Threat Assessment and Remediation Analysis (TARA)

Training Workshop

February 2020

MITRE

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TARA Training Agenda
(1-Day Workshop)

- 0830 - 0900 Admin, Introductions
- 0900 - 0945 TARA Overview
- 0945 - 1000 Break
- 1000 - 1015 Catalog demonstration
- 1015 - 1045 Cyber Threat Modeling
- 1045 - 1130 Cyber Threat Susceptibility Analysis
- 1130 - 1200 Exercise #1: Creating a shopping cart
- 1200 - 1230 Lunch
- 1230 - 1330 Cyber Risk Remediation Analysis
- 1330 - 1400 Exercise #2: Exporting catalog data
- 1400 - 1430 Catalog Content Management
- 1430 - 1500 Exercise #3: Updating the catalog
- 1500 - 1515 Break
- 1515 - 1545 TARA Risk and Cost Scoring Tools
- 1545 - 1600 Exercise #4: Using a risk calculator
- 1600 - 1615 Recap
- 1615 Adjourn

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TARA Overview

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Objectives

- Provide an overview of the TARA methodology
- Discuss the TARA data model support for vector groups, taxonomies, attack vectors, countermeasures and mappings
- Discuss application of TARA in Systems Security Engineering (SSE) contexts

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Threat Assessment & Remediation Analysis (TARA)

- **Methodology to identify and assess cyber threats and select countermeasures effective at mitigating those threats**
  - Leverages catalog of Attack Vectors (AVs), Countermeasures (CMs), and associated mappings
    - Use of catalog ensures that findings are consistent across assessments
  - Uses scoring models to quantitatively assess AVs and CMs
    - AVs ranked by risk, providing a basis for effective triage
    - CMs ranked by cost-effectiveness, providing a basis for identifying optimal solutions
  - Delivers recommendations
    - Allows programs to make informed choices on how best to improve a system's security posture and resilience
  - Can be performed separately or as follow-on to a Crown Jewels Analysis (CJA)
    - CJA results can inform TARA scope and assessment of risks

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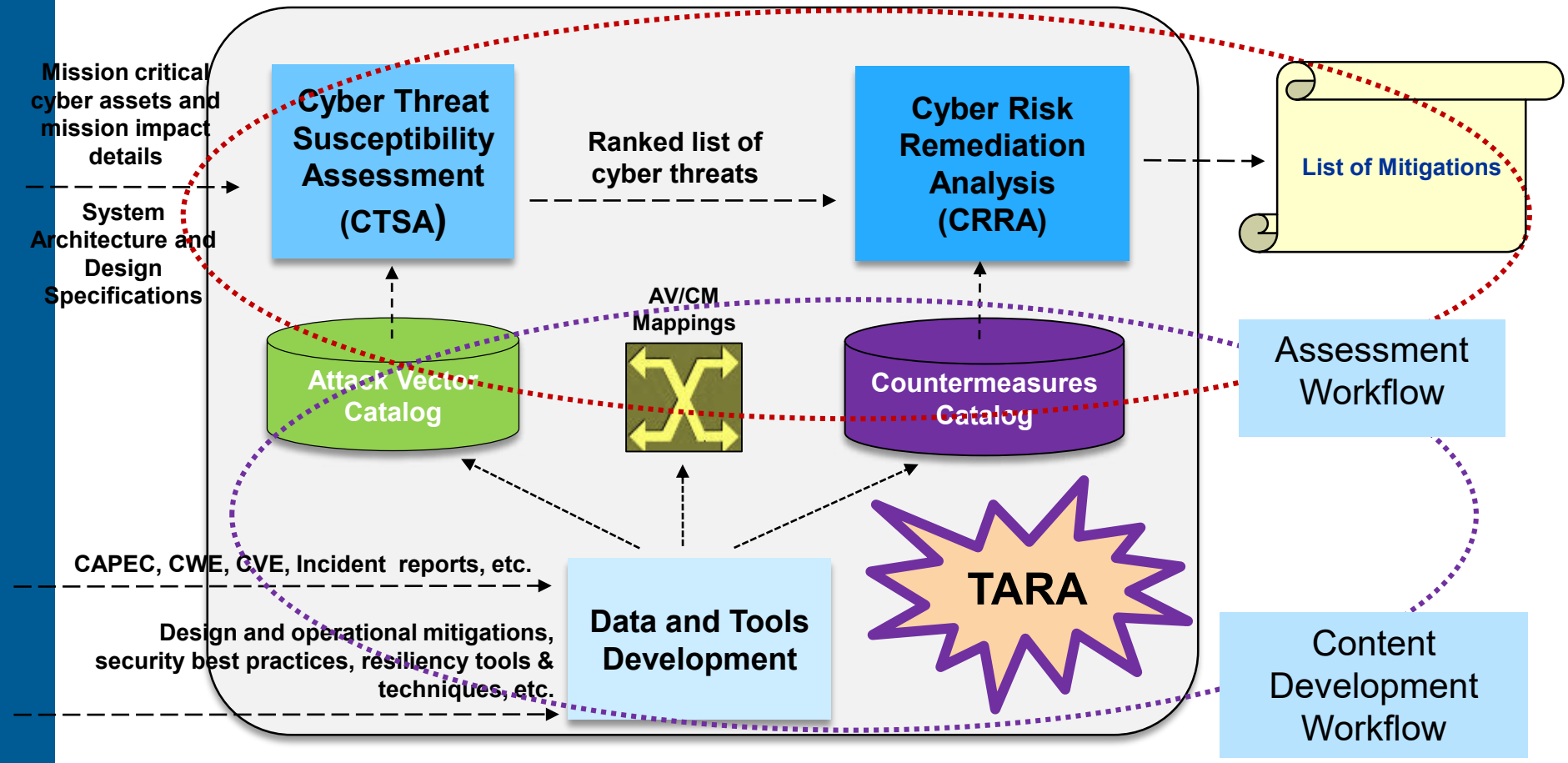
TARA Methodology Workflows



Workflow – Sequence of connected activities that produce useful work

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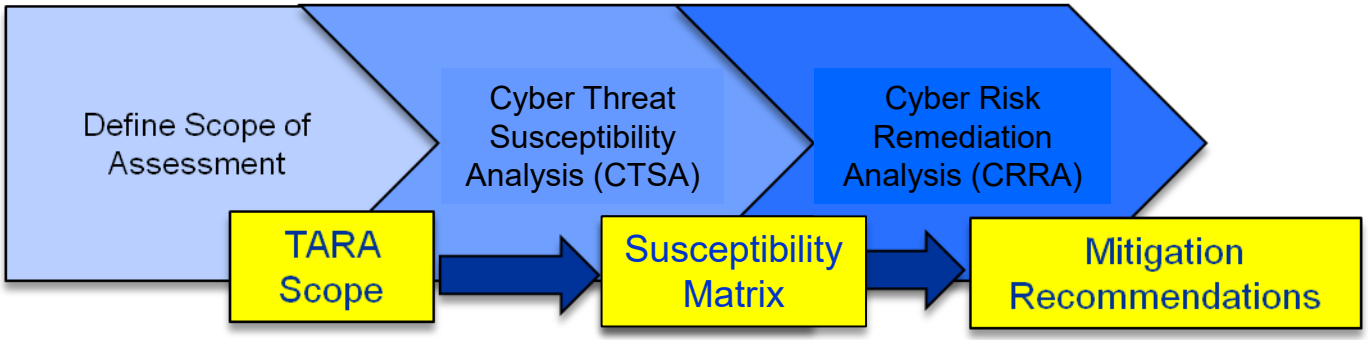
Phases of a TARA Assessment

Objective to identify and assess cyber threats and select countermeasures effective at mitigating those threats



The evaluation target

The range of threats to be assessed

Threat actor capabilities and intent

The phase of the system acquisition lifecycle

Prepare TARA assessment scope brief

Model the attack surface

Perform catalog search to identify candidate AVs

Eliminate implausible AVs

Define a scoring model to rank plausible AVs

Construct the Susceptibility Matrix

Select AVs to mitigate

Use mitigation mappings to identify candidate countermeasures (CMs)

Eliminate implausible CMs

Define a scoring model to rank CMs

Select the best CM solution set

Develop well-formed recommendations

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TARA Assessment Products

Susceptibility Matrix

Provides a ranked list of cyber threats, mapped to components of the evaluation target

Attack Vectors		Risk Score	Shopping cart			
AV ID	AV Name		Browser	Database	Web Server	Email App
T000049	Buffer Overflow	High	X	X	X	X
T000014	Accessing, Intercepting, and Modifying HTTP Cookies	Moderate	X			X
T000050	Forced Integer Overflow	Moderate		X		
T000071	SOAP Array Overflow	Moderate			X	
T000052	Inducing buffer overflow to disable input validation	Low		X		X
T000170	Attack through shared data	Low	X		X	

Answers the questions: Where and how is my system most susceptible?

Solution Effectiveness Table

Provides a ranked list of countermeasures, mapped to cyber threats, and identifies the preventative or mitigating effect each countermeasure provides

Countermeasure (CM)		Scoring	Effect (by Attack Vector ID)					
CM ID	Name	U/C Ratio	T000014	T000049	T000050	T000052	T000071	T000170
C000134	Select programming languages that minimize software defects	75		PM	PM	PM		
C000117	Apply principle of least privilege	67					RM	RM
C000093	Merge data streams prior to validation	50				PM		
C000096	Use vetted runtime libraries	50		PH			PH	
C000047	Encrypt session cookies	33	PH					
C000051	Use digital signatures/checksums	33	PH					
C000132	Use sandboxing to isolate running software	25						PM
	TOTALS	333	2	2	1	2	2	2

Answers the questions: How are my threats mitigated and where are the gaps?

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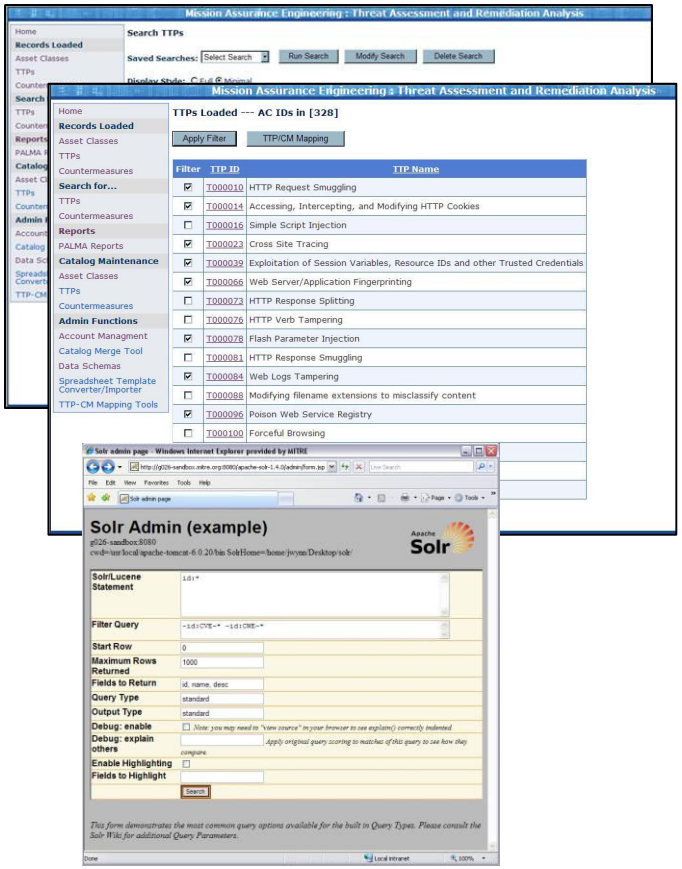
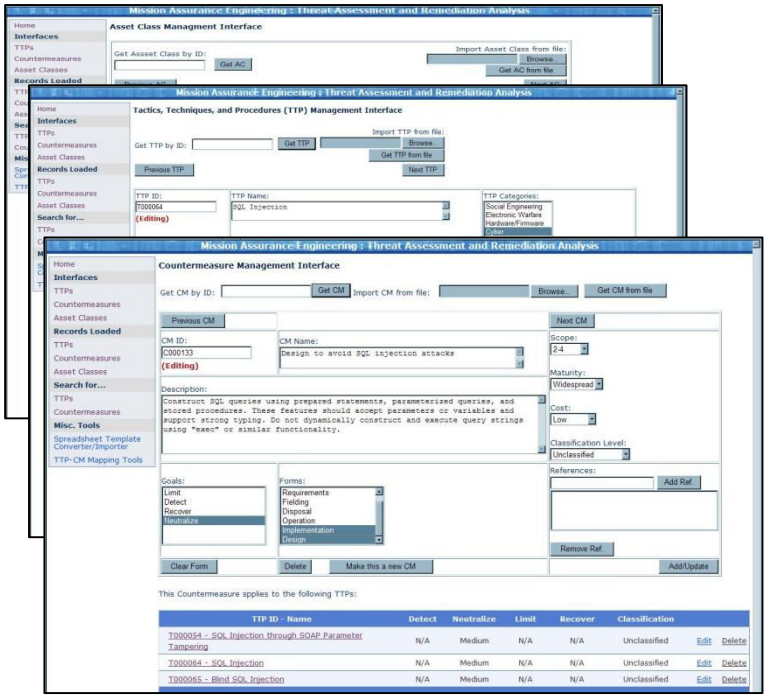
TARA Toolset

Web-based tools supporting TARA assessments and catalog development

Catalog Search Tools



Catalog Update Tools



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TARA Data Model

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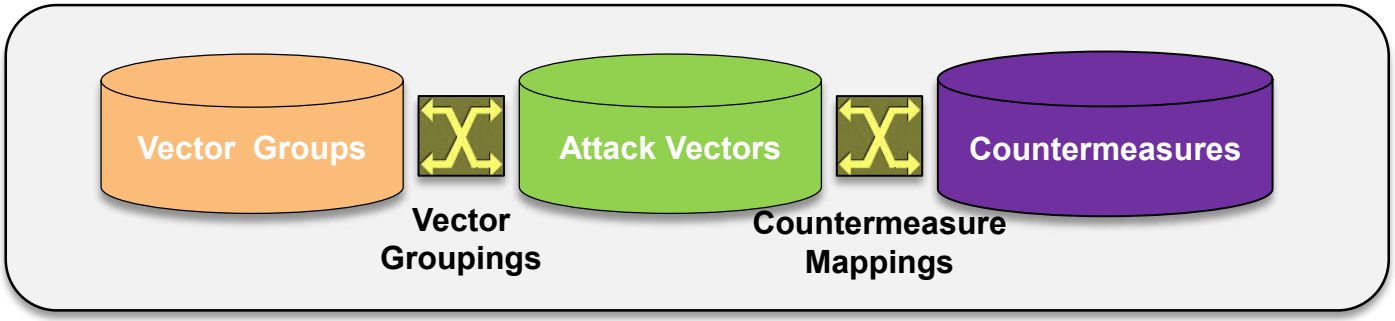
Objectives of the TARA Catalog



- Provide a repository of Attack Vector (AV) and Countermeasure (CM) data used in TARA assessments
- Support mappings and groupings used to integrate and traverse catalog data
- Implement an XML-based data model to represent AVs and CMs
- Help establish consistency from one TARA assessment to the next

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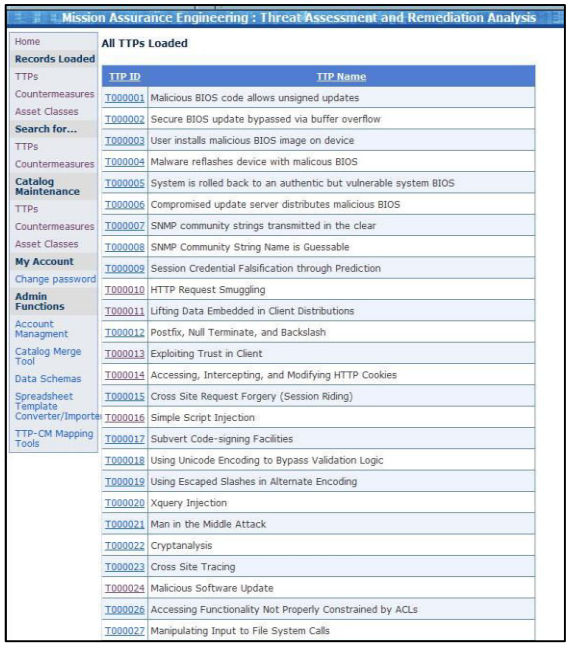
Navigating the TARA Catalog

Vector Groups (VGs)

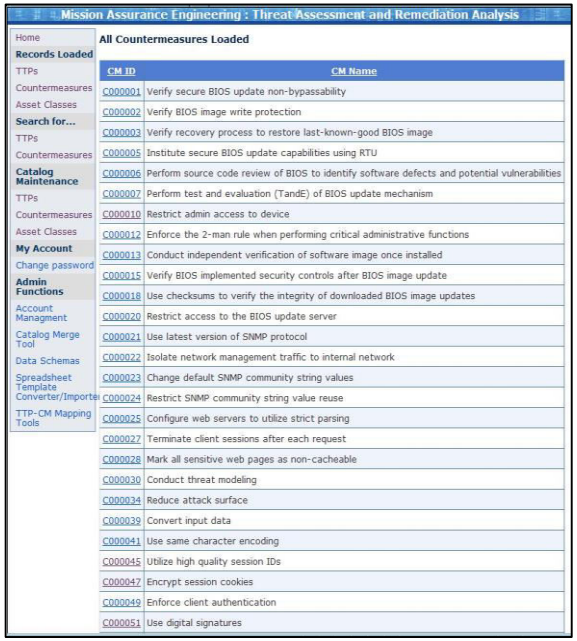
Named collection of attack vectors, e.g., architectural components, technologies, shopping carts, intrusion sets etc.

Attack Vectors (AVs)



Adversary approaches to compromise a cyber asset

Countermeasures (CMs)



Approaches for mitigating attack vectors

EXAMPLE

Vector Group
Password-based user authentication

Attack Vector
Dictionary attack, Rainbow tables, Brute force, etc.

Countermeasure
Strong passwords, Password aging, Account lockouts, etc.

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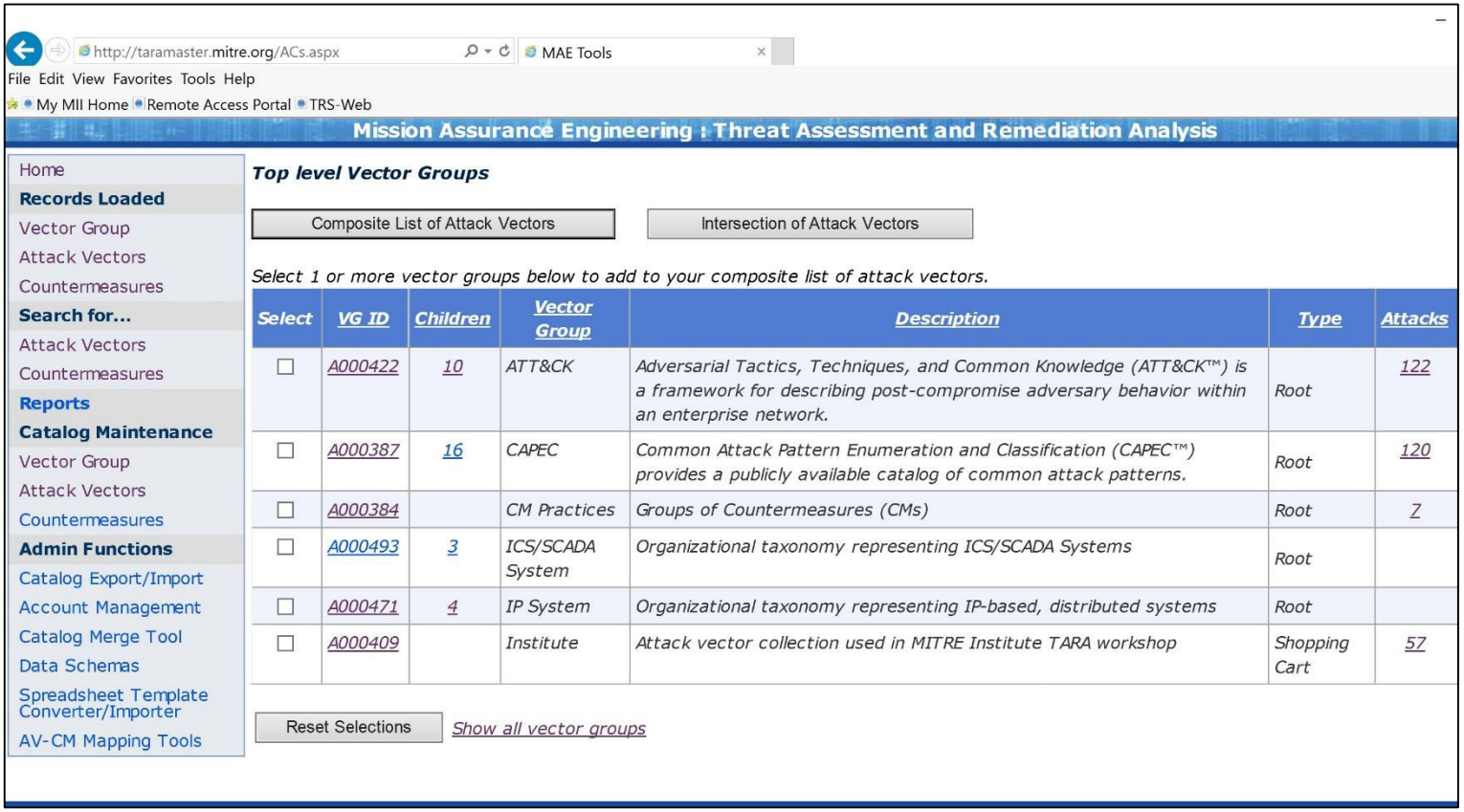
Vector Groups and Taxonomies

