Does your DevSecOps Pipeline only Function as Intended?

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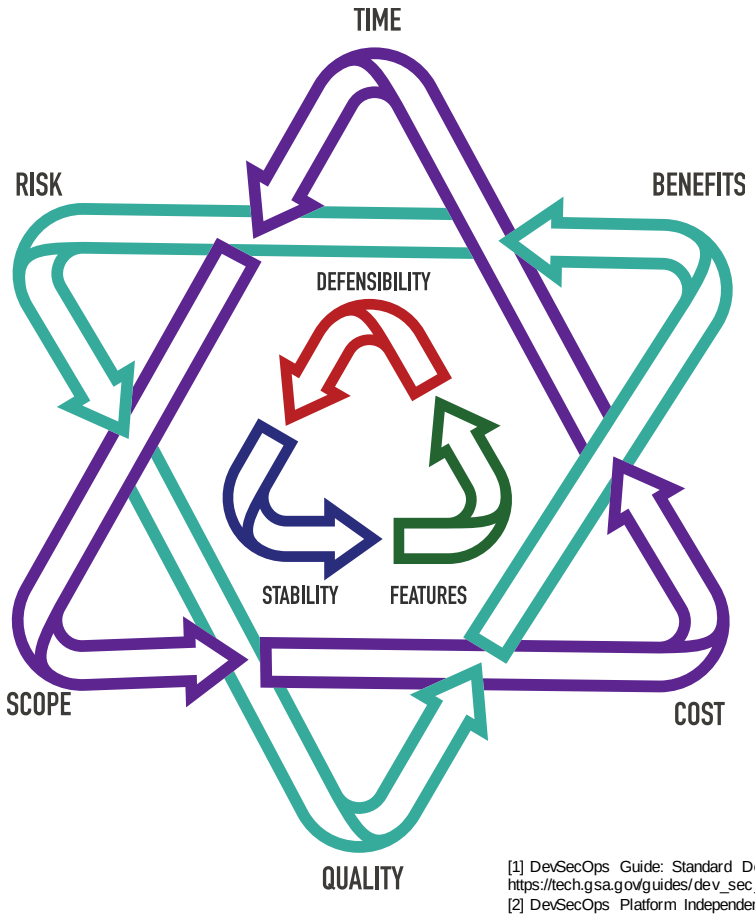
Document Markings

DevSecOps: Modern Software Engineering Practices and Tools that Encompass the Full Software Lifecycle



DevSecOps is a cultural and **engineering practice** that breaks down barriers and opens **collaboration between development, security, and operations** organizations **using automation** to focus on rapid, frequent delivery of secure infrastructure and software to production. It encompasses intake to release of software and manages those flows predictably, transparently, and with minimal human intervention/effort [1].

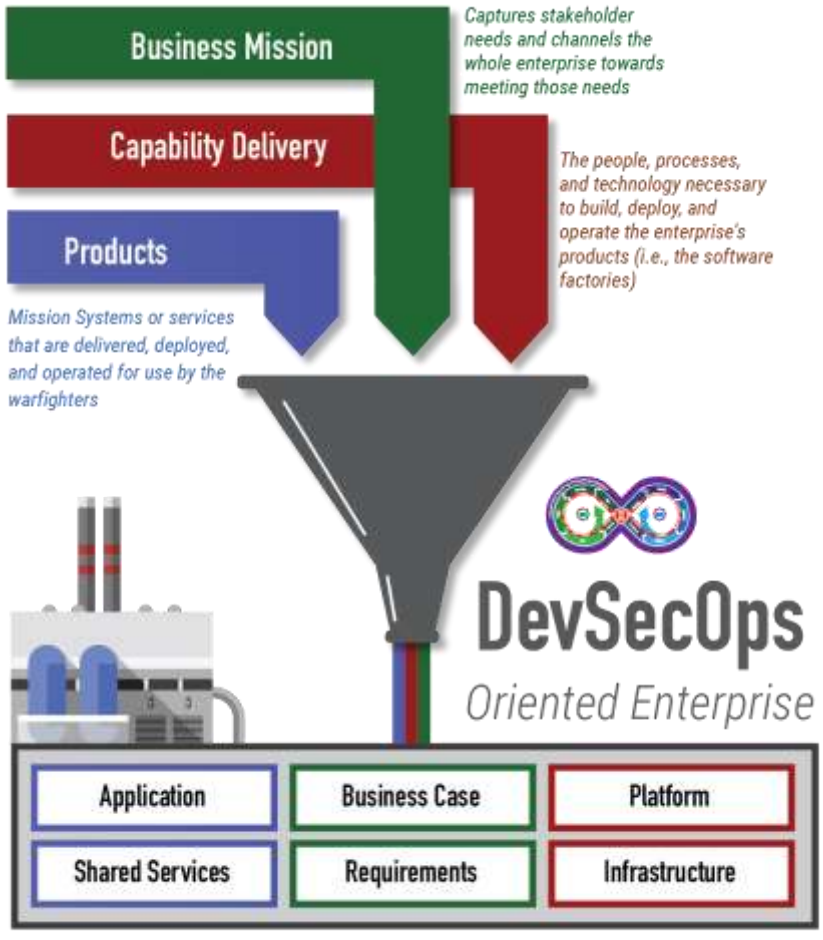
A **DevSecOps Pipeline** attempts to seamlessly integrate "three traditional factions that sometimes have opposing interests:

- **development**; which values features;
- **security**, which values defensibility; and
- **operations**, which values stability [2]."

Not only does one need to balance the factions. They must do so in a way that balances **risk**, **quality** and **benefits** within their **time**, **scope**, and **cost** constraints.

[1] DevSecOps Guide: Standard DevSecOps Platform Framework. U.S. General Services Administration. https://tech.gsa.gov/guides/dev_sec_ops_guide. Accessed 17 May 2021
[2] DevSecOps Platform Independent Model, https://cmu-sei.github.io/DevSecOps-Model/

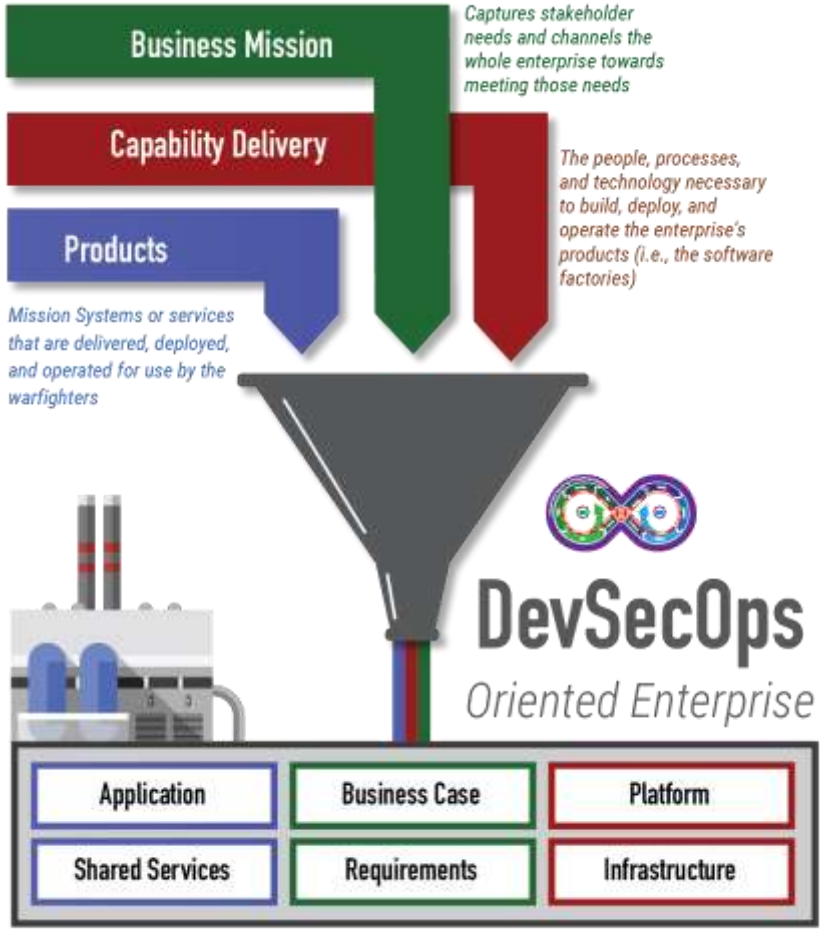
An Enterprise View



All DevSecOps-oriented enterprises are driven by three concerns:

- **Business Mission** – captures stakeholder needs and channels the whole enterprise in meeting those needs. It answer the questions *Why* and *For Whom* the enterprise exists
- **Capability to Deliver Value** – covers the people, processes, and technology necessary to build, deploy, and operate the enterprise's products
- **Products** – the units of value delivered by the organization. Products utilize the capabilities delivered by the software factory and operational environments.

