Implementing a Configuration Management (CM) Plan for Model/Tool Artifacts within a Digital Engineering (DE) Environment

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Agenda

- Introduction
- Key Tenets of a Configuration Management Plan for a DE Environment
- Workflows/Processes for Reuse
- Recommendations and Conclusions

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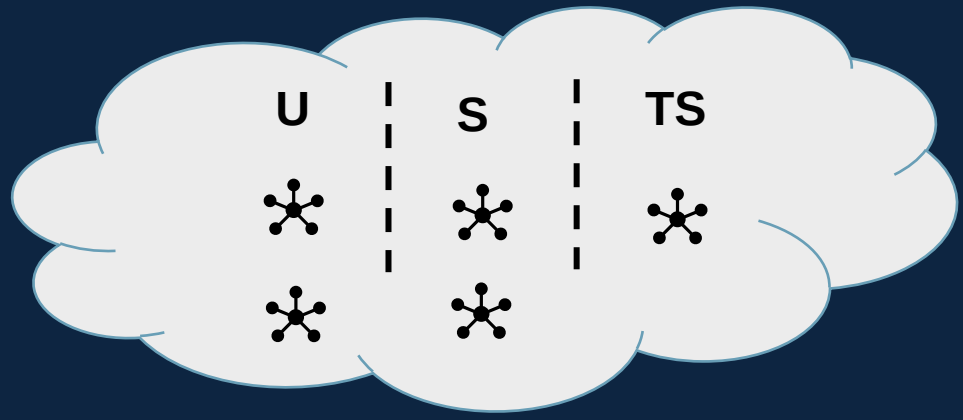
Introduction

Problem Statement

4 Cameo models and 2 Python-based tools, at different classification levels

Cameo Model #1	Cameo Model #2
Cameo Model #3	Cameo Model #4
Python-based Tool #1	Python-based Tool #2

DE Environment at 3 different classification levels with at least one infrastructure system available at each level



Large, geographically dispersed team of at least 20 people

How will you handle the management, maintenance, and tracking of these artifacts over time? Everything can scale quickly, and CM becomes a challenge in these situations.
This is where established CM processes come into play.

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Technical Approach

- A project should define a **"Configuration Management Plan"** that provides a comprehensive summary of implementable CM processes and procedures for the artifacts within its DE Environment

- **For whom:** All developers/users of a project's DE Environment artifacts

- **How to implement:** Demonstrated in this presentation, using a notional *"Project P"* consisting of notional artifacts (*Models A-D* and *Tools E-F*) that need to be configuration managed

Term	Definition
Configuration Management	Standard: "A management process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design and operational information throughout its life." (EIA 649) [11] In this context: The process of managing, maintaining, and tracking different versions of artifacts, and their linkages with other artifacts, for a project's DE Environment.
Digital Engineering Environment	A collection of infrastructure systems and tools that allow a project's DE goals to be achieved. Considered the Authoritative Source of Truth (ASoT) for the project data. May consist of several infrastructure systems at different security classification levels.
Artifacts (Models and Tools)	The term that encompasses both models (e.g., using Cameo) and tools (e.g., using Python) within a project's DE Environment.

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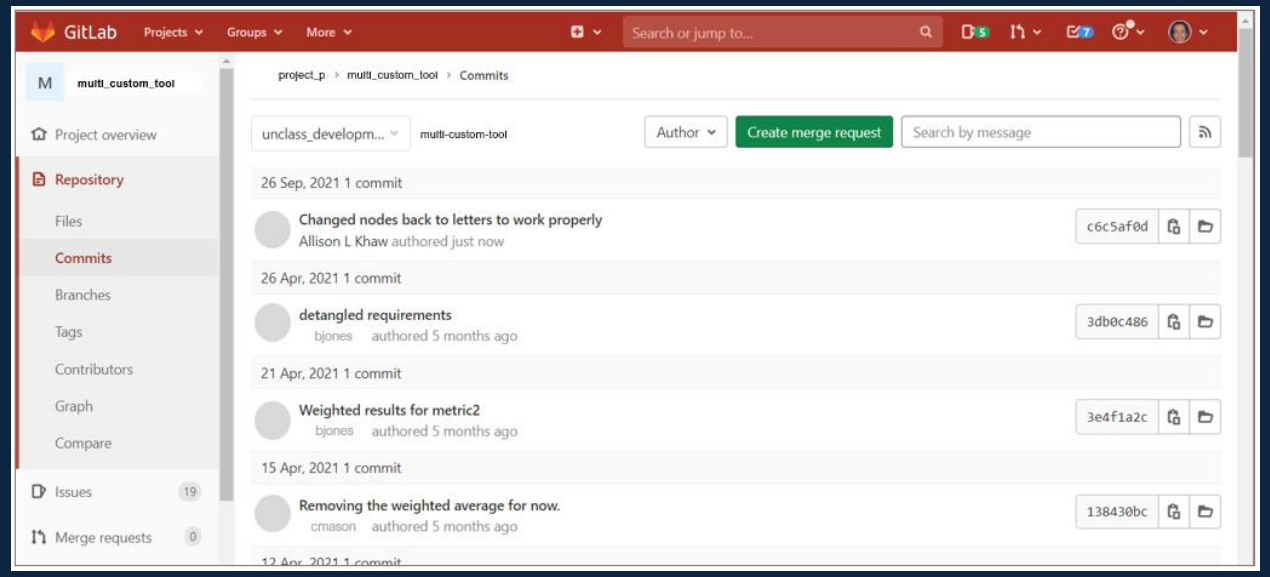
Key Tenets of a Configuration Management Plan for a DE Environment

CM Tools

Term	Definition
CM Tool	A tool that enables version control management, collaborative modeling/development, and role and permissions tracking.

