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Digital Transformation for Defense Acquisition: Digital Engineering Competency Framework (DECF)

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Digital Transformation for Defense Acquisition: Digital Engineering Competency Framework (DECF)

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Abstract

Digital transformation is fundamentally changing the way acquisition and engineering are performed across a wide range of government agencies, industries, and academia and is characterized by the integration of digital technology into all areas of a business, changing fundamental operations and how results are delivered in terms of new value to customers. It includes cultural change centered on alignment across leadership, strategy, customers, operations, and workforce evolution. Digital engineering (DE) is ‘‘an integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support life-cycle activities from concept through disposal. A DE ecosystem is an interconnected infrastructure, environment, and methodology that enables the exchange of digital artifacts from an authoritative source of truth." (ODASD [SE], 2017) The purpose of the Digital Engineering Competency Framework (DECF) is to provide clear guidance for the DoD acquisition workforce, in particular the engineering (ENG) acquisition workforce, through clearly defined competencies that illuminate the knowledge, skills, abilities, and behaviors (KSABs) required for DE professionals. Though the DECF includes considerations specific to the Defense acquisition workforce, data was also gathered from outside the defense community.

Introduction

Based on evidence across the Services and industry, digital engineering (DE) has been affirmed as a vital practice necessary to support acquisition in an environment of increasing global challenges, dynamic threats, rapidly evolving technologies, and increasing life expectancy of systems currently in operation and future systems. In order for the DoD to provide the best advantage for successful acquisitions and sustainment, the DoD must continue to practice systems engineering efficiently and effectively. DE updates the systems engineering practices to take full advantage of the digital power of computation, visualization, and communication to take better, faster actions throughout the life cycle.

Methodology

The Digital Engineering Competency Framework (DECF) was created in compliance with DoD Instruction 1400.25, volume 250, "DoD Civilian Personnel Management Systems: Civilian Strategic Human Capital Planning" (DoD, 2016). DoDI 1400.25, vol. 250 outlines five tiers of competencies:

- *Tier 1*. Core Competencies, which apply across DoD regardless of DoD component or occupation.
- *Tier 2*. Primary Occupational Competencies, which apply across discrete occupational series and or functions.
- *Tier 3*. Sub-occupational Specialty Competencies, which are unique to sub-occupational specialties.
- *Tier 4*. DoD Component-Unique Competencies, which are so unlike any of the other competencies identified that they exist at the component level and are unique to the context or environment in which the work is performed.

- *Tier 5.* Position-Specific Competencies, which are required for a particular position within an occupation and are not addressed in tiers above. (DoD, 2016)

DECF version 1.1. (DECF v. 1.1) addresses competencies in Tiers 2–5, with Tier 2 for acquisition professionals generally and Tier 3 specifically for acquisition ENG professionals being the primary focus. Though focused on the DoD, the overarching framework is intended to be relevant to a wide variety of stakeholders across government and industry and should provide critical insights for any organization looking to successfully implement DE.

Key Terminology

- **Competency Group**. Top-level grouping of related competencies that represents a core area of expertise in DE.
- **Competency Subgroup.** Subgroups contain related/like competencies.
- **Competency**. Major grouping of related KSABs; each competency is identified by its title and includes a description that succinctly encompasses the general knowledge and skills related to said competency.
- **KSAB**. A brief statement of *knowledge, skill, ability, or behavior* related to a competency and associated with a specific proficiency level in said competency.
- **Proficiency Level**. For each competency, there will be five possible levels of attainment or proficiency: awareness, basic, intermediate, advanced, and expert.

The entire DECF rests on a foundation of general digital competencies that are required for any individual who may have tasks within a digital environment.

Building on Existing Competency Models

Existing competency models and guidance from the practicing acquisition community were used to develop the DECF. For baseline terminology, the DoD competency models (DAU ENG and PM and U.S. Department of the Navy Systems Engineering Career Competency Model [SECCM]) are used, as these are already in use within the DoD for systems acquisition. The non-DoD competency models were mapped against the DoD models and existing competencies were updated to reflect a digital environment in lieu of the traditional acquisition environment where appropriate.

The existing competency models examined included:

- DAU ENG and PM competency models (DAU, 2016a, 2016b)
- INCOSE Systems Engineering Competency Framework (INCOSE, 2018)
- MITRE Systems Engineering Competency Model (MITRE, 2007)
- NASA SE/PM Competency Model (NASA, 2019)
- Helix *Atlas* Proficiency Model (Hutchison et al., 2020)
- IEEE Software Engineering Competency Model (IEEE, 2014)
- U.S. Department of Labor Engineering Competency Model (U.S. Department of Labor, 2017)
- Mission Engineering Competency Framework (Vesonder et al., 2018)
- U.S. Department of the Navy Systems Engineering Career Competency Model (SECCM; Whitcomb et al., 2017)

The team gathered materials from the DE community related to competencies, including in-progress competency frameworks such as the Naval Digital Engineering Body of Knowledge. Paired with the assessment of existing models, experts and practitioners in DE and Model-Based Systems Engineering (MBSE) provided insights into their common activities and current training programs. These inputs were collected and compared to the competency models to determine where they fit in the existing frameworks and where new competencies needed to be created to account for them.