Vector Group – Named collection of attack vectors

Taxonomy – Hierarchically structured collection of vector groups



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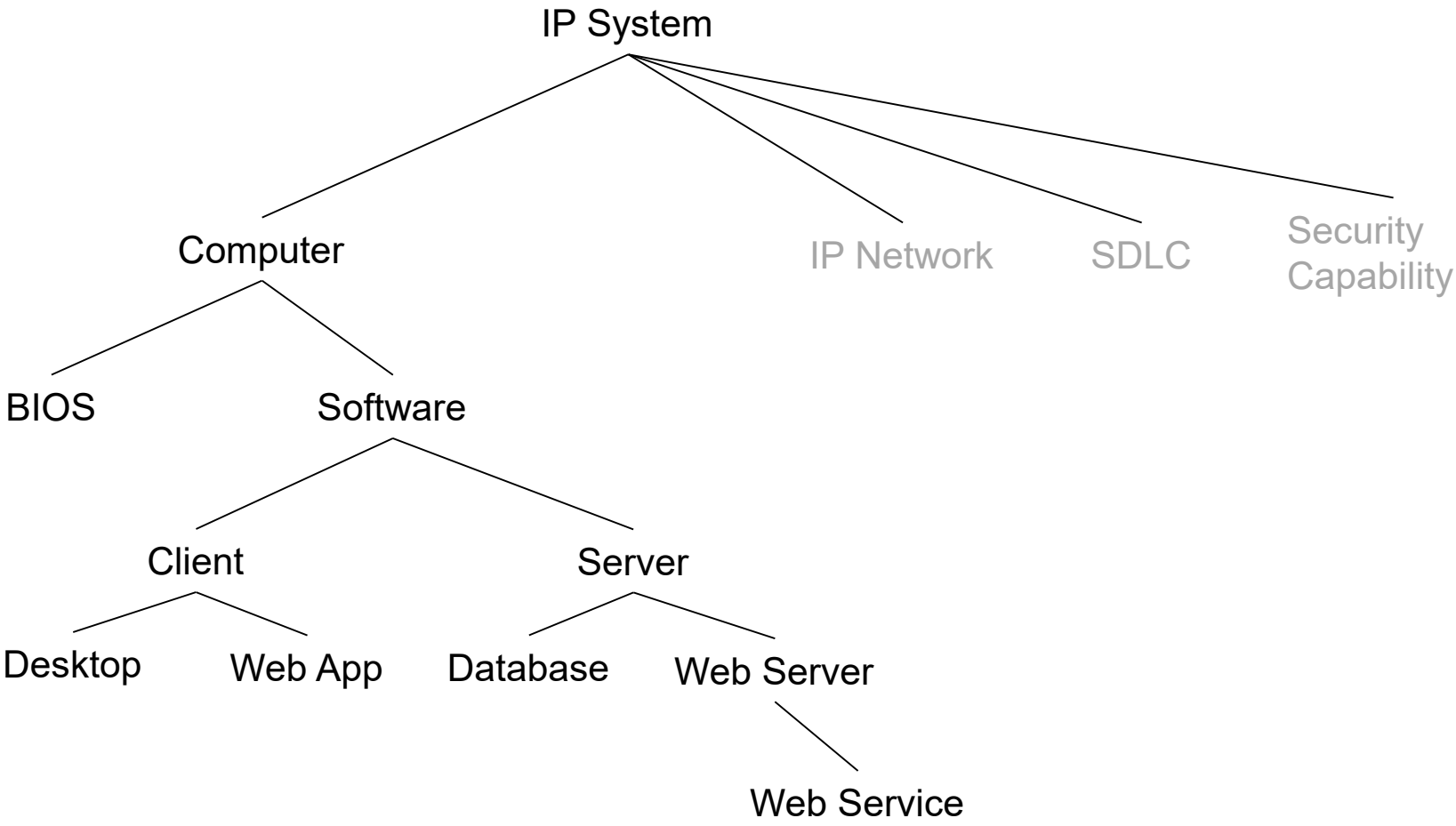
Taxonomy Example: *IP System*



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Attack Vectors (AVs)

A sequence of steps performed by an adversary in the course of conducting a cyber attack

- **Sources of Attack Vector data**
  - Open source info on attack patterns (CAPEC™), adversary TTPs (ATT&CK™), software weaknesses (CWE™), and vulnerabilities (CVE™)
  - National Institute of Science and Technology (NIST) publications
  - Reported security incidents from the commercial sector
  - Published security research
    - Includes exploits presented at hacker conferences, e.g., Blackhat, DEFCON, ShmooCon, etc.

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Common Attack Pattern Enumeration and Classification (CAPEC)

- **MITRE open source repository of cyber attack patterns**
  - Includes postulated attacks and real world security incidents
  - DHS-hosted, Community-contributed, MITRE-moderated
  - Updated quarterly

- **CAPEC catalog includes 400+ attack patterns**
  - Attack patterns contributed by the security research community at large, subject to MITRE review for quality and completeness
  - Patterns conform to XML schema and include fields that characterize the sophistication and resources required
    - CAPEC patterns provide analysis of underlying design weaknesses, which is key to follow-on mitigation engineering activities

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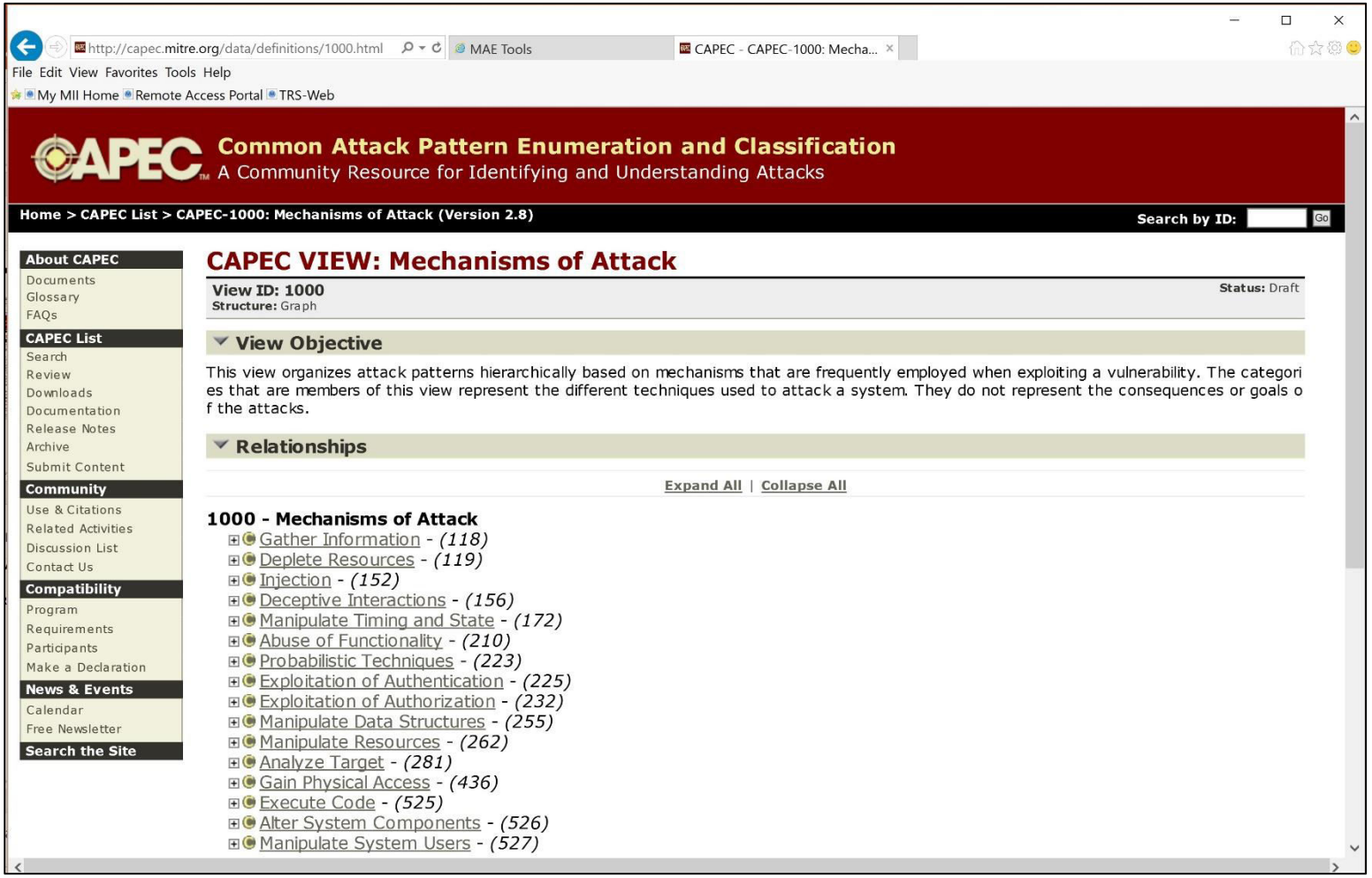
CAPEC Taxonomy: Mechanisms of Attack



http://capec.mitre.org/

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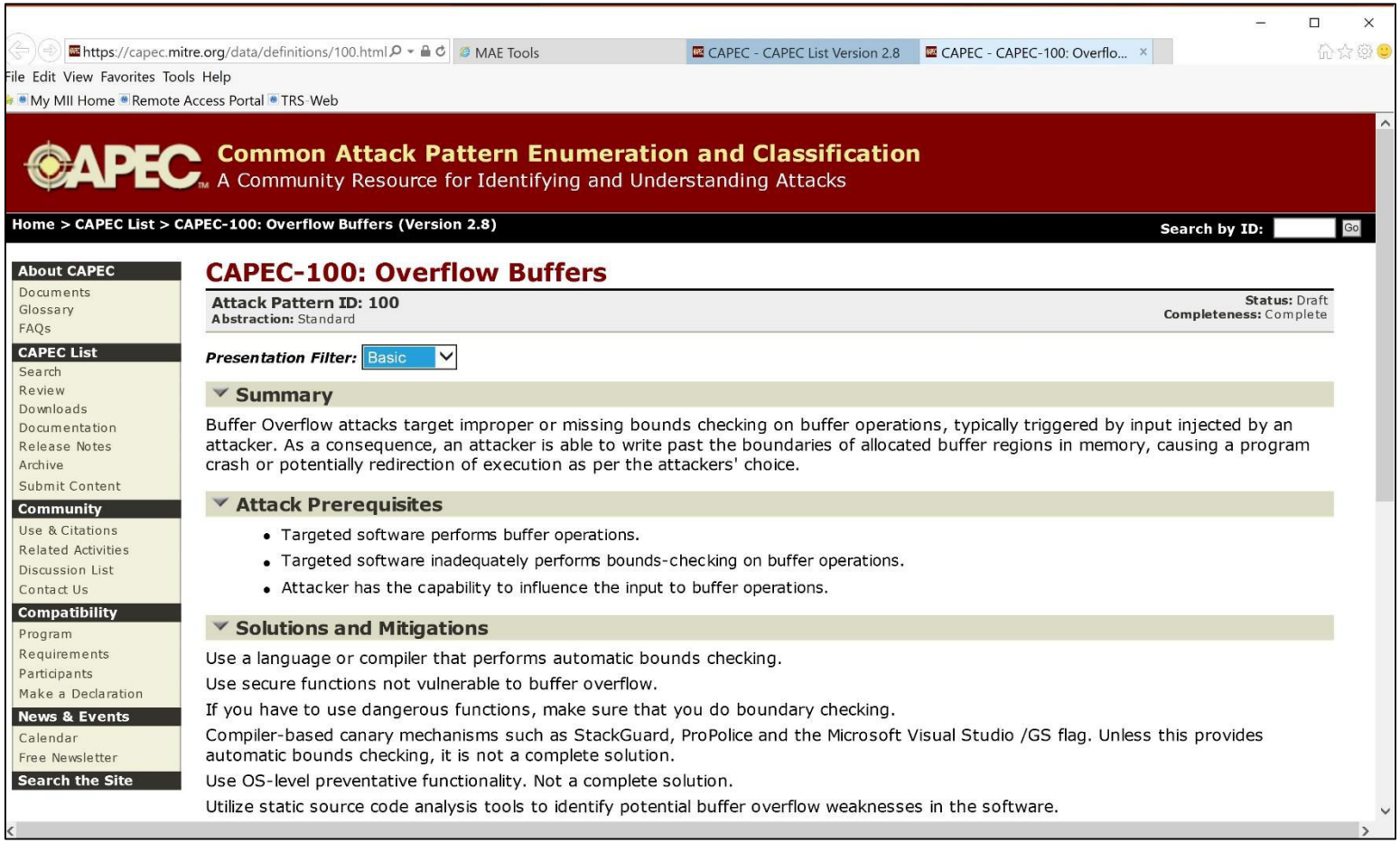
Example CAPEC Attack Pattern



https://capec.mitre.org/data/definitions/100.html

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Adversary Tactics, Techniques, and Common Knowledge (ATT&CK)

- **Adversarial Tactics, Techniques, and Common Knowledge (ATT&CK™) is a model for describing the actions an adversary may take while operating within an enterprise network**
  - Can be used to characterize post-Exploit adversary behavior
    - Focuses on Control, Execute, and Maintain steps within the cyber attack lifecycle[1]
  - Can be used to help prioritize network defense against advanced persistent threat (APT) threat actors operating within the network
  - TTPs provide technical descriptions, indicators, targeted platforms, sensor data, detection analytics, and potential mitigations

http://www.lockheedmartin.com/content/dam/lockheed/data/corporate/documents/LM-White-Paper-Intel-Driven-Defense.pdf

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ATT&CK Taxonomy of Post Exploit Adversary TTPs

Persistence	Privilege Escalation	Defense Evasion	Credential Access	Host Enumeration	Lateral Movement	Execution	C2	Exfiltration
Legitimate Credentials		Binary Padding	Credential Dumping	Account enumeration	Application deployment software	Command Line	Commonly used port	Automated or scripted exfiltration
Accessibility Features		DLL Side-Loading	Credentials in Files	File system enumeration	Exploitation of Vulnerability	File Access	Comm through removable media	Data compressed
AddMonitor		Disabling Security Tools	Network Sniffing	Group permission enumeration	Logon scripts	PowerShell	Custom application layer protocol	Data encrypted
DLL Search Order Hijack		File System Logical Offsets	User Interaction	Local network connection enumeration	Pass the hash	Process Hollowing	Custom encryption cipher	Data size limits
Edit Default File Handlers		Process Hollowing	Credential manipulation	Local networking enumeration	Pass the ticket	Registry	Data obfuscation	Data staged
New Service		Rootkit		Operating system enumeration	Peer connections	Rundll32	Fallback channels	Exfil over C2 channel
Path Interception		Indicator blocking on host		Owner/User enumeration	Remote Desktop Protocol	Scheduled Task	Multiband comm	Exfil over alternate channel to C2 network
Scheduled Task		Indicator removal from tools		Process enumeration	Remote Services	Service Manipulation	Multilayer encryption	Exfil over other network medium
Service File Permission Weakness		Indicator removal from host		Security software enumeration	Replication through removable media	Third Party Software	Peer connections	Exfil over physical medium
Shortcut Modification		Masquerad-ing		Service enumeration	Shared webroot	Windows management instrumentation	Standard app layer protocol	From local system
Web shell		NTFS Extended Attributes		Window enumeration	Taint shared content	Windows remote management	Standard non-app layer protocol	From network resource
BIOS	Bypass UAC	Obfuscated Payload			Windows admin shares		Standard encryption cipher	From removable media
Hypervisor Rootkit	DLL Injection	Rundll32					Uncommonly used port	Scheduled transfer
Logon Scripts	Exploitation of Vulnerability	Scripting						
Master Boot Record		Software Packing						
Mod. Exist'g Service		Timestomp						
Registry Run Keys								
Serv. Reg. Perm. Weakness								
Windows Mgmt Instr. Event Subsc.								
Winlogon Helper DLL								

http://attack.mitre.org

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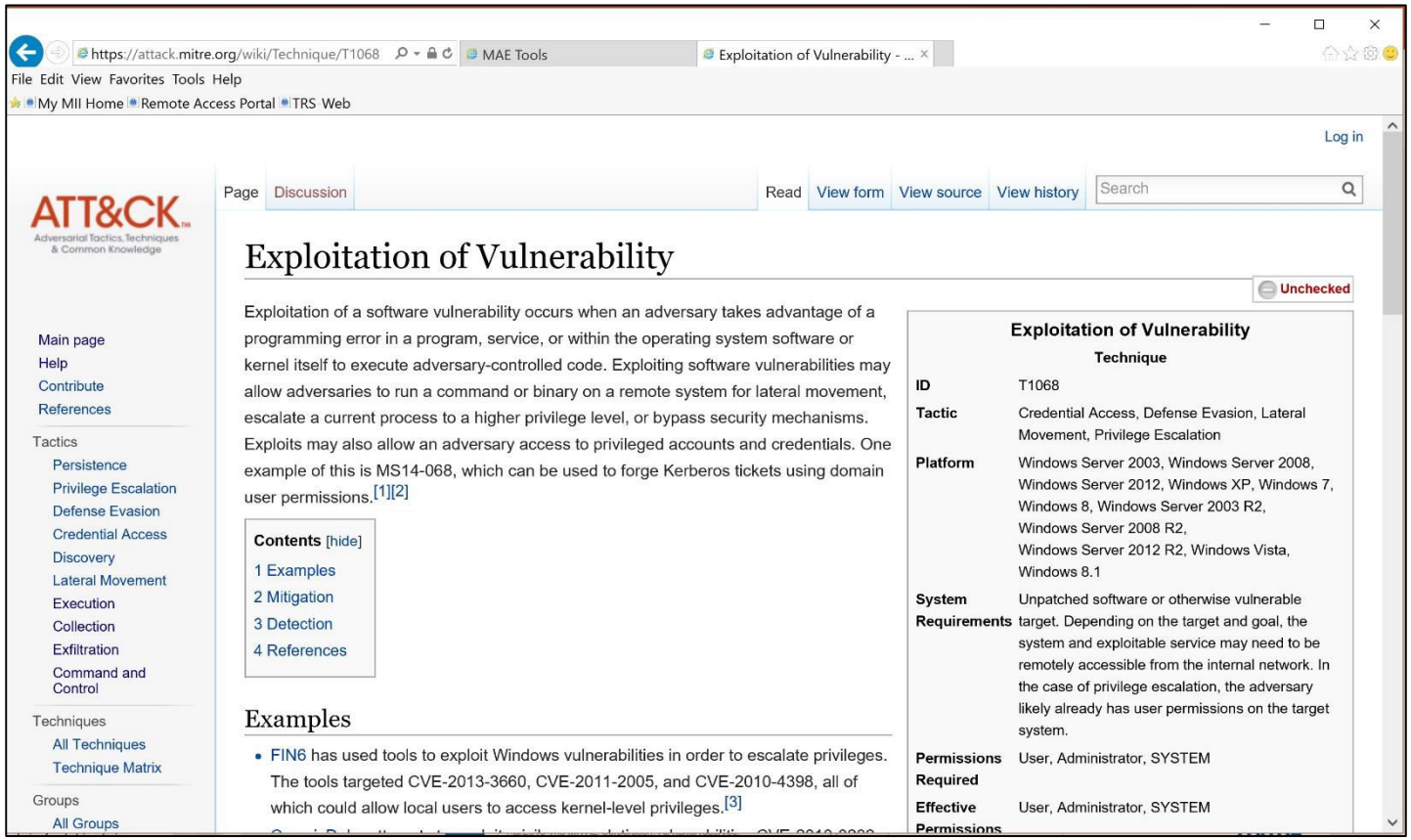
An Example ATT&CK Technique



https://attack.mitre.org/wiki/Technique/T1068

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Catalog support for Multiple Search Taxonomies

TARA attack vectors mapped into alternative taxonomy structures

CAPEC Mechanisms of Attack

1000 - Mechanisms of Attack

- Gather Information - *(118)*
- Deplete Resources - *(119)*
- Injection - *(152)*
- Deceptive Interactions - *(156)*
- Manipulate Timing and State - *(172)*
- Abuse of Functionality - *(210)*
- Probabilistic Techniques - *(223)*
- Exploitation of Authentication - *(225)*
- Exploitation of Authorization - *(232)*
- Manipulate Data Structures - *(255)*
- Manipulate Resources - *(262)*
- Analyze Target - *(281)*
- Gain Physical Access - *(436)*
- Execute Code - *(525)*
- Alter System Components - *(526)*
- Manipulate System Users - *(527)*

ATT&CK Tactics

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Hypervisor Rootkit		NTFS Extended Attributes			Shared webroot		Standard encryption cipher	From removable media
Logon Scripts		Obfuscated Payload			Taint shared content		Uncommonly used port	Scheduled transfer
Master Boot Record		Rootkit			Windows admin shares			
Mod. Exist'g Service		Rundll32						
Registry Run Keys		Scripting						
Serv. Reg. Perm. Weakness		Software Packing						
Windows Mgmt Instr. Event Subsc.								
Winlogon Helper DLL								

