MOSA Implementation Considerations, Information Needs and Metrics

National Defense Industrial Association

Systems Engineering Division, Architecture Committee

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1.0 Introduction:

Modular Open Systems Approach (MOSA) is one of the key elements of the Department of Defense Systems Engineering Modernization effort. The SE Modernization project has three primary goals: 1) build an integrating framework that incorporates key activities across these domains and focus areas; 2) align and integrate these systems engineering practices to specific acquisition pathways; and 3) develop a set of artifacts and associated meta-data for a categorization and information framework that captures policy, guidance, and lessons learned into a body of knowledge. Figure 1 highlights the systems modernization objectives.

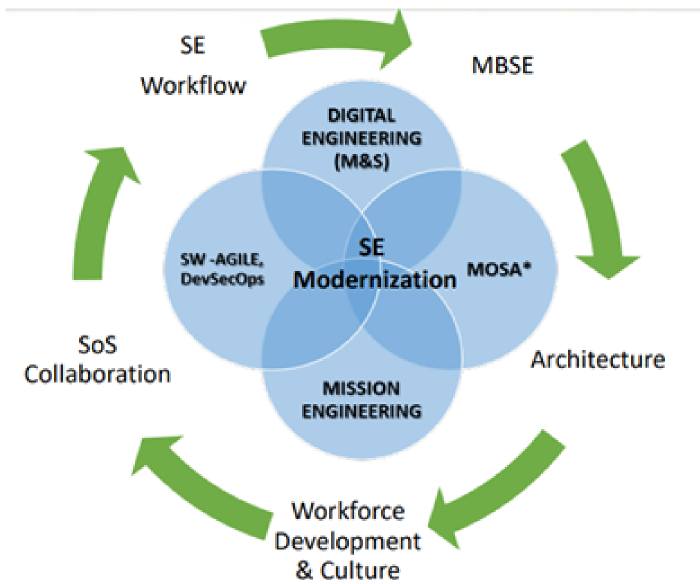


Figure 1 - SE Modernization, [OUSDR&E Graphic]

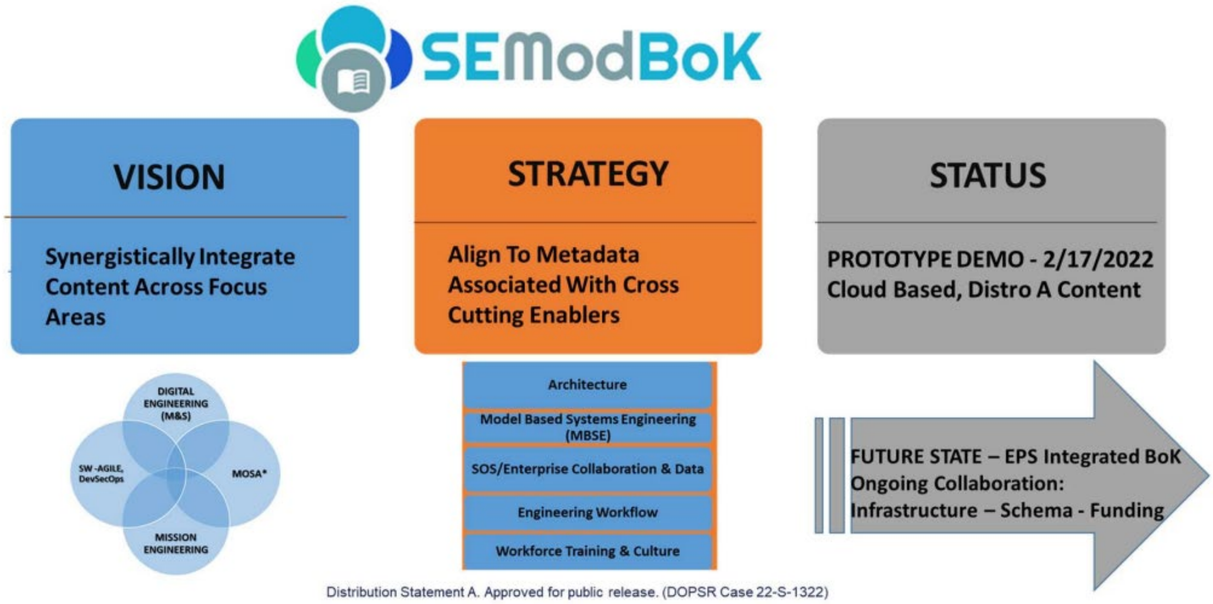


Figure 2 - SEModBok vision and strategy (sponsor diagram) [OUSDR&E Graphic]

The process is cyclic in nature and follows the core systems engineering principles and processes. It provides flexible life cycle entry points. The digital engineering provides an authoritative source of truth and facilitates communication. Continuous iterative development provides the agility need to meet rapidly changing requirements and threats. MOSA attributes and tenants provide the foundational elements of open architectures and standard based interfaces that enable rapid change and the ability to achieve cost savings through reuse and competition.

Every program should have a tailored Modular Open System Approach to address specific objectives of their program. The MOSA approach should be balanced with enterprise/product line level MOSA efforts. This includes the use of open standards, commonality, reference architecture, enterprise services, and adherence to DoD and Service implementation guidance. The requirement on MOSA and associated intellectual property/data rights on DoD programs is law. Figure 3 summarizes the statutory MOSA and data rights requirements.

- 10 USC 3771: Rights in technical data: regulations
- 10 USC 3772: Rights in technical data: provisions required in contracts
- 10 USC 3773: Domestic business concerns: programs for replenishment parts
- 10 USC 3774: Major weapon systems and subsystems: long-term technical data needs
- 10 USC 3775: Definitions
- 10 USC 4401: Requirement for **modular open system approach** in major defense acquisition programs
- 10 USC 4402: Requirement to address modular open system approach in **program capabilities development and acquisition weapon system design**;
- 10 USC 4403: Requirements relating to **availability of major system interfaces and support** for modular open system approach definitions

DoD MOSA Requirement Cliff Notes

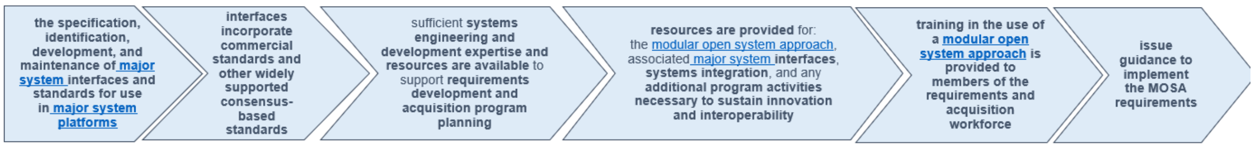


Figure 3 - DoD Modular Open Systems Approach (MOSA) Statutory Requirements

MOSA is an integrated technical and business approach. To achieve the desired MOSA benefits, acquirers and suppliers must collaboratively apply mature systems engineering processes and MOSA principals to the alternative solutions that satisfy both the mission and MOSA requirements. Digital engineering provides an “Authoritative Source of Truth” that maintains the system baselines, supports ongoing operations and support, and rapid evolution of the solution to meet changing threats. Figure 4, highlights the MOSA enablers required to successfully deliver MOSA benefits to the Acquires/Supplier and User.

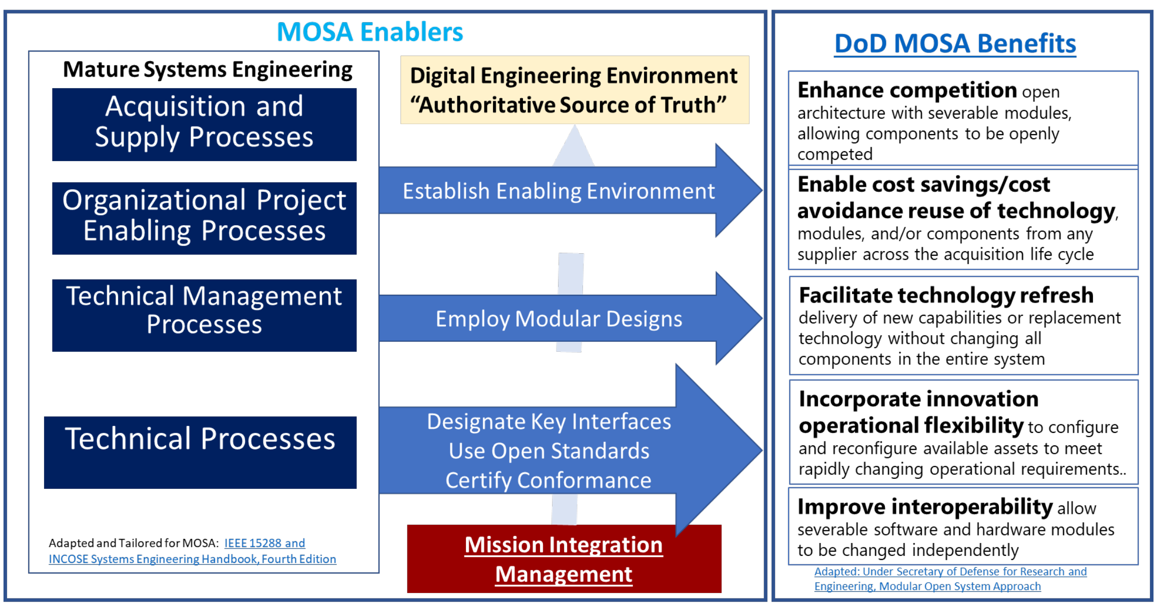


Figure 4 – How Do We Achieve MOSA Success?

IEEE 15288 provides a framework and approach to effectively integrate the Acquires/Suppliers business and technical approach to meet the users mission needs while achieving MOSA benefits. The use or tailored IEEE 15288 Systems and Software Engineering Agreement, Organizational Project Enabling, Technical Management, and Technical Process can greatly facilitate this effort. The IEEE 15288 Measurement Process provides guidance on how collect, analyses, and report objective data and information to support effective management and MOSA information needs and decision about the products, services, and processes. The project assessment and control process are used to evaluate projected cost, schedule, performance, and the impact of undesirable outcomes on the organization and MOSA implementation during execution. Appendix A is a master list of potential MOSA metrics, with definitions and example MOSA usage, of that can be used to assess MOSA implementation progress and achievement objectives. Appendix B maps potential MOSA information needs and metrics to each of the IEEE 15288 processes.

Figure 5 outlines a seven-step process highlighting MOSA implementation considerations, information needs, and metrics. Figure 5, Steps 1-3 reflect key pre-award or pre-contract change information needs for the Acquirer and User that define the program mission and MOSA requirements. Each step in Figure 5 identifies the key question that needs to be answered during implementation of the MOSA based Mission solution. Step 4 reflects Acquirer and Supplier planning; acquisition and intellectual property strategy needed to acquire and deliver mission capability and MOSA benefits. It is critical to successful MOSA implementation that acquirers understand the constraints, opportunities, and risks of industry contractors and suppliers implementing MOSA. 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 re-use 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. Both government and industry benefit when modularity decisions derived by the government align to industry PLAs. This modularity alignment, where supply is adequately balanced for meeting expected demand, involves strategic business decisions by each party for mutually beneficial outcomes.