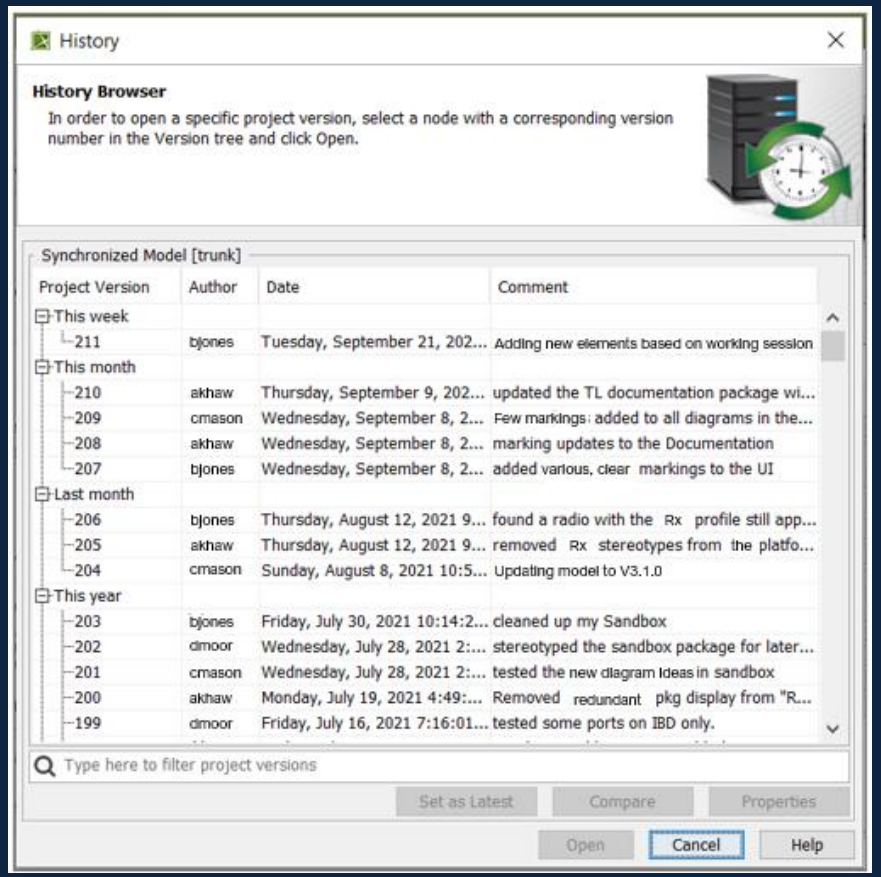
- For Models: Cameo Teamwork Cloud (or Magic Collaboration Studio), others
- For Tools: GitLab, others

GitLab Repository Commits Example



Source: Notional MITRE Tool Commits Shown in GitLab

Cameo TWC Model "Project History" Example



Source: Notional MITRE Model History Shown in Cameo TWC

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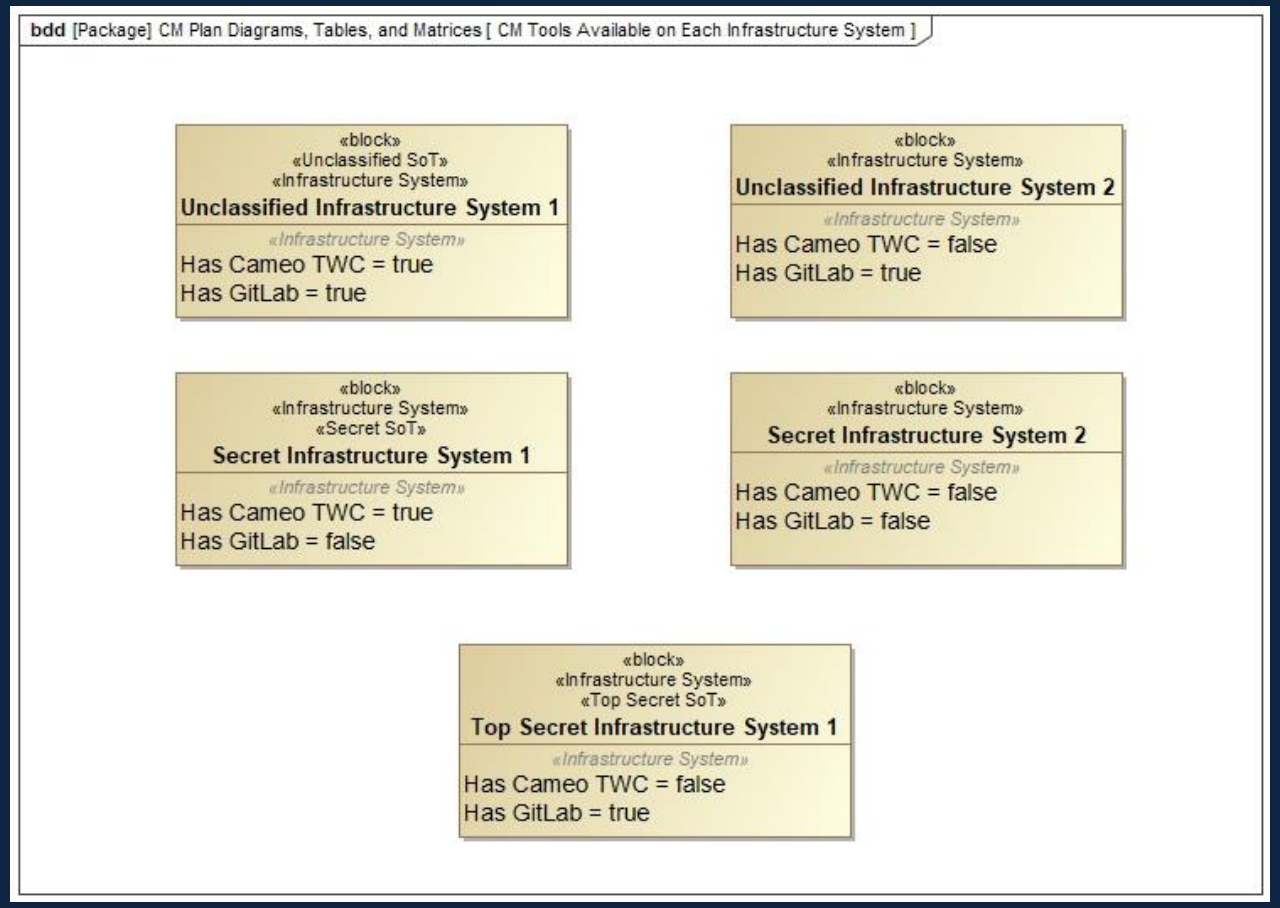
CM Infrastructure

Term	Definition
Infrastructure System	The infrastructure or network that houses the tools and enables collaborative work. There can only be one infrastructure system considered an ASoT at each security classification level.