Supports alternative search strategies

Attack Vectors

Can be extended to support sponsor-defined taxonomies

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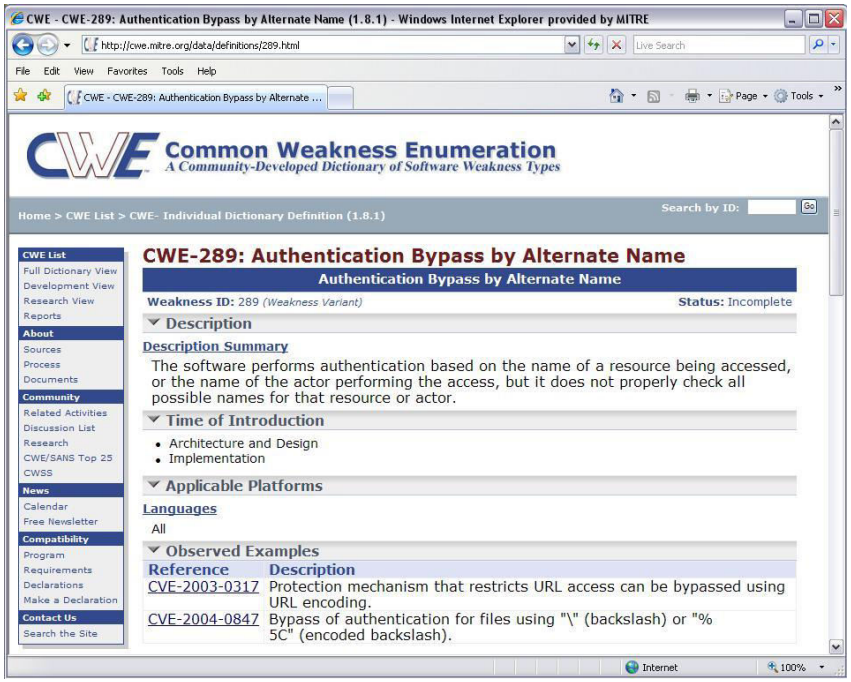
Other Sources of Catalog Data: Common Weakness Enumeration (CWE)

- **MITRE open source repository of software weaknesses**
  - Over 800 weaknesses currently identified
  - Updated quarterly



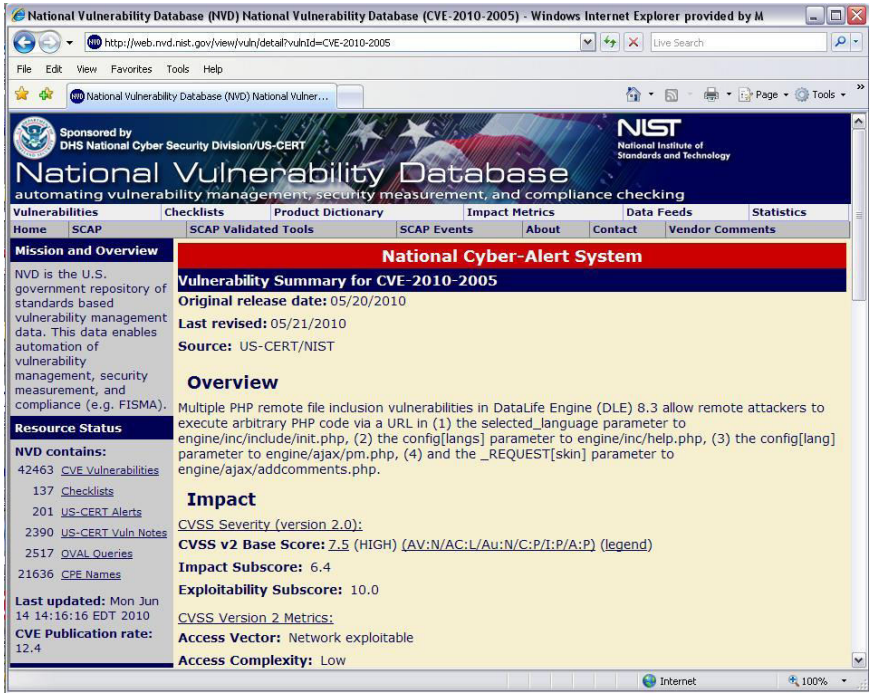
http://cwe.mitre.org/

Uses for TARA

- Cross-reference CWE and CAPEC to identify a range of attack patterns for a given set of software weaknesses
  - Example: Top 25 SANS/CWE weaknesses
- CWE entries identify mitigations intended to correct software weaknesses, which can be viable remediation alternatives

Other Sources of Catalog Data: Common Vulnerabilities and Exposures (CVE)

- **Open source repository of software vulnerabilities**
  - Over 79000 CVEs reported across commercial software products
  - Weekly release cycle
- **Uses for TARA**
  - Cross reference CVE with CAPEC attack patterns that can exploit a given software vulnerability
  - Can be used to correlate vulnerabilities with specific technologies
    - Example: SNMP related attack vectors added to TARA catalog based on CVE vulnerabilities reported for SNMP agents



http://cve.mitre.org/

Countermeasures (CMs)

"Actions, devices, procedures, or techniques that meet or oppose (i.e., counters) a threat, a vulnerability, or an attack by eliminating or preventing it, by minimizing the harm it can cause, or by discovering and reporting it so that corrective action can be taken."
Source: CNSS 4009

- **Sources of countermeasure data**
  - Open source info on adversary TTPs (ATT&CK), attack patterns (CAPEC), and software weaknesses (CWE) often includes mitigation details
  - DoD and NIST publications, e.g., NIST SP 800-53, etc.
  - Industry recognized security best practices
  - Published security research
    - Journal articles detailing new approaches for detecting anomalous behavior, malware, etc.

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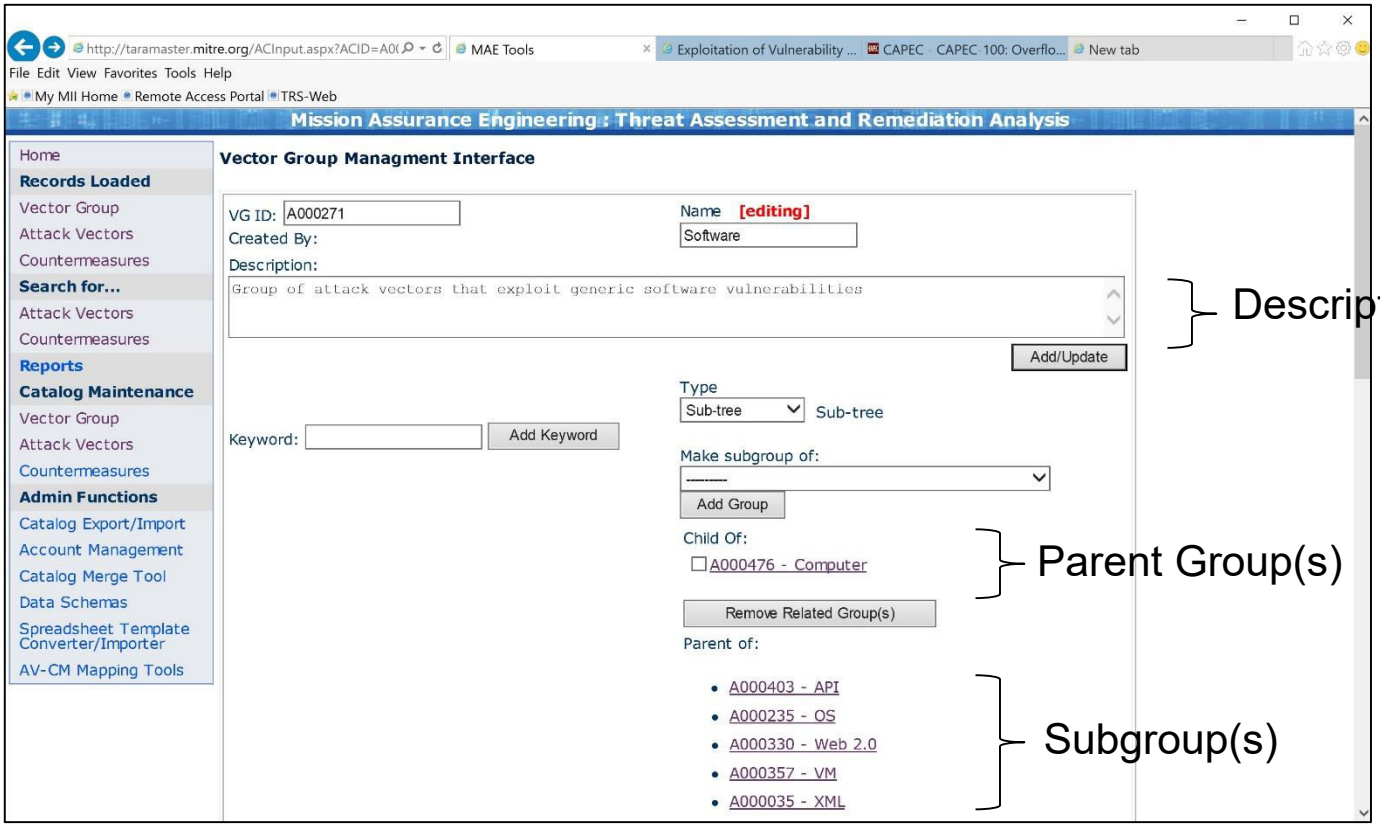
Example: Software Vector Group (1/2)



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Example: Software Vector Group (2/2)

Attack Vectors

AV ID	AV Name
T000019	Using slashes, escaped slashes, or UTF-8 encodings to bypass input validation
T000020	Xquery Injection
T000024	Malicious Software Update
T000026	Accessing Functionality Not Properly Constrained by ACLs
T000027	Manipulating Input to File System Calls
T000028	Manipulating User-Controlled Variables
T000030	JSON Hijacking (aka JavaScript Hijacking)
T000032	XPath Injection
T000036	Log Injection-Tampering-Forging
T000037	Accessing, modifying or executing executable files
T000038	Manipulation of resources loaded by a software application
T000041	Exploit race conditions and/or deadlock conditions in software
T000049	Buffer Overflow
T000055	Target Programs with Elevated Privileges
T000058	Manipulating Writeable Terminal Devices
T000067	XML Ping of Death

Countermeasures

CM ID	CM Name
C000152	Conduct penetration testing
C000187	Configure COTS hardware/software to disable unnecessary features and functions
C000235	Isolate network segments to limit exploitation of vulnerabilities
C000090	Validate input fields use of NULL, escape, backslash, meta, and control characters
C000117	Apply principle of least privilege
C000242	Regulate remote or external access through DMZs
C000248	Harden IT assets
C000091	Apply blacklist and whitelist validation in combination
C000051	Use digital signatures/checksums to authenticate source of changes
C000234	Design to log securely
C000238	Enforce software quality standards and guidelines that improve software quality
C000253	Establish a verifiable software update / patch management process
C000121	Verify input sources
C000118	Enforce default-deny access policies
C000244	Restrict network traffic
C000144	Encrypt sensitive data persistently stored

Entries are a partial listing, in no particular order

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Applications of TARA

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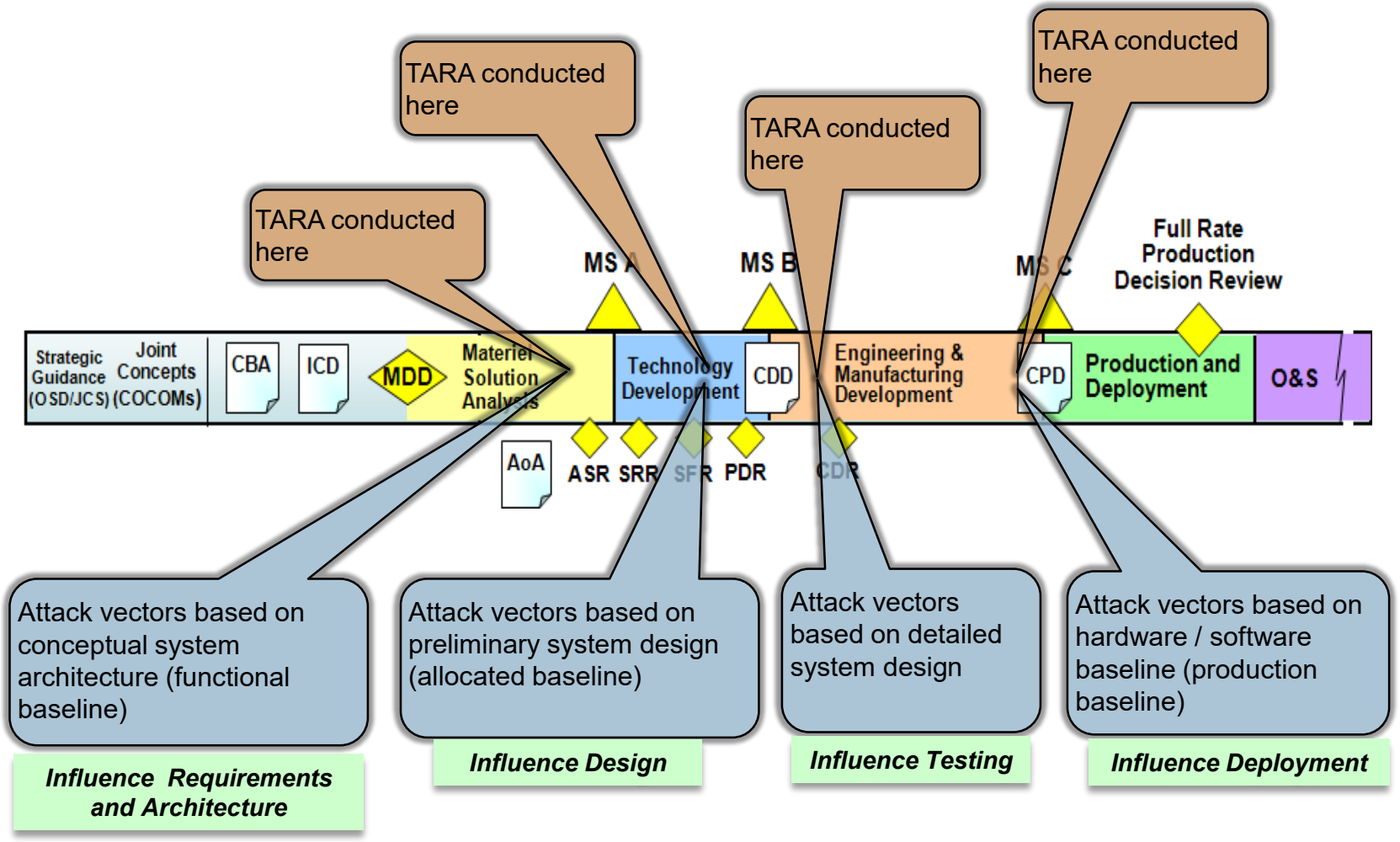
Threat-Informed Systems Analysis for Acquisition Programs



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Applications of TARA

- **Threat Model Development**
  - TARA can be used to develop cyber threat models that identify plausible cyber attacks for specified cyber threat actors
- **Cyber Risk Remediation**
  - TARA can be used to identify and select countermeasures that mitigate risks from identified cyber attacks
- **Cyber Resiliency Assessment**
  - TARA can be used to select resilience techniques to reduce the risk from identified cyber attacks
- **Vulnerability Assessment / Penetration Test Planning**
  - TARA assessment recommendations can be recast as vulnerability or penetration test objectives
- **Supply Chain Risk Management (SCRM) Analysis**
  - TARA can be used in conjunction with specialized catalog of supply chain threats and countermeasures

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Risk Management Framework (RMF)

- **RMF is a United States federal government policy and standards for securing information systems (computers and networks) developed by National Institute of Standards and Technology**

- **Applications of TARA within RMF include**
  - **Tailoring 800-53 controls**
    - The Risk Management Framework (RMF) supports program tailoring of security controls based on cost/benefit and risk tradeoffs. TARA has been applied in a limited context to the selection of 800-53 controls.
  - **Development of threat models**
    - Specific NIST 800-53 controls call for use of threat modeling “to identify use cases, threat agents, attack vectors, and compensating controls and design patterns to mitigate risk.” TARA is used to develop cyber threat models that identify attack vectors, assesses their risk, and identifies mitigating countermeasures.

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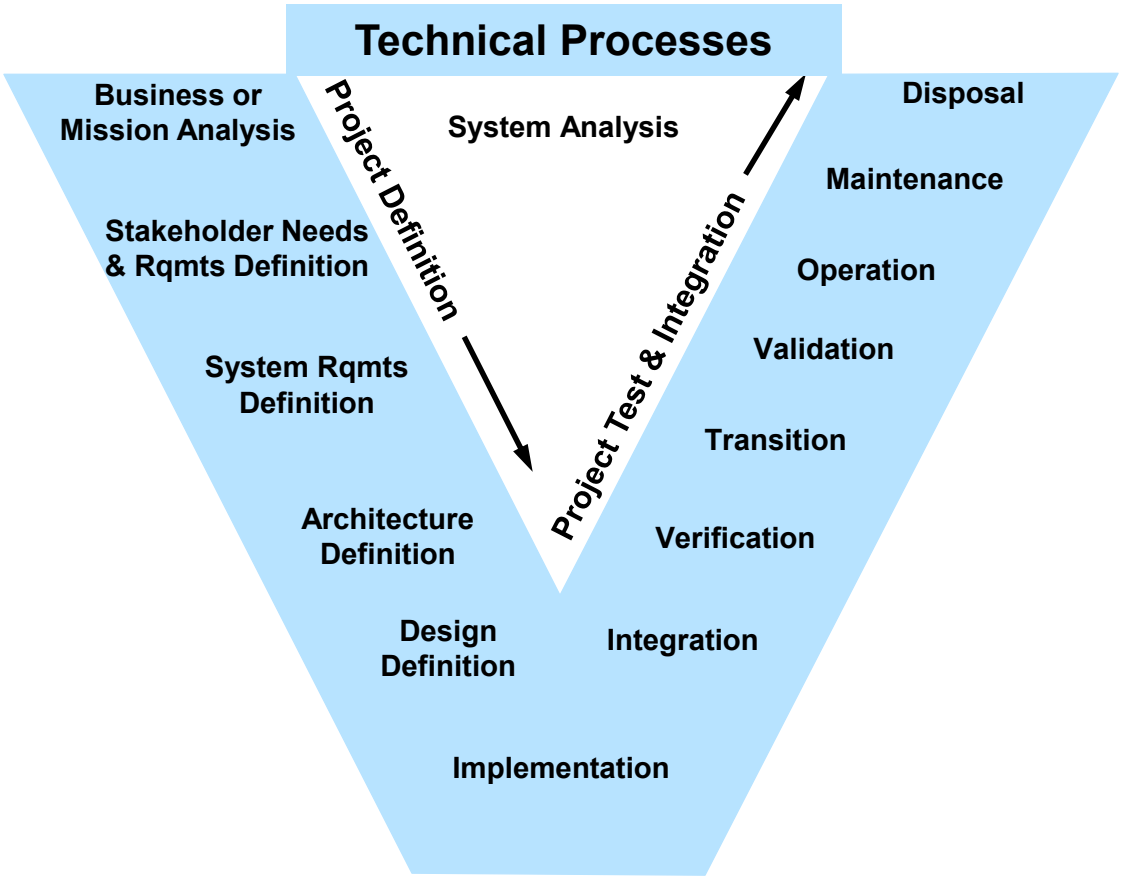
System Life Cycle Processes

The Systems Engineering "Vee" Model



ISO/IEC/IEEE 15288, System life cycle processes, 2015-05-15

Agreement Processes

- Acquisition
- Supply

Organizational Project-Enabling Processes

- Life Cycle Model Mgmt
- Infrastructure Mgmt
- Portfolio Mgmt
- Human Resource Mgmt
- Quality Mgmt
- Knowledge Mgmt

Technical Management Processes

- Project Planning
- Project Assess & Control
- Decision Mgmt
- Risk Mgmt
- Configuration Mgmt
- Information Mgmt
- Measurement
- Quality Assurance

