SYM-AM-24-046

Excerpt from the Proceedings of the Twenty-First Annual Acquisition Research Symposium

Acquisition Research: Creating Synergy for Informed Change

May 8–9, 2024

Published: April 30, 2024

The research presented in this report was supported by the Acquisition Research Program at the Naval Postgraduate School.

To request defense acquisition research, to become a research sponsor, or to print additional copies of reports, please contact any of the staff listed on the Acquisition Research Program website (www.acquisitionresearch.net).

Acquisition Research Program
Department of Defense Management
Naval Postgraduate School

Acquisition with Digital Engineering

Tom McDermott—is the Chief Technology Officer of the Systems Engineering Research Center (SERC) and a faculty member in the School of Systems and Enterprises at Stevens Institute of Technology in Hoboken, NJ. With the SERC he develops new research strategies and is leading research on digital transformation, education, security, and artificial intelligence applications. He previously held roles as Faculty and Director of Research at Georgia Tech Research Institute and Director and Integrated Product Team Manager at Lockheed Martin. McDermott teaches system architecture, systems and critical thinking, and engineering leadership. He provides executive-level consulting as a systems engineering and organizational strategy expert. He is a fellow of the International Council on Systems Engineering (INCOSE) and recently completed 3 years as INCOSE Director of Strategic Integration. [tmcdermo@stevens.edu]

Philomena Zimmerman—is a research scientist and fellow with the Acquisition Innovation Research Center (AIRC) at Stevens Institute of Technology in Hoboken, NJ. She was previously the Director for Engineering Tools and Environments within the Department of Defense (DoD) Office of the Deputy Director for Engineering. During her career, Zimmerman has also served in leadership positions within the Army's Future Combat System program, Program Executive Office Integration, and Defense Modeling and Simulation Office, and with NAVAIR. [pzimmerm@stevens.edu]

Abstract

Acquisition with Digital Engineering (DE) support, a.k.a. DE-enabled acquisition, cannot succeed as an engineering initiative pushed by engineers. It must be pulled into acquisition and sustainment by acquisition and sustainment functionals and fully integrated across all of their activities, including those that are not seen as technical. DE pilot efforts have demonstrated that it is fully possible to conduct government acquisition planning, contractor source selection, and engineering and manufacturing development in a shared Digital Engineering and Acquisition Ecosystem. This research conducted by the Acquisition Innovation Research Center (AIRC) developed a fundamental perspective and a set of recommendations for acquisition with DE. Research Issue Digital engineering is as fundamental a paradigm shift as the pathways in the Adaptive Acquisition Framework (AAF), affecting all pathways and supporting functions and enabling broad benefits in the transformation to Digital Acquisition. Digital engineering implementation and benefits involve and affect all acquisition functions—not just engineering and technical management.

Keywords: digital engineering, systems engineering, contracting, acquisition system

Introduction

In June 2018, the Under Secretary of Defense for Research and Engineering published the DoD Digital Engineering (DE) Strategy (Under Secretary of Defense for Research and Engineering, 2018). Since then, the DoD's engineering and technical communities have acknowledged and are adopting DE as a transformative, value-added approach to improving weapon system development, capability integration, testing, and sustainment. However, for successful DE implementation in acquisition and sustainment, the broader benefits and the realization of complete Digital Acquisition, must involve all acquisition functions—not just technical ones.

In other words, acquisition with DE support, a.k.a. DE-enabled acquisition, cannot succeed as an engineering initiative pushed by engineers. It must be pulled into acquisition and sustainment by acquisition and sustainment functionals and fully integrated across all of their activities, including those that are not seen as technical. An AIRC report, *Acquisition with Digital Engineering*, explored some of the methods, processes, and tools in the acquisition and sustainment functions beyond engineering that need to implement DE and realize its benefits, ultimately to our warfighters and taxpayers (McDermott et al., 2023).

