

## Building a Digital Engineering Culture

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### ABSTRACT

Transitioning to Digital Engineering (DE) from traditional Systems Engineering (SE) programs utilizing document centric processes can be daunting, time intensive, with difficult to quantify return on investment (ROI). Current technological progress and innovation are moving at an incredible speed, and traditional SE cannot keep pace. The solution requires modern approaches achieved through Digital Engineering (DE). DE uses modern tools to enable agile and responsive SE processes focusing delivery capability at the speed of relevance. This is achieved through formal processes and plans supported by maintenance of Authoritative Sources of Truth (ASOT) and Model Based System Engineering (MBSE) methodologies enabling a Digital Engineering Eco-System (DEE). A mature DEE will provide automated production of release artifacts, ensure effective configuration management of engineering and production artifacts. Organizations can utilize DE to build and maintain models of the complex Systems of Systems (SoS) being acquired and the acquisitions system. These models enable insight into the SoS and its acquisition at various levels of detail and reduce information sharing challenges by relying on the ASOT. A mature DEE will incorporate all key stakeholders in the acquisition of a system which requires considerations for information management including access permissions to the ASOTS, classification, releasability, and administration of these permissions. Effective DE offers increased communication, collaboration, and efficiency between stakeholders. DE utilizes MBSE models that can be displayed utilizing specific audience targeted views and reports to inform system stakeholders. This paper covers processes, prioritization and pain points for transitioning a legacy program using document centric processes into a modern DE program while ensuring effective ROI. The paper leverages the Defense DE and MBSE bodies of knowledge and frameworks to enable a SE team to transition a legacy defense program to a compliant DE program with minimal risk and friction.

Index Terms: Digital Engineering, Model Based System Engineering, Model Based Architecture, Formalized Process Description, Authoritative Source of Truth

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### INTRODUCTION

Traditional Systems Engineering (SE) is increasingly unable to keep pace with the rapid pace of technological development, particularly for complex systems of systems (SoS), due to a document centric focus and the bulk of knowledge being stored as tribal knowledge. Document-centric processes are time consuming and resource intensive resulting in less effective (efficient, timely, accurate) decision-making. This leads to degraded system outcomes including delayed delivery schedules, reduced performance and compromised capability.

#### Traditional Document Centric Systems Engineering suffers from several discrete issues:

- **Inefficient:** Document-centric engineering methods are time-consuming and resource-intensive.
- **Inconsistent:** The nature of document-centric methods often leads to inconsistencies, errors and reliance on individuals.
- **Complex:** Managing and maintaining documents as a source of truth adds unnecessary complexity that increases the workload for little gain.

Fortunately, the shortfalls in traditional SE have been identified and many recent policy decisions and governmental directives emphasize the need for a transformation to Digital Engineering (DE) practices.

Digital Engineering aims to solve issues with document-centric engineering using tools, processes, and concepts that improve shared understanding through centralization, increase efficiency through automation, maintain consistency through effective configuration management, and reduce complexity through abstraction and standardization. This is an interpretation of the 5 goals of the Digital Engineering Maturity Model (DEMM) (Cook, 2024).

Part of the challenge in implementing DE stems from understanding that DE in this context means defining methods, artifacts and concepts and not just using digital tools. This is because while many engineering functions have moved to modern digital tools, for example Computer Aided Design (CAD), or Finite Element Analysis (FEA) traditional delivery methods, acceptance/authorization artifacts and metrics have been retained. The primary methods of delivery and interface between documents and tools in these environments are people – even when the processes can be automated this often remains a nebulous “future state”. Challenges in translating from the traditional SE “V” to a model that enables Agile development of artifacts within the DE authorized source of truth (ASoT) means that many transitions are stifled before delivering the promised benefits. The proliferation and misappropriation of both DE and SE terms has increased this challenge, the DEMM addresses this issue (Cook, 2024).

