

# **Implementing a Modular Open Systems Approach in Department of Defense Programs**



February 2025

Office of Systems Engineering and Architecture

Office of the Under Secretary of Defense for  
Research and Engineering

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**Implementing a MOSA in Department of Defense Programs  
Change Record**

Date	Change	Rationale

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# 1 Introduction

This guidebook provides the Department of Defense (DoD) community, including Military Services, civilians, and DoD support contractors with information to help ensure programs incorporate a modular open systems approach (MOSA) as part of the defense acquisition program life cycle. The intended audience includes decision makers, program management offices (PMOs), program managers (PMs), and program lead systems engineers responsible for implementing and evaluating MOSA in defense programs.

Although MOSA has long been incorporated into DoD programs, this guidebook describes statute and DoD policy that now impose requirements to use MOSA. This guidebook provides best practices for planning, implementing, and evaluating MOSA, including implementation principles, benefits, challenges, and suggestions based on experience from practitioners in DoD and industry. It includes recommendations to consider when developing requests for proposals (RFPs) and evaluating planned approaches for implementing MOSA. The appendices provide supplemental information on the background efforts that have helped inform the DoD MOSA community.

The Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) Systems Engineering and Architecture (SE&A) prepared this guidebook and will continue to review, update, and incorporate feedback to acknowledge advances in the field.

## 1.1 MOSA Definition and Purpose

MOSA is an acquisition and design approach consisting of a technical and business architecture that supports using system interfaces compliant with widely supported and consensus-based standards, to the extent that standards are available and suitable. A MOSA system structure allows for severable components to be incrementally added, removed, or replaced throughout the life cycle to afford opportunities for enhanced efficiency, competition, and innovation.

MOSA integrates technical requirements with contracting mechanisms and legal considerations to support a more rapid evolution of technologies and capabilities throughout the product life cycle using architecture modularity, open systems standards, and appropriate business practices (10 U.S.C 4401). DoD MOSA is intended to allow the Department to achieve competitive and affordable acquisition and sustainment of a new or legacy system or component of hardware, software, or an integrated assembly of both.

This guidebook focuses on the technical (including programmatic) aspect of MOSA. In this document, a plan to implement MOSA refers primarily to a program's strategy to incorporate and support MOSA in the technical system structure.

## 1.2 Congressional Direction

In FY 2016, the House Armed Services Committee (HASC) asserted the conventional DoD acquisition system was “not sufficiently agile to support warfighter demands” (HASC Report 114-102). The FY 2017 National Defense Authorization Act (NDAA) began to address this issue by updating Title 10 of the United States Code (U.S.C.). Specifically, Congress directed DoD to implement MOSA in any Major Defense Acquisition Program (MDAP) receiving Milestone A or Milestone B approval after January 1, 2019, and introduced critical terms such as “major system component” and “major system interface.”

In the 2021 NDAA, Section 804, MOSA was amplified and somewhat reconceptualized with the new term “modular system interface” and included a greater focus on interface data, interface repositories, and the Government defining its modularity requirements within this new framework. Additional changes in the FY 2021 NDAA added requirements for the DoD to (1) establish MOSA interface repositories and (2) issue regulations and guidance for DoD and non-U.S. Government-authorized access and use of those interfaces to enable implementation of MOSA statutory objectives. Most important, the FY 2021 NDAA directed the DoD to expand its use of MOSA to **all** defense acquisition programs (to the maximum extent practicable):

*“...defense acquisition programs shall also be designed and developed, to the maximum extent practicable, with a modular open systems approach to enable incremental development and enhance competition, innovation, and interoperability” (10 U.S.C. 4401).*

MOSA is now a requirement for all DoD acquisition programs (to the maximum extent practicable) in accordance with 10 U.S.C. 4401-4403:

- 4401. Requirement for MOSA in major defense acquisition programs; definitions.
- 4402. Requirement to address MOSA in program capabilities development and acquisition weapon system design.
- 4403. Requirements relating to availability of modular system interfaces and support for MOSA.

10 U.S.C. requires a program’s modular system interfaces to comply with publicly disclosed or widely known standards, or the interfaces be delivered in accordance with Government requirements and with machine-readable documentation. The interfaces should contain functional descriptions sufficient to interconnect with publicly disclosed interfaces or documentation in Government interface repositories. In addition, the data rights need to be sufficient to use them for the intended purpose pursuant to Defense Federal Acquisition Regulation Supplement (DFARS) 252.227. The objective is to ensure the Government has defense systems and components that are modular and are readily interoperable with each other

or with new or improved systems and components and not constrained by proprietary connections. See Figure 1-1 for an overview of the MOSA statutory and regulatory timeline.

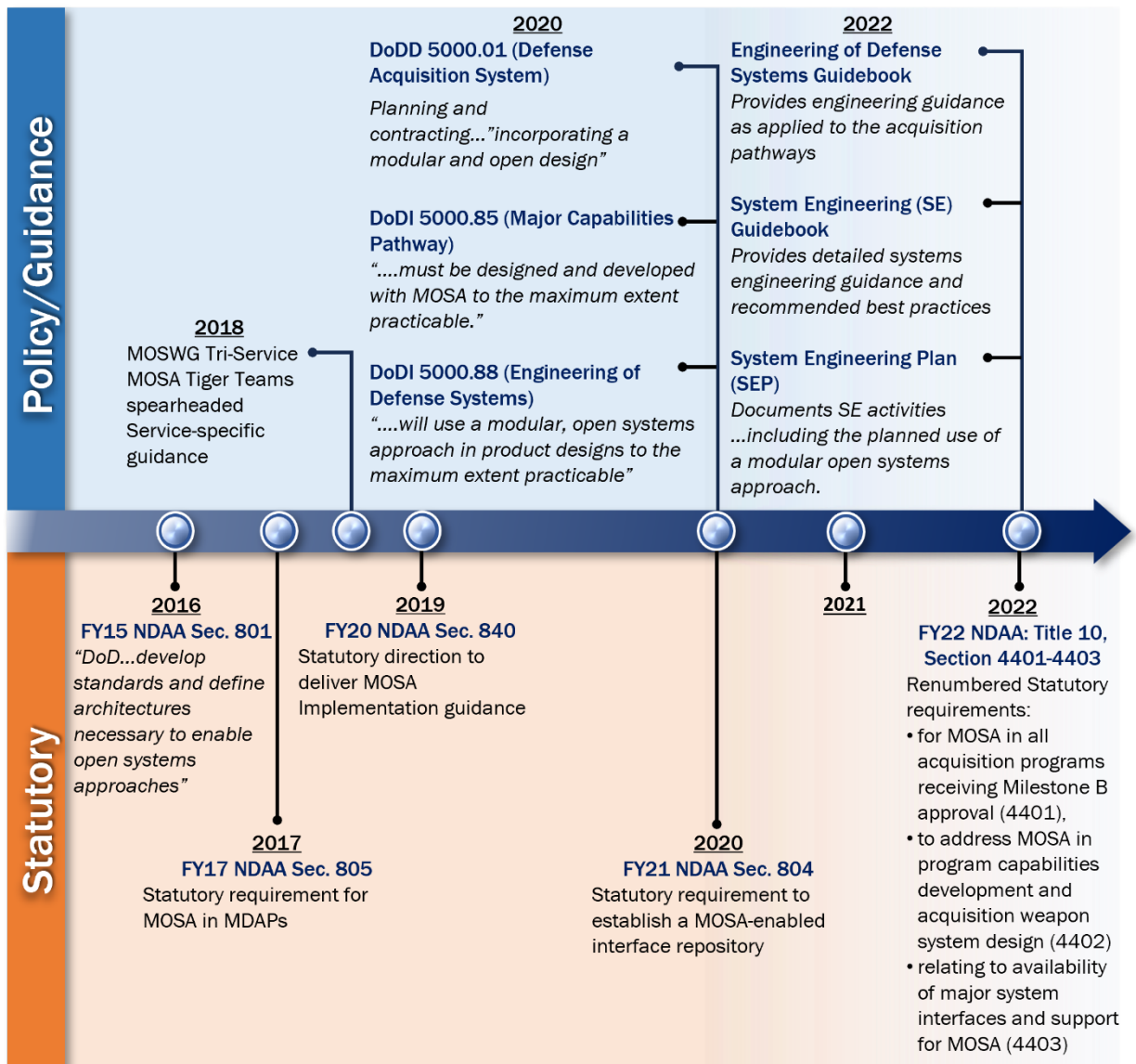


Figure 1-1. MOSA Statutory and Regulatory Timeline

### 1.3 Defense Federal Acquisition Regulation (DFARS) MOSA Policy

In addition to 10 U.S.C. 4401–4403, the Defense Federal Acquisition Regulation Supplement (DFARS) establishes policy and requirements for MOSA. Specifically, Part 207.106 requires the “use of modular, open architectures to enable competition for upgrades.” Part 227.7203-2 states, “The assessment of life-cycle needs should consider alternatives to the delivery of source code and related software design details for privately developed computer software as necessary

## 1. Introduction

to meet the Government’s needs, such as technical data and computer software sufficient to implement a modular open system approach or a similar approach.”

The DFARS also codifies common terminology and vocabulary in DFARS rulemaking case 2021-D005, affecting DFARS 252.227-7013, 252.227-7015, and 252.227-7018. The DFARS rulemaking case seeks to provide revisions to implement section 804 of the National Defense Authorization Act (NDAA) for FY 2021 (Pub. L. 116-283), section 809 of the NDAA for FY 2017 (Pub. L. 114-328), and section 815 of the NDAA for FY 2012 (Pub. L. 112-81). Sections 804, 809, and 815 amended 10 U.S.C. 2320 (currently 10 U.S.C. 3771), and section 804 amended 10 U.S.C. 2446a (currently 10 U.S.C. 4401). MOSA practitioners and PMs should be mindful of this evolving landscape and closely monitor updates to the DFARS.

While the use of non-statutory terms is not prohibited in contracts or other agreements, those implementing MOSA should ensure that such terms, if used, are related to statutory terms to ensure MOSA efforts and MOSA-compliant systems meet legally mandated requirements. For example, the term “key interface” is of historical and practical value; however, it is not defined in current law or congressional statute. Not all interfaces are key and not all interfaces are modular system interfaces. When using such terms in contracts or other agreements, it is critical to define the terms and connect them to statutory MOSA requirements.

## 2 MOSA Overview

The DoD seeks to develop critical and adaptable warfighting capabilities to meet growing threats. MOSA contributes to meeting this need by facilitating the interoperability and rapid transition and sharing of advanced capability. The following is a discussion of DoD MOSA pillars and MOSA benefits.

### 2.1 MOSA Pillars

OUSD(R&E)-led working groups developed the following MOSA pillars to ensure DoD programs have an effective strategy in place to meet MOSA goals. The Military Department Secretaries highlighted the pillars in an update to a joint tri-Service memorandum (December 2024) governing MOSA for DoD weapon systems. Programs may adapt and build on the MOSA pillars and can realize significant benefits by including the pillars in their program strategy. Appendix D provides a detailed list of considerations PMs can use when implementing the pillars.

- **Establish Enabling Environment:** By establishing and maintaining an enabling environment that supports MOSA, the DoD can ensure the development of modular, interoperable, and adaptable systems that meet evolving defense needs efficiently and effectively. This MOSA pillar involves establishing requirements, business practices, development strategies, acquisition approaches, T&E methods, and overall strategies that support MOSA.
- **Employ a Modular Design:** To accomplish the acquirer's business and technical objectives, the acquiring organization should identify the required functionality of the modular system components before issuing the RFP. Acquirers or developers who design modular systems can upgrade or change functions rapidly, with limited or no impact to the rest of the system. This pillar isolates functionality during the design process to simplify development, maintenance, changes, and upgrades.
- **Designate Modular Interfaces:** By designating modular system interfaces, the DoD can ensure that systems are flexible, interoperable, and easily upgradeable. Developers can manage changes effectively, maintain backward compatibility, and leverage open standards to achieve long-term system sustainability and effectiveness following this approach. This MOSA pillar focuses on decoupling the interface and service implementation of components to allow them to follow separate life cycles.
- **Leverage Consensus-Based Open Standards:** By standardizing modular system interfaces through open standards, the DoD can ensure systems are flexible, interoperable, and easily upgradeable. Employing consensus-based standards and

managing Government-owned interface repositories enables developers to leverage commercially developed technologies, which fosters increased competition, faster upgrades, and reduced costs.

- **Certify Conformance:** Developers need to verify and validate the implementation of MOSA and its requirements, ensuring conformance to selected internal and external open interface standards. Certification ensures the system conforms to both internal and external open interface standards, providing a framework for maintaining interoperability, flexibility, and futureproofing. Conformance is imperative as it guarantees modularity and openness objectives are met, ultimately supporting program success and system sustainability. By rigorously assessing conformance through these criteria and verification activities, the DoD can ensure the modular and open systems achieve their intended benefits, enhancing system flexibility, maintainability, and overall mission effectiveness.

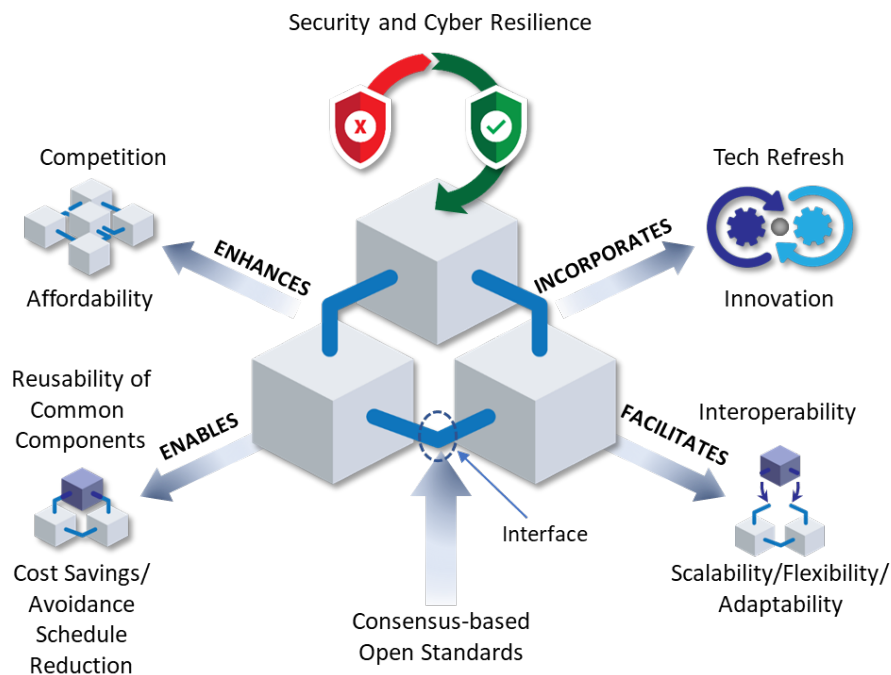
### 2.2 MOSA Benefits

Statute and DoD policy require MOSA because it provides several benefits including a potential competitive edge over adversaries. The Department places great value in the following primary benefits:

- **Improves interoperability** by allowing severable software and hardware modules to be changed independently, ensuring seamless integration and communication between different system components.
- **Enhances competition** by adopting an open architecture with severable modules, enabling components to be openly competed among a diverse range of suppliers, which fosters innovation and drives down costs.
- **Facilitates technology refresh** by allowing the delivery of new capabilities or replacement technologies without requiring changes to all components within the system, thus ensuring systems remain up-to-date and effective.
- **Incorporates innovation** by providing the operational flexibility to configure and reconfigure available assets quickly, meet rapidly changing operational requirements, and adapt to new threats.
- **Enables cost savings/cost avoidance/schedule reduction** by promoting the reuse of technology, modules, and components from any supplier across the acquisition life cycle, reducing the need for redundant development efforts, reducing test requirements, and leveraging existing investments efficiently.

## 2. MOSA Overview

Figure 2-1 provides an overview of the MOSA pillars and the primary benefits MOSA brings to acquisition programs.



**Figure 2-1. A Representation of the MOSA Pillars and Benefits**

In addition to the primary benefits, implementing MOSA offers several additional benefits that aid system performance and operational efficiency. One of the main advantages is **plug-and-play capability**, which ensures different modules and systems can effectively communicate and exchange data. This allows **interchangeability** so components from various vendors can work together seamlessly, promoting flexibility and reducing vendor lock-in. **Reusability** is another significant benefit, as MOSA encourages the design of components that can be reused across different systems or projects. Reusability not only reduces development time and costs but also allows for the reuse of test data, leading to substantial life cycle cost savings.

**Scalability** is also a key benefit of MOSA that enables systems to be easily scaled up or down based on requirements. New modules can be added, or existing ones can be replicated, to meet changing needs without significant disruptions. **Vendor independence** is another benefit, as MOSA's use of consensus-based standards and modular design reduces dependency on specific vendors. This fosters a competitive environment where different suppliers can provide compatible components, enhancing options and preventing vendor lock-in.

