SYSTEMS ENGINEERING RESEARCH CENTER

WRT 1006: Digital Engineering Competency Framework

Sponsor: OUSD(R&E) | CCDC

By

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11th Annual SERC Sponsor Research Review

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FHI 360 CONFERENCE CENTER

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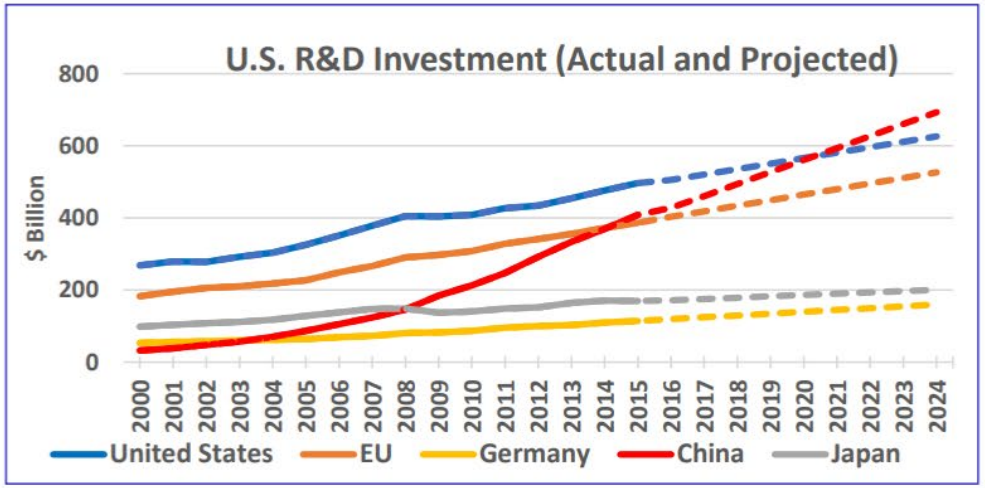
Outline

- Background & Objectives
- Methodology
- Results
  - —Taxonomy Framework
  - —Examples
  - —Gaps Analysis
- Next Steps

The World Today

Technology Is Transforming the Battlespace

- The proliferation of knowledge and technology erodes historic U.S. advantages
- Our near-peers are increasing their rate of investment in military R&D
- A hyper-competitive environment for National Security technologies
- The discriminators are speed and cycle time



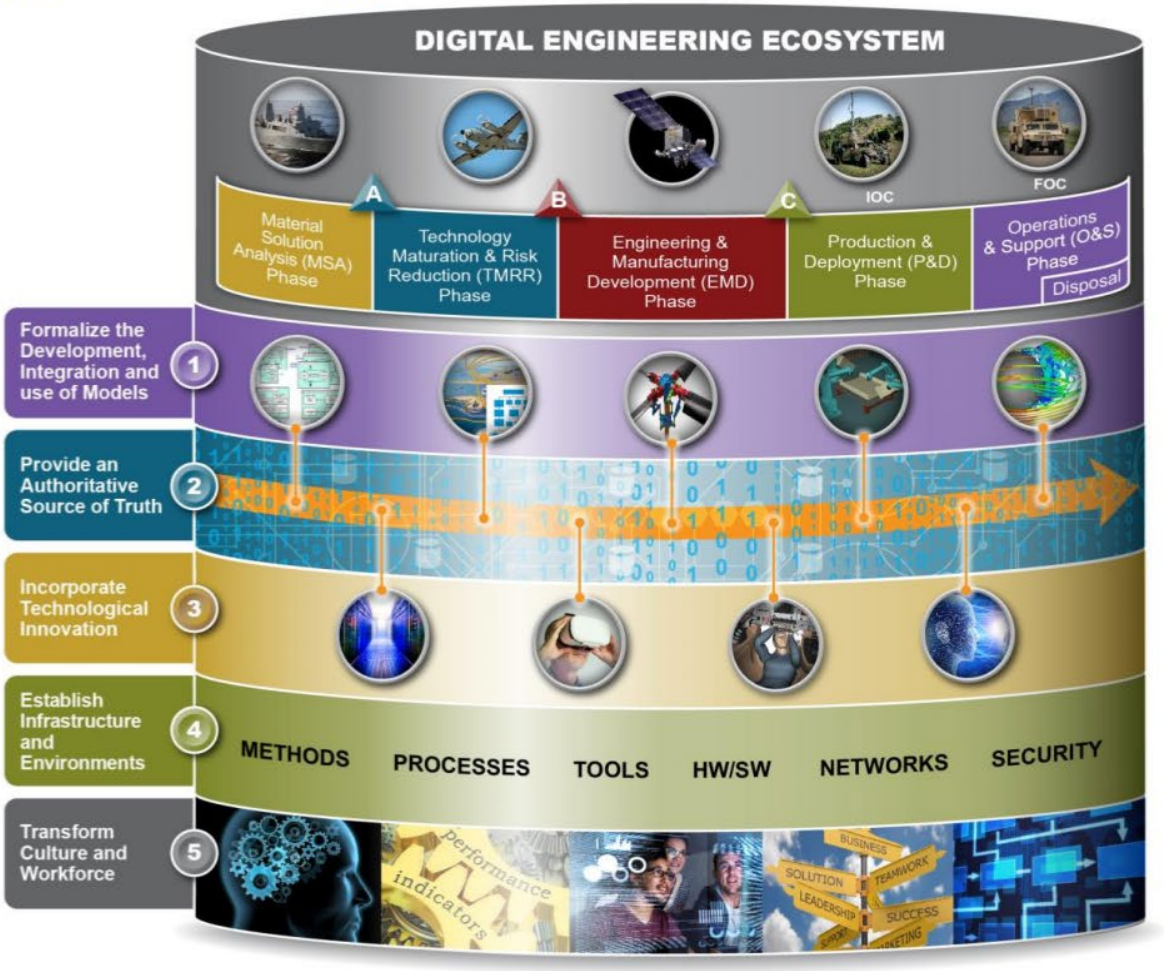
- NSF 2015 data predicted R&D investment parity with China in 2020
- Feb 2018, NSB estimates China R&D investment parity with U.S. by end of 2018

- 2017 GLOBAL R&D FUNDING FORECAST WINTER 2017 Industrial Research Institute, R&D Magazine

R&D – Research & Development
NSB – National Science Board

Digital Engineering Overview

- **What is Digital Engineering?**
  - Combines model-based techniques, digital practices, and computing infrastructure
  - Enables delivery of high pay off solutions to the warfighter at the speed of relevance
- **Reforms Business Practices**
  - Digital enterprise connects people, processes, data, and capabilities
  - Improves technical, contract, and business practices through an authoritative source of truth and digital artifacts



Modernizes how we design, operate, and sustain capabilities to outpace our adversaries

Goal 5: Transform the culture and workforce to adopt and support digital engineering across the lifecycle