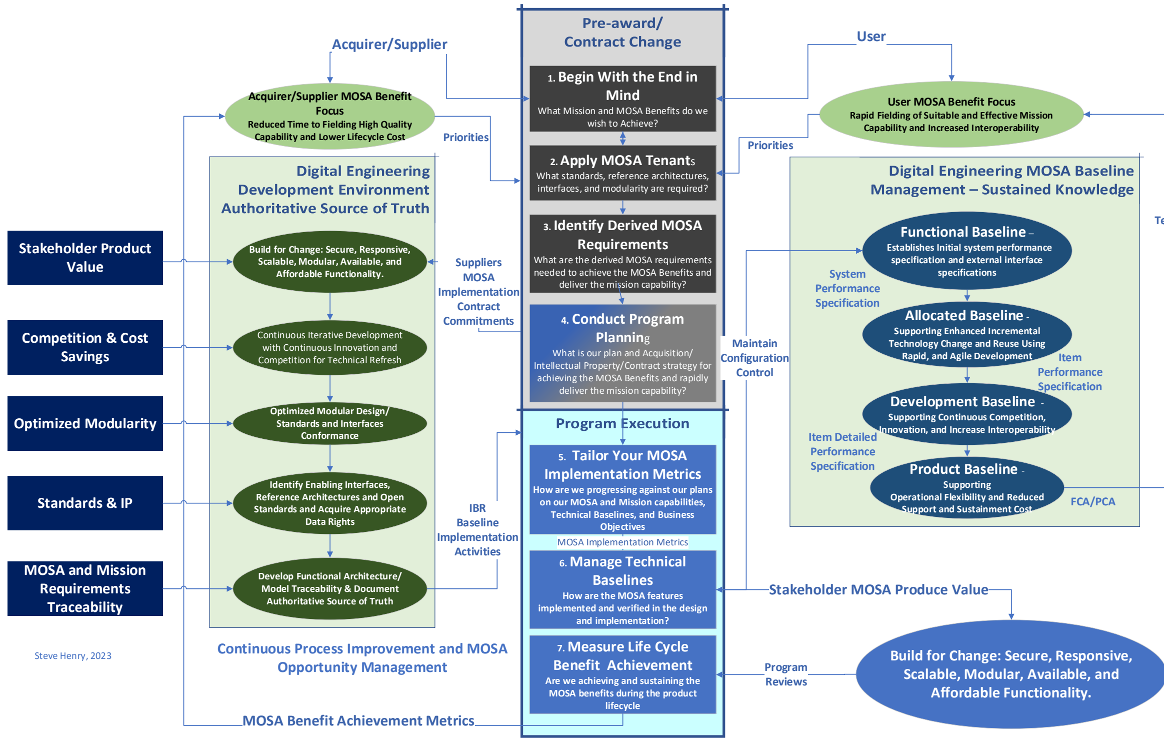


Figure 5 – Effective MOSA Implementations – What Gets Measured and Acted Upon Gets Done

The award of new contract or contract change order on existing program, at the end of Step 4, marks a transition from planning to program execution. Steps 5-7 must be executed with a common Acquirer and Supplier view of MOSA implementation plan and objectives. A winning Supplier proposal should reflect a low-risk approach for MOSA implementation and metrics for measuring implementation progress and achievement of MOSA objectives. Key technical MOSA risk assessment considerations include integration, manufacturing, and reuse readiness levels. Cost and schedule risk assessments provide insight into the affordability and feasibility of the MOSA implementation plans.

In program execution the Supplier and Acquirer implement the MOSA implementation plan. The Integrated Baseline Review (IBR) confirms the contract Program Management (PMB) Baseline and MOSA Implementation Plan covers the entire technical scope of the work, the work is scheduled realistically and accurately, the reducible and irreducible risks are reviewed, and the proper amount and mix of resources have been assigned to accomplish all contractual requirements. Both the mission and MOSA requirements are implemented, documented, and sustained in program technical baselines. During execution MOSA metrics should be included in program and technical reviews and focus on two areas:

- **Are we achieving and sustaining the desired MOSA benefit(s)?**
- **How are we progressing on the processes and efforts required to implement and field the mission capabilities and derived MOSA requirements?**

2.0 MOSA Seven Step Information Needs:

Mission engineering, mature systems engineering processes, and a digital engineering "Authoritative Source of Truth" are foundational elements of a successful MOSA implementation. IEEE 15288 Systems and software engineering — System life cycle processes and IEEE 15288.2, IEEE Standard for Technical Reviews and Audits on Defense Programs provide best practices planning and executing MOSA implementations. The MOSA and mission requirements reflect a backlog that must be burned down during program execution. To measure mission and MOSA implementation and program success, the program should develop and track metrics to control processes, measure against goals and objectives, and make decisions. More importantly, the metrics should be acted upon when they identify issues, risks, and deviations from plans. Metrics should be tracked and owned at the program, functional, and IPT levels to provide the information they need to do their job. There should be a minimum core set of metrics, but some teams may need more. In all cases the metrics should focus on the following:

- **Focus on Your Goal and Desired Benefit(s)**
- **Obtain Delivery Velocity/Meet Commitments**
- **Ensure Quality**
- **Enable Insight**

2.1 Pre-Award/Contract Change Activity

2.1.1 Step 1: Begin with The End MOSA Objective in Mind

What Mission and MOSA benefits do we wish to achieve?

The process begins with defining the mission need. Mission needs drive the solution and they provide opportunities to achieve MOSA benefits in the implementing the preferred solution. Early business and mission analysis, portfolio management, and market research are key to developing effective modular open system approaches and acquisition strategies. The Business and Mission Analysis process defines the overall strategic problem or opportunity, characterizes the solution space and determines potential solutions that can address the mission needs and MOSSA objectives. Step 1 process should be followed for both new and legacy program MOSA implementations. Key information needs include:

- High-level description of the preferred materiel solution(s) is available and sufficiently detailed and understood to enable further technical analysis.
- System of Systems (SoS) interfaces and external dependencies are adequately defined.
- System and MOSA objectives/requirements are sufficiently documented and understood to enable system functional definition.
- Draft system specification has sufficiently achievable mission and MOSA requirements to allow for design trade space.
- Relationship between draft system specification, competitive prototyping objectives, and MOSA objectives is established
- Initial producibility assessments of preferred system concept(s) indicate acceptable technology, integration, and producibility maturity levels.

Mission Engineering, Market Research, and the first two processes in the IEEE 15288 process flow, Business and Mission Analysis and Stakeholder Analysis are the key to defining the mission and MOSA objectives. Figure 6, illustrated the process relationships.

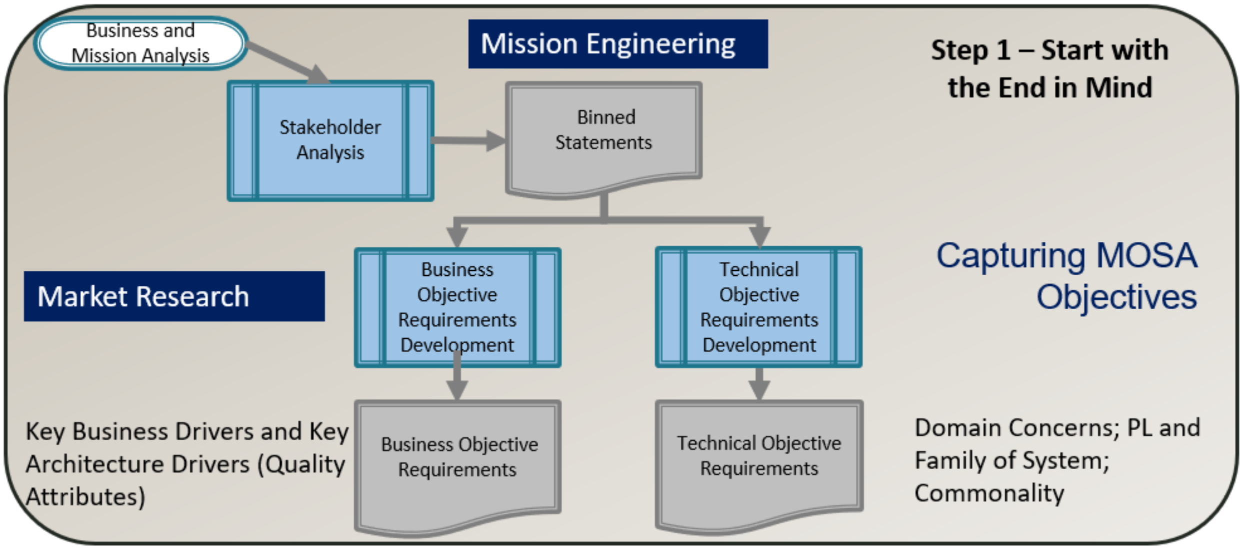


Figure 6 Effectively Defining MOSA Objectives and Requirements

2.1.1.1 Step 1 MOSA Information Needs/Outputs:

The business or mission analysis process defines the overall strategic problem characterizes the solution space, and determine potential solution class(es) that can address a problem or take advantage of a mission or MOSA opportunity. In Step 1 the business and mission analysis process is initiated. Key first outputs of the analysis and step 1 activities include:

- The problem or mission/MOSA opportunity space is defined
- The solution space and MOSA strategies are characterized.
  - The solution space characterization often invokes the system definition process for a user architecture resulting in architecture views that will capture the MOSA implementation principals
  - MOSA life-cycle costs and performance goals are defined
  - The extent is the system's architecture (including data, hardware and software) capable of adapting to evolving requirements and leveraging new technologies is assessed.
- Preliminary operational/support concepts and other MOSA concepts in the life cycle stages are defined
- Alternative solution classes are analyzed and prioritized against other business and capability needs
- The digital engineering authoritative source of truth is established

2.1.2 Step 2: Apply MOSA Tenants to Define the Required Standards, Interfaces, and Modularity

What standards, reference architectures, interfaces, and modularity are required to achieve the mission and MOSA benefit objectives?

When defining the solution space, the program must identify the standards, interfaces, and reference architectures to be use in the MOSA solution. DoD, Services, and Product capability portfolios have enterprise architectures that decomposes mission capability into functional boundaries for products/components and defines the interfaces between those functional boundaries. The functional boundaries and are defined in product interface specifications with reference standards and reference architectures. The level of modularity should be chosen to support the operational and support CONOPS and MOSA competition strategy for initial procurement and continued competition during technical refresh. Compliance with the standards, interfaces, and the appropriate level of modularity can enable significant savings through reuse and continuous competition. The modularity, key interfaces and standards required to provide the desired MSOA Product Value are baselined as system requirements in step 2. Figure 7 highlight the systems engineering process flow that supports this effort.

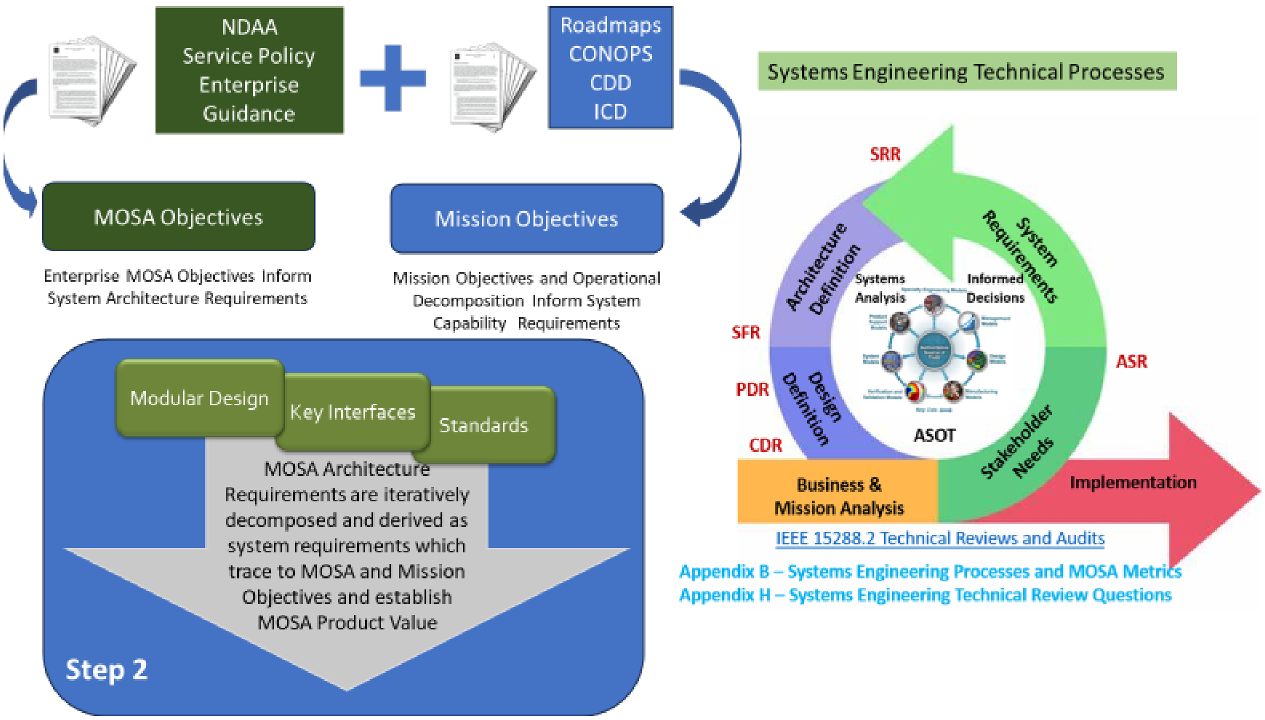


Figure 7 MOSA System Level Requirements

2.1.2.1 Step 2 MOSA Information Needs/Outputs:

Key outputs of the analysis and step 2 activities include:

- Each alternative solution class is assessed against defined criteria that are established by the organization's technical, MOSA, and intellectual property strategy.
    - 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
- Feasibility of the solution class, implementation risks and its capability to meet strategic needs and MOSA objectives/requirements are key decision criteria.
    - The IEEE 15288 portfolio management process provides and the MOSA Product Value specification provide criteria for consideration.
    - Reuse candidate implementation risks should be assessed against technology, integration, reuse and manufacturing readiness level maturity

    - Solution conformance to required standards, reference architectures, and interfaces
- MOSA Product Value is established (See Appendix C for detailed metrics and discussions)
    - Optimized Modularity
    - Functionality
    - Performance
    - Dependability
    - Security
    - Business Value
- The preferred modular alternative solution class(es) and MOSA strategy are selected
- Enabling systems or services needed for business or mission analysis are available
- Traceability of strategic problems and MOSA statutory requirements and opportunities and the preferred alternative solution classes is established.