**Flexibility and adaptability** are crucial for the DoD as MOSA systems can more easily accommodate changes in technology, requirements, or mission profiles. This feature ensures that systems remain relevant and effective over time without requiring complete overhauls. MOSA provides strategic flexibility, allowing for the rapid integration of new technologies and

## 2. MOSA Overview

capabilities, and operational flexibility, enabling agile mission groups to configure and reconfigure assets to meet rapidly changing operational requirements. In addition, MOSA fosters commercial flexibility, facilitating value and innovation in procurement.

Another benefit is **commonality**, as MOSA encourages the use of common components and interfaces across different systems. This promotes consistency, reduces development time, and simplifies training and maintenance. Having fewer unique parts also leads to a simplified logistics chain. MOSA enhances **security and cyber resilience** by promoting consensus-based open standards and modularity. This resilience allows security patches and updates to be applied to specific modules without affecting the entire system. Government-controlled interfaces can supersede consensus-based open standards in instances requiring heightened operational security.

These advantages collectively ensure DoD systems are adaptable, competitive, and cost-effective, ultimately supporting mission readiness and operational superiority.

### 3 DoD Considerations for Implementing MOSA

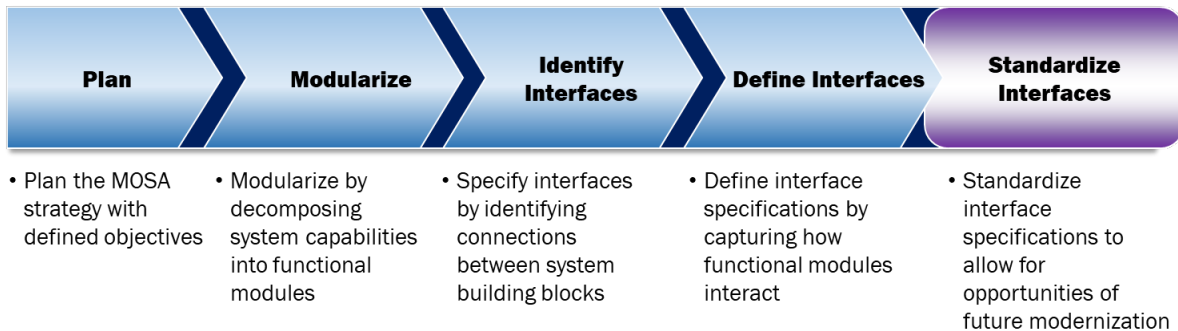
Implementing a MOSA requires careful planning and coordination among the PMO staff, from aligning with Acquisition Strategies and managing risk to balancing technical requirements and integrating standards to optimize program performance. Addressing these factors early and throughout the program life cycle enhances the benefits of MOSA.

Programs should carefully evaluate the costs and benefits of implementing MOSA to ensure long-term advantages are not overlooked. Systems engineers and PMOs should employ a cost-benefit analysis that incorporates a thorough discussion of risks and potential impacts on program costs and schedules. In addition, programs should include analysis that aids decision making by identifying and evaluating alternative courses of action. A cost analysis can help reduce costs and risks, leading to more affordable programs and less costly systems.

This section addresses the technical areas, including programmatic requirements, assessment tools, and technology changes practitioners should be aware of when implementing MOSA in their acquisition programs.

#### 3.1 Program Management Considerations

Before implementing a MOSA, the acquisition program should use a basic framework to plan, identify, define, manage, and ensure the compliance of system interfaces. Each program should develop its own method for documenting or modeling the framework. This section provides an overview of recommended steps to include (Figure 3-1). The framework should help ensure PMs capture all internal and external interface requirements in accordance with the program’s Acquisition Strategy. The framework should be implemented and consistently maintained throughout the acquisition life cycle.



**Figure 3-1. MOSA Planning Framework**

### 3.1.1 Plan

Planning the implementation of MOSA requires a clear definition of objectives that align with both technical and business goals. The PMO should establish specific, measurable, and achievable objectives that address the key benefits of MOSA, such as enhancing system flexibility, reducing life-cycle costs, and enabling rapid integration of new technologies. These objectives should be aligned with the system's immediate and long-term requirements, ensuring the modular approach supports innovation. Once objectives are defined, the planning process involves identifying the necessary resources, including technology and talent, to implement the strategy effectively. In addition, it is crucial to establish or identify governance frameworks and procedures to guide the development and integration of modular components, ensuring consistency and interoperability across the system. By setting clear objectives and carefully planning the implementation of MOSA, organizations can create a robust foundation for achieving their desired outcomes and maintaining competitive advantage.

### 3.1.2 Modularize

Decomposing system capabilities into functional modules is a critical step. PMOs and systems engineers should break down the system into smaller, self-contained modules, each responsible for a specific function or capability. By isolating these functions, the PMO and systems engineers can design modules that are independent yet interoperable, allowing for easier upgrades, replacements, and integration of new technologies without disrupting the entire system. Each module should have clearly defined interfaces to ensure seamless communication and collaboration with other modules while facilitating flexibility and scalability. This modular decomposition not only simplifies system design and development but also enhances maintainability and adaptability, enabling the system to evolve in response to changing requirements or advancements in technology. Through careful analysis and structured decomposition, organizations can create a modular architecture that supports efficient, cost-effective, and sustainable system development.

### 3.1.3 Identify Interfaces

Identifying interfaces is a crucial aspect of implementing a MOSA as it determines how different functional modules within a system interact and communicate. An interface serves as the boundary through which modules exchange data, signals, or commands, making it essential for ensuring interoperability and integration across the system. When the PMO and systems engineers identify interfaces, it is important to define clear, standardized specifications that are compatible with open standards, enabling modules to work together regardless of their origin or design. These interfaces should be robust enough to handle the necessary data flow and flexible enough to accommodate future upgrades or changes in system requirements. Properly identified

and well-defined interfaces not only streamline the integration process but also reduce the impact of incompatibility and facilitate easier maintenance and scalability. By focusing on the careful identification and standardization of interfaces, organizations can ensure their modular systems remain cohesive, adaptable, and capable of evolving with technological advancements.

#### **3.1.4 Define Interfaces**

After identifying interfaces, systems engineers should define them to establish clear protocols and data formats that adhere to open standards, allowing for interoperability across different vendors and systems. This standardization ensures that modules can be independently developed, tested, and upgraded without causing disruptions to the overall system. Moreover, well-defined interfaces should be both robust and flexible, capable of accommodating future enhancements or modifications to the system. By carefully defining interfaces, organizations can create a modular architecture that is not only cohesive and functional but also scalable and adaptable to changing technological and operational needs.

#### **3.1.5 Standardize Interfaces**

Standardizing interface specifications is fundamental to creating systems that are future-proof and adaptable to ongoing technological advancements. By establishing consistent, open standards for how modules within a system interact, organizations ensure that these modules can be easily upgraded, replaced, or enhanced without requiring extensive rework of the entire system. This standardization allows for the seamless integration of new technologies or capabilities as they become available, enabling the system to evolve in response to emerging needs and innovations. Moreover, standardized interfaces reduce dependency on specific vendors, fostering a competitive environment where multiple suppliers can contribute to system upgrades and modernization efforts. This not only accelerates the pace of innovation but also extends the system's life cycle, as it can be continually updated with the latest advancements without the need for extensive modifications. In essence, standardized interface specifications create a flexible and resilient framework that supports long-term modernization and keeps systems at the cutting edge of technology.

#### **3.1.6 MOSA-Related Acquisition Activities and Documentation**

MOSA should be a consideration for potential materiel solutions even before a formal program and program office are established. MOSA implementation should be integrated into the Joint Capabilities Integration and Development System (JCIDS) process, which ensures the capabilities required by the joint warfighter are identified, along with their associated operational performance criteria (requirements) to successfully execute the mission. The JCIDS process supports the acquisition process by allowing an organization to identify and assess capability

### 3. DoD Considerations for Implementing MOSA

needs and associated performance criteria. MOSA implementation for a potential acquisition should be integrated with the JCIDS process to ensure the strategy is consistently applied to the acquisition from inception and across all mission elements. MOSA implementation should be well-defined in the outputs of the JCIDS process including the Capabilities-Based Assessment (CBA), the Initial Capabilities Document (ICD), and the Capability Development Document (CDD) (CJCSI 5123.01).

Once the formal program is established and the PM completes the planning framework, the PM is required to include MOSA and its accompanying strategy in the acquisition and contracting process to ensure that requirements are translated into formal contract obligations, interests of Government and industry are balanced, and the Government's goals for capability acquisition and industry goals are met (see Appendix B for a list of industry recommendations on implementing MOSA).

In accordance with 10 U.S.C. 4401–4403, DoD Instruction (DoDI) 5000.85, and DoDI 5000.88, the DoD Components and PMs are required to include MOSA in the following acquisition activities and documents:

- Analysis of Alternatives (AoA) (10 U.S.C. 4402, paragraph (b)) or Economic Analysis for Decision Making. An AoA or Economic Analysis is an analytical comparison of the operational effectiveness, suitability, and life-cycle cost of alternatives that satisfy established capability needs. After the Materiel Development Decision (MDD), the DoD Components should initiate the AoA/Economic Analysis is initiated to examine potential materiel solutions with the goal of identifying the most promising option, thereby guiding the Materiel Solution Analysis (MSA) phase. The MSA phase is guided by the ICD and the analysis study. It is important for the program's MOSA implementation to be an integral part of the analysis to ensure alternate approaches include a complete assessment of how the MOSA would be implemented for that alternative (DoDI 5000.85; DoDI 5000.84; DoDI 7041.03).
- Request for Proposal (RFP) (10 U.S.C. 4402, paragraph (d)). An RFP is a solicitation used by an organization to obtain proposals or bids from a potential supplier(s) to satisfy a set of customer requirements. The RFP describes the needs and requirements of the requesting party so potential suppliers can send bids that meet those needs. The MOSA implementation needs to be an integral part of the RFP. Both the technical and non-technical tenets of the MOSA implementation needs to be well-defined to potential bidders so their offerings can be aligned to the needs of the MOSA implementation. Each of the key materials supplied to potential bidders as part of the RFP needs to communicate the appropriate level of detail from the MOSA implementation and should

### 3. DoD Considerations for Implementing MOSA

be consistent with its intent. Appendix C contains contracting considerations and sample contract language to assist in the contracting process.

- Systems Engineering Plan (SEP) (DoDI 5000.88, paragraph 3.4.a). The purpose of the SEP is to guide PMs in the development, communication, and management of the overall systems engineering approach and technical activities of a program. The SEP should include information relating to MOSA, including defining the technical approach, which includes a MOSA to the maximum extent practicable. Architectures should be described and should include all hardware and software defined modular system interfaces. The SEP should provide rationale if MOSA is not feasible or cost-effective. Additional information can be found in the SEP Outline Version 4.1 and DoDI 5000.88.
- Acquisition Strategy (DoDI 5000.85 paragraph 3C.3.a.(5)). The Acquisition Strategy<sup>1</sup> should describe:
  - How MOSA is intended to be used, including business and technical considerations.
  - The differentiation between the major system platform and major system components being developed under the program, as well as major system components developed outside the program that are intended to be integrated into the MDAP.
  - The evolution of capabilities that are planned to be added, removed, or replaced in future increments.
  - The additional major system components that may be added later in the life cycle.
  - How intellectual property (IP) and related issues, such as technical data deliverables, are planned to be addressed.
  - The system integration and system-level configuration management approach to ensure the system can operate in the applicable cyber threat environment.
- Program Capability Document (10 U.S.C. 4402, paragraph (a)). A Program Capability Document, also referred to as a CDD (Capability Development Document, including the Information System (IS) CDD variant), specifies capability requirements in terms of developmental Key Performance Parameters (KPPs), Key System Attributes (KSAs), Additional Performance Attributes (APAs), and other related information necessary to support development of one or more increments of a materiel capability solution. This document should describe MOSA as an enabler to achieve the system's KSAs, KPPs, and APAs.

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<sup>1</sup> The Defense Acquisition University website provides guidance on tailoring the Adaptive Acquisition Pathways and planning documents (<https://aaf.dau.edu/>) including incorporating MOSA into the Major Capability Acquisition (MCA) Acquisition Strategy (<https://aaf.dau.edu/aaf/mca/acquisition-strategy/>).

Additional program documents that should address MOSA as appropriate:

- Product Support Strategy (PSS) (10 U.S.C. 4324: Life cycle management and product support). The PSS should ensure sustainment activities, logistics, and life-cycle management align with the goals of MOSA.
- Life Cycle Sustainment Plan (LCSP) (10 U.S.C. 4324: Life cycle management and product support). The LCSP should detail product support plan that supports the goals of MOSA, including sustainment metrics, risks, costs, and analysis.
- Performance Specifications: System Performance Specification (sometimes called System Requirements Document (SRD)) and System/Subsystem Specification (S/SS). The SRD and S/SS should define clear, measurable standards for system operation.
- System Architecture Products: Systems Architecture Model, System/Segment Design Document, Software Architecture Description, Software Design Document, Architecture views, and Reference Architecture/Government Reference Architecture. These artifacts should provide the plan for managing the system architecture and should include an understanding of how the major system components (MSCs) relate to the system's MOSA.
- Contract Documents: Contractor Work Breakdown Structure (CWBS), Contract Data Requirements Lists (CDRLs), Interface Design Description (IDD) CDRLs, Software Requirements Specification (SRS) CDRLs, Software Test Report CDRLs, and Verification/Validation Checklists. Contract documents should align and support the MOSA.
- Interface Documents: Interface Control Document (ICD) and Interface Requirements Specification (IRS). The ICD and IRS are extremely important in describing MOSA details and define how different system components interact using standardized interfaces.

## 3.2 Technical Considerations

Implementing a MOSA requires PMs to evaluate both the management processes and the program's overall technical approach. This section highlights technical areas to consider when implementing MOSA.

### 3.2.1 Work Breakdown Structure as a Taxonomy for a MOSA Architecture

One way to help the program achieve these benefits is to prepare a Work Breakdown Structure (WBS). The WBS should be created by the PM or the lead systems engineer and takes a step-by-step approach to break down projects into smaller components. The WBS is defined,

### 3. DoD Considerations for Implementing MOSA

developed, and maintained throughout the system life cycle based on a disciplined application of the systems engineering process.

The WBS should be based on a system architecture that allows severable major system components and modular systems at the appropriate level to be incrementally added, removed, or replaced throughout the life cycle of a major system platform. This approach can be applied to hardware, software, or an integrated assembly of both. See Table 3-1 for additional details.

**Table 3-1. Steps to Align a MOSA to a WBS**

Process	Process Details
Align the end goals of the program and the MOSA principles that support it	Identify the key principles of MOSA, such as: <ul style="list-style-type: none"> <li>• Modularity</li> <li>• Openness</li> <li>• Scalability</li> <li>• Flexibility</li> <li>• Reusability</li> </ul>
Review and refine the WBS	Review the existing WBS to ensure it is comprehensive, accurate, and up to date. Refine the WBS to include the following: <ul style="list-style-type: none"> <li>• Modular components: identify the modules that are to be used to build the system.</li> <li>• Interfaces: define the interfaces between modules and external systems</li> <li>• Data exchange: identify the data exchange requirements.</li> <li>• Testing and validation: include testing and validation activities</li> </ul>
Identify and prioritize modules	Identify modules for the system's functionality and prioritize them accordingly
Define module boundaries and interfaces	Define the boundaries and interfaces for each module, including: <ul style="list-style-type: none"> <li>• Input/output requirements</li> <li>• Data formats and protocols</li> <li>• APIs and software development kits</li> <li>• Testing and validation requirements</li> </ul>
Allocate tasks and resources to modules	Allocate tasks and resources to each module, including: <ul style="list-style-type: none"> <li>• Development tasks</li> <li>• Testing and validation</li> <li>• Resource allocation</li> </ul>

### 3. DoD Considerations for Implementing MOSA

Process	Process Details
Establish a modular development process	Establish a modular development process that includes: <ul style="list-style-type: none"> <li>• Agile development methodologies</li> <li>• Continuous integration and continuous delivery (CI/CD)</li> <li>• Modular testing and validation</li> </ul>
Monitor and control module development	Monitor and control module development, including: <ul style="list-style-type: none"> <li>• Tracking module development progress</li> <li>• Identifying and addressing module dependencies</li> <li>• Managing module risks</li> </ul>
Integrate and test modules	Integrate and test modules to support system validation against business and technical requirements.

MIL-STD-881F, Work Breakdown Structures for Defense Materiel Items, addresses mandatory procedures for all programs subject to DoDI 5000.02, Operation of the Adaptive Acquisition Framework. The standard can assist the PMO or lead systems engineer in determining the proper system hierarchy and architecture. Applying MIL-STD-881F helps the PMO or lead systems engineer identify proper interface points for hardware, software, or an integrated assembly of both.

Implementing MIL-STD-881F can provide significant value as the WBS assists the program with systems engineering activities including the functional decomposition of the system and data flow traces.

MOSA objectives, characteristics, measures of merit, and potential acquisition requirements may vary based on the system’s location within the DoD enterprise or the DoD system of systems (SoS) (e.g., mission or functional modules for a composable task force versus composable vehicles and computer programs). The structure is related to the product-oriented WBS of MIL-STD-881F.