- Artifacts within the “Project P” DE Environment can reside on different infrastructure systems
- Although artifacts can reside on more than one infrastructure system, each artifact is mapped to a primary infrastructure system that will act as its “Source of Truth” hosting location

Key Point: All effort must be made to only modify each artifact at its Source of Truth hosting location, rather than updating artifact versions that reside on other infrastructure systems.



Source: MITRE-Developed “CM Plan” Model (in Cameo), with Notional Data

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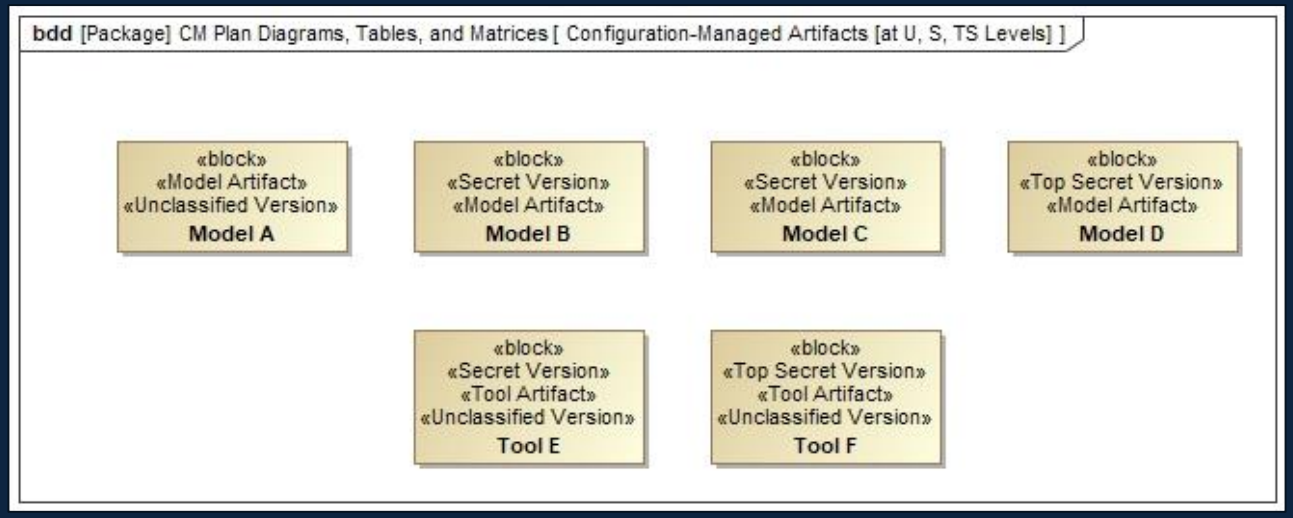
Artifacts and their Infrastructure Systems

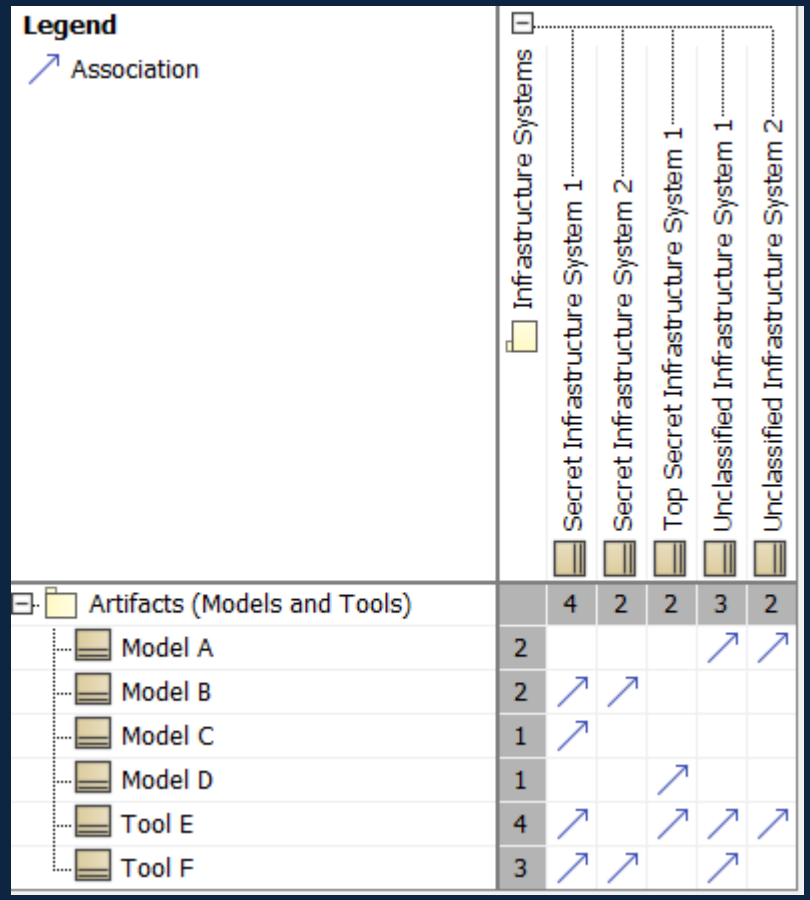
Configuration-Managed Artifacts Within "Project P" DE Environment



Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

Key Point: Each artifact can exist at more than one classification level. However, an artifact will only have a formal version defined at a higher classification level if relevant data for that artifact exists at that higher classification level.

Artifact Deployment Status on Infrastructure Systems



Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

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“Project P” Artifacts Log with Version Numbers (Notional)

#	Name	Documentation	Applied Stereotype	Secret CM Version Number	Unclassified CM Version Number	Top Secret CM Version Number
1	Model A	Model A description. POC: Alvin. Creation date of January 2022.	Block [Class] «» Model Artifact [Element] «» Unclassified Version [Element]		4.1.1	
2	Model B	Model B description. POC: Bailey. Creation date of April 2023.	Block [Class] «» Secret Version [Element] «» Model Artifact [Element]	2.0.0		
3	Model C	Model C description. POC: Cassandra. Creation date of April 2023.	Block [Class] «» Secret Version [Element] «» Model Artifact [Element]	1.1.6		
4	Model D	Model D description. POC: Dylan and Bailey. Creation date of September 2023.	Block [Class] «» Top Secret Version [Element] «» Model Artifact [Element]			1.0.0
5	Tool E	Tool E description. POC: Edward and Alvin. Creation date of January 2022 for Unclassified version, and October 2022 for Secret version.	Block [Class] «» Secret Version [Element] «» Tool Artifact [Element] «» Unclassified Version [Element]	1.3.5	3.2.0	
6	Tool F	Tool F description. POC: Francesca. Creation date of November 2022 for Unclassified version, and Feb 2023 for Top Secret version.	Block [Class] «» Top Secret Version [Element] «» Tool Artifact [Element] «» Unclassified Version [Element]		4.4.2	2.2.0

Source: MITRE-Developed “CM Plan” Model (in Cameo), with Notional Data

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Versioning for Models

Term	Definition
Semantic Versioning	The standardized method for determining incremental version numbers of software releases [6].

