determine supplier criticality [FFIEC BCP].

Once suppliers are identified, risks can be assessed, and suppliers can be prioritized by their criticality. Best practice organizations have established supplier requirements by criticality and include the use of master specifications for security requirements. These requirements are used in supplier contracts (e.g., Terms and Conditions), and adherence to these requirements is monitored during the supplier relationship lifecycle.

3.4 Understand your supply chain

To manage cybersecurity risks originating from supply chains, organizations need to understand their supply chains, including multiple layers of sub-suppliers. Today's supply chains are extended and extensive and include multiple organizations across the globe. In this environment, the risks may stem from suppliers' connectivity to their suppliers, component sourcing for hardware and software suppliers, technologies shared upstream and downstream within supply chains, and processes and people within those supply chains.

Best practice organizations establish real-time visibility into the production processes of their outsourced manufacturers with the capacity to capture not only defect rates but causes of failure and, therefore, prevent a supplier's ability to shortcut testing requirements before shipment. This includes the use of BOM as well as tools and methods to audit provenance claims at any point in the supply chain. Such visibility and transparency reduce the risk of counterfeiting and improve the quality of the resulting products. Additionally, best practice organizations have insight into how their suppliers vet their personnel, who they are outsourcing to, and who has access to the acquirer's data.

3.5 Closely collaborate with your key suppliers

Best practice organizations establish close relationships with their suppliers, up to and including creating shared ecosystems between acquirers and suppliers to increase coordination and simplify the management of complex shared supply chains. Increasingly, organizations are treating their suppliers as members of their ecosystem in a variety of ways:

- Acquirers work with suppliers in a much more collaborative way than in the past by investing into maintaining close work relationships through frequent visits and communications
- Acquirers invest into mentoring and coaching suppliers on C-SCRM and actively helping suppliers improve their cybersecurity and supply chain practices
- Acquirers and suppliers invest in common solutions
- Acquirers require use of the same standards within the acquirer organizations and by suppliers, thereby simplifying communications about cybersecurity risk and mitigations and helping to achieve a uniform level of quality throughout the ecosystem

It should be noted that the sophistication and level of formality of acquirer-supplier relationships increase with the maturity of the C-SCRM practices. For example, smaller businesses establish and maintain close relationships with their key suppliers by conducting frequent visits, phone calls, and other forms of informal communication. Larger and more mature organizations use more documented processes and procedures and hold multiple formal meetings with their suppliers. Acquirers and suppliers within the ecosystem coach each other upstream and downstream. Because most organizations find themselves in the roles of acquirers and suppliers, the presence of more mature acquirers in the overall ecosystem generally increases the maturity of the entire ecosystem. An example of this effect is when executives join Boards of more mature organizations and become exposed to the practices deployed in those organizations as well as the questions and topics discussed at Board meetings. Executives then bring those

practices and topics to their own organizations and advocate for adoption. A similar effect is achieved when organizations belong to industry groups, information-sharing organizations, and roundtables where individuals and organizations can learn from each other. Another method for acquirers and suppliers to coach each other is through the use of supplier questionnaires, which are used to identify opportunities for additional supplier mentoring and training. Some suppliers also use acquirer questionnaires to shape security requirements that suppliers apply to their products and services.

3.6 Include key suppliers in your resilience and improvement activities

Threat actors actively target acquirers through suppliers. In addition to cybersecurity risks, there are environmental risks, such as severe weather and geopolitical unrest, that continually threaten to disrupt the supply chain. Incidents will happen to even the most mature organizations, which makes resiliency planning essential. Mature organizations include their critical suppliers, products, and assets in their contingency planning, incident response, and disaster recovery. These organizations test such plans with key stakeholders to include suppliers to ensure the readiness of all involved parties and effectiveness of the plans. This ensures that critical procedures and protocols are established and well-understood ahead of any significant event. Resilience and improvement activities include:

- Rules and protocols for information sharing between acquirers and suppliers, sometimes within larger critical infrastructure sector ecosystems
- Joint development and review/revision of incident response, business continuity, and disaster recovery plans
- Protocols for communicating vulnerabilities and incidents
- Responsibilities for responding to cybersecurity incidents
- Coordinated communication methods and protocols
- Coordinated restoration and recovery procedures
- Collaborative lessons learned processes
- Updates of coordinated response and recovery plans based on lessons learned

More mature acquirers have formal continuous improvement processes that include collecting lessons learned from supply chain incidents; sharing potential improvements throughout the ecosystem; incorporating results into planning, response, and recovery processes; and sharing them with appropriate organizations throughout the enterprise. This process includes stakeholders from the organization and suppliers to ensure identified risks are remediated.