2.1.3 Step 3: Identify Derived MOSA Implementation Requirements

What are the derived MOSA requirements needed to achieve the MOSA Benefits and deliver the mission capability?

The IEEE 15288 Stakeholder Needs and Requirements Definition process defines the mission and MOSA stakeholder needs and requirements for a system ilities needed by users and other stakeholders in a defined environment of the system lifecycle. This analysis transforms the needs to a common set of stakeholder requirements that express the intended interactions the system will have in the operational environment, required modularity to support product roadmap for competition and technical refresh, and measures of success that will be used to validate achievement. The process iteratively defines, derives, and refines the functional performance, interfaces, and standards needed to implement the desired solution. The requirements should address the statutory, DoD, and Service MOSA requirements.

2.1.3.1 Step 3 MOSA Information Needs/Outputs:

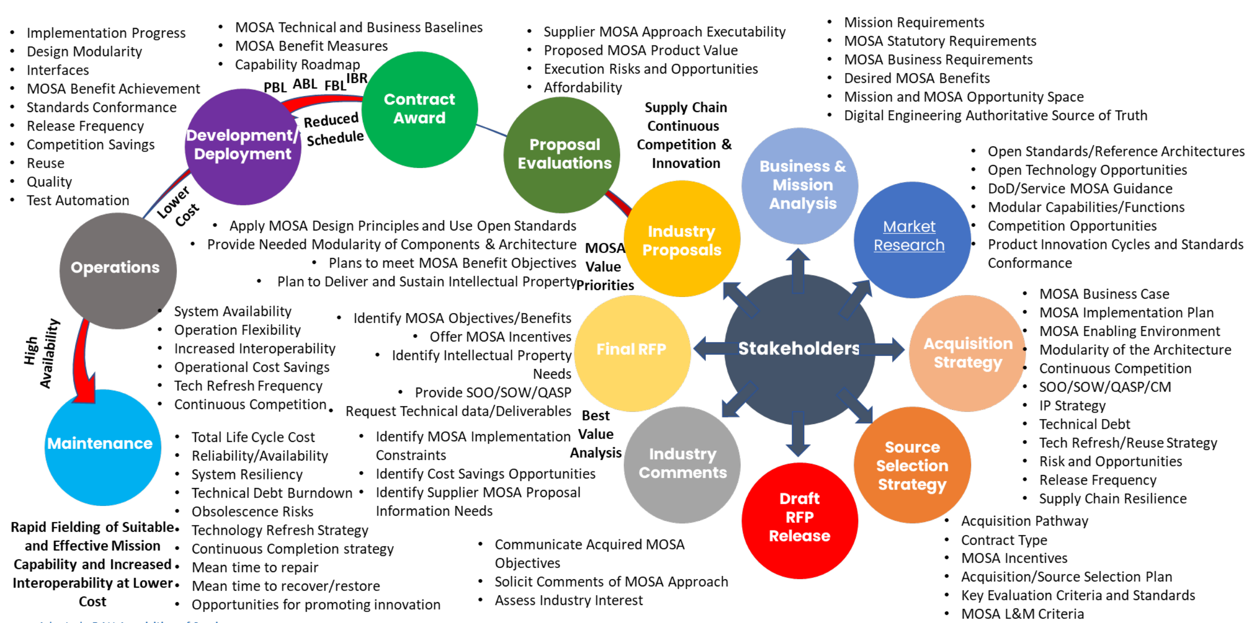
- Stakeholders of the system and interfacing SoS systems are identified
    - System interoperability and data exchanges are identified
- Required modular design characteristics, context of use of capabilities, operational/support concepts, and other life cycle concepts are defined
    - Acquisition path is chosen
    - Enhanced competition strategy defined
    - Technical refresh strategy defined
    - Commonality and component reuse to improve interoperability and reduce cost/schedule
- Constraints and risks on the system MOSA implementation are identified
    - Technical Debt is identified
    - Intellectual Property needs or backlog
    - Available budget
    - Development and deployment timelines
- Stakeholder mission and MOSA technical and business needs are defined
    - Level of modularity required to support enhanced competition, technical refresh, and operational flexibility and support concepts
    - Required standards, interfaces, and reference architectures
- Prioritized stakeholder needs and MOSA objectives are transformed into stakeholder requirements

- Critical mission performance, MOSA success measures and quality characteristics are defined
- Stakeholder agreement that their needs and expectations are reflected adequately in the requirements is achieved;
- Enabling systems or services needed for stakeholder needs, requirements, and MOSA business strategy are available
- Traceability of stakeholder mission and MOSA requirements to stakeholders and their needs is established.
- The MOSA and Mission requirements should reflect the following characteristics:
  - Complete
  - Consistent
  - Feasible/Affordable
  - Bounded
  - Verifiable

2.1 4. Step 4 - Conduct Program Planning - Information Needs and Metrics

What is our plan and Acquisition/ Intellectual Property/Contract strategy for achieving the MOSA benefits and rapidly deliver the mission capability?

MOSA is an integrated business and technical strategy. Figure 6 is a high-level view the steps for implementing a MOSA enhanced competition acquisition strategy. For new programs and replacements for retiring systems should ensure full an open competition. Seventy percent of the programs life cycle cost is in sustainment. Competition for technical refresh and implementation of new capability offer significant opportunities for cost savings. On legacy program, the contracting action might be a change order to existing contracts or a competition for replacing/migrating an existing component to open standards and interfaces. Continuous competition requires strong configuration management of the technical baselines and associated intellectual property. Continuous market research should be conducted to identify innovation opportunities and competition opportunities.



Adapted: DAU Acquisition of Services

Figure 8 - Implementing a MOSA Acquisition Strategy

2.1.4.1 MOSA Implementation Strategy Considerations – Information Needs and Metrics

Program planning for acquisition opportunities occurs continuously for both the Acquirer and the Supplier. The Acquirer should assess open standards and architectures and identify opportunities for applying new open standard technologies opportunities to meet evolving requirements and garner MOSA benefits. Industry is always updating products and investing to position for competitions and grow revenue when there is a good business case. The alignment of Acquirer and Supplier MOSA objectives can enhance the probability of success of the MOSA acquisition strategy. Key considerations the acquisition strategy include:

- **Modularity Optimization:** Is the system, product, or capability modularity implemented at the desired levels and have we obtained the data and intellectual property needed for life cycle competition, technical refresh, product support, and operational flexibility?
    - **Speed of Change:** What is the ease and speed with which the proposed system can be updated in response to changing business/capability?
        - Key factors in this assessment are maturity and modularity of the architecture, solution maturity and risks, and the ability of the suppliers to rapidly deliver high quality capabilities.
            - What percentage of 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?
            - To what extent do key interfaces conform to open and accessible standard interfaces and have been verified?
        - Can key components be replaced without modification to the component's interface and data product specifications?
        - Are the reuse opportunities that can shorten integration times and enable cost avoidance?
    - **Scalability:** How easily can the system can grow/scale to accommodate increased performance (e.g., higher transaction rates, more customers, etc.), expanded functionality (e.g., additional pricing methods) or scaled back to cost?
        - The selection of standards, defined interfaces, modularity and maturity of the solution and business practices are key factors in the scalability assessment.
        - Does MOSA business strategy and contracts support rapid scaling to meet mission needs?
    - **Modularity Implementation:** Too what extent is the system modularity implemented and verified?
        - Is the implemented system made up of well defined, functionally non-overlapping, modular elements with well documented interfaces allowing updates to or replacements of a portion of the system without affecting the remainder of the system?

        - Are data products exchanged between key components well documented, based on standard data models including syntactic and semantic specifications?
        - Are key components identified and good candidates separately procurements/competition?
    - **System Availability:** What is the ability of the system to provide the intended functionality, performance, and cost during all periods of desired use?
        - Assessment measures may include system resiliency, reliability, and supportability
- **System Functionality:** What functionality is needed to support achievement of the desired MOSA benefits and mission requirements?
    - Does the MOSA system, product, or capability work as intended or required?
        - Does each key component model the important aspects of a single relevant concept in the application domain, user interface, or technological domain?
            - To what extent do system components and selected commercial products conform to standards selected for system interfaces?
            - 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?
        - Are the MOSA benefits and derived business and technical requirements identified, defined and being implemented?
        - Do new or improved mission capabilities, functions, or features and performance meet or exceeds those requested or required.
        - How well do are competition, reuse, and ease of technology change and operational flexibility objectives supported?
    - Does the system, product, or capability satisfy or improve mission and MOSA needs?
        - Degree the system, or capability, satisfies the users mission, objective, or purpose
            - 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?

        - 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?
      - Degree the MOSA technical implementation satisfies the MOSA requirements and achieves defined MOSA benefit at acceptable cost and schedule risk.
  - Does the system, product, or capability, meet all MOSA contractual requirements and/or Capability Needs Statement?
      - Degree the system, product, or capability meets the contractual MOSA requirements imposed by the acquirer.
  - Does Modular Open System Approach for the system, product, or capability, align with the product roadmap, reference architectures or known future needs for the acquirer and supplier?
      - Degree by which the system, product, or capability satisfies or is consistent with the acquirer's MOSA product roadmap and the supplier business objectives.
  - Are there operational or sustainment issues with the system, product, or capability?
      - Degree by which the system, product, or capability is free from any known operational or sustainment issues and ability to achieve MOSA benefits throughout the life cycle.
  - Is the release cadence to push new capability to the field reasonable and acceptable?
      - Periodic releases of new capability will meet user needs
- **System Performance:** Does the MOSA solution satisfy both the mission and MOSA objectives?
  - Does the system, product, or capability, perform to expected system measures of performance (MOP) and effectiveness (MOE) within expected, or contractual, system resource limitations?
  - 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?
  - To what degree does the system, product, or capability perform its intended functions and operations efficiently within target resource constraints.
  - Does the MOSA system behave gracefully when approaching resource limits such as large number of users or transactions or increased demand?
      - Degree by which the system, product, or capability can continue to perform its intended functions as user demands or number of transactions increase.
      - How can the application of MOSA design principles address performance shortfalls?
  - Does the system, product, or capability provide the results within expected, or needed response time?
      - Degree by which the system, product, or capability provides the results, actions, or responses within contractual or expected response time.
  - Does the system, product, or capability meet or exceed the most important specified mission technical performance objectives, thresholds, or properties in an operational environment?

