DEPARTMENT OF DEFENSE

DIGITAL ENGINEERING STRATEGY

JUNE 2018

Office of the Deputy Assistant Secretary of Defense
for Systems Engineering

Washington, D.C.

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Michael D. Griffin

Under Secretary of Defense for Research and Engineering
U.S. Department of Defense

Foreword

In the Department of Defense (DoD) National Defense Strategy of 2018, Secretary of Defense James Mattis encouraged all of us to adopt new practices to achieve greater performance and affordability to meet current and future challenges. Without sustained and predictable investment to restore readiness and modernize, we will rapidly lose our military advantage, resulting in a Joint Force that has legacy systems irrelevant to the defense of our people. In order to meet the National Defense Strategy's lines of effort, we must modernize our defense systems and prioritize speed of delivery to be able to fight and win the wars of the future.

One way we can do this is by incorporating the use of digital computing, analytical capabilities, and new technologies to conduct engineering in more integrated virtual environments to increase customer and vendor engagement, improve threat response timelines, foster infusion of technology, reduce cost of documentation, and impact sustainment affordability. These comprehensive engineering environments will allow DoD and its industry partners to evolve designs at the conceptual phase, reducing the need for expensive mock-ups, premature design lock, and physical testing.

This DoD Digital Engineering Strategy outlines the Department's five strategic goals for the digital engineering initiative. The goals promote the use of digital representations of systems and components and the use of digital artifacts as a technical means of communication across a diverse set of stakeholders. The strategy addresses a range of disciplines involved in the acquisition and procurement of national defense systems, and it encourages innovation in the way we build, test, field, and sustain our national defense systems and how we train and shape the workforce to use these practices.

This strategy is the result of extensive research and collaboration among the DoD Components and academic partners, as well as interactions with industry, professional societies, and defense acquisition associations. The possibilities these digital practices bring arise from years of effort and advancements in technical, legal, and social sciences. The practices have demonstrated their usefulness in engineering-related tasks and in many areas of DoD operations.

This strategy describes the "what" necessary to foster the use of digital engineering practices. Those implementing the practices must develop the "how" — the implementation steps necessary to apply digital engineering in each enterprise. The Services should develop corresponding digital engineering implementation plans during 2018 to ensure the Department advances this timely and imperative effort.

Michael D. Griffin
Under Secretary of Defense for Research and Engineering

"Advancements in computing, modeling, data management, and analytical capabilities offer great opportunities for the engineering practice. Applying these tools and methods, we are shifting toward a dynamic digital engineering ecosystem. This digital engineering transformation is necessary to meet new threats, maintain overmatch, and leverage technology advancements."

Ms. Kristen Baldwin

Acting Deputy Assistant Secretary of Defense for
Systems Engineering (DASD(SE))

"Digital Engineering is the fundamental component to enable the U.S. Air Force to rapidly make informed decisions to facilitate agile acquisition and Rapid fielding of dominant weapon systems for the warfighter."

Mr. Jeff Stanley

Deputy Assistant Secretary of the Air Force for
Science, Technology, and Engineering,
Office of the Assistant Secretary of the Air Force for
Acquisition and Logistics

"Rapidly evolving threats, warfighting concepts, and technologies require us to innovate, engineer, and integrate quickly. Authoritative and accessible data, models, and architectures must underpin modernization."

COL Robert H. Kewley Jr.

Acting Executive Director,
Office of the Chief Systems Engineer
HQDA Assistant Secretary of the Army
(Acquisition, Logistics and Technology) (ASA(ALT))

"Digital engineering approaches and methods are a key enabler to delivery of affordable capability to the warfighter with speed and lethality. The Department of the Navy has proactively embraced digital engineering and believes it is the way we must execute business in the 21st century."

Mr. William Bray

Deputy Assistant Secretary of the Navy for
Research, Development, Test and Evaluation
(DASN(RDT&E))

CONTENTS

I. INTRODUCTION

The U.S. Department of Defense (DoD) requires robust engineering practices to develop the weapon systems the Nation needs to maintain superiority against threats from adversaries worldwide. Traditionally, the Department has relied on a linear process to develop complex systems that serve a range of missions and users. Often the acquisition engineering processes are document-intensive and stove-piped, leading to extended cycle times with systems that are cumbersome to change and sustain. The DoD faces the challenge of balancing design, delivery, and sustainment of complex systems with rapidly changing operational and threat environments, tight budgets, and aggressive schedules. Current acquisition processes and engineering methods hinder meeting the demands of exponential technology growth, complexity, and access to information.

To help ensure continued U.S. technological superiority, the Department is transforming its engineering practices to digital engineering, incorporating technological innovations into an integrated, digital, model-based approach. The Department seeks to advance the state of engineering practice to support lifecycle activities while shaping the culture and workforce to innovate, experiment, and work more efficiently.

Digital technologies have revolutionized business across most major industries, and our personal life activities. Through increased computing speed, storage capacity and processing capabilities, digital engineering has empowered a paradigm shift from from the traditional design-build-test methodology to a model-analyze-build methodology. This approach can enable DoD programs to prototype, experiment, and test decisions and solutions in a virtual environment before they are delivered to the warfighter.

Digital engineering will require new methods, processes, and tools, which will change the way the engineering community operates; however, this shift extends beyond the engineering community with an impact on the research, requirements, acquisition, test, cost, sustainment, and intelligence communities. The digital engineering transformation offers similar positive changes for business operations including acquisition practices, legal requirements, and contracted activities.

II. PURPOSE

The DoD Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD(SE)) developed this strategy in cooperation with stakeholders across government, industry, and academia. The strategy is a living document and will evolve to support the Department's continuing need to provide critical capability to the warfighter as quickly as possible. The Department intends to remain actively engaged with partners internal and external to the DoD, including the Defense Industrial Base, to maintain communication and alignment on the implementation of this strategy.

The strategy is intended to guide the planning, development, and implementation of the digital engineering transformation across the DoD. As the DoD Components continue to make progress in digital engineering, this document will help align implementation efforts across the Department.

This strategy does not intend to be prescriptive. It is designed to foster shared vision and ignite timely and focused action. ODASD(SE) will work with the DoD Components to guide the development of Service implementation plans, which will provide a roadmap and objectives for achieving the goals. ODASD(SE) will lead and coordinate actions shown in Figure 1.

