SYM-AM-25-332

Excerpt from the Proceedings

of the

Twenty-Second Annual Acquisition Research Symposium and Innovation Summit

Wednesday, May 7, 2025 Sessions
Volume I

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Published: May 5, 2025

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

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A Modular Open Systems Approach (MOSA) to Enable Technology Transition

Dr. Kelly Alexander—Chief Systems Engineer | System Innovation, Contractor Support to OUSD(R&E) SE&A. [kelly.d.alexander12.ctr@mail.mil]

Ms. Monique Ofori—Systems Engineering Manager | SAIC, Contractor Support to OUSD(R&E) SE&A. [monique.f.ofori.ctr@mail.mil]

Ms. Nadine Geier—Systems Engineering Director, OUSD(R&E) SE&A. [nadine.m.geier.civ@mail.mil]

Abstract

Technology Transition is referred to as the "valley of death" due to commonly experienced lack of successful transition to the next phase of system development. The high risk of technology development can cause a delay or cancellation that can be mitigated by Modular Open Systems Approaches (MOSA) principles. MOSA enables technology transition by providing a framework for integrating, upgrading, and replacing components with minimal disruption. By addressing these MOSA principles early in the development cycle, technology transition is more predictable and manageable:

(1) Modular Architecture: Focuses on modularity offer plug-and-play capability, where system components adhere to defined standards and interfaces. Modularity also supports incremental upgrades, enabling individual modules to be updated or replaced as technology evolves and parallel development for specified (potentially high-risk) components.

(2) Interface Management with Consensus Based Open Standards: (a) Well-Defined Interfaces that rely on widely recognized, consensus-based open standards, ensuring that new technologies from different vendors integrate effectively, reducing development and integration challenges. (b) Open Standards facilitate component reuse, which reduces integration time and can also reduce lifecycle costs by increased competition.

(3) Enabling Environment that promotes Model Based Systems Engineering (MBSE) tools and processes with access to data to enhance interoperability and options in configuration.

Background

The successful transition of emerging technologies into operational systems is a critical challenge in modern defense system development. Systems development often begins with a science and technology (S&T) development effort to mature a technology solution. Manufacturing objectives and sustainment are generally included in the effort, but the primary rationale for completing S&T development phase is an assessment of the technical maturity. Technical maturity is determined in accordance with the DoD technology readiness assessment guidelines (Office of Systems Engineering and Architecture & Office of the Under Secretary of Defense for Research and Engineering [OUSD(R&E)], 2025) which defines the parameters for the transition to the advanced systems development phase that is the entrance to an acquisition program. The transition from an S&T program to an acquisition program or technology transition is often referred to as the "valley of death" because of the commonly experienced lack of successful transition between these phases.

Based on prior studies, there are several ongoing efforts to improve the success rate of technology transition across the DoD. The DAU lists 19 separate programs or activities that are intended to improve or influence the success rate of this transition (Defense Acquisition University [DAU], n.d.) However, none of these programs explicitly addresses the role that a Modular Open Systems Approach (MOSA) can bring to the Defense Innovation Ecosystem. The principles of MOSA can provide a framework to improve the transition success within the

context of DoD S&T and Acquisition.

A MOSA provides a structured methodology to enhance adaptability (scalability and upgradability), interoperability, and lifecycle affordability. MOSA enables technology transition by providing a framework for integrating, upgrading, and replacing components. Aligning technology development and technology transition strategies with MOSA principles as a technical framework can improve integration, reduce obsolescence risks, provide opportunities for competition and accelerate innovation adoption. This paper will discuss the current technology transition concerns, followed by a description and discussion of MOSA principles that can enable technology transition, and finally, propose a MOSA Aligned Technology Transition Framework (MA-TTF) that can be implemented within the current technology development strategy documentation.

Current State and Challenges of Technology Transition

The DoD takes technology transition seriously and has worked to study and address the issues and challenges; however, integrating these solutions into larger, more complex defense systems is still a significant contributor to program delays. The current DAU website lists 19 ongoing technology transition management programs that target the technical and funding challenges identified in the various studies. While technology transition has technical, cultural and business challenges, the discussion below is focused on technical and related challenges.