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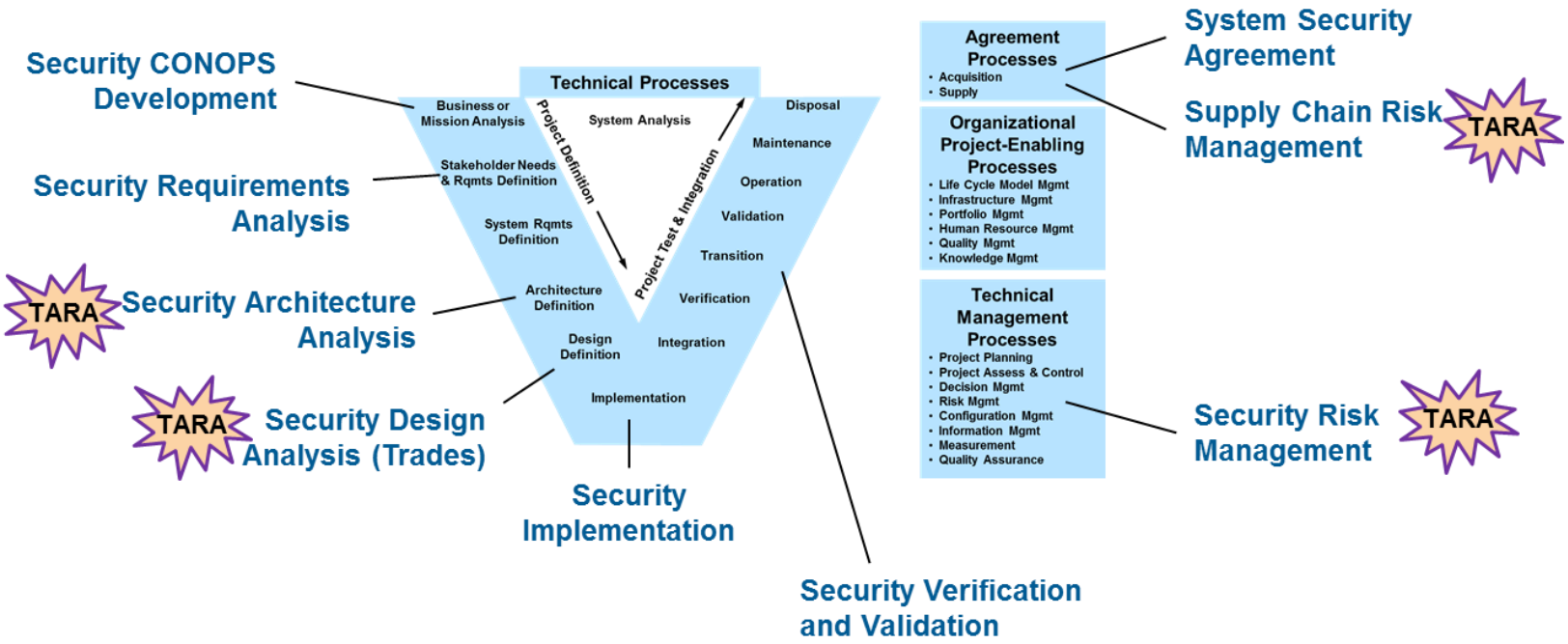
Systems Security Engineering (SSE) Framework



Applications of TARA in the SSE Framework

- Security architecture analysis and threat model development
- Countermeasure selection (trade)
- Cyber risk assessments
- SCRM assessments

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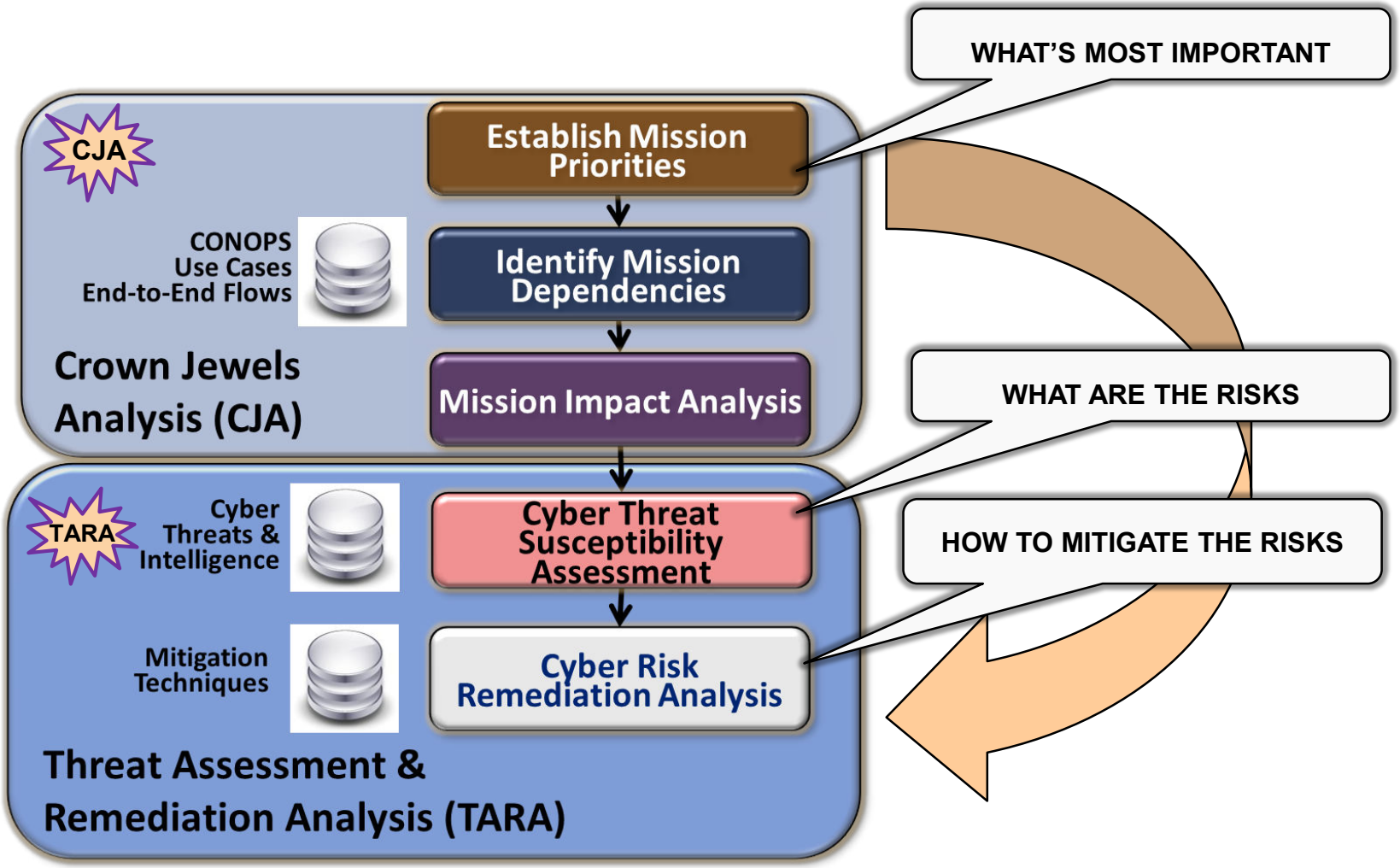
MITRE Mission Assurance (MA) Process Framework



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CJA and TARA

- **Crown Jewel Analysis (CJA)**
  - CJA is a process for identifying mission-critical cyber assets, enabling us to focus risk mitigation measures where they will be most effective
- **CJA and TARA can be performed separately or together**
  - When performed together, CJA and TARA support identification, assessment, and mitigation of cyber risk to mission critical assets
- **TARA use of CJA results**
  - Identified mission critical cyber assets (crown jewels) can be the focus of a TARA assessment
  - Mission impact used in assessment of attack vector risk
    - TARA performs triage on large lists of attack vectors based on risk
  - CJA mission impacts used in TARA assessment recommendations
    - A compelling TARA recommendation uses potential mission impacts to justify implementation of selected countermeasures

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Summary

- TARA is an engineering approach that is rigorous and repeatable, provides traceability, identifies gaps, and develops defense-in-depth
- TARA's objective is to influence programs early in the acquisition lifecycle where *the cost of change is less*
- TARA applies model-based systems engineering and tradeoff analysis to system security engineering
- TARA maintains and utilizes catalogs of attack vector and countermeasure data that incorporates data from a variety of sources including CAPEC, CWE, and CVE
- The TARA approach is flexible and can be tailored to meet the needs of users
- TARA has been applied to over 2 dozen Army, Navy, Air Force, and DoD acquisition programs

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TARA Cyber Threat Modeling

MITRE

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Objectives

- Discuss elements of a cyber threat model
- Discuss attack surface modeling
- Discuss cyber threat scenarios

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Cyber Threat Models

- **TARA can be used to develop cyber threat models that identify plausible cyber attacks for specified cyber threat actors**

- **Key Elements**
  - Cyber Threat Actor Profiles
    - Used to represent adversary capability and intent
  - Exploitable Attack Surface features
    - Used to identify attack vectors and associated effects

- **Optional Elements**
  - Assessed Risk
  - Plausible Countermeasures

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Cyber Threat Actors

- **Cyber threat actors include organizations or individuals that have the motivation, intent and capability to cause harm**
  - Common examples include nation state actors, transnational actors, criminal organizations, trusted insiders, etc.

- **Some Definitions** (courtesy of Merriam Webster)
  - **Motivation**
    - *The reasons for acting or behaving in a particular way*
  - **Intent**
    - *A determination (resolve) to act in a certain way*
      - Motivation leads to Intent
  - **Capability** [cyber]
    - *The facility for use or deployment [of disruptive cyber effects]*

Threat actor motivations, intentions, and capabilities continuously change

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Example Threat Actor Intentions

- **Discover system architecture, network topology, security capabilities, etc.**
  - Motivation: To identify ways to exploit the system
- **Monitor system utilization**
  - Motivation: To provide early indications and warnings (I&W)
- **Exfiltrate sensitive or classified data**
  - Motivation: Intelligence collection
- **Establish durable, persistent access**
  - Motivation: To provide quick and stealthy penetration
- **Disrupt: Momentary loss of use**
- **Deny: Longer term loss of use**
- **Destroy: Permanent loss of use**
- **Degrade: Reduced capacity or performance**
- **Deceive: Loss of data integrity and/or situational awareness**
  - Motivation: To achieve disruptive cyber effects on mission critical and mission essential systems or components (when necessary)

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Example Threat Actor Cyber Capabilities

- **Reconnaissance**
  - Use of open source intelligence (OSINT) to identify targets
  - Exfiltration of system data from cleared defense contractors (CDCs)
  - Identification of key system users via social media
- **Weaponization**
  - Develop injects that exploit known, unpatched vulnerabilities
  - Use of open source rootkits
  - Use of vulnerability analysis to identify zero-day exploits in commercial products
  - Weaponization of zero-days purchased on the dark web
  - Use of reverse engineering to develop new malware variants
- **Delivery**
  - Use of commercial penetration testing / vulnerability scanning tools
  - Use of TOR to stage attacks anonymously
  - Exploitation of supply chain vulnerabilities to deliver implants
  - Use of air-gap malware
  - Co-opting / recruitment of trusted insiders
- **C2**
  - Use of encrypted C2 to manage implants and for bulk exfiltration of data

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Cyber Threat Actor Profile

A Cyber Threat Actor Profile provides comparative analysis of threat actor motivation, intent, and capability

- Threat actor motivation, intent, and capabilities vary widely
  - Motivation and intent of a regional threat actor may be significantly higher for regionally deployed systems
- Projected adversary cyber capabilities for 2020, 2025, etc. can be especially useful for acquisitions programs

Threat Actor Cyber Capabilities

Threat Actor	Motivation	Intent	Finances (Annual)	Use of OSINT	Exfiltration through CDCs	Use of Social Media	Exploits unpatched vulnerabilities	Open source rootkits	Develops new zero-days	Purchases zero-days	Malware reverse engineering	Commercial scanning tools	Custom scanning tools	Use TOR to stage attacks	Supply chain implants	Recruits trusted insiders	Uses encrypted C2
Nation State Actor X	TBD	TBD	>1B	Demo'd	Demo'd	Demo'd	Demo'd	Demo'd	Demo'd	Likely	Demo'd	N/A	Demo'd	Likely	Likely	Demo'd	Demo'd
Nation State Actor Y	TBD	TBD	>500M	Demo'd	Possible	Demo'd	Demo'd	Demo'd	Likely	Possible	Likely	Demo'd	Possible	Unlikely	Unlikely	Possible	Demo'd
Crime Syndicate A	Steal money	Deny use of systems	>200M	Possible	Unlikely	Possible	Demo'd	Likely	Possible	Possible	Possible	Demo'd	Possible	Possible	Possible	Possible	Likely
Transnational Group 1	TBD	TBD	>50M	Possible	Unlikely	Likely	Likely	Likely	Unlikely	Unlikely	Unlikely	Possible	Unlikely	Unlikely	Unlikely	Possible	Likely
Disgruntled Employee	Perceived unfair treatment	Revenge	N/A	N/A	Possible	N/A	Likely	N/A	N/A	N/A	Unlikely	Demo'ed	N/A	N/A	Possible	Unlikely	Possible
Careless User	Minimal effort; lazy	Non malicious	N/A	N/A	N/A	N/A	Unlikely	N/A	N/A	N/A	N/A	Possible	N/A	N/A	Unlilkely	Unlikely	N/A

Example Cyber Threat Actor Profile

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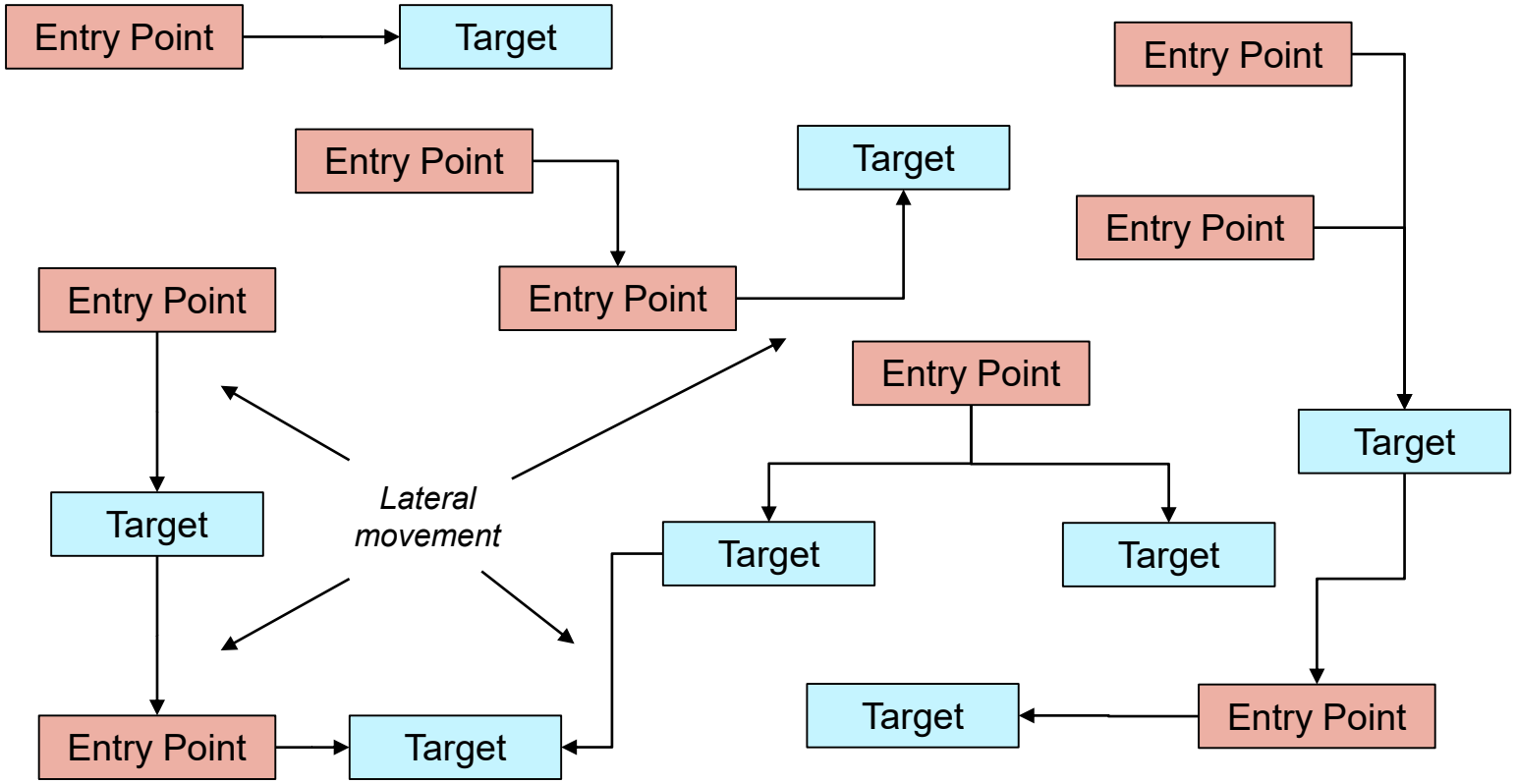
Exploitable Attack Surface Features

*"Attack surface is the set of ways in which an adversary can enter the system and potentially cause damage."**



*Manadhata, P.,. "An Attack Surface Metric", Carnegie Mellon University, CMU-CS-08-152, November 2008.

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Attack Vectors Redefined

- **Originally: A sequence of steps performed by an adversary in the course of conducting a cyber attack**
- **Redefined: A sequence of steps performed by an adversary to get from an Entry Point to an Intended Target**
  - Entry Points and Targets are attack surface features
    - Both compromised by exploiting a known or unknown vulnerability
  - Lateral Movement is the adversary's means (tradecraft) to get from an Entry Point to an intended Target
    - There can be multiple paths between an Entry Point and a Target
    - The same Entry Point can get to multiple Targets
    - Multiple Entry Points can get to the same Target
    - An Intended Target (once compromised) can become an Entry Point

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Example Entry Points

- User accounts
- Hidden backdoors
- USB ports
- Database query fields
- Unsecured web applications or web pages
- Email attachments, downloads, etc.
- Processes for system upgrades or maintenance
- Modem connections (Remember the movie Scanners?)
- Temporary network connections
- Vendor or partner connections

What exploitable vulnerabilities would these entry points possess?

An entry point can be structural, permanent, temporary, and can exist at any point in the system lifecycle

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Example Targets

- Mission critical and mission essential subsystems, components and assets
- System interfaces, APIs, etc. used to access and manage mission and system configuration data
- Special purpose algorithms
- System security features and perimeter access capabilities
- Critical Program Information (CPI)
- Baseline system configuration data
- IP network infrastructure / topology
- Data storage capabilities
- Supporting SCADA infrastructure, e.g., power distribution, HVAC, etc.
- Key development and testing facilities
- Critical component supply chains
- Key personnel
- Key locations

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Cyber Threat Scenarios

A cyber threat scenario is a narrative description that extends the attack vector with contextual information to better frame the cyber threat

Scenario Details	Description
Motivation	Reason(s) that drive an adversary's intent
Threat actor	The adversary initiating an attack
Effect(s)	1st order (component), 2nd order (system), and 3rd order (mission) effects
Vulnerability	The underlying vulnerability to be exploited (in the target)
Perimeter entry point	Weakness through which adversary gains access to target
Targeted component	Component being targeted for effect
Indicator [of compromise]*	Observable (detectable) characteristics that the attack has occurred (is occurring)
Likelihood*	Probability the attack will be successful
Impact*	Magnitude of harm caused by a successful attack
Risk*	The assessed risk
Mitigation(s)*	Countermeasure(s) that reduce the likelihood or impact of a successful attack

**Denotes optional scenario details*

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Example Cyber Threat Scenario

- ***Narrative Description***
  - *In conjunction with military operations, nation state X intends to disrupt plant operations by exploiting cyber vulnerability ICSA-14-079-01 in the Siemens SIMATIC S7-1200 Programmable Logic Controller (PLC) that regulates circulation of pressurized coolant within the Boiler Level / Pressure Control System. Disruption of the pressure control system may result in unscheduled plant shutdown. Indicators of this attack include specially crafted packets sent to the PLC on port 102/TCP (ISO-TSAP). This attack vector poses a low likelihood, moderate impact risk*

- **Scenario Elements**
  - **Motivation:** In conjunction with military operations
  - **Threat Actor:** nation state X
  - **Effect(s):** 1st order: disable PLC; 2nd order: disrupt pressure control system; 3rd order: trigger plant shutdown (deny)
  - **Vulnerability:** ICSA-14-079-01
  - **Targeted component:** Siemens SIMATIC S7-1200 PLC
  - **System impacted:** Boiler Level / Pressure Control System
  - **Indicator(s):** crafted packets on port 102/TCP (ISO-TSAP)
  - **Risk**: low likelihood, moderate impact

Reference: https://ics-cert.us-cert.gov/advisories/ICSA-14-079-01

Cyber Threat Scenario Development

- **Identify threat actors**
- **Evaluate attack surface entry points and targets**
- **For each target**
  - Identify potential entry points
    - The most plausible scenario(s) tend to use the most accessible entry point(s) and the least lateral movement
  - Evaluate first, second, third order effects
    - CJA results will inform effects analysis
  - Identify indicators that an attack has occurred or is occurring
    - Indicators include observables associated with lateral movement and component disruption
  - Assess risk
  - Identify potential mitigations

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Summary

- **This brief discusses cyber threat actor profiles and attack surface modeling**
  - Cyber threat actor profiles represent capability and intent of cyber threat actors
    - Different threat actor profiles for different systems, capabilities, regions of the world, etc.
  - Attack surface modeling identifies plausible attack vectors that target system components with disruptive effects, e.g., disrupt, deny, destroy, etc.
    - The vector model considers adversary lateral movement from an initial (exposed) system entry point to an intended target
  - Cyber Threat Scenarios develop narrative descriptions by adding contextual information to attack vectors
    - 1st, 2nd, and 3rd order effects derived from CJA results
    - Exploitable vulnerability
    - Indicators of compromise, assessed risk, and mitigations (optional)

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TARA Cyber Threat Susceptibility Analysis

MITRE

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Objectives

- Discuss TARA scoping considerations
- Discuss Cyber Threat Susceptibility Analysis (CTSA)
- Exercise #1: Creating a shopping cart