        - Degree by which the system, product, or capability can meet its specified mission and MOSA technical objectives, thresholds, or properties while in its expected operational environment.
    - Does the MOSA system provide enough margin or growth capability for future growth in performance required to accommodate anticipated future mission needs and/or reuse of the components?
        - Degree by which the system, product, or capability allows for future growth in performance and reuse.
    - Is the downtime required to perform upgrades or maintenance reasonable and acceptable?
        - Degree by which the downtime to perform upgrades and maintenance affect performance.
- **Dependability:** To what extent is the system reliable and maintainable?
    - Is the MOSA system, product, or capability reliable and available when needed?
        - Degree of impact of failures, shutdowns, system locking up, or waiting on system to the user, mission, or objective.
        - How well does the architecture provide failure isolation?
    - Did you get the system, product, or capability or MOSA benefit when you needed it?
        - How does MOSA support the ability to rapidly deliver, update, and/or fix system, or capability to meet operational needs?
        - MOSA solution provide opportunities for reductions in integration cost and schedule.
    - Does, or will, the system, product, or capability life expectancy and MOSA strategy meet contractual or customer needs?
        - Degree the system, or capability life expectancy meets planned mission or user needs and MOSA benefits.
        - Define metrics for DMSMS management efficiency and effectiveness.
        - MOSA can reduce the cost and schedule for technical refresh. This may also relate to product roadmap.
    - How easy does the MOSA system, product, or capability recover operation from failure mode?
        - What ability for the system, product, or capability to recover normal or degraded operation as the result of a failure?
    - How easy can the system, product, or capability be developed or changed or reused?
        - The degree of difficulty of development/integration of the system, product, or capability due to technical issues or technical maturity or lack of standards conformance and defined open interfaces.
        - Is the architecture sufficiently complete to proceed with design at acceptable risk?
    - Does the system, product, or capability provide enough information, detail, or resources to be maintained during operation?
        - Degree of information, detail, or resources provided to support maintenance during operations

    - Is the corresponding end-of-life for hardware and other modular components of the system reasonable and acceptable and/or can be easily replaced?
        - Degree by which all the components of the system have appropriate life expectancies
- **System Security:** Can the MOSA solution be operated in a secure fashion at acceptable risk?
    - Is the system, product, or capability using the MOSA supply chain secure to use?
        - Degree that the system, or capability protects the user and data from harm
    - Does the system, product, or capability resist cyber and/or physical interruption, intrusion, spoofing, or degradation of its intended functionality and operation?
        - Degree by which the system, product, or capability can prevent or resist any interruptions in normal operations due to external influences
    - Is the system, product, or capability, vulnerable to security attacks?
        - Degree of which the system, product, capability resists, or prevents security attacks.
    - Is the approach for recurring accreditation with a modular open system architecture reasonable and acceptable?
        - Does the MOSA implementation approach for renewing security accreditation meet needs of the user and acquirer?
- **Business Value:** Is the MOSA implementation strategy affordable and the best value for expending limited Acquirer and/or Supplier resources?
    - Will the system, product, or capability, improve mission needs and achieve MOSA benefits while meeting or exceeding project budget constraints?
        - Degree by which the system, product, or capability will improve the mission capability and yet stay within budget constraints using a MOSA approach.
    - Market Share/Revenue Growth: Does the MOSA based system, product, or capabilities, add to supplier portfolio and market share?
        - Degree of business impact and product portfolio.
        - Is this a new line of business or product line worth investing in or bidding?
    - Financial Value/Impacts: Does the MOSA designed system, product, or capability have financial value for the supplier?
    - Return on Investment/Life Cycle Cost Savings:
        - Is the MOSA designed system, product, or capability, cost effective to produce?
        - MOSA investment can provide life cycle cost savings through development, production, and sustainment.
    - MOSA Cost and Schedule Risk: Is there an impact to value due to delay in delivery of capability and/or MOSA benefits?
        - The answer to this question will vary for supplier, acquirer, and user impacts.
        - Degree of impact to the value of the system, product, or capability if it is delayed compared to its potential lifetime value.
- Is there a solid business case for both the Acquirer and Supplier to support competition throughout the product lifecycle?

2.1.4.2 System Engineering MOSA Metrics Considerations

Deploying mature system engineering processes is a key enabler for achieving MOSA success. Figure 7 is a high-level view the steps IEEE 15288 Technical Processes for implementing a MOSA acquisition strategy and Supplier MOSA implementation plan. Each program should tailor their systems engineering process to meet the program needs. [DoD Best Practices for Using Systems Engineering Standards, (ISO/IEC/IEEE 15288, IEEE 15288.1, and IEEE 15288.2) on Contracts for Department of Defense Acquisition Programs]() provide guidance on tailoring the level of system engineering needs to support the program.

Figure 9 - MOSA Systems Engineering Information Needs

2.1.4.3 MOSA Implementation Plan Value Metric Considerations

Program MOSA implementation plans are baselined during the solicitation and negotiations with suppliers. The solicitation should provide value for MOSA and mature system engineering in the source selection criteria. The request for proposal should ask for MOSA implementation plans and metrics that can be used to measure progress and success for the program. The planning and technical management MOSA evaluation criteria, based on risks and program MOSA objective(s), may consider some or all of the following criteria:

- **Technical Planning and Management:**
  - **Balanced Execution Approach:** The extent to which the offeror's MOSA systems engineering and business approach and schedule demonstrate an appropriate balance of cost, schedule, and performance risk to implement and sustain the proposed MOSA approach throughout the lifecycle
  - **Competition and Refresh Effectiveness:** The extent to which the offeror's MOSA systems engineering, business approach, IP Strategy and design enables continuous competition of high cost and rapidly changing technology components to lower costs and provide rapid technology refresh at acceptable risk within the program constraints

- Supply Chain Innovation and Cost Savings: The extent to which the offeror's integrated business and technical approach encourages and enables teammate and supply chain innovation to reduce cost and incorporate new technologies to maintain weapon system overmatch
  - **Optimizing for speed of change:** The extent the offeror's modular solution design and architecture supports systems resiliency and ability to make rapid changes to meet evolving threats and mission requirements.
  - **MOSA Planning:** The extent offerors MOSA implementation plan and System Engineering Master Plan addresses the program MOSA requirements, identifies relevant modular systems/components and intellectual property required to meet MOSA objectives throughout the lifecycle
- **Lower Cost and Rapid Refresh:** The extent to which the offeror's MOSA systems engineering, business approach, IP Strategy and design enables continuous competition of high cost and rapidly changing technology components to lower costs and provide rapid technology refresh at acceptable risk within the program constraints
  - **Responsiveness:** The ease and speed with which the system can be updated in response to changing business/capability needs
  - **Scalability** - Ease with which the system can grow to accommodate increased performance (e.g., higher transaction rates, more customers, etc.), expanded functionality (e.g., additional pricing methods) or scaled back to cost effectively support reduced levels of performance or functionality
  - **Modularity/Changeability** - The extent to which the system is made up of well defined, functionally non-overlapping, modular elements with well documented interfaces allowing updates to or replacements of a portion of the system without affecting the remainder of the system
  - **Affordability** – Are the cost and schedule estimated of the proposed solution, potential variances in the estimates and impacts of risks and opportunities on that estimate reasonable and realistic?
  - **Functionality** – To what extent do the uniquely identifiable functions and capability provided by the system enable effective delivery of the desired MOSA benefits?
- **Design Optimization:** The extent to which the offeror's integrated business and technical approach encourages and enables teammate and supply chain innovation to reduce cost and incorporate new technologies to maintain weapon system overmatch
  - **Authoritative Source of Truth:** The extent the offerors create and maintain a digital system model of the system, generated by all stakeholders, that integrates the authoritative technical data and associated artifacts, which defines all aspects of the system for the specific activities throughout the system life cycle.
  - **Employ Modular Designs:** The extent offerors employ modular designs that accurately isolates functionality during the design process to simplify development, maintenance, changes, and upgrades.
- **Standards and Reference Architecture Conformance:**
  - **Architecture Implementation/Lifecycle Effectiveness:** The extent technical proposal and architecture implements a modular open system architecture that addresses how

the use of existing/mandated MOSA enabling standards and applicable GRAs will achieve and maintain the MOSA objectives throughout the program lifecycle.

At contract award and subsequent Integrated Baseline Reviews, the MOSA implementation plan is approved and baselined. Cost, schedule, and performance risk assessments should be conducted at the IBR and each of the program technical baseline reviews. As the contract proceeds, progress should be measured against the plan implementation activities and achievement of the desired MOSA benefits. The MOSA and mission capability technical baseline(s) are maintained in the system baseline and documented in the program authoritative source of truth. The implementation of digital engineering and model-based systems engineering will significantly enhance communication and collaboration during implementation and sustainment of the MOSA solution(s).

2.1.4.4 MOSA in the Supply Chain

In a MOSA bid, the prime contractor's supply chain plays a critical role in ensuring the success of the project. The supplier and their supply chain follow the same process in responding to acquirer MOSA solicitations and program execution. I.E, what are MOSA benefits and tenants, and requirements that are flowed down to the supply chain? Overall, defense contractors' supply chains must possess a high degree of flexibility, scalability, standardization, reliability, security, and collaboration when developing and implementing MOSA solutions. By ensuring that these attributes are present in their supply chains, defense contractors can ensure successful implementation of MOSA and achieve the benefits of reduced lifecycle costs, increased interoperability, and improved system flexibility. The sections below address key questions and information needs that can help discriminate between different supply chain offerings. These discriminators may include:

- **MOSA expertise and experience:** MOSA is a relatively new acquisition strategy, and not all suppliers have the expertise and experience needed to deliver components that meet MOSA requirements. Prime contractors may look for suppliers who have a proven track record of delivering MOSA solutions in similar projects.
- **Technical and Business capabilities:** Prime contractor may evaluate a supplier's technical and business capabilities to ensure that they can deliver high-quality, reliable, and cost-effective components that meet the system's performance and MOSA requirements. This may involve reviewing a supplier's design and development processes, quality assurance and testing procedures, and overall technical expertise.
    - **Flexibility:** The MOSA approach relies on modular, open systems architecture, which requires a high degree of flexibility in the supply chain. Suppliers must be able to quickly adapt to changes in requirements and be able to deliver components that can be easily integrated into the system.
    - **Scalability:** Defense programs often involve large-scale systems with complex supply chains. Suppliers must be able to scale their production capabilities to meet the demands of the program and ensure that components are delivered on time and within budget.
    - **Standardization:** MOSA relies on open, standardized interfaces between components to ensure interoperability. Suppliers must be able to deliver components that meet these standards and can be easily integrated into the system.

- **Reliability/Maintainability:** Defense programs require high levels of reliability. Performance, and availability. Suppliers must be able to deliver components that meet strict performance requirements, able to operate in harsh environments, and are maintainable.
- **Cost-effectiveness:** MOSA aims to reduce lifecycle costs by promoting competition and using open interfaces and modular components. Prime contractors may evaluate suppliers based on their ability to deliver cost-effective solutions that meet the system's requirements within program constraints while keeping costs under control.
- **Manufacturing and production capabilities:** Suppliers need to have the manufacturing and production capabilities to deliver components on time and on budget. This may involve evaluating a supplier's production capacity, quality control processes, and supply chain management capabilities.
- **Collaboration and communication:** MOSA implementations require close collaboration and communication between the prime contractor and its supply chain. Prime contractors may evaluate suppliers based on their ability to work collaboratively, communicate effectively, and share information throughout the project. The extent the suppliers have a digital engineering authoritative source of truth and systems models that can support the prime integration efforts, reuse of design, standards conformance and test data can be a discriminator.
- **Innovation and Long-Term Investment:** Supplier selection should consider obsolescence risks when choosing products from the supply chain. If the supplier's product roadmap shows continued investment in improvements that conform to open standards and interfaces, there is a much lower obsolescence risk. Further, that innovation and investment ensure the generation of new capabilities and potential competition opportunities for technical refresh.
- **Intellectual Property and Security:** MOSA systems often involve the use of intellectual property and classified information. The availability and technical debt of the intellectual property, data, and documentation required to develop and support the MOSA solution is a key factor. Prime contractors may also evaluate suppliers based on program protection planning, their ability to protect intellectual property and classified information, and overall cyber security posture.
  - Defense programs involve sensitive information and assets that must be protected from security threats. Suppliers must have robust security protocols in place to ensure the security of their components and supply chain.

2.1.4.5 Supplier/Supply Chain MOSA Offerings Information Needs and Metrics

Overall, a winning bid strategy for bidding MOSA solutions on DoD programs requires a deep understanding of the customer's requirements, a commitment to MOSA principles, the ability to offer innovative solutions, a strong track record of past performance, a strong team, and competitive pricing. By focusing on these attributes, bidders can increase their chances of winning MOSA contracts on DoD programs. There are several key attributes that can help increase Supplier the chances of a winning bid strategy for the Prime Contractor and supply chain. These attributes include:

- **Supply Chain Understanding the customer's requirements:** The first step in developing a winning bid strategy is to thoroughly understand the customer's requirements. This includes not only the technical requirements but also the budget, schedule, and any other constraints. By understanding the customer's needs, bidders can develop solutions that best meet those needs.

  - For MOSA, this means having a clear understanding of the desired MOSA benefits, required standards and reference architectures, program constraints, and opportunities of innovation and technical refresh competition. This understanding will shape the supply chain business and technical objectives.

- **Supply Chain Leveraging MOSA principles**: MOSA is a key component of DoD acquisition policy, and bidders who can demonstrate their ability to implement MOSA principles in their solutions are likely to be viewed favorably by the Acquirer. This may include leveraging open, standardized interfaces, modular designs, and other MOSA principles to improve system flexibility, interoperability, and affordability.
  - The Prime Contractors design should optimize modularity to support the users operational and support concepts. In the supply chain, the level of modularity is key factor in enabling continuing supply chain competition/cost savings, and innovation. In manufacturing, design for assembly optimize modularity to reduce assembly touch labor.
  - Supply Chain bidders who can offer unique or innovative MOSA business and technical solutions that meet the customer's MOSA requirements/benefit objectives are more likely to win the contract. Supply chain investments can have a positive return on investment by in MOSA can enhance their probability of selection and opportunities for revenue growth, and position their product for reuse in other markets.
- **Offering Affordable Competitive Pricing:** Finally, bidders must offer competitive pricing that meets the Acquirer’s budget constraints. This requires a thorough understanding of the Acquirer’s and Supplier’s budget and the ability to deliver solutions that meet the customer's requirements at a reasonable cost. Affordability is not a number, but a decision and may vary by stakeholder/decision maker and is closely tied to prioritization. The suppliers MOSA strategy has a direct impact on program costs and provides opportunities for cost savings through competition, reuse, and program efficiencies. This should be viewed from both near term and life cycle cost perspective.