Challenges

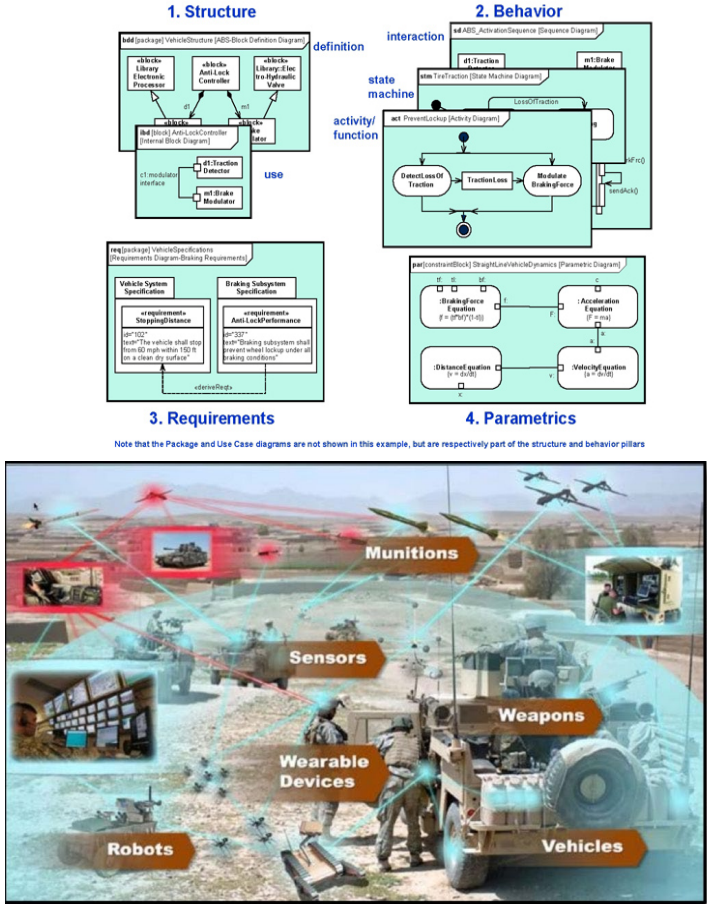
Topic	Short Description
Workforce Skills Training	Limited incentives workforce skills, insufficient training capacity and resources to meet the demand
Policy, Guidance, & Standards	Limited policies, guidance, and standards to comprehensively address digital engineering activities
Metrics	Lack of a common set of metrics that serve as leading indicators of adoption and effectiveness

Focus Areas

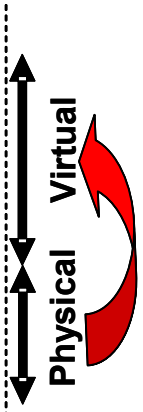
1. Improve the digital engineering knowledge base
2. Lead and support digital engineering transformation efforts
3. Build and prepare the workforce

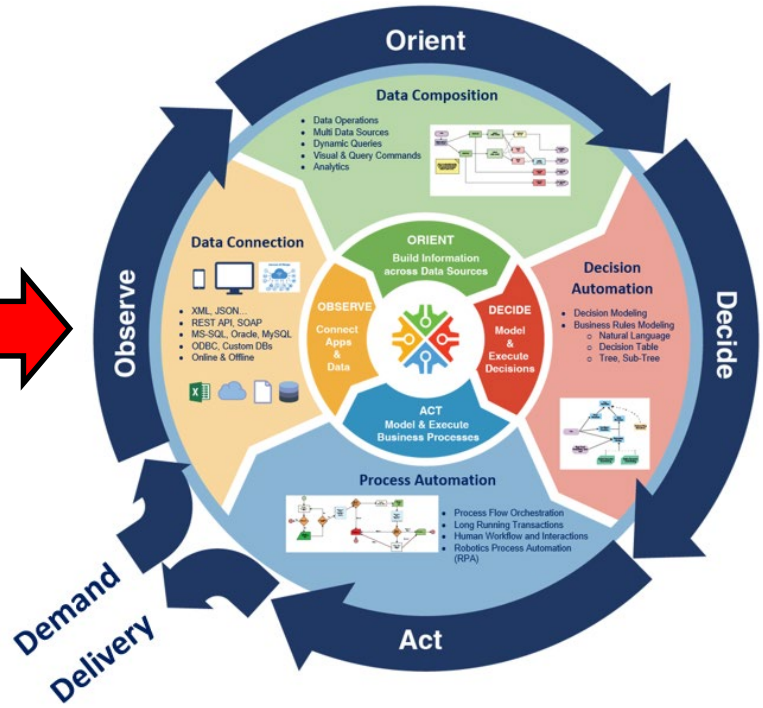
The Power of Digitalization

Exploiting the digital power of computation, visualization and communication to take better, faster actions