3.7 Assess and monitor throughout supplier relationship

Organizations and their environments are continuously evolving. A supplier assessment conducted prior to bringing a supplier on board is a snapshot in time that becomes obsolete before it is completed. Mature acquirers establish supplier-monitoring programs that cover the entire supplier relationship lifecycle and monitor a variety of risks, including security, quality, financial, and geopolitical risk, to name a few. This practice of monitoring and review includes validating that suppliers are meeting cybersecurity and other key SLA requirements and identifying any changes in supplier status (e.g., financial, legal, ownership).

Assessing supplier controls on a regular basis helps manage cyber supply chain risks by determining whether agreed-upon requirements and controls are being met, identifying improvements that may be required, and then monitoring the completion of those improvement actions.

Acquirers deploy a variety of supplier assessment and monitoring mechanisms, such as self-assessment, supplier attestation, third-party assessments, formal certifications, and site visits. For most critical suppliers, acquirers use a combination of formal certifications, third-party assessments, and site visits. Assessments allow organizations to understand the changes in a supplier's status and discover changes in risks. The frequency and robustness of the assessments should be established based on supplier criticality. Critical suppliers should be assessed more frequently, and more extensive assessment methods should be used to determine if there are any changes in risk.

Large organizations may rely on hundreds of supplier assessments every year, causing some suppliers to answer a burdensome number of questionnaires in turn. Shared assessments are an emerging practice within some critical infrastructure organizations, which involves using a single supplier assessment to satisfy multiple acquirers. In a shared assessment, a number of acquirers create a single assessment methodology and questionnaire which may then be applied to thousands of suppliers that support a particular need. Suppliers can then reuse their answers to such questionnaires by providing them to multiple acquirers. Some critical infrastructure sectors have established entities to run third-party risk processes for industry segments, with C-SCRM being included in these processes. While this approach may save acquirers and suppliers significant time and resources, organizations should carefully consider whether shared assessments fit their own particular needs, including risk tolerance, operating environment, and regulatory obligations.

In addition to supplier assessments, organizations can deploy technical processes and technologies to monitor any changes in a supplier's risk status. If suppliers have dedicated connections to the acquirer's infrastructure, the acquirer's security operations center can monitor any changes to the supplier's connection to the acquirer's network and systems. Acquirers can also use a variety of cybersecurity risk-rating solutions to provide insights into cybersecurity risks posed by suppliers.

3.8 Plan for the full lifecycle

When organizations put technical solutions into their infrastructures, they expect those solutions to continue working for as long as they are needed by the organization. However, organizations should plan for unexpected interruptions to the supply chain to ensure business continuity. Examples of such interruptions include suppliers stopping support of obsolete hardware and software, discontinuing production of hardware components, or adopting a significant change of business direction caused by acquisition or change in supplier ownership or management.

Organizations should deploy a variety of practices to manage this particular risk, including purchasing reserve quantities of critical components and establishing relationships with approved resellers that are likely to stay in business. An innovative method deployed by digital companies

is to bring ailing component manufacturers in-house to ensure an uninterrupted supply of critical components.

4 Recommendations

The following are key recommendations based on the first and second-generation case studies, reviewed standards, and best practice documents. These recommendations are organized according to the Key Practices. Appendix A provides a mapping of the recommendations to the Key Practices above, and Appendix C provides a mapping of the recommendations to various supply chain security resources.

- Establish supply chain risk councils to include executives from across the organization (e.g., cyber, product security, procurement, ERM, business units, etc.)
- Create explicit collaborative roles, structures, and processes for supply chain, cybersecurity, product security, and physical security functions
- Increase board involvement in C-SCRM through regular risk discussions and sharing of measures of performance
- Integrate cybersecurity considerations into the system and product lifecycle
- Clearly define roles and responsibilities for security aspects of specific supplier relationships
- Use master requirements lists and SLAs to establish requirements with suppliers
- Propagate security requirements to suppliers' sub-suppliers
- Train key stakeholders in your organization and within the supplier's organization
- Terminate supplier relationships with security in mind
- Use the Criticality Analysis Process Model or BIA to determine supplier criticality
- Establish visibility into your suppliers' production processes (e.g., capture defect rates, causes of failure, and testing)
- Know if your data and infrastructure are accessible to suppliers' sub-suppliers
- Mentor and coach suppliers to improve their cybersecurity practices
- Require the use of the same standards within both acquirer and supplier organizations
- Use acquirer assessment questionnaires to influence acquirer's cybersecurity requirements
- Include key suppliers in incident response, business continuity, and disaster recovery plans and tests
- Establish protocols for vulnerability disclosure and incident notification
- Establish protocols for communications with external stakeholders during incidents
- Collaborate on lessons learned and update joint plans based on lessons learned
- Use third-party assessments, site visits, and formal certification to assess critical suppliers
- Have plans in place for supplied product obsolescence