Older studies conducted by the Government Accountability Office (GAO, 2007, 2013) indicate challenges that align with business, technical and culture (workforce) elements. In one of the more recent studies, conducted in 2023, the Commission on Defense Innovation Adoption recommends 10 steps to increase transition of technologies and innovation, including using modular approaches to development efforts to leverage common components and align technology and acquisition portfolios. In this study, the “modular approaches” are in reference to architecting partitioned components or subsystems that allow individualized technology development with the intent to reduce risk by building options for substitutions where technical maturity lags or to allow refresh for new technology (McNamara et al., 2024). This approach is an enabler of MOSA that addresses challenges related to technology transition. Based on several similar reports, a summary of areas of technology transition that cause delays in DoD acquisition programs includes the following:

- **Integration**: Systems can require extensive modification and testing to incorporate new technologies once the S&T effort is complete, resulting in increased costs and transition delays.
- **Proprietary components** that may become unavailable or unsupported during an upgrade or development effort. Proprietary systems also restrict access to alternative suppliers, increasing costs and reducing innovation opportunities.
- **Custom-built, closed systems** require significant investment in development, integration, and sustainment

This list is not exhaustive but focuses on areas that can be addressed by MOSA.

How MOSA Addresses These Challenges

MOSA is defined by a business and technical approach that is based on five key principles: establish an enabling environment, employ modular design, designate open interfaces, use widely available consensus-based standards and certify conformance (shown in Figure 1). Implementing these MOSA principles into the S&T effort counters many of the technical challenges of technology transition by focusing on modular architecture, especially those associated with integration. Moreover, because many decisions that impact the architecture occur during the S&T phase, using a MOSA aligned architecture has a positive

impact on innovation and technology upgrades that may occur later in the system lifecycle.

The Office of the Under Secretary of Defense for Research and Engineering (OUSD[R&E]) recently released an *Implementing a Modular Open Systems Approach in Department of Defense Programs* guidebook that provides a robust discussion of MOSA and how it brings value to programs (Office of Systems Engineering and Architecture & OUSD[R&E], 2025). Each of the military departments have also released implementing guidance. A summary of the advantages that MOSA brings is below and depicted in Figure 1.

Facilitates Interoperability through: (a) Well-Defined Interfaces: MOSA relies on widely recognized, consensus-based open standards, ensuring that new technologies from different vendors integrate effectively, reducing development and integration challenges. (b) System Integration: Technologies developed for one system can be transitioned to another with minimal modifications, enhancing flexibility and operational efficiency along with scalability and upgradability. MOSA's modular architecture approach offers plug-and-play capability, when system components adhere to defined standards and interface modularity also supports incremental upgrades, enabling individual modules to be updated or replaced as technology evolves, ensuring a continuous and smooth transition without manageable impact on other parts of the system.

Incorporates Innovation and Tech Refresh Opportunities: By leveraging open standards, MOSA mitigates vendor lock-in, fostering a competitive environment that stimulates innovation among technology providers. MOSA also enables rapid adoption of innovative solutions from diverse sources, promoting technology refresh.

Enhances Competition and Affordability by Re-Usability of Common Components: MOSA can accelerate the development cycle by facilitating component reuse, which reduces the time needed to develop and deploy new capabilities. Modular architectures support parallel development, allowing specified (potentially high-risk) components to be developed, tested, and validated concurrently. This concurrent approach speeds up technology transitions and deployment.