Dynamic System Validation





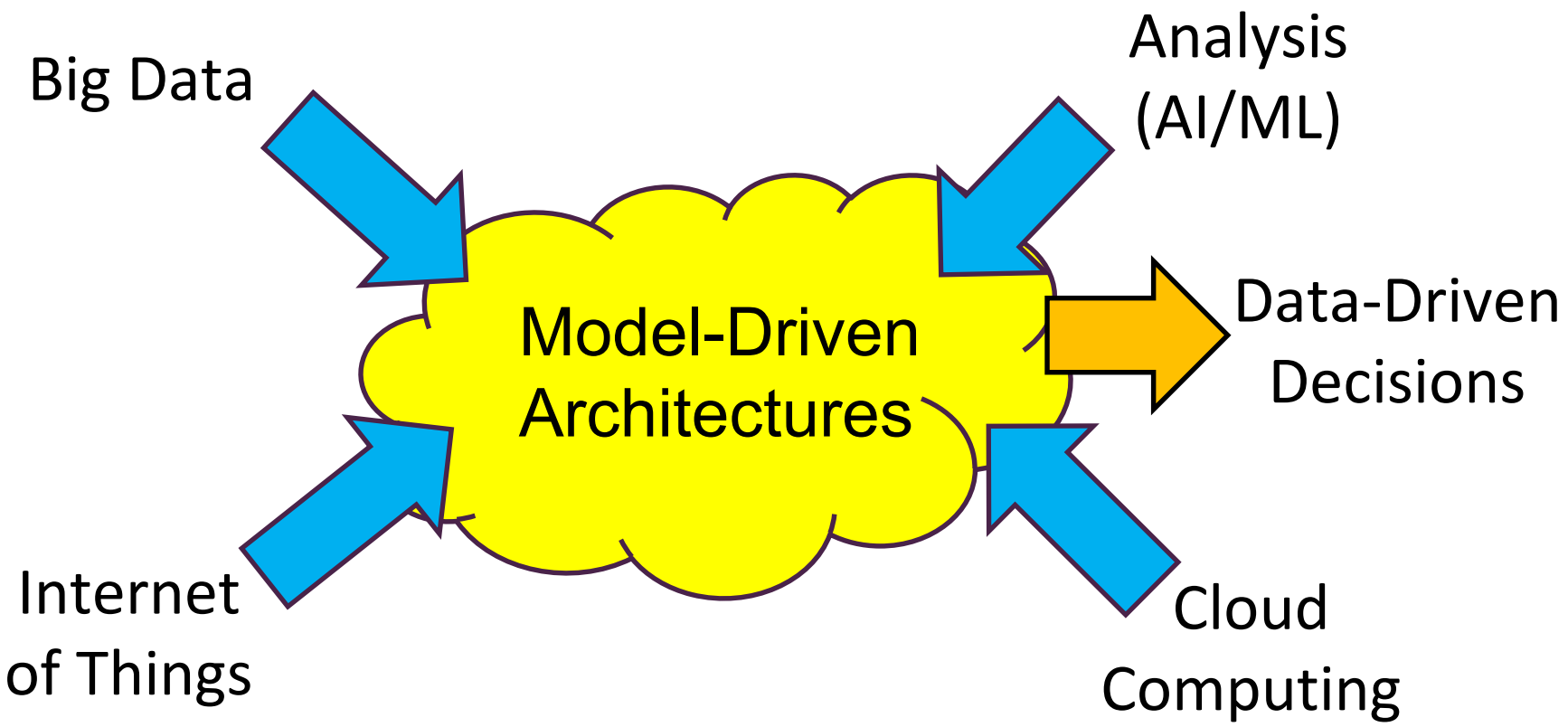
Systems Thinking & Digital Engineering

Digital engineering (DE):

- an engineering approach that captures and analyzes data that is in a digital format which is semantically rich and interconnected
- enables people to leverage the power of computing, visualization, and communication to significantly enhance efficiencies, quality, and innovation across the complex system development lifecycle

- Sandy Friedenthal, SERC DE Workshop, Nov. 15, 2019

Digital Convergence



DoD definition of model as 'a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process' (DoD 1998)

Thomas Siebel, "Digital Transformation: Survive and Thrive in an Era of Mass Extinction", 2019.

Research Needed

In support of the DoD's implementation of the Digital Engineering Strategy, researchers shall investigate the critical digital engineering knowledge, skills, and abilities needed by the DoD acquisition workforce. Researchers shall develop a Digital Engineering Competency Framework and take into consideration the following:

- Must support the implementation of 2018 Digital Engineering Strategy by each Component based on their organic DE processes and tools.
- Must be Component agnostic
- Must follow DoDI 1400.24 volume 250

Research Tasks

The SERC researchers shall perform seven tasks:

1. Define the digital engineering activities – and supporting competencies (knowledge, skills, and abilities) – required to support lifecycle phases from concept through disposal. These activities form the foundation of the Digital Engineering Competency Framework; and must include the considerations outlined above.

2. Building on task 1, identify aspects of the digital engineering lifecycle activities and competencies – that are specific, unique and relevant to the acquisition engineering (ENG) workforce.

3. Develop a Digital Engineering Competency Model, using the DoDI 1400.24 vol.250 “Competency Taxonomy. The competency model should be structured as follows:
   - Full set of digital engineering competencies
   - Subset of digital engineering competencies unique to the acquisition ENG workforce
   - Subsets of digital engineering competencies unique to the acquisition workforce broken out by career fields.

Research Tasks (cont.)

4. Based on the work done in task 1, map each competency set identified in task 3 to the lifecycle phase. This completes the Digital Engineering Competency Framework.

5. Conduct a gap analysis comparing Defense Acquisition University's (DAU) current curricula against the competency requirements.

6. Provide recommendations on creating a digital engineering curriculum as well as modifying the applicable acquisition career fields' curricula to build interdisciplinary digital engineering knowledge and abilities.

7. Map digital engineering knowledge and abilities to commercial job titles and job descriptions and requirements of Digital Engineering.

Use Cases

DECF use cases are a critical input into its design, structure, and scope. The critical objective is for the DECF to enable transformation of the acquisition workforce – in particular the ENG workforce – for successful acquisitions in a digital engineering environment. The following are some of these avenues:

- **Increase skills of current workforce**
  - —Workforce evaluation
  - —Career Planning
  - —Creating DE training programs
- **Grow workforce**
  - —Creating Position Descriptions
  - —Hiring for Digital Engineering Positions
- **Transform organization**
  - —Identifying Critical Roles

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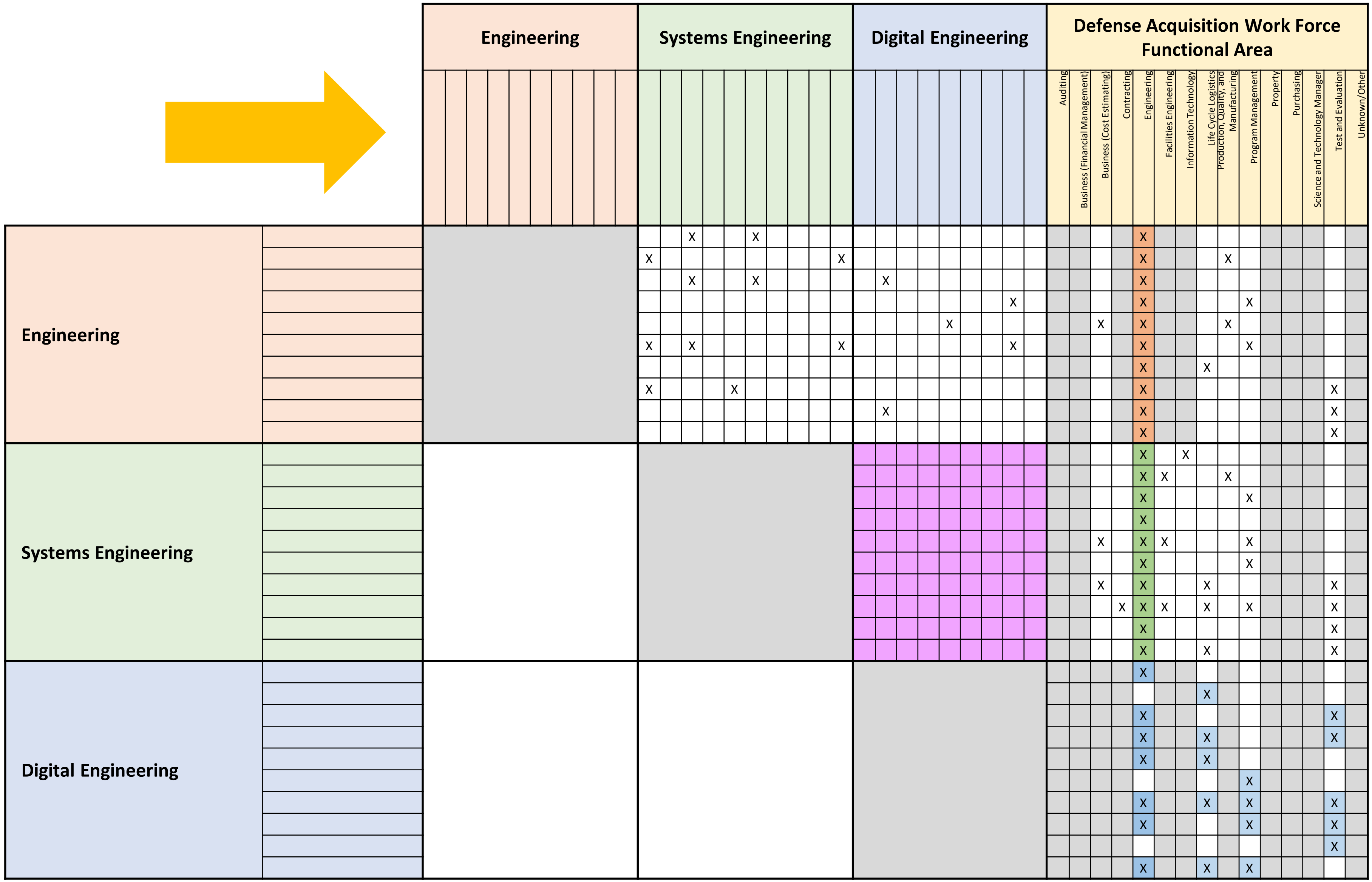
DECF Development Approach Methodology