Additionally, DE is often conflated with Model Based System Engineering (MBSE). However, DE is much more than just MBSE, it covers the entire eco-system around the specification, design, delivery, sustainment and disposal of a system or system of systems. The guidance of the DEMM is that not all organizations or parts of organizations need to reach full maturity on all threads, and this is particularly valid advice. For an organization or part of an organization that is aiming to prioritize DE this paper will provide decision points, tradeoffs and recommendations in moving up the maturity scale in specific areas.

### BACKGROUND

#### How does an organization move toward Digital Engineering?

The first thing to do is answer the question - Where is the organization on the DEMM assessment? This can be effectively achieved by modelling the current environment. This strategy will help to define the maturity level of the team(s). The process identifies the maturity level (Analog, Digital, Standardized, Integrated, Automated, Intelligent) of each “Thread” – Customer, Data, Technology, Internal Operations, External Operations, Culture. The following are recommended starting questions when beginning assessment.

- What processes are being used?
- What tools are being used?
- How are those tools integrated/connected?
- What purpose(s) does each tool serve?
- Are there duplicate tools?
- Are tools missing for specific requirements?

As stated in the DEMM, not all organizations should pursue level 5 –Intelligent. Where automated processes and operations leverage data collection, data aggregation, and data analytics to discover new information and optimize decisions in ways not previously possible (Cook, 2024). The current state of Naval Surface Warfare Center Dahlgren Division Dam Neck Activity (NSWCDD-DNA)'s Integrated Training Systems (ITS) program is level 3 with the near-term goal of reaching level 4. From assessing the current state of the organization by using the DEMM, an organization can formulate an effective plan of action to transform the processes necessary to reach the organization's desired maturity level.

## DISCUSSION

### Model the Processes

Modelling the processes and tools used to manage models and data that supports the model is a key step to success. Standardizing these processes and integrating these processes into the organization's Systems Engineering Plan (SEP) allows projects within an organization to align DE strategy. This alignment enables project and team specific capabilities that support delivery. Within NSWCDD-DNA ITS, these processes have been iteratively developed and incorporated into high level SEP with project specific annexes. This SEP provides critical information for the systems engineering team and all stakeholders associated with the project both internal and external.

The processes should be modeled in detail to enable all stakeholders to confidently operate in the model within their authorization and need to know. The details are key to building confidence while learning to work within a DE environment, especially for new MBSE stakeholders. This confidence ensures that people are more inclined to utilize the correct ASoT rather than reverting to document-based solutions such as Portable Document Format (PDF), Word, Excel, or email. The minimum set of processes identified by NSWCDD-DNA ITS are described below and have been identified as the necessary starting point to determine how to access, update, maintain, support, and retire DE tools and model(s).

### Access:

The most important processes to model and promulgate are access processes(s) for models and tools in the DE ecosystem. If key members of the team cannot obtain access to the tools or information required to sustain ASoTs then reversion to document base solutions will occur due to expediency. This results in conflict around what the ASoT is and where it can be found. Once an ASoT can no longer be trusted, this introduces confusion and complexity negating the beneficial values of DE. When the team's access to all models and ASoTs are validated, the next step is to validate processes regarding sharing. NSWCDD-DNA ITS developed a specific standard operating procedure (SOP) to distribute, facilitating this access. Key areas for future improvement are reducing the complexity and number of distinct actions required to gain access to the tools. It should be noted that high-level stakeholders will likely avoid lengthy access procedures or those that cannot be conducted by a third party due to competing time commitments.

### Share:

Not all stakeholders require the same level of access to models, data, and DE tools. First, identify the types of stakeholders associated with the project along with their specific needs. Then ensure that there are processes for sharing data with identified stakeholders effectively. NSWCDD-DNA ITS identified two main types of stakeholders. Those who create, maintain, and update models and those who consume and/or approve models. Once the types of stakeholders have been identified, access procedures and permissions can be implemented. Important questions to consider are as follows.

