OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE FOR
SYSTEMS ENGINEERING

Supply Chain Attack Patterns: Framework and Catalog

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1 INTRODUCTION

This paper provides a framework and catalog of supply chain attack patterns that could have an impact on Department of Defense (DoD) systems. This information is intended to assist defense programs to understand the nature and potential extent of supply chain attacks, which include malicious insertion of hardware (HW), software (SW), firmware (FW), or system data. This catalog will be extended as additional supply chain attack patterns are identified and submitted by DoD programs and industry.

Drawing on a number of sources (Section 2), the Office of the Deputy Assistant Secretary of Defense for Systems Engineering (DASD(SE)) team developed the robust catalog of supply chain attack patterns (Appendix A) and an initial set of potential countermeasures to mitigate those attacks (Appendix B). For the purposes of this effort, an "attack pattern" is considered one of many potential combinations of 12 common attributes. Attributes include, for example, the attack act (what), the attack vector (how), and the applicable life cycle phase. An "attack" refers to the specific combination of 2 of the 12 attributes, the attack act and the attack vector.

Section 3 describes the type and scope of attacks considered in this effort. Section 4 describes the attack framework (template) including all 12 attributes, and illustrates how the framework is populated to create entries in the catalog. Section 5 discusses the utility of the attack catalog and countermeasures and how programs might employ them. The DASD(SE) office will maintain this document on the DASD(SE) website, http://www.acq.osd.mil/se/pg/guidance.html, as a reference for defense system security engineering (SSE) practitioners.

Although SSE traditionally has been viewed as a specialty engineering area, it has become increasingly evident that implementing SSE to address emergent adversarial threats must be tightly integrated within systems engineering (SE). To address these threats, DASD(SE) has engaged in efforts to assure trusted systems and networks (TSN), including the development of an SSE methodology (Baldwin et al. 2012; Popick and Reed 2013) built upon standard SE processes (e.g., requirements definition and risk management) as well as traditional security practices (e.g., threat analysis and vulnerability assessment).

This SSE methodology provides a defined set of activities and analyses to be carried out by a multidisciplinary team, led by systems engineers, to identify and protect mission-critical system

components. Successful implementation of the methodology, however, depends on the availability of adequate data and procedures to carry out the defined activities, for example, threat analysis and vulnerability assessment. Engineers and security professionals within several subdisciplines of system security are engaging in ongoing efforts to address threats, vulnerabilities, and attacks at various levels. Building on this work, DASD(SE) has sponsored efforts to examine the supply chain and software development life cycle contexts of threat activity (Reed 2012) and to develop associated attack vector understanding (Miller 2013).

The general nature of the threat against DoD systems is malicious exploitation of vulnerabilities in fielded systems; however, in addition to cyber attacks initiated during system operation, emergent, more complex threat-actor involvement can occur early in and throughout the acquisition life cycle. By inserting malicious software and counterfeit components during system design and development and across the supply chain, adversaries can gain system control for later remote exploitation or plant "time bombs" that will degrade or alter system performance at a later time, either preset or event-triggered. The threat of malicious insertion and tampering throughout the development and supply of critical system components is thus a broad systems engineering concern.

2 RESEARCH SOURCES

To develop the framework and catalog, the DASD(SE) team initially included a broad range of research sources to analyze the problem from a systems engineering perspective. They considered attacks of malicious insertion by way of the supply chain, network-based attacks against fielded systems, and the connection between supply chain vulnerabilities that allow malicious insertion and the vulnerabilities implanted by malicious insertion that allow attacks during fielded operations. They also considered the potential mitigations and risk-cost-benefit trade-offs necessary to select countermeasures to effectively mitigate security risk.

Although this effort focused on supply chain attacks, the broader awareness of supply chain vulnerabilities and related issues provided context for describing the attributes typical of supply chain attacks. Accordingly, some of the sources focused on countermeasures but also provided perspectives on the types of attacks being considered. For example:

- A Software Engineering Institute technical report (Dougherty et al. 2009) describes 15 secure design patterns in three categories. It provides general (reusable) solutions as implementable design guidance. The report includes a general reference to eliminating the introduction of vulnerabilities into code and mitigating the consequences of such vulnerabilities. Specific attack information is discussed for each design pattern, albeit indirectly and in an un-normalized, unstructured manner.
- Research efforts at the University of Virginia describe four security practices, termed "smart, reusable security services," intended to reduce the success of cyber attacks (Bayuk and Horowitz 2011; Jones and Horowitz 2012; Horowitz and Pierce 2013; Jones, Nguyen, and Horowitz 2011; Babineau, Jones, and Horowitz 2012). These research papers contain a general reference to the

threat of cyber attacks, particularly with regard to the use of commercial off-the-shelf (COTS) HW and SW.

- A MITRE Corporation Cyber Resiliency Engineering Framework describes 14 security practices/techniques intended to reduce the success of cyber attack (Bodeau and Graubart 2011). These techniques are coordinated to different architectural layers that are susceptible to attack vector exploitation (12 architectural layers are itemized).

Whereas the above sources focused on protection against attacks on fielded systems, other sources included countermeasures for protection against malicious insertion via the supply chain, for example, the Supply Chain Risk Management (SCRM) Key Practices Guide (DoD SCRM 2010), which describes 32 key practices (KP) as risk mitigations for supply chain threats.

Engineers and security professionals within several subdisciplines of system security are engaging in efforts to address threats, vulnerabilities, and attacks at various levels. For example:

- The National Institute of Standards and Technology (NIST) recently updated and enhanced its guide for conducting information security risk assessments (NIST 2012). The guide describes threat events targeted at information systems and provides a compilation of representative examples of adversarial threat events.
- The Department of Homeland Security is sponsoring an ongoing effort to grow and maintain a publicly available catalog that provides a common attack pattern enumeration and classification (CAPEC) of typical methods for exploiting SW (MITRE Corporation 2012). The CAPEC attack patterns capture and communicate the SW attacker's perspective, derived from the concept of design patterns applied in a destructive rather than constructive context and generated from in-depth analysis of real-world SW exploits.
- The MITRE Corporation has developed a Threat Assessment and Remediation Analysis (TARA) methodology to identify and assess cyber and supply chain threats and to select effective countermeasures (Wynn et al. 2011). The TARA methodology relies on a catalog of adversarial tactics, techniques, and procedures (TTP) that has been built primarily from engagements with information system programs.

Building primarily on the NIST, CAPEC, and TARA but drawing on the other sources as well, the DASD(SE) team developed the catalog (Appendix A). The team used the SCRM Key Practices Guide (DoD SCRM 2010) as well as sources for end-to-end supply chain system mapping to ensure the catalog encompassed a broad set of supply chain attack patterns.

Each of the SCRM 32 KPs tracks to at least one attack pattern in the catalog. There are at least eight attack patterns identified for each of the points of attack within the supply chain (see Figures 1 and 2, page 6).

In addition, the team used the SCRM Key Practices Guide and other sources mentioned above to compile an initial set of countermeasures as a proof of concept for the overall process of tracing supply chain attacks to guidance for risk reduction. The team identified the following countermeasures as a starting point for future research (*see also* Appendix B):

- Secure Configuration Management of Software
- Prevent or Detect Critical Component Tampering
- Security-Focused Programming Languages
- Security-Focused Design and Coding Standards and Reviews
- Supply Chain Red Teaming
- Trusted Shipping
- Hardened Delivery Mechanisms
- Tracking Tags and Security Tags
- Pedigree Established Across the Supply Chain
- Bulk Spares Inventory
- Multiple Suppliers
- Trusted Suppliers
- Acquirer Anonymity
- Electromagnetic (EM) / Thermal Analysis
- Network Traffic Restriction
- Visual Inspection
- Cryptography
- Supply Chain Visibility
- Personnel Trust
- Software Update Security

3 SCOPE OF ATTACKS CONSIDERED

Supply chain attacks may take many forms, from the insertion of malicious SW into open-source libraries to the substitution of counterfeit HW components in a receiving department at a lower tier of the supply chain. The former exploits an acquisition process to create a design vulnerability (associated with open-source code). The latter exploits a receiving department process weakness. With such broad-reaching concerns in mind, it is useful to consider what was determined to be in or out of scope for this effort. Following are definitions and examples to illustrate the scope:

- Object of the attacks:
  - Information and communications technology (ICT)[1] components of a weapon system (or ICT system) being acquired or sustained

[1] ICT: "Includes all categories of ubiquitous technology used for the gathering, storing, transmitting, retrieving, or processing of information (e.g., microelectronics, printed circuit boards, computing systems, software, signal processors, mobile telephony, satellite communications, and networks). ICT is not limited to information technology (IT)…" (DoD 2012).

- Types of supply chain attacks:
  - Malicious insertion (which includes substitution, alteration, and malware insertion) of HW, SW, or FW in critical ICT components
  - Malicious insertion within any system-related data or information (which includes requirements, design, manuals, architectures, and roadmaps)
- Time frame of attacks:
  - Any time during the system acquisition life cycle, including pre-acquisition, acquisition, or sustainment
- Points of attack within the supply chain:
  - Locations (Figure 1): System and software development locations and their internal processes and environments; e.g., integrated development environments (IDE)
    - Malicious activity that occurs at any location in the supply chain, including development tools and processes owned/used by that site/facility
    - Supply chain locations that include the program office, prime contractor, and all tiers of sub-contractors/sub-suppliers and integrators (including field support activities, e.g., parts depots and software support activities and their suppliers)
  - Supply chain linkages between locations (Figure 2):
    - Malicious activity that occurs within the physical flow between supply chain locations (i.e., acquirer and supplier logistics networks)
    - Malicious activity that occurs within the information and data flow of the supply chain (i.e., acquirer and supplier external ICT/IDE environments)

Given this scope, the goal was to gather, structure, and elaborate the attack patterns used for malicious insertion in critical components across the full system-acquisition life cycle by identifying exploitable weaknesses in the system-acquisition supply chain, using a generic, end-to-end supply chain system as illustrated in Figures 1 and 2.