- Zoom out to Big Picture for context
- Identify focus areas at intersections
- Approach from multiple directions simultaneously
  - Review existing material for DE specific competencies and KSAB
    - Develop a start on DECF Competencies, Definitions, and KSAB
  - Review SECCM* Competency Definitions, Tasks & Proficiency Levels for DE Enhancements
    - Inform development of DECF
    - Identify specific SECCM/ENG DE enhancement edits
  - Investigate SECCM/ENG competency models for gaps and opportunities

*Systems Engineering Competency Career Model

Big Picture Context Approach Map

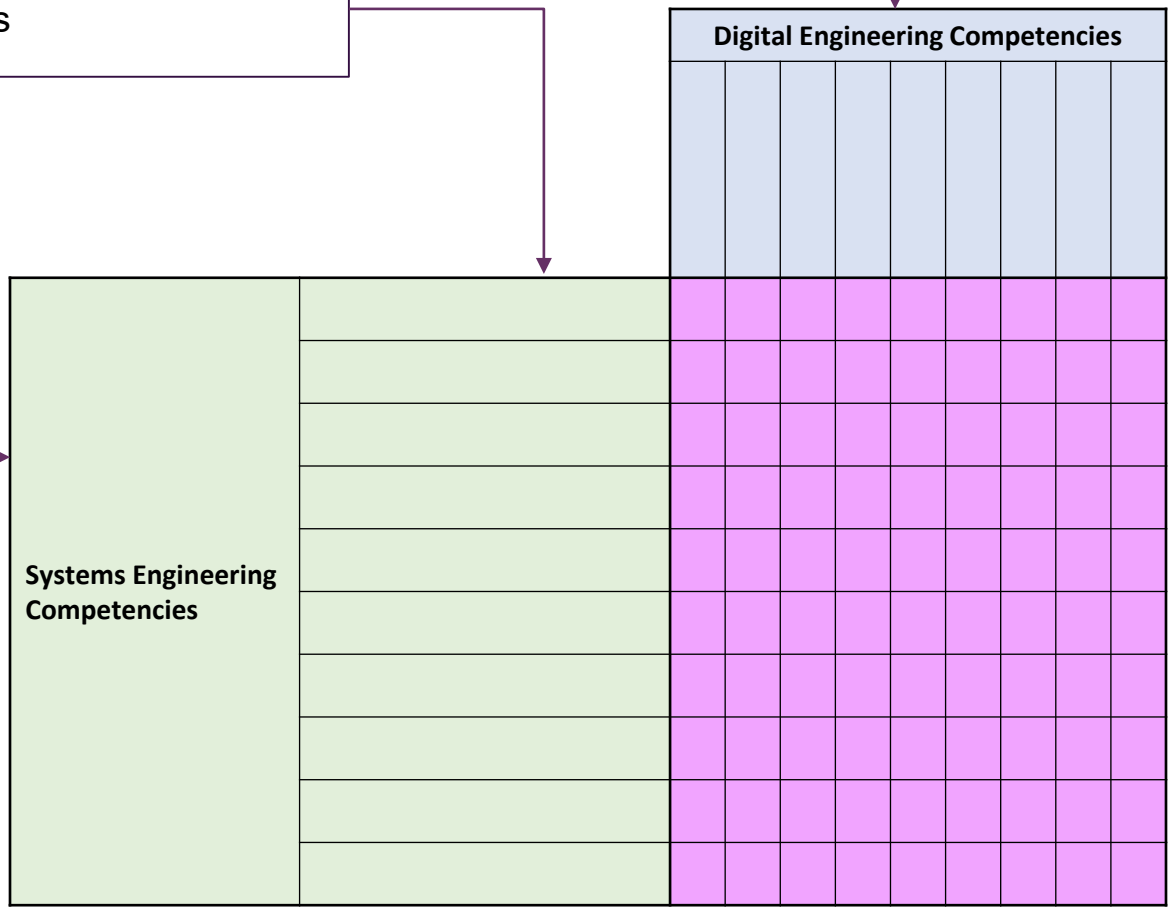


Cross Walking SE Competencies to Inform DECF

Reviewing Many SE Competency Models

Identifying SE Competencies and Gaps

Informing Development of DECF



Cross Walking DE to ENG/SECCM

Reviewing ENG/SECCM for DE Enhancements

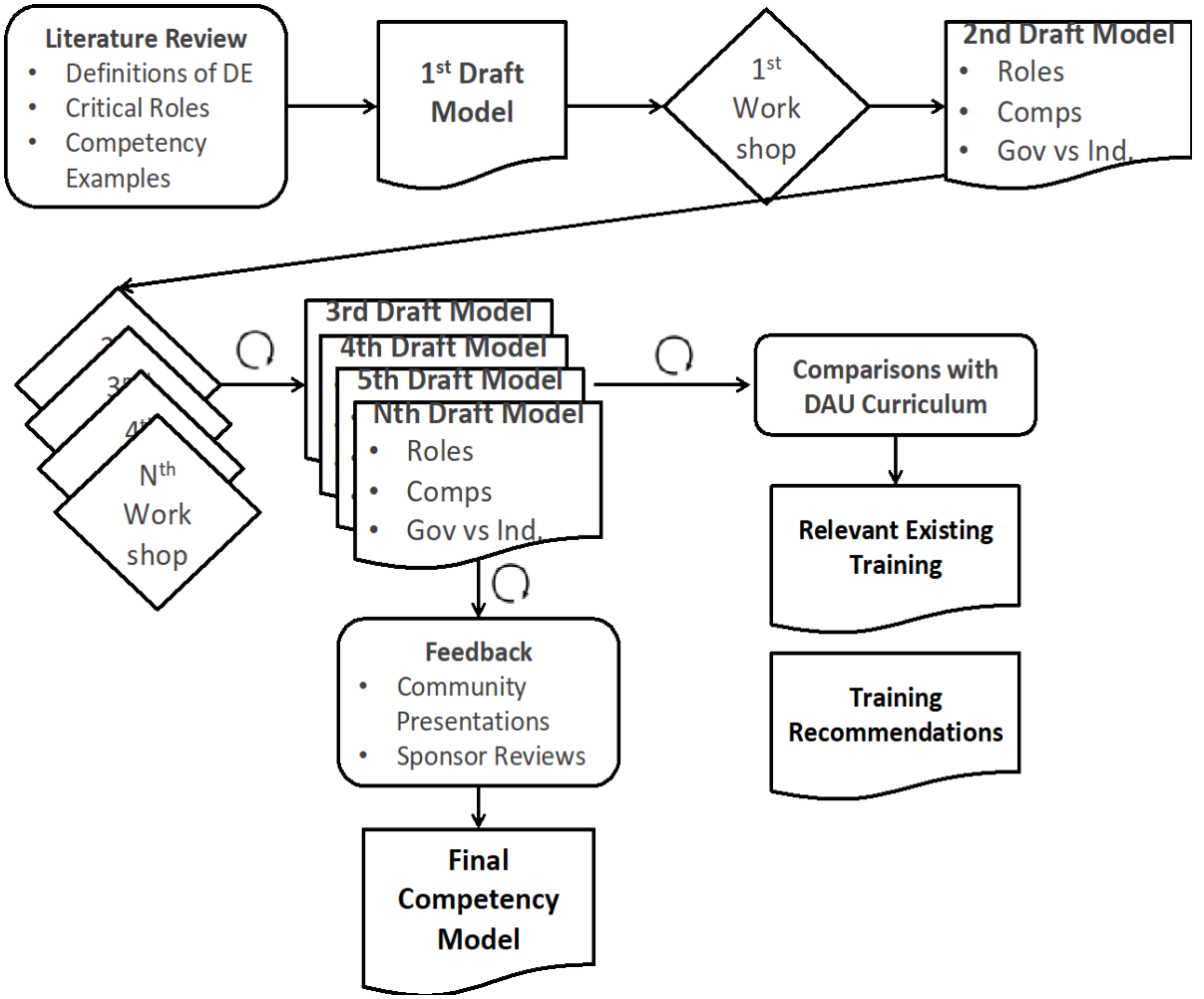
Mapping Between ENG/SECCM and DECF

Informing Development of DECF

	Defense Acquisition Work Force Functional Area														
	Auditing	Business (Financial Management)	Business (Cost Estimating)	Contracting	Engineering	Facilities Engineering	Information Technology	Life Cycle Logistics	Production, Quality, and Manufacturing	Program Management	Property	Purchasing	Science and Technology Manager	Test and Evaluation	Unknown/Other
Digital Engineering					X										
								X							
					X									X	
					X			X						X	
					X			X							
										X					
					X			X		X				X	
					X					X				X	
														X	
					X			X		X					

DECF Development Approach

- DECF will be developed through
  - —Workshops with SMEs and DE practitioners
  - —Review by SME panel
  - —Review by Sponsor, validating use models
  - —Broader Community Feedback



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Taxonomy

- Positions
- Roles
- Competencies
- KSABs
- Proficiencies

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ENG Career Field Competency Model

41 ENG Competencies				
1.0 Mission Level Assessment	10.0 Design Considerations	18.0 Data Management	26.0 Communication	34.0 Cost, Pricing, and Rates