- Three-part number based on the Semantic Versioning system:

4.2.1

Major Revision Number

- Significant model rescoping
- Significant data additions/ modifications (e.g., 50+ new elements imported)

Minor Revision Number

- Moderate data validation
- Moderate diagram modifications (e.g., edits to 10+ diagrams)

Patch Revision Number

- Element renaming
- Diagram reorganization (e.g., aesthetic updates to diagrams)

Key Points: The developers must adhere to this versioning procedure for all changes, no matter how small, made to the models on the Source of Truth hosting locations.
Early on, the project team should refine the set of rules for updating a version number (as shown above), based on the scope/size of their project models.

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Additional CM Aspects/Considerations

Maintaining User Permissions on Each Infrastructure System (E.g., For Cameo TWC, Use Role Assignments)

#	Name	User Permissions and Access Groups	Primary POCs
1	Secret Infrastructure System 1		
2	Secret Infrastructure System 2		
3	Top Secret Infrastructure System 1		
4	Unclassified Infrastructure System 1		
5	Unclassified Infrastructure System 2		

Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

Model Versioning Tracker and Change Log

Annotated Element	Body
model A : Model A	[Version 2.0.0]: Significant rescoping of entire model
model A : Model A	[Version 3.0.0]: Twenty new data additions
model A : Model A	[Version 4.0.0]: Fifteen new data additions
model A : Model A	[Version 4.1.1]: Reorganized some diagrams
model A : Model A	[Version 1.0.0]: Initial version
model A : Model A	[Version 4.1.0]: Moderate modifications to home page diagrams
model B : Model B	[Version 2.0.0]: Significant rescoping of entire model
model B : Model B	[Version 1.0.0]: Initial version
model C : Model C	[Version 1.0.0]: Initial version
model C : Model C	[Version 1.1.0]: Moderate modifications to BDDs and IBDs
model C : Model C	[Version 1.1.1]: Renaming of key Blocks
model C : Model C	[Version 1.1.2]: Reorganized key diagrams
model C : Model C	[Version 1.1.3]: Further reorganized key diagrams
model C : Model C	[Version 1.1.4]: Renaming of key Part Properties
model C : Model C	[Version 1.1.5]: Renaming of key Requirements
model C : Model C	[Version 1.1.6]: Renaming of key Activities
model D : Model D	[Version 1.0.0]: Initial version

Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

Sharing Artifacts Tracker

Body	Owned Comment	Annotated Element
[Version 1.0.0]: Initial version	Shared with External Partner 1 in April 2022. For ...	model A : Model A
[Version 4.1.0]: Moderate modifications to home page diagrams	Shared with External Partner 2 in August 2023. Wil...	model A : Model A
[Version 1.0.0]: Initial version	Shared with External Partner 1 in June 2023. For t...	model B : Model B
[Version 1.1.6]: Renaming of key Activities	Shared with External Partner 1 in September 2023. ... Shared with External Partner 3 in September 2023. ...	model C : Model C
[Version 1.0.0]: Initial version	Shared with External Partner 3 in October 2023. Wi...	model D : Model D
[Version 1.3.5]: Most updated version	Shared with External Partner 1 in August 2023. For... Shared with External Partner 1 in October 2023. Fo...	tool E - Secret version : Tool E
[Version 3.2.0]: Most updated version	Shared with External Partner 4 in June 2023. For V...	tool E - Unclassified version : Tool E
[Version 2.2.0]: Most updated version	Shared with External Partner 2 in August 2023. Wil...	tool F - Top Secret version : Tool F

Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

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Leveraging Cameo Project Usages

- Project Usages enable modularity and scalability for models
- They can be used to connect and maintain configuration-managed models across different classification levels

Term	Definition
Cameo "Project Usages"	An inherent ability of Cameo to allow for the interconnection of multiple models and enable the sharing of data and model elements [7]. For instance, Project Usages allow *Model B* to leverage a read-only copy of *Model A*. *Model A* is often called the "used project".

KEY: Within each table: for each Model row, an "X" shows that (1) the Model row leverages the Model column as a Cameo "Project Usage" and (2) the Model row actively uses or links to aspects of the Model column.

Unclassified Models: Cameo Project Usages Matrix

	Model A (Unclassified)
Model A (Unclassified)	

Secret Models: Cameo Project Usages Matrix

	Model A (Unclassified)	Model B (Secret)	Model C (Secret)
Model B (Secret)	X		
Model C (Secret)		X	

Top Secret Models: Cameo Project Usages Matrix

	Model A (Unclassified)	Model B (Secret)	Model C (Secret)	Model D (Top Secret)
Model D (Top Secret)		X		

Source: MITRE-Developed "CM Plan" Spreadsheet Tracker, with Notional Data

- Additional ways to enable model "plug and play" across classification levels:
  - Use placeholders for higher classification elements
  - Use Generalization relationships and Dependency Matrices
  - Redefine inherited properties
  - Use modular package structures
  - Follow Modeling Style Guide
  - Apply Security Classification labels to model elements using Cameo plug-ins

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Workflows/Processes for Reuse

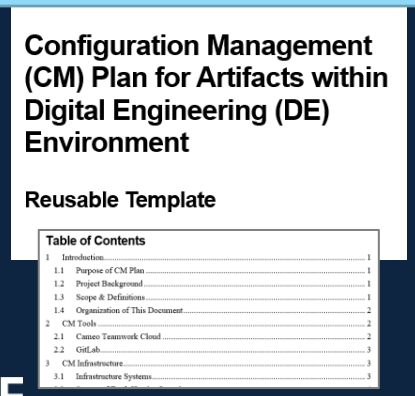
Example Workflow for Implementing a CM Plan

Prerequisites for a project in need of CM:

- Set of artifacts (models and tools)
- DE env at different classification levels
- Moderately sized team