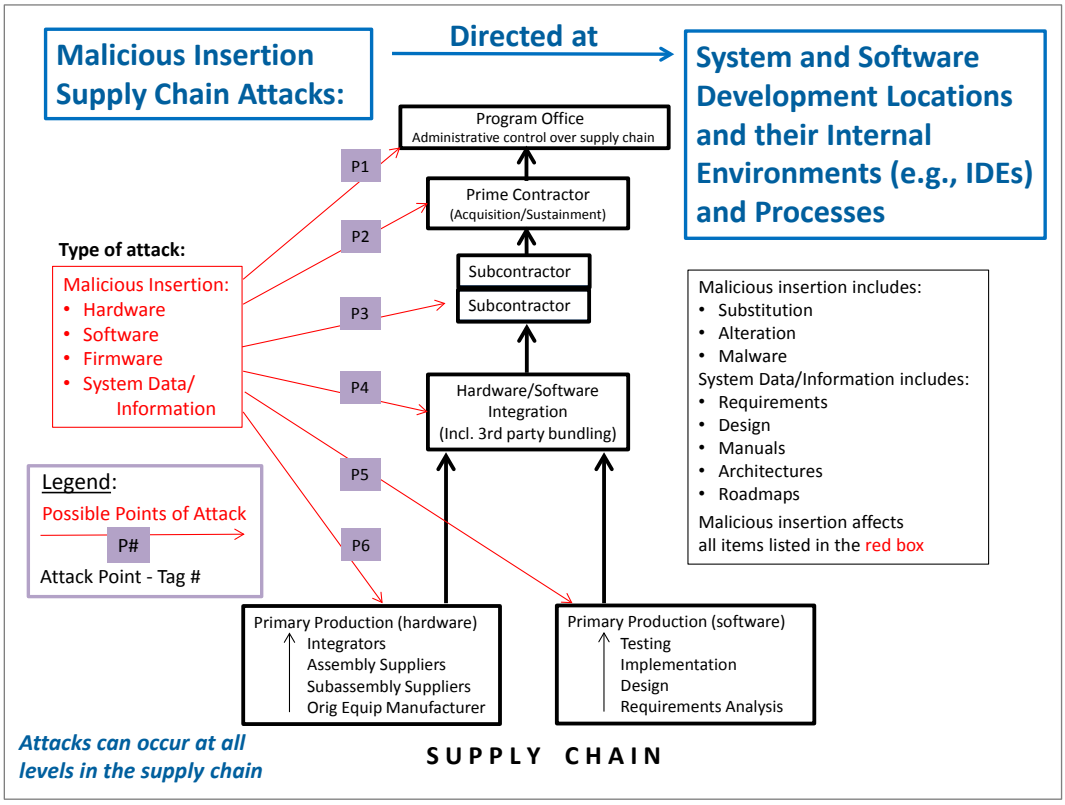

Figure 1. Points of Attack – Supply Chain Locations

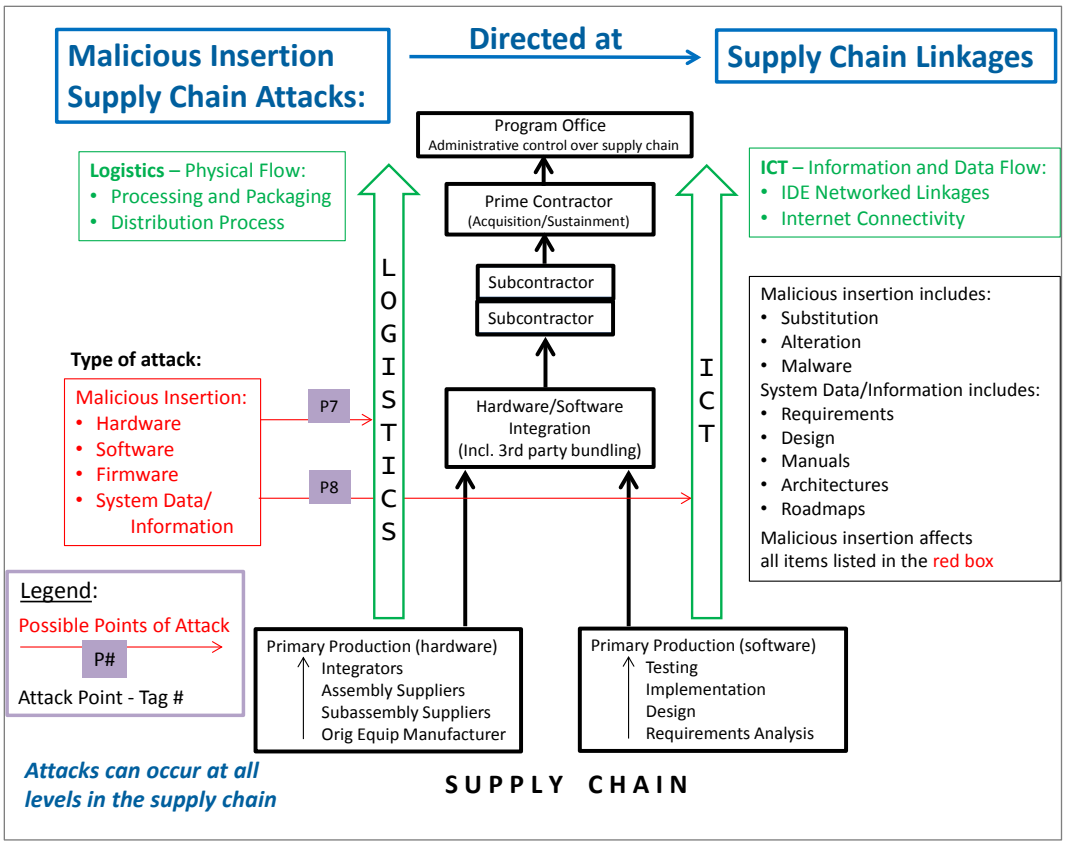

Figure 2. Points of Attack – Supply Chain Linkages

The following examples further illustrate attacks considered in or out of scope:

- Supply chain vs. a fielded system:
  - In Scope: Supply chain attacks against the system being acquired/sustained
    - Example: Implantation of a backdoor in system SW during development or maintenance
  - Out of Scope: Network-based, insider, or physical attacks against a fielded system during operations
    - Example: Exploitation of a backdoor in system SW that was implanted during development or maintenance
- Support systems:
  - In Scope: Supply chain attacks against "first-order" (directly related to system development) support systems for the acquisition
    - Examples: Maliciously altered compilers; malicious SW inserted in a HW development environment; maliciously altered field-programmable gate array (FPGA) programming tools
  - Out of Scope: Supply chain attacks against "second-order" support systems for the acquisition
    - Example: Malicious insertion of code into a shipping and receiving system to subvert distribution processes

Supply chain threats other than malicious insertion also were out of scope for this effort (although they could be accommodated by a framework expansion).

Out-of-scope:

- Malicious extraction in the supply chain, including loss of:
  - Advanced technology
  - Intellectual property
  - Unclassified controlled technical information
- Considerations of non-attack based security threats and vulnerabilities:
  - Example 1: Existing system design weaknesses (e.g., unintentional SW vulnerabilities) which could potentially be mitigated by supply chain countermeasures
  - Example 2: The contractor's use of a supplier for a critical-function application-specific integrated circuit (ASIC) different from the known/trusted supplier that was previously indicated in the contractor's procurement plans

4 FRAMEWORK AND CATALOG

The team created the attack pattern catalog (Appendix A) using supply chain data and information and by building on the TTPs of TARA, the supply chain elements of CAPEC, and the adversarial threats compiled by NIST. The resulting body of attack patterns brings what has already been captured in TARA and CAPEC for the supply chain to a refined level of detail. The NIST data was mined and translated for its relevance and applicability to DoD system acquisition.

Adversarial attacks are composed of many attributes, including the adversarial threat source, the method used by the adversary, the action that causes malicious insertion, and the adversary's goal. This effort developed a supply chain attack framework to structure and describe supply chain attack patterns where each pattern is elaborated by context data—provided in the form of 12 specific attributes that structure and codify the attack pattern. The catalog provides the content for 41 attack patterns that can be analyzed in various ways to support threat analyses and vulnerability assessments.

The framework includes the following 12 attack attributes:

1. Attack ID (unique ID number)
2. Attack Point (supply chain location or linkage)
3. Phase Targeted (acquisition life cycle phase)
4. Attack Type (malicious insertion of SW, HW, FW, or system information/data)
5. Attack Act (the "what")
6. Attack Vector (the "how")
7. Attack Origin (the "who")
8. Attack Goal (the "why")
9. Attack Impact (consequence if successful)
10. References (sources of information)
11. Threat (adversarial event directed at supply chain)
12. Vulnerabilities (exploitable weaknesses)

Figure 3 further defines the 12 attributes. (The *Attack Point* tag ("P#") designations listed in Figure 3 were graphically illustrated in Figures 1 and 2).

- ***Attack ID*: A unique identification number associated with a related and distinct set of attack attributes.**
  - Sequentially assigned number
- ***Attack Point*: The location at which, or the linkage through which, the supply chain attack is directed. Designated by a tag "P#." More than one may apply:**

Point of Attack	Tag
… at the program office	P1
… at the prime contractor location	P2
… at a sub-contractor location	P3
… at an integrator facility	P4
… at a software developer supplier	P5
… at a hardware developer supplier	P6
… into the supply chain physical flow	P7
… into the supply chain information/data flow	P8

- ***Phase Targeted*: The acquisition lifecycle phase targeted by an adversary. More than one may apply:**
  - Materiel Solution Analysis (MSA)
  - Technology Maturation and Risk Reduction (TMRR)
  - Engineering and Manufacturing Development (EMD)
  - Production and Deployment (P&D)
  - Operations and Support (O&S)
- ***Attack Type*: The focus of the malicious insertion. More than one may apply:**

Attack Type	
Malicious insertion of…	Hardware
	Software
	Firmware
	System Information/Data (Includes requirements, design, manuals, architectures, and roadmaps)

- ***Attack Act*: An action that causes a malicious payload or malicious intention to be delivered to or directed at a system for the purpose of adversely affecting that system.**
  - Example 1: Malware is inserted into system software during the build process
  - Example 2: System requirements or design documents are maliciously altered
- ***Attack Vector*: The route or method used by an adversary to exploit system design vulnerabilities or process weaknesses to cause adverse consequences. (Attack vectors are the means by which adversaries can access attack surfaces, which can be thought of as reachable and exploitable vulnerabilities.)**
  - Example 1: An adversary with access to software development tools and processes during the software integration and build process
  - Example 2: An adversary gains unauthorized access to system technical documentation
- ***Attack Origin*: The source of an attack.**
  - Information to identify the adversary's role, status, and/or relationship to the system development and acquisition (e.g., inside or outside the acquiring organization and/or supply chain, type of job performed, etc.).
- ***Attack Goal*: The adversary's reason for the attack. More than one may apply:**
  - Disruption
  - Corruption
  - Disclosure
  - Destruction

Note: An attack with these goals can be directed against the system at any of these locations:
- Program Office
- Prime contractor location (for Acquisition or Sustainment)
- Sub-contractor location
- Integration facility
- Software developer supplier
- Hardware developer supplier
- Supply chain physical flow
- Supply chain information/data flow

- ***Attack Impact*: What the attack accomplishes. A description of the adverse effect on the system.**
  - Impacts may vary widely and may affect any aspect of a system due to the variability in attack goals and phases targeted; e.g., the impact of implanted malicious software could include corruption of operational data or denial of service.
- ***References*: Source(s) from which this attack information was derived.**
- ***Threat*: An adversarial event directed at the supply chain, based on the adversarial action and the route or method used for exploitation.**
  - Threat descriptions are generated primarily by combining the Attack Act and Attack Vector (but may also draw upon the Attack Point, Type, and Origin).
- ***Vulnerabilities*: Exploitable weaknesses in the supply chain (including technical and procedural).**
  - The threat susceptibility.

Figure 3. Attack Attributes Defined

The framework, or attack pattern template, incorporates the 12 attributes as shown in Figure 4.

Attack Identifier:		
Target (Attack Type):	**Hardware:**	**Firmware:**
	Software:	**Sys Information or Data:**
Description (Attack Act):		
Attack Vector:		
Attack Origin:		
Attack Goal:	**Disruption:**	**Disclosure:**
	Corruption:	**Destruction:**
Attack Impact:		
References:		
Threat:		
Vulnerabilities:		
Attack Points:	**Program Office:**	**Software Developer:**
	Prime Contractor:	**Hardware Developer:**
	Subcontractor:	**Physical Flow:**
	Integrator Facility:	**Information Flow:**
Applicable Life Cycle Phases:		
	Materiel Solution Analysis:	
	Technology Maturation and Risk Reduction:	
	Engineering and Manufacturing Development:	
	Production and Deployment:	
	Operations and Support:	

Figure 4. Supply Chain Attack Pattern Framework

The attack patterns were built by populating the attack attributes in the framework with attack information gathered and structured from the various sources. It was often helpful to construct a graphic representation of the key attributes of an attack as it was being developed. For example, Figure 5 illustrates an attack of malicious insertion of SW in any of the SW engineering environments of SW developers/contractors during any life cycle phase after Milestone B (attack A3 in the catalog).