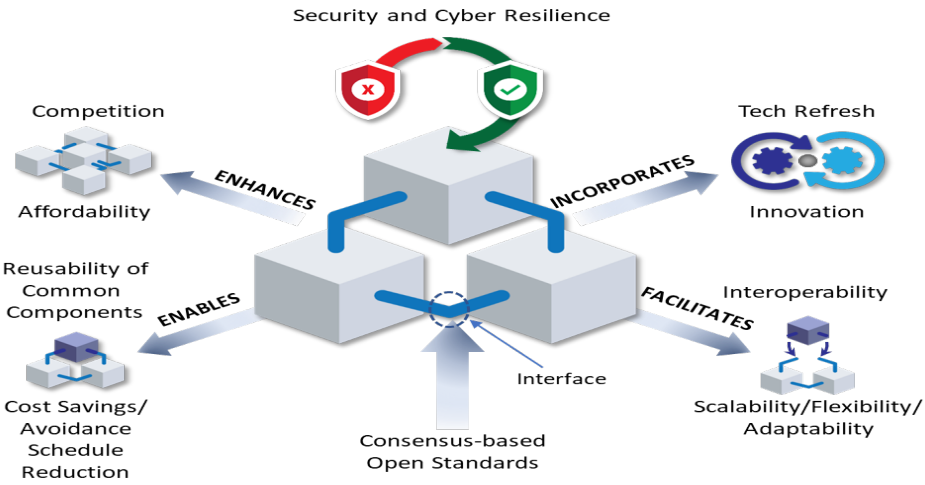

Figure 1. MOSA Pillars and Benefits (Office of Systems Engineering and Architecture & OUSD[R&E], 2025)

While this paper will not include a discussion on software specifically, MOSA also enables DevSecOps Integration and Agile practices that support Continuous Integration/Continuous Deployment (CI/CD). Modular designs in software enable frequent, minimally disruptive updates and seamless integration with legacy systems, contributing to more

efficient, secure, and resilient development cycles. Additional information on the ongoing OSD effort for SW Modernization can be found at the OSD R&E website (cto.mil).

Aligning Technology Development Challenges With MOSA Benefits

Connecting the technology transition challenges with MOSA pillars and benefits shows the synergy between the two. MOSA provides the opportunity to balance and address technology transition challenges, as shown in Table 1.

Table 1. MOSA Benefits Aligned to Technology Transition Challenges

Technology Transition Challenge	MOSA Benefit	MOSA Pillar
Integration challenges that slow capability deployment – Rigid architectures and lengthy integration and interoperability efforts delay the fielding of critical capabilities	**Interoperability through modularity** – Standardized interfaces and modular design enable faster integration of new components.	Standardized interfaces Modularity Open standards
Reliance on Proprietary Components– can result in components that may become unavailable or unsupported	**Technology Refresh & Lifecycle Agility** – Open architectures allow for incremental upgrades and replacement of obsolete parts without overhauling entire systems.	Open architecture Modularity
Custom built closed systems Proprietary systems restrict access to alternative suppliers, increasing costs and reducing innovation	**Open Market & Competition –** open interfaces foster a competitive supplier base, driving innovation and cost savings **Rapid Fielding & Iterative Upgrades** – Open, modular systems support incremental enhancements and faster certification through predefined compliance criteria.	Open interfaces Modular Open Standards

The alignment of technology transition challenges with MOSA benefits and pillars lead to the components of a MOSA aligned technology transition framework (MA-TTF). The MA-TTF can be used to bridge the gap between research, prototyping, and an acquisition program. The framework emphasizes architecture-driven development along with interface management and reliance on an enabling environment that supports MBSE. While MOSA offers a counter to many of the technology transition challenges, this paper proposes a focus on three key MOSA principles: modular architecture, interface management and an enabling environment that incorporates MBSE.

MOSA Aligned Technology Transition and Framework (MA-TTF)

Accompanying MOSA principles with MBSE as the means to manage the baseline and consider options for transition that enable interoperability and integration results in a framework that can bridge the technology transition valley of death." The establishment of MOSA in the technology development strategy can be implemented as discussed below and shown in Figure 2.