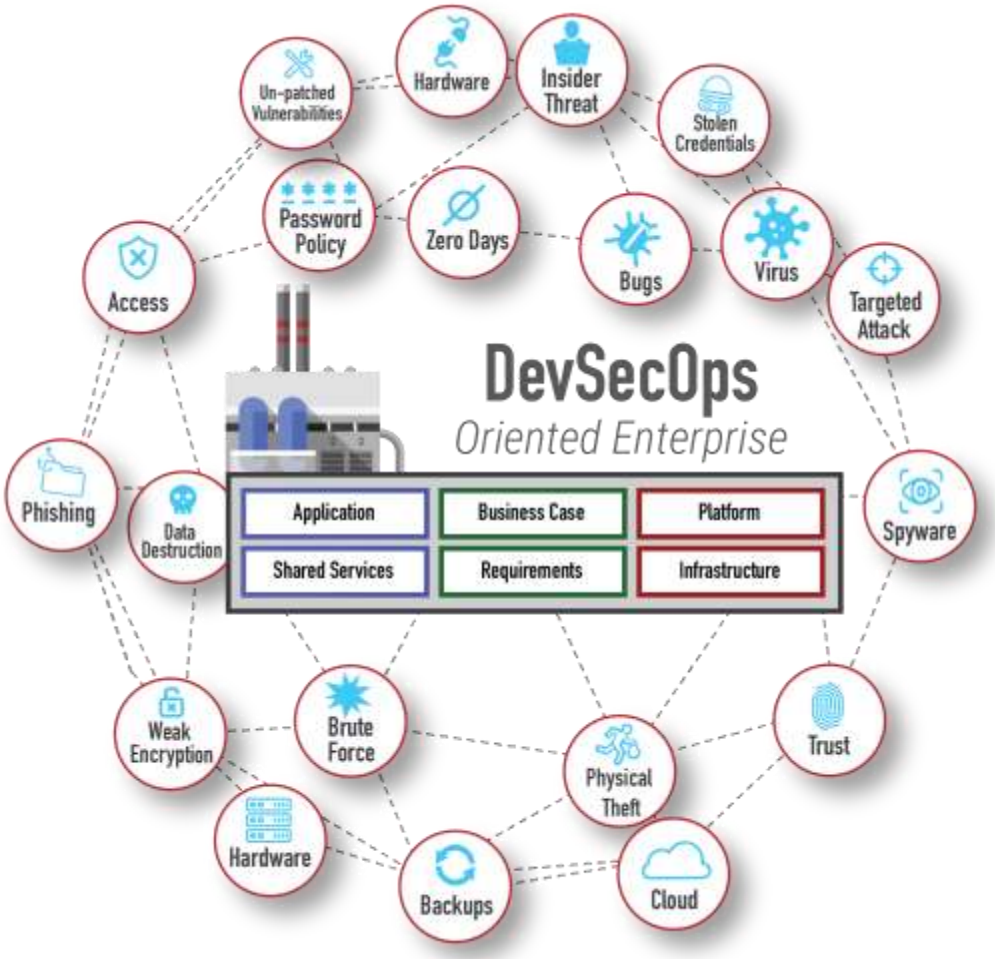
Challenge 1: connecting process, practice, and tools



Creation of the DevSecOps (DSO) pipeline for building the product is not static.

- Tools for process automation must work together and connect to the planned infrastructure
- Infrastructure and shared services are often maintained across multiple organizations (Cloud for infrastructure, third parties for tools and services, etc.)
- Processes, practices, and tools must evolve to meet the needs of the products being built and operated

Challenge 2: Cybersecurity of Pipeline and Product



The tight integration of Business Mission, Capability Delivery, and Products, using integrated processes, tools, and people, increases the attack surface of the product under development.

Managing and monitoring all the various parts to ensure the product is built with sufficient cybersecurity and the pipeline is maintained to operate with sufficient cybersecurity is complex.

How do you focus attention to areas of greatest concern for security risks and identify the attack opportunities that could require additional mitigations?

Software Assurance (SwA)

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DoD definition:

"the level of confidence that software is free from vulnerabilities, either intentionally designed into the software or accidentally inserted at anytime during its lifecycle, and that the **software functions in the intended manner**."

[CNSS Instruction No. 4009; DoDi 5200.44 p.12]

SwA Curriculum Model definition:

Application of technologies and processes to achieve a required level of confidence that **software systems and services function in the intended manner**, are free from accidental or intentional vulnerabilities, provide security capabilities appropriate to the threat environment, and recover from intrusions and failures.

[Mead, Nancy; Allen, Julia; Ardis, Mark; Hilburn, Thomas; Kornecki, Andrew; Linger, Richard; & McDonald, James. *Software Assurance Curriculum Project Volume I: Master of Software Assurance Reference Curriculum.* CMU/SEI-2010-TR-005. Software Engineering Institute, Carnegie Mellon University. 2010. http://resources.sei.cmu.edu/library/asset-view.cfm?AssetID=9415]

Risk

The perception of risk drives assurance decisions

- Assurance implementation choices (policies, practices, tools, restrictions) are based on the perception of threat and the expected impact should that threat be realized
- Perceptions are primarily based on knowledge about successful attacks
  - the current state of assurance is largely reactive
  - successful organizations learn from attacks and figure out how to react and recover faster and be vigilant in anticipating and detecting attacks
- Misperceptions are failures to recognize threats and impacts – “how could it happen to us?” or “it could not happen here!”

Mitigating Risk with Assurance Cases

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Understanding risk is hard!

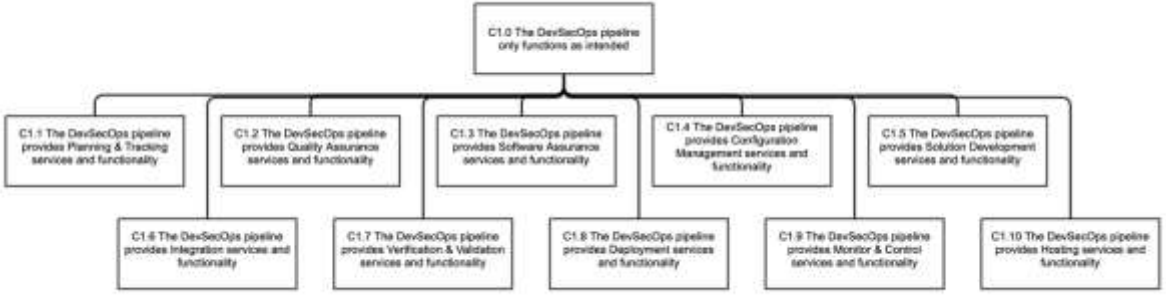
Without being able to quantify, or reason around, the cybersecurity risks associated with your product and DevSecOps pipeline, you will not be able to:

- properly balance between features, defensibility, and stability
- make necessary trade-off choices to achieve your organization's mission and vision in a cost-effective way

An assurance case can be used to reason about the adequacy for both the pipeline and the product.

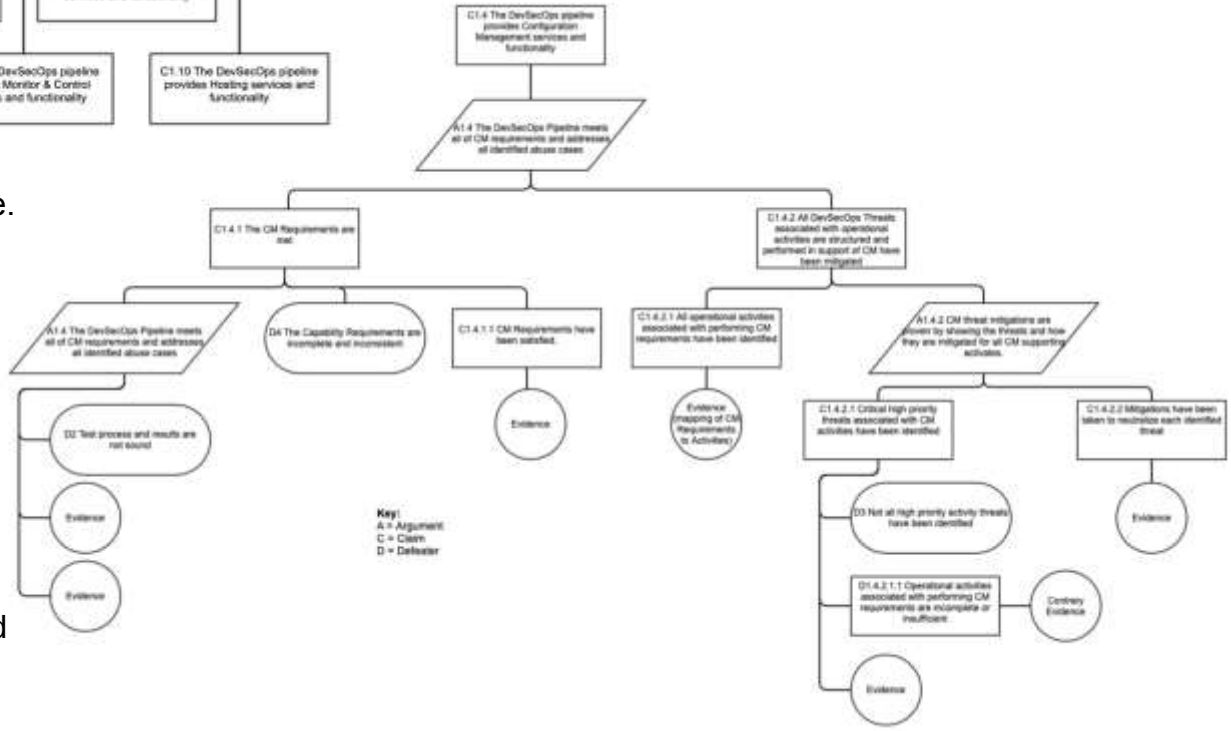
- It is a structured approach used to argue that available evidence supports a given claim
- It provides the organization with the basis for making risk-based choices tied to assuring that the pipeline only functions as intended.
- It provides requirements for automated systems testing, or other evidence collection techniques.
- Actual test results provide the evidence needed to support the assurance claims.

