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Enabling Digital Engineering (DE) in the Joint Capability Integration and Development System (JCIDS)

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Abstract

Digital Engineering (DE) is a term defined and used by the Office of the Deputy Assistant Secretary of Defense for Systems Engineering OUSD (SE) to encompass model-based engineering and its environment. The concept of using models in engineering to support acquisition is not new but the concept of using DE across the system or service lifecycle to enhance engineering effectiveness is new. DE also encompasses integrated models to enhance engineering activities with the intent of improving engineering to provide the end product/service more efficiently. This report will examine selected government acquisition documents to see if they contain barriers to DE, are silent on DE, or have features that enable or promote DE.

Contents

1. Introduction

The concept of Digital Engineering (DE) as an overarching approach to instituting model-based engineering (MBE) across a product/service lifecycle has emerged over the last several years. While many DE and MBE concepts may be thought of synonymously, DE has the intent to integrate the MBE more fully with themselves and with other engineering activities and may be thought of as more of a program. Model Based Systems Engineering (MBSE) is the label used for the MBE activities applied to Systems Engineering and is also part of the DE scope. Going forward in this document, the phase product will be used to represent both products and services being acquired and engineered. Specific notes will be provided when services are treated differently from product acquisition.

2. Background

DE has been a focus for The Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD [SE]) orchestrating and funding research and work to further the discipline. The Aerospace Corporation and Jet Propulsion Laboratories, which are both federally funded research and development centers, have organized workshops and run them to further the work providing examples and guidance. The International Council on Systems Engineering (INCOSE), National Defense Industrial Association (NDIA), and the Institute of Electrical and Electronics Engineers (IEEE) Systems Council have sponsored work to write guidance and standards. Industry is working on related concepts to improve their engineering practices to improve their profitability. This body of DE knowledge is distributed with federations of cooperation. This report has examined the recent works from most of these organizations with the intent to provide a perspective of how key government documents may be used to enable DE more fully than today.

3. Purpose

The government acquisition approach spans three domains:

1. The Defense Acquisition System[1]
2. The Joint Capability Integration and Development System (JCIDS)[2,3]
3. The Planning, Programming, and Budgeting Environment[4]

The ODASD [SE] website provides some information that has examined the DoD 5000.2 defense acquisition system to determine if it inhibits or enables digital engineering. This report is analogous and researches the question “Does the existing JCIDS inhibit or enable digital engineering?”.

4. Approach

The government acquisition approach spans the acquisition process, requirements process, and the budgeting process. The available research funding for this report is limited to a “proof-of-concept” to examine only the JCIDS. If warranted, the approach could be used to examine other elements of the government acquisition approach.

The currently approved JCIDS document was compared against a criteria to determine if there are barriers, are silent, or specifically enable digital engineering. The criteria approach was selected so that each document was reviewed against a standard providing consistent findings.

The criteria was developed using elements of the United States government, DASD(SE) web site published materials related to digital engineering and from The Aerospace Corporation publication "Model Based Systems Engineer Guidance for Government Acquired Programs.[5]" Appendix B identifies all of the criteria elements considered that were then synthesized and distilled into four criteria items shown in Table 1, each with DE impact.

Table 1. DE Criteria for Document Review

Criteria Item	DE Impact
Create digital engineering data (rethink documents; government documents and contractor delivered documents such as CDRL/DiD)	Data Barrier or Data Enabler to creating a Digital Systems Model
Use digital engineering data (milestone reviews, program reviews, and audits, as well as at the working level such as IPTs and working groups)	Workflow Barrier or Workflow Enabler for the Digital Engineering Ecosystem
Technology instituting digital data (models, simulations, connectivity, and interoperability)	Technology Barrier or Technology Enabler
Digital engineering of the three interacting processes: requirements (JCIDS), acquisition (DAS), and resources (PPBE)	Status quo performance of the acquisition approach or potential improvements in enterprise capabilities, coordination across the three interacting processes, improved stakeholder coordination and improved and timelier acquired system or service

5. Findings

5.1 Summary Findings for CJSCI 3170.01I January 2015

The findings below are a summary of the findings from Appendix C where specific JCIDS requirements were identified as being a DE enabler or barrier. Each finding corresponds to a criteria item. Each finding is accompanied by a recommendation that would improve the JCIDS through digital engineering.