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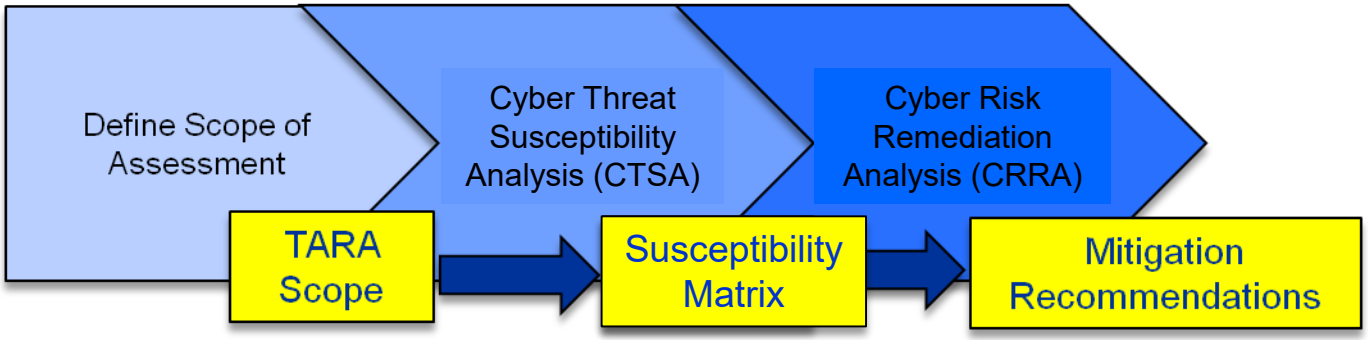
Phases of a TARA Assessment

Objective to identify and assess cyber threats and select countermeasures effective at mitigating those threats



The evaluation target

The range of threats to be assessed

Threat actor capabilities and intent

The phase of the system acquisition lifecycle

Prepare TARA assessment scope brief

Model the attack surface

Perform catalog search to identify candidate AVs

Eliminate implausible AVs

Define a scoring model to rank plausible AVs

Construct the Susceptibility Matrix

Select AVs to mitigate

Use mitigation mappings to identify candidate countermeasures (CMs)

Eliminate implausible CMs

Define a scoring model to rank CMs

Select the best CM solution set

Develop well-formed recommendations

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TARA Scoping Considerations

- **Evaluation target**
  - CJA results can help scope a TARA assessment to focus on mission critical systems and components
- **Threat actor capability and intent**
  - Identify key adversary capabilities to assess threat actors
- **Attack surface analysis**
  - Develop a representative, i.e., not exhaustive, set of plausible attack vectors
- **Staffing is critical**
  - Need experienced SSEs who can *think like the adversary*
- **Schedule and funding constraints**
  - Level of effort estimate 10 – 14 staff weeks (ballpark)
    - Additional time may be needed to produce assessment reports
  - Large assessments can be performed incrementally
- **Deliverables may be classified**
  - Executive Order (EO) 13526 may apply
  - Logistics for handling classified data

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Work Breakdown Structure (WBS)

Notional TARA Work Breakdown Structure (WBS)		Level of Effort (LOE)	
		Staff Weeks	Staff Hours
1	**Threat Susceptibility Analysis**		
1.1	Develop Cyber Threat Model	3	120
1.2	Identify Plausible Attack Vectors	1	40
1.3	Perform Risk Assessment	1	40
2	**Risk Remediation Analysis**		
2.1	Identify Plausible Mitigations	2	80
2.2	Assess Mitigation Utility and Cost	1	40
2.3	Perform Mitigation Selection	1	40
3	**Knowledge Management**		
3.1	Prioritize Information Needs	1	40
3.2	Identify and Evaluate External Data Sources	2	80
3.3	Update Catalog	1	40
	LOE Totals	13	520

13 staff weeks (~500 staff hours) is a ballpark estimate for a TARA assessment
(your mileage may vary)

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Information Used in a TARA Assessment

- **Technical details about the system are needed in order to model its attack surface and identify plausible attack vectors**
  - Mission capabilities, system logical and physical architecture, external interfaces, management interfaces, types of mission data stored and processed, critical program information, security capabilities, security perimeters, user roles and permissions, use of COTS, etc.

- **There is no laundry list of data, no minimum. However more is not always better…**
  - Availability of data depends on the lifecycle phase of the acquisition program and on what contractor data/deliverables are on contract
    - Previous TARA assessments have found use of CONOPS, system architecture documents, Crown Jewels Analysis (CJA) results, operating manuals, DODAF views, hardware and software baseline info, DIACAP package details, etc.
    - TARA is often conducted in the PDR – to – CDR timeframe when much of this data is likely to exist

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WARNING!

Make sure you obtain the Security Classification Guide (SCG) prior to conducting a TARA assessment

The SCG will specify the classification level of information collected and developed during the assessment

The SCG will identify the clearance level required for staff conducting the assessment, and whether classified processing is required

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TARA Scope Brief Outline

- **Purpose**
  - Details the plan to conduct a TARA assessment
- **Audience**
  - MITRE project management; program/project sponsor
- **Content**
  - The system being assessed, i.e., evaluation target
  - The range of threat actors and capabilities
  - Network diagrams, DODAF views, etc.
  - Aspects of the system that are in scope and out of scope
  - System technical information requirements
  - The range of countermeasures being considered
  - The types of recommendations
  - Staffing and schedule
  - Data classification and processing requirements

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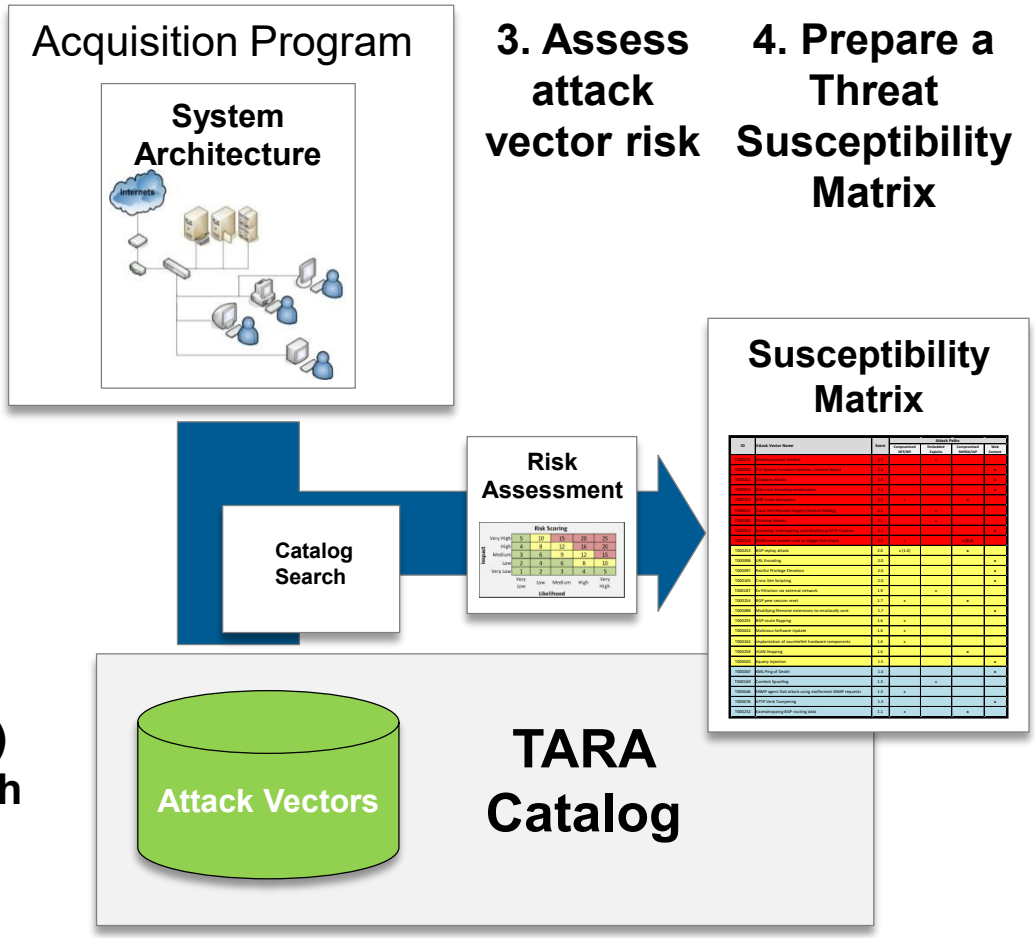
Cyber Threat Susceptibility Analysis (CTSA)

1. Develop a cyber threat model



2. Create shopping cart(s) and populate with attack vectors

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CTSA Workflow Details

- **Develop a cyber threat model**
  - Based on threat actor range of capabilities, exploitable attack surface of entry points and targets, and known attack patterns
- **Create shopping cart(s) and populate with attack vectors**
  - New and existing (catalog) attack vectors added to shopping cart(s)
  - Multiple shopping carts can be used to organize the work
- **Assess attack vector risk**
  - Compute a risk score for each attack vector that will be used to rank vectors in the Susceptibility matrix
- **Prepare Susceptibility Matrix**
  - TARA artifact used to transition from CTSA step Cyber Risk Remediation Analysis (CRRA) activity

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Developing the Cyber Threat Model

- **Cyber Threat Actor Profile used to identify adversary intent and range of capabilities**
  - Discussed previously
- **Exploitable attack surface features and known attack patterns used to identify plausible attack vectors**
  - Attack vectors based on Entry Points and Targets
    - Discussed previously
  - Attack vectors based on known attack patterns and TTPs, e.g., CAPEC, ATT&CK, etc.
    - Over 400 attack vectors are currently stored in the TARA catalog and discoverable using catalog search tools

TARA cyber threat models can leverage open source attack pattern data stored in TARA catalog

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Populating a Shopping Cart

Vector Groups

- Web Server
- Email
- Software
- SNMP
- HTML
- COTS

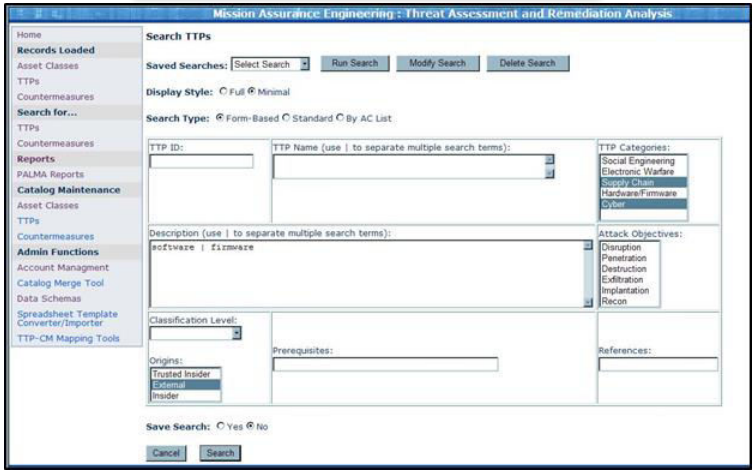
Search by Vector Group

Search by Category

Search by keyword

Catalog Search

Shopping Cart



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Shopping Cart Example

Filter	AV ID	AV Name
	T000004	Malware reflashes device with malicous BIOS
	T000006	Insider uploads malicious BIOS to update server for enterprise-wide distribution
	T000031	Choosing a Message/Channel Identifier on a Public/Multicast Channel
	T000040	File System Function Injection, Content Based
	T000085	Cache Poisoning
	T000091	Router DoS using TCP protocol messaging
	T000095	Exploitation of built-in back doors
	T000113	Router configuration access via crafted HTTP request
	T000114	Route forwarding misconfigured using multicast join messaging
	T000126	MITM attacks on KVM switch
	T000128	Router DoS using malformed IP packets
	T000134	Using malware signature generation capabilities to conduct a DDoS attack, aka allergy attacks
	T000145	Cisco IOS Software TCP Denial of Service Vulnerability
	T000151	Gain access using default usernames and passwords
	T000153	Scanning for default ports to identify installed COTS software
	T000160	Compromised automated software installation processes
	T000167	IDS/IPS not configured to detect adversary reconnaissance or penetration attempts
	T000168	DoS attack on IDS/IPS disrupts network connectivity
	T000173	Message traffic to disable or bypass IDS/IPS filters
	T000174	Using crafted content to disable or bypass antivirus capabilities
	T000175	TCP SYN packets used for host discovery and to bypass misconfigured firewalls
	T000176	UDP pings used for host discovery and to bypass misconfigured firewalls
	T000177	Use of TCP ACK segments to gather information about deployed firewalls
	T000178	Stateless firewalls ineffective against certain port scanning techniques
	T000179	Malware targets PKI readers
	T000181	Malicious software implantation through 3rd party bundling
	T000228	Virtual Machine (VM) embedded malware
	T000257	Router stack overflow arbitrary code execution
	T000261	Malware Attacks

- Example includes attack vectors from the firewall, IDS/IPS, malware, and network appliance vector groups
- Catalog search tools can be used to add additional attack vectors to the shopping cart
- There will always be unknown risks – objective is to identify a **representative NOT exhaustive** list of attack vectors to assess using TARA

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Assessing Attack Vector Risk

- **Sometimes the shopping cart contains too many vectors**
  - More than 25 attack vectors can be difficult to evaluate in a single TARA assessment
- **Risk scoring used to rank attack vectors**
  - Lower risk attack vectors can be omitted from CRRA step, i.e., treated as residual risk or deferred to follow on assessment
- **Different risk assessment approaches can be used**
  - Approaches include risk cubes, weighted sums, multi-attribute utility analysis (MAUA), etc.
    - CJA results can help calibrate risk based on mission impacts when a system or component is compromised

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Risk Calculators

Risk score calculated for each attack vector as a weighted sum of risk factors:

$$\text{Risk Score} \sim \sum \left((\text{risk factor value})_i * (\text{factor weighting})_i \right)$$

Risk Factor | Qualitative Effects | Factor Weight | Risk Factor Values

Factors for assessing TTP Risk				Factor Weight	Attack Vectors					
Factor Range	Low = 1	Medium = 2	High = 3		T000001	T000008	T000016	T000021	T000049	T000105
Locality: How localized are the effects posed by this TTP?	isolated to single unit	external networks potentially impacted	all units globally and associated infrastructure	0.2	1	2	1	2	2	3
Impact: How serious an impact is loss of data confidentiality resulting from successful application of this TTP?	no impact from TTP	limited impact requiring some remediation	Data spills routinely exercised	0.2	2	1	1	1	2	3
Impact: How serious an impact is loss of system availability resulting from successful application of this TTP?	no impact from TTP	limited impact requiring some remediation	Simulated system outages routinely exercised	0.2	1	1	2	2	1	2
Prior Use: Is there evidence that this TTP has been successfully used before?	no evidence of TTP use	confirmed evidence of TTP use	widespread use of TTP reported	0.3	2	3	3	1	2	1
Stealth: How detectable is this TTP when it is applied?	TTP obvious without monitoring	detection likely with routine monitoring	undetectable	0.1	2	2	1	1	1	2
			Score	1.0	1.6	1.9	1.8	1.4	1.7	2.1

Alternative risk calculators discussed later in the training

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Susceptibility Matrix Example

ID	Attack Vector	Risk Score	Shopping Carts			
			External Router	Internal Router	Web Server	Workstation
T000259	Malicious email content	2.7				x
T000040	File System Function Injection, Content Based	2.6			x	
T000261	Malware attacks	2.6			x	
T000019	Alternate Encoding combination	2.2			x	
T000250	BGP route disruption	2.1	x	x		
T000015	Cross Site Request Forgery (Session Riding)	2.1				x
T000260	Phishing Attacks	2.1				x
T000014	Accessing, Intercepting, and Modifying HTTP Cookies	2.1			x	
T000128	Malformed packet used to trigger DoS attack	2.0	x	x (1.3)		
T000253	BGP replay attack	2.0	x (1.4)	x		
T000098	URL Encoding	2.0			x	
T000097	Restful Privilege Elevation	2.0			x	
T000105	Cross Site Scripting	2.0			x	
T000187	Ex-filtration via external network	1.9				x
T000254	BGP peer session reset	1.7	x	x		
T000088	Modifying filename extensions to misclassify content	1.7			x	
T000255	BGP route flapping	1.6	x			
T000024	Malicious Software Update	1.6	x			
T000163	Implantation of counterfeit hardware components	1.6	x			
T000258	VLAN Hopping	1.6		x		
T000020	Xquery Injection	1.5			x	
T000067	XML Ping of Death	1.4			x	
T000169	Content Spoofing	1.3				x
T000046	SNMP agent DoS attack using malformed SNMP requests	1.3	x			
T000076	HTTP Verb Tampering	1.3			x	
T000252	Eavesdropping BGP routing data	1.1	x	x		

- Produced during CTSA
- Details attack vectors assigned to different shopping carts
  - Separate column for each shopping cart
- Lists top 20 – 25 highest risk attack vectors across all shopping carts
  - Highest risk vectors on top
- Risk scores depends on scoring model used
  - May be qualitative or quantitative
- Vector risk scores may be different for each shopping cart
  - Conflict resolution: highest risk score used with lower score noted

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Exercise #1: Creating a Shopping Cart

1. Go to the vector group maintenance page by clicking on Vector Group under Catalog Maintenance
2. Enter a vector group name, provide a description, Add/Update
3. Find your new vector group on the vector groups page under Records Loaded
4. Open it
5. Use the selection box at the bottom to add 3-4 attack vectors to the vector group (Use the Add New button to add the entry)
6. Go to the attack vectors search form under Search for…
7. Perform a keyword search in the description field (your choice of keywords)
8. Select 1-2 attack vectors and add them to your vector group
9. Perform a filtered search on the attack objectives field
10. Select 1-2 attack vectors and add them to your vector group

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Your Turn…

- **Create a shopping cart titled (your name)**
  - Add 7 – 10 attack vectors to your shopping cart for an evaluation target consisting of a web application running on a web server

- **Discussion**
  - Did you find everything that you were looking for?
  - How do your shopping carts compare?
  - How did you model the target, e.g., interfaces, perimeters, etc.?
  - What information about the evaluation target would be useful?
  - What filtered and keyword searches do you perform?
  - How to distinguish between what's plausible and what's not?

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Summary

- **Establishing the Assessment Scope**
  - Range of threats and countermeasures, schedule, staffing, etc.
  - Scoping brief
- **Cyber Threat Susceptibility Analysis (CTSA)**
  - Develops attack vectors based on system attack surfaces and evaluates catalog attack vectors based on CAPEC attack patterns
  - Uses shopping carts to construct persistent lists of attack vectors
  - Applies risk scoring to rank (select) vectors for remediation
  - Susceptibility Matrix
- **Exercise #1: Creating a shopping cart**

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TARA Cyber Risk Remediation Analysis

MITRE

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Objectives

- Discuss Cyber Risk Remediation Analysis (CRRA)
- Worked example: Apply countermeasure scoring and selection strategy to develop an optimized solution set
- Exercise #2: Exporting catalog data

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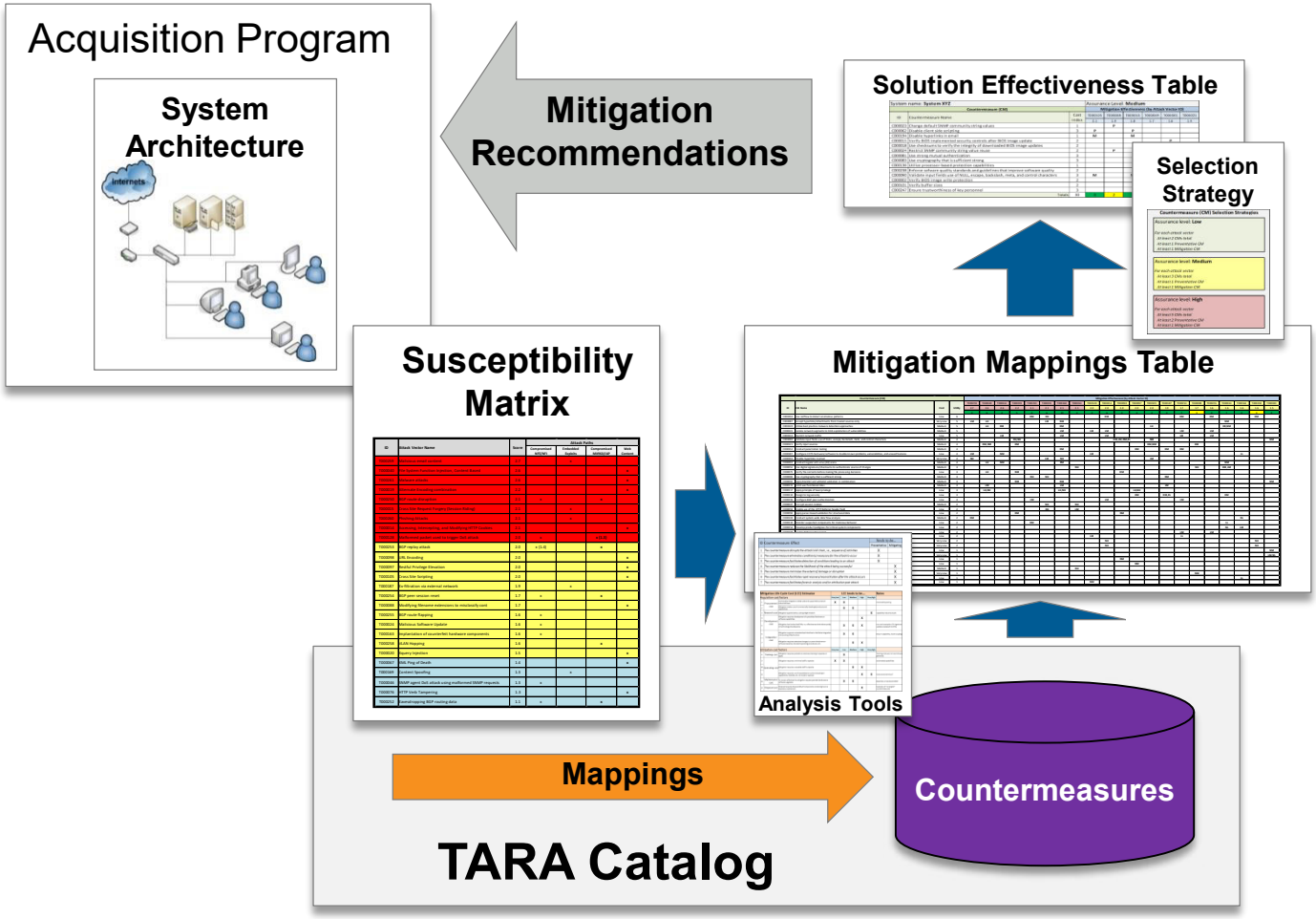
Cyber Risk Remediation Analysis (CRRA)