DE pilot efforts have demonstrated that it is fully possible to conduct government acquisition planning, contractor source selection, and engineering and manufacturing development in a shared Digital Engineering and Acquisition Ecosystem (DEAE; Blackburn et al., 2019, 2020, 2021). This requires government management and provisioning of program data and models as appropriate authoritative sources of truth (ASOT) and a collaborative digital environment with defined government and contractor access, workflows, and digital artifact "views." A concurrent research task conducted by SERC/AIRC and OUSD(R&E) found a significant number of pain points that are creating a slow adoption of DE in DoD program offices (McDermott & Benjamin, 2022; McDermott & Mesmer, 2023). These include a lack of the ways and means to drive adoption; a lack of fully integrated DEAE reference implementations; lack of modernized engineering and technical management processes; and poor understanding of the value and benefit of DE across all acquisition and non-engineering functions.

Consistent with the Federal Acquisition Regulation (FAR) and the Defense Federal Acquisition Regulation Supplement (DFARS), the digital artifacts that result from DE implementation can be viewed legitimately as technical data and computer software (McDermott & Mesmer, 2023). However, there are a few issues in simply specifying in a contract the delivery of these artifacts. Taking delivery of these artifacts versus their actual use are very different in terms of value and detail necessary in specification. In other words, viewing DE as a set of digitized artifacts using the same acquisition and sustainment intent historically applied to paper and document artifacts may not ensure the quality and information exchange needed, thus defeating the value of a DE-enabled Defense Acquisition System (DAS), on the journey to digital transformation of the DAS.

The programmatic value of DE and associated artifacts come from the government and contractor aligned teams conducting their respective development, analysis, decision-making, and certification activities from a common set of data and models (known collectively as the ASOT), continuously, in an appropriately shared government and contractor DEAE. These data and models must be managed and curated in the associated DEAE across the full life cycle of the weapon system, appropriate for the subsequent acquisition activities necessary to bring the product to realization. This could include Needs Statements, Mission Engineering, Requirements, Budgeting, Acquisition, Test, Operation, Sustainment, and Disposal phases.

The policy basis for DE-enabled acquisition must fully communicate the intent and benefits of DE methods and results from computational activities, to be used in other non-technical activities. Engineering activities (supported by DE) in policy remain overly focused within the Major Capability Acquisition (MCA) pathway. DE-enabled activities should be fundamental to any acquisition function in any Adaptive Acquisition Pathway. As with the pathways in general, it is not intuitive to move from DE support from MCA to any other pathway. It should be articulated for non-MCA-focused staff, how to transfer fundamental DE-enabled acquisition process knowledge from MCA to their pathways of choice.

The DoD is at an intersection in its ability to utilize industry-accepted, standard DE practices to improve defense acquisition and sustainment. All acquisition and sustainment functions—not just engineering and technical management disciplines—need to engage through a shared demand signal to the DE practitioner community. These research results lay out this fundamental perspective and identify several recommended areas of activity.

Research Results

The acquisition and sustainment communities have an opportunity to shape DE methods and reap benefits of DE-enabled acquisition and sustainment through active engagement and demand signals. Without a clear demand signal from the acquisition and sustainment user community, it is impossible for the DE practitioners to know how DE will be used by acquisition and sustainment, and how to prioritize the order of method development to benefit acquisition and sustainment. The who is clearly the acquisition and sustainment communities writ large; however, the what, when, where, and how needs to be further developed by the acquisition and sustainment functional communities along with their demand signals.

This research conducted a review of DoD issuances and other available guidance for DE-related contract artifacts and flows, as well as general acquisition policy and guidance (McDermott & Benjamin, 2022). Most of the available policy and guidance reflects the impact of DE on contracting in the regulatory domain of technical data and models, or as sets of recommended engineering processes. There is a general lack of related guidance that acknowledges the much broader changes that should be realized in fully digital processes and workflows. These can be characterized as (i) a general "shift left" to conduct program definition, development, and test activities earlier—some possibly even into government pre-acquisition activities, (ii) an exchange of digital development artifacts into manufacturing (commonly known as "digital thread"), and (iii) long-term life-cycle maintenance of digital models and environments ("digital twins," et al.) to inform and improve logistics, sustainment, and even feedback into requirements and mission engineering decision-making for related products.