2.0 Stakeholder Requirements Definition	11.0 Tools and Techniques	19.0 Interface Management	27.0 Coaching and Mentoring	35.0 Cost Estimating
3.0 Requirements Analysis	12.0 Decision Analysis	20.0 Software Engineering Management	28.0 Managing Stakeholders	36.0 Financial Reporting and Metrics
4.0 Architecture Design	13.0 Technical Planning	21.0 Acquisition	29.0 Mission and Results Focus	37.0 Business Strategy
5.0 Implementation	14.0 Technical Assessment	22.0 Problem Solving	30.0 Personal Effectiveness/Peer Interaction	38.0 Capture Planning and Proposal Process
6.0 Integration	15.0 Configuration Management	23.0 Strategic Thinking	31.0 Sound Judgment	39.0 Supplier Management
7.0 Verification	16.0 Requirements Management	24.0 Professional Ethics	32.0 Industry Landscape	40.0 Industry Motivation, Incentives, Rewards
8.0 Validation	17.0 Risk Management	25.0 Leading High-Performance Teams	33.0 Organization	41.0 Negotiations
9.0 Transition				

Analytical Technical Management Professional Business Acumen

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Systems Engineering Career Competency Model (SECCM) Background

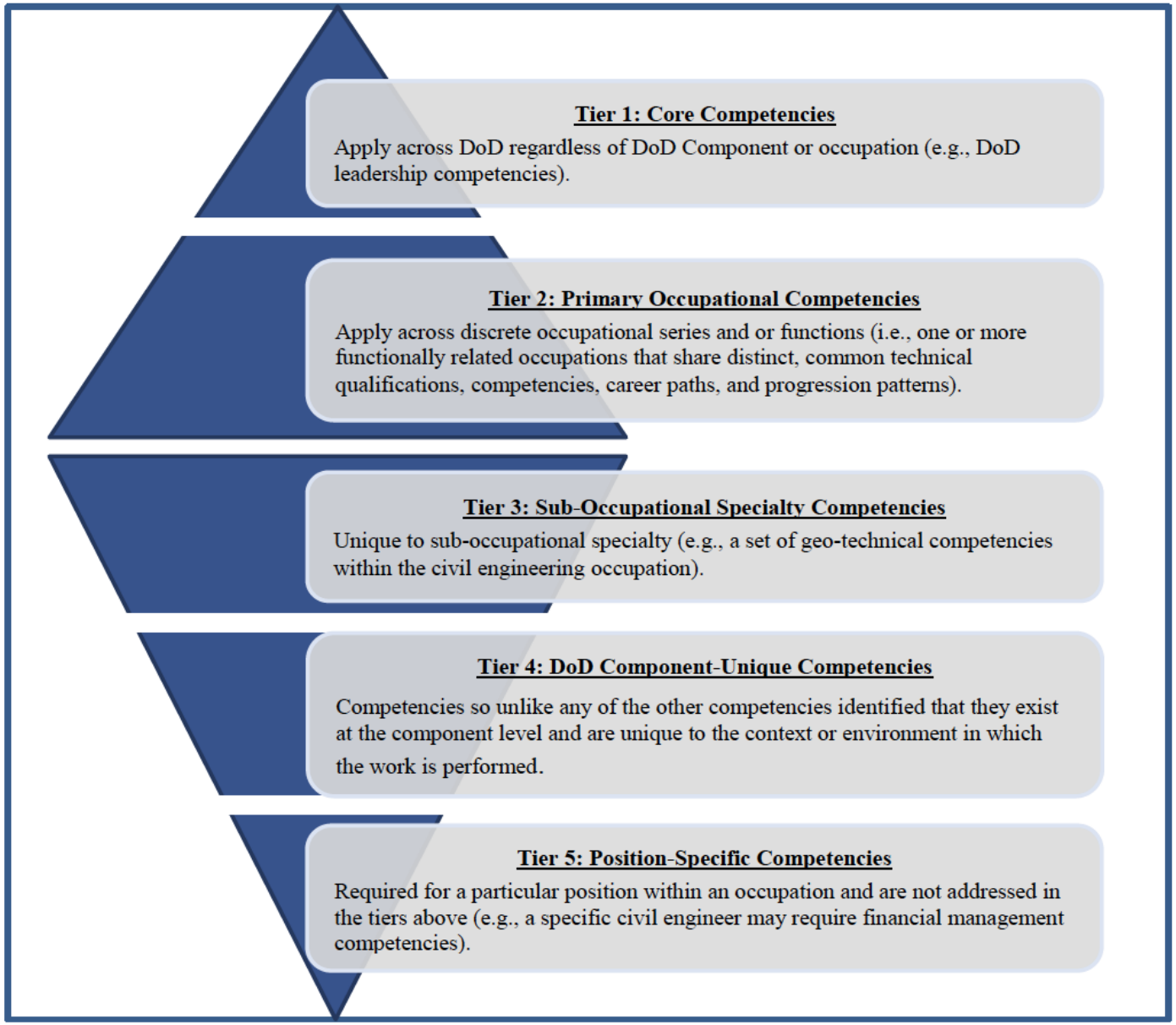
- The SECCM was aligned with the ENG model competencies to maintain consistency within DOD.
- The model was developed and verified by a collaborating team with members from the US Office of Personnel Management (OPM), Navy, Army, Air Force, Marine Corps, and the Missile Defense Agency to develop and verify the competencies used by defense systems engineers.
- OPM process used to ensure SECCM is verified IAW Uniform Guidelines on Employee Selection Procedures.
- Verification IAW Uniform Guidelines is critical to allow the SECCM to be used as a basis for “high stakes” human resource functions for all of the US Department of Defense.
- The US Deputy Assistant Secretary of the Navy, Research, Development, Test and Evaluation, sponsored the development of the SECCM.
- SECCM currently deployed by OCHR as the SECCM Competency Network.