Modeling the Framework

The team utilized a Model-Based Systems Engineering (MBSE) approach to create a SysML model of the DECF, its context, and its use cases. This approach leveraged the capabilities of DE and demonstrated the value proposition of their adoption. The primary focus of the model was to capture the structure and content of the DECF. Block definition diagrams (BDDs), such as that shown in Figure 1, are functional and visual representations of the structure of the DECF. The actual content of the model—the multitude of groups, competency areas and KSABs—is fulfilled by specified instances of each of these blocks.

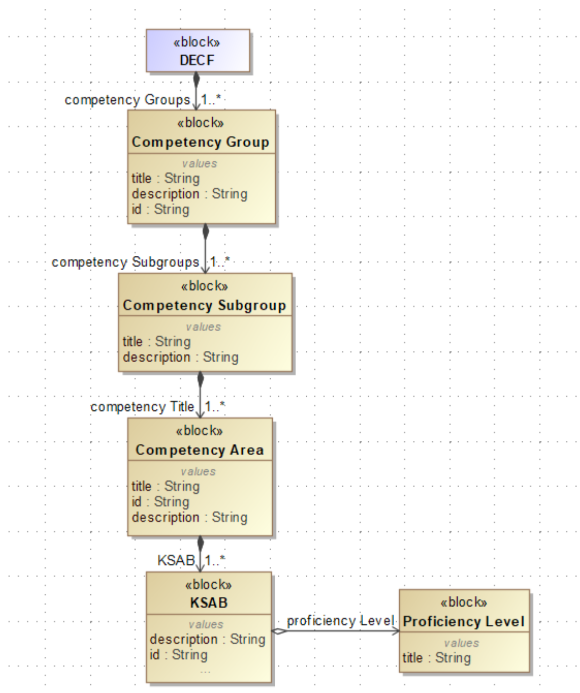


Figure 1. BDD of the DECF Structure

The primary purpose of the model was to capture the DECF structure and content, but initial efforts were made into exploring the use cases of the DECF. First the context of the relationship of the DECF to a defense organization was modeled as shown in Figure 2.

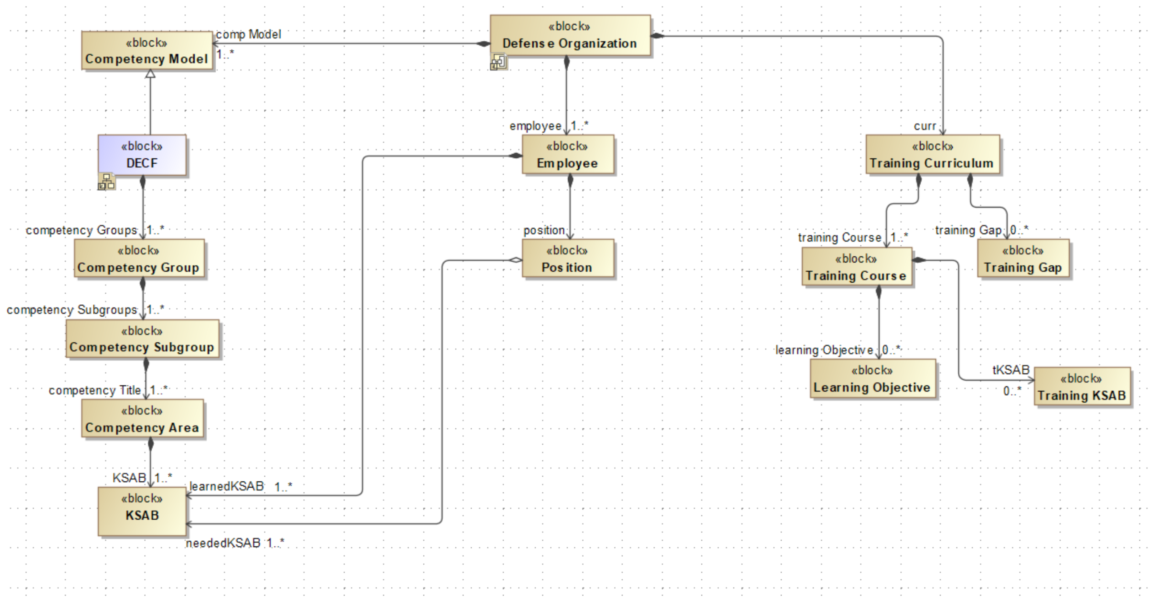


Figure 2. BDD of the DECF Context Within a Defense Organization

Although images captured from the SysML model may yield some insights to any person, attempting to browse model information natively is often inefficient and infeasible. Instead, an open-source tool called OpenMBEE was incorporated to generate text-based documents directly from model elements. (OpenMBEE, 2020). These documents were generated in, and accessible through, a web-based interface called View Editor. The View Editor interface not only allowed for easier sharing of model documents, but it also for direct commenting and modification of model elements. This modeling approach allowed reviews to take place in a DE environment using the online View Editor interface—giving potential users real-life experience using the required competencies—and it improved the visibility and collection of review feedback and facilitates its implementation. The model established an authoritative source for the DECF and followed DE practices for model management.