Digital Engineering Initiatives

Policy/Guidance	Pilots	Implementation	Tools
• Develop/update DoD policies that support realization of digital engineering goals (e.g. data rights, Intellectual Property) • Develop standard contract language for requests for proposals that encourages model-centric interaction between industry and government • Support standards development to support digital engineering goals	• Develop and execute cross-Service digital engineering virtual environment • Ensure alignment across the Services' pilot implementations	• Provide guidance and cohesion to Services for development of Service-level digital engineering implementation plans	• Convene tool summit between industry and government. Collaborate with industry on standards, formats, and interfaces to improve collaboration, data exchange, and internet protocal protection • Sponsor Federally Funded Research & Development Center-wide workshops to develop Digital Engineering Standards roadmap

Figure 1: ODASD(SE) Digital Engineering Leadership Role

III. VISION

The DoD vision for digital engineering is to modernize how the Department designs, develops, delivers, operates, and sustains systems. DoD defines digital engineering as an integrated digital approach that uses authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through disposal.

DoD's approach is to securely and safely connect people, processes, data, and capabilities across an end-to-end digital enterprise. This will enable the use of models throughout the lifecycle to digitally represent the system of interest (i.e., system of systems, systems, processes, equipment, products, parts) in the virtual world. DoD will incorporate technologies such as advanced computing, big data analytics, artificial intelligence, autonomous systems, and robotics to improve the engineering practice.

Digital engineering will enable stakeholders to interact with digital technologies and solve problems in new and ground-breaking ways. Using models is not a new concept; however, digital engineering emphasizes continuity of the use of models across the lifecycle. Transitioning to digital engineering will address long-standing challenges associated with complexity, uncertainty, and rapid change in deploying and using U.S. defense systems. By providing a more agile and responsive development environment, digital engineering will support engineering excellence and provides a foundation to fight and win the wars of the future. Expected benefits of digital engineering include better informed decision making, enhanced communication, increased understanding of and confidence in the system design, and a more efficient engineering process (Figure 2).

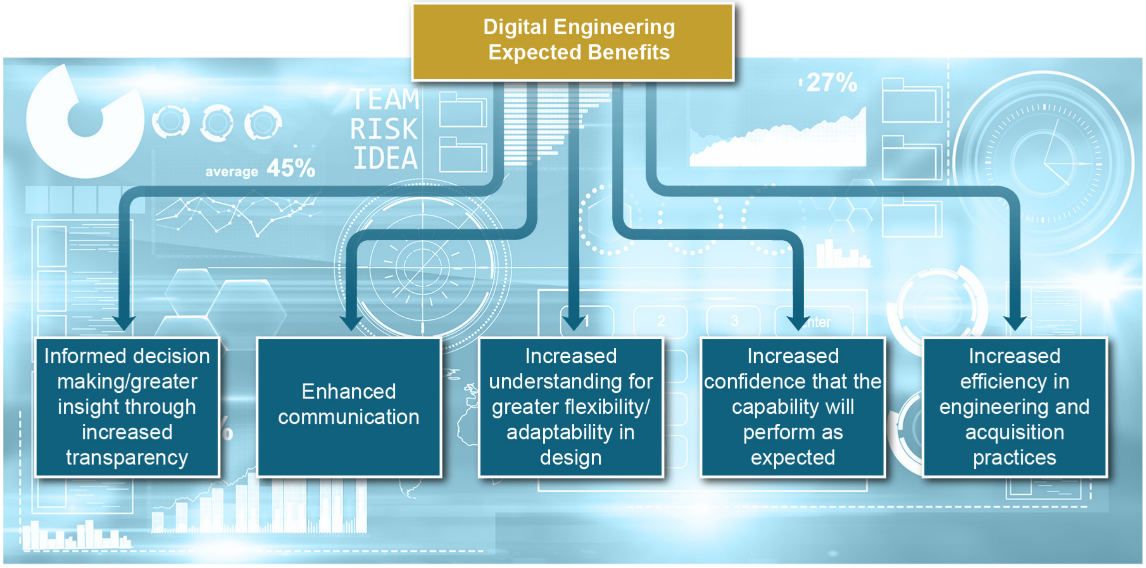

Figure 2: Digital Engineering Expected Benefits

IV. GOAL SUMMARY

Figure 3 illustrates the five goals that make up the digital engineering strategy.

1. **Formalize the development, integration, and use of models to inform enterprise and program decision making.** The first goal establishes the formal planning, development and use of models as an integral part of performing engineering activities as a continuum across the lifecycle. Such ubiquitous use of models will result in a continuous end-to-end digital representation of the system of interest. This will support consistent analysis and decision making for programs and across the enterprise.

2. **Provide an enduring, authoritative source of truth.** This goal moves the primary means of communication from documents to digital models and data. This enables access, management, analysis, use, and distribution of information from a common set of digital models and data. As a result, authorized stakeholders have the current, authoritative, and consistent information for use over the lifecycle.

3. **Incorporate technological innovation to improve the engineering practice.** This goal extends beyond the traditional model-based approaches to incorporate advancements in technology and practice. Digital engineering approaches also supports rapid implementation of innovations within a connected digital end-to-end enterprise.

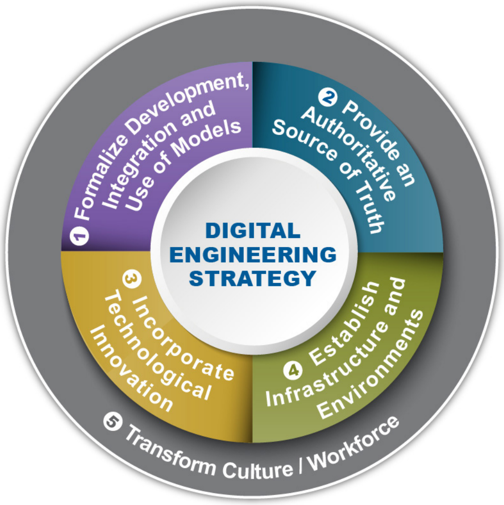

Figure 3: Digital Engineering Goals

4. **Establish a supporting infrastructure and environments to perform activities, collaborate, and communicate across stakeholders.** This goal promotes the establishment of robust infrastructure and environments to support the digital engineering goals. It incorporates an information technology (IT) infrastructure and advanced methods, processes, and tools, as well as collaborative trusted systems that enforce protection of intellectual property, cybersecurity, and security classification.