A PMO capturing interfaces and modules in this context helps increase traceability through the system life cycle. In addition to technical criteria, the PMO should consider programmatic consequences ranging from IP to the product supply chain at all levels of the system hierarchy along with respective modularity and interface decisions. The WBS should articulate the level of modularity required to support competition and technical refresh to ensure the program identifies proper architectural components and interfaces.

Successful MOSA implementations should have defined levels of taxonomy and modularity. A system taxonomy breakdown, as presented in MIL-STD-196G (i.e., System, Subsystems, Centers, Centrals, Sets, Group, Units), is useful for identifying the appropriate taxonomic conventions. Another aspect of a successful MOSA implementation involves defined levels of

integration (i.e., manual, automation type, etc.) expected between various participants in the SoS's taxonomy (e.g., platforms, systems, subsystems, and components).

#### **3.2.2 Requirements Involving MOSA**

Requirements for modularity and openness can influence both technical solutions and business strategies on a program. From the technical perspective, a MOSA leads to changes in the way system requirements are introduced in a specification. Whether the requirements are at the SoS level, system level, subsystem level, or below, they are still fundamental requirements the PMO and systems engineers should address in the system architecture and design process.

Integrating MOSA-related requirements into the complete design specification allows the PMO and systems engineers to manage them as any other type of requirement. How those requirements are expressed and their composition parameters, however, depend on the specific level of design involved. Furthermore, the way MOSA-related requirements are expressed may depend on the phase of a development and may depend on the level of maturity or existing constraints that a given design or design driver already has. Through the course of technical design reviews, MOSA success may be verified and validated at each technical baseline. For more information regarding MOSA requirements and verification at technical design reviews, see the Systems Engineering Guidebook (2022).

Figure 3-2 presents an iterative process to define a system with MOSA attributes built in and not added on. The outer blue border represents the constraints placed on the design based on known SE, MOSA, and business processes. Starting at the top, the figure presents an iterative dual path development process in which MOSA is integrated into the design. The bottom row shows the path for funding the system.

### 3. DoD Considerations for Implementing MOSA

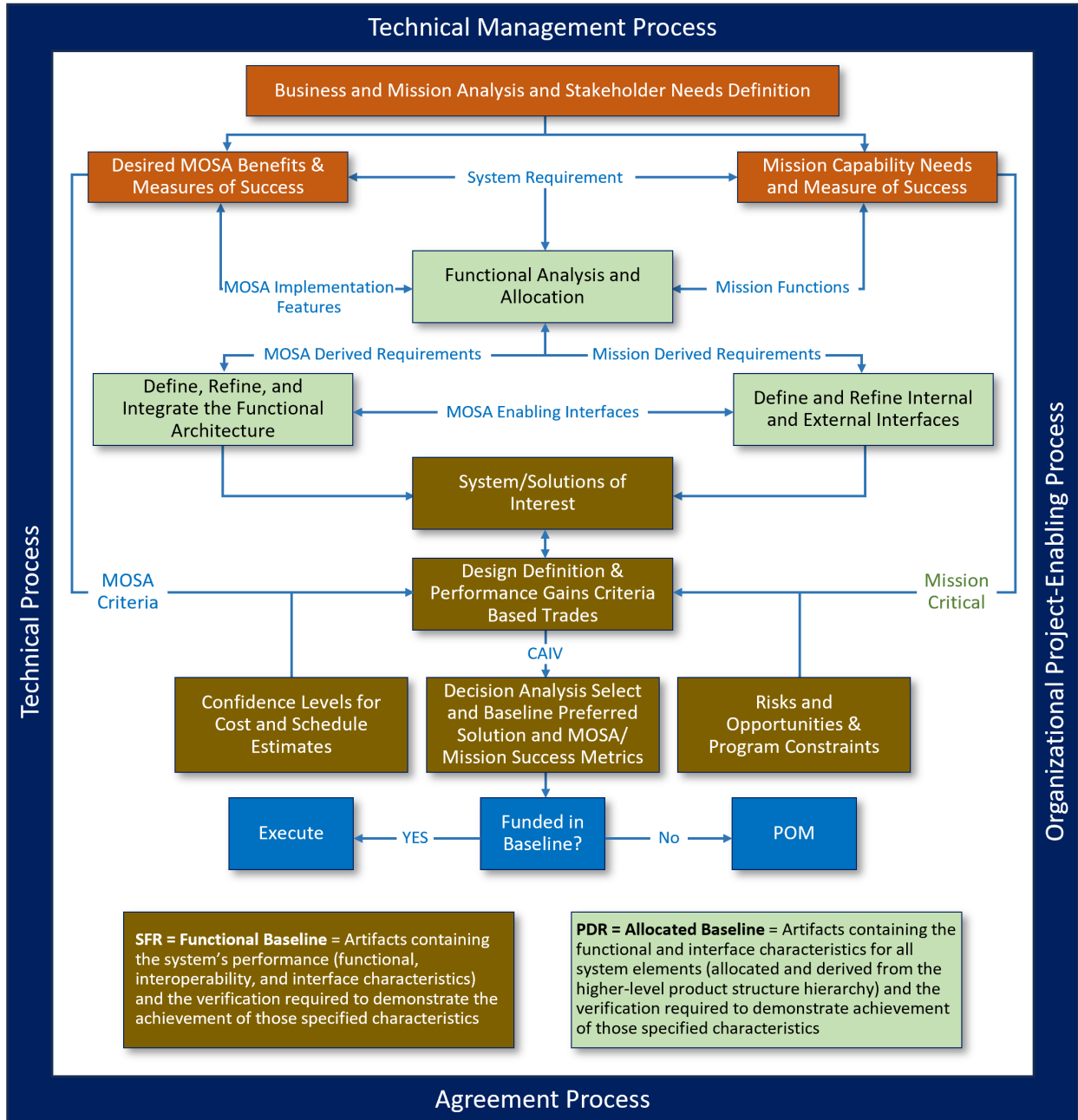


Figure 3-2. Integrating MOSA Requirements into a Capability Solution

#### 3.2.3 MOSA-Enabling Standards and Specifications

Standardization supports the achievement of compatibility, interchangeability, commonality, and interoperability of parts and processes within the DoD and U.S. allies and partners. It promotes safety, provides for life cycle sustainment, and allows for rapid, cost-effective technology insertion by system interfaces compliant with widely supported and consensus-based standards and modular open systems. The use of standards and specifications in a MOSA is foundational,

### 3. DoD Considerations for Implementing MOSA

as standards enable the core attributes of modularity, interoperability and flexibility for a system implementing a MOSA.

Except for several standards required by law (primarily addressing life, safety, transportation of hazardous materials, treaty obligations, and environmental considerations), PMs and systems engineers can select from a range of standards that best meet the program's requirements. Identifying the standard that best fits the system's MOSA requirements among competing standards may include favoring a consensus-based standard as directed by 10 U.S.C. 4401. The ASSIST database ([assist.dla.mil](http://assist.dla.mil)) is a robust and comprehensive collection of defense and federal specifications and standards, military handbooks, commercial item descriptions, data item descriptions, and related technical documents. The ASSIST Modular and Open Standards and Specifications (MOSS) area contains MOSA-specific guidance for use in DoD acquisition programs.

Many PMOs and systems engineers implementing a MOSA require multiple standards and specifications from industry and military. PMOs and systems engineers should tailor these standards to ensure maximum interoperability and follow any available conformance requirements these standards may provide. When multiple standards and specifications are in use, a PMO and systems engineers should develop a profile that identifies and limits the variability that may impede interoperability.

Appropriate selection and application of standards at key system interfaces can contribute to healthy competition among suppliers throughout the acquisition life cycle. Many standards are available for Government programs to choose. Assessing and selecting appropriate standards can be challenging, as most were developed to solve a specific problem set. Therefore, PMs and systems engineers should be careful to use the appropriate standards within contracts, tailored for each system.

PMOs implementing MOSA into their system design with sufficient standardization at interfaces, allow greater flexibility and agility to reconfigure components to address evolving threats and emerging technology. Developers of DoD systems require appropriate business knowledge regarding intended use, stakeholder context, data rights, and IP to select the best standards. Standards implemented at interfaces may contain options and default settings for which multiple combinations are possible, but once selected they may not interoperate with other implementations of the same standard. In addition, standards may serve as methods or processes for meeting a business or technical objective, and some process standards may influence the architecture process and support business implementation.

Multiple options, as well as inconsistent availability of information to verify standard implementation, can lead to interoperability problems. Therefore, standards guidance should

provide details on implementation and conformance, including which organizations provide verification. Programs should provide a test plan, procedures, and verification methods across the life cycle to ensure compliance.

#### **3.2.4 Software-Specific Considerations**

Programs should develop modularity in software with the same engineering rigor in design as hardware and should use the same modular approach as its corresponding hardware component so both can be replaced and/or upgraded concurrently. Program engineers should concisely and accurately define software interfaces to decrease complexity during technology refresh.

Poor software development practices may obscure modular components. Programs should ensure they employ foundational engineering practices of modularity and interface transparency in software and hardware development. These practices highlight a rediscovery of and focus on two engineering fundamentals: (1) modularity and (2) designating and identifying modular system interfaces, with an emphasis on software and software-dependent systems.

Software application partitioning begins at higher levels of capability but drives down to specific domains, with uniqueness in the domains emerging and evidenced in the various data and artifacts produced for that domain. MOSA-specific considerations involve software design levels that support technology refresh, desired competition, and innovation. In its most basic level of consideration, software modularity emphasizes separating functionality into independent, interchangeable modules necessary for the development of product line common software libraries. This facilitates software projects that are modular and more easily assembled. It also imparts more responsibility in managing the functional configurations and baselines of the functional modules that individually and collectively implement the system behavior and produce the associated data. The more participants in the software development activities, the more challenges that emerge in the development and maintenance process.

When designing software architectures for a system implementing MOSA, it is essential that a PMO develop an Application Programming Interface (API) approach, which emphasizes modularity, scalability, and reusability. By adopting this approach, a PMO places priority on the design and development of the API before implementing the underlying system. Additional information can be found in SE&A's API Technical Guidance (July 2024 or latest). Modularity and openness features of a system design implemented in software require considerations not only for the product but also for the frameworks and processes used for establishing, maturing, and maintaining the design.

Systems and digital engineering processes, including DevSecOps toolchains, can promote building things correctly, but a larger issue is how to choose to build the appropriate things, particularly those containing modularity and openness features.

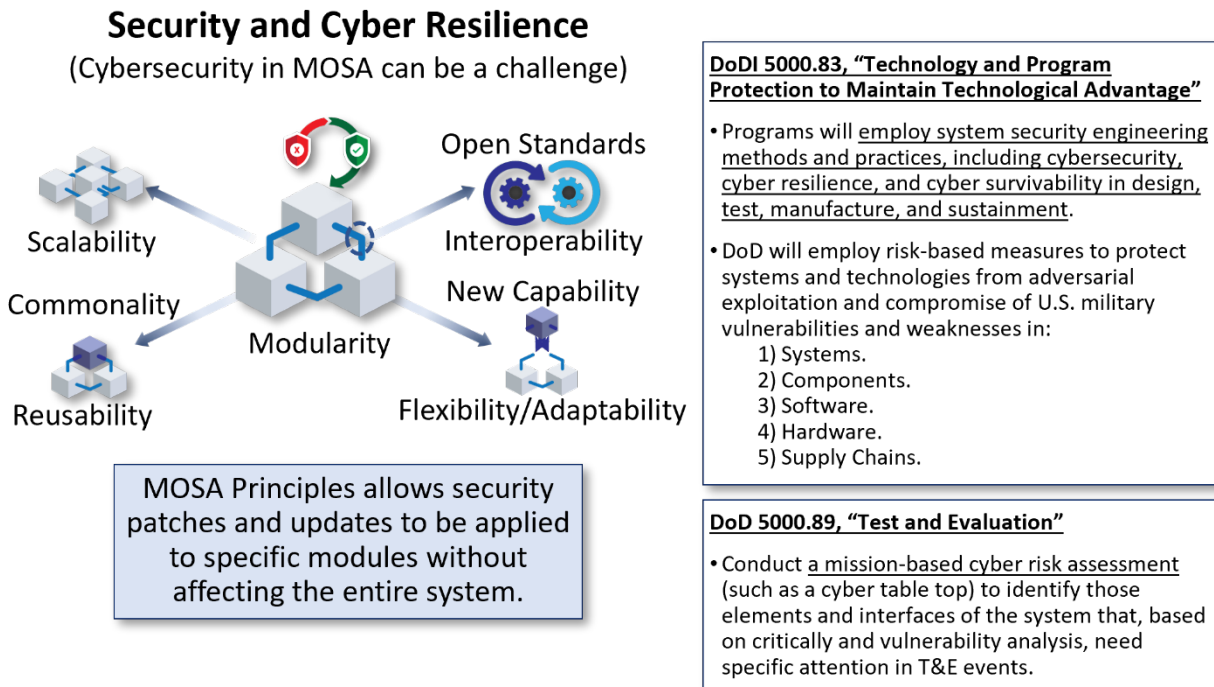
General considerations for MOSA in software involve a software architectural lexicon or reference architecture that portrays the levels of software decomposition needed through the course of enabling system functionality and behavior. MOSA requirements appropriate to software architecture levels of abstraction should then be determined, including to the SoS level. A software taxonomy like MIL-STD-881F can be used to guide development of software MOSA, with particular focus on modularity in software and standard interfaces. Using the reference architecture, a data model may be identified at varying levels of fidelity, including applicability of partitions in the various DoD domains. Critical to the interests of acquirers and suppliers alike, modular software data rights should be declared at appropriate levels of modular abstraction. See DoDI 5000.87, Operation of the Software Acquisition Pathway, for more information.

#### **3.2.5 Cybersecurity Considerations in a MOSA Solution**

Hardware cybersecurity considerations, such as cross-domain guards, firewalls, and encrypt/decrypt chips, can be addressed from a MOSA perspective through multiple suppliers of form-fit-function solutions to hardware items associated with meeting cybersecurity requirements for the system.

Software cybersecurity can be challenging in a MOSA solution. Historically, industry has adopted an approach that employs proprietary transport services (or similarly defined interface APIs) to implement cybersecure interactions between different modules of procurement. This approach can continue to work, but only if there are multiple competing proprietary transport service solutions that do not incur major costs for re-integration. See Figure 3-3 for security and cyber resilience in a MOSA system.

A novel approach to software cybersecurity with MOSA leverages the features of a life cycle DevSecOps toolchain adopting model-based systems engineering (MBSE), prescriptive consensus-based standards for integration (e.g., Future Airborne Capability Environment<sup>®</sup> (FACE) or Open Mission System (OMS)), and Agile methods, such as continuous integration/continuous delivery (CI/CD) and containers. This approach allows software cybersecurity requirements to be modeled, and the DevSecOps toolchain can convert those models to transport service or equivalent functionality.



**Figure 3-3. Security and Cyber Resilience in a MOSA**

### 3.2.6 Commercial Off-the-Shelf Components

When Commercial Off-the-Shelf (COTS) components or existing systems are adapted with MOSA-based features, the challenges with using or modifying the existing products should be adequately understood first. Industry recommends using a business case analysis in determining whether, and to what extent, to apply MOSA requirements to commercial products. Potential product challenges include effects of rapid and asynchronous changes, technology obsolescence, proprietary data, higher life cycle costs, multiple configurations, different quality practices, “as is” configuration, commercial standards, time-limited manufacturing support, and information security susceptibility. For situations with COTS implementations, design changes may trigger substantial regression testing or even recertification of the base platform, thus negating any projected benefits from a MOSA-related design.

### 3.3 Assessing a Modular Open Systems Approach

The implementing organization may evaluate the proposed architecture on a pass/fail basis, unless a specific MOSA implementation is evaluated with appropriate mechanisms in place (e.g., a WBS exists, desired MOSA features identified).

Metrics should be aligned with the following MOSA benefits: (1) Interoperability, (2) Technology Refresh, (3) Enhance Competition, (4) Innovation, and (5) Cost Avoidance/Cost

Savings. Most metrics should fit in one or more of those benefit classes. The collection of metrics needed for the broad number of MOSA use cases, levels of a system design, and specific phase of maturity can be reduced to the necessary few MOSA metrics for a given MOSA application.

The PMO establishes the metrics for the most likely use cases by drawing on guidance from the DoD, Services, and other relevant Government sources, along with industry practices and existing metrics sources. Most existing general metrics for engineering practice may be adapted to the needs of MOSA implementations and therefore may be used to evaluate MOSA characteristics.

Appendix A identifies criteria and describes a methodology for PMOs and PMs to use to assess MOSA in a program or system. The specific metrics needed for a case depends on the primary stakeholder's MOSA implementation along with the benefits that are desired or expected from the MOSA implementation.

#### **3.4 MOSA and Technology Change**

Successful technology management is vital to the acquisition and maintenance of a complex system throughout its life cycle. MOSA can be one important approach to managing technology as it supports technology updates and integration. This process involves adopting cutting-edge technologies to improve reliability, lower sustainment costs, and enhance warfighting capabilities to meet evolving demands.