Digital Engineering Competency Framework v. 1.1

The DECF begins with the data foundations that are required for an effective digital environment ("Data Engineering"). The competency groups constitute how DE takes full advantage of the digital power of computation, visualization, and communication to take better, faster actions throughout the life cycle. These competency groups can be seen as supporting the four elements of John Boyd's OODA loop: Observe, Orient, Decide, and Act. Data Engineering guides how to observe, ensuring that data is acquired, curated, compressed, secured, and prepared. Next, Modeling and Simulation provide the ability to orient this data to describe and understand a phenomenon of interest. Decision Making utilizes analysis tools and techniques to make appropriate decisions. Finally, Engineering Methods are used to transform these decisions into engineering actions (Figure 3).

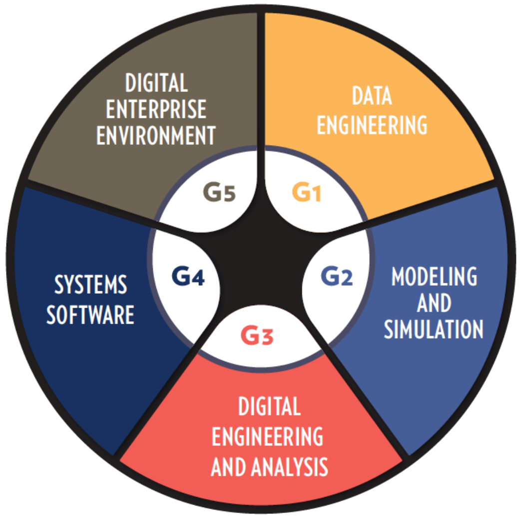


Figure 3. DECF Competency Groups

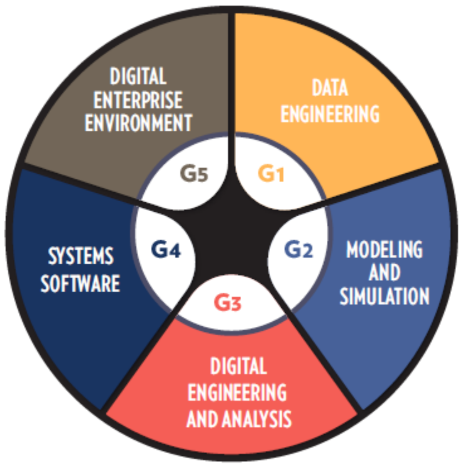
There are five competency groups identified for the DECF, as shown in Figure 4, along with a foundation of general digital competencies. Competency groups provide a logical structure for the individual competencies, making the DECF easier for users to understand and utilize. The groups in Figure 4 are intended to provide a holistic perspective of all the skills required to provide value in a digital environment. The five competency groups are defined in Table 1.

Table 1. Descriptions of DECF v. 1.1 Competency Groups

ID	Competency Title	Competency Description
G1	Data Engineering	Apply knowledge on how to acquire, curate, compress, secure, and prepare data resulting from a DE environment. Create or support data-focused processes. Data could originate from modeling and simulation, or from sensors in the physical world.
G2	Modeling and Simulation	Use of digital models to describe and understand phenomena of interest from initiation of the effort through the entire life cycle maturation. Model literacy—understanding what models are and how they work—is required to move into more advanced skills, from the ability to build a model using appropriate tools, standards, and ontology to creating a modeling environment.
G3	Digital Engineering and Analysis	Apply traditional engineering methods and processes in a digital environment. Create new engineering processes and methods for a digital environment. Create digital artifacts throughout the project or system life cycle. Use engineering methods, processes, and tools to support the engineering and system life cycle.
G4	Systems Software	Apply technical knowledge in various software or coding languages to create, support, and maintain applications. This includes the abilities to understand, apply, problem solve, create, and critique software in pursuit of particular learning and professional goals.
G5	Digital Enterprise Environment	Use the foundations of data, modeling, and software to create and maintain the digital enterprise. This requires creating the environment in which digital engineers, discipline and domain engineers, program managers, and decision-makers work.

The five competency groups are broken into nine competency subgroups and 31 competencies (including six foundational digital competencies). The competency hierarchy includes competency groups (G#), subgroups (S#), and individual competencies (C#). Where appropriate, the competency groups are divided into subgroups. Subgroups contain related like competencies. The competency hierarchy provides a logical structure for the individual competencies, making the DECF easier for users to understand and utilize. The hierarchy structure provides an overview of all the skills required to provide value in a DE environment regardless of specific roles. The overarching structure is shown in Figure 4.