5. **Transform the culture and workforce to adopt and support digital engineering across the lifecycle.** The final goal incorporates best practices of change management and strategic communications to transform the culture and workforce. Focused efforts are needed to lead and execute the change, and support the organization's transition to digital engineering.

V. DIGITAL ENGINEERING GOALS AND FOCUS AREAS

GOAL 1:
Formalize the Development, Integration, and Use of Models to Inform Enterprise and Program Decision Making

Models can provide a precise and versatile representation of a system, phenomenon, entity, or process. In early phases of the lifecycle, models enable virtual exploration of solutions before actually instantiating them. Over a solution's lifecycle, models mature and can become useful replicates to physical counterparts for virtual testing and logistics sustainment support.

This goal focuses on the formalized application of modeling to support all the system lifecycle phases from concept through disposal. Figure 4 represents examples of different types of models that are developed, integrated, and used as the foundation of an authoritative source of truth across the lifecycle. Various disciplines and domains can concurrently operate on different aspects of the system in the virtual environment. Instead of discarding and redeveloping models, the collection of models evolves from one phase to the next. As a result, models live throughout the life span of the system.

1.1 Formalize the planning for models to support engineering activities and decision making across the lifecycle

DoD organizations will develop formal plans for model creation, curation, integration, and related program and enterprise engineering activities throughout the lifecycle. The plans will describe how models will be realized in a coherent and effective manner as work activities are performed, and as analyses and decisions are supported.

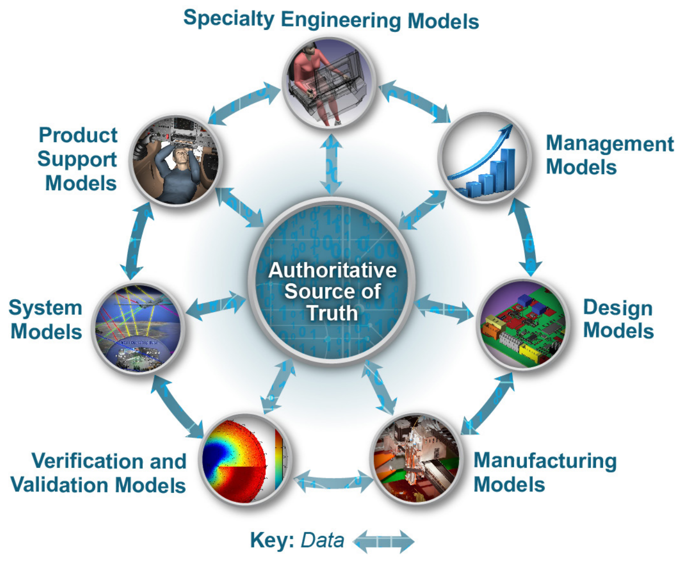

Figure 4: Examples of Models Connected via the Authoritative Source of Truth

V. DIGITAL ENGINEERING GOALS AND FOCUS AREAS

Formally develop plans to digitally represent the system of interest

DoD organizations will formally develop and implement plans to digitally represent the system of interest. This planning will establish an approach that uses models to enable the orchestration of activities, the efficient management of work, and the integration of work products across enterprises and multidisciplinary teams to result in a digital representation of the system of interest. This planning will set in place the formalisms which establish the foundational quality standards and rules (e.g., syntax, semantics, lexicons, standards, etc.) that model development will be expected to adhere to.

U.S. NAVY

Next Generation Aircraft Carriers – USS Ford (CVN-78)

USS Ford (CVN-78) is the first ship to be fully designed using a full-scale three-dimensional (3-D) product model. During the design process, the shipbuilders, with the integration and use of 3-D models, found hidden value in every square inch of the ship, saving the Navy a projected $4 billion in ownership costs over the ship's 50-year lifespan.

EXAMPLE: ***Formalize Development, Integration and Use of Models (Goal 1)***

1.2 Formally develop, integrate, and curate models

DoD organizations will use model formalisms to aid in the development, integration, and curation of models. Formalisms ensure consistency with the system and external program dependencies. DoD organizations will identify and maintain an approach that integrates models generated by all stakeholders to digitally represent the system of interest throughout the lifecycle.

Develop and ensure models are accurate, complete, trusted, and reusable

Models will be developed according to policy, guidance, standards, and model formalisms. The DoD organizations will capture and maintain model provenance and pedigree in order to establish trust, credibility, accuracy, and a basis for judging model reuse. Model-based reviews, audits, and trust, based on validation and verification attributes, are essential to effective collaboration and the system of interest's evolution.

Integrate and curate models across disciplines to support cohesive model-driven lifecycle activities

The collaborative lifecycle efforts will be supported by an integrated set of models. Models will be constructed to become the authoritative source of truth, which should include traceability of models from concept through disposal. Model integration and curation should adhere to plans to capture and communicate information to decision makers.

1.3 Use models to support engineering activities and decision making across the lifecycle

Models will be used as the basis for defining, evaluating, comparing, and optimizing alternatives and making decisions. The models will span all disciplines and will provide a unified representation that enables concurrent engineering and other program activities.

Use models to communicate, collaborate, and perform model-driven lifecycle activities

Models are used to answer questions, reason about the solution, support decisions, and communicate clearly and unambiguously at all levels of fidelity and across lifecycle activities. Models should be used to support full lifecycle activities. Exchange of information between technical disciplines or organizations should take place via model exchanges and automated transformations, whenever possible. Instructions will be prepared in support of collaboration to ensure accurate use and operation.

USS Ford (CVN-78)

GOAL 2:
Provide an Enduring, Authoritative Source of Truth

This goal provides the authoritative source of truth for stakeholders across organizations to access, manage, protect, and analyze the models and data from Goal 1. The primary means for communication moves away from static and disconnected artifacts and shifts the paradigm to models and data serving as the basis for connecting traditionally siloed elements and providing an integrated information exchange throughout the lifecycle. As shown in Figure 5, stakeholders will have the ability to collaboratively work within and through the authoritative source of truth using shared knowledge and resources across the lifecycle.