Figure 5 illustrates the key attack information. The *Attack Origin,* or "who," is the adversary's status, role, or relationship to the program. The *Attack Vector* describes the "how"—the route or method used by the adversary. The *Attack Act* tells the user what type of malicious insertion is targeted.

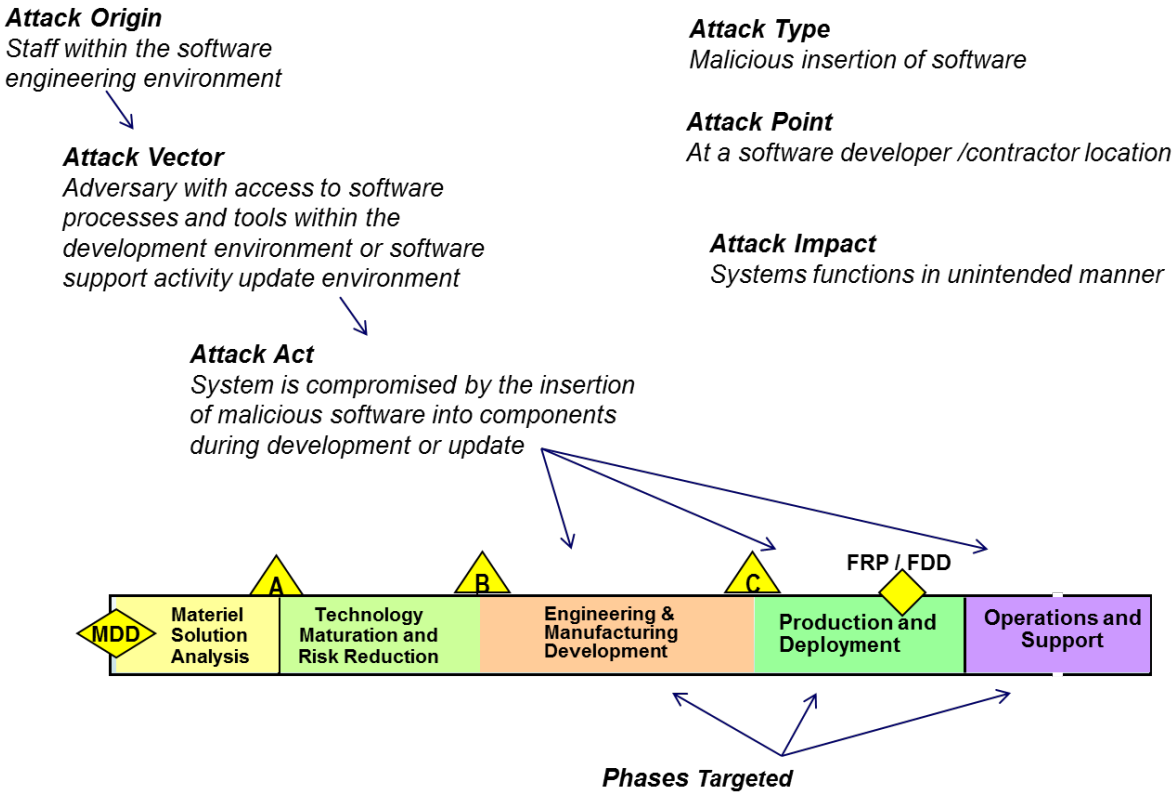

Figure 5. A Pictorial View of the Key Attributes for Attack A3

Building on this information, the team developed the remaining attributes for attack pattern A3. Figure 6 illustrates the attack pattern A3 from the catalog.

Attack Identifier:	A3				
Target (Attack Type):	**Hardware:**		**Firmware:**		
	Software:	Yes	**Sys Information or Data:**		
Description (Attack Act):	System is compromised by the insertion of malicious software into components during development or update.				
Attack Vector:	Adversary with access to software processes and tools within the development environment or software support activity update environment.				
Attack Origin:	Staff within the software engineering environment.				
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes	
	Corruption:	Yes	**Destruction:**		
Attack Impact:	System may function in a manner that is unintended.				
References:	Based on NIST SP 800-30; page E-4.				
Threat:	An adversary with access to software processes and tools within the development or software support environment can insert malicious software into components during development or update/maintenance.				
Vulnerabilities:	The development environment or software support activity environment is susceptible To an adversary inserting malicious software into components during development or update.				
Attack Points:	**Program Office:**		**Software Developer:**	Yes	
	Prime Contractor:	Yes	**Hardware Developer:**		
	Subcontractor:	Yes	**Physical Flow:**		
	Integrator Facility:	Yes	**Information Flow:**		

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Figure 6. Attack Pattern A3

5 UTILITY

The following paragraphs discuss the utility of this work as a reference for maturing the SSE discipline and as a decision support tool for acquisition programs to use in determining SCRM program protection actions.

5.1 Maturing the SSE Discipline

The structure and content of the catalog can be analyzed in various ways to provide insight into the understanding of current supply chain attacks. For example, Figure 7 shows the distribution of the 41 attack patterns across both the types of critical components that need to be protected and the life cycle phases targeted by the attacks.

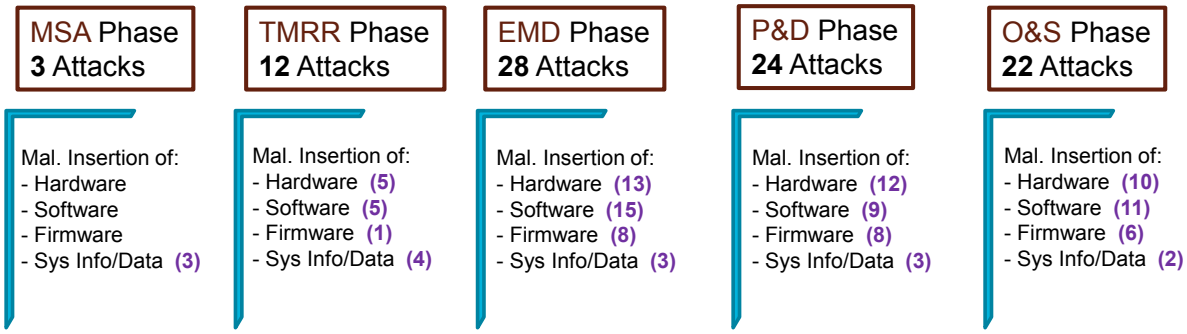

Figure 7. Analysis of Attack Types by Phase

While it is no surprise that the Engineering and Manufacturing Development (EMD) phase is susceptible to the greatest number of attacks (Figure 7), it is informative to examine how some of these attacks are applicable across the life cycle.

Several conclusions can be drawn from this analysis:

- Most attacks are applicable across multiple phases.
- There are a significant number of Technology Maturation and Risk Reduction (TMRR) phase attacks.
    - Planning for these attacks should occur during the Materiel Solution Analysis (MSA) phase.
- Early mitigation planning should aim to leverage cost-effective protection across the life cycle.
- More than two-thirds of the attacks are applicable to the EMD phase.
- Most attacks applicable to Production and Deployment (P&D) are applicable in earlier phases as well.
- There are important attacks that target only the sustainment supply chain.

Figure 8 illustrates that many attacks are applicable across multiple phases.

Attack ID	MSA	TMRR	EMD	P&D	O&S
A16	■	■			
A17	■	■			
A14	■	■	■		
A8		■			
A18		■	■		
A2		■	■	■	
A27		■	■	■	
A29		■	■	■	
A6		■	■	■	■
A38		■	■	■	■
A13		■	■		■
A36		■	■		■
A1			■		
A9			■		
A19			■	■	
A22			■	■	
A26			■	■	
A31			■	■	
A32			■	■	
A33			■	■	
A10			■		■
A40			■		■
A3			■	■	■
A4			■	■	■
A5			■	■	■
A7			■	■	■
A15			■	■	■
A20			■	■	■
A24			■	■	■
A39			■	■	■
A41			■	■	■
A11				■	
A12				■	
A25				■	
A30				■	■
A37				■	■
A21					■
A23					■
A28					■
A34					■
A35					■

Figure 8. Analysis of Phase Applicability Based on Current Attack Understanding

The analysis shown in Figure 9 demonstrates what can be learned about the potential points of attack for each attack.

Attack ID	Program Office	Prime Contractor	Sub-contractor	Integrator Facility	SW Developer	HW Developer	SC Physical Flow	SC Info/Data Flow
A14	■							
A7	■	■						
A30	■	■						■
A37	■	■						■
A36	■	■		■				■
A28	■					■		
A16	■							■
A17	■							■
A13		■	■		■			
A18		■	■		■			
A3		■	■	■	■			
A4		■	■	■	■			
A40		■	■	■	■			
A41		■	■	■		■		
A20		■	■	■	■			■
A21		■	■	■	■			■
A38		■	■	■	■			■
A39		■	■	■	■			■
A12		■	■	■	■	■	■	
A1		■	■	■	■		■	■
A8			■	■		■		
A9			■	■		■		
A23				■				
A19				■	■			
A26				■	■			
A32				■	■			
A10				■		■		
A25				■		■		
A5				■		■	■	
A29				■		■	■	
A31				■		■		■
A35					■		■	■
A6						■		
A22						■		
A24						■		
A33						■	■	
A34						■	■	
A2							■	
A11							■	
A15							■	
A27								■

Figure 9. Analysis of Attack Point Applicability

Conclusions from this analysis include:

- About half of the attacks can occur at either the program office or prime contractor locations.
- Most attacks applicable to prime contractors are also applicable to lower tiers.
- Most attacks applicable to subcontractors are also applicable to integrator facilities.
- SW developer suppliers and HW developer suppliers are targeted by the same number of attacks.

While this paragraph has provided several basic analyses, the attack patterns can be filtered and structured into other views to support program-specific consideration of specific types of supply chain attacks.

5.2 Concept of Use as a Decision Support Tool

The attack pattern catalog provides an elaboration of malicious insertion of HW, SW, FW, and system information and data into critical components of a DoD system being acquired or sustained. Acquisition programs may find this compilation useful for:

- Estimating and establishing program protection and SSE resourcing levels
- Guiding the TSN analysis
- Selecting and validating countermeasures
- Supporting abuse case analysis
- Performing supply chain penetration testing to verify how secure the supply chain really is against malicious insertion

As a decision support tool, the framework content can be analyzed and applied in various ways to identify specific types of supply chain attacks and to inform, from a technical and procedural point of view, the TSN supply chain threat analyses and vulnerability assessments across the full life cycle.

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Firmware	EMD	8	A4 A7 A10 A15 A20 A29 A33 A41
	P&D	8	A4 A7 A12 A15 A20 A29 A33 A41
	O&S	6	A4 A7 A10 A15 A20 A41
Sys Info/Data	MSA	3	A14 A16 A17
	TMRR	4	A14 A16 A17 A18
	EMD	3	A14 A18 A31
	P&D	3	A30 A31 A37
	O&S	2	A30 A37

Figure 10 filters and sorts all the attack patterns according to the types of critical components and phases targeted.