Systems Engineering Career Competency Model

Technical Management	Business Acumen	Analytical	Professional
• Acquisition	• Industry Awareness	• Transition	• Communication
• Risk Management	• Organization	• Integration	• Leading High Performance Teams
• Requirements Management	• Cost Estimating	• Design Considerations	• Personal Effectiveness/Peer Interaction
• Configuration Management	• Proposal Process	• Tools and Techniques	• Problem Solving
• Technical Assessment	• Supplier Management	• Stakeholders Requirements Definition	• Professional Ethics
• Data Management	• Negotiations	• Requirements Analysis	• Strategic Thinking
• Software Engineering Management	• Cost, Pricing and Rates/Cost Management	• Validation	• Coaching & Mentoring
• Decision Analysis	• Financial Reporting and Metrics	• Verification	• Managing Stakeholders
• Interface Management	• Business Strategy	• Mission-Level Assessment	• Mission and Results Focus
• Technical Planning	• Industry Motivation, Incentives, Rewards	• Architecture Design	• Sound Judgment
	• *Contract Negotiations*	• Implementation	• *Continual Learning*
		• *Engineering Disciplines*	

The SECCM consists of 44 competencies and 179 tasks

Context: DoD-I 1400.25 vol 250



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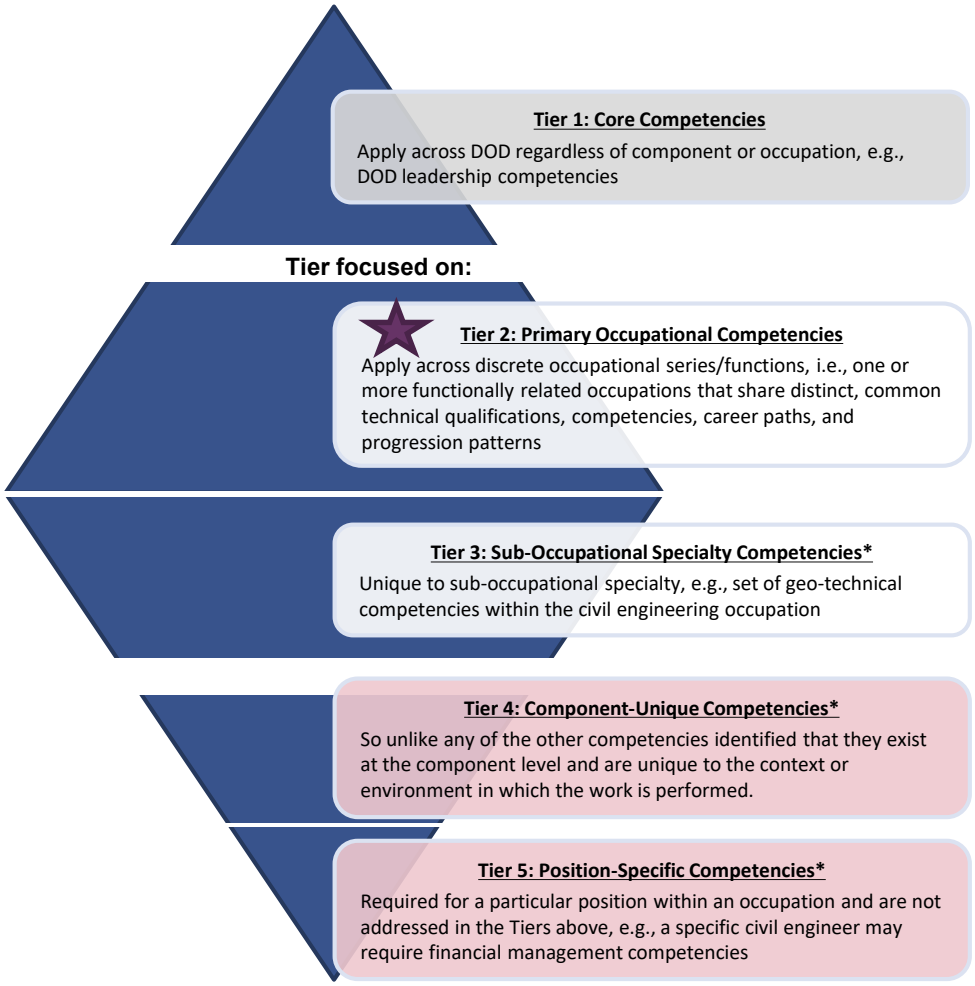
DOD-wide Competency Taxonomy

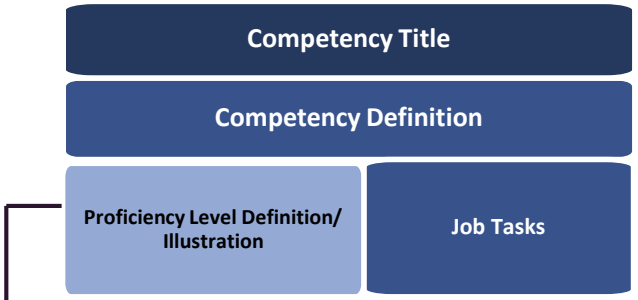
Five-Tiered Competency Framework



* To be developed at a later date

Competency Components

Each competency in the Five-Tier Framework is described by the following components:



Proficiency Levels (tied to assessments) indicate the degree to which employees performed a competency.