Structuring a DevSecOps Assurance Case



Assurance cases are composed of the following elements:

- Claims– "assertions put forward for general acceptance. They are typically statements about a property of the system or some subsystem. Claims that are asserted as true without justification become assumptions and claims supporting an argument are called subclaims [1]."
- Arguments – "link the evidence to the claim [1]" by stating the assumption(s) on which the claim and the evidence are built upon.
- Evidence – "Evidence that is used as the basis of the justification of the claim. Sources of evidence may include the design, the development process, prior field experience, testing, source code analysis or formal analysis [1]."
- Defeaters – "possible reasons for doubting the truth of a claim [2]."



[1] Bloomfield, R. E. and Netkachova, K. Building Blocks for Assurance Cases. Paper presented at the International Symposium on Software Reliability Engineering (ISSRE), 03-11-2014 - 06-11-2014, Naples, Italy.
[2] Goodenough, John B., Charles B. Weinstock, Ari Z. Klein. Toward a Theory of Assurance Case Confidence, CMU/SEI-2012-TR-002 September 2012.

Addressing the Cybersecurity Challenge with MBSE

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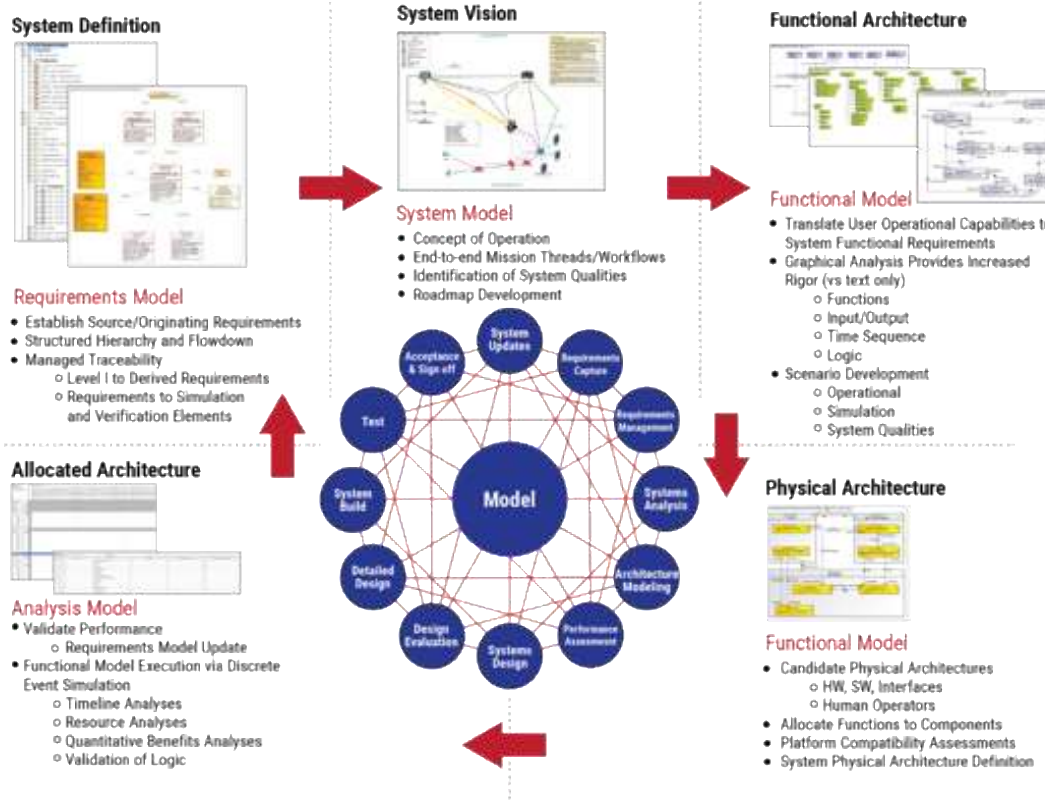
Model Based Systems Engineering

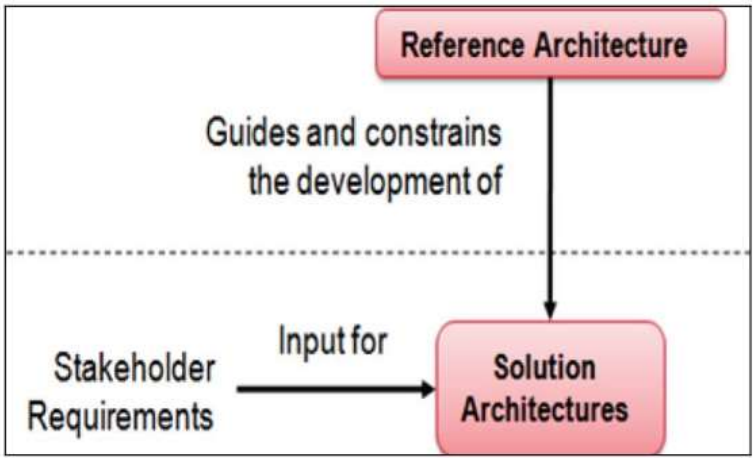


*The Digital System Model contains the most current requirements, key mission/business operations, architecture, design details, implementation details, test and evaluation details, and supporting documentation.

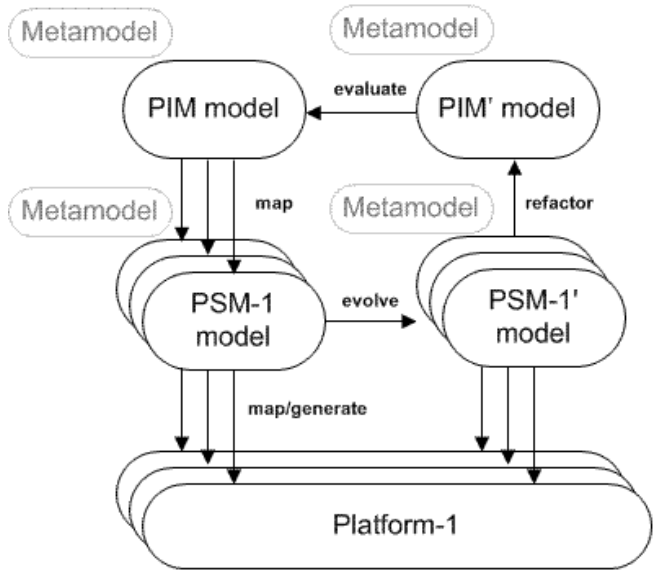
- ***Not* yesterday's Document-Centric Systems Engineering!**
- MBSE uses a Digital System Model* to facilitate common system understanding and decision-making.
- The Digital System Model* is the single authoritative source of truth
- System and Components can be integrated at various levels of abstraction and fidelity
- Model Views are chosen to best communicate information to a variety of stakeholders via the dynamic creation of multiple, consistent, accurate views
- Impacts of changes are more easily analyzed and evaluated

Reference Architecture/Platform Independent Model (PIM)

A **Reference Architecture** is an authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions [1].