- Will view only access to certain diagrams support certain types of stakeholders?
- Will feedback within the model be solicited directly from certain stakeholders?
- Does everybody who operates in the environment have the same need to know?

- Can this be managed effectively with permission?
- Who manages these permissions?
- Who authorizes changes in these permissions?
- Who ensures that access procedures and permissions are correct?

The administrative burden of managing access permissions can be significant, but it is necessary if multiple projects are sharing resources such as servers and licenses for DE tools. These sharing processes and permissions facilitate the next key process, creating model(s).

**Create:**

The processes around creating model(s) ensure that only the minimal number of models are created within the model repository and are structured in a way that is aligned across projects within the organization. This supports model reuse and integration resulting in gained efficiency and standardization. Certain models may require higher level authorization prior to creation. All MBSE practitioners can create local models and even locally cached versions of the authorized models on their machines for learning purposes. Changes to the authorized models are required to follow the processes outlined below. A high-level activity diagram of this process can be seen in Figure 1 below.

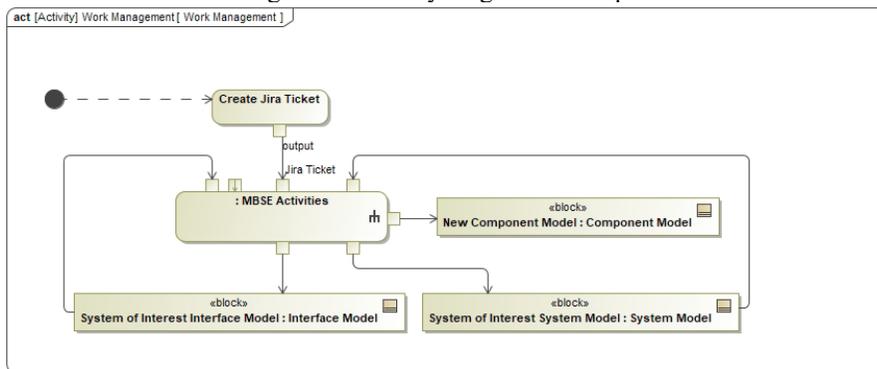


Figure 1: High Level Activity Diagram Describing Work Management in a DE Eco System

**Update:**

The processes for updating include change-management processes to handle modifications systematically. NSWCCD-DNA ITS has developed clear and concise processes to effectively manage change. One key step the team incorporated is to annotate model changes with JIRA ticket numbers for traceability of who/what/when/why for model changes, as shown in Figure 1. JIRA is an Atlassian product that allows for agile management and formation of tickets needed to plan, track and accomplish tasks, but any work management tool can be used for this purpose. Having an ASoT for work management traceability allows the organization to effectively manage stakeholder needs for development and change to requirements. Another key step to identify within the update process is to define roles and responsibilities which outline who can make updates, review, and approve. This builds confidence by providing users with direct guidance and authorization to update models using known criteria, standardization, and objective measures. Lower-level update processes are shown in Figure 2 below. Further detailed processes are available within the model.