Finding 1. The word "Documentation" is a CJSCI 3170.01I DE data barrier that appears throughout the document. CJSCI paragraphs that use words that discuss "output" or "capability requirements" instead of "documents" are DE enablers.

Recommendation 1. Changing the word "document, documents, and documentation" to "capability requirement" opens the door to DE and DE generated views, reports, and DE documents by allowing organizations to collaborate via configuration managed capability requirement data sets as part of the Digital Systems Model. It may enhance the development and approval of parts of the engineering to allow resources to be applied to those portions requiring more work.

Finding 2. The use of "Validation," "Approval," "Certifications," "Endorsements," and "Waivers" in the CJSCI 3170.01I are workflow barriers since they typically are physical-document-centric that require manual signature and coordination. While the acceptance/sign-off is necessary for the government to use the system, the documents present a barrier since the workflow process hasn't been integrated with the digital data, causing delays in approval.

Recommendation 2. Permit DE capture of these types of stakeholder inputs as well as their coordination to improve the speed of the workflow as part of the Digital Engineering Ecosystem.

Finding 3. The CJSCI 3170.01I does not enable or encourage DE technology as part of the development, coordination, approval, or use of capability requirements.

Recommendation 3. The engineering behind the JCIDS currently doesn't use an integrated digital engineering and workflow approach so there are all the barriers associated with documents, integrating document sets, and the problems associated with documents that require strong relationships being developed at different times by different organizations.

Finding 4. The purpose and intent of the JCIDS process includes: defining improvements in enterprise capabilities; coordination across the three interacting processes (capability requirements, acquisition, and budgeting); improved stakeholder coordination; and improved and timelier acquired system or service.

Digital Engineering holds the promise to meeting the purpose and intent of the JCIDS more fully than the current approach.

Recommendation 4. The two key components of the JCIDS are: (1) definition of the capability requirements themselves, and (2) coordination, update, and approval of the capability requirements through a workflow process. Anecdotally, the latter takes more time than the former. Instilling DE in the definition of capability requirements may move more quickly, be more acceptable, and be easier overall, to accomplish than improving the workflow. Both can be examined and planned to enhance the JCIDS process.

6. Conclusions

The CJSCI 3170.01I currently requires capability requirements documents to be produced and also be coordinated and approved with a specific KM/DS workflow. Simply changing phrases from "documents" to "capability requirements" would enable DE and allow greater innovation that may lead to engineering effectiveness and then could lead to engineering and KM/DS efficiency. Changing the KM/DS service to enable DE workflow is a significant task as would be putting in place a DE enabling electronic environment.

Appendix A. Definitions[6]

The following definitions relating to digital engineering are drawn from the Defense Acquisition University (DAU) and the Defense Federal Acquisition Regulation Supplement (DFARS):

Digital Artifact: The artifacts 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.

Digital Engineering: An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support lifecycle activities from concept through disposal.

Digital Engineering Ecosystem: The interconnected infrastructure, environment, and methodology (process, methods, and tools) used to store, access, analyze, and visualize evolving systems' data and models to address the needs of the stakeholders.

Digital Model-Centric Engineering (DMCE): The application of engineering practices through the use of digital environments and tools. DMCE enables practitioners to engineer systems using digital practices and artifacts in a collaborative environment, creating a digitally integrated approach using a federated single source of truth to evolve complex systems. A primary characteristic of this environment and approach is the digital authority's ability to capture pedigree of all system-related data to facilitate and automate traceability, show dynamic relationships and changes to various aspects of the system development, and support decision makers to make informed decisions.

Digital System Model: A digital representation of a defense system, generated by all stakeholders, that integrates the authoritative technical data and associated artifacts, which defines all aspects of the system for the specific activities throughout the system lifecycle. (DAU Glossary)

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 lifecycle by providing the capability to access, integrate, and transform disparate data into actionable information. (DAU Glossary)

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. (DAU Glossary)

Technical Coherence: The logical traceability of the evolution of a system's data and models, decisions, and solutions throughout the lifecycle.