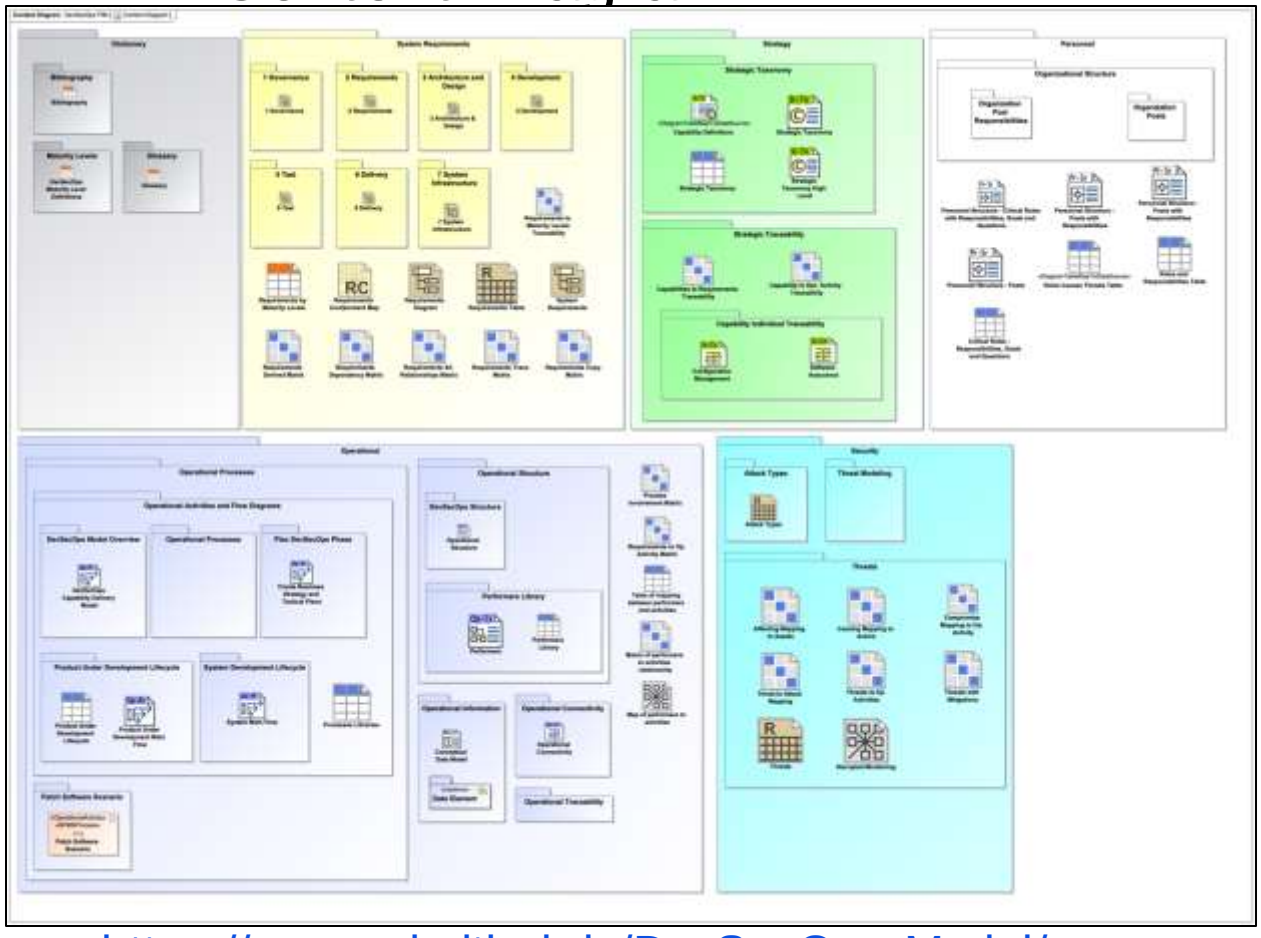
A PIM is a general and reusable model of a solution to a commonly occurring problem in software engineering within a given context and is independent of the specific technological platform used to implement it.



NOTE: PSM = Platform Specific Model

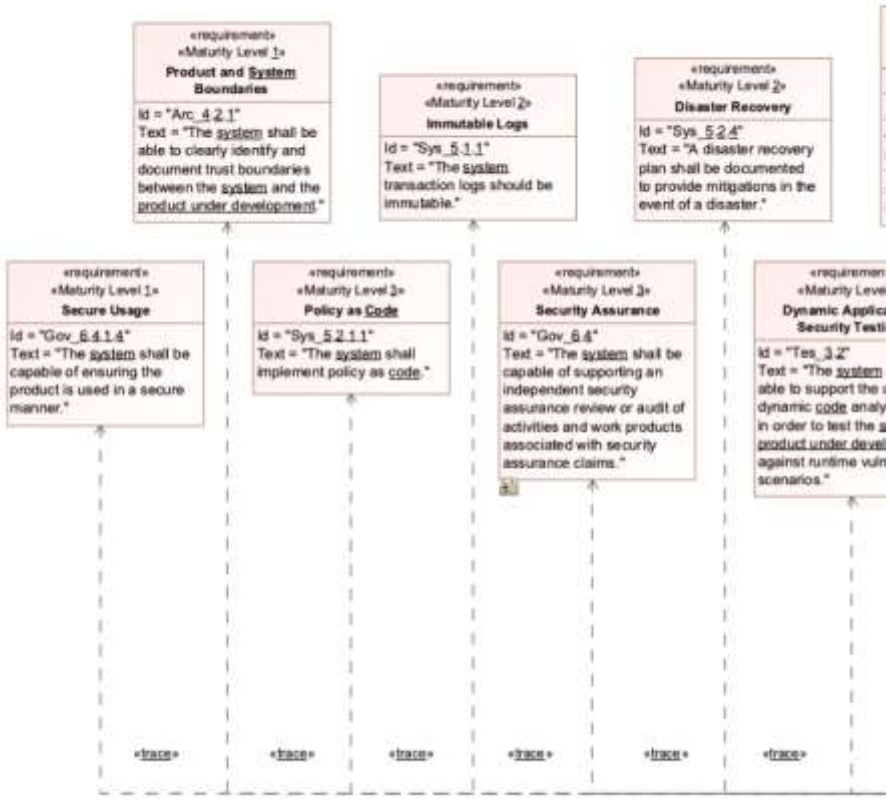
[1] DoD Reference Architecture Description, https://dodcio.defense.gov/Portals/0/Documents/DIEA/Ref_Archi_Description_Final_v1_18Jun10.pdf

DevSecOps PIM - Content Diagram



https://cmu-sei.github.io/DevSecOps-Model/

DevSecOps Requirements



Example of Requirements Representation in Diagrams from PIM

All requirements are organized into categories based on logical and functional groupings:

- Governance
- Requirements
- Architecture and Design
- Development
- Test
- Delivery
- System Infrastructure

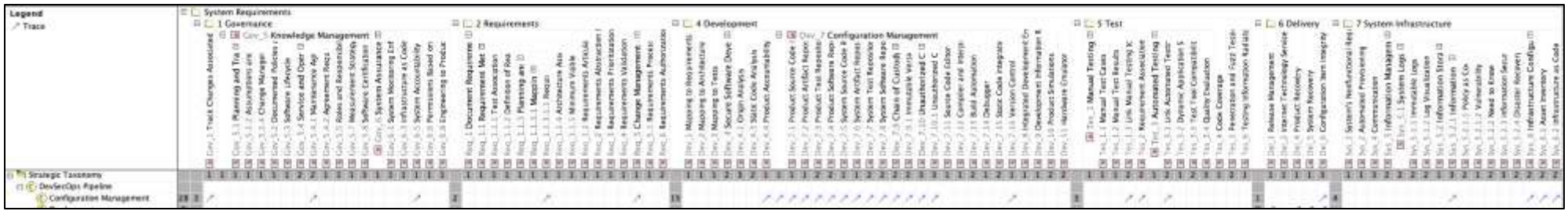
Requirements Table Link

DevSecOps Capability/Strategic Viewpoint

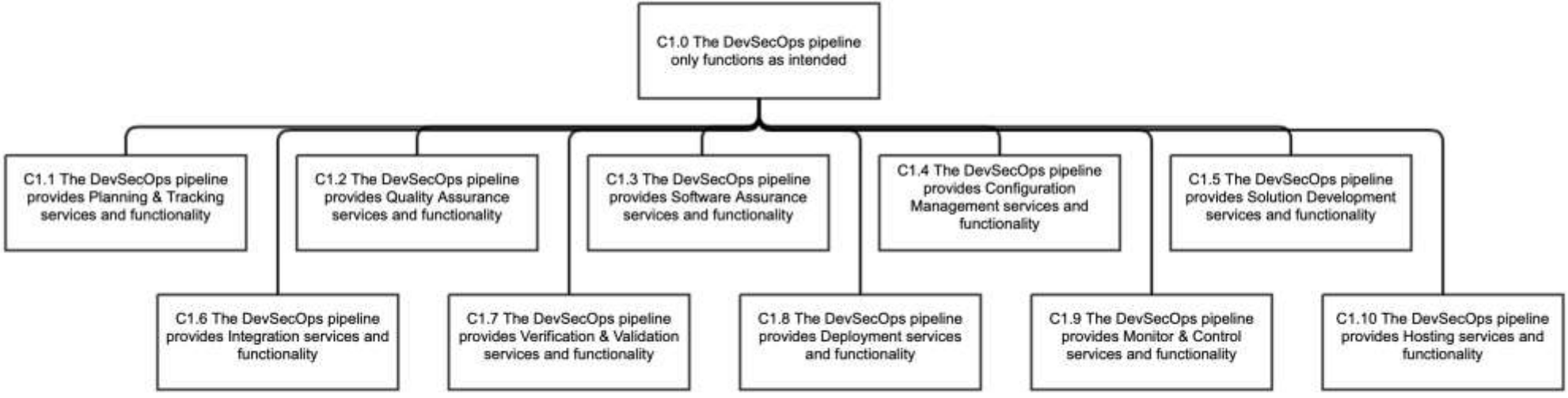
A capability is a high-level concept that describes the ability of a system to achieve or perform a task or a mission.

All requirements in the DevSecOps PIM were allocated to corresponding capabilities.