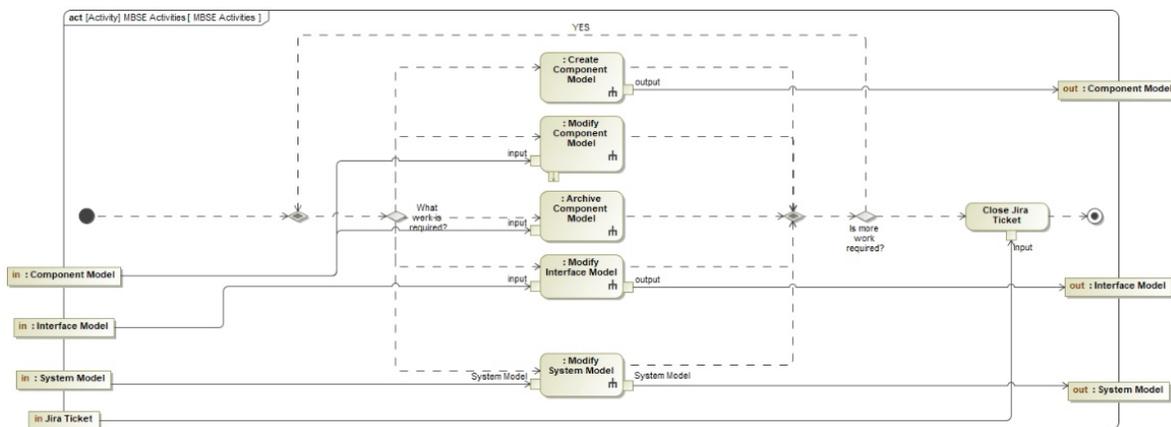


Figure 2: Lower-Level Activity Diagram Describing Model Element Updates

**Maintain:**

It is important to recognize the difference between updating and maintaining models. Updating refers to design and incorporating new information into models and maintaining refers to sustaining models, specifically to address accuracy and usefulness of models as time progresses. NSWCCD-DNA ITS has implemented regular maintenance schedules to keep models current with changes in the system, environment, and/or requirements. One human-factor identified as needed for this process is to implement ongoing training for personnel to ensure proficiency with the digital tools, processes, and methodologies.

**Support:**

Another aspect of maintaining the DE environment is to develop a support framework that includes technical support, user manuals, and troubleshooting procedures. NSWCCD-DNA ITS utilizes the Naval-Leveraging Innovations, Frameworks and Technologies (LIFT) system helpdesk and support team dedicated to assisting users with any issues related to digital tool infrastructure and models.

**Retiring:**

Retiring can best be defined as entering a non-maintenance state. It is necessary to define the criteria and processes for when and how models and tools should be retired, including archiving old models and transitioning to new ones. When retiring a model, NSWCCD-DNA ITS has identified the best approach is to ensure there is access via an easily accessible repository to the retired model to allow for knowledge transfer. This digital form of knowledge transfer is critical to reducing the loss of tribal knowledge that is extremely common. It has been standard practice for Subject Matter Experts (SMEs) to conduct a turnover which in theory is optimal, however it rarely results in capturing all knowledge due to a limited transition time, quantity of information needed to transfer, and a document-based approach. DE allows for continuous knowledge transfer and capture throughout a person's career, reducing the impact of a SME retiring or transferring. This ensures there is data capture and knowledge transfer to support a smooth transition into non-maintenance state.

**Modelling the Current Environment**

NSWCCD-DNA ITS utilizes Naval-LIFT provided Modelling tools to effectively integrate into the digital environment and align to a DEMM maturity level. Naval-LIFT hosts Cameo Systems Modeler (CSM), Teamwork Cloud (TWC), and several analysis tools. Below are the tools NSWCCD-DNA ITS utilizes to accomplish digital engineering maturity.

Key Tools/ASoTs:

- Modelling Tool(s) (Options: CSM)
  - CSM – Cameo Systems Modeler is an industry leading cross-platform collaborative MBSE environment, which provides smart, robust, and intuitive tools to define, track, and visualize all aspects of systems in the most standard-compliant SysML models and diagrams (Dassault Systèmes, 2025). The environment enables systems engineers to:
    - Run engineering analysis for design decisions evaluation and requirements verification
    - Continuously check model consistency
    - Track design progress with metrics
- Model Repository (Options: Cameo TWC, GitLab, BitBucket)
  - TWC – Teamwork Cloud is a central repository for storing Cameo and MagicDraw models. It is designed as a modelling platform for working with large models and includes features for accelerating team collaboration. Using Teamwork Cloud, team members can access and modify the same model or even the same diagram in parallel. The product supports data & change management, seamless project collaboration, and scalable performance (Systèmes, Dassault, 2025).
- Analysis Tool(s) for the Model(s) (Options: AutoCAD, Ansys, Cameo Simulation Toolkit, MATLAB/Simulink)
  - AutoCAD – Autodesk AutoCAD equips architects, engineers, and construction professionals with precision tools to: Design and annotate 2D geometry and 3D models with solids, surfaces, and mesh objects, automate drafting tasks to place objects with AI, compare drawings, create schedules, publish layouts, and Maximize productivity with customized workspaces, AutoLISP, APIs, and apps (Autodesk, 2025).
  - Ansys-Ansys simulation software, with its comprehensive Multiphysics capabilities, provides bundles that offer structural mechanics, explicit dynamics, fluid dynamics and thermal simulation capabilities (Technology, Office of Information, 2025).

