# OUSD(R&E) MOSA Assessment Criteria

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## Background

For several years, the Department of Defense (DoD) has defined five Modular Open Systems Approach (MOSA) Pillars (Enabling MOSA Tiger Team 2021), or tenets, to guide the use of MOSA in defense acquisition programs:

1. Establish Enabling Environment
2. Employ Modular Design
3. Designate Key Interfaces
4. Select Open Standards
5. Certify Conformance

The Services and programs have used the pillars to develop various tools, methods, and assessment approaches. Services or programs might share applicable strategies, but none have been required or standardized across the Department.

The National Defense Authorization Act (NDAA) of FY 2020 codified the use of MOSA by requiring the DoD to incorporate MOSA into programs and to assess MOSA compliance. As the Department continues to progress in using MOSA, it seeks greater fidelity in how to assess approaches on specific programs.

At an April 2021 meeting of the OUSD(R&E) Modular Open Systems Working Group (MOSWG) Steering Group, the Assessing MOSA Tiger Team reported that although it had identified general criteria for assessing the effectiveness of MOSA compliance, it had not agreed on specific criteria that would be applicable across all Service and program types.

To guide the next steps in refining MOSA assessment criteria, the Steering Group considered four options:

- Option 1. Continue Status Quo (Services use varying guidance they develop or adopt).
- Option 2. Select one Service methodology, tool, or set of criteria to be the standard for all Services to use.

- Option 3. Each Service provide OUSD(R&E) with a set of assessment criteria and scoring methodology; OUSD(R&E) develop a consensus from those inputs.
- Option 4. The Assessing MOSA Tiger Team use the five MOSA Pillars to map and define broad categories of criteria from law, policy, or current practice. Each Service then develop detailed quantitative or qualitative criteria within the categories (with scoring scales) tailorable to specific program(s).

The Steering Group chose Option 4 and recommended the Assessing MOSA Tiger Team focus its efforts on this option. The team coordinated with the OUSD(R&E) Enabling MOSA Tiger Team to refine the specific assessment criteria. This paper provides the results and invites the community to comment and to consider candidate programs to serve as pilots for a proof of concept to test the assessment criteria.

## Definition of MOSA Pillars

Following are the established characteristics of the MOSA Pillars:

### 1. Establish Enabling Environment

- Integration of Development and Operations
- Phased Technology Insertion by Module
- Cloud Data Sharing

This pillar establishes requirements, business practices, development, acquisition, test and evaluation, and strategies that support MOSA. It includes six sub-elements:

1. *Establish MOSA goals.* Expands capabilities and interoperability by establishing MOSA life cycle costs and continuous development, release, monitoring, and performance goals.
2. *Adopt MOSA.* Transforms requirements; business, management, technical, and acquisition practices; estimation and end user engagement strategies; contracts, data, licenses, and property rights; plans; and other key areas to align with MOSA principles.
3. *Include MOSA in contracts and data rights planning.* Considers a MOSA and an Open Systems Architecture (OSA) in contracts and data rights planning to reduce costs while balancing risk and ensuring proper government data rights.
4. *Embrace agile development culture.* Plans for and implements an agile development methodology, and continuously deploys functionality in frequent, small releases based on sponsor and end user feedback.

5. *Embrace automation.* Plans to use an automated development and testing pipeline, enabling Continuous Integration/Continuous Delivery (CI/CD) and continuous operations.
6. *Structure the organization for openness and modularity.* Follows Conway's Law (Conway 1968), which states that "Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization's communication structure."

## 2. Employ Modular Design

- Cohesive, Encapsulated, Self-Contained, Highly Binned

This pillar isolates functionality during the design process to simplify development, maintenance, changes, and upgrades. Developers who design modular systems have the ability to upgrade or change functions rapidly, with limited or no impact to the rest of the system. The pillar includes five sub-functions:

1. *The design separates components into scalable, reusable modules consisting of self-contained functional elements.* It horizontally scales instances of the same component without interrupting user sessions, losing data, or needing to restart other services.
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 are 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 software module into any environment, knowing it consists of the same code everywhere.
5. *Modules 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.

## 3. Designate Key Interfaces

- Published Key Interfaces

This pillar calls for decoupling the interface and service implementation of components so they can follow separate life cycles. To decouple the inner workings of components but retain the capability provided by each, developers expose openly available key interfaces to other components. Subfactors may include but are not limited to the following:

- *Document and ensure version control of the interfaces.* Make the interfaces available to others.
- *Use well-understood interfaces.* Do not reinvent the wheel, but use the right interface for each service.
- *Do not allow new interface versions to break previous versions.* A change to one component should not require changes to all other components; new interfaces should be backward compatible.