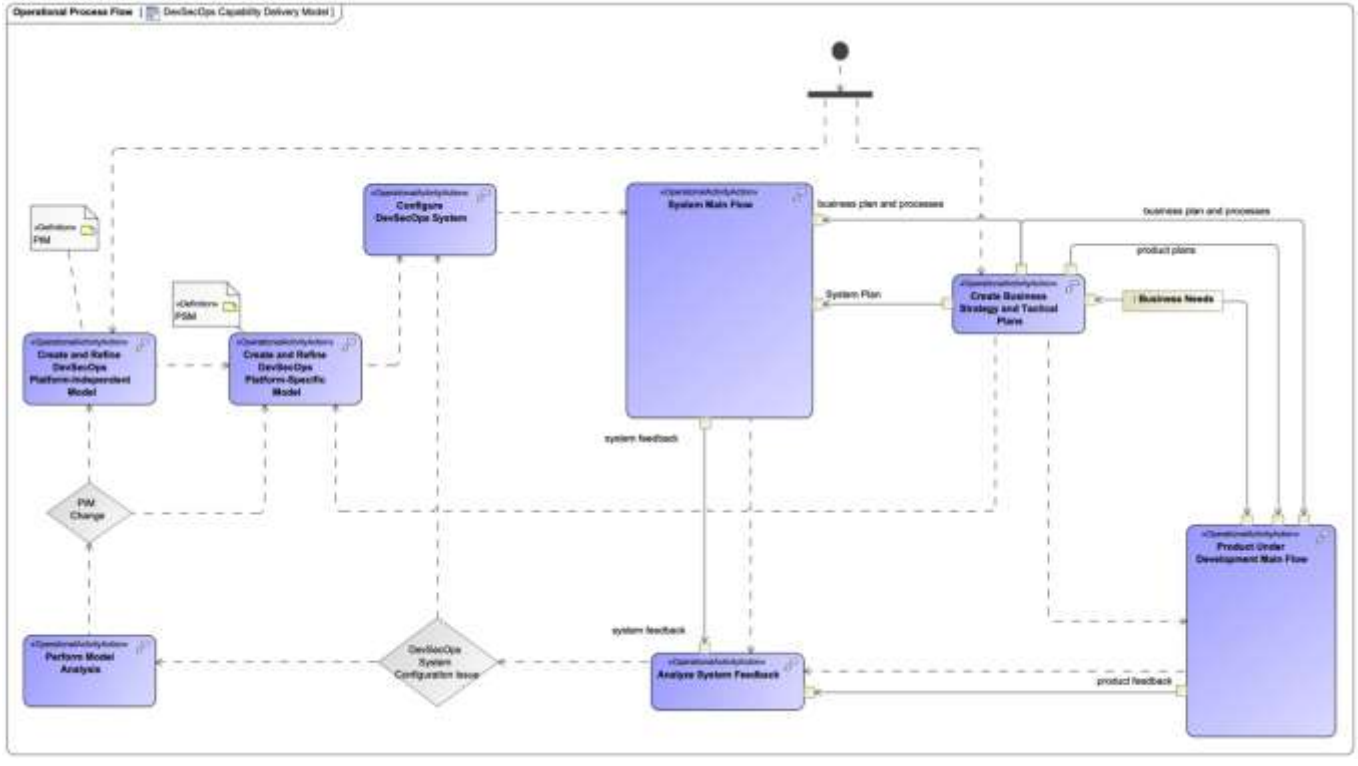
- Capability to Requirements Traceability Link
- Capability to Operational Activity Traceability Link
- Capability Definitions Link
- Strategic Taxonomy High Level



Structuring a DevSecOps Assurance Case Around Capability



DevSecOps Operational Viewpoints



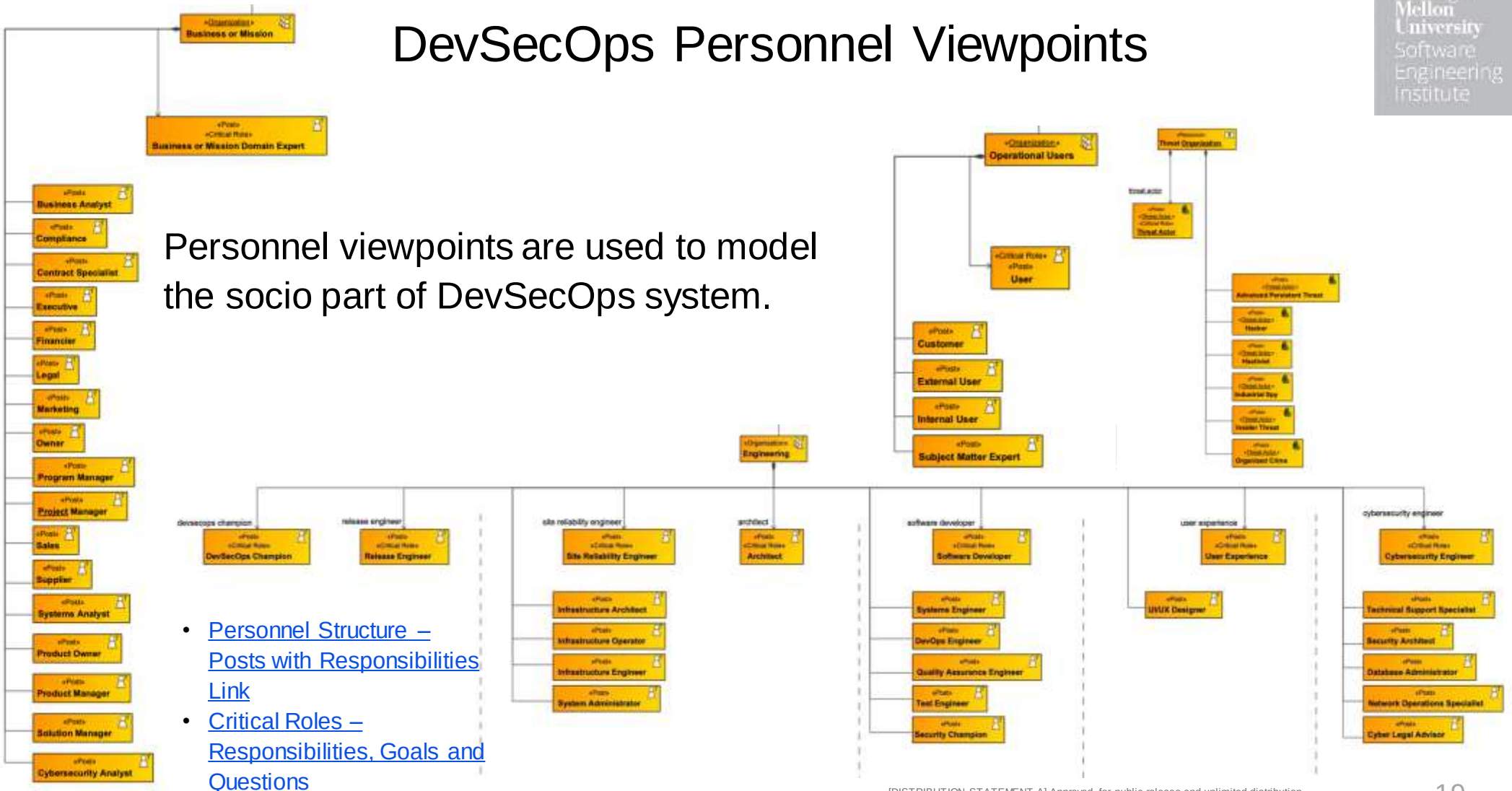
- DevSecOps Capability Delivery Model Link

An operational model for a system describes behavior of the system to conduct enterprise operations.

The main operational processes for DevSecOps includes development process for the product, as well as the DevSecOps process itself.

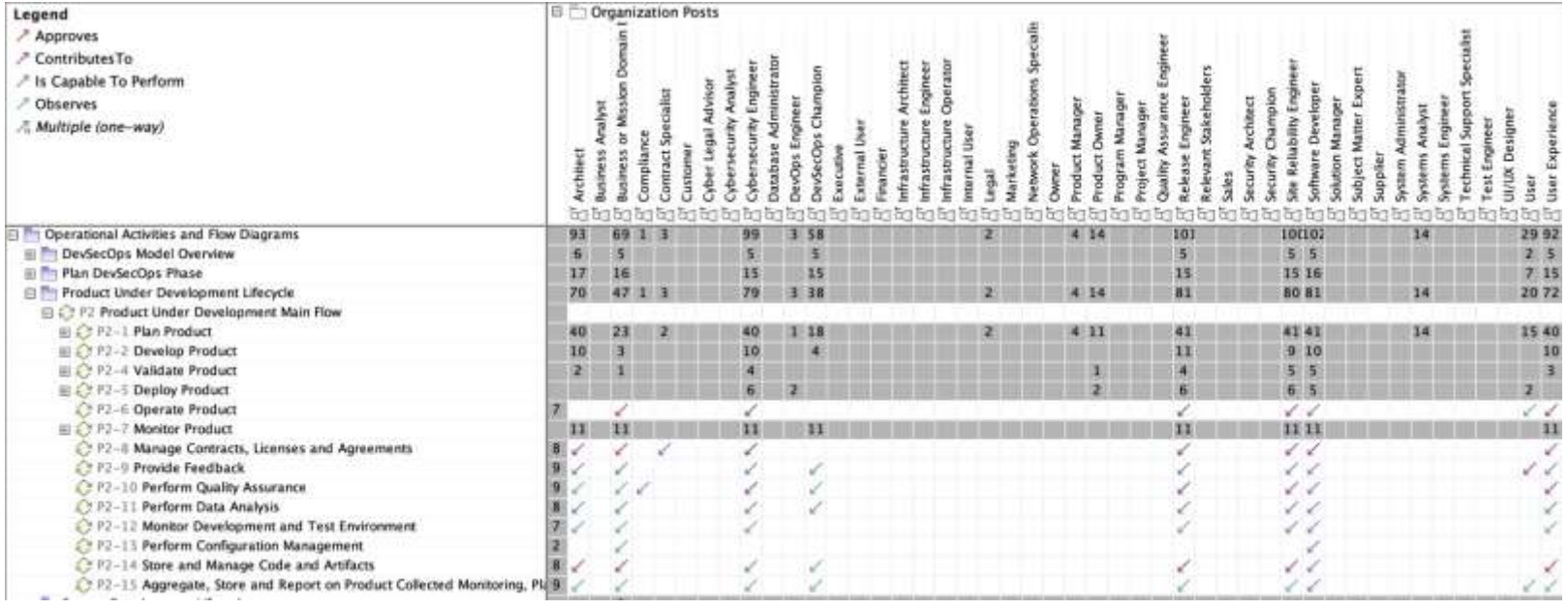
DevSecOps Personnel Viewpoints

Personnel viewpoints are used to model the socio part of DevSecOps system.