Technical Data: Recorded information, regardless of the form or method of the recording, of a scientific or technical nature (including computer software documentations). The term does not include computer software or data incidental to contract administration, such as financial and/or management information. (DFARS 252.227-7103(a)(15))

Appendix B. Digital Engineering Criteria Elements

Criteria elements were derived from the DASD(SE) website with standards extracted from The Aerospace Corporation report; "Model Based Systems Engineering Guidance for Government Acquired Programs." Criteria elements are identified below and then integrated into four specific criteria items along with their DE impact as shown in paragraph 4. The four specific criteria items were then used as the basis for the analysis against the JCIDS document as shown in Appendix C. This may be more detail than an executive reader needs so the Summary Findings are provided in paragraph 5.

- Improve tradecraft in acquisition of services with improved productivity of contracted engineering and technical services.
  - Create digital engineering data (rethink documents; government documents and contractor-delivered documents such as CDRL/DiD) via a digital systems model
  - Use digital engineering data (milestone reviews, program reviews and audits, as well as at the working level such as IPTs and working groups) to create a Digital Engineering Ecosystem
  - Incentivize technology instituting digital data (models, simulations, connectivity, and interoperability)
- Strengthen organic engineering capabilities through disciplined and consistent application of engineering through the application of modeling, simulation, and digital engineering.
  - Have people resources that are competent in digital engineering
- Improve identification, understanding, and mitigation of risks through quantitative analysis, quality data, and a more connected and informed Integrated Product Team, quickly finding patterns and improved insight and giving the program a better lens to look for defects early in a program's lifecycle.
  - Use digital engineering data (milestone reviews, program reviews and audits, as well as at the working level such as IPTs and working groups) to create a Digital Engineering Ecosystem
- Streamline documentation requirements and staff reviews.
  - Use digital engineering data (milestone reviews, program reviews and audits, as well as at the working level such as IPTs and working groups)
- Remove unproductive requirements imposed on industry.
  - A barrier to create digital engineering data (rethink documents; government documents and contractor-delivered documents such as CDRL/DiD) via a digital systems model
  - A barrier to use digital engineering data (milestone reviews, program reviews and audits, as well as at the working level such as IPTs and working groups) via a digital systems model to create a Digital Engineering Ecosystem
  - A barrier to the technology instituting digital data (models, simulations, connectivity, and interoperability)

- A barrier to having people resources that are competent in digital engineering

Another criteria item stems from the purpose, goals, and intents of the acquisition documents themselves. Improvements can be made in quality of the work, timeliness, and workflow.

- Improve government enterprise capabilities beyond the system/service acquisition
- Improve coordination across the capability requirements, acquisition system, and PPBS
- Improve stakeholder coordination
- Improved and more timely acquired system or service

Appendix C. Detailed Findings for CJSCI 3170.01I

This table provides a citation from the document, criteria comments as to why it is relevant as either an enabler or barrier and identifies the finding. This table provides the evidence for the summary findings presented in paragraph 5. Words in red alert the reader to barriers. Words in blue alert the reader to enablers. This appendix provides the analysis information for the general findings in paragraph 5. It may also be useful to those that may be updating the JCIDS document.