Overall, measuring success in a MOSA project involves a combination of technical, financial, and organizational metrics. By establishing clear information needs and metrics for measuring success, advisors can help ensure that the MOSA approach is implemented effectively and achieves its intended benefits. It is important to establish clear information needs and metrics for measuring supply chain MOSA success. Here are some examples of information needs and metrics that can be used to measure MOSA success in the supply chain:

- **System Performance:** One of the key metrics for measuring success in a MOSA project is system performance. This may include metrics such as system availability, reliability, and maintainability. These metrics can be used to assess the effectiveness of the MOSA approach in improving system performance. In the supply chain, each component is allocated performance measures that support the overall measurement of performance on the system. MOSA is not successful if the supplier and supply chain does field suitable and effective mission capability.
- **Cost Savings:** MOSA is designed to reduce lifecycle costs by leveraging modular, open systems architecture. Therefore, one of the key information needs is to measure the cost savings

achieved through the MOSA approach. This may involve comparing the costs of implementing MOSA against the costs of a traditional, proprietary approach. In step 1 of the process the program must clearly describe the benefits desired for the program. Cost savings can come from a variety of initiatives that should also be considered in the MOSA implementation planning. In step 4, the Prime Contractor and supply chain have to make business decisions. Is implementing MOSA in their product a good business decision. If the answer is not there will be less competition and innovation. The MOSA product value specification, business value attributes provide a good was to assess the supply chain business value proposition.

- **Affordability:** Will the system, product, or capability, improve mission needs and achieve MOSA benefits while meeting or exceeding project budget constraints? - Degree by which the system, product, or capability will improve the mission capability and yet stay within budget constraints using a MOSA approach.
- **Market Share/Revenue Growth:** Does the MOSA based system, product, or capabilities, add to supplier portfolio and market share? - Degree of business impact and product portfolio. Is this a new line of business or product line worth investing in or bidding?
- **Financial Value/Impacts:** Does the MOSA designed system, product, or capability have financial value for the supplier? Degree of financial impact to the company (Cash flow, revenue, profit…) or the ability of the organization to support the project with their current budget and resources. Will this positively impact company financial standing?
- **Return on Investment/Life Cycle Cost Savings:** Is the MOSA designed system, product, or capability, cost effective to produce? - Degree of cost investment versus return for the company /organization efficiency/effectiveness? (Return on Investment) MOSA investment can provide life cycle cost savings through development, production, and sustainment.
- **MOSA Cost and Schedule Risk:** Is there an impact to value due to delay in delivery of capability and/or MOSA benefits? Separate value for supplier, acquirer, and user impacts. - Degree of impact to the value of the system, product, or capability if it is delayed compared to its potential lifetime value.

2.1.6 Step 1 - 4 Choosing MOSA Metrics Getting Started

The pre-contract Steps 1-4 establish the mission and MOSA stakeholder needs and system requirements. The request for proposal should offer incentives for innovative MOSA solutions that provide MOSA product value and satisfy the mission needs. In the proposal, the supplier should provide and MOSA implementation plan and identify proposed measures that provide insight on implementation progress and achievement of MOSA objectives success. The proposal evaluation should assess the executability of the MOSA implementation, the MOSA product value of the offering, execution risks and opportunities, and affordability.

Once the contract has been awarded, the MOSA implementation plan and associated MOSA metrics can be baselined at the Integrated Baseline Review. The selected MOSA metrics should focus on two things. First, how are we executing against the planned MOSA implementation plan? These metrics are no different than metrics used to measure progress on other elements of the program. Specific attention should be paid to the critical elements of the MOSA implementation and areas of risk. The progress metrics are leading indicators for achievement of the MOSA benefit objectives. The second focus area is measurement of the actual achievement of the MOSA benefit. For example, committed vs delivered on cost saving or reductions in cycle time. MOSA can enhance competition, but was the competition effective? What percentage of the components can be completed during lifecycle technical refresh? Does the opportunity for competition stimulate innovation in the supply chain? The collection of these metrics from both the Acquirer and Supplier provides excellent data for assessing Supplier past performance and program risks.

In the system engineering process, we define the capability and MOSA benefits the stakeholder's desire. Based on those objectives we must clearly define the objectives and select the initial set of metrics for measuring MOSA implementation progress and achievements. There may be numerous uses to the same metric type for different implementation activities and different MOSA objectives. The metrics fall into five established metric classes: 1) Continuous Iterative Development, 2) Digital Engineering, 3) Technical Risk Assessments, 4) Business and Financial, and 5) Operations and Support. In steps 1-4 program should consider a minimal set of metrics that continue throughout development and the product lifecycle. During execution addition information needs may add addition measures based on the selected MOSA implementation plan. The following list represent a minimal set of metrics and associated information needs that should be considered when developing the MOSA implementation plan and bidding the MOSA solution solicitation. In all cases the metrics should be chosen/tailored to meet the program information needs!

- **Continuous Iterative Development** - Recommendations for the measurement of continuous iterative developments
  - **Cumulative Flow** – Cumulative flow is a tool to visualize work in progress, cycle time and throughput.
    - Is the flow of work moving forward through the MOSA implementation value stream (through the process workflow states)?
    - Is the throughput of work predictable
    - Are there queues or delays in our process workflows that prevent us from optimizing throughput for achieving MOSA benefits?
  - **Committed vs Delivered/Completed** - Committed vs Completed is a measure of progress toward delivering/completing planned, or expected, features, capabilities and benefits.
    - Are Stories, Features, MOSA interfaces, Capabilities or Benefits delivered as committed?
    - Are we meeting our commitments?
    - Is the team and project completing the assigned work?
  - **Technical Debt** - Technical debt may result from having implementation issues related to architecture, design, structure, duplication, test coverage, comments and documentation, potential defects, complexity, or coding practices. The impact of technical debt can be seen in several different program metrics.
    - How easy/difficult is it to update or refactor the design and code?
      - Can we support the desired release frequency, cycle time and program schedule risk assessment?
    - Can the open system architecture be expanded as the system continues to be developed and revised?
    - When does it become too costly or take too long to maintain the design or architecture?

        - What are the cost trends such a support cost?
        - How do the cost risk assessments compare to available budgets?
    - Is the documentation current, sufficient for user needs, and sustainable throughout the lifecycle?
    - When should identified technical debt be resolved, parts of the system replaced, or a new system started?
    - What is the impact of this technical debt on the MOSA implementation plan? Is it worth the investment and schedule to resolve it?
        - What is the return on investment?
- **MOSA Product Value** - The defined stakeholder objectives and the prioritize the product attributes to be evaluated for a particular product or project. What value is MOSA providing the program, product, capability, or system?
    - Optimized Modularity Attributes
        - Does it support competition, manufacturing, operations, and support?
        - Are the stakeholders satisfied with the MOSA implementation progress and delivered modular open system products and systems?
        - What is the ease and speed with which the proposed system can be updated in response to changing business/capability?
    - Functional Attributes
        - Do the MOSA enabled products provide the desired functionality when needed?
    - Performance Attributes –
        - Is the product effective?
        - Do the MOSA enabled products provide the desired performance when needed?
    - Product Dependability Attributes
        - Is it reliable, maintainable, changeable, and or reusable?
        - Does the MOSA implementation dependably deliver the product an MOSA benefits when needed?
    - Security Attributes
        - Is the product and product data/IP secure?
        - Is the MOSA system secure to use?
    - Business Value Attributes
        - What is the MOSA business case?
        - Is this approach a good business decision for the Acquired and the Supplier?
        - Is the Acquirers enhancing competition strategy effective?
        - How well does the system, product, or capability improve mission needs and is expected to perform well within budget constraints?
        - How well does the MOSA strategy enable continuous competition for technology refresh numerous standards-based reuse opportunities?
        - Are there market demands and portfolio advantages for the MOSA system, or capability?
        - Does the supplier and supply chain make financial gains with potential for future business or can the organization can provide significant increases support with lower cost and resource by investing in MOSA

        - Does the return on investment in MOSA investments meet or exceed expectations?
        - What are the risks and opportunities impact(s) of the chosen MOSA strategy?
- **Digital Engineering** - This measure is used to evaluate progress toward completion of an architecture in a system or product development. An architecture is foundational for aligning the problem space with the solution space and establishing the product baseline. Completeness and stability (i.e., absence of volatility) in the functions comprising the architecture provide a direct view into the maturity of a system development with digital engineering. The architecture evolves and is maintained as the program is completed and is the basis for technical baseline reviews.
    - **Functional Architecture Completeness and Volatility (8.1)** - This measurement specification can be utilized on different views of the architecture, including the functional, logical, physical, etc. The specific indicator used as an example in this specification discusses the functional architecture, but similar indicators can be developed for other architecture views. Similar measures may also be used to measure the completeness and volatility of other model elements (e.g., interfaces, hardware or software design elements).
        - How complete is the architecture? Does the architecture account for all MOSA required functions, interfaces and standards?
        - Is the architecture sufficiently complete to proceed with MOSA design at acceptable risk
    - **Model Traceability (8.2)** - The usefulness and quality of a digital model depends on the completeness and integrity of the relationships among model elements. Gaps in bi-directional traceability between the artifacts of two models or might indicate where further analysis or refinement are needed to effectively implement the MOSA architecture and design.
        - What is the extent of achieved traceability coverage from Source Elements, e.g., MOSA requirements, down to the logical or physical solution domain?
        - What is our progress in completing the digital model(s)?
        - What traceability gaps in the MOSA approach exist?
    - **Digital Engineering (DE) Anomalies (8.4)** - One of the major benefits expected from digital engineering is improved system quality, and early detection of any defects, when they are less costly to correct. The terms used to discuss quality vary widely across enterprises and projects. For the purposes of this specification, we will use the term anomaly to discuss deviations from expectations. Defects in the system modeling or technical debt can result in less than optimum decisions on how to implement MOSA and increase the risks of not achieving the MOSA benefits
        - Is the quality of the product in question adequate for the product to be used in subsequent phases or activities?
        - Are we finding and removing anomalies early in the life cycle using models and shared information?
        - Is the use of DE leading to the detection of anomalies earlier in the lifecycle compared to traditional methods or projects?
- **Technical Risk Assessments** - The Technical Assessment process provides a fact-based understanding of the current level of product knowledge, technical maturity, program status and technical risk by comparing assessment results against defined criteria. These assessment results enable a better understanding of the health and maturity of the program, giving the Program Manager (PM) a sound technical basis upon which to make program decisions. In all cases the

readiness levels reflect the current state of the program. The risk is associated with the program's ability reach the desired readiness levels with the program constraints and resources.

- **Technology Readiness Levels** - Technology Readiness Levels (TRLs) are a method for understanding the technical maturity of a technology during its acquisition phase. TRLs allow engineers to have a consistent datum of reference for understanding technology evolution, regardless of their technical background
  - What are the critical technologies for the MOSA implementation?
  - What is the risk of achieving the desired technology maturity levels for the MOSA solution given the program resources and schedule?
- **Integration Readiness Levels** - Integration Readiness Levels (IRLs) are a method for understanding the integration difficulty of a technology during its acquisition phase. IRLs allow engineers to have a consistent datum of reference for understanding integration risks, regardless of their technical background
  - What is the integration maturity of the MOSA solution(s)?
  - What is the confidence that components can be rapidly changed to meet evolving requirements?
  - What is the risk of achieving the desired integration maturity levels for the MOSA solution given the program resources and schedule?
- **Reuse Readiness Levels (NASA)** – A tool to assess the readiness and risk of reuse opportunities in the MOSA solution. A set of nine Reuse Readiness Levels (RRLs) is presented in this document. The RRLs are focused on pinpointing the ability of software components, software systems, and interfaces to be reused in a given context and on pinpointing the potential reusability of software components, systems, and interfaces downstream.
  - What technology reuse modules and/or components are available to support the mission needs and can deliver the desired cost savings/cost avoidance?
  - What is the maturity of the reuse candidate?
  - What is the program risk of reusing candidate modules and/or components given the program resources and schedule?
- **Manufacturing Readiness Levels** - Assessments of manufacturing maturity using the Manufacturing Readiness Level (MRL) criteria have been designed to identify and manage manufacturing risk in acquisition, decreasing the risk of technology transition for new technology to weapon system applications. MRL criteria and metrics create a measurement scale and vocabulary for assessing and discussing manufacturing maturity and risk
  - What is the current level of manufacturing maturity?
  - Can the MOSA system be produced consistently at the required level of cost and quality?
  - Can the supplier produce the MOSA solution with acceptable risks given the program resources and schedule?
  - Can the technology and industrial base support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal?
- **System Complexity Levels** – The complexity of the system, system of systems, and/or components make integration, verification, and validation of the system performance more difficult and costly.
  - What is the complexity of critical MOSA components and interfaces?

