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Digital Engineering: Accelerating the Defense Acquisition & Development Cycle in an Era of Strategic Competition

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Key Points

Digital engineering represents an evolution of design, modeling, simulation, and systems engineering practices for existing and future military capabilities enabled by advances in computing power, data analytics, cloud storage and processing, and secure information sharing.

Digital engineering provides a seamless "digital thread" of continuously updated, authoritative artifacts that program stakeholders can access in real time, keeping everyone from program managers to sub-tier suppliers on the same page.

Digital engineering reduces acquisition program costs, design reworks, and bureaucratic overhead. It enables higher production quality with less waste and improved sustainment and modernization activities. These benefits have the potential to accelerate the acquisition, development, and fielding of new capabilities independent of purely policy-based acquisition reform.

Senior defense leaders must understand the costs, benefits, and limitations of digital engineering practices if they are to optimize their implementation across the range of DOD programs, from older legacy capabilities to next-generation new start systems.

Despite broad implementation of digital engineering across U.S. prime defense contractors, its use remains limited among sub-tier suppliers and the Department of Defense's acquisition workforce.

Abstract

Today's Department of the Air Force (DAF) is in crisis and faces severe capability and capacity shortfalls across nearly every mission area. Despite the need to rapidly recapitalize and modernize the force, the Department of Defense's (DOD) legacy approaches to acquisition, development, and sustainment have proven too costly and inefficient to meet warfighter needs. They are also too slow to keep pace with the aggressive and ongoing modernization efforts of global adversaries like China. Moreover, perpetual efforts to reform U.S. acquisition policy have fallen short of the need to accelerate new capability development and fielding. Digital engineering has the potential to help develop and field new capabilities faster and at lower costs, independent of acquisition reform.

Digital engineering encompasses numerous advances in computing power, data analytics, cloud storage, and secure information sharing that are revolutionizing decades of incremental improvements in design, modeling, simulation, and systems engineering practices—areas where legacy approaches continue to create program challenges. With the right infrastructure and integration, digital engineering can connect the entire lifecycle of defense systems, from initial requirements definition through testing, manufacturing, operation, and sustainment. New-start defense acquisition programs can fully exploit these advantages and save time and resources, while the continued sustainment and modernization phases of legacy and hybrid weapon systems can benefit from digital engineering applications focused appropriately and pragmatically. However, older systems may require significant time and budget to reverse-engineer a digital engineering architecture, so decision-makers must be discerning about how and when to pursue these efforts.

Despite the advantages digital engineering offers, there are still barriers to its widespread adoption within DOD, including stand-up costs, interoperability issues, workforce training issues, cyber security considerations, model validation, and cultural resistance. U.S. defense leaders must become more literate in digital engineering to craft nuanced policy guidance that right-sizes its implementation across the scope of DOD programs and delivers on cost and speed goals. The DOD workforce must also be trained to use digital engineering in their workflows and processes in order to accelerate the development and delivery of capabilities that can restore America's military dominance.

Introduction

Technological superiority has long underpinned America's military dominance. However, decades of prioritizing counter-insurgency missions, deferring foundational recapitalization programs, and divesting force structure to cope with budget pressures have eroded that advantage. This is especially true for the Department of the Air Force. Today's Air Force flies the oldest, smallest aircraft inventory in its history, and the Space Force is pressed to overhaul most elements of its technical architecture to meet the rise in demand for space-based capabilities while mitigating the burgeoning threat environment on orbit.

Rapidly restoring and expanding American overmatch—especially in air and space—is now an urgent national security priority that requires fielding new technologies at scale. Yet, the DOD's legacy approaches to acquisition, development, and sustainment have proven too costly and inefficient to meet warfighter needs. New defense programs still require well over a decade to transition from requirements definition to initial operational capabilities. Likewise, modernization programs that insert new capabilities into existing weapon systems remain beset by cost overruns and schedule delays. This is proving *too slow* to keep pace with the aggressive and ongoing modernization efforts of global adversaries like China and cedes the innovation and agility initiative to these competitors.