2.1 Define the authoritative source of truth

The authoritative source of truth captures the current state and the history of the technical baseline. It serves as the central reference point for models and data across the lifecycle. The authoritative source of truth will provide traceability as the system of interest evolves, capturing historical knowledge, and connecting authoritative versions of the models and data. Changes made to the authoritative source of truth will propagate throughout the digital design model to all affected systems and functions. Properly maintaining the authoritative source of truth will mitigate the risk of using inaccurate model data, and support effective control of the current and historic configuration data files. The goal is to enable delivery of the right data to the right person for the right use at the right time.

Plan and develop the authoritative source of truth

The realization of the authoritative source of truth requires up-front planning and use of models addressed in Goal 1. Setting clear expectations for defining, developing, and using the authoritative source of truth across disciplines and throughout lifecycle is imperative. Planning includes determining the data needs for acquisition, engineering to support decisions, and creating seamless integration of authoritative data sources. The authoritative source of truth facilitates a sharing process across the boundaries of engineering disciplines, distributed teams, and other functional areas. It will provide the structure for organizing and integrating disparate models and data across the lifecycle. In addition, the authoritative source of truth will provide the technical elements for creating, updating, retrieving, and integrating models and data.

2.2 Govern the authoritative source of truth

Organizations will establish policies and procedures to ensure proper use of the authoritative source of truth. Governance will ensure the models and data are formally managed and trusted throughout the lifecycle. In addition, stakeholders will collect, share, and maintain the models and data accurately. Establishing standardized procedures is essential to maintain the integrity and quality of the models and data, and to ensure compliance with the organization and business rules. Governance processes will help stakeholders resolve issues, ensure consistency and accuracy of the authoritative source of truth, and enable stakeholders to make data-driven decisions.

Establish access and controls for the authoritative source of truth

Establishing access and controls is necessary to ensure authorized users have access to the right information at the right time. Properly defining access and controls for the authoritative source of truth will allow an uninterrupted flow of models and data across organizational boundaries. Data must be readily available to all intended recipients, but also protected from unauthorized users. Maintaining access and control criteria can ensure information will be appropriately created, managed, protected, and retained.

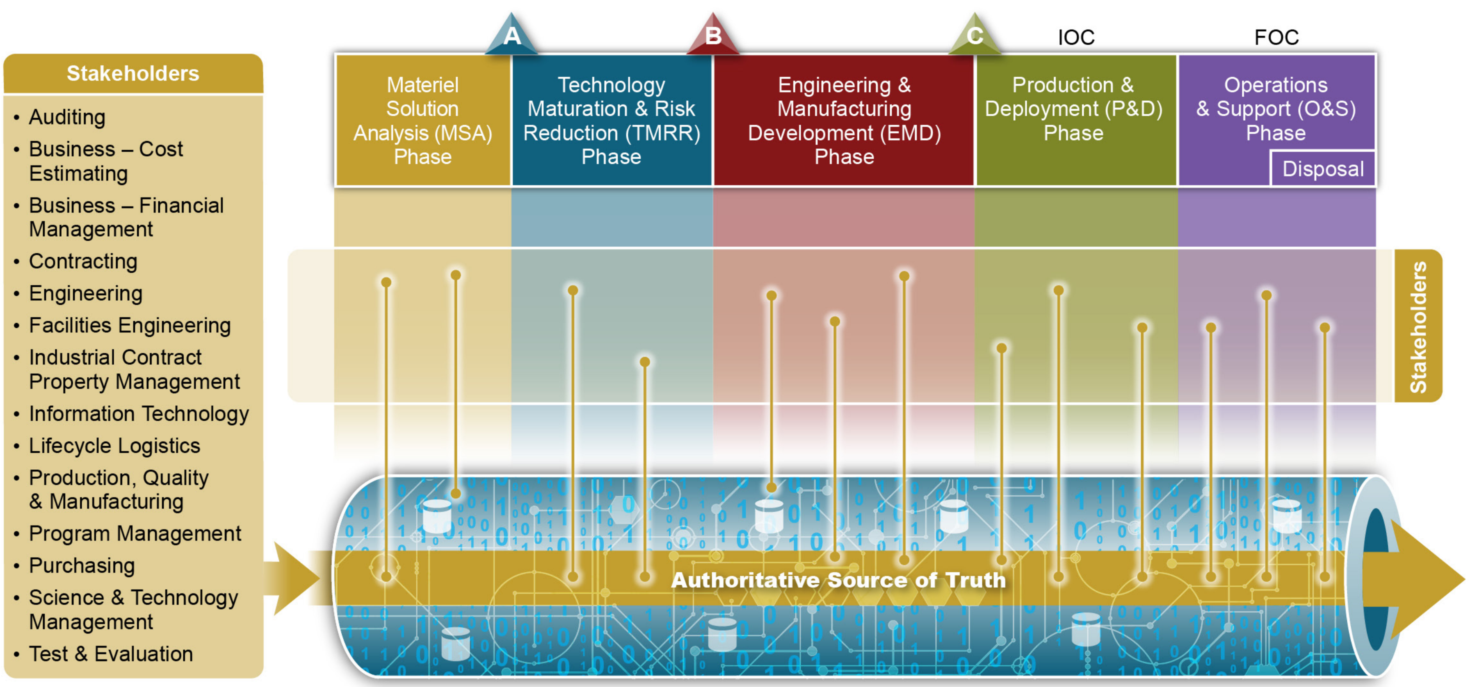

Figure 5: Authoritative Source of Truth

Execute governance of the authoritative source of truth

An effective and robust governance process involves responsibilities at various levels. Managing policies, procedures, and standards will ensure proper governance of the authoritative source of truth and enhance data quality across the lifecycle. Executing governance should result in increased stakeholder confidence in the integrity of the authoritative source of truth.

2.3 Use the authoritative source of truth across the lifecycle

The authoritative source of truth will be used to develop, manage, and communicate information about systems from concept through disposal. As such, the authoritative source of truth will serve as the primary means to share and exchange the models, data, and digital artifacts. The authoritative source of truth will equip programs with enterprise-wide knowledge needed to plan, design, and sustain systems.