4. Apply countermeasure selection strategy

3. Perform countermeasure scoring

2. Amend countermeasure list

1. Obtain initial list of countermeasures

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MITRE

CRRA Workflow Details

- **Obtain initial mitigation mapping table**
  - Countermeasure mapping data for attack vectors in Susceptibility Matrix used to obtain initial list of countermeasures
- **Amend countermeasures list**
  - Add countermeasures and/or mappings to fill gaps and address scoping requirements; remove countermeasures that don't apply
- **Perform countermeasure scoring**
  - Compute utility/cost (U/C) ratio for each CM; reorder mitigation mapping table to rank countermeasures based on U/C scores
- **Apply a countermeasure selection strategy**
  - Execute selection strategy to identify countermeasures for the Solution Effectiveness Table

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Mitigation Mappings Table

A mitigation mapping table conveys the effects that countermeasures have over a range of attack vectors

- Attack vectors represented as columns in the mapping table
- Countermeasures represented as rows in the mapping table
- Matrix cells identify what effect a countermeasure has on an attack vector

Countermeasures	Attack Vectors								
	A1	A2	A3	A4	A5	A6	A7	A8	…
C1	X			X	X	X			
C2									
C3	X			X			X		
C4			X			X			
C5				X					
C6			X			X		X	
C7					X		X		
C8				X	X	X			
…	X				X			X	

Mitigation Mappings Table

Coverage gap (no countermeasures mapped to attack vector)

Superfluous countermeasure (no attack vectors mapped to countermeasure)

Countermeasure C4 mitigates attack vector A3 and attack vector A6

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Countermeasure Effects

- **A countermeasure can have 3 potential effects on an attack vector**
  - **Prevent (denoted by a 'P')**
    - The countermeasure eliminates conditions that make the attack possible
  - **Detect (denoted by a 'D')**
    - The countermeasure makes it possible to determine if the attack has occurred, is occurring, or potentially could occur
  - **Respond (denoted by a 'R')**
    - The countermeasure reduces the likelihood that the attack will occur, or its impact will be significant

A countermeasure can have different effects on different attack vectors and multiple effects on the same attack vector

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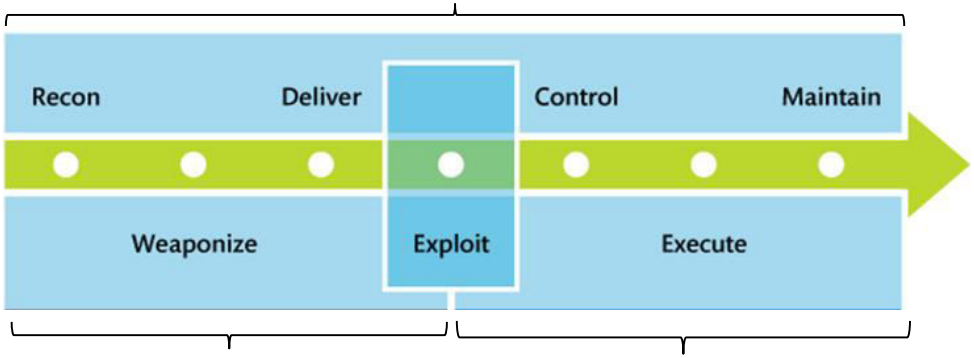
Countermeasure Effects and the Cyber Attack Lifecycle

The **Cyber Attack Lifecycle*** illustrates the stages that an adversary goes through to achieve its objectives and provides a framework for recognizing how attacks are structured.

Detect

makes it possible to determine if the attack has occurred, is occurring, or potentially could occur



Prevent

eliminate conditions that make the attack possible

Respond

reduce the likelihood or impact of the attack

*The cyber attack lifecycle is frequently referred to as the "cyber kill chain." See http://www.lockheedmartin.com/content/dam/lockheed/data/corporate/documents/LM-White-Paper-Intel-Driven-Defense.pdf

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Assessing Countermeasure Effects

The following table provides guidance for assessing the effect a countermeasure has on a given attack vector

ID	Countermeasure Effect	Tends to be…		
		Prevent	Detect	Respond
1	*The countermeasure disrupts the attack's sequence of activities*	X		
2	*The countermeasure eliminates condition(s) necessary for the attack to occur*	X		
3	*The countermeasure facilitates detection of conditions leading to an attack*	X	X	
4	*The countermeasure reduces the likelihood of the attack being successful*			X
5	*The countermeasure minimizes the extent of damage or disruption*			X
6	*The countermeasure facilitates rapid recovery/reconstitution after the attack occurs*			X
7	*The countermeasure facilitates forensic analysis and/or attribution following an attack*		X	X

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Effects Confidence

- **Estimates the certainty that a countermeasure effect will be realized**
  - High Confidence
    - Engineering verification confirms the effect, i.e., demonstration, inspection, testing, or analysis
  - Moderate Confidence
    - Effect based on judgment of a cyber Subject Matter Expert (SME)
  - Low Confidence
    - Plausible effect that has not yet been confirmed or substantiated

- **Applications**
  - Can be used to establish priorities for mapping table validation and applied security testing
  - Can be used to filter mapping table data, e.g., disregard all mappings with low confidence, etc.

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Mitigation Mappings Table Example

Countermeasure (CM)		Effect (by Attack Vector ID)					
CM ID	Name	T000014	T000049	T000050	T000052	T000071	T000170
C000103	Match buffer size to data input size		PH	PH			
C000293	Disable file and printer sharing			RM	RL		PL
C000134	Select programming languages that minimize potential software defects		PM	PM	PM		
C000238	Enforce software quality standards and guidelines that improve software quality		PM	PM	PM		
C000117	Apply principle of least privilege					RM	RM
C000135	Avoid use of dangerous memory functions and operations		RM		RM		
C000039	Convert input data into the data format in which it is used				PM		
C000059	Enable use of the HTTP Referrer header field	RM					
C000093	Merge data streams prior to validation				PM		
C000096	Use vetted runtime libraries		PH			PH	
C000123	Design software to fail securely		PM		RM		
C000136	Utilize processor-based protection capabilities		PL				PM
C000045	Utilize high quality session IDs	RM					
C000047	Encrypt session cookies	PH					
C000051	Use digital signatures/checksums to authenticate source of changes	PH					
C000089	Validate the range of numeric input			PM			
C000095	Convert input to canonical form before validating				PM		
C000101	Verify buffer sizes		PH				
C000102	Verify message size data					DH; PH	
C000137	Use unsigned variables to represent whole numbers			PM			
C000094	Validate data exchanges across language boundaries				RM		
C000132	Use sandboxing to isolate running software						PM
C000146	Apply transport-level mechanisms such as TLS and or VPNs to protect sensitive content	PH					

Mitigation mappings for attack vectors T000014, T000049, T000050, T000052, T000071, T000170

Countermeasure Effects

PH – Prevent Effect / High Confidence

RM – Respond Effect / Moderate Confidence

DL – Detect Effect / Low Confidence

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Countermeasure Scoring

- **Once the mapping table is constructed, countermeasures can be scored and ranked**

- **TARA uses a numeric scoring approach to calculate a utility-to-cost (U/C) ratio for each countermeasure**
  - **Utility** reflects the effectiveness of a countermeasure over the range of attack vectors being assessed
    - Computed as a weighted sum of P's and R's
  - **Cost** reflects the Life Cycle Cost (LCC) of ownership of a countermeasure
    - Cost scale used: [1…5] – *This in NOT a dollar cost estimate!*

Countermeasure U/C ratios reflect "bang for the buck" effectiveness

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Countermeasure Cost Factors

- **Acquisition Costs**
  - Cost to develop
  - Cost to test
  - Cost to integrate into system
- **Operational Costs**
  - Cost to staff
  - Cost to train
  - Cost to operate
  - Cost to maintain
  - Cost to dispose

Cost factors reflect the Lifecycle Cost (LCC) of a countermeasure

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A Life Cycle Cost (LCC) Calculator

Factors for assessing Mitigation Life Cycle Cost (LCC)						Factor Weighting	C000x	C000x	C000x
Acquisition cost factors	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	0.4	0.4	1.2	2
Maturity: How technically mature is the mitigation?	Proven technology	New to market product or technology	fielded operational prototype	fielded demonstration prototype	laboratory or research prototype	0.2	1	3	5
Development: Does the mitigation require specialized or hard to find hardware or software capabilities to install or operate?	minimal capabilities required to develop	limited capabilities needed to develop	some specialized capabililities required	wide range of specialized capabilities required	extensive specialized and hard-to-find capabilities required	0.2	1	3	5
Development: Does the mitigation have a limited shelf life, i.e., does its effectivness deminish over time?	90% effective after 10 years	75% effective after 8 years	60% effective after 5 years	40% effective after 1 year	10% effective after 6 months	0.2	1	3	5
Integration: Does the mitigation implement standard interfaces and/or protocols that would facilitate integration with other technologies?	Interoperable through industry standard interfaces	Limited interoperability with other vendor products	Proprietary interfaces and non standard protocols	Undeveloped external interfaces	Mitigation implemented as standalone capability	0.2	1	3	5
Integration: Would system hardware or software baselines require extensive change in order to adopt the mitigation?	Drop-in capability	Minor configuration changes to existing baseline	Major configuration changes to existing baseline	Requires changes to software baseline (recoding)	Requires changes to hardware baseline (retooling)	0.2	1	3	5
Utilization cost factors	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	0.6	0.6	1.8	3
Training: Would the mitigation require extensive training in order to operate or apply?	no training required	minimal training require	some training required	regular training required	extensive training required	0.2	1	3	5
Operation: Does the mitigation require significant staff to operate?	no additional staff required	minimal staff required	some staff required	significant staff commitment	labor intensive activity	0.2	1	3	5
Operation: Does the mitigation require specialized or hard to find hardware or software capabilities to install or operate?	no special capabilities required to install or operate	limited capabilities needed to install and operate	some specialized capabililities required	wide range of specialized capabilities required	extensive specialized and hard-to-find capabilities required	0.2	1	3	5
Maintenance: Would the mitigation require periodic hardware or software upgrades in order to remain effective?	infrequent	occasional	regular	frequent	very frequent	0.2	1	3	5
Disposal: Would disposal of the mitigation involve handling of toxic or hazardous substances?	No toxic or hazardous substances involved	Minimal likelihood of contact with harzardous substances	Contact with hazardous substances possible	Contact with hazardous subtances likely	Extensive contact with hazardous substances	0.2	1	3	5
					LCC Score		1	3	5

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Adding Scoring Data to Mapping Table

Countermeasure (CM)		Effect (by Attack Vector ID)						Scoring				
CM ID	Name	T000014	T000049	T000050	T000052	T000071	T000170	Total P's	Total R's	Utility	Cost	U/C Ratio
C000039	Convert input data into the data format in which it is used				PM						2	
C000045	Utilize high quality session IDs	RM									3	
C000047	Encrypt session cookies	PH									3	
C000051	Use digital signatures/checksums to authenticate source of changes	PH									3	
C000059	Enable use of the HTTP Referrer header field	RM									2	
C000089	Validate the range of numeric input			PM							3	
C000093	Merge data streams prior to validation				PM						2	
C000094	Validate data exchanges across language boundaries				RM						4	
C000095	Convert input to canonical form before validating				PM						3	
C000096	Use vetted runtime libraries		PH			PH					4	
C000101	Verify buffer sizes		PH								3	
C000102	Verify message size data					DH; PH					3	
C000103	Match buffer size to data input size		PH	PH							2	
C000117	Apply principle of least privilege					RM	RM				3	
C000123	Design software to fail securely		PM		RM						4	
C000132	Use sandboxing to isolate running software						PM				4	
C000134	Select programming languages that minimize potential software defects		PM	PM	PM						4	
C000135	Avoid use of dangerous memory functions and operations		RM		RM						3	
C000136	Utilize processor-based protection capabilities		PL				PM				4	
C000137	Use unsigned variables to represent whole numbers			PM							3	
C000146	Apply transport-level mechanisms such as TLS and or VPNs to protect sensitive content	PH									4	
C000238	Enforce software quality standards and guidelines that improve software quality		PM	PM	PM						4	
C000293	Disable file and printer sharing			RM	RL		PL				3	

New scoring section added

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Calculating a U/C Ratio

Countermeasure (CM)		Effect (by Attack Vector ID)						Scoring				
CM ID	Name	T000014	T000049	T000050	T000052	T000071	T000170	Total P's	Total R's	Utility	Cost	U/C Ratio
C000039	Convert input data into the data format in which it is used				PM			1		1	2	50
C000045	Utilize high quality session IDs	RM							1	1	3	33
C000047	Encrypt session cookies	PH						1		1	3	33
C000051	Use digital signatures/checksums to authenticate source of changes	PH						1		1	3	33
C000059	Enable use of the HTTP Referrer header field	RM							1	1	2	50
C000089	Validate the range of numeric input			PM				1		1	3	33
C000093	Merge data streams prior to validation				PM			1		1	2	50
C000094	Validate data exchanges across language boundaries				RM				1	1	4	25
C000095	Convert input to canonical form before validating				PM			1		1	3	33
C000096	Use vetted runtime libraries		PH			PH		2		2	4	50
C000101	Verify buffer sizes		PH					1		1	3	33
C000102	Verify message size data					DH; PH		1		1	3	33
C000103	Match buffer size to data input size		PH	PH				2		2	2	100
C000117	Apply principle of least privilege					RM	RM		2	2	3	67
C000123	Design software to fail securely		PM		RM			1	1	2	4	50
C000132	Use sandboxing to isolate running software						PM				4	
C000134	Select programming languages that minimize potential software defects		PM	PM	PM						4	
C000135	Avoid use of dangerous memory functions and operations		RM		RM						3	
C000136	Utilize processor-based protection capabilities		PL				PM				4	
C000137	Use unsigned variables to represent whole numbers			PM							3	
C000146	Apply transport-level mechanisms such as TLS and or VPNs to protect sensitive content	PH									4	
C000238	Enforce software quality standards and guidelines that improve software quality		PM	PM	PM						4	
C000293	Disable file and printer sharing			RM	RL		PL				3	

How the U/C ratio is computed

1. Total the number of P's and R's across all attack vector columns
2. Optional: Select a weighting scheme for P's and R's
3. Utility Score = (Total P's)*Weighting(P) + (Total R's)*Weighting(R)
4. Utility/Cost ratio = Utility Score / Cost Score * 100

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Reordering the Mapping Table

Countermeasure (CM)		Effect (by Attack Vector ID)						Scoring				
CM ID	Name	T000014	T000049	T000050	T000052	T000071	T000170	Total P's	Total R's	Utility	Cost	U/C Ratio
C000103	Match buffer size to data input size		PH	PH				2		2	2	100
C000293	Disable file and printer sharing			RM	RL		PL	1	2	3	3	100
C000134	Select programming languages that minimize potential software defects		PM	PM	PM			3		3	4	75
C000238	Enforce software quality standards and guidelines that improve software quality		PM	PM	PM			3		3	4	75
C000117	Apply principle of least privilege					RM	RM		2	2	3	67
C000135	Avoid use of dangerous memory functions and operations		RM		RM				2	2	3	67
C000039	Convert input data into the data format in which it is used				PM			1		1	2	50
C000059	Enable use of the HTTP Referrer header field	RM							1	1	2	50
C000093	Merge data streams prior to validation				PM			1		1	2	50
C000096	Use vetted runtime libraries		PH			PH		2		2	4	50
C000123	Design software to fail securely		PM		RM			1	1	2	4	50
C000136	Utilize processor-based protection capabilities		PL				PM	2		2	4	50
C000045	Utilize high quality session IDs	RM							1	1	3	33
C000047	Encrypt session cookies	PH						1		1	3	33
C000051	Use digital signatures/checksums to authenticate source of changes	PH						1		1	3	33
C000089	Validate the range of numeric input			PM				1		1	3	33
C000095	Convert input to canonical form before validating				PM			1		1	3	33
C000101	Verify buffer sizes		PH					1		1	3	33
C000102	Verify message size data					DH; PH		1		1	3	33
C000137	Use unsigned variables to represent whole numbers			PM				1		1	3	33
C000094	Validate data exchanges across language boundaries				RM				1	1	4	25
C000132	Use sandboxing to isolate running software						PM	1		1	4	25
C000146	Apply transport-level mechanisms such as TLS and or VPNs to protect sensitive content	PH						1		1	4	25

Alternative Reordering Strategies

Bang-for-the-buck – table ordered by descending U/C ratios

Max-Utility – table ordered by descending Utility scores

Least-Cost – table ordered by ascending Cost scores

Countermeasure selection always starts from the top, so reordering strategies will effect the selection

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Countermeasure Selection Strategy

- **A countermeasure selection strategy defines success criteria for the set of countermeasures selected to mitigate each attack vector**
- **Attack vectors with the highest risk scores are solved first**
  - A best practice is to order attack vectors (columns) from left to right by descending risk
- **Countermeasures with the highest ranking are selected first**
  - A best practice is to order countermeasure (rows) from top to bottom using the preferred reordering strategy
- **Once selected, the countermeasure applies to all attack vectors**
  - The goal is to select the minimum number of countermeasures that satisfy the selection strategy

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2 Example Selection Strategies

- *Construct a solution set containing at least 3 countermeasures for each attack vector with high risk, at least 2 countermeasures for each attack vector with moderate risk, and at least 1 countermeasure for each attack vector with low risk*

- *Construct a solution set containing at least 1 preventative and 1 responsive countermeasure for each attack vector AND at least 3 countermeasures for attack vectors with high risk, at least 2 countermeasures for attack vectors with moderate risk, and at least 1 countermeasure for attack vectors with low risk*

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Countermeasure Selection Example (1/5)

CM ID	T000010	T000011	T000013	T000014	T000016	T000023	T000030	T000036	T000060	T000066	Utility	Cost	U/C Ratio
	High	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Very Low			
C000112	X		X		X	X	X				5	20	25
C000100		X			X				X	X	4	20	20
C000325	X				X		X	X		X	5	30	17
C000102	X		X			X	X	X			5	40	13
C000313		X				X	X		X		4	40	10
C000326		X	X				X		X		4	40	10
C000324	X		X	X							3	40	8
C000118	X	X			X		X				4	60	7
C000114				X		X		X			3	50	6
C000116		X	X					X		X	4	80	5
Totals													

Start

The Countermeasure Selection Strategy

Construct a solution set containing at least 3 countermeasures for each attack vector with high risk, at least 2 countermeasures for each attack vector with moderate risk, and at least 1 countermeasure for each attack vector with low risk.