- Personnel Structure – Posts with Responsibilities Link
- Critical Roles – Responsibilities, Goals and Questions

Everyone Plays a Role in DevSecOps



Legend Approves ContributesTo Is Capable To Perform Observes *Multiple (one-way)*	Architect	Business Analyst	Business or Mission Domain	Compliance	Contract Specialist	Customer	Cyber Legal Advisor	Cybersecurity Analyst	Cybersecurity Engineer	Database Administrator	DevOps Engineer	DevSecOps Champion	Executive	External User	Financier	Infrastructure Architect	Infrastructure Engineer	Infrastructure Operator	Internal User	Legal	Marketing	Network Operations Specialis	Owner	Product Manager	Product Owner	Program Manager	Project Manager	Quality Assurance Engineer	Release Engineer	Relevant Stakeholders	Sales	Security Architect	Security Champion	Site Reliability Engineer	Software Developer	Solution Manager	Subject Matter Expert	Supplier	System Administrator	Systems Analyst	Systems Engineer	Technical Support Specialist	Test Engineer	UI/UX Designer	User	User Experience
Operational Activities and Flow Diagrams	93	69	1	3				99		3	58								2				4	14				101					101	0					14				29	92
DevSecOps Model Overview	5	5						5			5																	5					5	5									2	5
Plan DevSecOps Phase	17	16						15			15																	15					15	16									7	15
Product Under Development Lifecycle	70	47	1	3				79		3	38								2				4	14				81					80	81					14				20	72
P2 Product Under Development Main Flow																																												
P2-1 Plan Product	40	23		2				40		1	18								2				4	11				41					41	41					14				15	40
P2-2 Develop Product	10	3						10			4																	11					9	10										10
P2-4 Validate Product	2	1						4																1				4					5	5										3
P2-5 Deploy Product								6		2														2				6					6	5									2	
P2-6 Operate Product	7	✓						✓																				✓					✓	✓									✓	✓
P2-7 Monitor Product	11	11						11			11																	11					11	11										11
P2-8 Manage Contracts, Licenses and Agreements	8	✓	✓		✓			✓																				✓					✓	✓										✓
P2-9 Provide Feedback	9	✓	✓					✓			✓																	✓					✓	✓									✓	✓
P2-10 Perform Quality Assurance	9	✓	✓	✓				✓			✓																	✓					✓	✓										✓
P2-11 Perform Data Analysis	8	✓	✓					✓			✓																	✓					✓	✓										✓
P2-12 Monitor Development and Test Environment	7	✓	✓					✓																				✓					✓	✓										✓
P2-13 Perform Configuration Management	2		✓																														✓											
P2-14 Store and Manage Code and Artifacts	8	✓	✓					✓			✓																	✓					✓	✓										✓
P2-15 Aggregate, Store and Report on Product Collected Monitoring, Pl	9	✓	✓					✓			✓																	✓					✓	✓									✓	✓

- Process Involvement Matrix Link

Critical Roles are mapped to Operational Activities.

Threat Scenarios

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Template:

Part	Description
Activity	The activity diagrammed in the PIM or PSM. There can be more than one activity applied to the Threat Scenario.
Actor	The person, or group, that is behind the threat scenario. Threat actors can be malicious or unintentional. Developing a standard set of actors is beneficial for this step. Persona non grata could be useful in determining malicious actors. Threat actor may be a person, or group, internal to an organization structure.
Action	A potential occurrence of an event that might damage an asset, a mission, or goal of a strategic vision.
Attack	An action taken that utilizes one of more vulnerabilities to realize a threat to compromise or damage an asset, a mission, or goal of a strategic vision.
Asset	A resource, person, or process that has value.
Effect	The desired or undesired consequence resulting from the attack.
Objective	The threat actor's motivation or objective for conducting the attack
Statement	Structured prose summarizing the 6-part security scenario

Example:

Part	Description
Activity	Develop Product, Static and Dynamic Analysis
Actor	Insider Threat
Action	Results from analysis are disclosed for effect
Attack	Information Disclosure
Asset	Analysis Results
Effect	Damage organization, vulnerabilities are publicly enumerated for a product under development
Objective	Develop a targeted exploit for the product under development, financial attack
Statement	An insider threat publicly releases the results of static and dynamic analysis to the public to damage the organization's reputation.

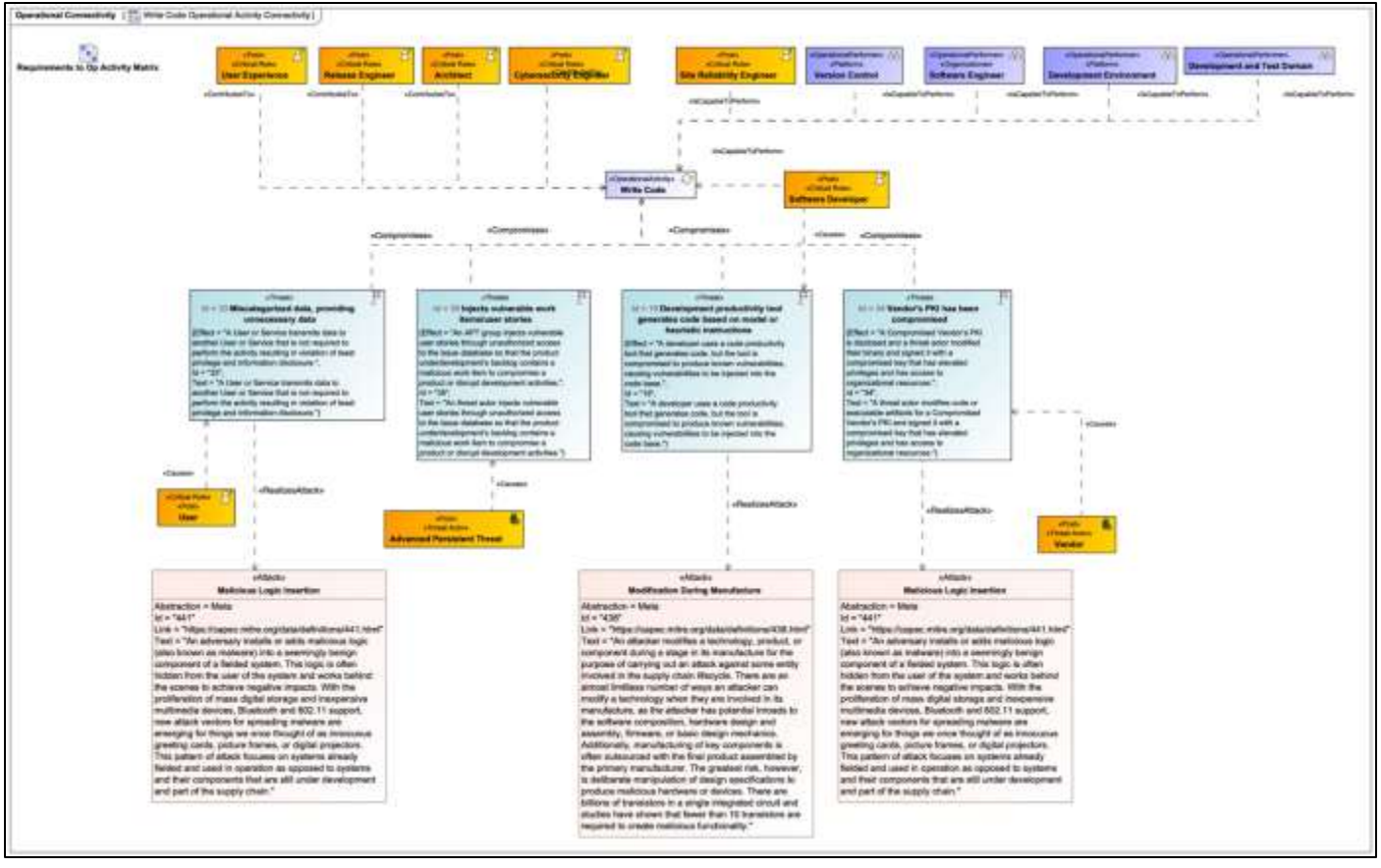
Threat Scenario Generation Workshop

Purpose	Identify threat scenarios for a given system	
Entry Criteria:	The following Unified Architecture Framework (UAF) defined views have been created for the system under evaluation: • Requirements Diagrams • Operational Process Flows • Relationships between Operational Activities and System Requirements • Operational resource structure, Posts (i.e. roles) and corresponding responsibilities including the Involvement relationships.	
General	• As the system architecture and associated system instantiation evolves, so will the threats and corresponding mitigations. While this process defines an approach to systematically define applicable threat scenarios for the given system, threats should be identified, evaluated, and captured continuously outside this process. • During the structured and unstructured brainstorming activities, there are no right or wrong ideas. The goal is to identify any reasonable action that can be taken to exploit the various activities within the system to ultimately impact the final product. The ideas will be evaluated later in the process.	
Step	**Activities**	**Description**
1	Planning	• Identify relevant stakeholders. Participants must contain a mix of engineering, operational, user, business, and cyber security experience. • Schedule a date and time, or series of events, in which all relevant stakeholders can actively participate.
2	Kick-off Event	• Review the workshop process and introduce participants • Discuss the goals and objectives of the workshop • Introduce participants to the concept of system threats and review a few example threat scenarios that follow the format of the Threat Scenario Template.