Citation	Criteria Comment	Finding
Repeated phrase "capability requirements"	This phrase doesn't necessarily mean a document can could mean a representation of the requirements in models	Data Enabler
4c. "Outputs of the JCIDS"	The word "output" enables DE and digital data	Data Enabler
4d. "The JCIDS process provides the baseline for documentation, review, and …	The word "Documentation" doesn't allow for the use of digital data such as the collection of requirements described in paragraph 4.c	Data Barrier
4e. Once validated, regardless of validation authority and Joint Staffing Designator (JSD) assigned in accordance with reference b, Sponsors will upload final versions of capability requirement documents and their associated validation memorandums to the Knowledge Management/Decision Support (KM/DS) system, or alternative for higher classification documents, for archiving purposes and for visibility in the capability requirement portfolios.	The words documentation and memorandums indicate a document-centric process that is a barrier to DE. DE could provide an approved digital set of requirements, and have electronic approval of that set of requirements. This would enhance requirement change flexibility as well as the coordination and approval process.	Workflow Barrier
4F(2). Certifications, endorsements, waivers	These are physical documents that could also be digitally created, configuration managed, and tracked	Workflow Barrier
4F(4). Document formats used in accordance with reference e remain acceptable in cases where documents must be submitted to JCIDS for validation.	These are physical documents that could also be digitally created, configuration managed, and tracked	Data Barrier
4(5)(a.) IC capability requirement documents will be developed,…	These are physical documents that could also be digitally created, configuration managed, and tracked	Data Barrier
4(5)(b) IC capability requirement documents will be developed,	These are physical documents that could also be digitally created, configuration managed, and tracked	Data Barrier
4(5) (c) IC capability requirement documents with any level of shared	These are physical documents that could also be digitally created, configuration managed, and tracked	Data Barrier
4g. (2) Reference b provides specific procedures for the operation of JCIDS, the development and staffing of capability requirement documents, and the mandated Requirements Management Certification Training program for personnel participating in the JCIDS process. It also outlines streamlined documents and expedited staffing for JUONs and JEONs, as well as documentation visibility and archiving of validated DoD Component UONs.	These are physical documents that could also be digitally created, configuration managed, and tracked	Data Barrier

Citation	Criteria Comment	Finding
4g. (3) The KM/DS system is the authoritative system for processing, coordinating, tasking, and archiving capability requirement documents, validation memorandums, and related action items when classified at or below the level of SECRET.	Documents are being managed, not capability requirements data sets	Workflow barrier
4. h. Applicability of Capability requirement Documents Developed Under Previous Versions of This Instruction	Documents	Data barrier
4.h. (1) Capability requirement documents that were validated under previous versions of this instruction, including Operational Requirements Document (ORD) updates and annexes, Initial Capabilities Documents (ICDs), DBS Problem Statements, Joint DOTMLPF-P Change Recommendations (DCRs), Capability Development Documents (CDDs), and Capability Production Documents (CPDs), remain valid and will be accepted to support development of capability solutions.	May/may not make sense to convert older documents to DE.	Data barrier
4.h.(2) As needs of the Joint Force evolve over time, the validation authority may require a sponsor to bring a previously validated capability requirement document back through the process to review and reaffirm, modify, or rescind the previous validation.		Data barrier, workflow barrier
4.h.(3) No additional changes or amendments will be made to previously validated ORDs or other legacy capability requirement documents unless minor changes are approved by the Gatekeeper and Lead Functional Capabilities Board (FCB). To facilitate significant amendments or changes, sponsors shall transcribe content, and any previously validated changes or amendments, into the appropriate current document format for staffing and validation. Updates will incorporate, or justify the absence of, the mandatory Key Performance Parameters (KPPs) in accordance with reference b.		Data barrier, workflow barrier
4.i. (1) The Joint Staff Gatekeeper will work in coordination with the document sponsor and the appropriate FCB to ensure any exceptions or variances meet the needs of the validation authority while allowing for appropriate flexibility in the capability requirements process.		Workflow barrier
4.i. (2) Waivers granted by the Joint Staff Gatekeeper shall be documented in memo format, and attached to associated documents in the KM/DS system to provide traceability in future staffing and validation activities.		Data barrier, workflow barrier
Enclosure A.	This enclosure continues to use the concept of documents throughout. This enclosure continues to use the concept of document centered workflow.	Data barrier, workflow barrier

Appendix D. Endnotes

[1] DoD Directive (DoDD) 5000.01, The Defense Acquisition System
[2] CJCSI 3170.01I, 23 January 2015
[3] JCIDS Manual, 12 February 2015, including errata as of 18 December 2016
[4] DoD Directive 7045.14 Planning, Programming, Budgeting & Execution (PPBE) Process 25 January 2013
[5] The Aerospace Corporation, "Model Based Systems Engineering for Government Acquired Programs." 14 March 2016
[6] US Government DASD(SE) site 16 March 2017 http://www.acq.osd.mil/se/initiatives/init_de.html

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