Technology insertion and refreshment efforts can be complicated by Diminishing Manufacturing Sources and Material Shortages (DMSMS) issues. To mitigate DMSMS issues, it is essential to involve DMSMS management practitioners in the technology insertion and refreshment planning process. By collaborating with program offices, DMSMS experts can help identify potential issues and develop strategies to address them.

The use of consensus-based open standards and interfaces in MOSA enables the integration of components from multiple vendors, facilitating the development of alternative sources for critical components and reducing dependence on a single supplier. By using consensus-based open standards, MOSA ensures systems and components can interoperate seamlessly, even if they are from different vendors, which enables the substitution of components with equivalent ones from other suppliers, mitigating DMSMS risks.

MOSA implementation reduces vendor lock-in, making it easier to switch to alternative suppliers if a vendor discontinues support or goes out of business, and promotes competition among vendors, encouraging innovation and reducing the likelihood of single-source dependencies. MOSA also simplifies maintenance and upgrades, as individual components can be replaced or

upgraded without affecting the entire system. Overall, MOSA helps build a more resilient supply chain by promoting the use of multiple suppliers and open standards, reducing the risk of DMSMS, and ensuring the continued availability of critical components.

By adopting a MOSA, organizations can reduce the risks associated with DMSMS, improve system maintainability and upgradability, and increase overall system resilience. This approach enables organizations to stay ahead of the curve in terms of technology and innovation while also minimizing the risks associated with obsolete or hard-to-find components. As a result, MOSA is an effective way to mitigate DMSMS issues and ensure the long-term sustainability of complex systems.

Furthermore, PMOs should coordinate DMSMS planning with the Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) to ensure that DMSMS issues are addressed at the highest level. The USD(A&S) provides oversight and guidance on acquisition and sustainment policies, including DMSMS management. By coordinating with the USD(A&S), program offices can ensure that their DMSMS plans align with DoD-wide policies and initiatives and that they are leveraging best practices and resources to mitigate DMSMS risks. For more information on DMSMS, see DoDI 4245.15, SD-19, SD-22, and SD-26.

### **3.5 Product and Technology Roadmaps and Management**

Product and technology roadmaps are useful tools for managing MOSA by isolating (through modularity) technology areas that are expected to rapidly evolve over time or may offer opportunities to improve a capability. A product roadmap (e.g., AAF Software Product Roadmap)<sup>2</sup> illustrates high-level, adaptable target value delivered over a designated period of time based on technology insertion, as indicated in the accompanying technology roadmap. Product and technology roadmaps help programs identify capability improvements, safety enhancements, or other new requirements by considering the following:

- When new capabilities need to be in place.
- When the technology needed to achieve the new capability requirements needs to be demonstrated successfully in relevant or operational environments.
- When the associated hardware and software changes are to be producible.
- Planned funding.
- Mission profile changes.

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<sup>2</sup> DoD Adaptive Acquisition Framework (AAF) Software Product Roadmap, Defense Acquisition University AAF website, <https://aaf.dau.edu/aaf/software/product-roadmap/>.

### 3. DoD Considerations for Implementing MOSA

MOSA and technology management are mutually beneficial practices. MOSA can improve technology management because identifying modular system interfaces makes it easier to substitute alternative and newer technologies, potentially reducing challenges and, therefore, the time and cost to integrate technology. MOSA can influence the type, extent, and timing of technology change and improvements throughout the life cycle, and technology refreshment and insertion plans can inform a priority scheme for MOSA implementation.

## **4 MOSA Requirements for DoD Acquisition Pathways**

The DoD Adaptive Acquisition Framework (AAF) defines the acquisition pathways and supports the Defense Acquisition System with the objective of delivering effective, suitable, survivable, sustainable, and affordable solutions to the end user in a timely manner. The AAF includes six acquisition pathways: Urgent Capability Acquisition (DoDI 5000.81); Middle Tier of Acquisition (DoDI 5000.80), Major Capability Acquisition (DoDI 5000.85), Software Acquisition (DoDI 5000.87), Defense Business Systems (DoDI 5000.75), and Acquisition of Services (DoDI 5000.74). Statute and policy require the PM to apply a MOSA to the maximum extent practicable regardless of the acquisition pathway.

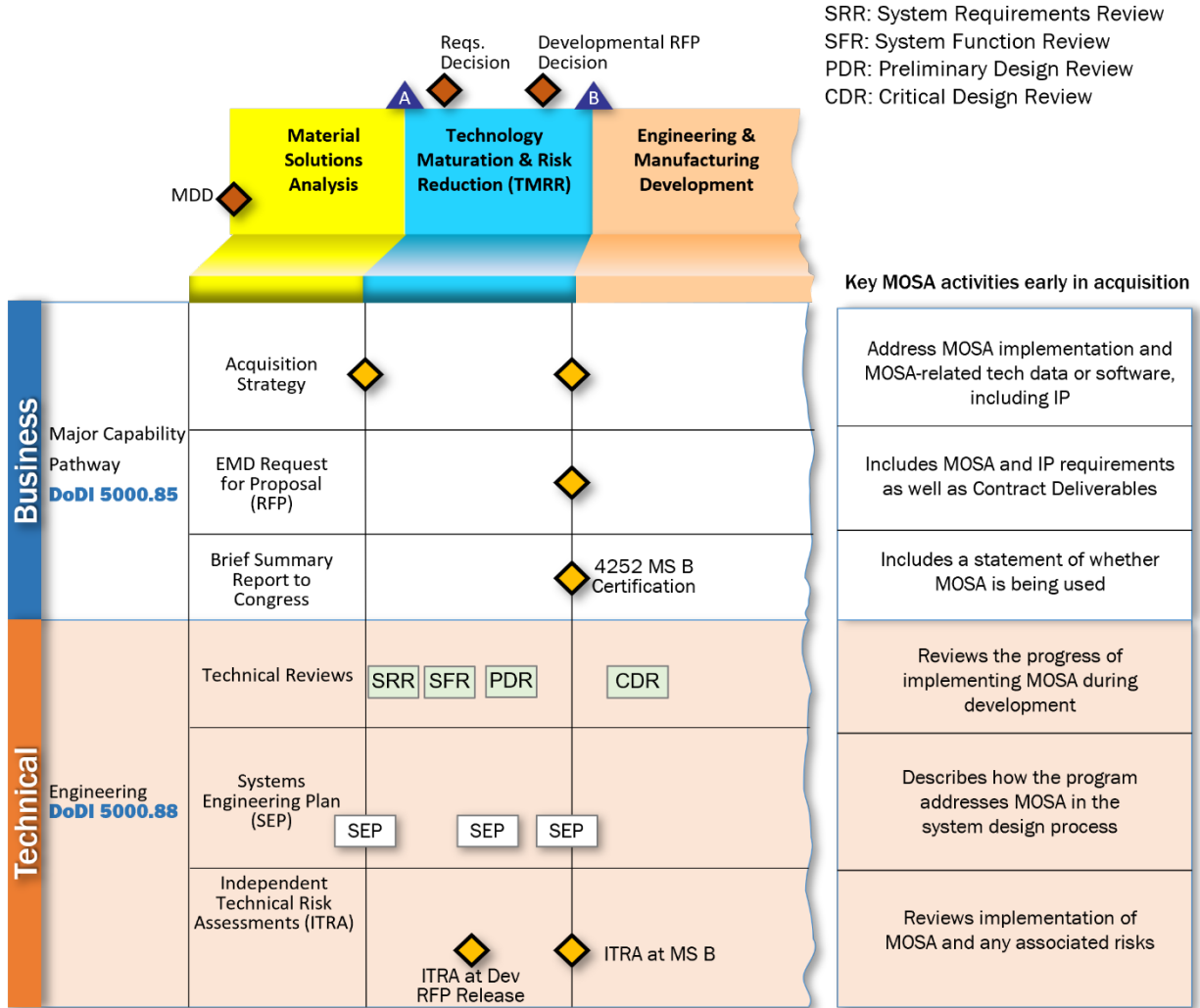
### **4.1 Major Capability Acquisition Pathway**

Pursuant to Title 10, U.S.C. 4401, PMs are responsible for evaluating and implementing MOSA to the maximum extent feasible. In the Major Capability Acquisition (MCA) pathway, MOSA is intended to enable incremental development and enhance competition, innovation, and interoperability. MDAPs that receive Milestone A or B approval after January 1, 2019, shall be designed and developed with MOSA. The Acquisition Strategy for a system should identify where, why, and how MOSA is to be used in the program as described in Section 3.1.6.

The Milestone Decision Authority for an MDAP that uses MOSA needs to ensure the RFPs for the Engineering and Manufacturing Development (EMD) phase and the Production and Deployment (P&D) phase describe the MOSA and the minimum set of major system components that are to be included in the system design.

Figure 4-1 provides a summary of key technical and business requirements for the MCA pathway. Additional information about using MOSA appears on the DAU website (DoD AAF <https://www.dau.edu/aaf>). Additional information about the MCA can be found in DoDI 5000.85.

## 4. MOSA Requirements for the Acquisition Pathways



**Figure 4-1. MOSA Technical and Business Requirements for the MCA Pathway**

### 4.2 Other Acquisition Pathways

PMOs shall apply MOSA to the other acquisition pathways to the maximum extent practicable pursuant to 10 U.S.C. 4401. Regardless of the pathway, all programs should employ and would benefit from employing a MOSA. Below are the requirements and importance for implementing a MOSA for the indicated pathways:

- Urgent Capabilities Acquisition (DoDI 5000.81): Although MOSA is not formally required for urgent capability programs, using components with modular open interfaces can improve the speed of development and employment while reducing the risk of problems interfacing to other systems in the battlefield. Using components and systems with widely accepted standards also would provide additional ease of employment.

#### 4. MOSA Requirements for the Acquisition Pathways

- Middle Tier of Acquisition (DoDI 5000.80): The Middle Tier of Acquisition pathway consists of the rapid prototyping path and the rapid fielding path. Although rapid prototyping programs are not required to implement a MOSA, they should use MOSA if practical to facilitate the interface and integration with existing systems as part of technology insertion and refresh. In a rapid fielding environment, proven technologies are fielded with minimal development. If these technologies were not developed with modular standardized interfaces, the PM should understand and manage the increased risk with a less modular system and the potential integration and operational issues that may arise as a result.
- Software Acquisition (DoDI 5000.87): It is extremely important for software systems to be designed and developed with a MOSA. DoDI 5000.87 requires software pathway programs to develop and implement architecture strategies to enable a MOSA that is interoperable with required systems. Also described in DoDI 5000.87, PMs, as much as practicable, need to require that any commercial or proprietary software used in or interoperable with software developed for the Government include documented open interfaces to allow for technology insertion and to support the use of MOSA. Programs are required to use modern, iterative software practices and continuously improve software quality, including using MOSA to support future capabilities. Programs are required to integrate IP considerations with other program strategies that include MOSA.
- Defense Business Systems Acquisition (DoDI 5000.75): In accordance with DoDI 5000.75, functional and acquisition leadership need to use COTS and government off-the-shelf (GOTS) solutions to the extent practicable. Although DoDI 5000.75 does not specifically require a MOSA, development and integration of COTS and GOTS solutions should maximize openness and modularity.

## 5 Conclusion

MOSA represents a significant shift in the design and development of complex systems, emphasizing interoperability, flexibility, and sustainability. By adopting MOSA, organizations can unlock numerous benefits, including increased flexibility, improved interoperability, and enhanced sustainability.

Key takeaways from the DoD's MOSA implementation efforts include the importance of modularity, consensus-based standards, and a holistic approach to system design, as well as the need for commitment, collaboration, and a forward-thinking mind-set among stakeholders.

The DoD has taken a proactive approach to implementing MOSA, establishing the Modular Open Systems Working Group (MOSWG) to lead guidance efforts, and developing coursework and training (see Appendix E). The MOSWG, in collaboration with the DoD MOSA Technical Standards Working Group (TSWG), has worked to identify common standards, barriers, and enablers to MOSA adoption.

For more information on MOSA and the DoD's priorities for its implementation, visit the SE&A MOSA web page (<https://www.cto.mil/sea/mosa/>). By working together to implement MOSA and leveraging resources like the MOSA web page, the DoD can unlock the full potential of this approach and create a more flexible, responsive, and effective defense enterprise.

## **Appendix A: Assessing MOSA and MOSA Assessment Tools**

PMOs should measure modularity and openness via specifically developed MOSA metrics and tools. The specific metrics depend on the primary stakeholder's MOSA implementation along with the benefits that are desired or expected to be received from the MOSA implementation. This appendix presents an overview of a variety of tools for assessing modularity.

### **Modular Open Systems Approach Program Assessment Tool (PART)**

PART was adapted from the former Office of Management and Budget Program Assessment Rating Tool (PART) and is referenced in the Army's Modular Open Systems Approach (MOSA) Implementation Guide as its assessment tool.

PART presents the user with a list of 24 questions for consideration and scoring. These questions assist PMs and their teams by prompting consideration of MOSA planning, implementation, self-assessment, and reporting. Each question is scored and recorded in four categories:

- Progress or Status (Planned, Achieved, or N/A)
- Extent to which each is achieved (None, Little, Moderate, Large)
- Rational or Explanation (Narrative of the status evaluation)
- Supporting Evidence or Date

PART helps PMs identify the degree of their MOSA implementations according to the Open Systems Joint Task Force five key MOSA pillars: Modular Design, Key Interfaces, Open Standards, Conformance, and Enabling Environment.

The tool provides instruction on its use, prompts to assist with scoring and recording assessment justifications, and citations of objective quality evidence in support of the scoring.

### **Open Architecture Assessment Tool (OAAT)**

OAAT is a tool designed to help Navy PMs assess the openness of their programs. It aligns to the Open Architecture Assessment Model (OAAM) as approved by ASN (RDA) and provides a reproducible and objective method of conducting program assessments. The OAAT is used to assess a weapon system's degree of openness in terms of the open architecture maturity of that specific weapon system program and its systems. Openness refers to both business and technical characteristics of weapon systems that support modular design, interoperability, and commercial standards. More openness both supports weapon system programs in terms of competition for development and support, as well as facilitates rapid technology insertion.

The OAAT is used to respond to a set of interrelated questions to provide program officers with an objective and evidence-based assessment of the degree that a program exhibits openness along two areas: Business/Programmatic and Technical. The business/programmatic dimension criteria and programmatic questions refer to the processes and documentation employed to acquire and manage systems and are outlined in Table A-1.

**Table A-1. Business and Technical Areas to Review by the OAAT**

Business/Programmatic Areas	Technical Areas
Open Systems Approach	Design Tenet: Interoperability
Open Architecture	Design Tenet: Maintainability
Modular Open Design	Design Tenet: Extensibility
Interface Design and Management	Design Tenet: Composability
Treatment of Proprietary Elements	Design Tenet: Reusability
Open Business Practices	General Design Tenet
Peer Review Rights	
Technical Insertion	
Commercial Standards	
Compliance	

The technical dimension criteria cover the essential OA design tenets of Interoperability, Maintainability, Extensibility, Composability, and Reusability. The technical questions refer to the technical features of computing environments and application software. The technical areas measured are described below:

- **Interoperability:** How readily can the program’s separate systems exchange information and appropriately use each other’s functional capabilities?
- **Maintainability:** What architectural characteristics address obsolescence and provide for timely technology refresh, fixes, and upgrades?
- **Extensibility:** Does the program follow a well-defined SE process for implementing capability extension?
- **Composability:** Are the program’s systems capable of being highly modular and having minimal dependencies (loosely coupled) so they can be readily combined with other modules to provide new types of functionalities?
- **Reusability:** Are the assemblies that are candidates for reuse readily available, certified for reliability and performance, and easily obtained for reuse?
- **MOSA:** What is the program’s level of MOSA Compliance?

The OAAT provides an OA Assessment Model (OAAM) that displays the program's current state with respect to business/programmatic and technical degrees of openness. Each of these areas (business and technical) is rated on a scale of 0 to 4.

The scores for these two dimensions are plotted on the OAAM, which provides a graphical depiction of the current state of OA maturity and identifies the progression toward higher levels of openness. The PM then uses the results of the OAAT assessment to help improve the program with respect to Naval Open Architecture. Using the OAAM, a program's degree of openness can be rated using the business/programmatic and technical levels shown below:

***Business/Programmatic Levels***

- 4: Open and Net-Centric
- 3: Common
- 2: Migrating to Openness
- 1: Connected
- 0: Isolated

***Technical Levels***

- 4: Enterprise
- 3: Common
- 2: Layered and Open
- 1: Layered
- 0: Closed

**Key Open Subsystem (KOSS) Tool**

The Naval Air Systems Command (NAVAIR) developed the Key Open Subsystems (KOSS) tool to evaluate which system components may be most susceptible to vendor lock because of proprietary interfaces. This tool offers one method for determining the most important subsystems/components for which the program office should seek license rights.