- Level 1 = Awareness
- Level 2 = Basic
- Level 3 = Intermediate
- Level 4 = Advanced
- Level 5 = Expert

DEPARTMENT OF DEFENSE
DCPAS
Defense Civilian Personnel Advisory Service

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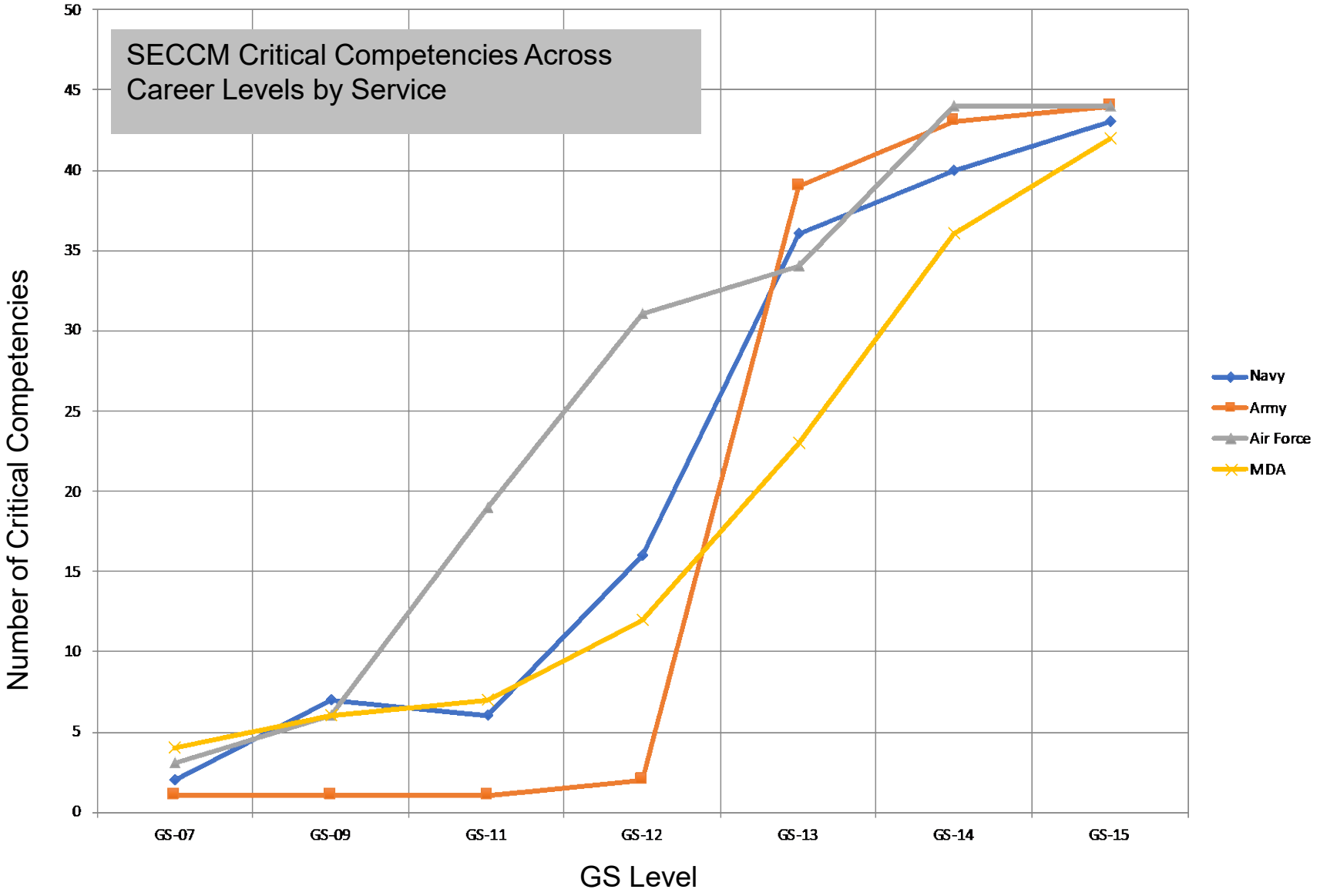
Proficiency Level Definitions

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.

Proficiency Levels Definitions Are Organization Dependent



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DECF v0.25 Competency Title and Definition Start

Number	Competency Title	Competency Description
1	Model Usage	Able to access and manipulate digital models to gain understanding of relationships to capture perspectives to show intent and translate model information to various contexts.
2	Model Development	Able to create and develop digital models from initiation of the effort through the entire life cycle maturation.
3	Model Exploration	Able to view and navigate digital models to access and understand relationships among model elements and use the the understanding as context for making decisions.
4	Digital Collaboration	Able to collaborate in a digital modeling environment while maintaining model integrity and configuration control.
5	Digital Literacy	Able to understand the ramifications of actions in the digital modeling environment.
6	Digital Communication	Able to communicate model-related information in the proper semantic and syntactic context.
7	Model Curation	Able to manage access controls, configuration control and archive models.

DoD definition of model as 'a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process' (DoD 1998)

DECF v0.25 DE KSAB Alignment - Partial View

Number	Competency Titled mapped to KSAB Atomic Level	Competency Description	KSAB Atomic Level
1	Model Usage	Able to access and manipulate digital models to gain understanding of relationships to capture perspectives to show intent and translate model information to various contexts.	Analyzes system model and architecture
1	Model Usage		Apply architecture to the remaining system disciplines and specification development
1	Model Usage		Apply integration using the integrated modeling environment to execute the MBSE process for complex system development efforts to represent the system requirements and design
1	Model Usage		Determine system model and architecture
1	Model Usage		Ensure that DE activities and digital artifacts development are performed according to intent
1	Model Usage		Evaluate multiple system models and architectures at the mission or system-of-system level.
1	Model Usage		Extend SysML-based MBSE at an enterprise by penetratating the concept into New Departments or Product Areas
1	Model Usage		Familiarity with integrating SysML system model with other product and analytical models including physics-based models.

SECCM Competency Definitions with DE Enhancement – Partial View

1.0 Mission Level Assessment	Collaborates with user community to assess mission areas end-to-end, across system and platform boundaries, to identify and close integration and interoperability (I&I) gaps in mission critical capabilities. Uses SE models to describe high level mission needs.
2.0 Stakeholder Requirements Definition	Works with the user to establish and refine operational needs, attributes, and performance parameters based on established processes in a requirements model and ensures all relevant requirements and design considerations are addressed to establish a set of baseline capability requirements
3.0 Requirements Analysis	Ensures the requirements derived from the stakeholder-designated capabilities are, analyzed, decomposed, functionally detailed across the entire system, feasible, and effective represented in a SysML model.
4.0 Architecture Design	Creates and maintains architectural products throughout the life-cycle integrating hardware, software, and human elements; their processes; and related internal and external interfaces that meet user needs and optimize performance. Uses SE models to describe the system solution/ parameters IAW a SE methodology.