Burgeoning global threats like China's military modernization and build-up demand rapid, responsive, and resilient capability development and fielding.[1] That is why digital transformation is integral for equipping America's military for dominance in the 21st-century battlespace. Digital engineering presents a set of tools and processes, like modern computing advances and model-based program management approaches, that can increase the speed, quality, affordability, and performance of DOD's capability development. This could transform and accelerate the Department of Defense's (DOD) legacy engineering, acquisition, and production processes, thereby speeding capability to the warfighter. Digital engineering technologies and techniques that already exist could remedy many acquisition ailments—lengthy timelines, cost overruns, performance shortfalls, and maintenance burdens, to name a few—if the DOD and the services fully embrace it.

A key reason why digital engineering holds such promise is that it can create a level of integration that facilitates unprecedented visibility and cross-team collaboration not found in legacy approaches. Digital models can serve as a program's authoritative source of truth—a definitive and robust master set of digital artifacts, including their work histories, encompassing all aspects of a program. As engineers make changes to a new weapon system design, a digital thread enabling access to the authoritative source of truth ensures all stakeholders will have the ability to see any and all changes instantly as they propagate across the project's entire ecosystem. That is not possible with older approaches. For example, engineers developing different subcomponents can check for whole-of-system consequences that a design change might incur. Program managers can also exercise real-time program oversight and drill down to specific details or anticipate potential issues. This level of collaboration can reduce incompatibility issues or design and manufacturing rework that can cause serious developmental delays. In other words, digital engineering empowers enterprise thinking, not just excellence within a stovepipe; great work, if produced in isolation, may yet prove incongruous when integrated later in the development process.

Understanding Digital Engineering

Digital engineering is the natural and transformational evolution of engineering practices that leverages exponential gains in computing power, data analytics, modeling and simulation software tools, and secure information transfer technologies. Together, these technologies have a synergistic effect that can empower all defense program stakeholders, who may be scattered across the globe, to collaborate from "authoritative artifacts" quickly and accurately—and in real time. An authoritative artifact is like the master version of a document but could be any of a number of products like 2D blueprints, program requirements documents, prototype testing models, and other digitized models. The complete collection of these artifacts for any one development project is called the "authoritative source of truth," and digital engineering tools open collaborative access to the authoritative source of truth across the development cycle to an unprecedented degree. Another way to understand this is that digital engineering combines longstanding digitized modeling and simulation tools with recent advancements in processing, networking, and systems engineering to create a real-time "digital thread," an architecture akin to the digital shared workspaces or sharing platforms becoming ubiquitous across private commercial workplaces. The increased integration that can be achieved across program teams improves the efficiency and quality of processes and products across the entire lifecycle of a system. It also safeguards the integrity of the authoritative source of truth. Moreover, the real-time integration and transparency of program activities can provide government officials, such as program managers and executive steering committees, full insight into and oversight of the program regardless of milestone dates. This can alert them to early issues or enable a flow of continuous certification and approval, thus streamlining program execution.

Digital Engineering Key Terms and Definitions

•**Artifact:** Product, model, document, or other technical or performance data related to a program's development, creation, operation, and sustainment.

•**Computer-aided design/computer-aided modeling (CAD/CAM):** Software programs and other tools to innovate digitally—instead of using paper-based designs or blueprints—and simulate physical models like aircraft in wind tunnels. CAD/CAM can supplement or, in some cases, fully replace paper design and simulation practices.

•**Digitized artifact:** The conversion of analog artifacts like paper blueprints and clay models into a digitized format like a Word document or CAD file.

•**Authoritative source of truth:** The central and definitive reference point for a program regarding requirements, design, and data in a digital engineering paradigm. When this source is digitized and cloud-based, changes propagate throughout the digital design model.

•**Digital thread:** The network infrastructure and software that connect and update digital models of programs and systems. Having a digital thread is what enables all stakeholders to have access to the authoritative source of truth in real time.

•**Digital engineering:** The combination of digitized engineering tools and practices like CAD/CAM and MBSE with cloud computing and big data analytics to enable program stakeholders to interact fluidly with an authoritative source of truth. Digital engineering supports a whole-of-enterprise lifecycle approach to systems requirement generation, design, manufacturing, sustainment, and operations.