The KOSS tool can identify important system components that may become obsolete or require upgrades more often than others. This tool can help a program to evaluate which key system components may prove most susceptible to the negative impacts of a vendor-locked situation. If only one vendor can replace or upgrade those key components, that de facto monopolist may be able to exert excess negotiating leverage over replacement or upgrade prices. Furthermore, the monopolist vendor's solutions may be inferior to those on the open market.

To combat these problems, the KOSS tool may help the Government identify any key component interfaces that follow proprietary standards and should be modified to use open standards, thus ensuring other qualified vendors can provide replacement components. By highlighting these key components, KOSS allows a program to focus its efforts on acquiring IP rights only for those highly volatile areas of the system and to conserve resources by disregarding IP for other, less important system components.

### **Air Force Systems Engineering Assessment Model (SEAM)**

The primary purpose of SEAM is to promote the application and use of standard systems engineering processes across the Air Force and to conduct continuous process improvement (CPI). The Air Force developed SEAM to support both self-assessment and independent validation of systems engineering process implementation. While the tool assesses the existence of SE process work products (CONOPS, plans, technical documents, etc.), it does not assess the outcomes delivered to the customer.

SEAM is a systems engineering model based on a set of best practices developed by representatives from Air Force acquisition programs. It is a self-assessment tool to ensure a consistent understanding of systems engineering, ensure core systems engineering processes are in place and practiced, document repeatable systems engineering best practices across the Air Force, identify opportunities for continuous improvement, improve program performance, and reduce technical risk. SEAM is not an appraisal of product quality or a report card on people or the organization. It defines 10 standard systems engineering process areas, lists associated goals under each process area, and provides associated specific and generic practices. These include:

1. Configuration Management
2. Decision Analysis
3. Design
4. Manufacturing
5. Project Planning
6. Requirements
7. Risk Management
8. Transition, Fielding, and Sustainment
9. Tech Management and Control
10. Verification and Validation

## **Appendix B: Industry Recommendations to Implement a MOSA**

### **Solicitation and Selecting MOSA Contract Partners**

Industry needs awareness of the Government's MOSA vision and roadmap, including near-term and long-term considerations. The PM should relay the required level of industry support that may be requested over time in the MOSA implementation. This information supports the business case and enables proper planning, forecasting, and resourcing of a resultant program to ensure that it can be adequately accomplished. Other questions to be addressed in a solicitation may include: What external dependencies are there in the expected MOSA implementation and what is the minimum viable content acceptable in the MOSA solution? Answers to questions such as these help address complexity matters as well as better address affordability requirements in the solution. Instructions to offerors should include the assigned value for the MOSA requested in the solicitation.

In selecting the appropriate MOSA-infused solution, the proposed architectures should be evaluated in the context of the ability, challenges, and opportunities for achieving the desired MOSA benefits through architectural attributes (i.e., responsiveness, scalability, modularity, availability, affordability, and functionality.) The MOSA pillars, described in Section 2.1 and Appendix D, can then readily be applied, as relevant, to evaluate the desired attributes of the open system architecture solution at the component, product, and system-of-systems levels. Application of the MOSA tenets is required but is not sufficient unless the application of those tenets addresses the business and technical requirements needed to achieve the desired MOSA benefits within the available resources and program constraints.

The PM can use Requests for Information (RFIs) and hold industry days to help identify opportunities for achieving MOSA benefits. This collaboration provides both fairness to the bidders and insights to the Government regarding appropriate evaluation criteria that can be used to discriminate between competitors. Criteria should address the ability to achieve the desired MOSA benefits or reduce risk. Such collaboration also makes it easier to measure MOSA in RFP responses and throughout a contracted development effort.

### **Flowing MOSA Requirements and Model Components Down to Suppliers**

The modeling conventions for both hardware and software need to instruct suppliers on what and how to provide content to the acquirer so it can be used for evaluation and validation of a supplier's response. This content includes (1) modeling patterns; (2) domain overlay (DO)

profiles;<sup>3</sup> (3) interface definitions; (4) analysis definitions; (5) templates and schemas; (6) evaluation criteria and scoring; (7) CDRLs and DIDs for document generation from models; and (8) requirements schemas.

Industry has mechanisms in place to work with its supply bases. These mechanisms are contractual, business, and technical, not only for specific programs but strategically when a single supplier contributes to multiple programs performed by a single integrator or original equipment manufacturer (OEM). Contractual mechanisms are expected to follow Government contractual guidance modified with MOSA considerations. Business mechanisms follow best practices of supply management implemented by integrators and OEMs with heightened considerations of MOSA concerns. Concerns include exposing interface boundaries and providing solutions that do not rely on producer-unique development tools or proprietary approaches needed to enable modular system interfaces.

### **Defining/Executing Statements of Work Involving MOSA**

A Statement of Work (SOW) that includes MOSA considerations should accommodate the appropriate MOSA specifications and standards along with the expected measures and controls. These planning elements should be incorporated into the offeror's proposal and be used to evaluate and guide the program for the life of the system acquisition.

MOSA-based SOWs should contain language that represents a flow-down from Title 10 U.S.C. law to DoD-wide implementations, to Service-specific guidance regarding how a MOSA approach is implemented across the Service, to PEO-specific implementation guidance flowed to their program acquisition offices.

### **Evaluation of a MOSA Implementations**

MOSA implementations should be evaluated with a method that is appropriate for the specific application of modularity and openness. MOSA implementation success depends on applying the proper modularity and openness principles at the appropriate level of design implementation (e.g., SoS, system, or below) as well as phase of development. Integrity of the evaluation depends on traceability to metrics that are as objective as possible. A contractor's MOSA should contain metrics that measure progress and achievement of MOSA objectives, implementation activities, and risk mitigations, according to the overall technical management and program reporting approach.

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<sup>3</sup> DO profiles, extended from the earlier term called Aspect Profiles, codify a domain's concern used to capture required data, analysis, visualization, and regulations addressing that concern along with specific metrics (e.g., MOSA, Cyber, Safety, Certifications).

Both modularity and openness need to be equated relative to the contract-stated goals and metrics associated with the specific project and design. MOSA metrics used to evaluate the solution should accommodate each case. In both cases, adherence to standards is a prerequisite. How well a design is modular or open can be evaluated through specifically developed MOSA metrics, providing decision support for assessment in execution and leading to achievement of the desired MOSA objectives. In short, what gets measured, analyzed, and acted upon gets done.

From an industry perspective, supply-side decisions involving MOSA are critical. Industry often employs Product Line Approaches (PLAs), or Product Line Engineering, with some commonality and reuse considerations already in their integrated solutions. These PLAs rely on business relationships between integrators and suppliers throughout the supply chain, as stakeholders strive to lower costs and reduce cycle times for both industry competitiveness and to help the Government achieve their MOSA objectives. This modularity alignment, where supply is adequately balanced to meet expected demand, involves strategic business decisions by each party for mutually beneficial outcomes.

Digital engineering, including MBSE, can support streamlined development and delivery of solutions following a MOSA acquisition. Strategically, the goal for this process dimension of a MOSA acquisition is the compatibility of delivered products and artifacts between digital engineering environments used by the Government and industry over the entire acquisition life cycle. With considerations for IP and DR, programs need to protect detailed methods and inherent assets used by industry members for competitive advantage pursuant to DFARS 252.227. These considerations may be prevalent at every level of design and supply chain source in the system integration. Primary areas of concern include management of the interfaces, transportation layer, and data exchanges.

When a MOSA implementation involves a significant number of off-the-shelf components or even full systems (e.g., complete air vehicles), acquirers should minimize or eliminate adverse effects involving design changes to an existing system that may undergo substantial modification. In these cases, design changes may trigger substantial regression testing or even recertification of the base platform, thus negating any projected benefits from a MOSA-related design modification. The Federal Aviation Administration (FAA) Commercial Off-the-Shelf (COTS) Risk Mitigation Guide (2002) provides important insights into the mitigation of such risks. Effective mitigation strategies include development and maintenance of flexible performance requirements suited to COTS products, COTS product testing capabilities, and strong configuration management practices.

To be successful in implementing MOSA, acquirers need to understand the constraints, opportunities, and risks of the industry contractors and suppliers involved. All members of a healthy defense industrial base compete to deliver balanced designs that satisfy requirements,

meet user needs, and achieve customer objectives at fair and affordable prices. The shifting of business models to align with the new realities of MOSA (vision and benefits), however, necessitates additional alignment of Government and industry objectives to the greatest extent possible and allowable under law. These new paradigms should include the supply-driven considerations of the defense industrial base.

## **Appendix C: Contracting Considerations and Sample Contract Language**

### **MOSA in Contracts**

Including MOSA in contracts is vital to the success of the program and requires diligence by the PM to ensure it is properly accounted for. To include MOSA in a contract, it is important to include statements in the contract's technical specifications and contract language. These statements should outline key elements such as open standards, modular design, defined interfaces, and the ability for the system to be easily repaired, upgraded, and adapted with new technologies throughout its life cycle. This appendix provides PMs with areas to consider when developing contract documents and sample contract language, which can be modified for a specific use case.

### **Intellectual Property Rights**

Acquisition of data and associated IP rights and MOSA go hand in hand. MOSA cannot be implemented in a contract without acquisition of necessary interface data and IP rights, in accordance with an IP strategy. Acquisition of data and associated rights without any thought to MOSA is possible but may lead to higher costs and reduced benefits of MOSA. When permitted by other technical performance requirements, designs should optimize to recognize and protect private investments and associated IP rights and provide the Government with maximum flexibility to replace or interchange modular components efficiently.

When systems are designed with modularity in mind, the ability to segregate data rights can be applied efficiently and in a way that proportionately and equitably protects private proprietary rights and return on private investments, while also allowing the Government to maintain necessary flexibility to ensure operational readiness, facilitate capability upgrades, and field resilient and adaptive operational capability.

### **Government-Desired Modularity and Defined Architectures**

The term “desired modularity” means the desired degree to which weapon systems, components within a weapon system, and components across weapon systems can function as modules that can communicate across component boundaries and through interfaces and can be separated and recombined to achieve various effects, missions, or capabilities, as determined by the program officer for such weapon system (NDAA FY 2021 Section 804(d)(f)(2)).

The term “default configuration” is not further defined statutorily. In practice, this leaves requiring activities or their parent organizations a great deal of discretion in defining default configurations. A popular approach is for DoD organizations to adopt one or more standardized architectures, sometimes called a Government Reference Architecture (GRA), for use at a

subsystem, system, program, enterprise, or other level. Examples include Future Airborne Capability Environment (FACE)<sup>®</sup>, a government-industry collaboration, or DoD proponent architectures such as the Ground Combat Systems Common Infrastructure Architecture (GCIA). The GRA should be included as part of the Government's specification for its desired level of modularity and identification of modular system interfaces. Such architectures and their use are described further in MOSA Reference Frameworks in Defense Acquisition Programs (2020).

### **Interface Data Rights**

Per 10 U.S.C. 3771, modular system interfaces need to be identified in its contractor solicitations and contracts to ensure its ability to acquire Government purpose rights in technical data pertaining to the interfaces developed exclusively at private expense or with mixed funding. The ability to enforce such rights is pending finalization of regulations in DFARS rulemaking case 2021-D005 (10 U.S.C. 3771(b)). In the meantime, requirements and acquisition planning should still include the identification of desired modularity and modular system interfaces. MOSA can be implemented with available data rights tools such as rules regarding rights in form, fit, and function data; rights in data necessary for operation, maintenance, installation, and training; and the development funding test.

Program and acquisition activities choosing to use non-Federal Acquisition Regulation (FAR) acquisition tools such as Other Transaction Authorities (OTAs) should bear in mind that none of these DFARS tools for data rights, including rights in interface data, are automatically included or available in non-FAR acquisitions, while requirements to implement MOSA apply, nonetheless. Systems engineering, requirements, and acquisition planning personnel should be mindful of this and the need to incorporate or create data requirements and agreement terms that enable the implementation of MOSA regardless of the type of agreement used.

### **Acquisition Strategy and IP Strategy**

Planning and choices regarding desired modularity and desired modular system interfaces require coordination of the SEP and the Acquisition Strategy, including an IP strategy and sustainment strategy, and a cost-benefit analysis. For a given level of desired modularity and configuration of these interfaces, there are associated costs and benefits and presumably more or less optimal levels of modularity and interface configurations. The spectrum can range from no modularity to near-microscopic modularity. Increasing modularity comes at greater costs, perhaps in technical performance, disincentive to OEMs, or price, but with related benefits in flexibility for upgrades or supportability, or future cost savings. An integrated Acquisition Strategy and IP strategy is valuable to the PMO as it analyzes cost-benefit, trade-off, or risk/issue/opportunity to determine the desired modularity, interface configuration, and affordability.

## **Solicitation and Evaluation Criteria Development**

In formal contracting under the FAR, at a higher level, contracting to develop and/or acquire a system starts with a set of technical requirements or a System Performance Specification along with a set of proposed contractor tasks in a SOW or Performance Work Statement (PWS) and a program WBS. These elements are combined into a solicitation document, usually an RFP that should also include proposal instructions in Section L and evaluation criteria in Section M. The combination of L and M (supported by the rest of the solicitation) in effect communicates to prospective offerors what the Government is looking to have accomplished or delivered. The sections communicate how the Government plans to evaluate a prospective offeror's capacity to meet those objectives and the asking price, and they indicate what information the Government needs to make its assessment and award one or more contracts.

## **Recommended Parts of a Solicitation Necessary to Implement MOSA**

### **Deliverable Data – Contract Data Requirements Lists (CDRLs) – Usual Exhibits**

CDRLs supported by Data Item Descriptions (DIDs) are the formal mechanism DoD uses to identify data that needs to be delivered to the Government under any agreement, FAR or non-FAR. DIDs provide a means for standardization of deliverable data content and format. Use of DIDs also facilitates compliance with the Paperwork Reduction Act. Digital engineering repositories and other means of facilitating access to needed data (including software) can be invaluable and can enable agile acquisition and development. However, the omission of CDRLs and DIDs may put a program at risk of not receiving needed data and, in the case of FAR/DFARS contracts, of not being able to apply and rely upon DFARS data rights contract clause terms. Program and contracting personnel should consult with acquisition legal counsel or DoD IP Cadre subject matter experts for more information.

CDRLs should identify all data (including technical data, computer software, and any other type of data) necessary to implement MOSA fully. See also the paragraph on Statement of Work (SOW) or Performance Work Statement (PWS).

### **Program Work Breakdown Structure (WBS)**

The WBS helps the Government understand a system in a hierarchical framework. This includes describing the desired level of modularity and identifying modular system interfaces to enable MOSA. Furthermore, using a WBS in the acquisition process allows the PM to formulate the scope of the project, improve communication between stakeholders, identify resource requirements and shortfalls, identify risks, and effectively track progress.

### **System Requirements Document (SRD)**

Using an SRD in the contracting process provides several benefits, including a clear communication of project expectations, minimizing confusion between key stakeholders, and establishing a solid foundation for project planning. When implementing MOSA, requirements specifications need to include and describe the desired level of modularity and identification of modular system interfaces. See *A Guide to Program Management Business Processes* (DAU 2022) for more information on the requirements development process.

### **Systems Engineering Plan (SEP)**

When the RFP is issued to potential bidders for an acquisition, it should include the SEP. The bidders are required to include a SEP-aligned Systems Engineering Management Plan (SEMP) with their proposal. The SEMP DID is DI-SESS-81785.

### **Statement of Work (SOW) or Performance Work Statement (PWS)**

The SOW template language provided below should be tailored for each program, based upon the MOSA requirements contained in that program's CDD, SEP, Acquisition Strategy, intelligence threat inputs/supportability considerations, and product support strategy as described in the program's Life Cycle Sustainment Plan (LCSP). (See 10 U.S.C. 4211(c), 4324(b), 4401-4402, DoDD 5000.1, DoDI 5000.61, DoDI 5000.82, DoDI 5000.85, DoDI 5000.86, DoDI 5000.87, DoDI 5000.88, DoDI 5000.89, DoDI 5000.90, DoDI 5010.44, AFPD63-1/20-1, AFI63-101/20-101, DAFPAM63-128, and AFGM2018-63-146-01.)

The WBS and GRA depict the physical, logical, and functional decomposition of the weapon system. Accordingly, the SOW should include tasking statements that identify what CDRL deliverables the development, production, or sustainment contractor needs to deliver to the Government written to the appropriate WBS element(s) and GRA graphical node levels of indenture for specific Hardware Configuration Items (HWCI) and Computer Software Configuration Items (CSCI) that reside in the "modular system platform's" system architecture.

To use this SOW template language, the program office should establish a properly staffed cross-functional team (consisting of system engineers, software engineers, logisticians, contracting officers, and program counsel) that has the knowledge and expertise necessary to:

- (i) Populate the fill-ins and tailor the language as necessary before including it into the Request for Proposals (RFP),
- (ii) Properly evaluate offerors' proposed levels of system modularity during source selection (assuming express MOSA evaluation criteria are included in Section M of the RFP), and

- (iii) Properly verify/validate the contractor’s “major system platform” features the level of system modularity required by the populated SOW language prior to accepting (DD Form 250) that “major system platform”.