## 4. Select Open Standards

- Well Defined, Mature, Widely Used, Readily Available

Open standards allow developers to use commercially developed technologies, increasing competition. In addition, they offer faster upgrades at reduced cost and complexity. Fielded systems are more affordable and maintainable. This pillar includes five elements:

1. *Prioritize open standards published by internationally recognized groups.*
2. *Expose software and data services via Application Programming Interfaces (APIs), while simultaneously protecting and controlling those services.*
3. *Use open licenses without restrictions and without requirements that could place the government in legal risk.*
4. *Choose secure interfaces that use open encryption ciphers certified to Federal Information Processing Standard (FIPS) 140-2 cryptographic standards.*
5. *Ensure standards align with the DoD Information Technology Standards Registry (DISR).*

## 5. Certify Conformance

- Published Conformance Criteria
- Automatic Testing and Certification

Developers need to verify and validate MOSA strategy and requirements, ensuring conformance to selected internal and external open interface standards. Checklists can aid developers with this verification. The pillar includes the following factor:

- *Develop relevant MOSA Measures of Effectiveness (MOEs) and Measures of Performance (MOPs)* to enable tracking the effectiveness of the MOSA strategy in supporting program success.

## Identifying MOSA Criteria Categories

To develop broad categories of assessment criteria, the tiger teams examined current law, policy, standards, and other sources.

### Criteria in Law and Policy

Law and DoD policy (see References) include the following recurring ideas that serve as criteria for compliance in a MOSA program:

- Establishes an enabling environment
- Employs a modular design that uses major system interfaces
- Is subjected to verification to ensure major system interfaces comply with, if available and suitable, widely supported and consensus-based standards
- Uses a system architecture that allows severable major system components at the appropriate level to be incrementally added, removed, or replaced throughout the life cycle of a major system platform to afford opportunities for enhanced competition and innovation while yielding significant cost savings or avoidance; schedule reduction
- Allows opportunity for technical upgrades
- Provides for increased interoperability, including system of systems interoperability and mission integration
- Complies with technical data rights.
- Demonstrates technology maturity
- Incorporates user requirements that respond to identified threats
- Demonstrates supportability
- Allows for rapid acquisition using evolutionary approaches
- Uses an open systems designs
- Promotes effective competition

### Criteria in MOSA Standards

MOSA standards (see References) note the following characteristics that could serve as criteria for compliance in a MOSA program:

- Participation from the entire community (Government/industry), guided by openness and fairness to all parties
- Sound, reliable, and efficient open technologies

- Conformance
- Mature technology
- User requirements that respond to identified threats
- Layered, holistic architectures
- Standard characterization
- Architecture characterization
- Service and functionality
- Data model characterization
- Configuration management
- Decision analysis
- Design
- Manufacturing
- Project planning
- Requirements
- Risk management
- Transition, fielding, and sustainment
- Technology management and control
- Verification and validation
- Reconfigurability
- Portability
- Maintainability
- Technology insertion
- Vendor independence
- Reusability
- Scalability
- Interoperability
- Upgradeability
- Long-term supportability
- Extensibility

- Composability

## Criteria in Other Sources

The MOSA Metrics Sub-Committee of the National Defense Industrial Association (NDIA) Systems Engineering Division's Architecture Committee developed a process (MOSWG Feb 9, 2022) to identify MOSA metric criteria. They mapped the MOSA Pillars (Tenets) to the following five benefits (Figure 1):