START

Use CM Plan "Reusable Template" Report and associated materials


Configuration Management (CM) Plan for Artifacts within Digital Engineering (DE) Environment

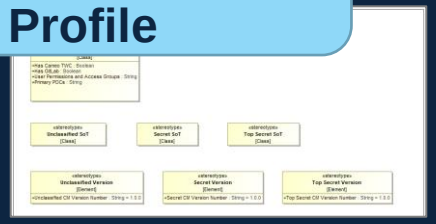
Reusable Template

Table of Contents

1 Introduction 1
1.1 Purpose of CM Plan 1
1.2 Project Background 1
1.3 Scope & Definitions 1
1.4 Organization of This Document 2
2 CM Tools 2
2.1 Cameo Teamwork Cloud 2
2.2 GitLab 3
3 CM Infrastructure 3
3.1 Infrastructure Systems 3

Source: MITRE

Option A: Use CM Plan Cameo Template Model with Profile



Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

Option B: Use CM Plan Spreadsheet Tracker

Artifact Name	System 1?	System 2?	System 1?	System 2?	On Top Secret Infrastructure System 1?
Model A	yes	yes	no	no	no
Model B	no	no	yes	yes	no
Model C	no	no	yes	no	no
Model D	no	no	no	no	yes
Tool E	yes	yes	yes	no	yes
Tool F	yes	no	yes	yes	no

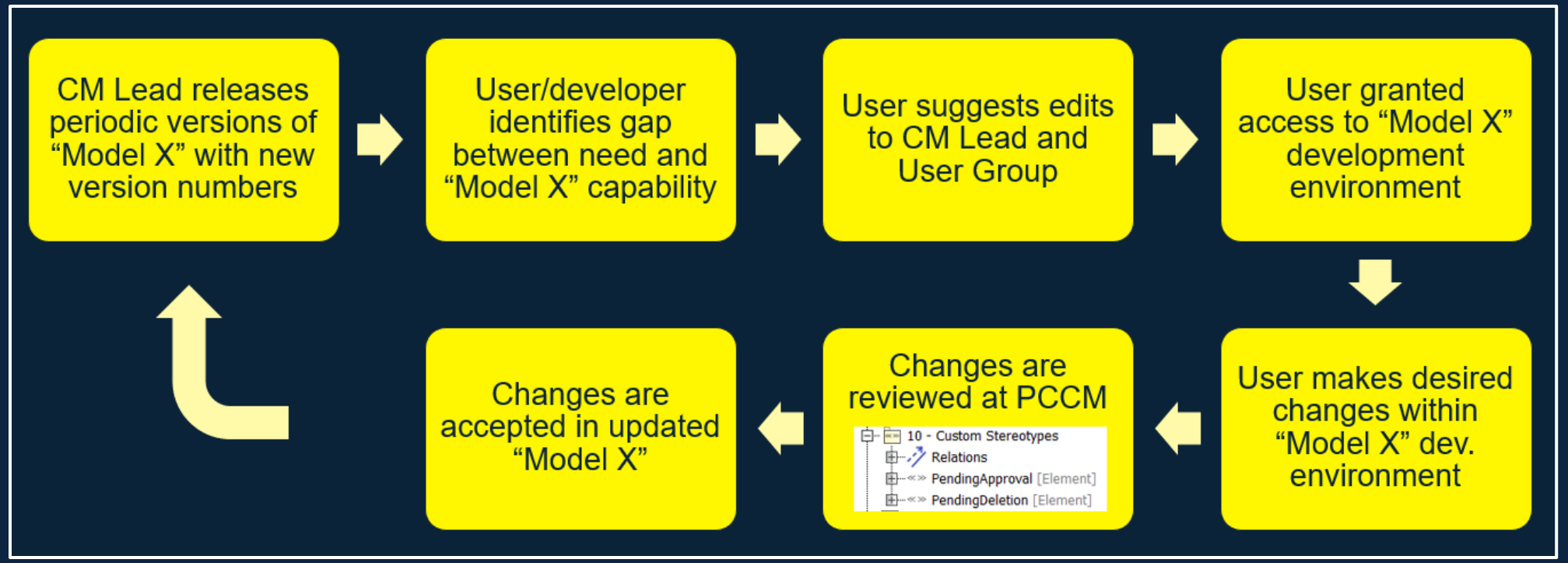
Source: MITRE-Developed "CM Plan" Spreadsheet Tracker, with Notional Data

Customize CM Plan for Your Project, and Begin Implementation

Update Your CM Plan As Needed:

- Update version number of an existing artifact
- Add new artifact (model or tool)
- Add new Cameo Project Usages
- Add/modify Infrastructure Systems
- "Source of Truth" hosting location changes for a given artifact

General Process for Following Strict CM Within a Cameo Model, via Product Change Control Meetings (PCCMs)



Source: MITRE

Recommendations and Conclusions

Recommendations for Setting Up a CM Plan

1. At least one person needs to take ownership and become “CM Lead” of the effort
2. CM Plan purpose and definitions (project-specific) need to be established upfront
3. All project members involved in modeling or tool development need to apply significant discipline to follow the CM processes for maximum impact
4. Start small in implementation, and then scale up
5. Be ready to adapt
6. Don’t reinvent the wheel

Conclusions

- Configuration management is often overlooked at the start of a project, but **as project scope increases, it is needed more than ever**
  - Model-based approaches require new ways of performing CM
  - Facilitates collaboration, improves productivity, increases consistency across artifacts

- This work was developed in a project-agnostic way to be **truly implementable and scalable** to any number of models/tools and classification levels

- **Potential future work**
  - Automation of these CM processes, via Cameo plug-in and expansion of template models
  - Additional conference presentations or papers

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Thank You!