DIGITAL ENGINEERING COMPETENCY FRAMEWORK (DECF) VERSION 1.1



FOUNDATIONAL DIGITAL COMPETENCIES	
F1	Digital Literacy
F2	Digital Engineering Value Proposition
F3	DoD Policy/Guidance
F4	Coaching and Mentoring
F5	Decision Making
F6	Software Literacy

LEGEND:
C# - Competency Title
F# - Foundational Competency Title
G# - Competency Group
S# - Competency Subgroup

G1 DATA ENGINEERING			
S1	Data Engineering	C1	Data Governance
		C2	Data Management

G2 MODELING AND SIMULATION			
S2	Modeling and Simulation	C3	Modeling
		C4	Simulation
		C5	Artificial Intelligence/Machine Learning
		C6	Data Visualization
		C7	Data Analytics

G3 DIGITAL ENGINEERING AND ANALYSIS			
S3	Digital Systems Engineering	C8	Digital Architecting
		C9	Digital Requirements Modeling
		C10	Digital Validation and Verification
		C11	Model-Based Systems Engineering Processes
S4	Engineering Management	C12	Digital Model-Based Reviews
		C13	Project and Program Management
		C14	Organizational Development
		C15	Digital Engineering Policy and Guidance
		C16	Configuration Management

G4 SYSTEMS SOFTWARE			
S5	Systems Software	C17	Software Construction
		C18	Software Engineering

G5 DIGITAL ENTERPRISE ENVIRONMENT			
S6	Digital Enterprise Environment Development	C19	Digital Environment Development
S7	Digital Enterprise Environment Management	C20	Management
		C21	Communications
		C22	Planning
S8	Digital Enterprise Environment Operations and Support	C23	Digital Environment Operations
		C24	Digital Environment Support
S9	Digital Enterprise Environment Security	C25	Digital Environment Security

Figure 4. Overview of DECF v. 1.1

Any acquisition role is likely to require some skills from each of these competencies in a digital environment; however, no role should require all the skills in every competency in each group at top proficiency level. The specific competency, proficiency levels, and KSABs required for an individual are dependent upon the role(s) being played.

Each of the competencies listed in Figure 4 is defined in the addendum at the end of this paper.

Proficiency Levels

In compliance with DoD Instruction 1400.25, each competency is broken down into KSABs relevant to proficiency levels within each competency (DoD, 2016). Not every individual will fully obtain all the competencies. The individual's proficiency level must be assessed to understand the true status of the workforce with respect to DE. Proficiency is the level to which an individual attains a competency, as illustrated in Table 2.

Table 2. Proficiency Levels of DECF v. 1.1

Proficiency Level	0	1	2	3	4	5
	None	**Awareness**	**Basic** General Knowledge (Entry)	**Intermediate** General Knowledge (Junior)	**Advanced** Detailed Knowledge (Senior)	**Expert** In-Depth Knowledge (SME)
Definition	No experience with or knowledge of the competency.	Applies the competency in the simplest situations.	Applies the competency in somewhat difficult situations.	Applies the competency in difficult situations.	Applies the competency in considerably difficult situations.	Applies the competency in exceptionally difficult situations.
		Requires close and extensive guidance.	Requires frequent guidance.	Requires occasional guidance.	Generally requires little or no guidance.	Serves as a key resource and advises others.
		Demonstrates awareness of concepts and processes.	Demonstrates familiarity with concepts and processes.	Demonstrates understanding of concepts and processes.	Demonstrates broad understanding of concepts and processes.	Demonstrates comprehensive, expert understanding of concepts and processes.

DECF v. 1.1 contains 962 KSABs divided among these competency areas. Each represents a unique and important aspect of what will enable a successful digital transformation and productive DE practices. The distribution of these KSABs in terms of both their competency area and respective proficiency level is shown in Table 3.