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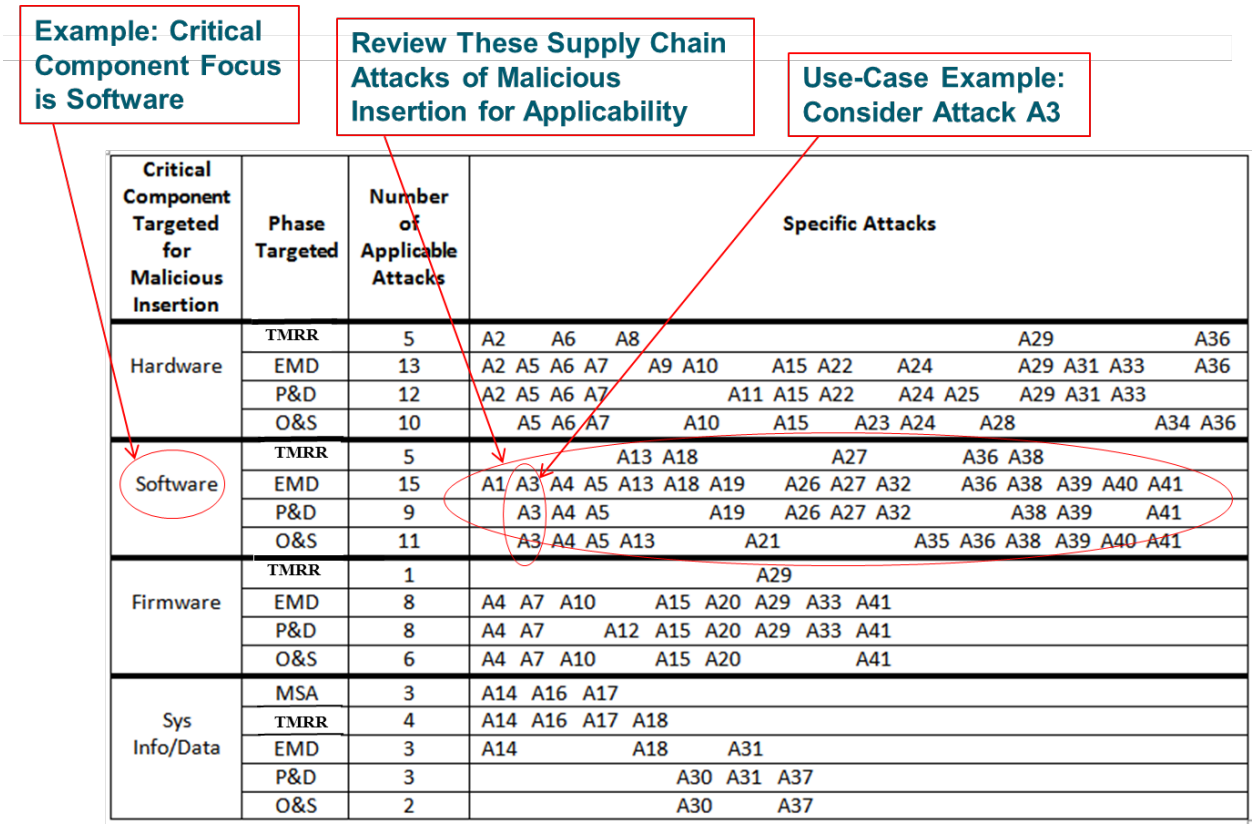
Sys Info/Data	TMRR	4	A14 A16 A17 A18
	EMD	3	A14 A18 A31
	P&D	3	A30 A31 A37
	O&S	2	A30 A37

Figure 10 (i.e., A1, A3, A4, A5, A13, etc.) to achieve a holistic view of the potential attacks of malicious insertion targeting SW.

Most of the attacks are applicable across multiple life cycle phases. Dealing with such attacks early can limit the costs of securing the supply chain later. Some of the attacks are applicable during the TMRR phase and, although a program's immediate interest is in the EMD phase and beyond, it may prove useful to consider what might have been done for protection during the TMRR phase and whether this type of attack is still a significant concern for the program.



Critical Component Targeted for Malicious Insertion	Phase Targeted	Number of Applicable Attacks	Specific Attacks
Hardware	TMRR	5	A2 A6 A8 A29 A36
	EMD	13	A2 A5 A6 A7 A9 A10 A15 A22 A24 A29 A31 A33 A36
	P&D	12	A2 A5 A6 A7 A11 A15 A22 A24 A25 A29 A31 A33
	O&S	10	A5 A6 A7 A10 A15 A23 A24 A28 A34 A36
Software	TMRR	5	A13 A18 A27 A36 A38
	EMD	15	A1 A3 A4 A5 A13 A18 A19 A26 A27 A32 A36 A38 A39 A40 A41
	P&D	9	A3 A4 A5 A19 A26 A27 A32 A38 A39 A41
	O&S	11	A3 A4 A5 A13 A21 A35 A36 A38 A39 A40 A41
Firmware	TMRR	1	A29
	EMD	8	A4 A7 A10 A15 A20 A29 A33 A41
	P&D	8	A4 A7 A12 A15 A20 A29 A33 A41
	O&S	6	A4 A7 A10 A15 A20 A41
Sys Info/Data	MSA	3	A14 A16 A17
	TMRR	4	A14 A16 A17 A18
	EMD	3	A14 A18 A31
	P&D	3	A30 A31 A37
	O&S	2	A30 A37

Figure 10. Use-Case Scenario Attacks for Consideration

Selecting attack A3 to continue this example, the program would next examine the key attributes of that attack pattern (Figure 3). Based on that analysis, the program would determine the applicability of attack A3 to the program-specific supply chain structure and the SW engineering environment(s) with a consideration of how these will change over time across the EMD, P&D, and Operations and Support (O&S) phases of acquisition.

Each attack pattern in the catalog includes specific threat and vulnerability information associated with that attack. Figure 6 provided a snapshot of attack A3 from the catalog. By examining the *Threat* and *Vulnerabilities* attributes for attack A3, users can see that the *Attack Act* and *Attack Vector* (with supporting information from the *Attack Origin*) are primarily what feed into describing the *Threat* and *Vulnerabilities* that A3 delivers.

For attack A3, the following information from the catalog may prove useful to the TSN analysis and to the subsequent development of the Program Protection Plan (PPP) (DASD(SE) 2011):

- *Threat*: An adversary with access to software processes and tools within the development or software support environment can insert malicious software into components during development or update/maintenance.
- *Vulnerabilities*: The development environment or software support activity environment is susceptible to an adversary's inserting malicious software into components during development or update.

In summary, the anticipated uses and benefits of the supply chain attack framework and catalog include the following:

- Users can identify specific types of supply chain attacks that can harm their systems, whether in acquisition or in the field.
- The attack pattern data can be sorted on any of the attributes as deemed relevant by the user (e.g., the *Attack Type,* the *Attack Points,* or the *Applicable Life Cycle Phase*).
- Users include DoD programs (and their contractors) charged with performing a TSN analysis to protect critical components.
- Results can inform specific sections of the PPP; e.g., PPP sections 5.1 (threats in PPP Tables 5.1-2 and 5.2; vulnerabilities in PPP Table 5.2-1).

Appendix A
Supply Chain Attack Pattern Catalog

This catalog contains the supply chain attack patterns that target the malicious insertion of hardware, software, firmware, and/or system information and data.

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Attack Identifier:	A1			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	"Targeted" malware (e.g., specifically designed to later take control of system, identify and exhilarate data or information, and conceal these actions) is introduced into system software during development.			
Attack Vector:	An adversary uses common delivery mechanisms (e.g., email attachments or removable media) to infiltrate the IDE or other development environment tools.			
Attack Origin:	An outsider with knowledge of the development environment, staff, and/or procedures.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the "targeted" capability of the malware. System may function in a manner that is unintended.			
References:	Based on NIST SP 800-30; page E-2			
Threat:	During software development, an outsider with knowledge of the development environment, staff, and/or procedures can breach the security of the IDE and/or other software development environment tools for unauthorized insertion of malware.			
Vulnerabilities:	The IDE and/or other software development environment tools are susceptible to an outsider (with knowledge of the development environment, staff, and/or procedures) inserting malware.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	Yes
	Integrator Facility:	Yes	**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A2			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	Legitimate hardware is replaced with faulty counterfeit or tampered hardware in the supply chain distribution channel.			
Attack Vector:	Adversary intercepts hardware from legitimate suppliers en route to contractor/integrator (in order to modify or replace it).			
Attack Origin:	Supply chain distribution personnel (packaging, shipping, receiving, or transfer).			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the counterfeit or tampered hardware.			
References:	Based on NIST SP 800-30; page E-3 (Also based on TARA).			
Threat:	Adversarial supply chain distribution channel personnel (e.g., packaging, shipping, receiving, or transfer) can intercept and replace legitimate critical hardware components with malicious ones.			
Vulnerabilities:	The distribution channel (e.g., packaging, shipping, receiving, or transfer) is susceptible to adversarial personnel intercepting and replacing legitimate critical hardware components with malicious ones.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	Yes
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A3			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	System is compromised by the insertion of malicious software into components during development or update.			
Attack Vector:	Adversary with access to software processes and tools within the development environment or software support activity update environment.			
Attack Origin:	Staff within the software engineering environment.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	
Attack Impact:	System may function in a manner that is unintended.			
References:	Based on NIST SP 800-30; page E-4.			
Threat:	An adversary with access to software processes and tools within the development or software support environment can insert malicious software into components during development or update/maintenance.			
Vulnerabilities:	The development environment or software support activity environment is susceptible To an adversary inserting malicious software into components during development or update.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A4			
Target (Attack Type):	**Hardware:**		**Firmware:**	Yes
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malicious logic (e.g., a back-door Trojan) is programmed into software or microelectronics (e.g., FPGAs) during development or an update.			
Attack Vector:	An adversary with access privileges within the software or firmware configuration control system during coding and logic-bearing component development.			
Attack Origin:	A software or firmware programmer during coding and integration.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the malicious logic.			
References:	Based on CAPEC: Attack ID 441			
Threat:	A software or firmware programmer with access to the configuration control system can introduce malicious logic into software or microelectronics during coding and/or logic-bearing component development or update/maintenance.			
Vulnerabilities:	The configuration control system is susceptible to the introduction of malicious logic into software or firmware/microelectronics during coding, integration, and/or logic-bearing component development or update/maintenance.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:

Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A5			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malware is embedded in a replacement server motherboard (e.g., in the flash memory) in order to alter server functionality from that intended.			
Attack Vector:	An adversary with access to the procurement, maintenance, and/or upgrade of servers, during the server procurement or hardware update process.			
Attack Origin:	A software-savvy adversary with hardware procurement control deep in the supply chain.			
Attack Goal:	**Disruption:**		**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the malware.			
References:	Based on web post by Slashdot: Dell Ships Infected Motherboards July 21, 2010			
Threat:	An adversary with access to hardware procurement, maintenance, or upgrade control can embed malware in a critical component server motherboard.			
Vulnerabilities:	The control processes and mechanisms for hardware procurement, maintenance, and/or upgrade are susceptible to embedded malware in a critical component server motherboard.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	Yes
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A6			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A microprocessor (or other chip) with a secret backdoor is substituted for a legitimate hardware component, where the backdoor is in the actual chip itself rather than in the firmware installed on it.			
Attack Vector:	An adversary with the ability to introduce malicious microelectronics components into the commodity procurement process without independent testing of those devices.			
Attack Origin:	A microelectronics manufacturer deep in the supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the backdoor.			
References:	Based on web post by samzenpus (protect-ya-neck dept.).			
Threat:	An adversary with access to the hardware commodity procurement process can insert improperly vetted or untested malicious critical microelectronics components into the system during development.			
Vulnerabilities:	The hardware commodity procurement process is susceptible to insertion of improperly vetted or untested malicious critical microelectronics components during system development.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:

Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A7				
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	Yes	
	Software:		**Sys Information or Data:**		
Description (Attack Act):	A microelectronics component (e.g., an FPGA) containing malicious logic (e.g., a back-door) is substituted for an approved, delivered component by direction from the program office or the prime contractor.				
Attack Vector:	An adversary positioned to direct program activity to cause the inclusion of compromised microelectronics components in the system being acquired or sustained.				
Attack Origin:	A program office or prime contractor engineer (“trusted insider”).				
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes	
	Corruption:	Yes	**Destruction:**		
Attack Impact:	Can vary widely, depending on the capability of the malicious logic.				
References:	Derived from multiple sources, including interviews with SCRM practitioners.				
Threat:	An adversary positioned to direct program activity can cause the inclusion of compromised microelectronics components in the system being acquired or sustained.				
Vulnerabilities:	Trusted-insider processes for directing program activity are susceptible to an adversary positioned and able to direct the inclusion of compromised microelectronics components in the system being acquired or sustained.				
Attack Points:	**Program Office:**	Yes	**Software Developer:**		
	Prime Contractor:	Yes	**Hardware Developer:**		
	Subcontractor:		**Physical Flow:**		
	Integrator Facility:		**Information Flow:**		

Applicable Life Cycle Phases:

Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A8			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A maliciously altered hardware component is substituted for a baseline component at the PDR timeframe.			
Attack Vector:	An adversary with access to system components during allocated baseline development.			
Attack Origin:	Assembly subcontractor engineers and technicians.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:		**Destruction:**	
Attack Impact:	System may function in a manner that is unintended, leading to disruption of the acquisition program and system design process.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to system components during allocated baseline development can substitute a maliciously altered hardware component for a baseline component in the PDR timeframe.			
Vulnerabilities:	Access to system components during allocated baseline development is susceptible to substitution of a maliciously altered hardware component for a baseline component in the PDR timeframe.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	

Attack Identifier:	A9			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A maliciously altered hardware component is substituted for a legitimate component during system test and integration.			
Attack Vector:	An adversary with access to system components during system test and evaluation.			
Attack Origin:	Test engineers and hardware integrators at a lower tier in the supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	System may function in a manner that is unintended.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to system components during system test and evaluation can substitute a maliciously altered hardware component for a legitimate component during system test and integration.			
Vulnerabilities:	Access to system components during system test and evaluation is susceptible to substitution of a maliciously altered hardware component for a legitimate component during system test and integration.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	
Operations and Support:	

Attack Identifier:	A10			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	Yes
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A counterfeit component is supplied from a lower-tier component supplier to a sub-system developer or integrator, which is then built into the system being acquired or sustained.			
Attack Vector:	An adversary with the ability to introduce counterfeit components into the procurement process in such a way that they are not thoroughly tested or otherwise verified for security. Includes hardware and firmware acquired through a commodity purchase, system acquisition, or sustainment process.			
Attack Origin:	A small-company component supplier feeding into the acquisition or sustainment supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	System may function in a manner that is unintended.			
References:	Based in part on Slashdot, March 09, 2010; as well as a web post by kdawson (do-not-get-too-close-to-the-viewfinder dept.).			
Threat:	An adversary with access to the procurement process can introduce counterfeit hardware and firmware components that have not been thoroughly tested or verified for security.			
Vulnerabilities:	The supply chain lower-tier component procurement process is susceptible to the introduction of counterfeit hardware and firmware components that have not been thoroughly tested or verified for security.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A11			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A maliciously altered hardware component is substituted for a tested and approved component.			
Attack Vector:	An adversary with access to production component supplier shipping channels during transfer of system components.			
Attack Origin:	Component transfer personnel (e.g., shipping, receiving, and transferring) at a lower tier in the supply chain, including transportation companies.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	System may function in a manner that is unintended, including destruction.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to production component supplier shipping channels during transfer of system components can substitute a maliciously altered hardware component for a tested and approved component.			
Vulnerabilities:	The supplier shipping channels, during transfer of system components, are susceptible to the substitution of maliciously altered hardware components for tested and approved components.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	Yes
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A12			
Target (Attack Type):	**Hardware:**		**Firmware:**	Yes
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A counterfeit firmware component is substituted for an authentic component.			
Attack Vector:	An adversary with access to production component supplier shipping channels during transfer of system components.			
Attack Origin:	Component transfer personnel (e.g., shipping, receiving, and transferring) at a lower tier in the supply chain, including transportation companies.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	System may function in a manner that is unintended, including destruction.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to supplier shipping channels during transfer of system components can substitute a counterfeit firmware component for an authentic component.			
Vulnerabilities:	Access to supplier shipping channels during transfer of system components is susceptible to the substitution of counterfeit firmware components for authentic components.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	Yes
	Subcontractor:	Yes	**Physical Flow:**	Yes
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A13			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malicious code (e.g., a logic bomb) is hidden in custom software during coding, integration, or test, either directly during the release or update processes, or via installation programs and device drivers (support systems) and/or development tools (e.g., a compromised compiler).			
Attack Vector:	An adversary with access privileges within the software development environment and associated tools, including the software unit/component test system, software configuration management system, and/or other software support and development tools.			
Attack Origin:	Software engineers and test engineers at any custom software developer facility.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	Can vary widely, depending on the capability of the malicious code.			
References:	Based in part on various news stories; e.g., http://www.theregister.co.uk/2010/06/25/spanish_logic_bomb_probe.			
Threat:	An adversary with access privileges within the software development environment and to associated tools, including the software unit/component test system and the software configuration management system, can hide malicious code in custom software.			
Vulnerabilities:	Access privileges within the software development environment, including associated access to software support and development tools (e.g., the software unit/component test system and the software configuration management system), are susceptible to allowing hidden malicious code in custom software.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A14			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:		**Sys Information or Data:**	Yes
Description (Attack Act):	Advanced technology and critical component architecture (including design and interface) descriptions are altered to circumvent dial-down functionality requirements associated with Defense Exportability Features (DEF).			
Attack Vector:	An adversary with access to DEF considerations within the program office's acquisition documents that include descriptions of advanced technology and/or specific components' criticality.			
Attack Origin:	Program office staff ("trusted insider").			
Attack Goal:	**Disruption:**		**Disclosure:**	Yes
	Corruption:		**Destruction:**	
Attack Impact:	Unintended release, distribution, or disclosure of advanced technology.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to DEF considerations contained in a program office's acquisition documents, considerations that include descriptions of advanced technology and/or specific components' criticality, can alter documents to circumvent dial-down functionality requirements for DEF.			
Vulnerabilities:	Access to DEF considerations contained in a program office's acquisition documents (including descriptions of advanced technology and/or specific components' criticality) are susceptible to malicious alteration to circumvent dial-down functionality requirements for DEF.			
Attack Points:	**Program Office:**	Yes	**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:

Materiel Solution Analysis:	Yes
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	
Operations and Support:	

Attack Identifier:	A15			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	Yes
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A hardware or firmware component is intercepted by an adversary for the purpose of substitution or manipulation.			
Attack Vector:	The distribution channel of a system component being transferred between supplier and acquirer, either in transit or at a transfer point.			
Attack Origin:	Any supplier personnel with undue access privileges.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the adversary's goal.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	A hardware or firmware component can be intercepted by an adversary while in transit between supplier and acquirer, for the purpose of substitution or manipulation.			
Vulnerabilities:	The distribution channels are susceptible to hardware or firmware components being intercepted while in transit between supplier and acquirer, for the purpose of substitution or manipulation.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	Yes
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:

Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A16			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:		**Sys Information or Data:**	Yes
Description (Attack Act):	Descriptions of system capabilities in the ICD and/or the CDD are misrepresented or altered, intending to cause errors in derived system requirements.			
Attack Vector:	Program Office domain of acquisition activities associated with potential submissions into the JCIDS document development and review processes.			
Attack Origin:	DoD Components and other "Sponsors" of JCIDS documents ("trusted" insiders).			
Attack Goal:	**Disruption:**		**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	JCIDS documents that do not reflect capability gaps or associated needed capability requirements.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	Within program office acquisition activities associated with potential Joint Capabilities Integration and Development System (JCIDS) submissions, descriptions of system capabilities in the ICD and/or the CDD can be misrepresented or altered, intending to cause errors in derived system requirements.			
Vulnerabilities:	The program office acquisition processes associated with Joint Capabilities Integration and Development System (JCIDS) submissions and descriptions of system capabilities in the ICD and/or the CDD are susceptible to malicious alteration or misrepresentation.			
Attack Points:	**Program Office:**	Yes	**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	Yes

Applicable Life Cycle Phases:

Materiel Solution Analysis:	Yes
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	

Attack Identifier:	A17			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:		**Sys Information or Data:**	Yes
Description (Attack Act):	Mission data, for example the mission threads and Concept of Operations (CONOPS), and/or requirements in the System Requirements Document (SRD) or the Technical Requirements Document (TRD) are altered, in order to cause errors in system development.			
Attack Vector:	Program Office domain of acquisition activities associated with mission data integrity and stakeholder and system requirements development.			
Attack Origin:	Systems engineers (“trusted” insiders).			
Attack Goal:	**Disruption:**		**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Faulty or inadequate system specification and design.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	Within program office acquisition activities, mission data (e.g., mission threads and CONOPS) and/or requirements in the SRD or the TRD can be altered in order to cause errors in system development.			
Vulnerabilities:	The program office acquisition processes are susceptible to allowing malicious alteration of mission data (e.g., mission threads and CONOPS) and/or requirements in the SRD or the TRD.			
Attack Points:	**Program Office:**	Yes	**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	Yes

Applicable Life Cycle Phases:

Materiel Solution Analysis:	Yes
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	

Attack Identifier:	A18			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	Yes
Description (Attack Act):	The requirements allocated to software are corrupted or the software design documents are altered, in order to cause errors in system design.			
Attack Vector:	An adversary with access to the requirements allocation processes and tools, and/or with access to the software design processes and tools.			
Attack Origin:				
Attack Goal:	**Disruption:**		**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Faulty or inadequate system design.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to requirements allocation and/or software design processes and tools can corrupt or alter either, in order to cause errors in system design.			
Vulnerabilities:	Requirements allocation and/or software design processes and tools are susceptible to malicious insertion in the software requirements or design.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	
Operations and Support:	