3	System and Architectural Overview	• Outline system purpose and constraints
		• Review system's architectural views and relationships
		  ○ Requirements
		  ○ Strategy
		  ○ Personnel
		  ○ Operational

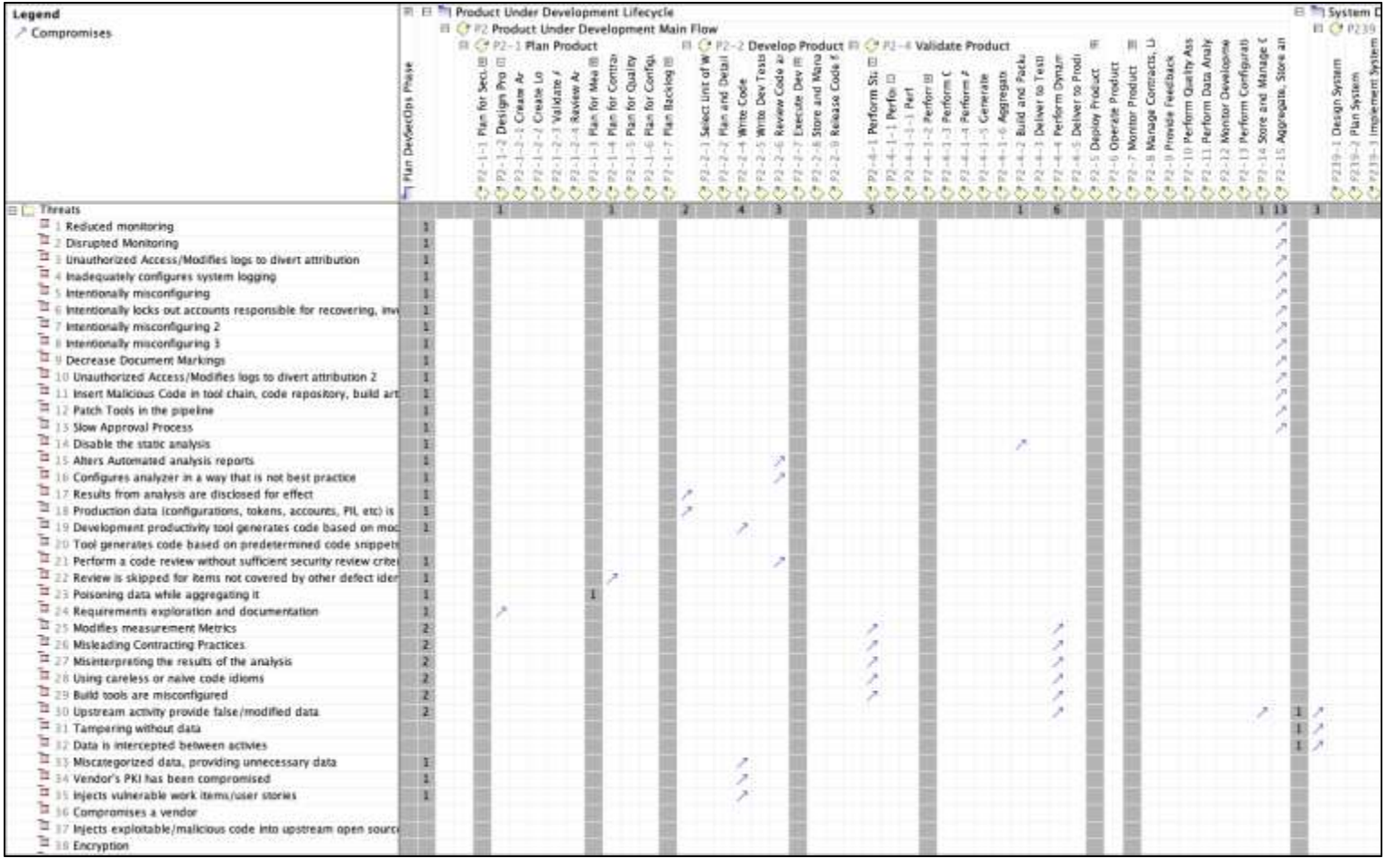
4	Operational Process Flow Focus Area	• Select an operational process flow to focus the threat scenario generation • Review the selected operational process flow to gain understanding of the process, data flow between operational activities, and performers involved. This may include reviewing associated requirements to understand the scope and context of the various operational activities.
5	Unstructured Brainstorming	• Select an operational activity within the operational process flow • Either working individually or in pairs, brainstorm threats for the selected operational activity and write them down. Threats can bridge multiple operational activities. The brainstormed ideas should be captured in the individual's natural language. • Using an affinity diagram, organize the threats identified by the whole group and remove duplicates. • Create a list of potential threats to the system.
6	Structured Brainstorming	• Use the same operational activity as in step 5. • Break into groups of 2-3 people. • In small groups, identify ways that the operational activity may be exploited to interrupt the confidentiality, integrity, and/or availability of the system. Utilize the Process Specific STRIDES Threat Modeling Taxonomy to reduce individual bias and to holistically identify threats to the given activity. • Using an affinity diagram, organize the threats identified by the whole group and remove duplicates. • Add new threats to the list of potential threats to the system created in step 5.
7	Define Threat Scenarios	• If this is the first time any of the participates have written threat scenarios, select a threat from the list and complete the Threat Scenario Template as a group. Repeat until everyone understands how to complete the Threat Scenario Template. • Break into small groups of 3-4 people. • Divide the list of potential threats to the system between the small groups. Alternatively, create a pull system in which the small groups claim a potential threat from a centralized list as needed. • In small groups, complete the Threat Scenario Template for each assigned, or pulled, potential threat. • Review and update all completed threat scenarios as a whole group, removing or consolidating duplicates.
8	Operational Activity Threat Identification	• Select next operational activity within the selected operational process flow. • Repeat steps 5-7. • Repeat step 8 until threats have been identified for all operational activates within the selected operational process flow.
9	Identify Operational Process Flow Threats	• Repeat steps 4-8 until threats have been identified for all operational process flows for the given system.
10	Consolidate and Review	• Consolidate all threat scenarios into a central list. • Review and accept the threat scenarios
Exit Criteria		A list of structured threat scenarios that cover the operational activities in the given system.

Example Threat Modeling Diagram for Write Code Operational Activity



[Write Code Operational Activity Connectivity Link]

DevSecOps Threat to Operational Activity Matrix



[Threats to Operational Activities Link]