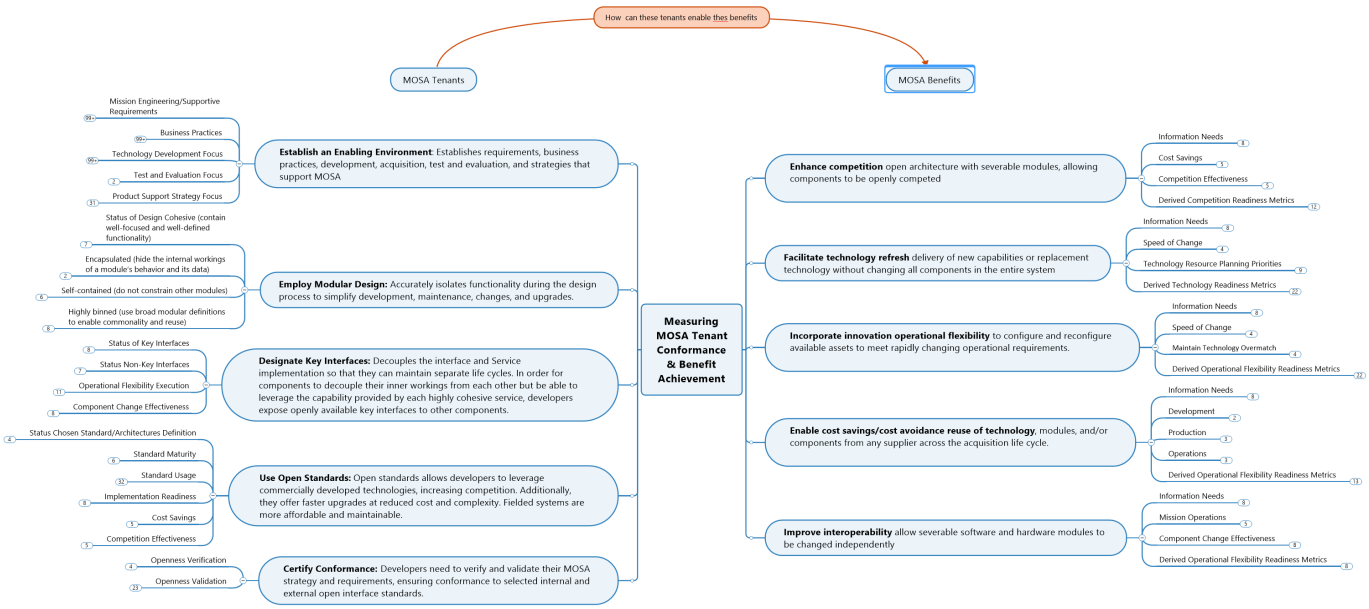


**Figure 1: Mapping MOSA Pillars to MOSA Benefit**

1. Enhance competition by employing open architectures with severable modules, allowing architectural functions / system components to be openly competed.
2. Facilitate technology refresh by enabling delivery of new capabilities or replacement technology without changing all components in the entire system.
3. Incorporate innovation by ensuring operational flexibility to configure and reconfigure available assets to meet rapidly changing operational requirements.
4. Enable cost savings/cost avoidance through reuse of technology, modules, or components from any qualified supplier across the acquisition life cycle.
5. Improve interoperability by allowing severable software and hardware modules to be changed independently

## Recommended Criteria

Upon examining the sources and pillars, the tiger teams recommend the following criteria for assessing MOSA compliance. The approach requires the reviewer to include all the pillars in an assessment. Criteria should be evaluated on a 0-5 scale to allow a quantitative scoring and life-cycle measurement in which 0 represents no/minimal capability and 5 represents total/maximum capability for that criterion.

As an Example:

*Establishing Enabling Environment: To What Extent are MOSA requirements documented?*

0 – No documentation supporting MOSA requirements

1 – Minimal documentation. Approximately 10% of complete MOSA required documents

2 – 25% complete

3 – 50% complete

4 – 75% complete

5 – Complete set of MOSA required documents

The following example criteria are not exhaustive. Services are encouraged to develop criteria that are appropriate for their Service and program(s) but must ensure the criteria are incorporated into the appropriate pillar. Services may consider the NDIA MOSA Metrics Sub-Committee process for ideas (MOSWG Feb 9, 2022).

### Establish Enabling Environment

- To what extent does the program document MOSA requirements?
- What are the MOSA life-cycle costs and performance goals?
- Is MOSA included in sustainment planning?
- To what extent is MOSA integrated into contracts and data rights strategy?
- To what extent does the program employ agile development?
- Do Analysis of Alternatives plans consider evolutionary acquisition, prototyping, and MOSA?
- To what extent is the system's architecture (including data, hardware and software) capable of adapting to evolving requirements and leveraging new technologies?

## Employ Modular Design

- Are components separated into scalable, reusable modules consisting of self-contained functional elements?
- To what extent does the system's architecture exhibit modular design characteristics?
- Does the architecture provide failure isolation?
- To what extent can system components be substituted with similar components from competitive sources?
- Does the system architecture allow severable major system components at the appropriate level to be incrementally added, removed, or replaced throughout the life cycle of a major system?
- Are key components identified and good candidates separately procurable?
- Are all parts of each key component necessary to implement the component?
- Does the component contain only related parts?
- Does each key component model the important aspects of a single relevant concept in the application domain, user interface, or technological domain?
- Are data products exchanged between key components well documented, based on standard data models including syntactic and semantic specifications?
- Are key components well documented with respect to functionality and behavior?
- Can key components be treated as black boxes in that they hide the internal implementations of their functionality and behavior behind well-documented key interfaces?
- Can key components be replaced without modification to the component's interface and data product specifications?