    - How does the complexity of critical MOSA components and interfaces impact:
        - Delivery of new capabilities or replacement technology without changing all components in the entire system?
        - Ability to configure and reconfigure available assets to meet rapidly changing operational requirements
        - Improve interoperability allow severable software and hardware modules to be changed independently
  - **Reliability and Maintainability** - Reliability growth curves should be stated in a series of intermediate goals and tracked through fully integrated, system-level test and evaluation events until the reliability goals have been reached. Reliability growth metrics reflects the rate at which the system's reliability is improving as a result of implementation of corrective actions.
    - What is the probability that the component or system will perform intended function for a specified interval under stated conditions?
    - What is the probability that the component or system will be restored to a specified condition in a given period of time, when the maintenance is performed in accordance with the prescribed procedures and resources?
  - **Technical Performance Measures** - Technical Performance Measurement (TPM) involves a technique of predicting the future value of a key technical performance parameter of the higher-level end product under development based on current assessments of products lower in the system structure. TPM's are used to continuously measure growth of a measure toward meeting the required goal at the end of development. Continuous verification of actual versus anticipated achievement for selected technical parameters confirms progress and identifies variances that might jeopardize meeting a higher-level end product requirement
    - Does the MOSA system meet the operational suitability and effectiveness measures for the program?
    - Does the MOSA system meet the contract performance requirement?
- **Business and Financial** - To achieve MOSA benefits, there must be a strong business case supporting the technical solution and measures on program progress and achievement of desired MOSA benefits.
  - **Cost Risk Assessments** - A key MOSA objective is cost reduction and cost avoidance. A program cost estimate is the summation of individual cost elements, using established methods and valid data, to estimate the future costs of a program, based on what is known today.
    - How does the work breakdown structure segregate MOSA cost elements and components?
    - What are the cost estimates for the MOSA implementation effort?
    - What are the risks, opportunism, and uncertainties associated with the cost estimates?
    - What is the range of uncertainty in the cost estimate?
  - **Schedule Risk Assessments** - A well-planned schedule is a fundamental management tool that can help acquirer and supplier organizations use program funds effectively by specifying when work will be performed in the future and measuring program performance against an approved plan. Moreover, as a model of time, an integrated and reliable schedule can show when major events are expected as well as the completion dates for all activities leading up to them, which can help determine if the program's parameters are realistic and achievable
    - Have we captured all the MOSA implementation activities?

        - Are the MOSA activities properly sequenced and integrated with product development activities?
        - Are the activities properly resourced?
        - Are the MOSA activities linked to outcomes?
        - Is the critical path valid?
        - Do we have reasonable float on the critical path?
        - Are we maintaining a baseline schedule?
    - **Affordability** - Affordability is not a number, but a decision and may vary by stakeholder / decision maker and is closely tied to prioritization. A programs MOSA strategy has a direct impact on program costs and provides opportunities for cost savings through competition, reuse, and program efficiencies
        - Will the system, product, or capability, improve mission needs and achieve MOSA benefits while meeting or exceeding project budget constraints?
        - What are the priorities of the Mission and MOSA objectives?
        - What fraction of budget available for the needs?
        - What is the cost estimate for the effort?
        - What are the overall capability implications of the decision?
- **Operations and Support**
    - **Key Performance Parameters** -Performance attribute of a system considered critical or essential to the development of an effective military capability. KPPs are contained in the Capability Development Document (CDD) and the updated CDD and are included verbatim in the Acquisition Program Baseline (APB). KPPs are expressed in term of parameters which reflect Measures of Performance (MOPs) using a threshold/objective format. KPPs must be measurable, testable, and support efficient and effective Test and Evaluation (T&E). Mandatory KPPs are specified in the JCIDS Manual.
        - Does the MOSA system meet the operational suitability and effectiveness measures for the program?
    - **Operational Availability** - The degree (expressed as a decimal between 0 and 1, or the percentage equivalent) to which one can expect a piece of equipment or weapon system to work properly when it is required, that is, the percent of time the equipment or weapon system is available for use. AO represents system "uptime" and considers the effect of reliability, maintainability, and Mean Logistics Delay Time (MLDT).
        - Does the operational availability of the MOSA system meet the mission requirements
        - What components have lower reliability and are candidates for technical refresh or replacement?
    - **Operational Flexibility** – The modular open systems ability to provide the capability to configure and reconfigure available assets to meet rapidly changing operational requirements
        - Does the modular open system support the operational configuration and reconfiguration requirements?
            - Number of operational configurations committed vs delivered/completed
            - Operational configuration backlog burndown
    - **Reliability and Maintainability** – Reliability and Maintainability is a key element of operational availability.

- What is the probability that the component or system will perform intended function for a specified interval under stated conditions?
- What is the probability that the component or system will be restored to a specified condition in a given period of time, when the maintenance is performed in accordance with the prescribed procedures and resources?
- Are the modular open system components and interfaces reliable?
  - What is the Mean Time Between Failures?
  - What is the corrective maintenance time?

2.2 Program Execution

2.2.1 Step 5 5. How to Status of MOSA Implementation

How are we progressing against our plans on our MOSA and Mission capabilities, Technical Baselines, and Business Objectives?

Program Situational Awareness (SA) is all about the program team and stakeholders establishing and maintaining an integrated picture of cost, risk, schedule and performance in order to anticipate program outcomes and support proactive decision making. This is not a simple feat and may require additional metrics at different levels of the organization. Metrics should be collected and analyzed on a strategic rhythm that support the program decision process and technical reviews.

The supplier MOSA implementation plan/metrics and solicitation negotiations will baseline the MOSA implementation plans at the IBR after contract award. Depending on the scope of that plan and key risk areas, additional metrics may be chosen and implemented at the IBR. The Table 1 expands on the initial MOSA metrics recommendation. Appendix A, Master List of MOSA Metric, provides definition of each metric, and examples how they could be used to support different aspects of the MOSA implementation. In all cases the metric selection should be tailored to the program's needs. The metric chosen and their importance may vary depending of the lifecycle of the program. The papers appendices provide MOSA Use Cases outlining information needs and potential metrics that can help support MOSA metrics for your program. A brief description of each MOSA use case is found in Section 3.0, later in this paper.

Table 1 – MOSA Metrics Recommendations

Continuous Iterative Development	Digital Engineering	Technical Risk Assessments	Business and Financial	Operations and Support
MOSA Product Value (Secure, Responsive, Scalable, Modular, Available, and Affordable)				
Automated Test Coverage	Functional Architecture Completeness and Volatility (8.1)	Technology Readiness Levels	Trend Line Chart	Reliability and Maintainability
Burndown	Model Traceability (8.2)	Integration Readiness Levels	Cost Risk Assessments	Mean time Between Failures
Committed vs Delivered/ Completed	Product Size (8.3)	Reuse Readiness Levels (NASA)	Schedule Risk Assessments	Operational Availability
Cumulative Flow	Digital Engineering (DE) Anomalies (8.4)	Manufacturing Readiness Levels	Market Share/Revenue Growth	Corrective Maintenance Time (CMT)
Cycle Time/Lead Time	Adaptability and Rework (8.5)	System Complexity Levels	Return on Investment (ROI)	Key Performance Parameters (KPP)
Defect Detection	Product Automation (8.6)	Change Failure Rates	Profit Margin	Change Failure Rates
Defect Resolution		Reliability and Maintainability	Probability of Competition (Pgo)	Lifecycle Cost Trends
Mean Time to Detect (MTTD) and Mean Time to Restore (MTTR)		Technical Performance Measures	Probability of Win (Pwin)	MOE/MOPS
Release or Deployment Frequency			Competition Effectiveness	
Team Velocity			Change Failure Rates	
Technical Debt			Lifecycle Cost Trends	

Table 2.2.1 – MOSA Metrics Recommendations

2.2.2 Step 6 Managing MOSA In Technical Baselines – Information Needs and Metrics

How are the MOSA features implemented and verified in the technical baselines and implementation?

The MOSA implementation is an integral part of the product baselines. The product baselines are documented and maintained in the system technical baselines. DoD 5000.88 states, "The Program Manager (PM) will implement and describe in the Systems Engineering Plan (SEP) a technical baseline management process as a mechanism to manage technical maturity, to include a mission, concept, functional, allocated, and product baseline". The overall technical approach for system design and development will balance system performance, life-cycle cost, schedule, and risks in addressing mission needs. For MDAPs, the technical approach will incorporate a modular open systems approach (MOSA) to the maximum extent practicable. All other programs should consider implementing MOSA. The engineering management approach should include technical baseline management; mission and MOSA requirements traceability; Configuration Management (CM); risk, issue, and opportunity management; and technical trades and evaluation criteria. The relationship with systems engineering activities, the technical reviews, and supporting MOSA metrics is shown in paragraph 2.1.4.2 System Engineering MOSA Metrics Considerations. The Suppliers Systems Engineering Management Plan (SEMP) and MOSA Implementation Plan document the Suppliers systems engineering and MOSA implementation.

DoD 5000.88 also states, "If practicable, the PM will establish and manage the technical baseline as a digital authoritative source of truth. The digital engineering authoritative source of truth will establish and maintain the functional, allocated, and product baselines via the appropriate systems engineering technical reviews as described in the Defense Acquisition Guidebook." The digital engineering implementation plan to include model must include the evolution of a continuous end-to-end digital representation, or integrated set of digital representations, of the system being produced and the establishment of a digital authoritative source of truth

DoD 5000.88 says, "The PM will assume control of the initial product baseline Class I configuration changes, as defined in accordance with the program's CM plan, from the contractor at completion of the system-level critical design review (CDR)". Configuration Management facilitates the orderly development of a system through establishment of the technical baseline (including the functional, allocated and product baselines), and their assessment and approval at various technical reviews and audits. A baseline is an agreed-upon description of the MOSA solution attributes of a product at a point in time, which serves as a basis for change. Upon approval, the technical baseline documentation is placed under formal configuration control. Through Configuration Management, the program identifies, controls and tracks changes to the technical baseline, ensuring changes occur only after thorough assessments of performance, cost and schedule impacts, as well as associated risks. (DAU Configuration Management)

The requirements for technical reviews and audits to be performed throughout the acquisition life cycle for the US Department of Defense (DoD) and other defense agencies are established in IEEE 15288.2, IEEE Standard for Technical Reviews and Audits on Defense Programs. This standard provides the definition, description, and intent, as well as the entry/exit/success criteria, for each technical review and audit. It is to be used to establish agreement between acquirers and suppliers on the technical reviews and audits that are needed for the project, as well as the focus and expectations of each. (Adopted by ISO as ISO/IEC/IEEE 24748-8:2019)

2.2.2.1 MOSA Functional Baseline

Functional Baseline: Describes the system's performance (functional, interoperability and interface characteristics) and the verification required to demonstrate the achievement of those specified characteristics. It is directly traceable to the operational requirements contained in the Initial Capabilities Document (ICD) and the Program MOSA Objectives and selected standards and reference architectures, The Program Manager (PM) establishes Government control of the functional baseline at the System Functional Review (SFR) and verifies it through Functional Configuration Audits (FCA) leading up to the system-level FCA or the System Verification Review (SVR). Attributes of the functional baseline include: (Adapted: DAU Configuration Management)

- Achievability and implementation risks of the MOSA solution within program cost and schedule constraints?
- Documentation of established interfaces between functional segments
- Documented performance requirements traced to (draft) Capability Development Document (CDD) and MOSA objective requirements
- Architecture reflects design considerations and clear linkage in the systems of systems (SoS) context
- Documented MOSA and mission verification requirements
- MOSA Solution Product Value Assessment

Key Functional Baseline MOSA Implementation Questions:

- How have we ensured that the system under review can proceed into preliminary design with acceptable risk, and that all system requirements and functional performance requirements derived from the approved preliminary system specification are defined and are consistent with the program budget, program schedule, risk and other program and system constraints?
- What is the maturity/status of the system functional review activities and products?
- What is the maturity/status of the major system elements and interface definition?
- What is the status of the MOSA implementation into program technical plans and schedules? (EG. SEP/SEMP, Modeling and Simulation, Software Development, Hazard Mitigation, Test, and product support…)

A more comprehensive set of Functional Baseline review questions is provided in Appendix H, MOSA Technical Review Questions.