- Cameo Simulation Toolkit – With Cameo Simulation Toolkit, users can test how the system reacts to user interaction or predefined testing data and execution scenarios. It allows simulation of system models, which can be beneficial for testing and validating various aspects of your system's behavior (Systèmes, Dassault, 2025).
- MATLAB/Simulink – Integration of the MBSE model with a high-fidelity physics-based model developed in the MATLAB/Simulink. This integration allows for a physics-based representation of system's behavior gaining a more realistic perception of the systems and their relationships (Rangel, Pavalkis, & Yakimenko, 2023).
- Collaboration Tool(s) (Options: Cameo Collaborator for TWC, Confluence)
  - Cameo Collaborator for TWC – Cameo Collaborator for Teamwork Cloud is a web-based product designed to present models in a simplified form for stakeholders, sponsors, customers, and engineering teams. It allows editing and reviewing models (Systèmes, Dassault, 2025).
  - Confluence – Confluence is a team workspace where knowledge and collaboration meet. Dynamic pages give your team a place to create, capture, and collaborate on any project or idea. Spaces help your team structure, organize, and share work, so every team member has visibility into institutional knowledge and access to the information they need to do their best work (Atlassian, 2025).
- Knowledge Management Tool(s) (Options: Confluence, SharePoint)
- Work Management Tool(s) (Options: Jira, Gitlab)
  - Jira – Jira is the #1 agile project management tool used by teams to plan, track, release and support world-class software with confidence. It is the single source of truth for your entire development lifecycle, empowering autonomous teams with the context to move quickly while staying connected to the greater business goal (Atlassian, 2025).
  - Gitlab – GitLab is an all-in-one platform designed for software development and DevOps.it has since evolved into a fully integrated solution for managing the entire software development lifecycle (SDLC) (Pykes, 2025).
  - In essence, GitLab enables developers to:
    - Handle version control
    - Automate CI/CD pipelines
    - Manage project tasks
    - Monitor performance

Example: Naval integrated modelling environment diagram below in Figure 3.