Digital Engineering as a technical and management approach is "an integrated digital approach that uses authoritative sources of systems' data and models, along with other information, as a continuum across disciplines to support life cycle activities from concept through disposal" (Office of the Deputy Assistant Secretary of Defense [Systems Engineering], 2017). Today the acquisition and sustainment communities are in the initial stages of their DE transformation and need additional research and guidance to define the workflows and processes to contract for, use, and sustain fully digital model-based artifacts and the associated digital environments. The acquisition and sustainment communities, from practitioners to decision-makers, based on current policy, guidance, and observed practice, still retain a document-centric view of engineering technical and management data, as periodically delivered artifacts. The benefit of DE application comes from government/contractor collaboration around and through models (vs. document generation and review) in environments that continuously allow the use of models and associated data to generate results from, and for computational analysis and review. Program offices do not have adequate guidance on how to enable effective use of DE methods, tools and associated products when making materiel development, or sustainment decisions anywhere in a system life cycle.

Additionally, the vision in the DoD Data Strategy (conceived separately from DE) of "a data-centric organization that uses data at speed and scale for operational advantage and increased efficiency" (Under Secretary of Defense for Research and Engineering, 2018) is not yet sufficiently captured into engineering or acquisition and sustainment policy and guidance. Program offices need additional guidance in various areas that can effectively define their workflow and enable data-supported decisions within the engineering, acquisition, and sustainment activities.

Initial example acquisition artifacts are being exchanged through various pilot projects, and in a small set of acquisition programs of record, but these are not the norm. There are statutory requirements for delivery of technical data and computer software. These easily support exchange of data and models between government and contractor, but not the widespread use needed for the continuum of product life-cycle operations. Additionally, some statutory requirements generally echo existing standards for written documents, which are static entities and do not meet the goal of the DoD Digital Engineering Strategy—to collaborate around, with, and through data and models.

The decision process that drives contracting and contracting language should not just define what the technical data requirements are for data/models and delivered computer software. The decision process should reflect how the government and contractor teams make best use of data and models "for operational advantage and increased efficiency" within the context of acquisition and sustainment activities.

The complete value of DE implementation is realized with collaborative knowledge exchange among practitioners of varying activities, and results in improved agility in design, shorter lead times, increased confidence in the end product, and improved product life-cycle sustainability. A related SERC project on DE benefits and measures clearly articulates this value. DE does not necessarily result in cost savings but will improve program timelines and quality if implemented and measured as an integrated process across all engineering, management, and related acquisition disciplines.

Acquisition Functional Roles

Each of the current seven managed acquisition workforce areas (DAU, n.d.), at a minimum, have a role to play in the DE transformation of acquisition and sustainment practices, to benefit from the continuum of digital artifact availability and use.[1] Below are some of the new or modernized acquisition and sustainment processes that are recommended to be addressed in the digital transformation of the DAS, as an example of the scale and need beginning with implementation of DE within the DAS:

- Life-Cycle Logistics: ensuring that authoritative data and models and their use are included in the system Life-Cycle Sustainment Plan (LCSP), life-cycle cost analyses, and the government/contractor product support analyses and strategy and made available to the logistics and supply domain.
- Engineering and Technical Management: developing the collective ASOT and associated DEAE per the life-cycle management plan, as documented in the program Digital Engineering Implementation Plan (DEIP), as a main part of the Systems Engineering Plan (SEP).
- Program Management: planning and budgeting for data and models across the full life cycle, defining and managing program office requirements that are consistent with the use and expected benefits of DE, selecting acquisition pathways and defining appropriate DE model-based review processes, staffing the program office with sufficient digitally skilled program office personnel in appropriate functions, defining data exchange requirements for data and models across the spectrum of their use, defining and tracking DE activities in earned value management systems (EVMS) as well as Integrated Master Plan (IMP) and Integrated Master Schedule (IMS), defining a DE measurement plan and inspecting program digital artifacts delivery for completeness and consistency.
- Test and Evaluation: defining and planning the verification and validation (V&V) requirements and operational assessment with and of models, using data from live events to update models and the collective ASOT, capturing appropriate digital test artifacts in the ASOT, developing the digital Test and Evaluation Master Plan (TEMP).
- Business Financial Management/Cost Estimating: DE data and models integrated into cost modeling, updating cost estimation models to reflect the relative resource (time, budget, and personnel) costs, cost avoidance and potential savings of DE in the