The text proposed below assumes the existence of a GRA to serve as the foundation upon which the contractor’s delivered Digital System Model (DI-SESS-82364) (digital twin) is based. The SOW should contain additional Digital Engineering tasks the contractor needs to perform, the scope of which are beyond this template.

Terms in ***bold italics*** are defined in 10 U.S.C. § 4401. Terms associated with various CDRLs are, in almost all cases, DID titles. Listed DIDs when specified in DD Form 1423 Contract Data Requirements Lists (CDRL) incorporated as Exhibits in RFPs and contracts may assist in implementing a MOSA. Those DIDs may be found at <https://quicksearch.dla.mil/qsSearch.aspx>. “HWCI” is defined in MIL-HDBK-61B § 3.3, available at [https://quicksearch.dla.mil/qsDocDetails.aspx?ident\\_number=202239](https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=202239). “CSCI” is defined in MIL-STD-881F, Appendix B § B.4.2.2.3, available at [https://quicksearch.dla.mil/qsDocDetails.aspx?ident\\_number=36026](https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=36026). Notional Work Breakdown Structures (WBS) for various DoD platforms may be found in MIL-STD-881F. The terms “internal block diagram”, “diagram frame heading name”, “graphical node”, and “graphical path” are defined in SysML™ V1.6, available at <https://sysml.org/sysml-specs/>.

## Sample SOW Language

### X.X.X. Modular Open Systems Approach

X.X.X.1 The contractor shall design, develop, produce, and deliver the \_\_*[fill-in w/ name of major system platform being procured]*\_\_ in accordance with Modular Open System Approach design principles. Accordingly, the hardware and software architecture of the \_\_*[fill-in w/ name of major system platform being procured]*\_\_ shall implement those principles to the levels of indenture of the contract Work Breakdown Structure (WBS) and Digital System Model (DSM) identified in Table C-1.

X.X.X.2. All functionality to be provided by the ***modular systems (MS)*** and ***major system components (MSC)*** listed in the table residing ***within*** the \_\_*[fill-in w/ name of major system platform being procured]*\_\_ shall be partitioned into discrete, cohesive, and self-contained (encapsulated) units.

**Table C-1. Configuration Items (HWCI)/Computer Software Configuration Items (CSCI)**

Modular Systems (MS)					
HWCI			CSCI		
Name	Contract WBS Element No.	Digital System Model (DSM) Internal Block Diagram - Diagram Frame Heading Name	Name	Contract WBS Element No.	Digital System Model (DSM) Internal Block Diagram - Diagram Frame Heading Name
___[Fill-in with name of hardware <b>MS</b> ]___	___[Fill-in with corresponding WBS Element Number]___	___[Fill-in with corresponding DSM Internal Block Diagram Diagram Frame Heading Name]___	___[Fill-in with name of CSCI or software unit <b>MS</b> ]___	___[Fill-in with corresponding WBS Element Number]___	___[Fill-in with corresponding DSM Internal Block Diagram Diagram Frame Heading Name]___
<b>Major System Components (MSC)</b>					
HWCI			CSCI		
Name	Contract WBS Element No.	DSM Internal Block Diagram Diagram Frame Heading Name	Name	Contract WBS Element No.	Internal Block Diagram DSM Diagram Frame Heading Name
___[Fill-in with name of hardware <b>MSC</b> ]___	___[Fill-in with corresponding WBS Element Number]___	___[Fill-in with corresponding DSM Internal Block Diagram Diagram Frame Heading Name]___	___[Fill-in with name of CSCI or software unit <b>MSC</b> ]___	___[Fill-in with corresponding WBS Element Number]___	___[Fill-in with corresponding DSM Internal Block Diagram Diagram Frame Heading Name]___

X.X.X.3 The contractor shall develop, produce, and deliver the following technical data and computer software to the Government: CDRL A0 \_\_\_[insert number]\_\_\_ (Contract Work Breakdown Structure), CDRL A0 \_\_\_[insert number]\_\_\_ (Software Architecture Document), CDRL A0 \_\_\_[insert number]\_\_\_ (Digital System Model), CDRL A0 \_\_\_[insert number]\_\_\_ (System/Subsystem Specification), CDRL A0 \_\_\_[insert number]\_\_\_ (Software Requirements Specification), CDRL A0 \_\_\_[insert number]\_\_\_ (Interface Control Document), CDRL A0 \_\_\_[insert number]\_\_\_ (Interface Requirements Specification), CDRL A0 \_\_\_[insert number]\_\_\_ (Interface Design Description), CDRL A0 \_\_\_[insert number]\_\_\_ (Software Test Plan), CDRL A0 \_\_\_[insert number]\_\_\_ (Software Test Description), CDRL A0 \_\_\_[insert number]\_\_\_ (Software Test Report), CDRL A0 \_\_\_[insert number]\_\_\_ (Test Plan), CDRL A0 \_\_\_[insert number]\_\_\_ (Test/Inspection Report), CDRL A0 \_\_\_[insert number]\_\_\_ (Software Product Specification).

### **X.X.Y. Digital Engineering (DE)**

X.X.Y.1. The contractor shall develop and deliver a Digital System Model (DSM) that accurately reflects the logical, functional, and physical configuration of each \_\_[fill-in w/ name of **major system platform being procured**]\_\_ (CDRL A0 \_\_[insert number]\_\_.) [**Note:** The DD Form 1423 for this deliverable must:

- (1) *invoke DI-SESS-82364;*
- (2) *identify what modeling language (e.g., SysML™) and modeling software (e.g., Dassault Cameo/Magi System of Systems, Sparx Systems Enterprise Architect, IBM Rational Rhapsody) the contractor must use to develop its DSM,*
- (3) *state the DSM must accurately reflect the logical, functional, and physical configuration of each \_\_[fill-in w/ name of **major system platform being procured**]\_\_,*
- (4) *state that the modeling software's style sheet content must feature a scriptable Application Program Interface (API) that permits use of full SysML™ implementation such that that API can access all model elements so that all information contained in the DSM can be imported into and exported from the modeling language and modeling software the program used to create the Government Reference Architecture (GRA),*
- (5) *state the DSM must not modify any of the model elements within the GRA that identify all HWCIs/CSCIs the Government has designated as MSs and MSCs, and*
- (6) *state the DSM must not modify any of the graphical paths in the GRA that identify the modular system interfaces.]*

### **Open System Management Plan (OSMP)**

To implement a MOSA most effectively and ensure that the intended modular open system complies with statutory requirements, the Government should specify its desired level of modularity and identify modular system interfaces when releasing a solicitation. This best practice requires critical thinking and decision making around desired levels of modularity prior to RFP release, which differs from historical OSMP delivery and evaluation.

The OSMP as described in the DID (DI-MGMT-82099) captures the offeror's approach to modular, open design; intercomponent dependencies; design information documentation; technology insertion; life cycle-sustainability; interface design and management; treatment of proprietary or vendor-unique components; reuse of pre-existing or common items; and treatment of proprietary elements. However, this deliverable is most often received and evaluated by the Government after the contract award. An alternative approach to align with the best practice is to use proposal instructions that request a draft or initial OSMP and evaluate how closely it aligns with the Government's desired modularity and modular system interfaces.

### **Source Selection and Contract Award**

See the DoD Source Selection Procedures (2011) for more information on source selection using FAR contracts. See the DoD Other Transaction Guide (2023) for information on selecting industry partners in Other Transaction Agreements.

### **Monitoring Contract Performance**

Monitoring contract performance is essential when implementing MOSA in defense systems to ensure compliance with standards and architectures in use, to control costs and schedules, and to ensure appropriate risk management. It helps verify that systems remain flexible for future upgrades, align with acquisition strategies, and meet performance and quality standards. Monitoring also ensures contractors fulfill their obligations, delivering the expected benefits of modularity while preventing issues like vendor lock or system obsolescence. PMOs and systems engineers should include the following activities during key milestones and following any contractual changes:

- Inspection and Acceptance of Data Deliverables for MOSA. Changes to the contract should address the impact on systems design with respect to modularity in major systems and/or major components including the impact on IP and Data Rights (DR).
- Technical Monitoring and Validation of modularity. Ensure the system architecture maintains severable major system components at the appropriate level to accomplish PM MOSA objectives including the following:
  - Highly cohesive and loosely coupled architecture goals are maintained.
  - Demonstration, analysis, testing, inspection of interfaces and standards confirm openness goals are maintained.

## **Appendix D: MOSA Pillars and MOSA Implementation Considerations**

### **Five MOSA Pillars**

A PMO team needs to establish requirements, business practices, development, acquisition, test, and evaluation (T&E), and strategies that support MOSA. The team should then accurately isolate functionality during the design process. Isolating the functionality simplifies development, maintenance, changes, and upgrades. Developers who design modular systems can upgrade or change functions rapidly, with limited or no impact to the rest of the system. They need to sufficiently decouple the interface and service implementation so they can maintain separate life cycles.

Consensus-based standards, if available and suitable, need to be selected to allow developers to leverage commercially developed technologies, increasing competition. In addition, they offer faster upgrades at reduced cost and complexity. Fielded systems are more affordable and maintainable. Finally, developers should verify and validate their MOSA implementation and requirements, ensuring conformance to selected internal and external open interface standards. A checklist may be used for this verification.

OUSDR(R&E)-led MOSA working groups developed the five pillars of MOSA to ensure DoD programs have an effective approach for MOSA implementation in place for the life cycle of a product or service.

- 1. Enabling Environment**
- 2. Modular Design**
- 3. Designated Interfaces**
- 4. Consensus-Based Open Standards**
- 5. Certifying Conformance**

### **Establish Enabling Environment**

By establishing and maintaining an enabling environment that supports MOSA, the DoD can ensure the development of modular, interoperable, and adaptable systems that meet evolving defense needs efficiently and effectively. Creating an enabling environment is fundamental for implementing MOSA effectively across the life cycle of a product or service. To achieve this, PMOs and systems engineers should establish requirements, business practices, development strategies, acquisition approaches, T&E methods, and overall strategies that support MOSA. The following items ensure a PMO is taking the correct steps to create an enabling environment for MOSA:

1. Establish MOSA Goals:

- Set clear MOSA goals that function on expanding capabilities and interoperability.
- Define MOSA life cycle costs and continuous development, release, monitoring, and performance goals to ensure the system evolves with technological advancements.

2. Adopt MOSA Practices:

- Transform requirements, business, management, technical, and acquisition practices, estimation methods, and end-user engagement strategies to align with MOSA principles.
- Update contracts, data, licenses, and property rights; plans; and other key areas to support modularity and openness.

3. Integrate MOSA in Contracts and Data Rights Planning:

- Incorporate MOSA considerations into contracts and data rights planning to improve cost reduction.
- Ensure necessary data rights are obtained to support long-term system maintenance and upgrades.

4. Embrace an Agile Development Culture:

- Plan and implement agile development methodologies.
- Deploy functionality in frequent, small releases based on continuous feedback from sponsors and end users, allowing for rapid adaptation to changing requirements.

5. Embrace Automation:

- Use automated development and testing pipelines to enable continuous integration, continuous delivery (CI/CD) and continuous operations.
- Ensure communication structures and team arrangements facilitate the creation of modular and interoperable systems.

6. Structure the Organization for Openness and Modularity:

- Align organizational structure with systems design.
- Ensure the organization's communication and collaboration patterns reflect the desired system architecture. This principle is based on Conway's Law (1968), which states that systems will mirror the communication structures of the organizations that design them.

7. Adopt Digital Engineering Practices:

- Use digital engineering practices necessary to capture, assess, and support MOSA elements in product development to promote modularity and openness using data and models throughout the life cycle.
- Follow the guidelines established in the DoD Digital Engineering policy (DoDI 5000.97) by adopting the use of models and data to support life cycle activities, ensuring that organizational structures and processes are aligned with the principles of modular system design and digital transformation.
- By integrating digital engineering, organizations can enhance collaboration, streamline communication, improve decision making, and ensure that system designs are aligned with modularity and openness principles.

8. Document MOSA in the Acquisition Strategy:

- Collaborate with capability owners to commit to developing and implementing MOSA.
- Identify business and technical objectives and life cycle characteristics that guide the system's evolution, ensuring these goals are reflected in the system's design and implementation.

9. Identify and Derive MOSA Functional Life Cycle Characteristics:

- Ensure MOSA addresses life cycle requirements such as affordability, interoperability, maintainability, and replaceability.
- Consider the quality attributes that are critical for the system's long-term success such as safety, reusability, scalability, etc.

10. Trace MOSA from User Requirements:

- Derive modularity and openness objectives from operational and life cycle requirements.
- Ensure MOSA objectives are included in System Requirements Document and reflected in T&E activities.

11. Manage Architecture Requirements:

- Establish architecture constraints that drive system development, ensuring developers meet MOSA requirements alongside operational and performance objectives.

12. Develop and Implement Intellectual Property and Data Rights Strategy:

- Create a strategy for IP and data rights that supports MOSA objectives.
- Ensure the necessary technical data and computer software rights are obtained to facilitate modular open system approaches.

13. Incorporate MOSA in Contracting and Deliverables:

- Include MOSA requirements in RFPs, SOWs, Statements of Objectives, and CDRLs.
- Ensure contracts support the acquisition of services and products aligned with MOSA objectives.

14. Enable and Empower the Team:

- Maintain a disciplined approach and enable a team that understands program objectives. Assign MOSA implementation responsibilities to the Lead System Integrator (LSI) and ensure the Systems Engineering Integrated Product Team (SE IPT) addresses MOSA objectives across the program life cycle.

15. Record MOSA Intent and Expectations:

- Document the program-specific plans, milestones, and expected outcomes clearly. Ensure communication and accountability through a MOSA-enabled SEP or Simplified Acquisition Management Plan (SAMP).

16. Plan for Life Cycle Sustainment:

- Begin planning life cycle sustainment early, ensuring MOSA objectives support enhanced product support, technology insertion, and innovation throughout sustainment and modernization.

17. Include MOSA in Technical Risk Management:

- Use widely accepted, consensus-based standards, and standardized interfaces to mitigate identified technical risks.
- Consider the full spectrum of technology, engineering, and integration risk of the program's MOSA requirements.
- The Defense Technical Risk Assessment Methodology: Criteria Volume 6.3, 30 September 2020, provides evaluation criteria and assessment framework for use in conducting technical risk assessments of the maturity of planning and execution of

defense acquisition programs for 1) Independent Technical Risk Assessments (ITRA) as directed by statute and policy, 2) Test and Evaluation Sufficiency Assessments, 3) informing readiness for milestone decisions, 4) the adequacy of Systems Engineering Technical Review (SETR) and Test and Evaluation events, and 5) reviews of technical planning documentation (e.g., Systems Engineering Plans, Test and Evaluation Master Plans, and Program Protection Plans). This methodology is applicable to all DoD Components and Office of the Secretary of Defense in the conduct of all technical assessments (to include technology and manufacturing) of programs, prototypes, and systems, regardless of acquisition pathway, in the Defense Acquisition System (DAS).

#### 18. Execute and Record MOSA Implementation:

- Ensure conformance to MOSA requirements through system integration and design documentation. Include provisions for T&E and configuration management (CM) to verify and maintain MOSA implementation.

#### **Employ Modular Design**

To accomplish the acquirer's business and technical objectives, the acquiring organization should identify the required functionality of the modular system components before issuing the RFP. Acquirers or developers who design modular systems can upgrade or change functions rapidly, with limited or no impact to the rest of the system. Modular design isolates functionality during the design process to simplify development, maintenance, changes, and upgrades and includes five sub-functions:

1. The design separates components into scalable, reusable modules consisting of self-contained functional elements.
2. The architecture provides failure isolation. When a module fails, the rest of the system remains available except for the single service provided by the failing module.
3. Modules can be independent of technology choices. Developers can use or change each module to different technologies without affecting others. The only constant between the modules is the interface.
4. Modules are immutable and disposable. Developers can deploy the same module into any environment, knowing it consists of the same code everywhere.
5. Modules can run as unprivileged users. Services and data calls avoid requiring administrative privileges, providing just enough permissions to run the service or to query or update a particular data set the user can access.

## Designate Key Interfaces

By designating modular system interfaces, the DoD can ensure that systems are flexible, interoperable, and easily upgradeable. Developers can manage changes effectively, maintain backward compatibility, and leverage open standards to achieve long-term system sustainability and effectiveness following this approach.

This MOSA tenet focuses on decoupling the interface and service implementation of components to allow them to follow separate life cycles. Decoupling the inner workings of components while retaining their approved capabilities enables developers to expose openly available key modular system interfaces to other components.