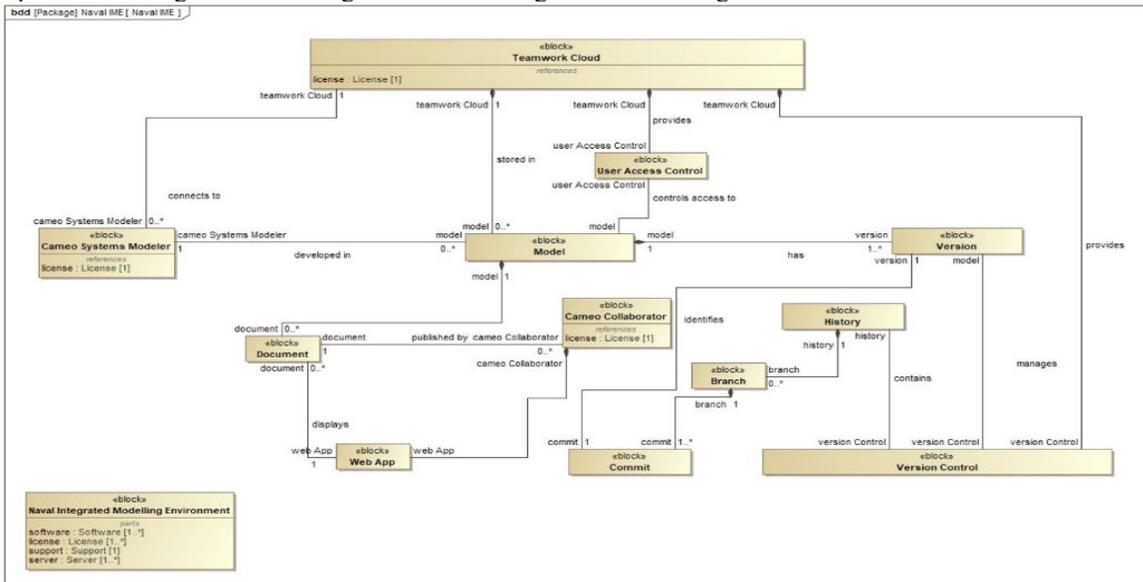


Figure 3 Naval Integrated Modelling Environment as utilized at NSWCDD DNA

### Model the System of Systems

A System of systems architecture model shows team(s) how to build a model(s) that will interact with other models in the same ecosystem. Figure 4 below is a generic system of system example. Identify standardized nomenclature and relationships for discussing a model as shown in Figure 5 below. By organizing information effectively and

ensuring proper integration with other systems, a robust and efficient system model can be developed serving as a reliable foundation for DE efforts. This enables individuals to answer the following questions:

- Where does this information belong?
- How does it tie to other peer/related systems and associated models?

In a structured digital engineering approach, information should be categorized and stored in an organized manner to ensure consistency, traceability, and accessibility. Requirements should be linked directly to system components and model elements, enabling requirement integration into the model and traceability. Data repositories should be maintained for different types of data (e.g., simulation data, performance metrics, test results). Ensure proper metadata and tagging for ease of search and retrieval. Employ a holistic configuration management system to track changes to the system model. This ensures version control and traceability across the system lifecycle.