Table 3.Distribution of KSABs in DECF v. 1.1

Competency Group	Competency	Total KSABs	Proficiency Level				
			Awareness	Basic	Intermediate	Advanced	Expert
G1 Data Governance	C1 Data Governance	48	3	11	7	14	13
	C2 Data Management	30	2	7	1	14	6
G2 Modeling and Simulation	C4 Modeling	122	11	25	36	35	15
	C5 Simulation	56	8	8	16	16	8
	C6 Artificial Intelligence/Machine Learning	32	2	19	8	3	0
	C7 Data Visualization	22	2	4	12	2	2
	C3 Data Analytics	47	2	5	12	17	11
G3 Digital Engineering and Analysis	C8 Digital Architecting	55	3	14	18	18	2
	C9 Digital Requirements Modeling	24	1	3	15	4	1
	C10 Digital Validation and Verification	13	2	2	6	3	0
	C11 Model-Based Systems Engineering	108	11	33	17	35	12
	C12 Digital Model-Based Reviews	15	2	1	6	5	1
	C13 Project and Program Management	42	2	18	12	7	3
	C14 Organizational Development	18	1	2	1	4	10
	C15 Digital Engineering Policy and Guidance	23	1	3	2	7	10
	C16 Configuration Management	19	1	3	5	8	2
G4 Systems Software	C17 Software Construction	18	1	8	3	5	1
	C18 Software Engineering	47	3	5	5	24	10
G5 Digital Enterprise Environment	C19 Digital Environment Development	47	1	15	3	15	13
	C20 Management	28	2	2	1	10	13
	C21 Communications	12	1	2	1	3	5
	C22 Planning	11	1	2	2	3	3
	C23 Digital Environment Operations	27	3	4	8	10	2
	C24 Digital Environment Security	42	6	2	7	16	11
	C25 Digital Environment Support	56	2	5	12	22	15
		962	74	203	216	300	169

The KSABs within each competency are specifically targeted to DE. Therefore, a broader competency area like Communications has a relatively low number of KSABs related to DE, while a specific area like Model-Based Systems Engineering Processes, that is intrinsically linked with DE, has many KSABs.

It is also interesting to note the distribution of the KSABs across the five proficiency levels. KSABs at the Awareness and Basic levels represent broad fundamentals within a competency area, while KSABs at the Advanced and Expert levels include the practice of specific techniques that make up the various applications of the competency area. The DECF is established to be a general framework that can be used to create specific competency models that will be tailored based on component implementation of the Digital Engineering Strategy. As a result, the KSABs must cover the breadth of potential DE practices, even if all these practices are not utilized within every organization.

Cross-Cutting Elements in the DECF

Because there is not a specific competency surrounding them, it could be perceived that some relevant key elements in DE are not included in the DECF. The DECF is structured in a manner that concisely captures the breadth of DE enabling skills with a minimal number of competencies. Most technologies are inherently multidisciplinary in practice, and so creating distinct competencies for each potentially relevant technology would create significant overlaps in the framework. To demonstrate this potential overlap, three noteworthy cross-cutting DE elements were identified and analyzed:

- **Digital Twin:** An integrated multiphysics, multiscale, probabilistic simulation of an as-built system, enabled by Digital Thread, that uses the best available models, sensor information, and input data to mirror and predict activities/performance over the life of its corresponding physical twin.
- **Digital Thread:** An extensible, configurable, and component enterprise-level analytical framework that seamlessly expedites the controlled interplay of authoritative technical data, software, information, and knowledge in the enterprise data-information-knowledge systems, based on the Digital System Model template, to inform decision-makers throughout a system's life cycle by providing the capability to access, integrate, and transform disparate data into actionable information.
- **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.

These elements are all enablers of the digital transformation of the DECF. An analysis of the DECF showed that each of these technologies had several dozen corresponding KSABs across various competencies. There were 55 KSABs related to Digital Artifacts spread across ten different competencies, 32 KSABs related to Digital Twin found in seven competencies, and another 32 KSABs related to Digital Thread in 11 different competencies. Each of these elements has more associated KSABs than several of the individual competencies included in the DECF. However as shown in Figure 6, the spread of these KSABs across the variety of competencies demonstrates the inherent interdisciplinary nature of these elements and how much overlap would occur if they were uniformly included as their own competencies. The exception to this rule is the competency for AI/ML, which was deemed both vital for inclusion and unique in its content. In the future there may be some additional unique, self-contained elements that may also warrant their own competencies in future iterations of the DECF.