[1] The current seven managed acquisition workforce functional areas are Auditing, Business Financial Management/Cost Estimating, Contracting, Engineering and Technical Management, Life Cycle Logistics, Program Management, and Test and Evaluation (DAU, n.d.).

complete, executed life cycle of a system, including but not limited to development, production, and sustainment.
- Contracting: incorporating DE processes, data and model exchanges, and digital review processes into the Statement of Work (SOW), defining data and model exchange and delivery requirements, defining program DEAE requirements.
- Auditing: ensuring appropriate management of program digital artifacts so curation is possible.

Recommendations

Life-cycle management activities for models, in total, should extend beyond the acquired system to equally cover the authoritative data and models, their development environments, and especially, non-engineering uses. In the system life cycle, the government must be prepared (at the appropriate time and defined in the Acquisition Strategy and Acquisition Plan) to manage and further develop data and models as an organic enterprise resource, to be reused, recast, or modified if appropriate. These activities need to be developed and approved in the LCSP, SEP, and TEMP, as well as planned into program requirements, SOW, and IMS/IMP. **Thus, digital artifacts are more than just product deliverables; they must be contractually required in a way that ensures they convey complete and common understandings, for a continuum of use, not only between the DoD and the contractors but across other functions and the product lifecycle and beyond.** From this research, additional broad recommendations were developed (McDermott et al., 2023). As a next step, this team is moving from broad to specific recommendations, with a specific pilot implementation using one or more ongoing acquisition programs at various life-cycle stages. Specific recommendations follow:

1. Services should develop appropriate enterprise strategies for governance and support of the system ASOT and DEAE and define, develop, and train to, appropriate templates for Acquisition Plans. Data and models and other components of product ASOT, as well as the DEAE, should be identified and planned in the agency's Acquisition Plan as defined in FAR Part 7. Since data and models and the associated DEAE are associated with the system, a system basis should be used for planning (expand beyond an individual contract or order). The research team did not find any examples of Acquisition Plan language for acquisition with DE.
2. Services should define appropriate product support strategies and LCSP templates for the ASOT and DEAE at the enterprise level. Digital data and models are products and should be represented in the system Product Support Management Plan as defined in DoDI 5000.91 and the system LCSP (DoD, 2021). The LCSP outline version 3.0 section 4.6.3 "Digital Product Support" provides high-level guidance for both digital product data and the DEAE. The research team did not find any examples of program LCSP language for acquisition with DE.
3. A mature Digital Engineering and Acquisition Ecosystem framework will allow program offices and associated personnel to use their practice and expertise to determine what activities they need to do in, and with, the DEAE. NASA-HDBK-1004 has a comprehensive description of the components and operation of a DEAE framework, but no equivalent description exists in DoD guidance (NASA, 2020). The actual DEAE implementation will vary by acquisition pathway and program objectives. The SE Modernization project found a lack of mature DEAE reference implementations were inhibiting government adoption and that the DoD should invest in development of DEAE concepts of operations and reference tool and use patterns (McDermott et al., 2023).
4. The research team recommends that, consistent with existing standards as much as practical, a set of Data Exchange Exemplar Reference Implementations be developed to aid