Investigating SECCM/DE Job Task Possibilities – Partial View

Competency	Competency Description	Task		
1.0 MISSION-LEVEL ASSESSMENT	Assesses mission areas end-to-end, across system and platform boundaries, to identify and close integration and interoperability (I&I) gaps in mission critical capabilities.			
		Analyzes gaps in the portfolio between mission objectives, existing or planned capabilities, and available funding.	V	Able to view relationships in the digital model and inputs.
		Analyzes mission-level requirements to determine if they are obtainable across programs or an enterprise.	V	
		Analyzes the solution space to identify potential solutions that could address a problem or take advantage of an opportunity.	U	Able to directly use the digital model.
		Creates various scenarios for system use, functions, and performance that include the Concept of Operations.	Cr	Able to create and manipulate digital models
		Defines operational and top-level systems requirements that are reasonable, complete, and testable.	N	No direct interaction with the digital model needed.
		Demonstrates how requirements relate to key performance parameters and measures of effectiveness.	V	
		Defines the mission problem(s) or opportunity(s).	N	
2.0 STAKEHOLDER REQUIREMENTS DEFINITION	Works with the user to establish and refine operational needs, attributes, performance parameters, and constraints that flow from the Joint Capability Integration and Development System described capabilities, and ensure all relevant requirements and design considerations are addressed to establish a set of baseline requirements.			
		Collaborates with the customer/sponsor to achieve understanding and agreement about systems requirements.	Co	Interact with others by collaborating within the digital model
		Conducts a needs assessment to elicit user requirements.	Co	
		Creates a Concept of Operation to address the results of a needs assessment.	Cr	
		Translates stakeholder expectations into system or program requirements.	Cr	
		Defines the business and mission need for systems that will provide services, capabilities or platforms to end-users and other stakeholders.	N	
		Directs the base lining of stakeholder expectations for a system or program.	N	
		Documents the decisions and rationale for end user requirements to ensure understanding during the final development stages.	V	
		Validates stakeholder requirements for a system or a program.	V	
		Analyzes capability needs and operational constraints, in collaboration with the customer, to derive system requirements and technical performance measures for system development.	Co	
		Identifies the individual stakeholders or stakeholder classes who have a legitimate interest in the system throughout its life cycle.	N	
		Elicits stakeholder requirements from the identified stakeholders.	Co	

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SECCM/DE Proficiency Levels Example

Tools & Techniques: Applies tools, techniques, and procedures to enable systems engineering practice.		
	Level	**Example**
1	Awareness of the systems engineering tools and techniques; understanding of their purpose and proper uses.	• Researches the systems engineering tools and techniques to identify the most current tools available. • Correlates the tools with the general products developed by systems engineers. • Operates tools (e.g., CSM, SysML/UML) unrelated to a systems engineering task, for the purpose of gaining familiarity with them.
2	Uses systems engineering tools and techniques with assistance.	• Identifies one or more tools that are available options for a given systems engineering task. • Uses tools (e.g., CSM, SysML/UML) in the execution of a simple task to generate a draft product.
3	Assesses and determines the proper tool for a systems engineering task based on the capabilities and limitations; recognizes the impact of the tools' limitations on the ability to complete the task; uses systems engineering tools and techniques.	• Provides assessment of all available systems engineering tools and recommends the appropriate tool(s) for use on the project or program. • Uses tools (e.g., CSM, SysML/UML) in the execution of a project to generate a product(s). • Uses systems engineering tool(s) to analyze the existing data and evaluate performance.
4	Coordinates the exchange of data between programs or system commands using systems engineering tools and techniques; ensures guidance on preferred tools and techniques for a given task is implemented; manages the maturation of tool development.	• Selects the systems engineering tool(s) for use on a given project or program. • Reviews and approves the technical analysis and recommendations resulting from the data analysis and distributes for external action. • Assesses user guides and manages and documents the standard processes for which the tools are used within the program or system command.
5	Provides guidance as to what tools should be used within the program or system command; sets required training levels for the tools and techniques; determines which tools and techniques need to be developed or modified in order to meet program goals.	• Establishes processes in accordance with policy and guidance for the standard application of the tools within the program or system command. • Guides tool integration and/or defines the common data model for an organization(s). • Approves user guides and manages and documents the standard processes for which the tools are used within a system-of-systems. • Contributes to communities of interest for systems engineering tools standardization.

Gaps Analysis Approach

- At the *competency* level, compare the non-DoD models/frameworks and those identified by the ENG model
- Identify gaps not covered in ENG (draft)
- Break the competency descriptions into tasks (not common outside DoD models)
- Compare the task-level items in the identified gaps with the ENG models ("true" gaps)

- INCOSE SE Competency Framework
- NASA SE/PM Competency Model
- Helix Atlas Proficiency Model
- US Department of Labor Engineering Competency Model
- Mission Engineering Competency Model (SERC)
- SECCM Mission Level Assessment Competencies
- MITRE SE Competency Model (2007)
- IEEE Software Engineering Competency Model (in progress)

Competency Model Identified Gaps

- 57 competency-level items not reflected in ENG
- Broken down into 260 task-level items

- Example Gap: Communication (3 models)
- Tier 1 (Core Competencies)
- Questions:
  - What are the critical implications for communication skills in a DE Environment?
  - How might these differ from a more traditional acquisition environment?

Example Gap: Thinking Patterns

- Big-Picture Thinking (SERC Helix)
- Systems Thinking (INCOSE SECF)
- Critical Thinking (INCOSE SECF)
- Big Picture Thinking (SERC MECF)
- Paradoxical Mindset (SERC Helix)

How does a DE environment enhance/complicate the ability to think holistically/systemically?
What Tier is this? (i.e. is this specific to ENG or more broad, e.g. other AQU professionals?)

- **Example Tasks (from source descriptions):**
  - Understand the System in Operation
  - Understand Interfaces with Other Systems
  - Understand the Development in Organizational Context
  - Understand the Development in Broader Acquisition Context
  - Create Vision for the End Goal/System
  - Understand Variety of Stakeholder Perspectives
  - Facilitate Trade-offs between Stakeholder Perspectives

Example Gap: Teaming

- Building and Orchestrating a Diverse Team (SERC Helix)
- Team Dynamics (INCOSE SECF)
- Team Building (SERC MECF)
- Working in a Team (SERC Helix)

How does a DE environment enhance/complicate the ability to work with team members?
What Tier is this? (i.e. is this specific to ENG or more broad, e.g. other AQU professionals?)

- **Tasks (from models):**
  - Build Diverse Teams
  - Guide Diverse Teams
  - Coach Diverse Teams
  - Identify Team Members' [Strengths, Weaknesses, Capacities, Capabilities, Limitations, Personalities, Expertise, Working Styles]
  - Empower Diverse Teams
  - Build Team Trust
  - Delegate to Team Members

Gaps Analysis Approach

- Critical questions:
  - —Are these tasks relevant/critical to ENG activities in a DE environment?
  - —Which Tier(s) do these tasks support?
  - —How should these tasks group together into new competencies?

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Next Steps

- Review and update draft DECF based on Nov. 15th Workshop feedback
- Update DECF Competency categories to provide support of DE artifact lifecycle
- Create draft DECF and SECCM/Eng update for Use Case validation by sponsor
- Continue work on DECF analysis, SECCM/Eng augmentation, and Gaps analysis
- Prepare for gaps analysis of DAU curricula

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Questions?