Use the authoritative source of truth as the technical baseline

Stakeholders should use the authoritative source of truth to make informed and timely decisions to manage cost, schedule, performance, and risks. For example, contract deliverables should be traced and validated from the authoritative source of truth. This will allow stakeholders at various levels to respond knowledgeably to the development, operation, and execution of the system, thereby avoiding technical and management barriers to mission success.

Use the authoritative source of truth to produce digital artifacts, support reviews, and inform decisions

As the technical baseline matures, preserving the knowledge across programs and lifecycle phases is essential. Technical reviews can be conducted from the authoritative source of truth on a continuous basis. Stakeholders will generate digital artifacts, representing multiple views and various perspectives from the authoritative source of truth. Digital artifacts provide visibility of appropriate information across functional domains, disciplines, and organizations.

U.S. ARMY

Lifecycle Product Data Management (LPDM) and Enterprise Product Data Management (LPDM/ePDM)

U.S.ARMY

The Army is implementing a lifecycle approach for the extensive and complex product data required in the engineering design, acquisition, and sustainment of military systems. The Lifecycle Product Data Management and enterprise Product Data Management (LPDM/ePDM) system provides an authoritative source of truth that Army will use to manage all weapon system and end item data throughout the lifecycle.

EXAMPLE: ***Provide and Enduring Authoritative Source of Truth (Goal 2)***

Collaborate and communicate using the authoritative source of truth

The authoritative source of truth will enable teams to work collaboratively, with access to up-to-date models, data, and information, while seamlessly integrating their work. As established in Goal 1, models serve as a continuum across the lifecycle. This paradigm shift will fundamentally change the current practice of accepting documents to accepting models and provides the technical underpinnings for acquisition domains and functional areas. Users can generate various views using a shared network of models and data to offer coherent digital artifacts, while reducing time-consuming effort and rework. As a result, stakeholders will be able to propose alternative solutions, collaborate between teams, and promote reuse and increase productivity, while analyzing the impact of change.

V. DIGITAL ENGINEERING GOALS AND FOCUS AREAS

GOAL 3
Incorporate Technological Innovation to Improve the Engineering Practice

This goal is designed to enable DoD organizations to maintain technological superiority by innovating rapidly and providing access to and use of advanced technologies. Building upon the model-based approaches from Goal 1 and Goal 2, this goal infuses advancements in technology and practice to build an end-to-end digital enterprise. By connecting our stakeholders, processes, capabilities, and data digitally, DoD organizations will have the ability to analyze, and adapt quickly in order to modernize capabilities and make more timely and relevant decisions. This approach also creates opportunities to leverage technologies that learn, adapt, and act autonomously. Figure 6 illustrates examples that will enable a digitally connected enterprise and drive innovation to transform the practice of engineering. Examples include advanced computing, big data analytics, artificial intelligence, autonomous systems, robotics, and so on.

3.1 Establish an end-to-end digital engineering enterprise

DoD's vision is to have an engineering enterprise that connects the digital and physical worlds across a system's lifecycle. The end-to-end digital enterprise will incorporate a model-based approach in a digitally connected environment enabled by advanced technologies to conduct full lifecycle activities from concept to disposal. In the earlier phases of the lifecycle, the focus is on evaluating concepts, engaging the user, and identifying tradeoffs using a

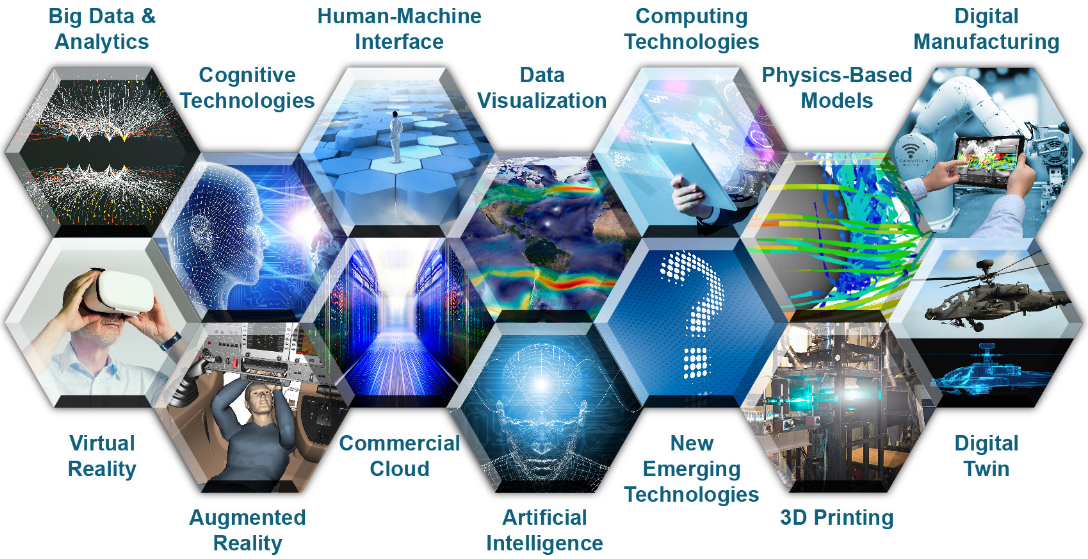

Figure 6: Technological Innovation Examples

digital representation of the system of interest. Later in the lifecycle, the focus is on production, delivery and sustainment of the end item. The goal is to continually evolve the digital representation alongside the end item, gaining continuous insight and knowledge from the operational environment.

U.S. AIR FORCE

A-10 Thunderbolt II

The A-10 aircraft was designed in the 1970s using 2-D drawings. The A-10 Wing Replacement Program (WRP) infused 3-D model-based design (MBD). The program developed approximately 10,000 unique models that required new methods to allow for handling and integrating data. A-10 also adopted a new technology, NLign, to map repairs onto the 3-D model. The adoption of 3-D MBD and Product Lifecycle Management (PLM) allowed A-10 to construct the digital thread for the sustainment phase of the lifecycle and identify the authoritative source of truth for A-10 engineering data.

EXAMPLE: ***Incorporate Technological Innovation (Goal 3)***

A-10 Thunderbolt II

Infuse technological innovations to enable the end-to-end digital enterprise

DoD's strategy is to improve its technology insertion processes to support cutting-edge technology infusion that leverages the marketplace while finding high-payoff solutions. Stakeholders should consider current and future enterprise and program needs when selecting technologies to support the digital enterprise. DoD will implement rigorous processes to support cost-effective technology development and selection decisions.