Designating modular system interfaces enhances flexibility, improves interoperability, and facilitates ease of upgrades when considering the following best practices:

1. Identify Modular Interfaces:
  - Conduct a thorough analysis of all interfaces required by the modular design. Define the interface boundaries, including physical, syntactic, semantic, and behavioral characteristics. Rank interfaces by criticality based on the module's function and information needs.
2. Develop and Implement an Interface Management Plan (IMP):
  - Create an IMP that outlines interface management processes, responsibilities, and procedures for upgrading interface standards.
  - Include certifications and tests applicable to each interface or standard.
3. Assign Interface Ownership:
  - Assign ownership for key interfaces to control their definition, design, development, and implementation, ensuring compliance throughout system development and production.
4. Create Unique Identifiers for Modular System Interfaces:
  - Develop and apply a consistent naming convention to uniquely identify each system interface, facilitating easier identification and management of interfaces.
5. Trace Interface Requirements:
  - Ensure traceability from MOSA and operational requirements to key interface specifications. Document requirements that influence interface characteristics and constraints to support modular design.

6. Document Key Interfaces:

- Maintain detailed records of key interfaces in Interface Control Documents (ICDs), including physical, syntactic, semantic, behavioral, and temporal parameters at the module boundary.
- Document interfaces in corresponding Interface Requirement Specifications (IRS).

7. Adopt an Integrated Business and Technical Strategy:

- Use a modular approach that separates the system into major functions and elements, working together across interfaces based on consensus-based standards supporting modular design.

8. Facilitate Technology Refresh and Interoperability:

- Employ MOSA to enable the sharing of modular components across weapon systems, easing sustainment and parts procurement, and facilitating technology refresh and interoperability.
- The use of extensible and exportable features can ease the integration of advanced technology and modifications to mission capabilities.

9. Collaborate Among Stakeholders by Establishing Interface Control Working Groups (ICWGs):

- Effective MOSA implementation requires collaboration among multiple stakeholders, including technical design, standards selection, acquisition business processes, and legal means. This collaboration ensures supportive elements are aligned with system objectives.
- Create an ICWG to manage interface coordination and control to conduct the following:
  - Expose the design and drivers for all interfaces to an open forum.
  - Ensure internal interface synchronization across teams.
  - Engage with external organizations to maintain interface compliance.

**Select Open Standards When Available and Suitable**

By standardizing modular system interfaces through these practices, the DoD can ensure systems are flexible, interoperable, and easily repairable/upgradeable. Employing consensus-based standards and managing Government-owned interface repositories enable developers to leverage commercially developed technologies, fostering increased competition, faster upgrades, and

reduced costs. Implementing MOSA standardization best practices contributes to the affordability and maintainability of fielded systems.

The following elements are paramount in using consensus-based standards at modular system interfaces:

1. Prioritize Consensus-based Standards:
  - Use standards from internationally recognized groups or Government-owned repositories to ensure broad acceptance and compatibility, creating an environment conducive to interoperability and collaboration.
2. Select Appropriate Standards:
  - Prudently assess and select standards tailored for DoD at modular interfaces to open systems to competition among suppliers, enhancing flexibility and agility to address evolving threats and emerging technologies.
3. Ensure Proper Standards Implementation:
  - Correctly implement standards to avoid interoperability problems, ensuring that modular design principles are effectively applied.
4. Standardize Modular System Interfaces:
  - Standardize modular interfaces to the maximum extent feasible to support interoperability using non-proprietary, widely accepted, consensus-based standards for hardware and software functional boundaries.
5. Document and Manage Interface Specifications for Modular System Interfaces:
  - Document, define, and control modular system interfaces using an Interface Requirement Specification (IRS) to identify interfaces and associated modules, including external data exchange, data flow items, and interface constraints.
6. Engage in Cooperative Efforts:
  - Participate in cooperative efforts or consortiums to shape standards development that addresses domain or community-wide technological issues, ensuring the use of consensus-based open standards.
7. Expose Software and Data Services via Application Programming Interfaces (APIs):
  - Use APIs to expose software and data services while maintaining security and integrity, fostering an environment in which data and services are accessible yet protected.

8. Obtain and Manage Data Rights:

- Secure necessary data rights by statute, negotiate beneficial data rights, and review license agreements to ensure appropriate use in Government systems, creating a clear and legally sound environment.

9. Choose the Appropriate Security Standards at Interfaces:

- Implement secure interfaces using Federal Information Processing Standard (FIPS) 140-2-certified encryption standards to ensure robust security measures and to create a safe, secure environment for system operations.

10. Align Information Technology Standards with the DoD Information Technology Standards Registry (DISR):

- Ensure IT standards align with DISR to provide a cohesive framework for technology integration and interoperability within DoD systems, facilitating a standardized environment.

### **Certify Conformance**

Developers need to verify and validate the MOSA implementation and requirements, ensuring conformance to selected internal and external open interface standards. This certification ensures that the system conforms to both internal and external open interface standards, providing a framework for maintaining interoperability, flexibility, and futureproofing. Conformance is imperative as it guarantees that modularity and openness objectives are met, ultimately supporting program success and system sustainability. By rigorously assessing conformance through these criteria and verification activities, the DoD can ensure that the modular and open systems achieve their intended benefits, enhancing system flexibility, maintainability, and overall mission effectiveness.

The following factors are required to certify conformance:

1. MOSA Measures of Effectiveness (MOEs) and Measures of Performance (MOPs):

- Establish relevant MOEs and MOPs to track and evaluate the effectiveness of the MOSA implementation for supporting program success. These metrics help in assessing whether the system meets its intended modularity and openness goals.

2. Checklists for Verification:

- Use checklists to assist developers in verifying conformance to the MOSA standards. Checklists can aid developers with verification ensuring that all aspects of modularity and openness are addressed and validated systematically.

## 3. Conformance Criteria and Verification (Table D-1):

- Establish specific criteria where T&E results indicate the following:

**Table D-1. MOSA Conformance Criteria and Verification Methods**

<b>Conformance Criteria</b>	<b>Verification</b>
MOSA objectives	Demonstrate severable modular components in accordance with operational and performance requirements.
Key Interfaces	Demonstrate modular system interfaces are designed, implemented, and traceable to requirements.
Standards Compliance	Confirm that widely used, consensus-based standards selected for modular system interfaces are properly implemented.
MOSA Modules	Show that MOSA modules implement minimal functions, are functionally independent, encapsulated, and traceable to requirements.
Modularity	Ensure that MOSA components adhere to modular design principles, such as being encapsulated, cohesive, loosely coupled, and organized into functional categories.
Openness	Ensure MOSA components have standardized modular system interfaces implementing widely used, consensus-based standards, enabling interchangeability without negatively impacting performance.
Life Cycle Characteristics	Ensure MOSA components conform to life cycle characteristics such as being severable, replaceable, interoperable, and allowing for competition and technology insertions.
MOSA Conformance	Demonstrate the program's ability to certify conformance to MOSA.

## 4. Verification and Validation (V&amp;V) Mechanisms:

- Prepare mechanisms for verifying and validating the program's MOSA-related requirements. V&V includes integrating these requirements into test strategies and plans to evaluate conformance to standards and operational performance needs. Key V&V activities include:
  - Documentation Validation:
    - Ensure all MOSA-related documentation is accurate, complete, and up to date.
    - Validate that the documentation supports the verification of modularity and openness objectives.
  - Modularity Requirements Verification:
    - Confirm that the system's modular components are designed and implemented according to the defined modularity criteria.
    - Verify the functional independence and encapsulation of each module.

- Tool Development Verification:
  - Validate the tools and processes used for developing and maintaining the MOSA components, ensuring they support continuous integration and deployment practices.
- 5. Documentation and Interface Management:
  - Maintain thorough documentation and management of interfaces to ensure transparency and accountability. Managing the documentation to support interfaces involves specifying deliverables in contracts to ensure that vendors provide necessary artifacts for verifying conformance.
- 6. Testing and Evaluation Planning:
  - Incorporate MOSA requirements into T&E plans, ensuring that the use and implementation of standards, key interfaces, and modular designs are thoroughly tested. Evaluation should cover all life cycle characteristics, including affordability, interoperability, maintainability, and replaceability.

Ask the following questions:

- Identify accountability for the disposition of, access to, release of and control of the technical baselines.
- Establish and maintain plans for managing the configuration of the product.
- Identify the configuration items and related work products that should be placed under configuration management.
- To what extent are relevant MOSA MOEs/MOPs developed, tracked, and used to support senior leader cost, schedule, and performance decisions?

OUSD(R&E) also recommends using a Multi-Attribute Utility Theory (MAUT) for scoring. MAUT is a structured methodology designed to handle the trade-offs among multiple objectives. Many MOSA models/tools used by the services today use this process to provide a *quantitative* MOSA evaluation of their program(s). Although several COTS tools are available to conduct MAUT, a simple Excel spreadsheet is often the preferred tool.

Figure D-1 shows an example spreadsheet using a subset of the criteria categories. The example shows the pillars equally weighted. This is not always the case, and pillars should be weighted according to service and program needs.

## Appendix D: MOSA Pillars and MOSA Implementation Considerations

Program X MOSA Evaluation					
Criteria	Pillar Weight	Score (0-5)	Weighted Score	Justification for Score	Comments
<b>Establish Enabling Environment</b>	0.2				
To what extent are MOSA requirements documented?		2	0.40		
Establish and monitor MOSA life-cycle costs and performance goals		4	0.80		
Is MOSA included in sustainment planning?		3	0.60		
Extent to which MOSA is integrated into contracts and data rights strategy		5	1.00		
<b>Weighted Pillar Score</b>			2.80		
<b>Employ Modular Design</b>	0.2				
Are components separated into scalable, reusable modules consisting of self-contained functional elements?		4	0.80		
To what extent does the system's architecture exhibit modular design characteristics?		5	1.00		
Does the architecture provide failure isolation?		3	0.60		
<b>Weighted Pillar Score</b>			2.40		
<b>Designate Key Interfaces</b>	0.2				
Are key interfaces openly available to other components?		5	1.00		
To what extent has the criteria for designating key interfaces been established?		5	1.00		
To what extent has the program designated key interfaces?		5	1.00		
<b>Weighted Pillar Score</b>			3.00		
<b>Select Open Standards</b>	0.2				
Does the system use open licenses without restrictions and without requirements?		2	0.40		
Are Open standards in alignment with IP/data rights strategy?		4	0.80		
<b>Weighted Pillar Score</b>			1.20		
<b>Certify Conformance</b>	0.2				
To what extent are MOSA standards and requirements verified and validated?		4	0.80		
What is the program's level of MOSA Compliance?		5	1.00		
How well are the MOSA goals for the program being reached?		2	0.40		
<b>Weighted Pillar Score</b>			2.20		
<b>Overall Score for Program X (Sum of Weighted Pillar Scores)</b>			11.60		
Maximum Score Achievable			15.00		
<b>Percent MOSA Achieved</b>			0.77		

Source: "OUSD(R&E) MOSA Assessment Criteria" May 2022 (<https://www.cto.mil/sea/pg>).

**Figure D-1. Example MOSA Quantitative Process Summary of MOSA Assessment Tools**

The example shows only the benefit (or performance) of a particular program's MOSA compliance. To completely evaluate a program, the reviewer should conduct a cost/benefit analysis using the program's calculated performance versus its life cycle cost. OUSD(R&E) conducted a proof-of-concept assessment by using this spreadsheet to assess a current, active program.

## **Appendix E: Workforce Development and Training for a MOSA**

As congressional requirements continue to emphasize the implementation of MOSA, it is imperative to provide guidance and training for the defense workforce regarding the implementation, evaluation, and use of MOSA (from both acquirer and supplier perspectives) throughout the systems engineering and design process.

Workforce training for MOSA should describe the principles from a business and a technical perspective. The training should provide program examples of successful MOSA implementation as well as sources that can assist an organization in implementing MOSA. Training should be designed to provide familiarization with life cycle best practices for MOSA, present a MOSA definition, major system components, modular system interfaces, interface standards, Government and commercial standards, and other widely supported consensus-based standards. MOSA implementations should identify the benefits of MOSA sought in the program, and training should demonstrate how and when to adopt MOSA. It should describe the importance of MOSA for IP, data, and data rights.

The Defense Acquisition University (DAU) has created the training course Continuous Learning Education (CLE) 019 Modular Open Systems Approach. The course provides examples of how to use MOSA, a trade study demonstrating the risks and benefits of implementing MOSA, and a demonstration of data rights that the Government needs to implement MOSA. The course also describes the potential benefits of MOSA and highlights applicable DoD policy for the acquisition and management of MOSA and its importance to IP, data, and data rights.

The DAU CLE 019 course structure may provide guidance for programs to develop future MOSA training (Table E-1).

In addition to CLE 019, DAU manages the following webinar series, workshops, and courses with MOSA educational information (Table E-2).

Table E-1. DAU CLE 019 Course Structure

DAU CLE 019 – Modular Open Systems Approach		
Units of Instruction	TLOs	Description
CLE 019.U01 – Introduction to a Modular Open Systems Approach (MOSA)	CLE019.U01.01	Show how MOSA has evolved
	CLE019.U01.02	Discuss MOSA as defined in law, policy, and guidance
	CLE019.U01.03	Explain when MOSA is and not practicable to use
CLE 019.U02	CLE 019.U02.01	Define the use of an architecture in MOSA
	CLE 019.U02.02	Discuss interfaces as a significant characteristic of MOSA
	CLE 019.U02.03	Explain the use of key open standards in MOSA
CLE 019.U03	CLE 019.U03.01	Summarize MOSA benefits and impacts to technical design and business approaches
	CLE 019.U03.02	Identify MOA enablers Lesson Topics
	CLE 019.U03.03	MOSA Benefits
	CLE 019.U03.04	MOSA Enablers
CLE 019.U04	CLE 019.U04.01	Show how MOSA can be implemented in a System
	CLE 019.U04.02	Understand how MOSA fits into Digital Engineering (DE)
	CLE 019.U04.03	Explain MOSA trade space considerations
	CLE 019.U04.04	Summarize Government and commercial interface standards
CLE 019.U05	CLE 019.U05.01	Identify technical data and computer software needed to implement MOSA
	CLE 019.U05.02	Explain delivery requirement considerations for technical data (TD) and computer software needed to implement MOSA
	CLE 019.U05.03	Describe what is required in a Request for Proposal (RFP) for MOSA to be used effectively in development
CLE 019.U06 – Assessing MOSA	CLE 019.U06.01	Identify the major aspects of assessing MOSA
	CLE 019.U06.02	Summarize assessment of MOSA implementation Lesson Topics
	CLE 019.U06.03	Aspects of MOSA Assessment
	CLE 019.U06.04	MOSA Implementation Assessment

**Table E-2. Courses, Workshops, and Webinars**

Course/Workshop/Webinar Title	Course/Workshop/Webinar Description
Let's Be Modular and Open Webinar Series	A playlist of recorded presentations containing business and technical information on MOSA and MOSA implementations
ETM 1020 Mission and Systems Thinking Fundamentals	This Online Training (OLT) course provides members of the Engineering and Technical Management (ETM) Functional Area with essential foundational knowledge on the universal aspects of approaching technical projects with a mission and systems thinking perspective.
ETM 1040 Technical Management Fundamentals	This is an entry level Online Training (OLT) course that introduces students to the eight Technical Management process of the systems engineering “vee” model. This course provides the essential foundations needed for systems engineers and others to effectively participate in the management of DoD Systems Engineering processes and their related activities.
ETM 1050 Design Considerations Fundamentals	<p>This is an Online Learning Training (OLT) course. Learners will explore the 24 Design Considerations at the foundational level. Learners will understand why program teams need to consider and document all statutory and regulatory requirements, as well as other design considerations, in order to:</p> <ul style="list-style-type: none"> <li>• Translate the end-user desired capabilities into a structured system of interrelated design specifications that support delivery of required operational capability.</li> <li>• Enable trade-offs among the design considerations in support of achieving desired mission effectiveness within cost and schedule constraints.</li> <li>• Incorporate design considerations into the set of system requirements, as some are mandated by laws, regulations, or treaties, while others are mandated by the domain or DoD Component or Agency; these mandates should be incorporated during the Requirements Analysis process to achieve balance across all system requirements.</li> </ul>
ETM 1070 Digital Literacy Fundamentals	This Online Training (OLT) course introduces digital literacy concept and strategies. Students will understand digital behaviors and practices to support implementations of digital concepts. Students gain foundational level skills to understand the importance of identifying, communicating, and preserving information when operating within a digital environment. Students learn digital approaches that use authoritative sources of systems’ data and models as a continuum across disciplines to support life cycle activities from concept through disposal.
ETM 2020 Mission and Systems Thinking for Practitioners	This virtual instructor-led training (VILT) course provides students with the opportunity to apply what they learned in ETM 1020 via several individual and team exercise scenarios. The scenarios allow the student to exercise the universal aspects of approaching technical projects with a mission and systems thinking perspective.