Attack Identifier:	A19			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malicious software is implanted in a system during the hardware-software integration phase.			
Attack Vector:	An adversary with access to 3rd party bundling processes and tools during the integration of system components for delivery to a higher-level supply chain contractor.			
Attack Origin:	A system integrator at a lower tier in the supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	System can function in a manner that is unintended.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to 3rd party bundling processes and tools can implant malicious software in a system during the hardware-software integration phase.			
Vulnerabilities:	3rd party bundling processes and tools are susceptible to implantation of malicious software during the hardware-software integration phase.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A20			
Target (Attack Type):	**Hardware:**		**Firmware:**	Yes
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A BIOS containing known vulnerabilities is installed for future exploitation.			
Attack Vector:	An adversary with access to download system software and update associated firmware with versions containing vulnerabilities.			
Attack Origin:	Hardware/ software integrators at lower tier in supply chain.			
Attack Goal:	**Disruption:**		**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the inserted vulnerabilities.			
References:	Based on TARA; AV ID 003.			
Threat:	An adversary with access to download and update system software installs a BIOS containing known vulnerabilities for future exploitation.			
Vulnerabilities:	Processes and tools for access to download system software and update associated firmware are susceptible to malicious installation.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A21			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	A software update containing malicious code is applied to the system being sustained.			
Attack Vector:	An adversary leverages an automated process to download and install malicious code that is believed to be a valid and authentic software update or patch.			
Attack Origin:	Software integrators and maintainers at lower tier in supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the malicious code.			
References:	Based on TARA; AV ID 024.			
Threat:	An automated software update/patch downloader/installer can be corrupted to download malicious code and apply it to systems being sustained.			
Vulnerabilities:	Access to an automated software update/patch downloader/installer is susceptible to corruption for downloading malicious code.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A22			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	The design and/or fabrication of hardware components is compromised.			
Attack Vector:	An adversary compromises the design and manufacture of critical hardware at targeted suppliers.			
Attack Origin:	Hardware design and manufacture engineers at lower tier in supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Faulty or inadequate system design.			
References:	Based on TARA; AV ID 121.			
Threat:	The design and manufacture of critical hardware at targeted suppliers can be compromised.			
Vulnerabilities:	Processes and tools for the design and manufacture of critical hardware are susceptible to compromise.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A23			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	During sustainment, legitimate faulty hardware or firmware is replaced by hardware into which malicious subcomponents have been placed.			
Attack Vector:	An adversary with access to intercept replacement hardware or firmware from a legitimate supplier and substitute components that have been maliciously altered.			
Attack Origin:	Technician with knowledge of and access to systems within the support supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	Can vary widely, depending on the capability of the malicious subcomponents.			
References:	Based on TARA; AV ID 122.			
Threat:	During sustainment, legitimate faulty hardware/firmware can be replaced by hardware/firmware into which malicious subcomponents have been placed.			
Vulnerabilities:	Access to systems within the sustainment supply chain are susceptible to unauthorized substitution of replacement hardware or firmware components.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A24			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	An ASIC for the system being acquired or maintained is designed and produced with malicious functionality built in.			
Attack Vector:	An adversary gains access to the hardware design and development processes within a DMEA accredited "trusted supplier" facility.			
Attack Origin:	Hardware designer or fabricator at a lower tier in the supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the maliciously designed ASIC.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An ASIC for a system being acquired or maintained can be designed and produced with malicious functionality built in.			
Vulnerabilities:				
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A25			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	A counterfeit hardware component is implanted in the system being acquired.			
Attack Vector:	An adversary produces counterfeit hardware components and includes them in product assembly.			
Attack Origin:	Engineers and technicians at an assembly sub-contractor site.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	The assembly containing counterfeit components (e.g., counterfeit routers, switches, LAN, or WAN cards) results in a system specifically designed for malicious purposes.			
References:	Based on TARA; AV ID 163.			
Threat:	A counterfeit hardware component can be implanted in a system being acquired. (This is different from: A counterfeit hardware component can end up in a system being acquired.)			
Vulnerabilities:	Processes and tools at an assembly or sub-assembly site are susceptible to the implantation of a counterfeit hardware component.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A26			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malicious software is implanted in the system being integrated.			
Attack Vector:	An adversary includes unsecured 3rd party components in a technology, product, or code-base, packaging a potentially malicious component with the product before shipment to the acquirer.			
Attack Origin:	Software developers/ integrators at lower tier in supply chain.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	Can vary widely, depending on the adversary's goal.			
References:	Based on TARA; AV ID 181.			
Threat:	Unsecured, potentially malicious 3rd party components of a technology or code-base can be packaged with a product before shipment to an acquirer.			
Vulnerabilities:	Processes and tools for software integration are susceptible to the implantation of unsecured, malicious 3rd party software components.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A27			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malicious code is inserted into open source software used for math libraries.			
Attack Vector:	An adversary with access to open source library code and knowledge of its particular use for the system being acquired.			
Attack Origin:	An outsider (or insider) with knowledge of the software development plans for acquisition.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the adversary's goal.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to open source code and knowledge of its particular use for the system being acquired can insert malicious code into open source software used for math libraries.			
Vulnerabilities:	Access to open source software and/or the processes and tools for including it in system math libraries are susceptible to malicious code insertion.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A28			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	Insertion of maliciously altered hardware components into the gray market.			
Attack Vector:	During life cycle sustainment, spare components (from original suppliers) will often become unavailable. As a result, the obsolescence program to find replacements introduces a potential avenue for attack by adversaries who offer the necessary replacement parts, but with malware incorporated.			
Attack Origin:	The gray market or "bogus" components intended to be accepted as genuine from reputable, trusted sources.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	Can vary widely, depending on the adversary's goal.			
References:	Based on TARA; AV ID 124.			
Threat:	A gray market adversary can exploit an obsolescence program to introduce replacement hardware with malware incorporated.			
Vulnerabilities:	Use of the gray market for hardware replacement components is susceptible to the introduction of malware-infested components.			
Attack Points:	**Program Office:**	Yes	**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A29			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	Yes
	Software:		**Sys Information or Data:**	
Description (Attack Act):	Rogue processes in an integration facility are established in order to clandestinely insert maliciously altered components into the system.			
Attack Vector:	An adversary with access to critical components as they are being integrated into the acquired system.			
Attack Origin:	Organization with the ability to establish deceptive processes.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	System may function in a manner that is unintended, which can vary widely.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to critical components as they are being integrated into the acquired system can insert maliciously altered hardware or firmware into the system.			
Vulnerabilities:	Processes in an integration facility are susceptible to the insertion of maliciously altered hardware.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	Yes
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A30			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:		**Sys Information or Data:**	Yes
Description (Attack Act):	During the system build process, the system is deliberately misconfigured by the alteration of the build data.			
Attack Vector:	An adversary with access to the data files and processes used for executing system configuration and performing the build.			
Attack Origin:	Engineers who are performing the system build and configuration activities.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	Compromise of the external mission load, which can lead to a variety of final impacts.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with access to the data files and processes used for executing system configuration and performing the build can deliberately misconfigure the build data.			
Vulnerabilities:	Access to system configuration data files and build processes are susceptible to deliberate misconfiguration of the system.			
Attack Points:	**Program Office:**	Yes	**Software Developer:**	
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A31			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	Yes
Description (Attack Act):	Manipulation of design specifications to produce malicious hardware (e.g., the modification of transistor specifications for an integrated circuit).			
Attack Vector:	An adversary with access to design specifications during the hardware manufacturing process.			
Attack Origin:	Hardware engineers at a lower-tier to whom the manufacture of key components has been outsourced.			
Attack Goal:	**Disruption:**		**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Faulty hardware manufactured to compromised design specifications.			
References:	Based on CAPEC: Attack ID 438.			
Threat:	An adversary with access to design specifications during the hardware manufacturing process can manipulate the design specifications to produce malicious hardware.			
Vulnerabilities:	Access to design specifications during the hardware manufacturing process are susceptible to allowing production of malicious hardware.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A32			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malware is embedded into a sub-assembly via a linked library or by directly pre-installing it in a software file.			
Attack Vector:	An adversary with access to software being integrated into a system during a "sub-assembly" manufacturing process.			
Attack Origin:	Software engineers at a lower-tier to whom software integration of key components has been outsourced.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	Yes
	Corruption:		**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the malware.			
References:	Based on CAPEC: Attack ID 438.			
Threat:	An adversary with access to software being integrated into a system during a "sub-assembly" manufacturing process can embed malware into a sub-assembly.			
Vulnerabilities:	Access to software and associated integration processes during sub-assembly manufacturing are susceptible to insertion of malware via linked libraries and/or pre-installed software.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A33				
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	Yes	
	Software:		**Sys Information or Data:**		
Description (Attack Act):	A malicious component is substituted for a legitimate component during the packaging and distribution processes.				
Attack Vector:	An adversary with access to services provided from a manufacturer to a supplier during packaging and distribution.				
Attack Origin:	Technical and non-technical staff at an Original Equipment Manufacturer (OEM) facility.				
Attack Goal:	**Disruption:**	Yes	**Disclosure:**		
	Corruption:	Yes	**Destruction:**	Yes	
Attack Impact:	Can vary widely, depending on the capability of the malicious component.				
References:	Based on CAPEC: Attack ID 439 .				
Threat:	An adversary with access to critical components during packaging and distribution can substitute a malicious component for a legitimate component.				
Vulnerabilities:	Packaging and distribution processes at an OEM are susceptible to insertion of malicious hardware or firmware.				
Attack Points:	**Program Office:**		**Software Developer:**		
	Prime Contractor:		**Hardware Developer:**	Yes	
	Subcontractor:		**Physical Flow:**	Yes	
	Integrator Facility:		**Information Flow:**		

Applicable Life Cycle Phases:

Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	

Attack Identifier:	A34			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:		**Sys Information or Data:**	
Description (Attack Act):	Malicious hardware is substituted for a legitimate component during life cycle maintenance.			
Attack Vector:	An adversary with access to the fielded operational system that is offline for scheduled maintenance and/or with access to parts depot logistics.			
Attack Origin:	Technical and non-technical staff at a field support activity.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	Can vary widely, depending on the capability of the malicious hardware.			
References:	Based on CAPEC: Attack ID 440 .			
Threat:	An adversary with access to a fielded operational system that is offline for scheduled maintenance and/or with access to parts depot logistics can substitute malicious hardware for a legitimate component during life cycle maintenance.			
Vulnerabilities:	A fielded operational system offline for scheduled life cycle maintenance and/or access to parts depot logistics are susceptible to the insertion of malicious hardware.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:		**Hardware Developer:**	Yes
	Subcontractor:		**Physical Flow:**	Yes
	Integrator Facility:		**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A35			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malicious software is substituted for a legitimate component during a software upgrade.			
Attack Vector:	An adversary with access to software support activity upgrades.			
Attack Origin:	Technical and nontechnical staff at a field support activity.			
Attack Goal:	**Disruption:**		**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Can vary widely, depending on the capability of the malicious code.			
References:	Based on CAPEC: Attack ID 440 .			
Threat:	An adversary with access to a software support activity can substitute malicious software for a legitimate component during a software upgrade.			
Vulnerabilities:	Software support activity upgrade processes and tools are susceptible to the introduction of malicious software.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:		**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	Yes
	Integrator Facility:		**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A36			
Target (Attack Type):	**Hardware:**	Yes	**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	An adversary manipulates any of the following hardware and/or software baselines during Acquisition; functional baseline; allocated baseline; product baseline; or the product baseline updates during sustainment.			
Attack Vector:	An adversary with access to configuration control tools and processes during the establishment and/or update of system baselines.			
Attack Origin:	Configuration management personnel.			
Attack Goal:	**Disruption:**		**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	This configuration management breach will likely produce a faulty baseline with unquestioned integrity. The final impacts could vary widely.			
References:	Based on TARA: Several AV IDs.			
Threat:	An adversary with access to configuration control tools and processes can manipulate any of the hardware and/or software development baselines during acquisition, or product baseline updates during sustainment.			
Vulnerabilities:	Processes and tools for hardware and software baseline creation and updates are susceptible to manipulation and corruption.			
Attack Points:	**Program Office:**	Yes	**Software Developer:**	
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A37			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:		**Sys Information or Data:**	Yes
Description (Attack Act):	An adversary corrupts critical operational data by injecting false but believable data into the system during configuration.			
Attack Vector:	An adversary with access to the data files and processes used for providing operational data loads during system configuration.			
Attack Origin:	Engineers or technicians who are loading operational data during system configuration.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Suboptimal system performance (at varying degrees of degradation) during operations, with an associated loss of confidence.			
References:	Based on NIST SP 800-30; pages E-5 and E-6.			
Threat:	An adversary with access to the data files and processes used for providing operational data loads can corrupt critical operational data by injecting false but believable data into the system during configuration.			
Vulnerabilities:	Data files, processes, and tools for configuring the system and establishing operational data loads are susceptible to malicious tampering.			
Attack Points:	**Program Office:**	Yes	**Software Developer:**	
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:		**Physical Flow:**	
	Integrator Facility:		**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A38			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Maliciously altered COTS software is introduced into a primary support system (e.g., system design tools, a compiler, or a configuration management system).			
Attack Vector:	An adversary with the ability to subvert web-based delivery and/or on-site software updates.			
Attack Origin:	Technical or non-technical staff at a support system vendor location or with access to its distribution process.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Faulty support system operation which could delay or degrade the system acquisition processes, or if undetected, the operational system itself.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with the ability to subvert web-based delivery and/or on-site software updates can introduce maliciously altered COTS software into a primary support system (e.g., system design tools, a compiler, or a configuration management system).			
Vulnerabilities:	Web-based delivery and/or on-site software update processes are susceptible to the introduction of maliciously altered COTS software into a primary support system (e.g., system design tools, a compiler, or a configuration management system).			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	Yes
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A39			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Maliciously altered COTS software is introduced into the system being acquired or sustained.			
Attack Vector:	An adversary with the ability to subvert web-based delivery of COTS software and/or the ability to access on-site insertion of COTS software into the system being acquired or sustained.			
Attack Origin:	Technical or non-technical staff at a software supplier or integrator location or with access to their COTS distribution process.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	Yes
Attack Impact:	Can vary widely, depending on the capability of the malicious COTS code.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with the ability to subvert web-based delivery of COTS software and/or the ability to access on-site insertion of COTS software into the system being acquired or sustained can introduce maliciously altered COTS software into the system.			
Vulnerabilities:	Web-based delivery and/or on-site software update processes are susceptible to the introduction of maliciously altered COTS software into the system being acquired or sustained.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	Yes