3.2 Use technological innovations to improve the digital engineering practice

Advances in data analytics can help gain greater insights from existing model data. Stakeholders should use technological innovations to improve decision making, system capabilities, and performance of computationally intensive engineering activities. Technology advancements will also transform how machines communicate and collaborate with each other and with humans, and will use the strengths of both humans and machines to improve the engineering practice.

Make use of data to improve awareness, insights, and decision making

There has been an exponential growth of data from various formats, data structures, and sources. Technological advancements in big data and analytics now make it possible to not only to help warfighters on the battlefield but also to make better use of the vast and growing amount data across each phase of the lifecycle to help inform the lifecycle processes. DoD's vision is to build an enterprise capability that securely leverages data and analytics to enable insights and achieve faster and better data-driven decisions. By capturing and continuously assessing data as the design evolves, potential improvements and options can be compared and optimized in short periods of time.

Advance human-machine interactions

Realizing an end-to-end digital enterprise, automating tasks and processes, and making smarter, faster decisions all require the next frontier of technologies that transform the way humans and machines interact. Advances in artificial intelligence have given rise to cognitive technologies that are able to perform tasks that traditionally required human intelligence. Machines are now able to build knowledge, continuously learn, understand natural language, and reason and interact more naturally with human beings than traditional systems. DoD's vision expects humans to interact with machines to make faster data-driven decisions and help exploit data more effectively than humans could on their own. The DoD will advance human-machine interactions by developing awareness of these technologies, evaluating opportunities to pilot them, and demonstrating options for creating value with them.

GOAL 4
Establish a Supporting Infrastructure and Environments to Perform Activities, Collaborate, and Communicate Across Stakeholders

This goal focuses on building digital engineering infrastructures and environments to support all of the digital engineering goals. Current DoD IT infrastructures and environments do not fully support digital engineering stakeholder needs. They are often stove-piped, complex, and difficult to manage, control, secure, and support because their use varies on a program-by-program basis. DoD will advance its infrastructures and environments toward a more consolidated, collaborative trusted environment. DoD will provide infrastructure solutions at the enterprise and program level that support realization of the digital engineering objectives. Figure 7 shows core elements of the infrastructures and environments that will keep pace with technology, enhance cybersecurity and intellectual property protections, and improve information sharing.

4.1 Develop, mature, and use digital engineering IT infrastructures

Digital engineering IT infrastructures include a collection of hardware, software, networks, and related equipment. They span geographical locations and organizations, and they must satisfy security requirements. Digital engineering

Figure 7: Digital Engineering Infrastructure & Environments

IT infrastructures are a crucial enabler and foundation for advancing the state of the practice.

Provide secure connected information networks to perform digital engineering activities

Reliable, available, secure, and connected information networks are necessary to perform digital engineering activities across the lifecycle. The networks must include computing infrastructures and enterprise services at all classification levels that securely facilitate the flow of information and the authoritative source of truth. The networks help improve collaboration, enhance learning, facilitate information sharing, and enable data-driven decision making.

Provide hardware and software to perform digital engineering activities

The DoD will plan, resource, and deploy digital engineering hardware and software solutions to meet the needs of the workforce and associated digital engineering activities. The DoD will consider modular approaches and a wide range of hardware and software solutions to provide flexible scalability, sizable cost savings, and rapid deployment when establishing the digital end-to-end enterprise. The DoD, will incorporate adoption of commercial cloud platforms, technologies, and Service solutions when appropriate.

4.2 Develop, mature, and use digital engineering methodologies

Effective use of a model-based enterprise requires transforming from a document-based approach to a digital approach. As a result, the DoD will evolve in the way engineers work, manage, engineer, and deliver solutions. To take advantage of technical capabilities, the DoD must evolve in the way engineers work, manage, engineer, and deliver solutions.

Develop, mature, and implement methods and processes to support digital engineering activities across the enterprise and lifecycle

The DoD will support this effort by developing, maturing, and implementing engineering methods and processes across an evolving digital engineering infrastructure. This will result in the DoD updating engineering processes, manuals, and instructions to achieve desired digital engineering benefits. At a minimum, these new engineering methods should incorporate technological innovations, authoritative sources of truth, formalized modeling, workforce, and cultural opportunities to improve quality, productivity, and acquisition efficiency.

Develop, mature, and implement digital engineering tools

The DoD will evaluate and identify digital engineering tools for stakeholders based on current and future needs. The tools should be a mix of scalable, enterprise-ready solutions that meet the requirements of stakeholders across disciplines and domains. Stakeholders should consider license agreements

JOINT

Engineered Resilient Systems (ERS)

ERS is a DoD joint program to develop an integrated suite of modern computational engineering tools within an architecture that aligns both acquisition and operational business processes. The suite includes models, simulations and related capabilities, and trade space assessment and visualization tools. The Navy developed more than 19 million ship designs using the ERS tools. ERS uses cost versus capability analysis to determine the affordable capability space for a future surface combatant.

EXAMPLE: *Establish Infrastructure and Environments (Goal 4)*

and data exchange requirements when selecting tools. DoD's strategy is to focus on standards, data, formats, and interfaces between tools rather than being constrained to particular tools. Key factors for digital engineering tools include: visualization, analysis, model management, model interoperability, workflow, collaboration, and extension/customization support. Developing, maturing, and implementing innovative digital engineering tools will help bind people and technology in ways that increase engineering efficiency.

4.3 Secure IT infrastructure and protect intellectual property

The digital engineering transformation relies on the protection of models and data classification, availability, and integrity. Given the amount of information residing in models, the DoD must mitigate cyber risks and secure digital engineering environments against attacks from internal and external threats. The DoD and industrial base will ensure intellectual property and sensitive information are protected, while promoting collaboration between industry and government.

Secure IT infrastructure while facilitating realization of digital engineering goals

The DoD will integrate cybersecurity into all phases of digital engineering planning and execution. Digital engineering stakeholders must ensure the protection of the IT infrastructure, while facilitating the realization of digital engineering goals. The DoD will collectively mitigate known vulnerabilities that present a high risk to DoD networks and data. The DoD and industrial base will mitigate the risk posed by collaboration and access to the vast amounts of information in models. Methods, processes, and tools will be updated and developed to address the unique challenges of collaboration among different networks and levels of security.