in maturing data constructs, data exchange mechanisms, security architectures, and configuration management provisions to realize the vision noted in the Systems Engineering Modernization report (McDermott & Mesmer, 2023). Data constructs, data exchange mechanisms, security architectures and configuration management processes are tied together, and are referenced, directed, and encouraged from disconnected organizations, policies, guidance, and other issuances. The DEAE is an Enterprise Information System and is thus covered by the DoDI 5000.82 *Acquisition of Information Technology and Associated Requirements for the Acquisition of Digital Capabilities* guidebook (DoD, 2023b). The DoD Chief Information Officer (CIO) office is a major player in data exchange policies and guidance. This office is tasked to support other areas as well and may not understand the full nature of the acquisition and sustainment communities. Meanwhile, within the shift to DE-enabled acquisition, much of the transformation is still manual interpretation of disparate data and analyses.

5. The research team recommends long-term evolution of the SEP and TEMP to digital resources as noted in the SE Modernization Report (McDermott et al., 2023). Programs should define acquisition with DE across all requirements of the SEP in any AAF pathway, and not as a separate appendix. As the SEP is generally referenced as the authoritative guidance for DE, the DoD SEP Outline Version 4.1 (DoD, 2023a) should be regularly updated to reflect evolving practice and lessons learned for acquisition with DE. At this point the SEP outline defines a separate Digital Engineering Implementation Plan as an Appendix to the program SEP covering the DE architecture and digital tool chain. In the long-term, a fully digital SEP is recommended that defines ASOT governance and DEAE implementation by reference to the appropriate digital environments.
6. Very few acquisition and sustainment activities are underway which are deemed to be digital in nature. In order to populate a DEAE and establish an ASOT that is 1) usable by government and contractor teams, 2) across all activities within a program life cycle, 3) as a matter of common and best practice rather than something new to be attempted, the research team recommends that an inclusive review of DIDs, CRDLs, from sample program office contracts, as well as issuances be reviewed and suggestions for revisions developed, in order to enable modifications of, and computational use of the artifact, in a continuum across the relevant acquisition activities.
7. The research team recommends that policies and guidance on the AAF site be reviewed and suggestions offered to increase the strength of digital transformation and connectivity. The AAF represents an evolutionary change in acquisition thinking. In reviewing the issuances on the DAU's AAF website it is evident that there is language in the collection that implies a digital transformation within the technical functional acquisition activities. However, this DE-enabled continuum is not linked from data sender to receiver, through the policy and guidance.
8. The research team recommends workflow guidance for DE-enabled acquisition and sustainment for program management offices and staff be drafted, as a means to close this gap in the transformation guidance and continue with the acquisition activities evolution in the AAF. There is a knowledge gap with the lack of the top-down, supporting digitalized-view from the Program Manager (PM). Neither the *Guide to Program Management Business Processes* (DAU, 2022a) nor the *Guide to Program Management Knowledge, Skills and Practices* (DAU, 2022b) in the current DAU Acquisition Guidebooks discuss any aspects of the ongoing DoD digital transformation and its impact on management of acquisition programs.

9. The research team recommends that benefits of digital transformation be developed for each pathway, and for each decision point within each pathway, targeting the “why” of digital transformation and away from directed change. Furthermore, the research team recommends that programs quantitatively measure their engineering progress using DE tools. It is typical to claim the need to invoke technical and process advancements, because it is required. In reality, this is not always true. In the time since Digital Engineering Strategy, DoD Data Strategy, and AAF have been released, research has been conducted and published related to measuring value of different areas of digital transformation, and DE. Digital Engineering will make many engineering activities explicitly and continuously measurable that were previously only assessed at program milestone reviews.
10. The research team recommends that a strategy, and overarching roadmap for digital transformation of the acquisition, and eventually sustainment processes be developed to aid in decision-making process for what and when to digitalize, separately, and similarly for the sustainment system. Digital transformation is a complex task. The acquisition and sustainment processes are also complex. For the engineering community, the release of the Digital Engineering Strategy, containing the “what” that needs to be done led the shift toward digitally based engineering to support design and development.