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Appendix A—Recommendations Mapped to Key Practices

	Integrate across the organization	Establish a formal program	Know and manage your critical suppliers	Understand your supply chain	Closely collaborate with your key suppliers	Include key suppliers in your resilience and improvement activities	Assess and monitor throughout supplier relationship	Plan for the full lifecycle
Establish supply chain risk councils to include executives from across the organization (cyber, product security, procurement, ERM, business units, etc.)	✓	✓						
Create explicit collaborative roles, structures, and processes for supply chain, cybersecurity, product security, and physical security functions	✓	✓						
Increase board involvement in C-SCRM through regular risk discussions and sharing of measures of performance	✓	✓						
Integrate cybersecurity considerations into system and product lifecycle	✓	✓						
Clearly define roles and responsibilities for security aspects of specific supplier relationships		✓			✓			
Use master requirements list and SLAs to establish requirements with suppliers		✓	✓					
Propagate security requirements to supplier's sub-suppliers		✓	✓		✓			
Train key stakeholders in your organization and within supplier organization		✓	✓		✓	✓		
Terminate supplier relationships with security in mind	✓	✓	✓	✓				
Use Criticality Analysis Process Model or BIA to determine supplier criticality			✓					
Establish visibility into your suppliers production processes to capture, e.g., defect rates, causes of failure, and testing			✓	✓	✓			
Know if your data and infrastructure are accessible to supplier's sub-suppliers			✓	✓	✓			
Mentor and coach suppliers to improve their cybersecurity practices					✓	✓		
Require use of the same standards within acquirer and supplier organizations	✓	✓			✓			
Use acquirer assessment questionnaires to influence acquirer cybersecurity requirements		✓	✓		✓	✓		
Include key suppliers in IR, DR, and CP plans and tests	✓	✓	✓	✓	✓	✓		
Establish protocols for vulnerability disclosure and incident notification	✓	✓	✓	✓	✓	✓		
Establish protocols for communications with external stakeholders during incidents	✓	✓	✓	✓	✓	✓		
Collaborate on lessons learned and update joint plans based on lessons learned	✓	✓	✓	✓	✓	✓		
Use third party assessments, site visits, and formal certification to assess critical suppliers		✓	✓	✓	✓		✓	
Have plans in place for supplied product obsolescence		✓		✓				✓

Appendix B—Government and Industry Resources

This section includes available government and industry resources that organizations can use to learn more. These resources are presented with additional information that the readers of this document may find useful for deciding which resources are relevant for their particular needs. The following information is provided for each resource:

- Scope – specific sector of the acquirer or a type of supplier that is being sought
- Audience – whether the resource speaks to both acquirers and suppliers
- Context of use – high-level summary of what the resource provides

Document	Scope	Audience	Context of Use
NIST SP 800-161, *Supply Chain Risk Management Practices for Federal Information Systems and Organizations*	Federal information systems	Acquirers	Identifying, assessing, and mitigating ICT supply chain risks
NIST Cybersecurity Framework	Any	Acquirers and Suppliers	General information on the Key Practices of supply chain in the cybersecurity context
NISTIR 7622, *Notional Supply Chain Risk Management Practices for Federal Information Systems*	Federal information systems	Acquirers and Suppliers	Security in supplier relationships for federal information systems
Financial Services Sector Cybersecurity Framework Profile	Financial services	Acquirers and Suppliers	Security in financial services, including internal and external dependencies
International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) ISO/IEC 27001: *Information Security Management Systems – Requirements*	Any	Acquirers and Suppliers	Establishing information security management system within an organization
ISO/IEC 27002: *Code of practice for information security controls*	Any	Acquirers and Suppliers	Guidance for implementing security controls in support of information security management system in ISO/IEC 27001