The MA-TTF is based on an architectural approach that relies on MOSA technical

principles, modular architecture, and identifying and managing key interfaces that relies on open standards. The MOSA Implementation Guide (MIG) emphasizes these key steps to incorporate a MOSA into the program strategy. The following into the technology development strategy:

1. **Architecture Development & Management planning** that uses MBSE tools to manage model-based systems engineering (MBSE) to consider optional solutions.
2. **Interface Management** that supports integration & interoperability goals to include reuse strategies such as product line architecture.
3. **Plan for Consensus-based Open Standards** that facilitate future upgrades and technology refresh cycles.
4. **Architecture Development & Management planning** that uses MBSE tools to manage Use model-based systems engineering (MBSE) to consider optional solutions.
5. **Interface Management** that supports integration & interoperability goals to include reuse strategies such as product line architecture.
6. **Plan for Consensus-based Open Standards t**hat facilitate future upgrades and technology refresh cycles.

If the technology is software focused, establish a DevSecOps Pipeline for Technology Insertion by implementing continuous integration, verification, and cybersecurity measures that utilizes the MOSA driven architecture. Current SW Modernization ongoing in the DoD is implementing these principles on some programs using the SWA pathway.

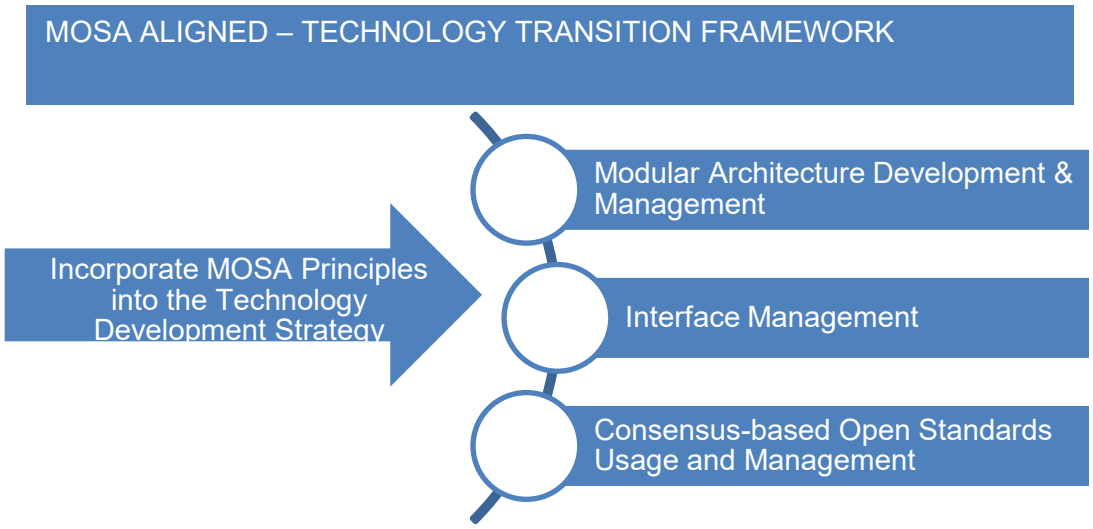

Figure 2. MA-TTF

Conclusion

As these MOSA principles are applied to technology development, the technology transition into a system or an integrated capability is more predictable and provides for strategies that allow for future competition and technology refresh. Incorporating an architecture-driven strategy that is rooted in MOSA principles early in the lifecycle ensures that validation pipelines (reuse) and sustainment planning are better accommodated. Most importantly, integration and interoperability are enabled, thus reducing risk early in the development cycle. Overall incorporation of a MA-TTF can result in more predictable and manageable technology transition.

Additional information on MOSA is available at the Systems Engineering and

Architecture website (https://www.cto.mil/sea/pg/), including the MOSA implementing guidance that provides the DoD community of stakeholders including Military Services, Civilians, and DoD contractors with information to support a MOSA as part of the defense program acquisition lifecycle. Each of the Military Departments have also released MOSA guidance that provides service specific approaches to MOSA implementation. Additionally, the DoD Standardization office has established a database of open standards that facilitates their use and implementation into programs (https://www.dsp.dla.mil/Publications/DSP-Journal/News-Display/Article/4117175/new-mosa-enabling-standard-in-assist/).

This paper is a current look at MOSA and how it can enable system development during the S&T phase and create long term benefits. However, future work should include a deeper look at programs and assess the impact based on examples using this approach or a similar architecture driven development cycle.

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