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

Attack Identifier:	A40			
Target (Attack Type):	**Hardware:**		**Firmware:**	
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Software development tools are maliciously altered. Such tools include requirements management and database tools, software design tools, configuration management tools, compilers, system build tools, and software performance testing and load testing tools.			
Attack Vector:	An adversary with the ability to manipulate components of primary support systems and tools within the software development environment.			
Attack Origin:	Staff charged with the installation, management, and/or maintenance of primary support systems for software development.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Faulty operation of a primary acquisition support system.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with the ability to manipulate components of primary support systems and tools within the software development environment can maliciously alter those software development tools (which include, e.g., requirements management and database tools, software design tools, configuration management tools, compilers, system build tools, and software performance testing and load testing tools).			
Vulnerabilities:	Access to components of primary support systems and tools within the software development environment are susceptible to malicious alteration.			
Attack Points:	**Program Office:**		**Software Developer:**	Yes
	Prime Contractor:	Yes	**Hardware Developer:**	
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	
Operations and Support:	Yes

Attack Identifier:	A41			
Target (Attack Type):	**Hardware:**		**Firmware:**	Yes
	Software:	Yes	**Sys Information or Data:**	
Description (Attack Act):	Malicious software is inserted within the hardware development environment (e.g., malware inserted in a robotic control system) or within the firmware development environment (e.g., a maliciously altered FPGA programming tool).			
Attack Vector:	An adversary with the ability to manipulate components of primary support systems and tools within the hardware and/or firmware development and production environments.			
Attack Origin:	Staff charged with the installation, management, and/or maintenance of primary support systems for hardware and/or firmware development and production.			
Attack Goal:	**Disruption:**	Yes	**Disclosure:**	
	Corruption:	Yes	**Destruction:**	
Attack Impact:	Faulty operation of a primary acquisition support system.			
References:	Derived from multiple sources, including interviews with SCRM practitioners.			
Threat:	An adversary with the ability to manipulate components of primary support systems and tools within the development/production environments can insert malicious software within the hardware development environment (e.g., malware inserted in a robotic control system) or within the firmware development environment (e.g., a maliciously altered FPGA programming tool).			
Vulnerabilities:	Access to components of primary support systems and tools within the hardware development and/or firmware production environments are susceptible to malicious insertion of software and firmware.			
Attack Points:	**Program Office:**		**Software Developer:**	
	Prime Contractor:	Yes	**Hardware Developer:**	Yes
	Subcontractor:	Yes	**Physical Flow:**	
	Integrator Facility:	Yes	**Information Flow:**	

Applicable Life Cycle Phases:	
Materiel Solution Analysis:	
Technology Maturation and Risk Reduction:	
Engineering and Manufacturing Development:	Yes
Production and Deployment:	Yes
Operations and Support:	Yes

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Appendix B
Initial Potential Countermeasures Catalog

This catalog contains the initial set of potential countermeasures for supply chain attacks of malicious insertion focused on: Hardware, Software, Firmware, and/or System Information and Data.

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Countermeasure (CM) ID:	CM-1
CM Name:	Secure Configuration Management of Software
CM Focus:	Software + Sys Info/Data
Mitigation Approach:	Implement configuration management security practices that protect the integrity of software and associated data.
CM Description:	Include security enhancements in the Software Configuration Management system that: monitor and control access to the configuration management system, harden centralized repositories against attack, establish acceptance criteria for configuration management check-in to assure integrity, plan for and audit the security of the configuration management administration processes, and maintain configuration control over operational systems.
CM Goals: (Prevent, Detect, Respond)	Prevent + Detect + Respond
Earliest Implementation Phase:	MSA
Timeframe to Implement:	Ongoing
Cost to Implement: (High, Medium, Low)	Medium
Resources Needed: (Centers, Staff, Equipment)	Staff + Equipment
CM Type: (Process, Technical, Device)	Process + Device
Expected Risk Reduction: (Limited, Significant)	Significant
References:	TARA pilot catalog entry: C000022; NSA draft document on configuration management process; NIST SP 800-128, August 2011

Countermeasure (CM) ID:	CM-2
CM Name:	Prevent or Detect Critical Component Tampering
CM Focus:	Hardware + Firmware
Mitigation Approach:	Prevent or detect tampering with critical hardware or firmware components while in transit, across all life cycle phases, through use of state-of-the-art anti-tamper devices.
CM Description:	Plan for, use, and monitor anti-tamper techniques and devices to prevent and/or detect tampering (unauthorized interference to cause damage), in order to safeguard shipments, transfers, and deliveries of critical hardware and firmware across the system's full life cycle. Use tamper-resistant and tamper-evident packaging (e.g., plastic coating for circuit boards, tamper tape, paint, sensors, and/or seals for cases and containers) and inspect received system components for evidence of tampering.
CM Goals: **(Prevent, Detect, Respond)**	Prevent + Detect
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	Low
Resources Needed: **(Centers, Staff, Equipment)**	Equipment
CM Type: **(Process, Technical, Device)**	Device
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	TARA pilot catalog entry: C000011

Countermeasure (CM) ID:	CM-3
CM Name:	Security-Focused Programming Languages
CM Focus:	Software
Mitigation Approach:	Choose programming languages (and support tools) that counter software vulnerabilities and minimize the potential for exploitable weaknesses.
CM Description:	Choose programming languages that protect against both unintentional and intentional software vulnerabilities. Select languages and support tools that reduce the likelihood of exploitable weaknesses and/or provide constructs that make software weakness and vulnerabilities easier to avoid.
CM Goals: (Prevent, Detect, Respond)	Prevent
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Between Milestone A and Milestone B
Cost to Implement: (High, Medium, Low)	Low
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Technical
Expected Risk Reduction: (Limited, Significant)	Significant
References:	TARA pilot catalog entry: C000021SCRM; Key Practices Guide-2010-02-25.pdf

Countermeasure (CM) ID:	CM-4
CM Name:	Security-Focused Design and Coding Standards and Reviews
CM Focus:	Software
Mitigation Approach:	Establish the use of security-focused design and coding standards/guidelines and use them for inspections and reviews.
CM Description:	Establish the use of design and coding standards and guidelines to improve security (in addition to quality, readability, and maintainability) of software components. Use them as part of the criteria for design inspections to ensure integrity (and traceability) of allocated software requirements and design and to ensure minimized attack surfaces in the architecture. Conduct manual source code reviews on all critical software components to discover exploitable weaknesses and vulnerabilities.
CM Goals: **(Prevent, Detect, Respond)**	Prevent + Detect
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	Low
Resources Needed: **(Centers, Staff, Equipment)**	Staff
CM Type: **(Process, Technical, Device)**	Process
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	https://www.securecoding.cert.org/confluence/display/seccode/Top+10+Secure+Coding+Practices; http://cwe.mitre.org/top25/index.html; www.cert.org/archive/pdf/09tr010.pdf - 2009-10-23; SafeCode referenced from the TSN Analysis Tutorial: http://www.safecode.org/publications/SAFECode_Dev_Practices0211.pdf

Countermeasure (CM) ID:	CM-5
CM Name:	Supply Chain Red Teaming
CM Focus:	Hardware + Software + Firmware + Sys Info/Data
Mitigation Approach:	Use red teams to perform supply chain penetration testing.
CM Description:	A supply chain red team conducts penetration testing to assess specific vulnerabilities as well as the overall security of the supply chain, by simulating various potential attack actions of an adversary; e.g., by penetration testing of the hardware development environment. In so doing, they identify potential vulnerabilities in the supply chain.
CM Goals: **(Prevent, Detect, Respond)**	Detect
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	Medium
Resources Needed: **(Centers, Staff, Equipment)**	Staff
CM Type: **(Process, Technical, Device)**	Process + Device
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	Based on TARA pilot catalog entry: C000017; SCRM Key Practices Guide-2010-02-25.pdf

Countermeasure (CM) ID:	CM-6
CM Name:	Trusted Shipping
CM Focus:	Hardware + Firmware
Mitigation Approach:	Utilize trusted shipping to protect deliveries
CM Description:	The contractors and sub-suppliers use trusted means of shipping (e.g., bonded/cleared/vetted and insured couriers) to ensure that the critical components, once purchased, are not subject to compromise during their delivery.
CM Goals: (Prevent, Detect, Respond)	Prevent
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: (High, Medium, Low)	Medium
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Process
Expected Risk Reduction: (Limited, Significant)	Significant
References:	Based on TARA pilot catalog entry: C000010

Countermeasure (CM) ID:	CM-7
CM Name:	Hardened Delivery Mechanisms
CM Focus:	Hardware + Software + Firmware
Mitigation Approach:	Harden supply chain delivery mechanisms.
CM Description:	Ensure that critical component delivery mechanisms (both physical and logical) used by all supplier tiers do not provide opportunities for unauthorized access to the component or information about its uses (including the identities of end users). Unauthorized access includes unauthorized modification which could lead to malicious substitution and subversion). This practice covers the entire life cycle, including the delivery of system components to integrators, delivery of the system itself to users, and system maintenance (including repair and delivery of replacement parts or software). This practice also includes inventory management for the system and its elements.
CM Goals: **(Prevent, Detect, Respond)**	Prevent
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	Medium
Resources Needed: **(Centers, Staff, Equipment)**	Centers + Staff + Equipment
CM Type: **(Process, Technical, Device)**	Process
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	Based on TARA pilot catalog entry: C000069; SCRM Key Practices Guide-2010-02-25.pdf

Countermeasure (CM) ID:	CM-8
CM Name:	Tracking Tags and Security Tags
CM Focus:	Hardware + Firmware
Mitigation Approach:	Use optical tags and/or RFID tagging to track shipments. Embed security tags into hardware and firmware components.
CM Description:	1. Incorporate optical tags onto the surface of critical components. (The tag, which is very small, is validated at point of receipt.) 2. Use RFID tagging to track transit of shipped components at each leg of the distribution channel. 3. Incorporate "security tag" technology into a system that can be used to verify the authenticity of semiconductor devices and detect falsely marked "ghost" chips. Such a tag could take the form of a small digital circuit which is added to the chip design and communicates through the package with an external sensor.
CM Goals: **(Prevent, Detect, Respond)**	Detect
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	High
Resources Needed: **(Centers, Staff, Equipment)**	Equipment
CM Type: **(Process, Technical, Device)**	Technical + Device
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	Based on the following TARA pilot catalog entries: C000015 for optical tags, C000059 for RFID tagging, and C000064 for embedded tags; http://cs.ucsb.edu/~koc/ccs130h/2011/00-hw-trojans/05.pdf