DevSecOps Threats with Attributes

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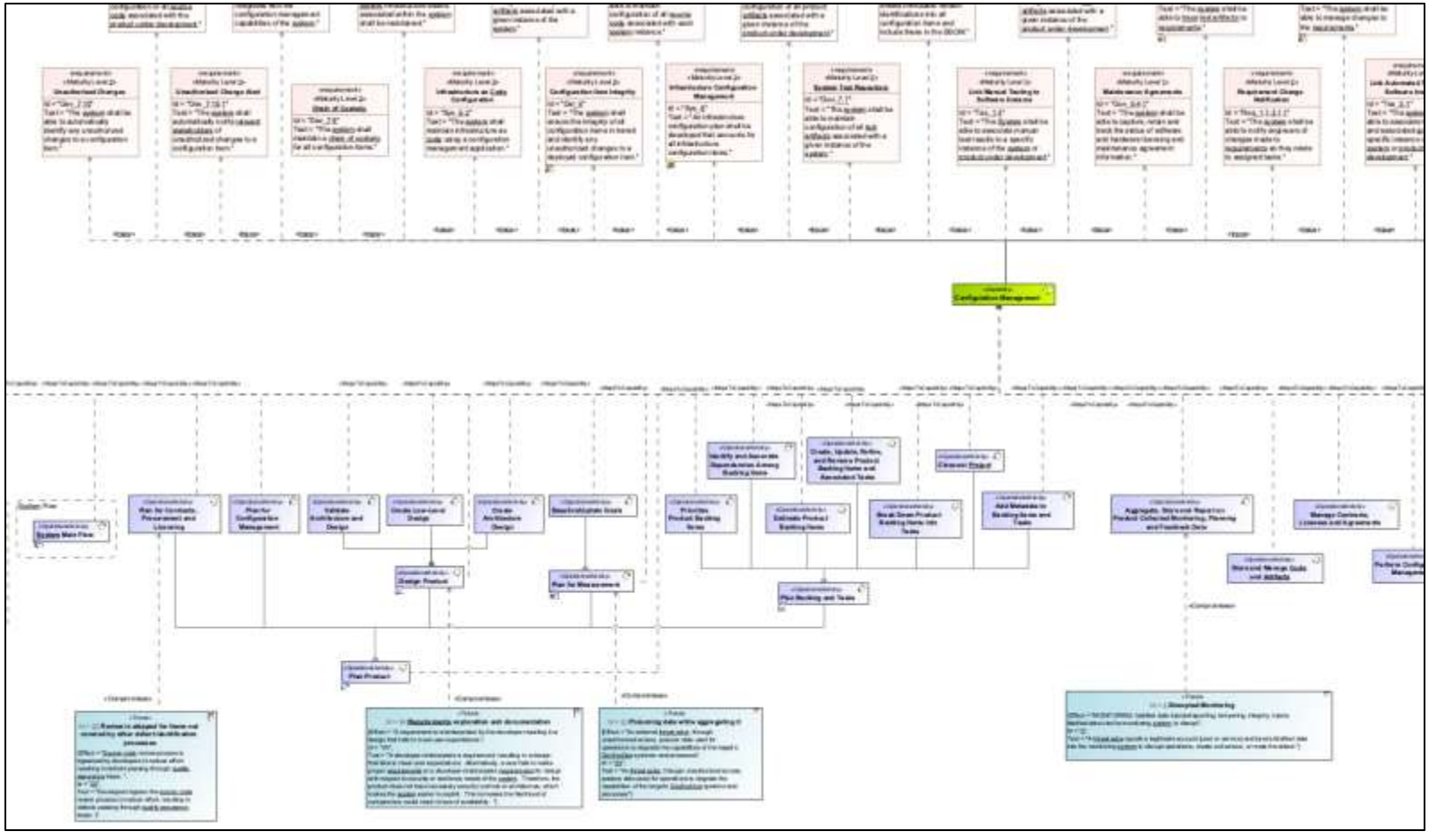
Id	Name	Text	Effect	Compromises	Realized By Attack	Caused By	Mitigated By	Document
1	Reduced monitoring	A threat actor is made aware of a monitoring system's reduced capacity resulting in regular service outages leaving an open window of opportunity for an unobservable attack.	Reduced or misconfigured monitoring allows for nefarious activity to occur	P2-15 Aggregate, Store and Report on Product Collected Monitoring, Planning and Feedback Data	607 Obstruction	Insider Threat		Much of this was pulled from CAPEC info https://capec.mitre.org/data/definitions/1000.html
2	Disrupted Monitoring	A threat actor spoofs a legitimate account (user or service) and injects falsified data into the monitoring system to disrupt operations, create a diversion, or mask the attack.	MONITORING: falsified data injected/spoofing, tampering, integrity, injects falsified data into the monitoring system to disrupt	P2-15 Aggregate, Store and Report on Product Collected Monitoring, Planning and Feedback Data	161 Infrastructure Manipulation	Advanced Persistent Threat Insider Threat Architect Cybersecurity Engineer	SC1 Mitigation Strategy 1	Keep at the Meta Level and better explained in the "star
3	Unauthorized Access/Modifies logs to divert attribution	A threat actor gains unauthorized access to logging data, alters system logs to conceal illicit activity from forensic audits, automated responses and alerts, or to divert attribution.	Logs: insider threat modifies the logs to conceal activity	P2-15 Aggregate, Store and Report on Product Collected Monitoring, Planning and Feedback Data	161 Infrastructure Manipulation	Insider Threat Site Reliability Engineer Cybersecurity Engineer		
4	Inadequately configures system logging	A threat actor has configured the collection of system logs in a way that limits the effectiveness of forensic audit activities.	Accidentally misconfiguring Logging - can't perform forensics work against what is captured	P2-15 Aggregate, Store and Report on Product Collected Monitoring, Planning and Feedback Data	176 Configuration/Environment Manipulation	Software Developer		Could be 1617 Most significa improper configuration
5	Intentionally misconfiguring	A threat actor has configured the collection of system logs in a way that limits the effectiveness of forensic audit activities in order to conceal subsequent activities.	Intentionally misconfiguring the system	P2-15 Aggregate, Store and Report on Product Collected Monitoring, Planning and Feedback Data	176 Configuration/Environment Manipulation	Insider Threat		
6	Intentionally locks out accounts responsible for recovering, investigating, or repairing the system	A threat actor spoofs an individual's account in order to create user action logs with the objective of making a targeted user in violation of security policy and reducing the targeted individual's organizational effectiveness.	Targeting individual with the intent that their login is denied, locking out individuals who should have access	P2-15 Aggregate, Store and Report on Product Collected Monitoring, Planning and Feedback Data	212 Functionality Misuse	Insider Threat		Could be a CAPEC - 184 So Attack
		Unit testing is insufficient to cover the requirements and abuse cases. A software or site reliability engineer doesn't		P2-15 Aggregate, Store and Report on Product Collected	176 Configuration/Environment	Software Developer		

[Threats Link]

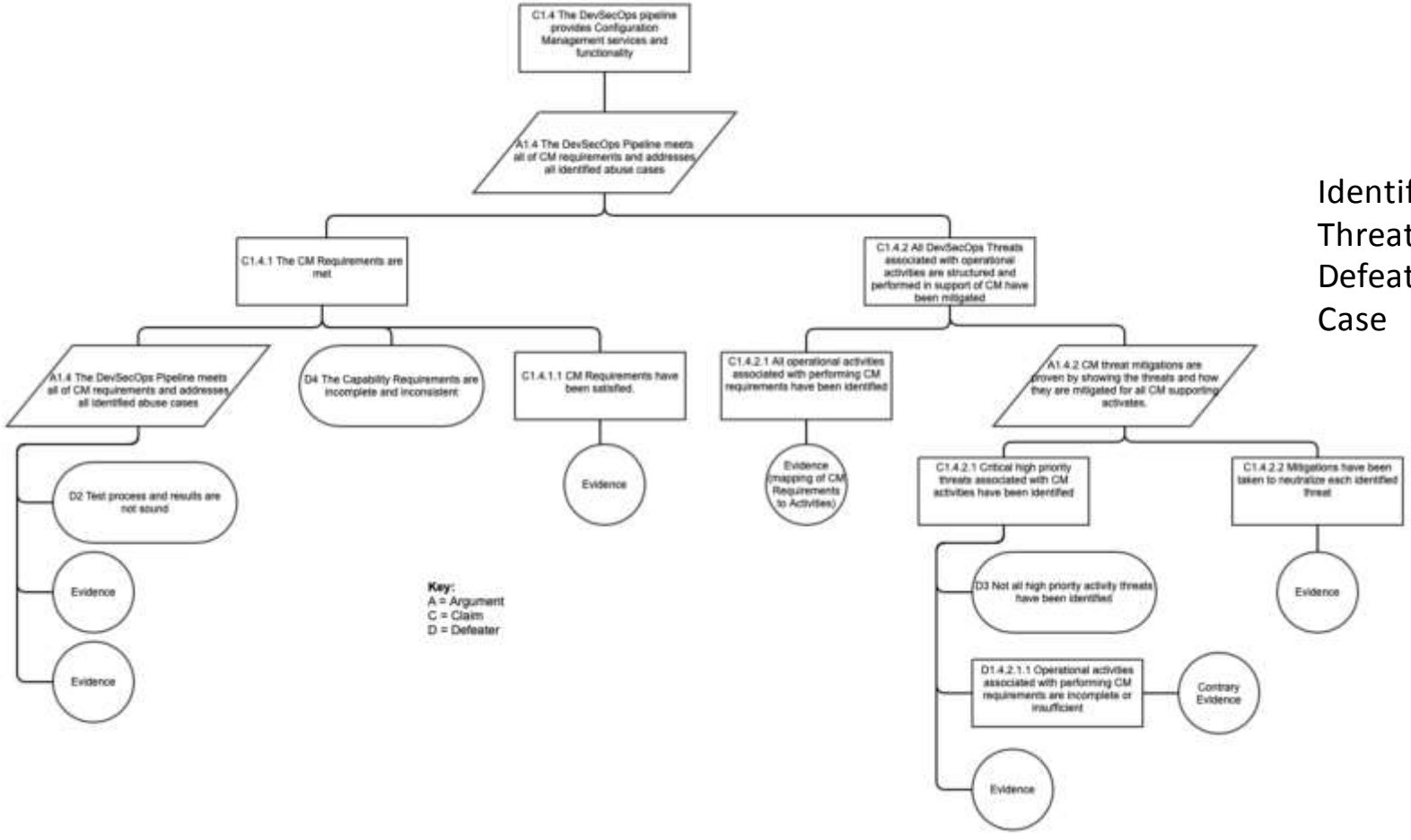
Capturing the Complexity of the DevSecOps System



Example of Threats Traced to Capabilities via Operational Activities

[Configuration Management Complexity Link]

Addressing Assurance Case Defeaters



Identifying and Mitigating Threats helps to address Defeaters in your Assurance Case

Summary

The use of model based systems engineering in the design, implementation, and sustainment of your DevSecOps socio-technical system will assist you in building a system that is:

- Trustworthy – No exploitable vulnerabilities exist, either maliciously or unintentionally inserted.
- Predictable – When executed, software functions as intended and only as intended.
- Timely – Features are delivered as the speed of relevance.

Contact Information

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