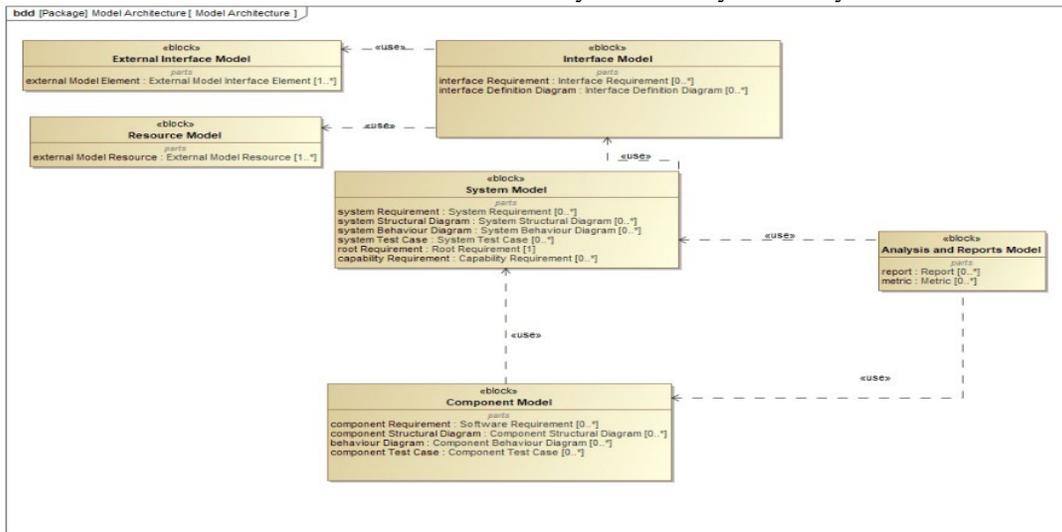


Figure 4 Generic Structure of a Systems of Systems Model Set

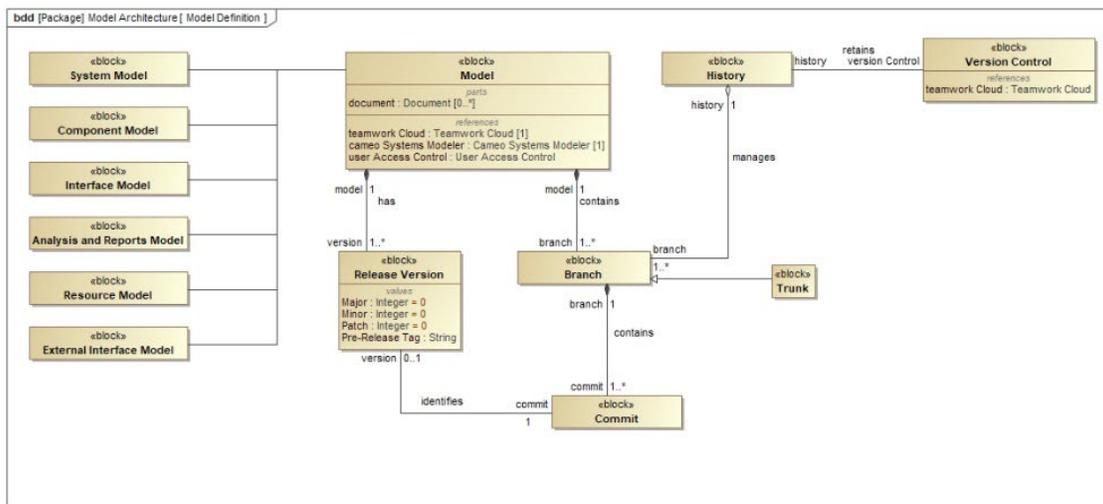


Figure 5 Generic Model Structure for use in a Systems of Systems Model Set and Digital Engineering Environment

**Model Accuracy and Validation:**

Regular validation against real-world results and requirements is needed to ensure accuracy. Automation of the validation process in real time ensures that invalid states of the model are not introduced into the ASoT. The mentioned tools provide these capabilities, but they must be tailored directly to the project/system of interest. A large amount of resistance to change will come in this area as it can introduce fear. This is both the fear of having weakness or errors publicly displayed and the fear that these errors will be used to punish. It is important to establish comprehensive and supporting processes and policies around implementation and management to assuage these fears.

**Performance Metrics:**

Assessing the efficiency of models in terms of processing time, resource utilization, etc.

**Change Impact Analysis:**

Reports on how changes in requirements, design, or environment impact models and overall system.

**Configuration and Version Management Metrics:**

Tracking updates, version control, and configuration changes to maintain consistency and traceability.

**User Adoption and Feedback:**

Surveys and feedback reports from users on the usability and effectiveness of digital tools and models.

**Model the System**

Following the defined processes and using the architecture to produce models. If the processes, environment, system architecture are modeled and have methods for measuring the accuracy, validity and performance then the models of the system will be produced effectively and generate value. This will be observed as an increase in speed to capability, reduced costs and reduced complexity management.

**Model the Future Environment (Goal Setting)**

NSWCDD DNA modelling was achieved by modelling the future environment and planned models as seen above. Increasing the maturity level against the DEMM will be achieved by setting a new target environment and model state. This new future state will be drawn from data that can be evaluated from the validation, metrics and analysis of the models and associated processes. This will inform new tools, new processes, process refinement and the retirement of tools and processes as they are superseded. Modelling this future environment is a key to mapping how it will be achieved.

Key considerations for a future environment include the consideration of classified models and answering how those complement and integrate with the current environment. Further discussions that need to occur will be around describing how the organization matures from level 3 to level 4 for model maturity or beyond. It may be that the organizational goals can be achieved effectively with the current DEE and model maturity, in which case the effort expended may not be a good ROI.