Protect intellectual property while using models to collaborate throughout a program lifecycle

The DoD will update its methods, processes, and tools to enable data and model exchanges while protecting property rights for both vendors and for the government. Identification and protection of intellectual property is an extremely complex challenge that government and industry partners must address together. Both DoD and its industrial partners have the responsibility to protect copyrights, trademarks, patents, and competition-sensitive information while simultaneously facilitating the free flow of relevant information throughout the lifecycle between stakeholders.

GOAL 5
Transform the Culture and Workforce to Adopt and Support Digital Engineering Across the Lifecycle

The fifth goal takes a deliberate and systematic approach to planning, implementing, and supporting the DoD's digital engineering transformation. This transformation requires the DoD to move beyond the technical aspects to address workforce challenges such as the people and the culture, which includes shared values, beliefs, and behaviors of an organization. These norms and beliefs fundamentally influence how people behave and perform operations.

To succeed at implementing digital engineering, the DoD needs to make a deliberate effort to transform the workforce to promote a cultural change. Some of these efforts include training, education, strategic communication, leadership and continuous improvements as depicted in Figure 8.

Figure 8: Digital Engineering Culture and Workforce Enablers

V. DIGITAL ENGINEERING GOALS AND FOCUS AREAS

5.1 Improve the digital engineering knowledge base

The digital engineering knowledge base is evolving at various levels of maturity. The DoD documents this knowledge in a broad array of standards, web resources, and academic and trade literature that detail silos of digital engineering excellence. A concerted effort is needed to continually improve, update, and further organize this knowledge base.

Advance digital engineering policy, guidance, specifications, and standards

The DoD uses policy, guidance, specifications, and standards to ensure consistency and discipline across engineering activities. Currently a wide range of standards enable digital engineering (e.g., modeling languages, processes, architecture frameworks), but no set of digital engineering standards covers the range of models and data that must be captured and exchanged across disciplines, domains, and phases of the lifecycle. As a result, the DoD will need to encourage commonality in terminology, develop a shared understanding of concepts, and ensure consistency and rigor in implementing digital engineering across engineering activities. To identify the gaps, the DoD should begin by evaluating current policy, guidance, specifications, and standards to determine what changes are necessary to implement digital engineering.

Streamline contracting, procurement, legal, and business practices

The DoD's procurement practices guide and transform behavior and support effective performance on contracts. The existing processes are paper-based and need to transition to a model-based approach. While a model-based approach offers flexibility, automates manual tasks, and supports collaboration, it will require changes to DoD processes for planning, evaluating, awarding, and managing procurements post-award. For example, digital engineering will influence the Request for Proposal (RFP), Statement of Work (SOW), Contract Data Requirements Lists (CDRL), and any accompanying Data Item Descriptions (DID). This evolution will require engaging

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U.S. NAVY

Systems Engineering Transformation

The Naval Air Systems Command (NAVAIR) Systems Engineering (SE) Transformation initiative aims to modernize how systems engineers use new technologies and model-based approaches to specify, develop, and verify weapon systems. Currently, NAVAIR efforts include improving capabilities in the areas of integrated modeling environments, policy and process, workforce and culture, and experimental pilot projects and demonstrations. NAVAIR's objective is to improve throughput and reduce cycle time to develop weapon systems.

EXAMPLE: *Transform Culture and Workforce (Goal 5)*

contracting and legal teams to streamline business and contracting practices.

Establish and share best practices

To help organizations solve challenges and institutionalize digital engineering, the DoD will advance existing initiatives and networks to synchronize information sharing across digital engineering stakeholders. Best practices should be available for reuse or adaptation. Sharing information about effective courses of action and the lessons learned from experiences allows the broader community to collaborate and learn from each other. This focus area will require a strategic, Department-wide effort to inform, involve, and mobilize the DoD and its partners toward capturing, discovering, and implementing improvements in digital engineering practice. In addition to codifying policy, guidance, and standards, it will include establishing and sharing best practices across the defense acquisition community.

5.2 Lead and support digital engineering transformation efforts

By definition, transformation requires management of change. Driving a culture of innovation, experimentation, and continuous improvement involves shaping organizational team and individuals' values, attitudes, and beliefs about the transformation. Leaders enable the transformation process by encouraging and energizing people to contribute and grow. Such leaders provide the framework for change.

These leaders seek to engage people to accept and embrace changes through communicating and executing a vision and strategy; building and leveraging a wide range of knowledge and innovation; and demonstrating and rewarding tangible results.

Communicate and execute the digital engineering vision, strategy, and implementation

Digital engineering is a fundamental change to the way people work and operate. To encourage participation, the DoD leaders will build and communicate the vision and strategy for digital engineering. An effective vision and strategy help clarify the purpose, direction, and priorities for the organization. It is essential to build open and frequent communication strategies through multiple channels that provide awareness and a common understanding to stakeholders across disciplines and organizations. Leadership should work to remove barriers and address resistance to change, provide resources, establish priorities and key milestones, and define roles and responsibilities to enable implementation of the digital engineering vision and strategy. There should be a mechanism for people to ask questions and provide feedback.

Build alliances, coalitions, and partnerships across government, industry, and academia

A wide range of stakeholders are developing solutions within various aspects of the digital engineering enterprise. Tapping into stakeholders' skills, ingenuity, and advancements can bring insights and ideas that contribute to collectively advancing the state of practice. The DoD can use alliances, coalitions, and partnerships to co-create and deploy concepts to facilitate the sharing of information and resources. It is important for DoD organizations to cultivate and maintain situational and enduring collaborations across the government, international partners, Services, academia, federally funded research and development centers (FFRDC), and industry.

Establish accountability to measure, foster, demonstrate, and improve tangible results across programs and the enterprise

Organizations should identify leadership teams (e.g., champions, sponsors, etc.) that are accountable to actively participate in managing and implementing the transformation efforts. The leadership will initiate broad-based action that generates short-term wins as well as long-term outcomes. Leadership should define metrics and the criteria for success, as a means to create incentives, monitor, reward, take corrective action, and improve results across the enterprise.