Countermeasure (CM) ID:	CM-9
CM Name:	Pedigree Established Across the Supply Chain
CM Focus:	Software + Sys Info/Data
Mitigation Approach:	Identify and assess trustworthiness of software and information, from the lowest levels/tiers of the supply chain up to system deployment.
CM Description:	Critical software and information is identified. For each, information concerning the design, development, maintenance, and delivery is known and assessed for its trustworthiness. For example, the developers, maintainers, and distributors of critical software are known, and have been assessed in terms of their trustworthiness. This pedigree and lineage of software is monitored to ensure that trust is maintained. Similarly, critical and sensitive information is monitored from origination, to storage, to delivery to ensure that the integrity of the information is maintained.
CM Goals: **(Prevent, Detect, Respond)**	Prevent
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	Medium
Resources Needed: **(Centers, Staff, Equipment)**	Staff
CM Type: **(Process, Technical, Device)**	Process
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	Based on TARA pilot catalog entry: C000006

Countermeasure (CM) ID:	CM-10
CM Name:	Bulk Spares Inventory
CM Focus:	Hardware + Firmware
Mitigation Approach:	Maintain a large spare parts inventory/depot.
CM Description:	Bulk purchases of spare parts for critical ICT components are made early on, usually at the same time the critical component is acquired. Doing so, instead of purchasing them as needed, mitigates the threat of an adversary replacing the spare parts with substandard or malware infected components.
CM Goals: (Prevent, Detect, Respond)	Prevent
Earliest Implementation Phase:	P&D
Timeframe to Implement:	Between Milestone B and Milestone C
Cost to Implement: (High, Medium, Low)	Low
Resources Needed: (Centers, Staff, Equipment)	Centers
CM Type: (Process, Technical, Device)	Process
Expected Risk Reduction: (Limited, Significant)	Limited
References:	Based on TARA pilot catalog entry: C000009

Countermeasure (CM) ID:	CM-11
CM Name:	Multiple Suppliers
CM Focus:	Hardware + Software + Firmware
Mitigation Approach:	Use multiple suppliers for key critical components.
CM Description:	Use multiple suppliers of critical components and critical-component assemblies to limit the chance that an adversary may compromise some of the components during design, development, manufacturing, and/or integration at one of the supply chain locations.
CM Goals: **(Prevent, Detect, Respond)**	Prevent
Earliest Implementation Phase:	EMD
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	Medium
Resources Needed: **(Centers, Staff, Equipment)**	Staff
CM Type: **(Process, Technical, Device)**	Technical
Expected Risk Reduction: **(Limited, Significant)**	Limited
References:	Based on TARA pilot catalog entry: C000007

Countermeasure (CM) ID:	CM-12
CM Name:	Trusted Suppliers
CM Focus:	Hardware + Software + Firmware
Mitigation Approach:	Use trusted foundries for critical hardware or software components.
CM Description:	Use or develop trusted components to protect functions that are so critical that their exploitation would cause severe harm to the system/mission. For critical hardware that may be susceptible to supply chain attacks, trusted foundries or more stringent controls around design, development, and distribution of these components should be used. For critical software assets, trust may be increased through the use of TPM, HAP, and trusted OSs.
CM Goals: **(Prevent, Detect, Respond)**	Prevent
Earliest Implementation Phase:	EMD
Timeframe to Implement:	After Milestone B
Cost to Implement: **(High, Medium, Low)**	High
Resources Needed: **(Centers, Staff, Equipment)**	Centers
CM Type: **(Process, Technical, Device)**	Process + Technical
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	Based on TARA pilot catalog entry: C000008

Countermeasure (CM) ID:	CM-13
CM Name:	Acquirer Anonymity
CM Focus:	Hardware + Firmware
Mitigation Approach:	Utilize anonymous, bulk purchase of stock components and blind buy acquisition of custom components.
CM Description:	When possible, avoid acquisition/purchase of custom configurations of critical components and purchase stock components instead. When custom configurations are necessary, implement a blind-buy contractual arrangement early in the acquisition life cycle. The purpose of such procedures is to limit activities that might reveal to a potential attacker the end user of critical components.
CM Goals: (Prevent, Detect, Respond)	Prevent
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: (High, Medium, Low)	Low
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Process
Expected Risk Reduction: (Limited, Significant)	Significant
References:	Based on TARA pilot catalog entry: C000012

Countermeasure (CM) ID:	CM-14
CM Name:	Electromagnetic (EM) / Thermal Analysis
CM Focus:	Hardware + Firmware
Mitigation Approach:	Conduct EM/thermal emanations analysis.
CM Description:	Use EM and/or thermal analysis to detect any changes that have been made to hardware (or counterfeit hardware). These analyses can allow detection of gold-standard circuits as well as tampered circuits.
CM Goals: **(Prevent, Detect, Respond)**	Detect
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	High
Resources Needed: **(Centers, Staff, Equipment)**	Staff + Equipment
CM Type: **(Process, Technical, Device)**	Technical + Device
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	Based on TARA pilot catalog entry: C000016

Countermeasure (CM) ID:	CM-15
CM Name:	Network Traffic Restriction
CM Focus:	Software + Sys Info/Data
Mitigation Approach:	Restrict traffic on all supply chain networks and IDEs.
CM Description:	Specify "deny all" or "permit by exception" for both inbound and outbound network traffic on all supply chain networks and IDEs over which critical software and sensitive data and information will be delivered and/or maintained. This includes the program office and all contactor tiers of the supply chain.
CM Goals: (Prevent, Detect, Respond)	Prevent
Earliest Implementation Phase:	MSA
Timeframe to Implement:	Ongoing
Cost to Implement: (High, Medium, Low)	Low
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Process
Expected Risk Reduction: (Limited, Significant)	Significant
References:	Based on TARA pilot catalog entry: C000030

Countermeasure (CM) ID:	CM-16
CM Name:	Visual Inspection
CM Focus:	Hardware + Firmware
Mitigation Approach:	Use visual inspection to detect counterfeit components and tampering.
CM Description:	Visually inspect ICT component for tampering, anomalies, defects, or counterfeits.
CM Goals: (Prevent, Detect, Respond)	Detect
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: (High, Medium, Low)	Low
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Process
Expected Risk Reduction: (Limited, Significant)	Limited
References:	Based on TARA pilot catalog entry: C000058

Countermeasure (CM) ID:	CM-17
CM Name:	Cryptography
CM Focus:	Software + Firmware + Sys Info/Data
Mitigation Approach:	Use cryptography to authenticate sources of software and information/data.
CM Description:	Require and use digital signatures, encryption, checksums, and/or other cryptographic techniques to verify sender authenticity of all information and data received, including software and firmware.
CM Goals: **(Prevent, Detect, Respond)**	Prevent + Detect
Earliest Implementation Phase:	MSA
Timeframe to Implement:	Ongoing
Cost to Implement: **(High, Medium, Low)**	Medium
Resources Needed: **(Centers, Staff, Equipment)**	Staff
CM Type: **(Process, Technical, Device)**	Process + Technical
Expected Risk Reduction: **(Limited, Significant)**	Significant
References:	Based on TARA pilot catalog entry: C000061

Countermeasure (CM) ID:	CM-18
CM Name:	Supply Chain Visibility
CM Focus:	Hardware + Software + Firmware
Mitigation Approach:	Maximize the acquirer's visibility into all tiers of the supply chain.
CM Description:	Acquirers should seek to maximize visibility into all suppliers and their supporting tiers (including both custom and OTS products) to understand how elements are created, tested, delivered, and supported throughout the life cycle, and to assess potential supply chain structures (suppliers and linkages). This visibility enables acquirers to evaluate the supply chain sufficiently to manage supply chain risks and protect the integrity and availability of critical components.
CM Goals: (Prevent, Detect, Respond)	Prevent + Detect
Earliest Implementation Phase:	TMRR
Timeframe to Implement:	Ongoing
Cost to Implement: (High, Medium, Low)	Medium
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Process
Expected Risk Reduction: (Limited, Significant)	Significant
References:	Based on TARA pilot catalog entry: C000067; SCRM Key Practices Guide-2010-02-25.pdf

Countermeasure (CM) ID:	CM-19
CM Name:	Personnel Trust
CM Focus:	Hardware + Software + Firmware + Sys Info/Data
Mitigation Approach:	Ensure trustworthiness of key personnel.
CM Description:	Acquirers and suppliers should evaluate all staff for trustworthiness to the extent that these individuals occupy key roles or perform tasks that if not done correctly will cause the system or mission to degrade or fail. Identify roles or positions where opportunities to access critical components and information could lead to malicious insertion. Evaluate key personnel for competency and trustworthiness. Conduct periodic reevaluation of key personnel. Consider supplier past performance as part of source selection requirements.
CM Goals: (Prevent, Detect, Respond)	Prevent + Detect
Earliest Implementation Phase:	MSA
Timeframe to Implement:	Ongoing
Cost to Implement: (High, Medium, Low)	Low
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Process
Expected Risk Reduction: (Limited, Significant)	Significant
References:	Based on TARA pilot catalog entry: C000076; SCRM Key Practices Guide-2010-02-25.pdf

Countermeasure (CM) ID:	CM-20
CM Name:	Software Update Security
CM Focus:	Software
Mitigation Approach:	Minimize supply chain risks during software update processes.
CM Description:	Software updates and patches can change the system in ways that create new vulnerabilities. On the other hand, failing to update or apply a patch may leave a known vulnerability in place that an attacker could exploit. Treat each patch as a new element in the system. Authenticate patch sources. Examine patch delivery approaches. Test patches to ensure that they are "as produced." Apply patches and updates in a way that permits rollback.
CM Goals: (Prevent, Detect, Respond)	Prevent + Detect + Respond
Earliest Implementation Phase:	O&S
Timeframe to Implement:	After Milestone C
Cost to Implement: (High, Medium, Low)	Low
Resources Needed: (Centers, Staff, Equipment)	Staff
CM Type: (Process, Technical, Device)	Technical
Expected Risk Reduction: (Limited, Significant)	Significant
References:	Based on TARA pilot catalog entry: C000078; SCRM Key Practices Guide-2010-02-25.pdf

Acronyms

ASIC	Application-Specific Integrated Circuit
CAPEC	Common Attack Pattern Enumeration and Classification
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
DASD(SE)	Deputy Assistant Secretary of Defense for Systems Engineering
DEF	Defense Exportability Features
DoD	Department of Defense
DoDI	Department of Defense Instruction
EM	Electromagnetic
EMD	Engineering and Manufacturing Development
FPGA	Field-Programmable Gate Array
FW	Firmware
HW	Hardware
ICT	Information and Communications Technology
IDE	Integrated Development Environment
KP	Key Practice
MSA	Materiel Solution Analysis
NIST	National Institute of Standards and Technology
NIST SP	National Institute of Standards and Technology Special Publication
OEM	Original Equipment Manufacturer
O&S	Operations and Support
P&D	Production and Deployment
PPP	Program Protection Plan
SCRM	Supply Chain Risk Management
SE	Systems Engineering
SEI	Software Engineering Institute
SRD	System Requirements Document
SSE	System Security Engineering
SW	Software
TARA	Threat Assessment and Remediation Analysis
TMRR	Technology Maturation and Risk Reduction
TRD	Technical Requirements Document
TSN	Trusted Systems and Networks
TTP	Tactics, Techniques, and Procedures

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Supply Chain Attack Patterns: Framework and Catalog

Melinda Reed, John F. Miller, and Paul Popick

This work brings together a comprehensive set of sources to provide a holistic view of supply chain attack patterns.

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