Course/Workshop/Webinar Title	Course/Workshop/Webinar Description
ETM 2040 Technical Management for Practitioners	This virtual instructor-led training (VILT) course offers an opportunity to apply the concepts covered in ETM 1040, Technical Management Fundamentals, in practical exercise scenarios. The student will evaluate the scenario and implement appropriate Technical Management activities in developing designs, assessing risks, and managing requirements, data, and configurations.
ETM 2050 Design Considerations for Practitioners	This virtual instructor-led training (VILT) course is on the 24 Design Considerations. Learners will participate in one or more synchronous, instructor led interventions that will provide instruction, afford learners the opportunity to seek clarity from an instructor, engage in collaborative activities and projects with other learners, and enable learners to receive immediate, constructive feedback.
ETM 2070 Digital Literacy for Practitioners	This Virtual Instructor-Led Training (VILT) course builds upon ETM 1070 Digital Literacy Fundamentals. Students learn how to apply digital engineering behaviors and practices to support implementations of digital concepts. Students gain practitioner level skills for identifying, communicating, and preserving information when operating within a digital environment. Students learn how to integrate digital approaches that use authoritative sources of systems' data and models as a continuum across disciplines to support life cycle activities from concept through disposal. As a group, students discuss best practices and lessons learned that will help them overcome barriers when implementing digital concepts within their own organizations.
TST 2040 Test and Evaluation for Practitioners	This classroom (CLRM) course builds upon professionals' knowledge, skills, and on-the-job experience relating to DoD test and evaluation (T&E) policies, processes, and practices. Several problem-solving situations engage participants in the application of T&E concepts and principles. Course topics include the role of T&E in systems acquisition; T&E planning and T&E strategy; T&E master plan development; managing a T&E program; and planning, preparation for, executing, analyzing, evaluating, and reporting the results of T&E events.

## Glossary

Term	Definition	Source
Architecture	The structure of components, their relationships, and the principles and guidelines governing their design and evolution over time.	DAU Glossary
Design Interface	The integration of the quantitative design characteristics of systems engineering (reliability, maintainability, etc.) with the functional logistics elements. Design interface reflects the driving relationship of system design parameters to product support resource requirements. These design parameters are expressed in operational terms rather than as inherent values and specifically relate to system requirements. Product support requirements are derived to ensure the system meets its availability goals, and to effectively balance design and support costs of the system.	DAU Glossary
Desired Modularity	The desired degree to which weapon systems, components within a weapon system, and components across weapon systems can function as modules that can communicate across component boundaries and through interfaces and can be separated and recombined to achieve various effects, missions, or capabilities, as determined by the program officer for such weapon system	P.L. 116-283 (FY21 NDAA); Sec. 804(f)(2)
Digital Engineering	A means of using and integrating digital models and the underlying data to support the development, test and evaluation, and sustainment of a system.	DoD Instruction 5000.97 Digital Engineering
Department of Defense Architecture Framework StdV-1	StdV-1 Standards Profile – standards, specifications, guidance, policy applying to elements of the preferred alternative (solution) architectures.	OSD Mission Engineering (ME) Guide
Intellectual Property (IP)	Includes inventions, trademarks, patents, industrial designs, copyrights, and technical information including software, data designs, technical know-how, manufacturing information and know-how, techniques, Technical Data Packages (TDPs), manufacturing data packages, and trade secrets.	DAU Glossary
Intellectual Property Strategy	Strategy to identify and manage the full spectrum of IP (e.g., technical data and computer software deliverables, patented technologies, and appropriate license rights) from program inception and throughout the life cycle. The IP Strategy will describe how program management will assess program needs for, and acquire competitively, when possible, IP deliverables and associated license rights needed for competitive, affordable acquisition and sustainment	DAU Glossary

## Glossary

Term	Definition	Source
	<p>over the life cycle. The IP Strategy is updated throughout the life cycle, summarized in the Acquisition Strategy, and in the Life-Cycle Sustainment Plan during the Operations and Support Phase. Program management is responsible for evaluating and implementing open systems architectures, where cost effective, and implementing a consistent IP Strategy. This approach integrates technical requirements, contracting mechanisms, and legal considerations to support continuous multiple competitive alternatives throughout the life cycle.</p>	
Interchangeability	<p>A condition that exists when two or more items possess such functional and physical characteristics as to be equivalent in performance and durability, are capable of being exchanged one for the other without alteration on the items themselves or of adjoining items, except for adjustment, and without selection for fit and performance.</p>	DAU Glossary
Interface	<p>The functional and physical characteristics required to exist at a common boundary or connection between persons, between systems, or between persons and systems. A system external to the system being analyzed that provides a common boundary or service that is necessary for the other system to perform its mission in a degraded mode, e.g., a system that supplies power, cooling, heating, air services, or input signals.</p>	DAU Glossary
Interface Control Agreement	<p>Describes the relationship between two components of a system in terms of data items and messages passed, protocols observed and the timing and sequencing of events. For example, an ICA may describe the interaction between a user and system, software components and hardware devices or two different software components. Data to meet the needs of the ICA can be extracted from the Interface Control Document and/or the supporting architecture.</p>	DAU Glossary
Interface Requirements Specification (IRS)	<p>1. Documentation that specifies requirements for interfaces between or among systems and components.                  2. A type of Item Performance Specification that defines the required software interfaces for a given Software Item (SI) in the allocated baseline, the requirements for which are described by a Software Requirement Specification (SRS).                  The IRS is frequently combined with the SRS.</p>	DAU Glossary
Interoperability	<p>The ability of systems, units, or forces to provide data, information, materiel, and services to, and accept the same from, other systems, units, or forces,</p>	DAU Glossary

## Glossary

Term	Definition	Source
	<p>and to use the data, information, materiel, and services exchanged to enable them to operate effectively together. Information Technology (IT) interoperability includes both the technical exchange of information and the end-to-end operational effectiveness of that exchange of information as required for mission accomplishment. Interoperability is more than just information exchange. It includes systems, processes, procedures, organizations, and missions over the life cycle and must be balanced with cybersecurity.</p>	
Joint Interface	<p>An Information Technology (IT) interface that passes or is used to pass information between systems and equipment operated by two or more combatant commanders, Services, or agencies.</p>	DAU Glossary
Life Cycle Management	<p>A management process applied throughout the life of a product that bases all programmatic decisions on the anticipated usage and economic benefits derived over the life of the product.</p>	TA-STD-0017, Product Support Analysis
Logistics Product Data	<p>That portion of Product Support Analysis (PSA) documentation consisting of detailed data pertaining to the identification of Product Support resource requirements of a product. See GEIA-STD-0007 for LPD data element definitions.</p>	TA-STD-0017, Product Support Analysis
Machine-readable Format	<p>A format that can be easily processed by a computer without human intervention.</p>	P.L. 116-283 (FY21 NDAA), Sec. 804(f)(3)
Maintainability	<p>The ability of a product to be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources at each prescribed level of maintenance and repair.</p>	TA-STD-0017, Product Support Analysis
Major System Component	<p>(A) a high-level subsystem or assembly, including hardware, software, or an integrated assembly of both, that can be mounted or installed on a major system platform through modular system interfaces; and (B) includes a subsystem or assembly that is likely to have additional capability requirements, is likely to change because of evolving technology or threat, is needed for interoperability, facilitates incremental deployment of capabilities, or is expected to be replaced by another major system component.</p>	10 U.S.C. § 4401(b)(3)
Modular System Interface	<p>(A) a shared boundary between a major system platform and a major system component, between major system components, or between major system platforms, defined by various physical, logical, and</p>	10 U.S.C. § 2446a.(b) (Updated by 10 U.S.C. § 4401 (b)(4))

## Glossary

Term	Definition	Source
	functional characteristics, such as electrical, mechanical, fluidic, optical, radio frequency, data, networking, or software elements; and (B) is characterized clearly in terms of form, function, and the content that flows across the interface in order to enable technological innovation, incremental improvements, integration, and interoperability	
Major System Platform	The highest-level structure of a major weapon system that is not physically mounted or installed onto a higher-level structure and on which a major system component can be physically mounted or installed.	10 U.S.C. § 4401(b)(2)
Mission Engineering	An interdisciplinary process encompassing the entire technical effort to analyze, design, and integrate current and emerging operational needs and capabilities to achieve desired mission outcomes.	OSD Mission Engineering (ME) Guide
Mission Integration Management (MIM)	The management, synchronization, and coordination of concepts, activities, technologies, requirements, programs, and budget plans to guide key decisions focused on the end-to-end mission.	<a href="https://ac.cto.mil/mission-engineering/">https://ac.cto.mil/mission-engineering/</a>
Modular Open Systems Approach	See Section 1.1	10 U.S.C. § 4401.(b) (1)
Modular System	A weapon system or weapon system component that— (A) is able to execute without requiring coincident execution of other specific weapon systems or components; (B) can communicate across component boundaries and through interfaces; and (C) functions as a module that can be separated, recombined, and connected with other weapon systems or weapon system components in order to achieve various effects, missions, or capabilities.	10 U.S.C. § 4401 (b)(5)
Modular System Interface	A shared boundary between major systems, major system components, or modular systems, defined by various physical, logical, and functional characteristics, such as electrical, mechanical, fluidic, optical, radio frequency, data, networking, or software elements.	10 U.S.C. § 4401 (b)(4)
Module	An independently compliable software component made up of one or more procedures or routines or a combination of procedures and routines.	DAU Glossary
Open Architecture	A technical architecture that adopts open standards supporting a modular, loosely coupled and highly cohesive system structure that includes publishing of	DAU Glossary

## Glossary

Term	Definition	Source
	key interfaces within the system and full design disclosure.	
Open Interface	A public standard for connecting hardware to hardware and software to software. With hardware, it implies there is more than one brand of product that can be hooked up to the device with the open interface. With software, it implies that more than one program exists to interface with the application that has the open interface or that a program can be readily written to communicate with it.	OSA Contract Guidebook for Program Managers, v1.1, June 2013
Open Specification	Refers to a set of documented requirements to be satisfied by a material, design, product, or service. In acquisition, it is a type of technical standard. An Open Specification is publicly available and has various rights to use associated with it and may also have various properties of how it was created.	Form and Style of Standards, ASTM Blue Book (PDF). ASTM International. 2012
Open Standards	Widely accepted and supported standards set by recognized standards organizations or the marketplace. These standards support interoperability, portability, and scalability and are equally available to the public at no cost or with a moderate license fee.	DAU Glossary
Open System	A system whose technical architecture adopts open standards and supports a modular, loosely coupled, and highly cohesive system structure. This modular open architecture includes publishing of key interfaces within the system and relevant design disclosure.	DAU Glossary
Open Systems Acquisition of Weapon Systems	An integrated technical and business strategy that defines key interfaces for a system (or a piece of equipment under development) in accordance with those adopted by formal consensus bodies (recognized industry standards' bodies) as specifications and standards, or commonly accepted (de facto) standards (both company proprietary and non-proprietary) if they facilitate use of multiple suppliers.	DAU Glossary
Open Systems Architecture	A characteristic of a system which uses a technical architecture that adopts consensus-based standards supporting a modular, loosely coupled, and highly cohesive system structure that includes the publishing of key interfaces within the system and relevant design disclosure.	DAU Glossary
Program Capability Document	With respect to a major defense acquisition program, a document that specifies capability requirements for	10 U.S.C. § 4401 (b) (6)

## Glossary

Term	Definition	Source
	the program, such as a capability development document or a capability production document.	
Reference Architecture	An authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions	OSD Mission Engineering (ME) Guide
Reference Model	An abstract framework or domain-specific ontology consisting of an interlinked set of clearly defined concepts produced by an expert or body of experts in order to encourage clear communication.	OASIS Reference Model
Standards Viewpoint	Models within the Standards Viewpoint are the set of rules governing the arrangement, interaction, and interdependence of parts or elements of the Architectural Description. These sets of rules can be captured at the enterprise level and applied to each solution, while each solution's architectural description depicts only those rules pertinent to the architecture described. Its purpose is to ensure that a solution satisfies a specified set of operational or capability requirements.	DAU Glossary
Standardization	The process by which members achieve the closest practicable cooperation — the most efficient use of research, development, and production resources — and agree to adopt on the broadest possible basis the use of (1) common or compatible operational, administrative, and logistics procedures; (2) common or compatible technical procedures and criteria; (3) common, compatible, or interchangeable supplies, components, or equipment; and (4) common or compatible doctrine with corresponding organizational compatibility.	TA-STD-0017, Product Support Analysis
Subsystem	A functional grouping of components that combine to perform a major function within an element such as electrical power, attitude control, and propulsion.	DAU Glossary
Supportability	A key component of availability. It includes design, technical support data, and maintenance procedures to facilitate detection, isolation, and timely repair and/or replacement of product anomalies.	TA-STD-0017, Product Support Analysis
Systems	An aggregation of system elements and enabling system elements to achieve a given purpose or provide a needed capability.	DAU Glossary
Systems Engineering Management Plan	Contractor-developed plan for the conduct, management, and control of the integrated engineering effort. It should be consistent with the Government Systems Engineering Plan (SEP) to ensure that Government and contractor technical	DAU Glossary

## Glossary

Term	Definition	Source
	plans are aligned. The SEMP should define the contractor technical planning and how technical work is accomplished from the contractor perspective. It articulates details of the contractor's processes, tools, and organization.	
Systems Engineering Plan	An acquisition program's primary technical planning document to help program managers develop, communicate, and manage the overall systems engineering (SE) approach that guides all technical activities of the program. The SEP documents key technical risks, processes, resources, metrics, systems engineering (SE) products, organizations, design considerations, and completed and scheduled SE activities. It serves as the blueprint for the integration and management of technical processes and design development in order to define and balance system performance, cost, schedule, risk, and security within the program and throughout its life cycle. The SEP is a living document in which SE planning should be kept current and fidelity should evolve as the program progresses through each acquisition phase.	DAU Glossary
Technical Data	Recorded information, regardless of the form or method of the recording, of a scientific or technical nature (including computer software documentation). The term does not include computer software or financial, administrative, cost or pricing, or management information, or information incidental to contract administration.	DFARS 252.227-7013
Technical Data Package	The authoritative technical description of an item. This technical description supports the acquisition, production, inspection, engineering, and logistics support of the item. The description defines the required design configuration and/or performance requirements, and procedures required to ensure adequacy of item performance. It consists of applicable technical data such as models, engineering design data, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.	MIL-STD 31000

**Acronyms**

API	Application Programming Interface
AS/AP	Acquisition Strategy/Plan
ASSIST	Acquisition Streamlining and Standardization Information System
C4	Command, Control, Communication, Computers
C5	Command, Control, Communication, Computers, Cyber
C5ISR/EW	Command, Control, Computers Communication, Computers, Cyber Intelligence, Surveillance, and Reconnaissance and Electronic Warfare
CAC	Common Access Card
CDD	Capability Development Document
CDRL	Contract Data Requirements List
CI/CD	Continuous Integration/Continuous Delivery
COTS	Commercial Off-the Shelf
CSCI	Computer Software Configuration Item
CWBS	Contractor Work Breakdown Structure
DAS	Defense Acquisition System
DID	Data Item Description
DAU	Defense Acquisition University
DFARS	Defense Federation Acquisition Regulation Supplement
DevSecOps	Development Security Operations
DRFP	Draft Request for Proposal
DE	Digital Engineering
DISR	Defense Information Technology Standards Registry
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoD	Department of Defense
DO	Domain Overlay
DSC	Defense Standardization Council
DSPO	Defense Standardization Program Office
FAA	Federal Aviation Administration

## Acronyms

FACE	Future Airborne Capability Environment
FAR	Federal Acquisition Regulation
FIPS	Federal Information Processing Standard
FY	Fiscal Year
GFE	Government Furnished Equipment
GAO	Government Accountability Office
GRA	Government Reference Architecture
HWCI	Hardware Configuration Item
ICD	Initial Capabilities Document
ICD	Interface Control Document
IDD	Interface Design Description
IDL	Interface Definition Language
IP	Intellectual Property
IRS	Interface Requirements Specifications
ISR	Intelligence, Surveillance and Reconnaissance
ITAR	International Traffic in Arms Regulations
MAUT	Multi-Attribute Utility Theory
MDAP	Major Defense Acquisition Program
MIL-STD	Military Standard
MMO	MOSA Management Office
MOA	Memorandum of Agreement
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOSA	Modular Open Systems Approach
MOSS	Modular and Open Standards and Specifications
MOSWG	Modular Open Systems Working Group
NDAA	National Defense Authorization Act
NDIA	National Defense Industrial Association
NII	Networks & Information Integration

## Acronyms

OASD	Office of the Assistant Secretary of Defense
OEM	Original Equipment Manufacturer
OMS	Open Mission System
OPSEC	Operations Security
OSA	Open Systems Architecture
OUSD(A&S)	Office of the Under Secretary of Defense for Acquisition and Sustainment
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
PEO	Program Executive Office
PSS	Product Support Strategy
RFI	Request for Information
RFP	Request for Proposal
S/SS	System/Subsystem Specification
SEP	Systems Engineering Plan
SRS	Software Requirements Specifications
STD	Standard
TSWG	Technical Standards Working Group
U.S.	United States
U.S.G.	United States Government
UCI	Universal Command and Control Interface
UCS	Unified Command Suite
UML	United Modeling Language
U.S.C.	United States Code
VICTORY	Vehicle Integration for Command, Control, Computers Communication, and Computers, Cyber Intelligence, Surveillance, and Reconnaissance and Electronic Warfare Interoperability
WBS	Work Breakdown Structure

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