**INSIGHTS**

**Practical Lessons learned and Recommendations**

One of the biggest challenges is getting stakeholders into the model. This is due to unwillingness, inability to use the tools, or inability to access the tools based on permission. Convincing stakeholders to actively engage and contribute to the modelling effort can be challenging. Stakeholders may be resistant to change or skeptical about the benefits of DE and the upfront investment of modelling.

**Transforming the culture**

Another challenge is the culture of the organization when it comes to SE prioritization and funding for DE efforts that aren't seen as critical. For NSWCDD-DNA, DE is considered an extra step to an existing SE process, especially when it comes to mature programs of records that already have established SE work accomplished. However, this culture is slowly changing because using a model instead of tools (PowerPoint, Visio, etc.) to create views of the system is a more effective and efficient way to develop and convey larger mission architectures in a standardized way (Shreve, 2024). Developing modelling expertise enables the aggregation, and digital representation of a mission's architecture in a centralized and authoritative source. Additionally, models can be modularized to encourage reuse. Building modelling expertise takes time to develop the necessary skills and expertise in digital modelling. Finding or training personnel with proficiency in relevant tools and methodologies can be costly and time-constraining.

**Tool reliability Challenges**

Tool reliability ties into all the challenges, without a standardized tool framework, modelling will become increasingly more challenging. The models need to be accessible to all stakeholders and down time needs to be low for the models

to be effective. The tools also need to be available to all stakeholders, and this becomes challenging when working with different security classifications in data and granting user access.

### **Mitigations**

#### **Remove admin around model access – ensure granular access control but at the right level**

Utilizing “view only” capabilities within the tools allows stakeholders without MBSE skills to obtain information regarding the systems components, requirements, and the relationships visually explaining the who, what, why, and how of the system. Automating the process for accessing models while maintaining granular access control will allow easier access for stakeholders while ensuring that the right people have access to the right parts of the model without cumbersome administrative overhead.

#### **Investment in Digital Engineering skill sets**

The use of automated tools to generate documents from models will help mitigate the upfront cost and time associated with model generation. This can serve as a stepping-stone to fully publishing documents within the model, helping to bridge the transition from document-based to model-based practices. Implementing the use of AI will make model development exponentially faster.

### **Innovation**

AI is a hot word in today's technical innovation arena. AI and digital engineering go hand in hand. Once models are built and frameworks are created, the ability to implement AI into these models will be a smooth transition. AI can be used to generate models, predict system failure and improve model performance. AI will be able to improve model design time which is currently a large upfront effort.

### **CONCLUSION**

DE is an ongoing transformation process that for NSWCDD-DNA ITS, establishes a Navy training-centric ontology while developing an extensive body of knowledge to generate actionable information to identify training gaps, duplications, and inefficiencies in naval surface warfare training. The shift from traditional document-centric SE to DE represents a necessary evolution to keep pace with rapid technological advancements and the complexities of modern systems. Traditional SE methods are increasingly inefficient, inconsistent, and overly complex, leading to suboptimal outcomes. This methodology relies heavily on the tribal knowledge of individuals, leading to gaps in system knowledge when those individuals leave. DE addresses these shortcomings by emphasizing digital centralization, automation, effective configuration management, and standardization. Implementing DE requires more than just adopting digital tools. For NSWCDD-DNA ITS, it involved a fundamental change in the way the organization looks at the engineering process, methods, artifacts, and concepts. Our next steps will be to proceed forward with maturing NSWCDD-DNA ITS's DEMM level 3 to level 4 for model maturity by incorporating automation into our processes.

By understanding and applying the principles of the DEMM, NSWCDD-DNA ITS strategically enhanced the engineering practices that assist the Navy training community. This paper's mission was to guide organizations towards developing their own DE strategy by providing insight into how to assess their current DE maturity state, develop the processes for DE success, and provide first-hand knowledge of NSWCDD-DNA ITS's experience towards the goal a DE enterprise.

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