2.2.2.2 MOSA Allocated Baseline

Allocated Baseline: Describes the functional and interface characteristics for all system elements (allocated and derived from the higher-level product structure hierarchy) and the verification required to demonstrate achievement of those specified characteristics. The allocated baseline for each lower-level system element (hardware and software) is usually established and put under configuration control at the system element Preliminary Design Review (PDR). This process is repeated for each system element and culminates in the complete allocated baseline at the system-level PDR. The PM then verifies the allocated baseline at the FCA and/or SVR. Attributes of the allocated baseline include: (Adapted: DAU Configuration Management)

- All system-level functional performance requirements decomposed (or directly allocated) to lower-level specifications (configuration items (CI) for system elements)
- Uniquely identified CIs for all system elements at the lowest level of the specification tree
- All interfaces, both internal (between element CIs) and external (between the system under development and other systems), documented in interface control documents
- Verification requirements to demonstrate achievement of all specified functional performance characteristics (element CI to element CI level and at the system level) documented
- Design constraints documented and incorporated into the design
- Intellectual property requirements and technical debt are identified and validated

Key Allocated Baseline MOSA Implementation Questions:

- What is the status of system-level functional, performance, and MOSA requirements base lined at SRR and SFR decomposition and allocation?
- What MOSA trade studies did we conduct and what where the results?
- What is the status of the allocated baseline and MOSA implementation?
- How are performing against our design to cost targets and reuse cost savings?
- How are we communicating MOSA solution design decisions between parallel development teams and suppliers?
- What MOSA opportunities have we identified and how will we exploit them?
- Are we prepared to proceed at acceptable cost, schedule, and performance risk? Why?

A more comprehensive set of Allocate Baseline review questions is provided in Appendix H, MOSA Technical Review Questions.

2.2.2.3 MOSA Production Baseline

Product Baseline: Describes the detailed design for production, fielding/deployment and operations and support of the MOSA solution. The product baseline prescribes all necessary physical (form, fit and function) characteristics and selected functional characteristics designated for production acceptance testing and production test requirements. It is traceable to the system performance requirements contained in the CDD and MOSA objectives. The initial product baseline includes "build-to" specifications for hardware (product, process, material specifications, engineering drawings, interfaces, standards and other related data) and software (software module design - "code-to" specifications). The initial system element product baseline is established and placed under configuration control at the system element Critical Design Review (CDR) and verified later at the Physical Configuration Audit. In accordance with DoDI 5000.88, the PM will assume control of the initial product baseline Class I configuration changes, as defined in accordance with the program's CM plan, from the contractor at completion of the system-level CDR. This does not necessarily mean that the PM takes delivery and acceptance of the Technical Data Package. If one or more performers are on contract and competing for a follow-on contract when CDR is conducted, the PM may delay assuming control of the initial product baseline until after down select to one contractor. Attributes of the product baseline include: (Adapted: DAU Configuration Management)

- Requirements Traceability Matrix (RTM) and conformance to MOSA standards is complete.
- The detailed design (hardware and software), including interface descriptions, satisfies the CDD or equivalent and pertinent design considerations and MOSA objectives.

- Hardware, software and interface documentation and standard selections are complete.
- Key product characteristics having the most impact on the systems performance and MOSA objectives have been identified
    - System performance, assembly, cost, reliability, survivability, cybersecurity, ESOH and sustainment
    - MOSA standards and reference architectures enabling enhance competition, technology refresh, reuse, and increased interoperability
- Traceability from design documentation to system and system element verification requirements and methods is complete.
- Manufacturing processes that affect the key characteristics have been identified, and capability to meet design tolerances has been determined.
- The intellectual propriety required to maintain and support the system is acquired and verified.
- Cost baseline.

A more comprehensive set of Allocate Baseline review questions is provided in Appendix H, MOSA Technical Review Questions.

2.2.2.4 Technical Baseline Supporting Metrics

- Systems Engineering Implementation Status
    - Burndown
    - Cumulative Flow
    - Cycle Time
    - Defect Detection
    - Defect Resolution
    - Team Velocity
    - Technical Debt
- Digital Engineering/Modeling and Simulation
    - Functional Architecture Completeness and Volatility
    - Model Traceability
    - Digital Engineering Anomalies
    - Adaptability and Rework
    - Product Automation
- Technical Risk Assessments
    - Technology Readiness Levels
    - Integration Readiness Levels
    - Reuse Readiness Levels
    - Manufacturing Readiness Levels
    - Change Failure Rate
    - Reliability and Maintainability
    - Technical Performance Measures
- MOSA Conformance
    - MOSA Product Value
    - Open Standard Interfaces Completed vs Committed
    - Open Standard Interface Implementation Cumulative Flow

    - MOSA Conformance Verification Cumulative Flow
- Business and Financial
    - Life Cycle Cost Trends
    - Cost Risk Assessments
    - Schedule Risk Assessments
- Operations and Support
    - Reliability and Maintainability
    - Operational Availability
    - Key Performance Parameters
    - MOEs/MOPs

2.2.3 Step 7 – Measuring Lifecyle MOSA Benefit Achievement

Are we achieving and sustaining the MOSA benefits during the product lifecycle?

The DoD USDR&E MOSA guidance identifies five areas where MOSA benefits can be achieved. As part of Steps 1-4, the program MOSA objectives and measures of success should be defined. The following sections of Step 7 provide considerations, activities and measures that can be used to define and measure MOSA Success. They are as follows:

- **Enhance Competition:** open architecture with severable modules, allowing components to be openly competed
- **Enable cost savings/cost avoidance reuse of technology:** reuse of modules, and/or components from any supplier across the acquisition life cycle
- **Facilitate technology refresh:** delivery of new capabilities or replacement technology without changing all components in the entire system
- **Incorporate innovation operational flexibility**: enable operations to configure and reconfigure available assets to meet rapidly changing operational requirements.
- **Improve interoperability:** allow severable software and hardware modules to be changed independently

These benefits will generally manifest themselves in the following ways:

- **Significant cost saving or avoidance**
    - Life Cycle Cost Trends
    - Cost Risk Assessments
    - Material Cost Trends
    - Unit Cost Trends
    - Touch Labor Hours
    - Competition Effectiveness
- **Schedule reduction and rapidly deploy new technology**
    - Schedule Risks Assessments
    - Cycle Time
    - Lead Time
    - Release Frequency
    - Defect Detection
    - Defect Resolution

- **Opportunities for technical upgrades and refresh**
  - Competition Frequency
  - Opportunity Pipeline
  - Investment Trends
  - Return on Investment (ROI)
- **Interoperability, including system of systems interoperability and mission integration**
  - # of Operational Configurations
  - Operational Flexibility
- **Other benefits during the sustainment phase of a major system**
  - Reliability and Maintainability
  - DMSMS Issue Burndown
  - Support Cost
  - Mean Time Between Failures
  - Operational Availability
  - Corrective Maintenance Time

3.0 MOSA Use Case Example Descriptions

3.1 Appendix A - Master MOSA Metrics List

The MOSA metrics in the Appendix, are derived works from the Practical Software Measurement (PSM) Continuous Iterative Development and Digital Engineering metrics specifications and program and business and systems engineering best practices. The first column provides a name and link to the source's specification for the metric. Column 2 lists key information needs associated with each metric type. Column 3 provides examples of how the measures might be used to measure progress and/or achievement of the desired MOSA benefits. However, these metrics can be applied to any business or mission requirement. Table 2 is a summary of the MOSA metrics categories and metrics. Each is hot linked to specifications or more information on how to apply the metrics. These metrics are repeatedly referenced in the main document and Use Case Appendices. Table 3.1 is a list of the recommend MOSA metrics found in Appendix A. Each metrics is hot linked to a metrics specification or more information on how to use the metric.

Table 2 - Key MOSA Measurements/Metrics Categories

Continuous Iterative Development	Digital Engineering	Technical Risk Assessments	Business and Financial	Operations and Support
MOSA Product Value (Secure, Responsive, Scalable, Modular, Available, and Affordable)				
Automated Test Coverage	Functional Architecture Completeness and Volatility (8.1)	Technology Readiness Levels	Trend Line Chart	Reliability and Maintainability
Burndown	Model Traceability (8.2)	Integration Readiness Levels	Cost Risk Assessments	Mean time Between Failures
Committed vs Delivered/ Completed	Product Size (8.3)	Reuse Readiness Levels (NASA)	Schedule Risk Assessments	Operational Availability
Cumulative Flow	Digital Engineering (DE) Anomalies (8.4)	Manufacturing Readiness Levels	Market Share/Revenue Growth	Corrective Maintenance Time (CMT)
Cycle Time/Lead Time	Adaptability and Rework (8.5)	System Complexity Levels	Return on Investment (ROI)	Key Performance Parameters (KPP)
Defect Detection	Product Automation (8.6)	Change Failure Rates	Profit Margin	Change Failure Rates
Defect Resolution		Reliability and Maintainability	Probability of Competition (Pgo)	Lifecycle Cost Trends
Mean Time to Detect (MTTD) and Mean Time to Restore (MTTR)		Technical Performance Measures	Probability of Win (Pwin)	MOE/MOPS
Release or Deployment Frequency			Competition Effectiveness	
Team Velocity			Change Failure Rates	
Technical Debt			Lifecycle Cost Trends	

Table 3.1 - Key MOSA Measurements/Metrics Categories

3.2 Appendix B – Systems Engineering Processes and MOSA Metrics

Figure 8 outlines the MOSA systems engineering IEEE 15288-2023 based technical flow, processes and key information needs. Appendix B provides a table that further breaks out the process steps, key information needs and metrics that can be used to support the MOSA implementation. The system engineering processes support the program technical reviews which provide key points throughout the system development to evaluate significant achievements and assess technical maturity and risk. The

DAU SE Brain Book and [IEEE 15288.2 Technical Reviews and Audits on Defense Programs]() provides further detail on [Technical Reviews and Audits](). The This process applies to all programs regardless of their position in the acquisition lifecycle. In agile engineering programs the information needs may be satisfied by iterative sprints and technical reviews.

Figure 10 – MOSA Technical Implementation Flow

The MOSA business strategy is supported by the systems engineering processes. Figure 9 outlines the business strategy implementation flow and key MOSA information needs.

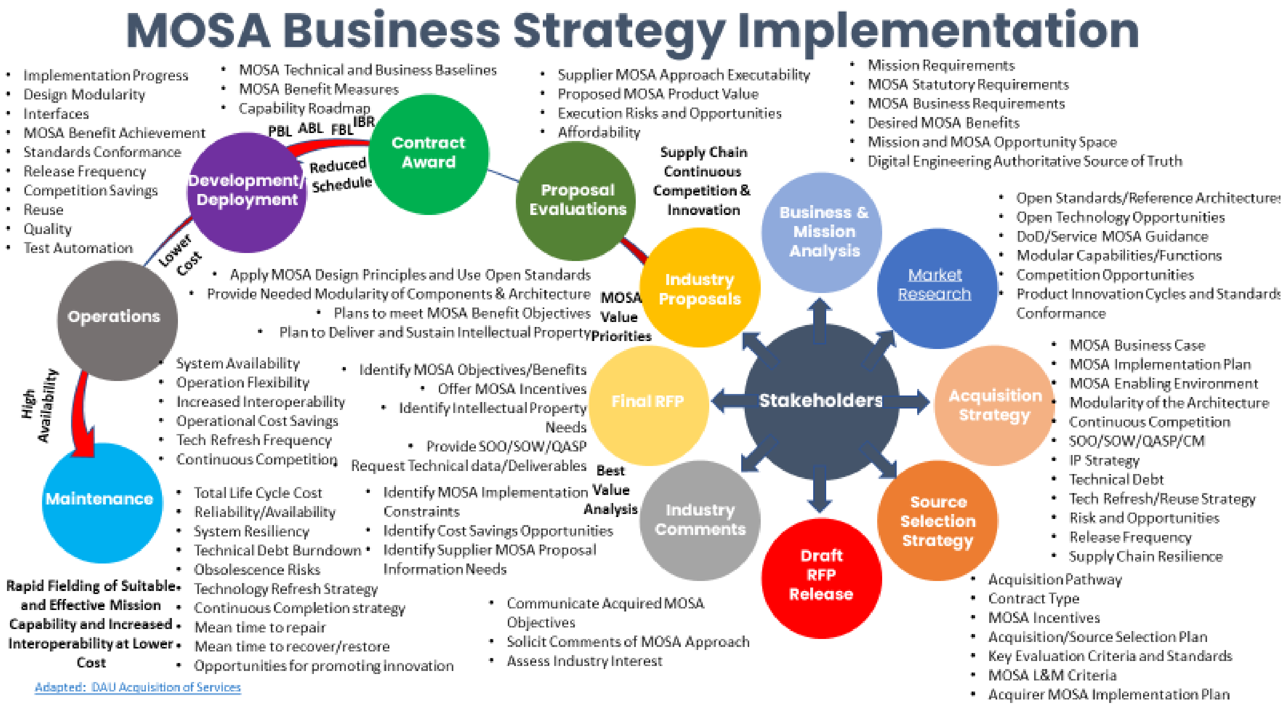


Figure 3.2.2 -MOSA Business Strategy Implementation

Figure 11 - MOSA Business Strategy Implementation

The supporting systems engineering processes include: Agreement, Organizational Project Enabling, Technical Management, and Technical Processes. Appendix B provides a table that identifies the process, the process purpose, the MOSA information need, and sample applications of MOSA metrics (See Appendix A) to satisfy the information need.