5.3 Build and prepare the workforce

The workforce of the future is geographically dispersed, multidisciplinary, and multigenerational. A new generation of engineers will enter the workforce and will take the place of subject matter experts (SME) that will soon retire. The DoD will need the junior engineers to operate alongside the SMEs and carry on into the future. It has become increasingly important to transfer knowledge, competence, and skills by training and educating the workforce at all levels.

Develop knowledge, competence, and skills for the workforce

Workforce training and education are a critical component to developing the knowledge, competence, and skills for the workforce to support the digital engineering transformation. Through training and education of digital engineering and related disciplines, the organization can disseminate information consistently. This is vital to the individual, team, and organization as a whole. The DoD will need to holistically educate and train the workforce in new concepts and methods, processes, and tools.

Ensure active participation and engagement across the workforce in planning and implementing transformation efforts

Training and education are not the only driver of organizational culture change. The DoD must encourage the application of that knowledge through the formation of new habits and behaviors. While training and education are important, "doing" is critical to an organization gaining experience and adapting to new ways of operating. Engaging stakeholders, whether internal or external to the organization, allows for active participation in deciding, designing, and delivering digital capabilities across the lifecycle.

VI. NEXT STEPS

The ODASD(SE) and the DoD Components will collaborate on the digital engineering transformation through the implementation of this *Digital Engineering Strategy*. Although the DoD Components will own their digital engineering implementation plans, the ODASD(SE) will coordinate efforts to ensure the DoD engineering enterprise progresses to improve the engineering practice. As the DoD Components create, share, and execute their implementation plans, the ODASD(SE) will work to close gaps, eliminate duplication, and share best practices. The next steps include the following:

1. **Coordinate DoD Digital Engineering Efforts.**

   ODASD(SE) will convene a digital engineering summit with representative leaders from the DoD Components to discuss Service implementation plans. In addition, ODASD(SE) will continue to collaborate with the DoD Components as part of the Digital Engineering Working Group (DEWG). The DEWG will address common practices and concerns, facilitate information exchange and collaboration, align technical initiatives, propose policy and guidance, and pursue cross-cutting issue resolution.

2. **Develop DoD Implementation Plans.**

   The DoD Components, supported by ODASD(SE), will develop digital engineering implementation plans that show desired outcomes to achieve the goals in this *Digital Engineering Strategy.*

3. **Implement Pilot Programs.**

   DoD Components will implement a number of digital engineering pilot programs to identify barriers and evaluate tools, processes, and cost before full-scale implementation of digital engineering in major programs. The goal of the digital engineering pilots is to learn, measure, and optimize digital approaches for engineering efficiencies and effectiveness.

4. **Sustain Digital Engineering Transformation.**

   The DoD will implement policy, guidance, training, and continuous improvement initiatives to institutionalize digital engineering across government, industry, and academia.

VII. CONCLUSION

We live in a time of growing threats to U.S. interests at home and abroad. Our military must have the ability to equip the warfighter in a timely fashion in the face of ever-changing landscapes and threats. The current engineering practice limits that ability, with stove-piped processes and schedule overruns.

Transforming to digital engineering will allow for risk taking in a digital environment and increased rapid fielding of prototypes. Sectors of private industry and engineering centers in the DoD have embraced this transition, implementing digital engineering activities to great benefit.

The goals identified in this strategy present a plan for DoD to improve its engineering capabilities to continue to defend the United States and its interests. Leaders from across the Department will take action to achieve the goals outlined in this strategy and hold their programs and organizations accountable. Because the Department operates multiple missions, faces different threats and uses a spectrum of technologies, no single approach will suffice. Success requires collaboration, business and cultural change across DoD, with the private sector, with U.S. allies and partners, and within the evolving future workforce.

APPENDIX 1

DIGITAL ENGINEERING GOALS AND FOCUS AREAS

GOALS	FOCUS AREAS
Formalize the development, integration, and use of models to inform enterprise and program decision making	• Formalize the planning for models to support engineering activities and decision making across the lifecycle - Formally develop plans to digitally represent the system of interest • Formally develop, integrate, and curate models - Develop and ensure models are accurate, complete, trusted, and reusable - Integrate and curate models across disciplines to support cohesive model-driven lifecycle activities • Use models to support engineering activities and decision making across the lifecycle - Use models to communicate, collaborate, and perform model-driven lifecycle activities
Provide an enduring, authoritative source of truth	• Define the authoritative source of truth - Plan and develop the authoritative source of truth • Govern the authoritative source of truth - Establish access and controls for the authoritative source of truth - Execute governance of the authoritative source of truth • Use the authoritative source of truth across the lifecycle - Use the authoritative source of truth as the technical baseline - Use the authoritative source of truth to produce digital artifacts, support reviews, and inform decisions - Collaborate and communicate using the authoritative source of truth
Incorporate technological innovation to improve the engineering practice	• Establish an end-to-end digital engineering enterprise - Infuse technological innovations to enable the end-to-end digital enterprise • Use technological innovations to improve the digital engineering practice - Make use of data to improve awareness, insights and decision making - Advance human-machine interactions

GOALS	FOCUS AREAS
Establish a supporting infrastructure and environments to perform activities, collaborate, and communicate across stakeholders	• Develop, mature, and use digital engineering IT infrastructures - Provide secure connected information networks to perform digital engineering activities - Provide hardware and software to perform digital engineering activities • Develop, mature, and use digital engineering methodologies - Develop, mature, and implement methods and processes to support digital engineering activities across the enterprise and lifecycle - Develop, mature, and implement digital engineering tools • Secure IT infrastructure and protect intellectual property - Secure IT infrastructure while facilitating realization of digital engineering goals - Protect intellectual property while using models to collaborate throughout a program lifecycle
Transform the culture and workforce to adopt and support digital engineering across the lifecycle	• Improve the digital engineering knowledge base - Advance digital engineering policy, guidance, specifications, and standards - Streamline contracting, procurement, legal, and business practices - Establish and share best practices • Lead and support digital engineering transformation efforts - Communicate and execute the digital engineering vision, strategy, and implementation - Build alliances, coalitions, and partnerships across government, industry, and academia - Establish accountability to measure, foster, demonstrate, and improve tangible results across programs and the enterprise • Build and prepare the workforce - Develop knowledge, competence, and skills for the workforce - Ensure active participation and engagement across the workforce in planning and implementing transformation efforts

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