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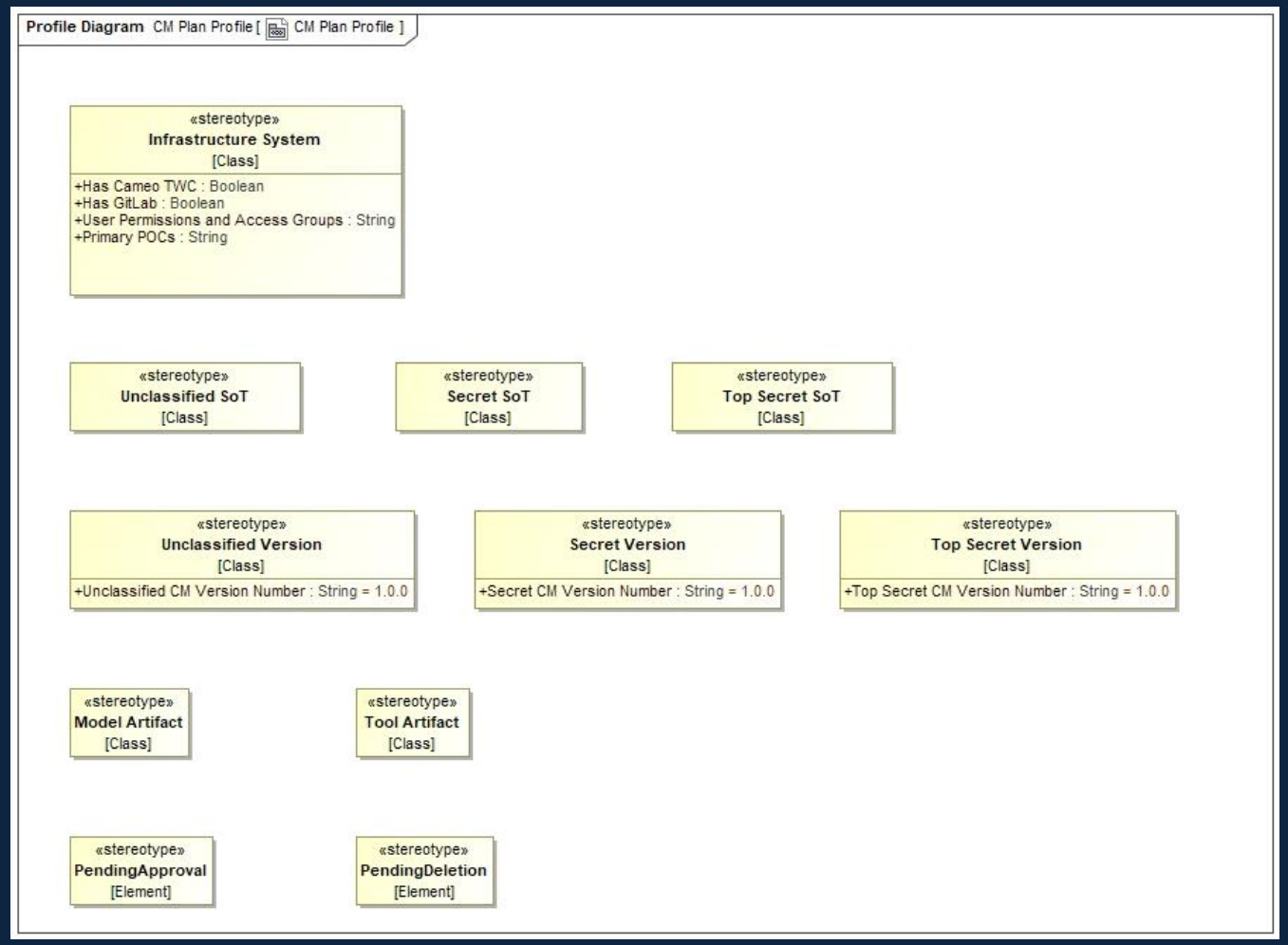
Backup

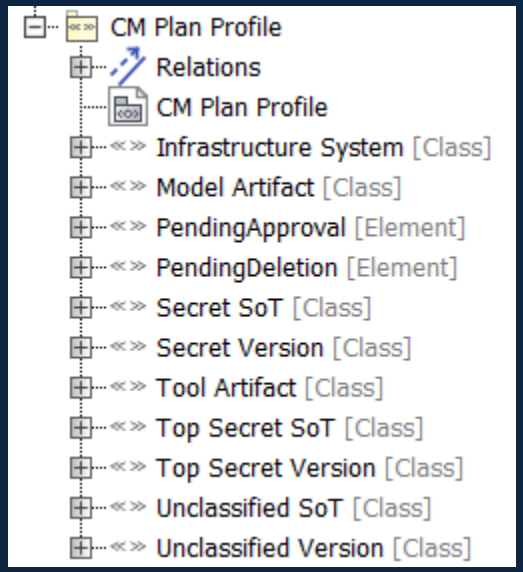
CM Plan Cameo Model with Profile (Reusable Template)

Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

CM Plan Cameo Profile



Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data



Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

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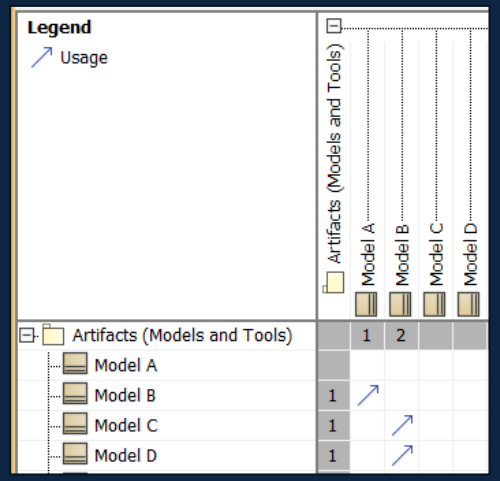
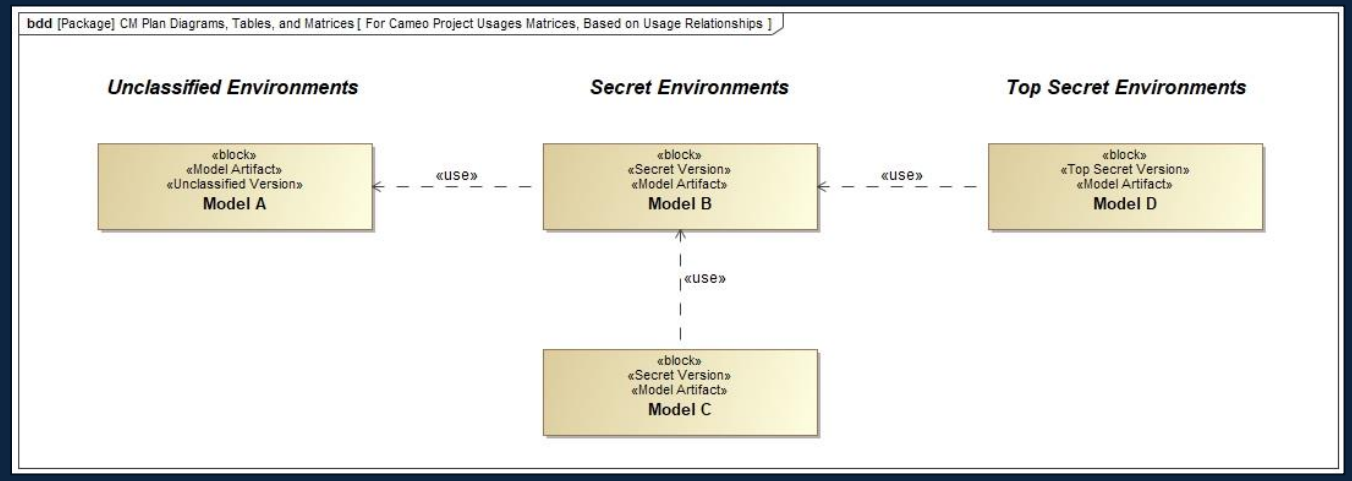
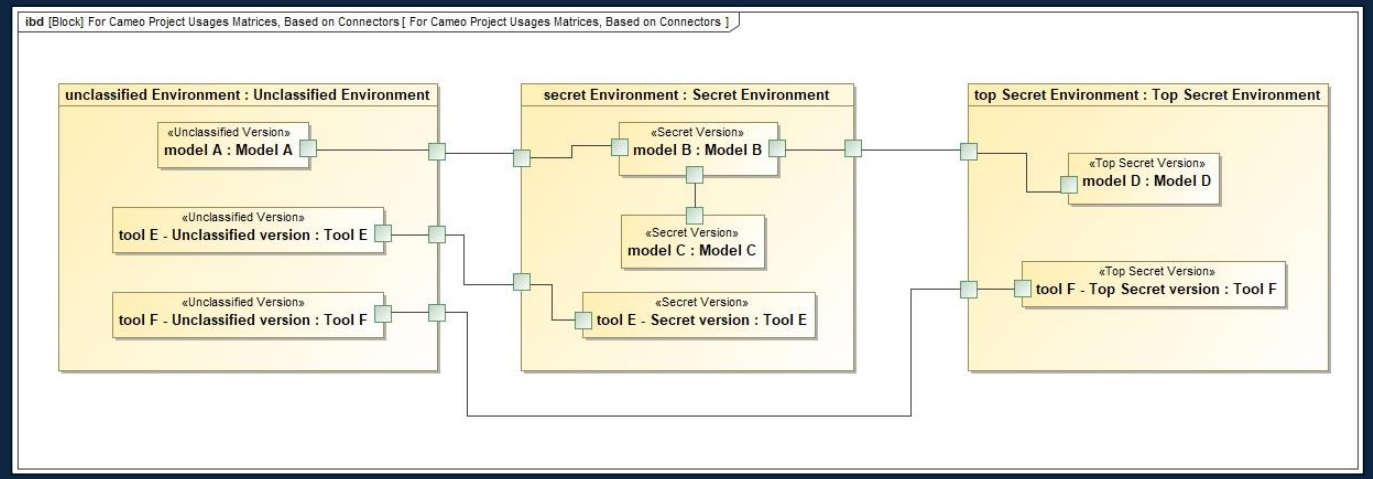
Additional Examples from CM Plan Cameo Model

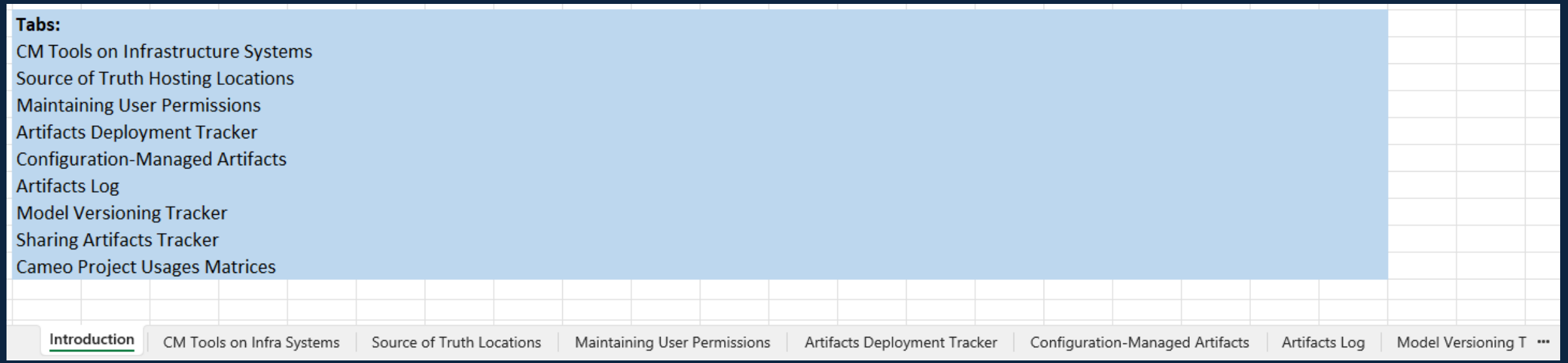






Source: MITRE-Developed "CM Plan" Model (in Cameo), with Notional Data

CM Plan Spreadsheet Tracker (Reusable Template)



Source: MITRE-Developed "CM Plan" Spreadsheet Tracker, with Notional Data

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Additional Examples from Spreadsheet Tracker

Artifacts Deployment Tracker on Infrastructure Systems					
Artifact Name	On Unclassified Infrastructure System 1?	On Unclassified Infrastructure System 2?	On Secret Infrastructure System 1?	On Secret Infrastructure System 2?	On Top Secret Infrastructure System 1?
Model A	yes	yes	no	no	no
Model B	no	no	yes	yes	no
Model C	no	no	yes	no	no
Model D	no	no	no	no	yes
Tool E	yes	yes	yes	no	yes
Tool F	yes	no	yes	yes	no

Source: MITRE-Developed "CM Plan" Spreadsheet Tracker, with Notional Data

Configuration-Managed Artifacts [at U, S, TS Levels] Within "Project P" DE Environment			
Artifact Name	Unclassified Version [U]	Secret Version [S]	Top Secret Version [TS]
Model A	X		
Model B		X	
Model C		X	
Model D			X
Tool E	X	X	
Tool F	X		X