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Countermeasure Selection Example (2/5)

CM ID	T000010	T000011	T000013	T000014	T000016	T000023	T000030	T000036	T000060	T000066	Utility	Cost	U/C Ratio
	High	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Very Low			
1. C000112	X		X		X	X	X				5	20	25
C000100		X			X				X	X	4	20	20
2. C000325	X				X		X	X		X	5	30	17
3. C000102	X		X			X	X	X			5	40	13
C000313		X				X	X		X		4	40	10
C000326		X	X				X		X		4	40	10
C000324	X		X	X							3	40	8
C000118	X	X			X		X				4	60	7
C000114				X		X		X			3	50	6
C000116		X	X					X		X	4	80	5
Totals												90	

Start Next

Applying the selection strategy to the first vector selects 3 countermeasures

- The selected countermeasures apply to all attack vectors that they are mapped to
- The total cost (so far) is 90

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Countermeasure Selection Example (3/5)

CM ID	T000010	T000011	T000013	T000014	T000016	T000023	T000030	T000036	T000060	T000066	Utility	Cost	U/C Ratio
	High	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Very Low			
1. C000112	X		X		X	X	X				5	20	25
4. C000100		X			X				X	X	4	20	20
2. C000325	X				X		X	X		X	5	30	17
3. C000102	X		X			X	X	X			5	40	13
5. C000313		X				X	X		X		4	40	10
6. C000326		X	X				X		X		4	40	10
C000324	X		X	X							3	40	8
C000118	X	X			X		X				4	60	7
C000114				X		X		X			3	50	6
C000116		X	X					X		X	4	80	5
Totals												190	

Start Next **Next**

Applying the selection strategy to the second vector selects 3 more countermeasures

- Note that 3 countermeasures have already been selected for the third vector, so no additional countermeasures are needed for that vector
- The total cost is now 190

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Countermeasure Selection Example (4/5)

CM ID	T000010	T000011	T000013	T000014	T000016	T000023	T000030	T000036	T000060	T000066	Utility	Cost	U/C Ratio
	High	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Very Low			
1. C000112	X		X		X	X	X				5	20	25
4. C000100		X			X				X	X	4	20	20
2. C000325	X				X		X	X		X	5	30	17
3. C000102	X		X			X	X	X			5	40	13
5. C000313		X				X	X		X		4	40	10
6. C000326		X	X				X		X		4	40	10
7. C000324	X		X	X							3	40	8
C000118	X	X			X		X				4	60	7
8. C000114				X		X		X			3	50	6
C000116		X	X					X		X	4	80	5
Totals												280	

Start Next Next **Next**

Applying the selection strategy to the fourth vector selects 2 countermeasures

- Only 2 countermeasures are needed to satisfy the strategy for moderate risk vectors
- The total cost is now 280

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Countermeasure Selection Strategy (5/5)

CM ID	T000010	T000011	T000013	T000014	T000016	T000023	T000030	T000036	T000060	T000066	Utility	Cost	U/C Ratio
	High	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Very Low			
1. C000112	X		X		X	X	X				5	20	25
4. C000100		X			X				X	X	4	20	20
2. C000325	X				X		X	X		X	5	30	17
3. C000102	X		X			X	X	X			5	40	13
5. C000313		X				X	X		X		4	40	10
6. C000326		X	X				X		X		4	40	10
7. C000324	X		X	X							3	40	8
C000118	X	X			X		X				4	60	7
8. C000114				X		X		X			3	50	6
C000116		X	X					X		X	4	80	5
Totals	4	3	4	2	3	4	5	3	3	2		280	

Start → **Finish**

Total Cost

Countermeasures selected so far are sufficient to satisfy the strategy for the remaining vectors in the mapping table

- The number of countermeasures selected is totaled for each column. Green indicates the strategy is satisfied.
- The total cost of this solution is 280

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Finding an Optimal Solution

CM ID	T000010	T000011	T000013	T000014	T000016	T000023	T000030	T000036	T000060	T000066	Utility	Cost	U/C Ratio
	High	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low	Very Low			
1. C000112	X		X		X	X	X				5	20	25
4. C000100		X			X				X	X	4	20	20
2. C000325	X				X		X	X		X	5	30	17
3. C000102	X		X			X	X	X			5	40	13
5. C000313		X				X	X		X		4	40	10
6. C000326		X	X				X		X		4	40	10
7. C000324	X		X	X							3	40	8
C000118	X	X			X		X				4	60	7
8. C000114				X		X		X			3	50	6
C000116		X	X					X		X	4	80	5
Totals	3	3	3	2	3	3	4	2	3	2		240	

Total Cost

An optimal solution will <u>minimize</u> the number of countermeasures selected while satisfying the strategy

- While selecting CMs is performed starting from the top, de-selecting CMs is performed starting from the bottom
- C0000102 is deselected, reducing the total cost by (280-240)/280 ~ 14%

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What if the strategy cannot be satisfied?

CM ID	T000010	T000011	T000013	T000014	T000016	T000023	T000030	T000036	T000060
	High	High	Moderate	Moderate	Moderate	Moderate	Low	Low	Low
C000112							R		
C000100		R							
C000325	P							R	
C000102									
C000313		R					R		P
C000326		P							R
C000324	R		P	R					
C000118	R				P		R		
C000114				R				P	
C000116			P						
Totals	3	3	2	2	1	0	3	2	2

Green = satisfied

Yellow = deficiency

Red = gap

Alternatives

- Add mappings
- Add countermeasures (and mappings)
- Adjust the strategy
- Recognize that there are deficiencies in the model

For bonus points: Can you deduce the selection strategy from this table?

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Solution Effectiveness Table

The solution effectiveness table represents a solution set. For each countermeasure it identifies the preventative or mitigating effect(s) it has over the range of attack vectors. The table also provides a cost summary and indicates whether the selection strategy is satisfied for each attack vector, or where gaps exist.

Countermeasure (CM)		Scoring	Effect (by Attack Vector ID)					
CM ID	Name	U/C Ratio	T000014	T000049	T000050	T000052	T000071	T000170
C000134	Select programming languages that minimize software defects	75		PM	PM	PM		
C000117	Apply principle of least privilege	67					RM	RM
C000093	Merge data streams prior to validation	50				PM		
C000096	Use vetted runtime libraries	50		PH			PH	
C000047	Encrypt session cookies	33	PH					
C000051	Use digital signatures/checksums	33	PH					
C000132	Use sandboxing to isolate running software	25						PM
TOTALS		333	2	2	1	2	2	2

The solution effectiveness table is produced by removing unselected countermeasures from the mapping table and tabulating the totals

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Exercise #2: Exporting Catalog Data

1. Go to the vector group list
2. Select (check) your vector
3. Generate a Composite List of Attack Vectors (button at top)
4. Generate a Composite List of Countermeasures (button at top)
5. Export TARA Spreadsheet (button at top)
6. Save as.. On the desktop, call it TARA extract.xlsx

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Your Turn…

- **Discussion**
  - Did you find everything you were looking for?
  - Do you agree with the mappings?

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Summary

- **Cyber Risk Remediation Analysis (CRRA)**
  - Extends initial mapping table with additional countermeasures and mappings
  - Applies cost scoring to estimate lifecycle cost for countermeasures
  - Computes U/C ratios for countermeasures
  - Applies selection strategy to select countermeasures
  - Produces a Solution Effectiveness table and associated recommendations

- **Worked example**
  - Use of mapping table and U/C ratio scoring
  - Use of a selection strategy to select countermeasures
  - Solution set optimization
  - Sensitivity analysis to develop and evaluate alternative solutions

- **Exercise #2 : Exporting Catalog Data**

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TARA Catalog Content Management

MITRE

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Objectives

- Discuss Knowledge Management (KM) activities
- Discuss taxonomies
- Discuss catalog virtualization
- Exercise #3: Updating the catalog

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KM in TARA

- **The TARA catalog is never complete and never up-to-date**
  - Numerous content gaps
  - Constantly evolving cyber threat landscape
  - Did you find everything you were looking for? Probably not.

- **No elves behind the scenes to maintain the catalog**
  - Catalog updates necessary for every assessment
    - Attack vectors, countermeasures, and mitigation mappings added depending on assessment needs

- **Content added to the catalog is reused in subsequent assessments**

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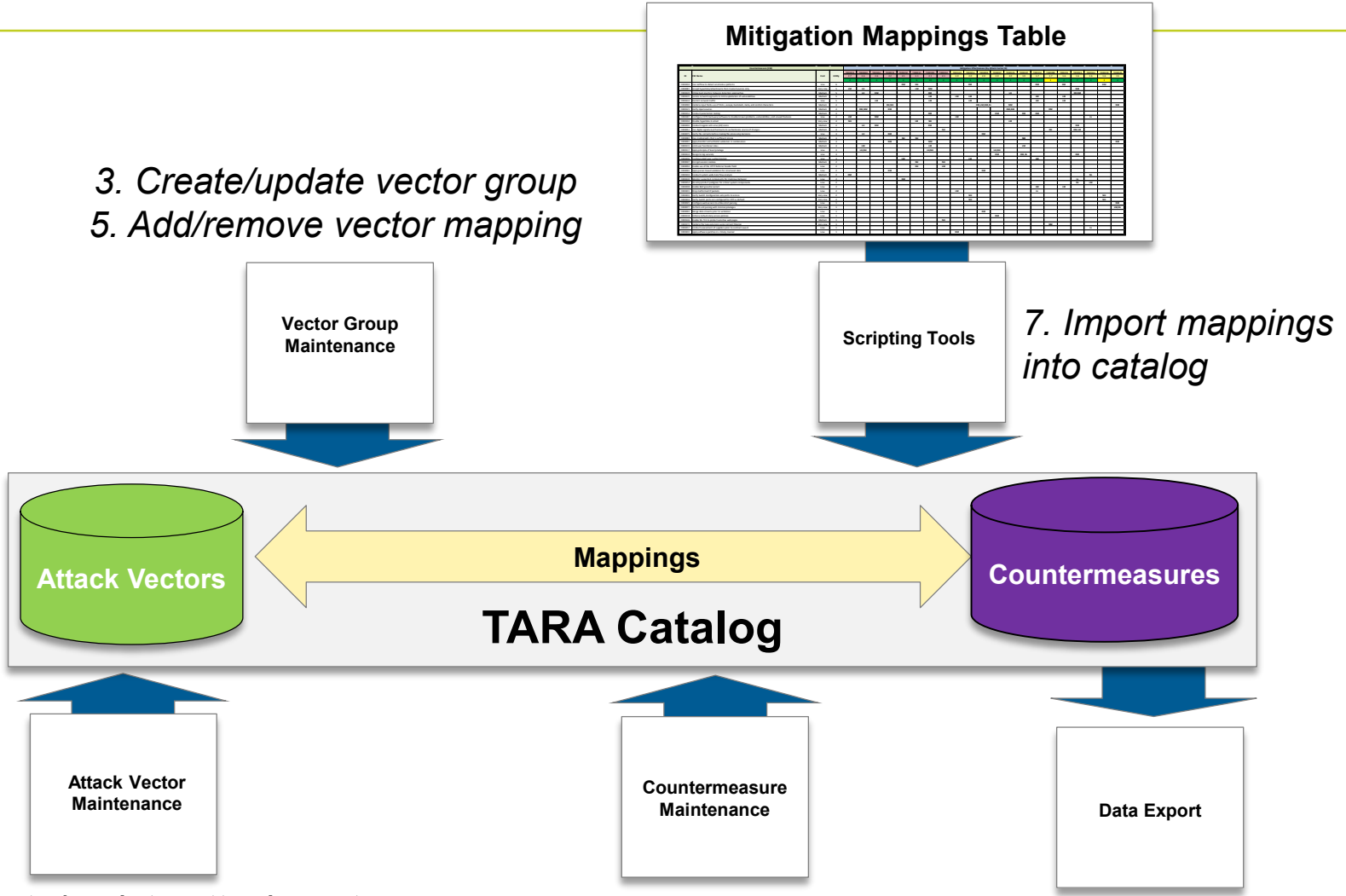
KM Workflows



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KM Workflow Details

1. **Create / update attack vector**
2. **Create / update countermeasure**
3. **Create / update vector group**
   - Used to create and manage attack vectors, countermeasures, and vector groups
4. **Add / remove mapping**
   - Used to manage mappings between attack vectors and countermeasures
     - Performed in the context of attack vector or countermeasure maintenance
5. **Add / remove vector mapping**
   - Used to manage mappings between attack vectors and vector groups
     - Also used to manage contents of shopping carts
   - Used to manage hierarchical relationships between vector groups
     - Support taxonomy development
6. **Export catalog spreadsheet**
   - Used to generate a TARA export spreadsheet containing attack vectors, countermeasure, and mapping details
7. **Import mappings into catalog**
   - Supports bulk importation of mappings from a mitigation mappings table (spreadsheet)

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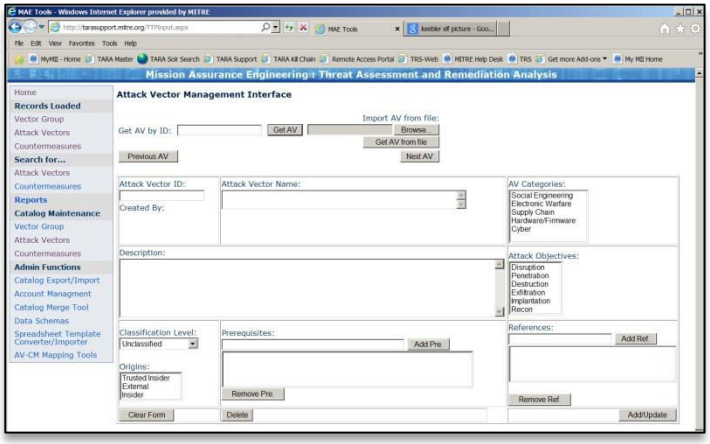
Managing Attack Vectors and Countermeasures (1/3)

Catalog Menu

- Home
- **Records Loaded**
- Vector Group
- Attack Vectors
- Countermeasures
- **Search for...**
- Attack Vectors
- Countermeasures
- **Reports**
- **Catalog Maintenance**
- Attack Vectors
- Countermeasures
- **Admin Functions**
- Catalog Export/Import
- Account Managment
- Catalog Merge Tool
- Data Schemas
- Spreadsheet Template Converter/Importer
- AV-CM Mapping Tools

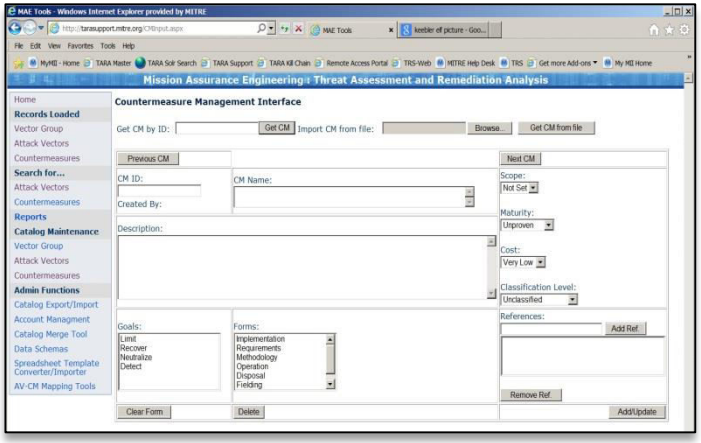
Requires maintainer privileges to access

Attack Vector Maintenance Screen



Screen used to create, modify, and delete an attack vector in the TARA catalog

Countermeasure Maintenance Screen



Screen used to create, modify, and delete a countermeasure in the TARA catalog

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Managing Attack Vectors and Countermeasures (2/3)

Attack Vector Maintenance Screen (Bottom)

Mapped Countermeasure(s):

CM ID - Name	Prevent	Detect	Respond	Classification		
C000062 - Disable client side scripting	High	N/A	N/A	Unclassified	Edit	Delete
C000090 - Validate input fields use of NULL, escape, backslash, meta, and control characters	Medium	N/A	N/A	Unclassified	Edit	Delete
C000121 - Verify input sources	Medium	Medium	N/A	Unclassified	Edit	Delete
C000115 - Limit user functional roles	N/A	N/A	Low	Unclassified	Edit	Delete
C000132 - Use sandboxing to isolate running software	N/A	N/A	Medium	Unclassified	Edit	Delete
C000194 - Disable hyperlinks in email	N/A	N/A	Low	Unclassified	Edit	Delete
C000197 - Automated attack signature detection and firewall update	N/A	Medium	Medium	Unclassified	Edit	Delete
C000220 - Supplement signature-based malware detection with anomaly-based capabilities	Medium	N/A	N/A	Unclassified	Edit	Delete
C000344 - Enforce use of pre-configured or well know redirection URIs	Medium	N/A	N/A	Unclassified	Edit	Delete
C000001 - Verify secure BIOS update non-bypassability	N/A	N/A	N/A	Unclassified	Add New	

Screen also used to create, update, and delete mappings to countermeasures in the catalog

Countermeasure Maintenance Screen (Bottom)

Mapped Threat Vectors:

Threat Vector ID - Name	Prevent	Detect	Respond	Classification		
T000182 - Software defects hidden/obscured by code complexity	N/A	Low	N/A	Unclassified	Edit	Delete
T000189 - Adversary gains unauthorized access by exploiting software vulnerabilities	N/A	Medium	N/A	Unclassified	Edit	Delete
T000312 - Software assurance practices	N/A	N/A	N/A	Unclassified	Edit	Delete
T000269 - Spoofed authenticated router access	Medium	N/A	N/A	Unclassified	Edit	Delete
T000157 - Force Use of Corrupted Files	Medium	N/A	N/A	Unclassified	Edit	Delete
T000290 - Using Leading 'Ghost' Character Sequences to Bypass Input Filters	Low	N/A	N/A	Unclassified	Edit	Delete
T000001 - BIOS replaced with version that allows unsign	N/A	N/A	N/A	Unclassified	Add New	

Screen also used to create, update, and delete mappings to attack vectors in the catalog

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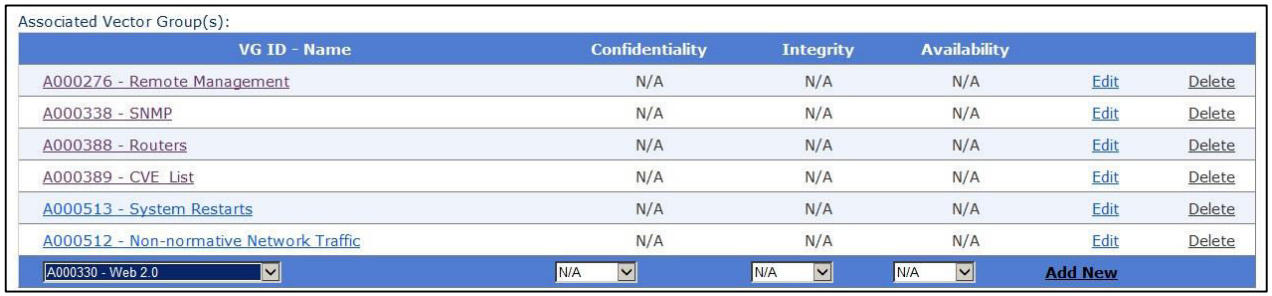
Managing Attack Vectors and Countermeasures (3/3)

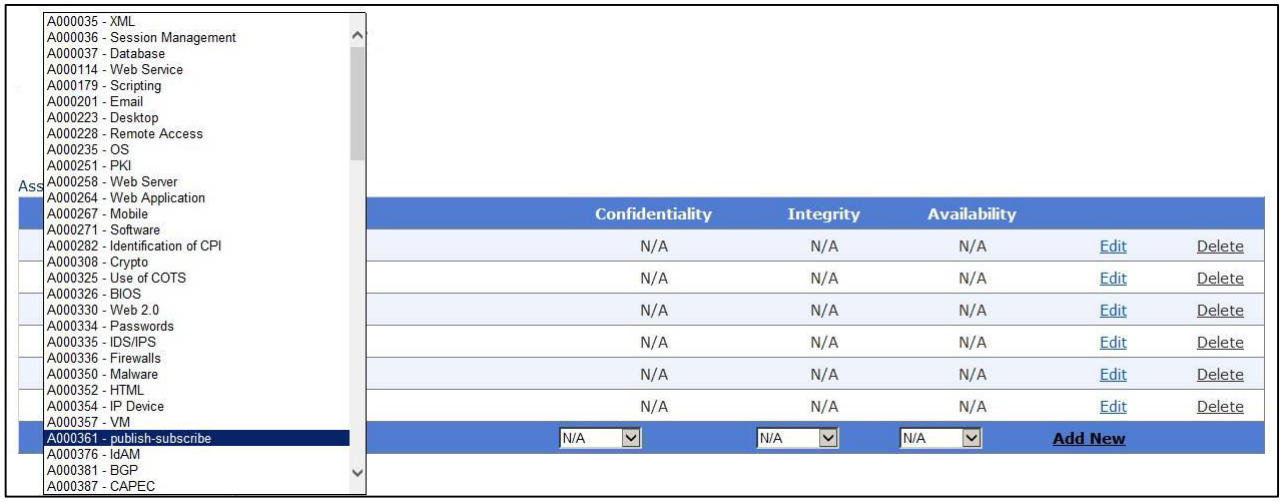

Associated Vector Group(s):

VG ID - Name	Confidentiality	Integrity	Availability		
A000276 - Remote Management	N/A	N/A	N/A	Edit	Delete
A000338 - SNMP	N/A	N/A	N/A	Edit	Delete
A000388 - Routers	N/A	N/A	N/A	Edit	Delete
A000389 - CVE List	N/A	N/A	N/A	Edit	Delete
A000513 - System Restarts	N/A	N/A	N/A	Edit	Delete
A000512 - Non-normative Network Traffic	N/A	N/A	N/A	Edit	Delete
A000330 - Web 2.0	N/A	N/A	N/A	Add New	

Screen used to create, update, and delete mappings of attack vector to vector groups.

Vector groups selected based on attack vector details.

Select all that apply.



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Guidance for Updating the Catalog

- **Use catalog search to verify that an attack vector or countermeasure is not already represented in the catalog**
  - Duplicate entries effect performance and assessment quality
- **Always cite external reference(s)**
  - Allows users to assess the veracity of the data and/or to locate additional details
- **Add new attack vector to all taxonomy groups that apply**
- **An attack vector without a countermeasure is a problem without a solution; a countermeasure without an attack vector is a solution without a problem**
  - Neither provide value in the TARA catalog

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WARNING !

<u>NEVER</u> store classified data in a TARA catalog

Always store classified data on a classified system

TARA data can be exported in a spreadsheet and transferred to the classified system

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Taxonomies

Vector Group – Named collection of attack vectors
Taxonomy – Hierarchically structured collection of vector groups

Taxonomies can be used to organize attack vectors based on technology, system architecture, attack vector properties, etc.

Taxonomies listed on the Top Level Vector Groups page with type “Root”

VG ID	Children	Vector Group	Description	Type
A000422	10	ATT&CK	Adversarial Tactics, Techniques, and Common Knowledge (ATT&CK™) is a framework for describing post-compromise adversary behavior within an enterprise network.	Root
A000387	16	CAPEC	Common Attack Pattern Enumeration and Classification (CAPEC™) provides a publicly available catalog of common attack patterns.	Root
A000384		CM Practices	Groups of Countermeasures (CMs)	Root
A000493	3	ICS/SCADA System	Organizational taxonomy representing ICS/SCADA Systems	Root
A000495	2	Indicators	Organizational taxonomy of Indicators of Compromise (IOCs)	Root
A000471	4	IP System	Organizational taxonomy representing IP-based, distributed systems	Root

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WARNING !