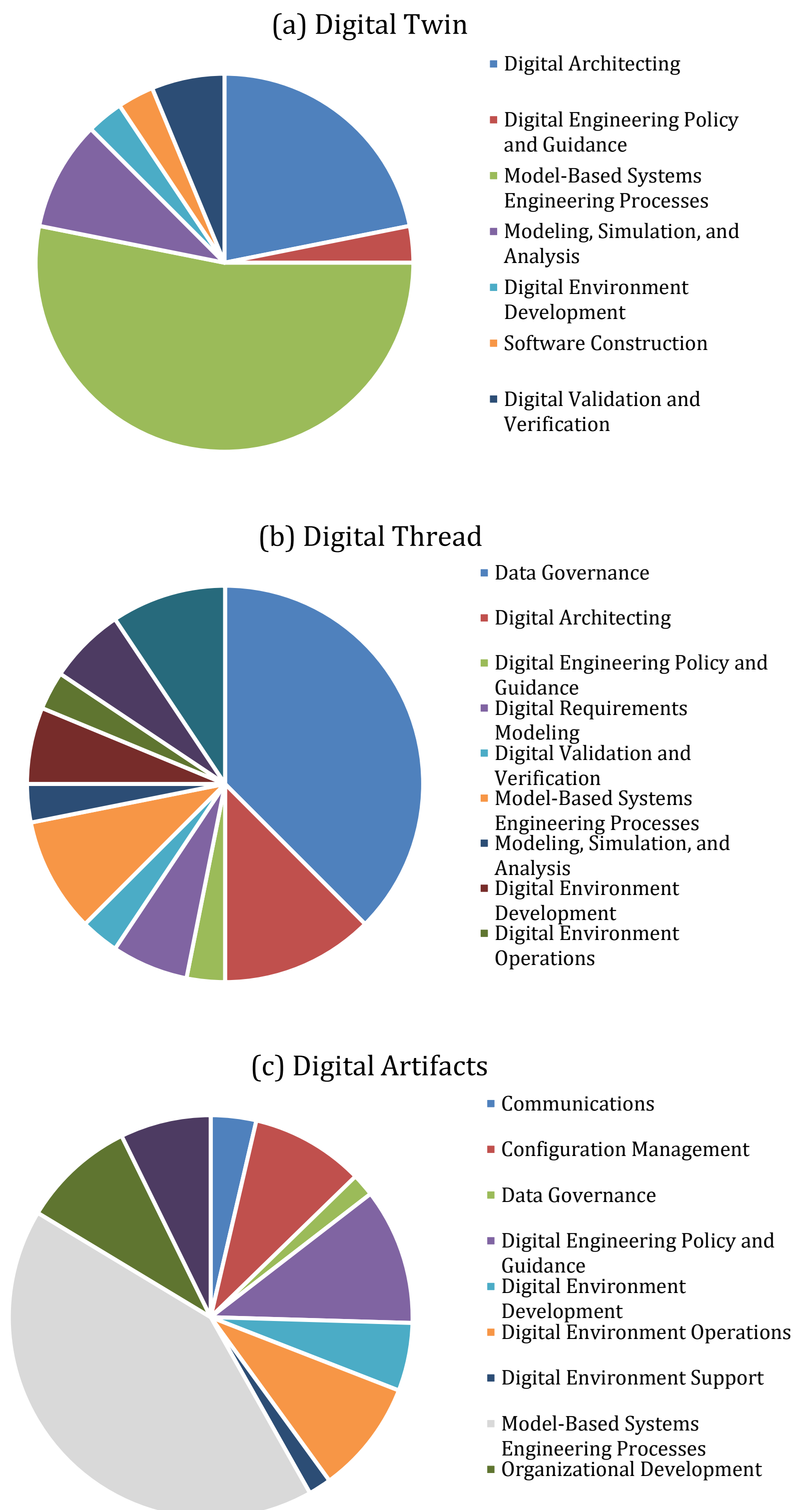


Figure 5. Distributions of Cross-Cutting Elements in the DECF: (a) Digital Twin; (b) Digital Thread; and (c) Digital Artifacts

Digital Engineering Competencies in DoD Resources

Using the DECF as a baseline, the team has been conducting a gap analysis using existing curriculum for digital engineering training in the DoD. Specifically, the team has investigated three courses:

- Defense Acquisition University (DAU) CLE084: Models, Simulations, and Digital Engineering;
- Coursera MBSE: Model Based Systems Engineering (currently utilized by the DAU); and
- MIT Architecture and Systems Engineering Program (utilized by NAVAIR), which includes relevant courses such as Models in Engineering and MBSE Documentation and Analysis.

The method used was to review course materials and attend the course as appropriate. Researchers captured the knowledge, skills, and abilities (KSAs) illustrated in the curriculum as well as the stated learning objectives. These were then compared against the KSABs in the DECF to determine the level of coverage and any major gaps. In addition, materials covered in the courses but not reflected in the DECF were flagged by the team for consideration and, where appropriate, incorporated into the DECF.

The key recommendations based on this analysis are outlined here. Additional details on the analysis can be found in (Hutchison et al., 2021).

The current courses in use by the Defense Acquisition University (DAU; DAU's internal course CLE084 and Coursera's MBSE course) are useful for providing a common foundation and orientation to the terminology and benefits of MBSE and DE. They would help individuals attain "Awareness" or "Basic" proficiencies—understanding of the concepts and in some instance the ability to apply them with heavy guidance or supervision. They are particularly helpful for individuals who have no background in systems engineering or modeling or who are firmly entrenched in a document-based acquisition approach. However, seasoned systems engineers and engineers would require substantially deeper training to become practitioners of DE.

Based on mapping of the DECF to the limited course materials available online for the MIT Architecture and Systems Engineering Program, the team found that the courses provided a solid fundamental understanding of models in engineering, MBSE, systems engineering, and digital architecting. In some cases, individuals can obtain proficiencies as high as the "Advanced" level. This program is recommended by NAVAIR for individuals who are facilitating change in their departments or organizations as they transition towards digital transformation.