Summary

Digital engineering is as fundamental a paradigm shift as the pathways in the Adaptive Acquisition Framework (AAF), affecting all pathways and supporting functions and enabling broad benefits in the transformation to Digital Acquisition. Digital engineering implementation and benefits involve and affect all acquisition functions—not just engineering. Acquisition with DE support cannot succeed as an engineering initiative pushed by engineers. It must be pulled into acquisition and sustainment by acquisition and sustainment functionals and fully integrated across all of their activities, including those that are not seen as technical.

References

Blackburn, M. R., Bone, M. A., Dzielski, J., Kruse, B., Peak, R., Cimtalay, S., Ballard, M., Baker, A., Carnevale, A., Stock, W., Ramaswamy, A., Szostak, M., Rizzo, G., Rouse, W., Rhodes, D., Austin, M., & Coelho, M. (2020, June 20). *Transforming systems engineering through model-centric engineering* (Final Technical Report SERC-2020-TR-009, WRT1008 (NAVAIR)).

Blackburn, M. R., Bone, M. A., Dzielski, J., Kruse, B., Peak, R., Edwards, S., Baker, A., Ballard, M., Austin, M., Coelho, M., Rhodes, D., & Smith, B. (2019, May 28). *Transforming systems engineering through model-centric engineering* (Final Technical Report SERC-2019-TR-103, RT-195 (NAVAIR)).

Blackburn, M. R., Dzielski, J., Peak, R., Cimtalay, S., Fields, T., Stock, W., Panchal, S., Sisavath, J., & Rizzo, G. (2021, August 3). *Transforming systems engineering through model-centric engineering* (Final Technical Report SERC-2021-TR-012, WRT1036 (NAVAIR)).

DAU. (n.d.). *About*. https://www.dau.edu/back-to-basics

DAU. (2022a). *A guide to program management business processes*. https://www.dau.edu/pdfviewer?Guidebooks/DAG/A-Guide-to-DoD-Program-Management-Business-Processes.pdf

DAU. (2022b). *A guide to program management knowledge, skills and practices*. https://www.dau.edu/pdfviewer?Guidebooks/DAG/A-Guide-to-Program-Management-Knowledge-Skills-and-Practices.pdf

DFARS 227.71–72, https://www.acquisition.gov/far/part-7.

DoD. (2021, November 4). *DOD Instruction 5000.91, Product support management for the adaptive acquisition framework*.

DoD. (2023a, May). *Department of Defense systems engineering plan (SEP) outline version 4.1*. https://ac.cto.mil/wp-content/uploads/2023/05/SEP-Outline-4.1.pdf

DoD. (2023b, June 1). *DOD Instruction 5000.82, Requirements for the acquisition of digital capabilities*.

McDermott, T., & Benjamin, W. (2022, September). *Program manager's guide to digital and agile systems engineering process transformation* (Final Technical Report SERC-2022-TR-0092, WRT1051).

McDermott, T., & Mesmer, B. (2023, April). *Systems engineering modernization policy, practice, and workforce roadmaps* (Final Technical Report SERC-2023-TR-0002, WRT1058).

McDermott, T., Zimmerman, P., Long, D., Kerr, G., & Esser, K. (2023, June). *Acquisition with digital engineering* (Final Technical Report AIRC-2023-ITR-002, WRT1057.18g).

NASA. (2020, April). *NASA digital engineering acquisition framework handbook NASA-HDBK-1004*. https://standards.nasa.gov/sites/default/files/standards/NASA/Baseline/0/2020_04_01_nasa_hdbk_1004_approved.pdf.

Office of the Deputy Assistant Secretary of Defense (Systems Engineering). (2017). *DAU glossary: Digital engineering*. https://www.dau.edu/glossary/digital-engineering

Under Secretary of Defense for Research and Engineering. (2018). *2018 digital engineering strategy*. https://cto.mil

Acquisition Research Program
Department of Defense Management
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

www.acquisitionresearch.net