Do NOT use system or program names for vector group names

For DoD systems, that association may be classified

For National Security Systems (NSS), that association will be classified

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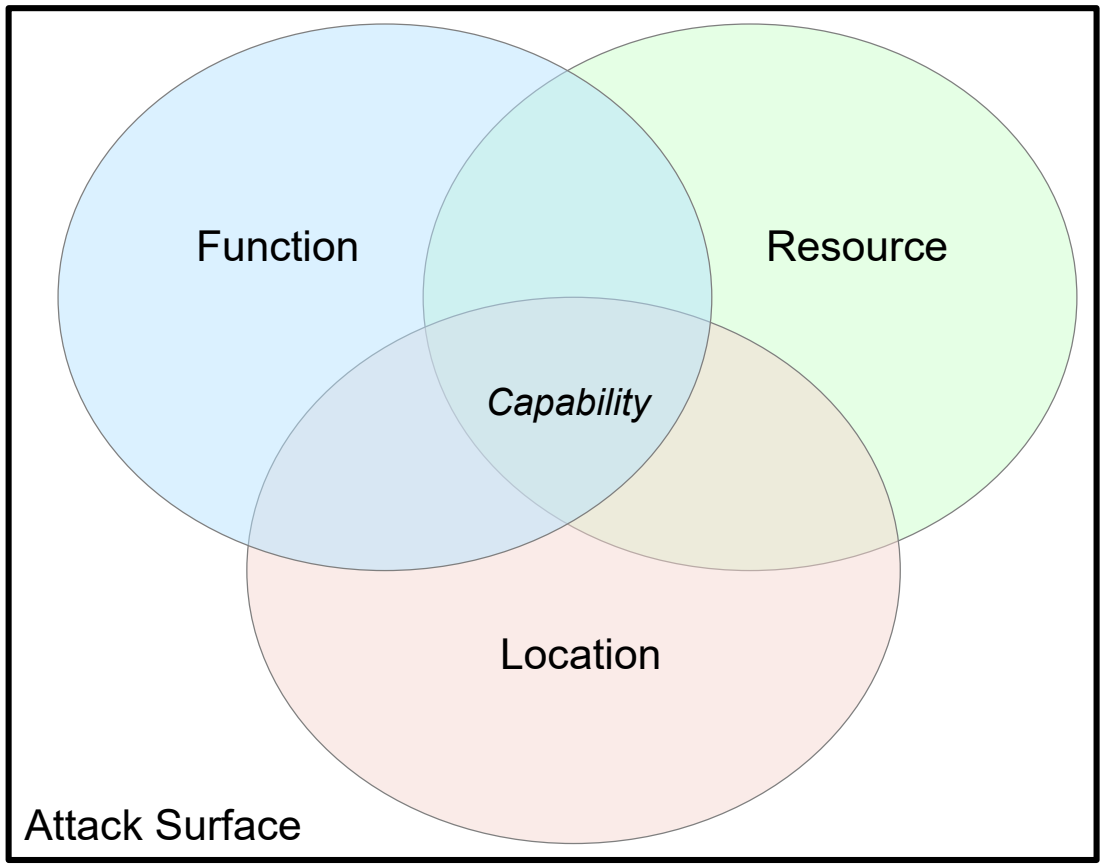
Taxonomy for Representing Attack Surfaces



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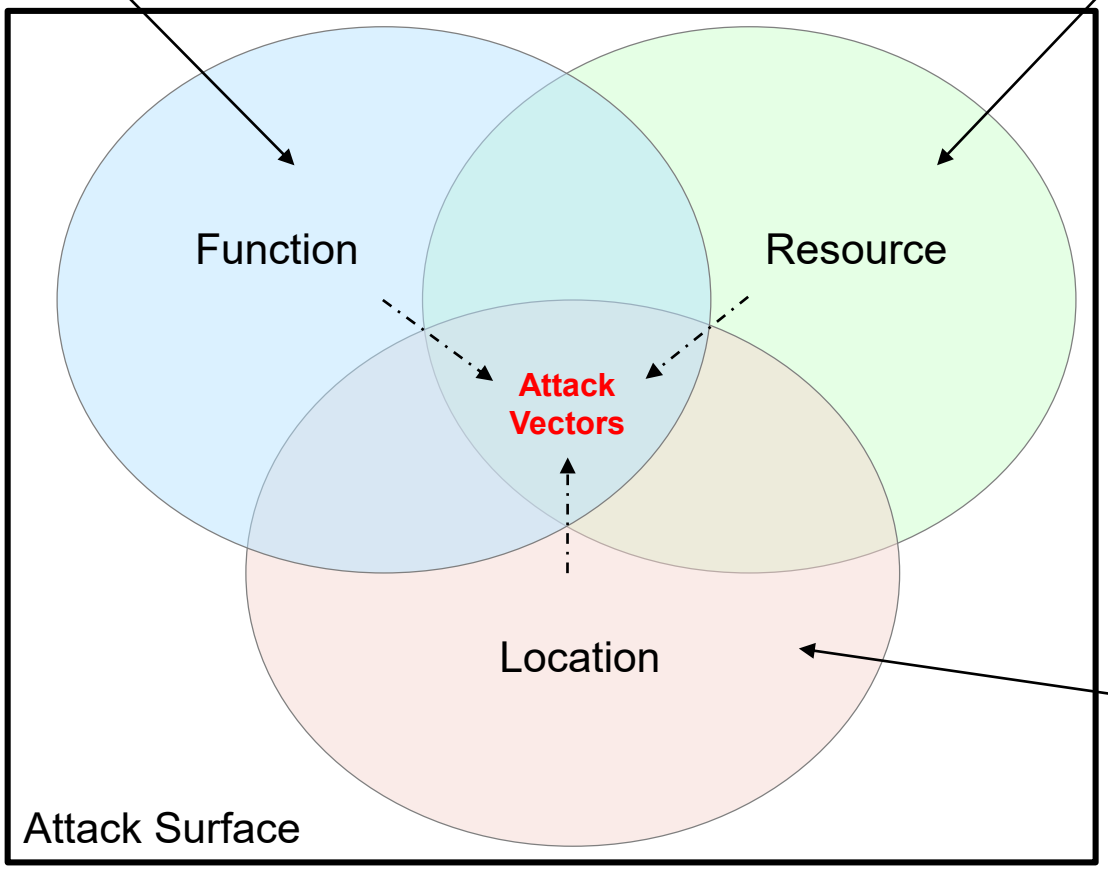
Targeting for Effect

Attack vectors targeting system functions for effect (disrupt, degrade, deceive, ex-filtrate)

Attack vectors targeting system resources for effect (deny, disrupt, degrade, destroy)



Attack vectors targeting system locations for effect (deny, degrade, destroy)

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TARA Catalog as a Virtual Resource

- **The TARA catalog is deployed as a virtualized resource within the MITRE Enterprise**
  - Several instances of the TARA catalog are currently hosted
    - Catalog content tailored to support specific acquisition lifecycle timeframes and/or program or sponsor specific requirements
    - Finesses multi-tenancy issues
- **Catalog import/export can be used to share (exchange) catalog data between virtual catalog instances**
  - Each catalog instance uses the same data representation format and software baseline
  - “Chunks” of the TARA master catalog can be imported into other catalog instances

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Exercise #3: Updating the Catalog

Create a Mapping

1. Open the attack vector (or countermeasure) you wish to create a mapping for
2. Find a countermeasure (or attack vector) you wish to map it to in the appropriate drop-down list
3. Select the mapping type press Add New

Create an Attack Vector

1. Perform a keyword search to verify the attack vector doesn't already exist
2. Under Catalog Maintenance open a new attack vector maintenance page
3. Enter name, description, reference, prerequisite(s)
4. Select category, attack objectives, origin
5. Select Add/Update
6. Create a mapping to at least one countermeasure

Create a Countermeasure

1. Perform keyword search to verify countermeasure doesn't already exist
2. Under Catalog Maintenance open a new countermeasure maintenance page
3. Enter name, description, reference
4. Select maturity, cost, goals, forms
5. Select Add/Update
6. Create a mapping to at least one attack vector

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Your Turn…

- **Create an Attack Vector**
  - Create an attack vector and add it to the shopping cart created in the previous exercise.
- **Create a Mapping**
  - Create a mapping to a countermeasure for the attack vector you created above. Use keyword search to locate a countermeasure to use for the mapping.
- **Create a Countermeasure**
  - Create a new countermeasure and map it to your attack vector.
- **For BONUS Points..**
  - Re-export the spreadsheet to incorporate the updates.

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Summary

- **There are TARA catalogs available on the MII for conducting TARA assessments**
  - Periodically resynchronized with the Catalog master
  - Read only access typically granted
- **A separate catalog instance can be set up to support sponsor or program**
  - For projects that intend to use different catalog data and are willing to take responsibility for managing that data
- **Guidance for adding new attack vectors and countermeasures**
  - No duplicates
  - Cite your sources
  - Don’t forget to add new attack vectors to applicable taxonomy structures
- **The value of TARA catalog data is in the mappings between attack vectors and countermeasures**
  - Without mappings, neither individually provides value

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TARA Risk and Cost Scoring Tools

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Objectives

- **Discuss TARA risk and cost scoring tools**
- **Example #4: Using a risk calculator**

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Risk and Cost Calculators

- **TARA provides spreadsheets for risk and cost scoring**
  - Risk calculators used to score attack vectors
  - LCC calculator used to score countermeasure costs

- **Different risk calculators[1] use different risk factors**
  - Standard risk calculator
    - Risk factors are likelihood and impact, equally weighted
  - CIA risk calculator
    - Impact: loss of confidentiality, integrity, and availability treated as separate factors (possibly different weightings)
  - Mission risk calculator
    - Impact represented as impact to mission and/or mission readiness
  - V x E risk calculator
    - Likelihood factor replaced with vulnerability and exposure
  - Custom risk calculator
    - Supports customizable set of risk factors based on program or sponsor requirements

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Standard Risk Calculator

Factors for assessing Attack Vector Risk (Standard)							T000x	T000x	T000x
Factor Range	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	**Factor Weight**			
Likelihood: What is the likelihood that the attack will be successful?	Very unlikely	Unlikely	Possible	Likely	Very likely	1	1	3	5
Impact: What impact would result if the attack is successful?	Negligible impact	Minimal impact	Moderate impact	Serious impact	Catastrophic impact	1	1	3	5
						Risk Score	1.0	9.0	25.0

Two risk factors: likelihood and impact, equally weighted

Note that the likelihood and impact scales used in the standard risk calculator align with the risk scales used in NIST 800-30

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Confidentiality, Integrity, Availability (CIA) Risk Calculator

Factors for assessing Attack Vector Risk (CIA Impacts)							T000x	T000x	T000x
Factor Range	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	**Factor Weight**			
Likelihood: What is the likelihood that the attack will be successful?	Very unlikely	Unlikely	Possible	Likely	Very likely	1	1	3	5
Impact: What impact to confidentiality would result if the attack is successful?	Negligible impact	Minimal impact	Moderate impact	Serious impact	Catastrophic impact	0.3	1	3	5
Impact: What impact to integrity would result if the attack is successful?	Negligible impact	Minimal impact	Moderate impact	Serious impact	Catastrophic impact	0.3	1	3	5
Impact: What impact to availability would result if the attack is successful?	Negligible impact	Minimal impact	Moderate impact	Serious impact	Catastrophic impact	0.4	1	3	5
						Risk Score	1.0	9.0	25.0

Two risk factors: likelihood and impact, equally weighted.

Note that impact is decomposed into separate factors (loss of confidentiality, integrity, and availability)

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Mission Risk Calculator

Factors for assessing Attack Vector Risk (Mission Impact)							T000x	T000x	T000x
Factor Range	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	**Factor Weight**			
Likelihood: What is the likelihood that the attack will be successful?	Very unlikely	Unlikely	Possible	Likely	Very Likely	1	1	3	5
Mission Impact: What would be the impact to the mission if the attack is successful?	Sporadic loss of mission capability	Intermittent loss of mission capability	Regular loss of mission impact	Extended loss of mission capability	Permanent loss of mission capability	1	1	3	5
						Risk Score	1.0	9.0	25.0

Two risk factors: likelihood and impact, equally weighted.

Note that impact is defined in terms of impact to mission. This could be further decomposed into mission impact(s) for individual mission capabilities, as would be reflected in CJA results

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Vulnerability x Exposure (V x E) Risk Calculator

Factors for assessing Attack Vector Risk (V x E)							T000x	T000x	T000x
Factor Range	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	**Factor Weight**			
Vulnerability: How vulnerable is the system to attack?	Negligible vulnerabilities	Limited vulnerabilities	Moderate vulnerabilities	Serious vulnerabilities	Extremely vulnerable	0.5	1	3	5
Exposure: How accessible is the system to malicious threat actors?	Negligible exposure	Limited exposure	Moderately exposed	Serious exposures	Extremely exposed	0.5	1	3	5
Impact: What impact would result if the attack is successful?	Negligible impact	Minimal impact	Moderate impact	Serious impact	Catastrophic impact	1	1	3	5
						Risk Score	1.0	9.0	25.0

Two risk factors: likelihood and impact, equally weighted.

Note that likelihood is defined in terms of vulnerability and exposure

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Custom Risk Calculator

Factors for assessing Attack Vector Risk					T000x	T000x	T000x
Factor Range	**Low = 1**	**Medium = 2**	**High = 3**	**Factor Weight**			
Locality: How localized are the effects posed by this Attack Vector?	isolated to single unit	external networks potentially impacted	all units globally and associated infrastructure	0.2	1	3	5
Impact: How serious an impact is loss of data confidentiality resulting from successful application of this Attack Vector?	no impact from Attack Vector	limited impact requiring some remediation	COOP remediation activites routinely exercised	0.2	1	3	5
Impact: How serious an impact is loss of system availability resulting from successful application of this Attack Vector?	no impact from Attack Vector	limited impact requiring some remediation	COOP remediation activites routinely exercised	0.2	1	3	5
Likelihood: Has this attack vector been seen before in the wild?	unconfirmed indications	indications Attack Vector attempted previously	widespread use of Attack Vector apparent	0.3	1	3	5
Stealth: How detectable is this Attack Vector when it is applied?	Attack Vector obvious without monitoring	detection possible with specialized monitoring	undetectable	0.1	1	3	5
				Risk Score	1.0	3.0	5.0

Multiple risk factors, individually weighted.

Note that custom risk calculators can be developed using sponsor or program specified risk factors and weightings

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Life Cycle Cost (LCC) Calculator

Factors for assessing Mitigation Life Cycle Cost (LCC)						Factor Weighting	COOx	COOx	COOx
Acquisition cost factors	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	0.4	0.4	1.2	2
Maturity: How technically mature is the mitigation?	Proven technology	New to market product or technology	fielded operational prototype	fielded demonstration prototype	laboratory or research prototype	0.2	1	3	5
Development: Does the mitigation require specialized or hard to find hardware or software capabilities to install or operate?	minimal capabilities required to develop	limited capabilities needed to develop	some specialized capabilities required	wide range of specialized capabilities required	extensive specialized and hard-to-find capabilities required	0.2	1	3	5
Development: Does the mitigation have a limited shelf life, i.e., does its effectivness deminish over time?	90% effective after 10 years	75% effective after 8 years	60% effective after 5 years	40% effective after 1 year	10% effective after 6 months	0.2	1	3	5
Integration: Does the mitigation implement standard interfaces and/or protocols that would facilitate integration with other technologies?	Interoperable through industry standard interfaces	Limited interoperability with other vendor products	Proprietary interfaces and non standard protocols	Undeveloped external interfaces	Mitigation implemented as standalone capability	0.2	1	3	5
Integration: Would system hardware or software baselines require extensive change in order to adopt the mitigation?	Drop-in capability	Minor configuration changes to existing baseline	Major configuration changes to existing baseline	Requires changes to software baseline (recoding)	Requires changes to hardware baseline (retooling)	0.2	1	3	5
Utilization cost factors	**Very Low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very High = 5**	0.6	0.6	1.8	3
Training: Would the mitigation require extensive training in order to operate or apply?	no training required	minimal training require	some training required	regular training required	extensive training required	0.2	1	3	5
Operation: Does the mitigation require significant staff to operate?	no additional staff required	minimal staff required	some staff required	significant staff commitment	labor intensive activity	0.2	1	3	5
Operation: Does the mitigation require specialized or hard to find hardware or software capabilities to install or operate?	no special capabilities required to install or operate	limited capabilities needed to install and operate	some specialized capabilities required	wide range of specialized capabilities required	extensive specialized and hard-to-find capabilities required	0.2	1	3	5
Maintenance: Would the mitigation require periodic hardware or software upgrades in order to remain effective?	infrequent	occasional	regular	frequent	very frequent	0.2	1	3	5
Disposal: Would disposal of the mitigation involve handling of toxic or hazardous substances?	No toxic or hazardous substances involved	Minimal likelihood of contact with harzardous substances	Contact with hazardous substances possible	Contact with hazardous subtances likely	Extensive contact with hazardous substances	0.2	1	3	5
					LCC Score		1	3	5

Same idea as risk calculator but replace risk factors with cost factors

LCC cost is the sum of acquisition costs and utilization costs

Weightings based on applicability of cost to program

LCC cost scores in range [1…5] used in U/C ratio calculation

Custom LCC calculators utilize program or sponsor specified cost factors, scales, weighting schemes, etc.

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Exercise #4: Using a Risk Calculator

- **Using the Risk Calculator**
  - Open the TARA scoring models spreadsheet on the Desktop
  - Go to the CIA Scoring model
  - Select IDs of 3 attack vectors from your shopping cart
  - For each attack vector:
    - Enter the ID into the spreadsheet
    - Find the attack vector description in the catalog (search or from the master list)
    - Follow the reference URL and review info about the vector
    - In the spreadsheet enter likelihood and impact estimates

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Your Turn…

- **Evaluating the risk scoring process and the results..**
  - Does the ranking surprise you?
  - Is the ranking consistent with the level of risk reflected in the reference data?
  - Did all of the risk factors apply equally?
  - What additional risk factors would be relevant?
  - Would more precise qualitative effects make analysis easier?
  - Would adjusting the weightings improve the scores?

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Threat Assessment and Remediation Analysis (TARA)

Recap

MITRE

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Summary of Material Covered

- Provided an overview of the Threat Assessment and Remediation Analysis (TARA) methodology
- Discussed the TARA data model elements: vector groups, taxonomies, attack vectors, countermeasures, mappings
- Discussed application of TARA in Systems Security Engineering (SSE) contexts
- Discussed uses of open source data: CAPEC, ATT&CK, CWE, CVE, etc.
- Provided a TARA catalog demonstration
- Discussed cyber threat actor motive, intentions, capabilities, etc.
- Discussed modeling of attack surfaces
- Discussed cyber threat scenarios
- Discussed phases of a TARA assessment: Scoping, CTSA, CRRA
- Practiced creation of shopping carts
- Provided a worked example of applying countermeasure scoring and selection strategy to develop an optimized solution set
- Practiced exporting catalog data
- Discuss Knowledge Management (KM) activities
- Practiced catalog maintenance activities
- Discussed taxonomies for organizing attack vectors
- Discussed the TARA catalog as a virtual resource
- Discussed TARA risk and cost scoring tools
- Practiced using risk scoring tool

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TARA Acronyms

APT	Advanced Persistent Threat
ATT&CK™	Adversarial Tactics, Techniques, and Common Knowledge
AV	Attack Vector
C2	Command and Control
CAPEC™	Common Attack Pattern Enumeration and Classification
CDC	Cleared Defense Contractor
CDR	Critical Design Review
CJA	Crown Jewels Analysis
CM	Countermeasure
CONOPS	Concept of Operations
COTS	Commercial off-the-shelf
CPI	Critical Program Information
CRRA	Cyber Risk Remedation Analysis
CTSA	Cyber Threat Susceptibility Analysis
CVE™	Common Vulnerability Enumeration
CWE™	Common Weaknesses Enumeration
DHS	Department of Homeland Security
DoD	Department of Defense
KM	Knowledge Management
LCC	Life Cycle Cost
MAUA	Multi-Attribute Utility Analysis
NIST	National Institute of Science and Technology
OSINT	Open Source Intelligence
PDR	Preliminary Design Review
RMF	Risk Management Framework
SCADA	Supervisory Control & Data Acquisition
SCG	Security Classification Guide
SCRM	Supply Chain Risk Management
SSE	Systems Security Engineering
TARA	Threat Assessment and Remediation Analysis
TTP	Tactics, Techniques, and Procedures
U/C ratio	Utility/Cost ratio
VG	Vector Group
XML	eXtensible Markup Language

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For More Information

Public release information and resources

http://www.mitre.org/sites/default/files/publications/pr-2359-threat-assessment-and-remediation-analysis.pdf

http://www.mitre.org/publications/technical-papers/threat-assessment--remediation-analysis-tara/

http://www.mitre.org/publications/systems-engineering-guide/enterprise-engineering/systems-engineering-for-mission-assurance/cyber-threat-susceptibility-assessment

http://www.mitre.org/publications/systems-engineering-guide/enterprise-engineering/systems-engineering-for-mission-assurance/cyber-risk-remediation-analysis

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