Overall, the Department needs to:

- **Screen for foundational skills.** The DECF assumes a foundation of skills on which to build digital engineering competency. However, when it comes to training, this foundation cannot be assumed. The DoD needs to implement some basic screening approaches to ensure that individuals who do not have this foundation are offered opportunities to build it. Courses like DAU's CLE084 and Coursera's MBSE are already in use by the department and provide some of the necessary foundations. But it is important that only individuals who need these foundations utilize the resources, while individuals who will not gain proficiency through these courses be directed to other courses.
- **Introduce courses using modeling and simulation projects and problems as part of the curriculum.** As currently structured, CLE084 and Coursera MBSE training focus

on the lowest levels of proficiency. While Awareness level skills are a critical foundation on which to build skills for practical application of DE, they are not sufficient in and of themselves. Because up to 70% of learning is gained through experience (rather than classroom instruction), creating models and simulations that students can use to practice the skills of the task is paramount.

Ideally, implementation of modeling and simulation projects would impact not only DE-focused curriculum but could help enable a variety of disciplines for digital transformation. A modeling environment that spans, for example, the ENG and PM training courses at DAU would enable systems engineers and program managers to improve their familiarity with working in a digital environment before they are exposed to DE-specific training.

- **Include coaching and mentoring as part of the longer-term curriculum.** While coaching and mentoring can be applied within a single course, it would be most beneficial if longer-term coaching relationships were established specifically around the transition to DE in the DoD. The DAU may be in a unique position to broker such coaching opportunities, allowing individuals the opportunities to apply their DE knowledge on the job with expert guidance.

Future Work

The DECF provides only a starting point for updating the skills of the Defense acquisition workforce. In order to move forward, the DECF must be integrated into efforts such as the Office of the Under Secretary of Defense for Research and Engineering (OUSD [R&E]) and in particular, the Engineering and Technical Management (ETM) competency framework. The DECF and related competencies need to be understood and embraced by the workforce, including not only individuals playing primary roles in acquisition but their management and leadership as well. A baseline assessment against these competencies will be a critical first step to understanding how far along the path of digital transformation the workforce has come and in developing a plan to help the workforce continue to grow along this path.

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Addendum

Tables 4–8 display the specific competencies contained within the competency hierarchy shown in Figure 6.

Table 4. Competencies in the Data Engineering Group in DECF v. 1.1.

Subgroup	#	Competency	Description
S1-Data Engineering	C1	Data Governance	Data governance is a collection of practices and processes that help to ensure the formal management of data assets within a digital enterprise. Data governance practices help an enterprise gain better control over its data assets, including methods, technologies, and behaviors around the proper management of data. Data governance also entails security and privacy, integrity, usability, integration, compliance, availability, roles and responsibilities, and overall management of the internal and external data flows within an organization.
	C2	Data Management	Data management is applying policies, procedures, and information technology to plan for, acquire, access, manage, protect, and use data of a technical nature to support the total life cycle of the system. Data management includes verifying that all the data are secure, collected, documented, and archived along with descriptions of data to ensure completeness of data collected. Data management also ensures the distribution of data is in accordance with the data management plan for analysis.

Table 5. Competencies in the Modeling and Simulation Group in DECF v. 1.1.

Subgroup	#	Competency	Description
S2 Modeling and Simulation	C3	Modeling	Modeling is essential to aid in understanding complex systems and system interdependencies, and to communicate among team members and stakeholders.
	C4	Simulation	Simulation provides a means to explore concepts, system characteristics, and alternatives; open the trade space; facilitate informed decisions and assess overall system performance.
	C5	Artificial Intelligence/ Machine Learning	Artificial intelligence (AI) is the ability of machines to perform tasks that normally require human intelligence. Machine Learning (ML) is the application of AI that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it to learn for themselves.
	C6	Data Visualization	Data visualization is the creation of graphic representations of data, particularly to improve communication about that data. Data visualization is also the ability to identify patterns, trends, and correlations in the data and place them in a visual context to describe their importance. This entails building and managing data visuals, models, and artifacts.
	C7	Data Analytics	This is the process of inspecting, cleansing, transforming, modeling, and simulating data with the goal of discovering useful information, informing conclusions, and supporting decision making.

Table 6. Competencies in the Digital Engineering and Analysis Group in DECF v. 1.1.