Source: MITRE-Developed "CM Plan" Spreadsheet Tracker, with Notional Data

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Six-Step Procedure for Updating a Model Version Number

1. Complete the modifications to the model *(e.g., Model A [U])*. If using Cameo TWC, be sure to include a description of what you changed in your commit messages (e.g., *"Moderate modifications to Diagrams X, Y, and Z"*).
2. Propose to the rest of the team, and agree upon, an updated model version number (whether to update the model's major, minor, or patch revision number) and a justification *(e.g., update to V4.2.1 because of moderate diagram modifications within the model)*. Obtain written confirmation from the CM Lead before proceeding.
3. Update the version number in the Documentation tab of the Specification window of the highest-level package of the model *(e.g., change the text "Version: V4.1.1" to "Version: V4.2.1" in the Documentation tab for Model A [U])*.
4. Commit this update to Cameo TWC, with a commit message that describes the update to the new version number *(e.g., "Updating to V4.2.1")*.
    a. If not using Cameo TWC, create a new local folder labeled by the latest model version number *(e.g., "Model A (V4.2.1)")*. Copy and paste the updated model and all its Project Usages models into this new folder. Due to the need for manual versioning without TWC, this new folder will act as your new Source of Truth storage location going forward, until you create a new version.
5. Update your project's *"CM Plan Cameo Model with Profile" or "CM Plan Spreadsheet Tracker"* in two places:
    a. Update your Artifacts Log with the updated model version number.
    b. Add a new row to the "Model Versioning Tracker and Change Log".
6. Send a written confirmation to the team (including the CM Lead) stating that this process was completed for this model and version number *(e.g., updating Model A [U] to V4.2.1)*.

Source: MITRE

Glossary

Term	Definition
Artifact	Standard: For Digital Artifact, "An artifact produced within, or generated from, the digital engineering ecosystem. These artifacts provide data for alternative views to visualize, communicate, and deliver data, information, and knowledge to stakeholders" [9]. In the context of this presentation: The term that encompasses both models and tools within a project's DE Environment.
Authoritative Source of Truth	Standard: "Captures the current state and the history of the technical baseline. It serves as the central reference point for models and data across the lifecycle" [10]. In the context of this presentation: See "Digital Engineering Environment", "Infrastructure System", and "'Source of Truth' Hosting Location".
Cameo "Project Usages"	Standard: "Project partitioning, when the model has weakly dependent parts, such as type libraries, models of different phases of software/system development, etc. A part of the model moved to a separate project can be used in many projects. From the perspective of the project using elements from another project, we refer to the other project as a project usage or used project" [7]. In the context of this presentation: An inherent ability of Cameo to allow for the interconnection of multiple models and enable the sharing of data and model elements. For instance, Project Usages allow *Model B* to leverage a read-only copy of *Model A*. *Model A* is often called the "used project". If *Model A* were updated, then *Model B* would be able to obtain and leverage an updated version of that project through an automated "Update used projects" Cameo process [8].
Configuration Management	Standard: "A management process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design and operational information throughout its life" [11]. In the context of this presentation: The process of managing, maintaining, and tracking different versions of artifacts, as well as their linkages with other artifacts, for a project's DE Environment.
Configuration Management Plan	Standard: "The document defining how configuration management will be implemented (including policies and procedures) for a particular acquisition or program" [12]. In the context of this presentation: A comprehensive summary of implementable CM processes and procedures for the artifacts within a project's DE Environment.

Term	Definition
Configuration Management Tool	Standard: A tool that supports CM activities: version control management, collaborative modeling/development, and role and permissions tracking.
Digital Engineering	Standard: "An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support lifecycle activities from concept through disposal" [10].
Digital Engineering Environment	Standard: For DE Ecosystem, "The interconnected infrastructure, environment, and methodology (process, methods, and tools) used to store, access, analyze, and visualize evolving systems' data and models to address the needs of the stakeholders" [9]. In the context of this presentation: A collection of infrastructure systems and tools that allow a project's DE goals to be achieved. The DE Environment is considered to be the Authoritative Source of Truth (ASoT) for the project data, meaning that it contains the data that is considered true even if similar, but different data exists somewhere else. A project's DE Environment may consist of several infrastructure systems at different security classification levels.
Infrastructure System	Standard: The system or network that houses the tools and enables collaborative work. This can be a cloud-based or non-cloud-based system. In the context of this presentation: Individually, there can only be one infrastructure system considered an ASoT at each security classification level.
Model (or Model Artifact)	Standard: "A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process" [13]. In the context of this presentation: An abstraction of a real-world entity, expressly developed to help answer a question or set of questions about certain aspects of interest of that entity. One of the most popular software tools used to develop a MBSE model is called Cameo Enterprise Architecture (contains Cameo Systems Modeler), recently rebranded as Magic System of Systems Architect (MSoSA) and based on the MagicDraw modeling platform (and owned by Dassault Systèmes); for simplicity, this tool will be referred to as "Cameo" [14]. Additionally, Cameo Teamwork Cloud is the product name for CATIA No Magic's model repository and is also now analogous to Magic Collaboration Studio; this product will be referred to as "Cameo TWC" [1].
Model-Based Systems Engineering	Standard: "The formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase

Term	Definition
	and continuing throughout development and later life cycle phases" [15].
Model Management	In the context of this presentation: A subset of Configuration Management, focused only on models, not tools.
Modeling Style Guide	Standard: A set of naming conventions, diagram guidelines, and model structure recommendations to be used as a reference by developers and users of a project's current and future models. In the context of this presentation: These details are out of scope of this presentation, but having a project-specific Modeling Style Guide facilitates the consistency of the implementation of a CM Plan.
Semantic Versioning	Standard: The standardized method for determining incremental version numbers of software releases [6]. In the context of this presentation: The standard version of semantic versioning is used for tool development, and a customized version of semantic versioning is applied to model development.
"Source of Truth" Hosting Location	In the context of this presentation: Each artifact is mapped to a primary infrastructure system that will act as its "Source of Truth" (SoT) hosting location. In this way, all modifications made to the master "golden copy" of each artifact will remain centralized at its Source of Truth hosting location. Each time an artifact needs to be distributed to an external location, the latest artifact version would be packaged and shared via a controlled CM process.
Tool (or Tool Artifact)	In the context of this presentation: Broad term for a code-based (e.g., Python-based) application that is custom-developed for a project; considered separate from a Model.

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References

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