Document	Scope	Audience	Context of Use
ISO/IEC 27036-1, Information Security for Supplier Relationships – Part 1: *Overview and concepts*	Any	Acquirers and Suppliers	Overview of ISO/IEC 27306 series standard
ISO/IEC 27036-2, Information Security for Supplier Relationships – Part 2: *Requirements*	Any	Acquirers and Suppliers	Security in supplier relationships for any products and services
ISO/IEC 27036-3, Information Security for Supplier Relationships – Part 3: *Guidelines for ICT Supply Chain Security*	Information and Communication Technology (ICT) products and services	Acquirers and Suppliers	Security in supplier relationships for ICT products and services
ISO/IEC 27036-4, Information Security for Supplier Relationships – Part 4: *Guidelines for Security of Cloud Services*	Cloud services	Acquirers and Suppliers	Security aspects of cloud services acquisition
ISO/IEC 20243 / O-TTPS, *Open Trusted Technology Provider Standard*	Commercial off-the-shelf products	ICT Providers	Cyber supply chain risk management of COTS products engineering and acquisition
ISO/IEC 15408, *Common Criteria*	Any	Acquirers and Suppliers	Evaluation criteria for ICT products
IEC 62443-2-4, *Security for industrial automation and control systems* – Part 2-4	Industrial Control Systems suppliers	Suppliers	Security capabilities of Industrial Control Systems Suppliers
2015 Case Studies – NIST Best Practices in Cyber Supply Chain Risk Management: • Cisco • Boeing and Exostar • Cisco • Communications Company • Deere • Dupont • Exelon • Fire Eye • Fujitsu	Any	Acquirers	Industry best practices

Document	Scope	Audience	Context of Use
• Great River Energy (GRE) • Intel • Juniper • NetApp • Northrop Grumman • P&G • Resilinc • Schweitzer Engineering Laboratories, Inc. (SEL) • Smart Manufacturing • Utility			
Software Assurance Forum for Excellence in Code (SAFECode), Framework for Supply Chain Integrity	Software	Software developers	Guidance on software integrity practices
SAFECode Overview of Software Integrity Controls	Software	Software developers	Guidance on software integrity practices
UTC: Cyber Supply Chain Risk Management for Utilities – *Roadmap for Implementation*	Utilities	Acquirer	Basic C-SCRM practices for acquirers
NERC CIP-013 Implementation Guidelines	Electric energy utilities	ICS Acquirer	Implementation guidance for C-SCRM requirements for energy utilities
Cybersecurity Procurement Language for Energy Delivery Systems	Electric energy utilities	Acquirer and Suppliers	Requirements language to include in procurement of energy delivery systems

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Appendix C—Recommendations to Key Government and Industry Resources

	NIST SP 800-161	NISTIR 7622	2015 Case Studies	2019 Case Studies	CSF	FSP	UTC	ISO/IEC 27002	ISO/IEC 27036	ISO/IEC 20243
Establish supply chain risk councils to include executives from across the organization (cyber, product security, procurement, ERM, business units, etc.)	✓		✓	✓	✓	✓				
Create explicit collaborative roles, structures, and processes for supply chain, cybersecurity, product security, and physical security functions			✓	✓		✓				✓
Increase board involvement in C-SCRM through regular risk discussions and sharing of measures of performance			✓	✓		✓				
Integrate cybersecurity considerations into system and product lifecycle	✓	✓	✓	✓	✓	✓		✓	✓	✓
Clearly define roles and responsibilities for security aspects of specific supplier relationships	✓		✓	✓		✓	✓	✓	✓	✓
Use master requirements list and SLAs to establish requirements with suppliers	✓		✓	✓			✓	✓	✓	✓
Propagate security requirements to supplier's sub-suppliers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Train key stakeholders in your organization and within supplier organization	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Terminate supplier relationships with security in mind	✓	✓				✓	✓	✓	✓	✓
Use Criticality Analysis Process Model or BIA to determine supplier criticality	✓			✓	✓	✓			✓	
Establish visibility into your suppliers production processes to capture, e.g., defect rates, causes of failure, and testing		✓	✓	✓					✓	✓
Know if your data and infrastructure are accessible to supplier's sub-suppliers	✓			✓				✓	✓	✓
Mentor and coach suppliers to improve their cybersecurity practices	✓		✓	✓	✓	✓	✓			✓
Require use of the same standards within acquirer and supplier organizations				✓						
Use acquirer assessment questionnaires to influence acquirer cybersecurity requirements				✓						
Include key suppliers in IR, DR, and CP plans and tests	✓		✓	✓	✓	✓	✓	✓	✓	
Establish protocols for vulnerability disclosure and incident notification	✓		✓	✓	✓	✓	✓	✓	✓	✓
Establish protocols for communications with external stakeholders during incidents	✓		✓	✓	✓	✓	✓	✓	✓	
Collaborate on lessons learned and update joint plans based on lessons learned	✓		✓	✓	✓	✓	✓	✓	✓	✓
Use third party assessments, site visits, and formal certification to assess critical suppliers	✓		✓	✓	✓	✓	✓	✓	✓	✓
Have plans in place for supplied product obsolescence	✓	✓				✓	✓	✓	✓	✓