Subgroup	#	Competency	Description
S3 Digital Systems Engineering	C8	Digital Architecting	Digital architecture activities use digital models to define a comprehensive digital system model based on principles, concepts, and properties logically related to and consistent with each other. Digital architecture has features, properties, and characteristics that satisfy, as far as possible, the problem or opportunity expressed by a set of system requirements (traceable to mission/business and stakeholder requirements) and life cycle concepts (e.g., operational, support) and which are implementable through digital enterprise related technologies. Digital architecture competencies relate to the ability to create system digital models and required architectural products and digital artifacts for a system or system-of-systems in accordance with applicable standards and policies.
	C9	Digital Requirements Modeling	Digital requirements modeling refers to being able to capture stakeholder high-level requirements by documenting stated needs in the form of a model, assist in the clarification and translation of need statements into a more digital engineering-oriented basis, create and derive system requirements, that are related to the system architecture definition. It is also used to establish requirements traceability throughout the digital model architecture; examine the relationships of requirements to digital artifacts, and trace design solutions to requirements; and ensure designs can be traced to the system capabilities and requirement sets within digital enterprise environment.
	C10	Digital Validation and Verification	Digital verification is the process for determining whether or not a product fulfills the requirements or specifications established for it, by using digital models and artifacts for testing and verification. Enabling this practice is important to ensure that digital practices correlate well with their real-world projects.
	C11	Model-Based Systems Engineering Processes	Model-based systems engineering is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.
S4 Engineering Management	C12	Digital Model-Based Reviews	Digital model-based reviews define the series and sequence of model-based systems engineering activities that bring stakeholders to the required level of commitment, prior to formal reviews. It utilizes system models, artifacts, and products for analysis of design and technical reviews to execute trade-off and design analyses, prototyping, manufacturing, testing, and sustainment of the system.
	C13	Project and Program Management	Project management is the planning, coordinating, and monitoring of the work activities needed to deliver a product, service, or enterprise endeavor within the constraints of schedule, budget, resources, infrastructure, and available staffing and technology.
	C14	Organizational Development	Organizational development focuses on developing organizational policies, standards, and guidelines for model-based systems engineering methods and artifacts.

Subgroup	#	Competency	Description
	C15	Digital Engineering Policy and Guidance	Digital engineering policy and guidance focuses on identifying process improvements to model-based engineering methods and contributing to organization of system life cycle development standards and definition of best practices. It includes defining strategy and approach to be used for modeling and analysis of complex systems.
	C16	Configuration Management	Configuration management refers to the development of configuration management strategies, policies, standards, and guidelines for digital engineering related artifacts in accordance with model-based systems engineering methods.

Table 7. Competencies in the System Software Group in DECF v. 1.1.

Subgroup	#	Competency	Description
S5 Systems Software	C17	Software Construction	Software Construction refers to the detailed creation of working software through a combination of coding, verification, unit testing, integration testing, and debugging.
	C18	Software Engineering	Software Engineering is the systematic application of digital engineering approaches to the development of software.

Table 8. Competencies in the Digital Enterprise Environment Group in DECF v. 1.1.

Subgroup	C#	Competency	Description
S6 Digital Enterprise Environment Development	C19	Digital Environment Development	A digital enterprise environment is an integrated digital development framework in which digital models and representations are interconnected such that the content and activities within it are managed to accomplish the organizational objectives of the enterprise.
S7 Digital Enterprise Environment Management	C20	Management	Management in the digital enterprise environment aims to deliver a framework that ensures transformational processes in enterprises occur with pace, high-quality, and security. This is achieved through a set of IT solutions that are designed to make digital businesses fast, seamless, and optimized at every level.
	C21	Communications	Communications include using digital model artifacts from the digital enterprise environment to investigate and manage the adoption of appropriate model-based tools, techniques, and processes for the operation of digital enterprise environment systems and services. Communications also establishes the appropriate guidance to enable transparent decision-making to be accomplished, allowing senior leaders to ensure the needs of principal stakeholders are understood, the value proposition offered by digital enterprise environment is accepted by stakeholders and the evolving needs of the stakeholders and their need for balancing benefits, opportunities, costs, and risks is embedded into strategic and operational plans.
	C22	Planning	Planning in the digital enterprise environment includes establishing strategies to monitor and manage the performance of digital artifacts and services, in respect to their contribution towards enterprise performance goals. Planning ensures that a framework of policies, standards, processes, and practices is in place to guide provision of

Subgroup	C#	Competency	Description
			digital enterprise environment services, and that suitable monitoring of the governance framework is in place to report on adherence to these obligations.
S8 Digital Enterprise Environment Operations and Support	C23	Digital Environment Operations	Operations within the digital enterprise environment include creating digital models and simulation artifacts and technology roadmaps, and sharing knowledge and insights from processes and results, with others. It encourages adoption to changes in the digital enterprise environment process or technology. It includes setting parameters for the prioritization of digital resources and the changes to be implemented and the configuration of digital engineering methods and tools to address the project needs.
	C24	Digital Environment Support	Support within a digital enterprise environment includes abilities to develop, mature, and implement methods and processes to support digital enterprise environment activities across the enterprise and life cycle.
S9 Digital Enterprise Environment Security	C25	Digital Environment Security	Digital Environment Security includes developing policies, standards, processes, and guidelines to ensure the physical and electronic security of digital environments and automated systems. This includes performing security risk and vulnerability assessments, and business impact analyses related to security and information assurance in the digital enterprise environment. It is intended to provide advice and guidance on the application and operation of digital environment physical, procedural, and technical security controls.

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