## Designate Key Interfaces

- Are key interfaces openly available to other components?
- To what extent has the criteria for designating key interfaces been established?
- To what extent has the program designated key interfaces?
- To what extent has the program assessed the feasibility of using open standards for key interfaces?
- Do key interfaces conform to open and accessible standard interfaces and have been verified?

- To what extent do system components and selected commercial products conform to standards selected for system interfaces?
- To what extent are new interface versions backward compatible?
- Are key interfaces fully documented to decrease ambiguity and ensure they meet their associated open and accessible interface standards (syntactically and semantically)?
- Are key interfaces defined and well-documented via interface standards?
- Do the interface standards specify the syntactic and semantic aspects of the interface?
- Do the interface standards expose the functional and behavioral aspects of the interface but avoid exposing unnecessary implementation details?
- To what extent is proprietary information protected?
- Are key components built in accordance with appropriate interface standards, and are they confirmed through verification?
- Are data products communicated between key components through defined and well-documented key interfaces?

### Select Open Standards

- Does the system use open licenses without restrictions and without requirements?
- Do open standards align with intellectual property and data rights strategy?
- To what extent have standards selection criteria been established that give preference to open interface standards?
- To what extent are open standards selected for key interfaces?
- Are data message contents defined using a standardized interface/data definition language (e.g. IDL or XML schemas) and message data models (e.g. UCS)? Are these definitions accessible and open to the community of interest?
- To what extent are open and accessible standards used for specification of reusable key components? Do the reusable key components include executable models (e.g., Unified Modeling Language (UML), Architecture Analysis and Design Language (AADL), etc.), documentation, training material, test procedures, etc.?

### Certify Conformance

- To what extent are MOSA standards and requirements verified and validated?
- What is the program's level of MOSA compliance?
- How well are the MOSA goals for the program being reached?

- 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 will 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 tradeoffs among multiple objectives. Many MOSA models/tools used by the services today utilize this process to provide a *quantitative* MOSA evaluation of their program(s). Although several COTS tools are available to conduct MAUT, a simple Excel spread sheet is often the preferred tool.

Figure 2 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.

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.

| Program *X* MOSA Evaluation | | | | | |
|---|---|---|---|---|---|
| **Criteria** | **Pillar Weight** | **Score (0-5)** | **Weighted Score** | **Justification for Score** | **Comments** |
| **Establish Enabling Environment** | 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 | | |
| **Weighted Pillar Score** | | | 2.80 | | |
| **Employ Modular Design** | 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 | | |
| **Weighted Pillar Score** | | | 2.40 | | |
| **Designate Key Interfaces** | 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 | | |
| **Weighted Pillar Score** | | | 3.00 | | |
| **Select Open Standards** | 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 | | |
| **Weighted Pillar Score** | | | 1.20 | | |
| **Certify Conformance** | 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 | | |
| **Weighted Pillar Score** | | | 2.20 | | |
| Overall Score for Program X (Sum of Weighted Pillar Scores) | | | 11.60 | | |
| Maximum Score Achievable | | | 15.00 | | |
| Percent MOSA Achieved | | | 0.77 | | |

**Figure 2: Example MOSA Quantitative Process**

## Acronyms

| | |
|---|---|
| AADL | Architecture Analysis and Design Language |
| API | Application Programming Interface |
| CI/CD | Continuous Integration/Continuous Delivery |
| DAS | Defense Acquisition System |
| DISR | Defense Information Technology Standards Registry |
| FIPS | Federal Information Processing Standard |
| MAUT | Multi-Attribute Utility Theory |
| MOE | Measure of Effectiveness |
| MOP | Measure of Performance |
| MOSA | Modular Open Systems Approach |
| MOSWG | Modular Open Systems Working Group |
| NDAA | National Defense Authorization Act |
| NDIA | National Defense Industrial Association |
| OSA | Open Systems Architecture |
| OUSD(R&E) | Office of the Under Secretary of Defense for Research and Engineering |
| SE | Systems Engineering |
| UML | Unified Modeling Language |

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