3.3 Appendix C – MOSA Product Value Specification

MOSA product Value can be used to assess different MOSA approaches and associated risks. To perform this assessment, begin with the end goal in mind. The desired MOSA benefits drive the modularity and openness requirements needed to enable both technical changes in a solution and support the contactor/supplier business strategies. From the technical perspective, MOSA benefits induce changes in the way system requirements are introduced in a specification for a solution. Fundamentally, the MOSA benefits may be thought of as capability needs to be addressed by the Systems Engineering Process and where MOSA requirements are derived from MOSA benefit objectives. The MOSA benefits and requirements are prioritized along with mission objectives and requirements. The system trades assess the value of these benefits and determine optimal solution alternatives that can be achieved within the program resources and constraints and satisfy the program stakeholders. This specification identifies information needs and value measures that can be used to support program decisions.

There are six MOSA product value attributes. The attributes were adapted for MOSA from the Practical Software Measurements (PSM) specification. Each attribute has information needs that are supported by different measurements and metrics (See Appendix's A and C). The following are the key MOSA value attributes. Program should select the value attributes that support their MOSA objectives. Appendix C provides detailed guidance on the use of the MOSA Product Value Speciation. Key considerations include the following: (Optimized Modularity, Functionality, Performance, Dependability, Security, and Business Value). Each measure has multiple information needs and recommendations for supporting metrics. The MOSA value specification should be adapted to meet each program needs.

3.3.1 Optimized Modularity

The extent and status if the architecture and business practices are optimized to the level of system and component modularity for the desired lifecycle competition, technical refresh, innovation, support concept, and operational flexibility to configure and reconfigure available assets to meet rapidly changing operational requirements. Architecture optimization assessments include considerations for: Responsiveness/Speed of Delivery, Scalability, Modularity, Availability, Affordability and Functionality.

The degree to which a system interfaces and components conform to the desired open standards and reference architectures while meeting or exceeding mission technical requirements using severable modules, that can be changed independently without changing the whole system. A Key Architecture Driver (KAD) as the combination of functional (operational) requirements, quality attribute requirements, and business (I.E. MOSA) requirements that shape the architecture under consideration. Typical architectural views include the functional, hardware, software, and data architectures (Comprehensive Architecture Strategy (CAS)). When optimizing the modularity of a system of or component, consider the following:

- Is the system, product, or capability modularity implemented at the desired levels and have we obtained the data and intellectual property needed for life cycle competition, technical refresh, product support, and operational flexibility?
- What is the ease and speed with which the proposed system can be updated in response to changing business/capability?
- How easily can the system can grow/scale to accommodate increased performance (e.g., higher transaction rates, more customers, etc.), expanded functionality (e.g., additional pricing methods) or scaled back to cost?
- Too what extent is the preferred system modularity implemented and verified?
- What is the ability of the system to provide the intended functionality, performance, and cost during all periods of desired use?
- Is the proposed MOSA approach affordable?

3.3.2 Functionality/Component Reuse

Ability of a product, system, or capability, to provide or facilitate all the specified tasks and user objectives with the correct results and the needed degree of precision; and meet mission capability needs. This includes completeness, correctness, appropriateness and readiness for reuse. Other factors include:

- Degree the system, or capability, operates as expected, or required, in its intended environment
- Degree the system, or capability, satisfies the users mission, objective, or purpose. Degree the MOSA technical implementation satisfies the MOSA requirements and achieves defined MOSA benefit at acceptable cost and schedule risk.

- Degree the system, product, or capability meets the contractual MOSA requirements imposed by the acquirer.
- Degree by which the system, product, or capability satisfies or is consistent with the acquirer's MOSA product roadmap and the supplier business objectives.
- Degree by which the system, product, or capability is free from any known operational or sustainment issues and ability to achieve MOSA benefits throughout the life cycle.

3.3.4 Performance

MOSA is an integral part of the solution. Performance is measures against the mission objectives. Performance measures the degree by which the system, product, or capability performs its intended functions and operations efficiently within target resource constraints. Other factors include:

- Degree the system behaves gracefully when approaching resource limits such as large number of users or transactions or increased demand
- Degree by which the system, product, or capability provides the results, actions, or responses within contractual or expected response time
- Degree by which the system, product, or capability provides the results, actions, or responses within contractual or expected response time
- Degree by which the system, product, or capability can meet its specified mission and MOSA technical objectives, thresholds, or properties while in its expected operational environment
- Degree by which the system, product, or capability allows for future growth in performance and reuse.
- Degree by which the downtime to perform upgrades and maintenance affect performance

3.3.3 Dependability

Ability of a product, system, or capability, to consistently perform its intended functions over time, recover from any failure condition, be available and operable when needed. This includes availability, reliability, recoverability, maintainability, and maintenance support. A MOSA objective of dependability includes the flowing:

- Ability to mitigate the impact of failures, shutdowns, system locking up, or waiting on system to the user, mission, or objective.
- Ability of the system to rapidly deliver, update, and/or fix system, or capability to meet operational needs.
- A life expectancy meets planned mission or user needs and MOSA benefits
- Ability of the system, product, or capability to recover normal or degraded operation as the result of a failure
- An acceptable degree of difficulty of development/integration of the system, product, or capability due to technical issues or technical maturity or lack of standards conformance and defined open interfaces
- Information/data with sufficient detail or resources to support maintenance during operations
- Minimal impacts do to end of life issues

3.3.4 Security

MOSA provides many benefits, but there are also security risks associated with different MOSA approaches. Security addresses the ability of a product, system, or capability, to resist cyber and/or physical interruption, intrusion, spoofing, or degradation of its expected operation and functionality. Security must be built in from the start and addressed in Program Protection Planning. Program should consider the following:

- Degree that the system, or capability protects the user and data from harm
- Degree by which the system, product, or capability can prevent or resist any interruptions in normal operations due to external influences
- Degree of which the system, product, capability resists, or prevents security attacks
- Is the approach for recurring accreditation with a modular open system architecture reasonable and acceptable?

3.3.5 Business Value

Ability of a product, system, or capability, to satisfy customer initial and total cost targets; supplier contract performance, including product delivery when promised; and supplier financial expectations throughout its lifecycle. Business value assessment include competition business opportunities, competition, effectiveness, cost and schedule risk assessment, and opportunities to increase affordability. A Key Business Driver (KBD) is defined as a resource, process or condition that has major impact on the business and is vital for the continued success of an organization. KBDs are a means of communicating stakeholder vision, guidance and critical business concerns. KBDs answer "why" the architecture is needed. Clearly conveying the key business objectives enables the selection of proven architectural concepts that meet the KBDs, independent of design and implementation decisions. KBDs succinctly state the critical business drivers that must be met. All subsequent stakeholder objectives, constraints and quality attributes should ideally trace back to one of the KBDs (Comprehensive Architecture Strategy (CAS)). Key MOSA business consideration include:

- Degree by which the system, product, or capability will improve the mission capability and yet stay within budget constraints using a MOSA approach.
- Degree of business impacts on product portfolios and mission capabilities
- Degree of financial impact to the company (Cash flow, revenue, profit…) or the ability of the organization to support the project with their current budget and resources.
- Degree of cost investment versus return for the company /organization efficiency/effectiveness? (Return on Investment) MOSA investment can provide life cycle cost savings through development, production, and sustainment
- MOSA Cost and Schedule Risk: Degree of impact to the value of the system, product, or capability if it is delayed compared to its potential lifetime value

3.4 Appendix D – NASA Software Reuse Readiness Levels

Reuse provides significant opportunities for cist savings/avoidance and schedule/cycle time reductions. The NASA reuse level assessment identify to attributes that should be considered when assessing the risk of reuse software. (NASA Reuse Readiness Levels) Figure 10 describes the high level criteria for each reuse level. Table 2 of Appendix D provides the definitions for each the 8 evaluation subfactors and their contribution to MOSA benefits. Brief descriptions of the evaluation subfactors are found below.

Reuse Readiness Level	Reuse Recommendation	Reuse Level Characteristics
Level 1	Limited reusability; the software is not recommended for reuse	Little is provided beyond limited source code or pre-compiled, executable binaries
		There is no support, contact information for developers or rights for reuse specified
		The software is not extensible, and there is inadequate or no documentation
Level 2	Initial reusability; software reuse is not practical.	Some source code, documentation, and contact information are very limited provided
		Initial testing has been done, but reuse rights are still unclear
		Reuse would be challenging and cost-prohibitive.
Level 3	The software might be reusable by skilled users at substantial effort, cost, and risk	Software has some modularity and standards compliance
		Some support is provided by developers
		Detailed installation instructions are available, but rights are unspecified.
		An expert may be able to reuse the software, but general users would not.
Level 4	Reuse is possible; the software might be reused by most users with some effort, cost, and risk	Software and documentation are complete and understandable
		Software ahs been demonstrated in a lab on one or more specific platforms
		Infrequent patches are available, and intellectual property issues would need to be negotiated.
		Reuse is possible, but may be difficult
Level 5	Reuse is practical; the software could be reused by most users with reasonable cost and risk	Software is moderately portable, modular, extendable, and configurable
		Low-fidelity standards compliance
		User manuals are available
		Software has been tested in the lab
		A user community exists but there may only be a few experts
		Developers may be contacted to request limited rights for reuse.
Level 6	Software is reusable; the software can be reused by most users although there may be some cost and risk	Software has been designed for extensibility, modularity, and portability
		Software and documentation may still have limited applicability
		Tutorials are available
		The software has been demonstrated in a relevant context
		Developers may be contacted to obtain formal statements on restricted rights or to negotiate additional rights
Level 7	Software is highly reusable; the software can be reused by most users with minimum cost and risk	Software is highly portable and modular, has high-fidelity standards compliance, provides auto-build installation, and has been tested in a relevant context.
		Support is developer organized, and an interface guide is available
		Software and documentation are applicable for most systems.
		Brief statements are available describing limited rights for reuse and developers may be contacted to negotiate additional rights
Level 8	Demonstrated local reusability; the software has been reused by multiple users	Software has been shown to be extensible, and has been qualified through test and demonstration
		An extension guide and organization-provided support are available
		Brief statements are available describing unrestricted rights for reuse and developers may be contacted to obtain formal rights statements.
Level 9	Demonstrated extensive reusability; the software is being reused by many classes of users over a wide range of systems	Software is fully portable and modular, with all appropriate documentation and standards compliance, encapsulated packaging, a GUI installer
		A large support community that provides patches exists
		Software has been tested and validated through successful use of application output.
		Multiple statements describing unrestricted rights for reuse and the recommended citation are embedded into the product

Figure 12 - NASA Software Reuse Readiness Levels

3.4.1 Documentation

Information that describes the software asset and how to use it.   Reuse risks are lower it the documentation enables potential adopters to determine whether the software addresses the need and informs adopters how to utilize the software and reduce the risks and costs of reuse. The documentation should include descriptions of interfaces and capabilities, information about the execution environment, and instructions for the consumer on the purpose of the asset and on ways in can be reused. Documentation should also describe plans for subsequent releases and future development.

3.4.2 Extensibility

Extensibility measures the ability of the asset to be grown beyond its current context. MOSA benefits can more easily be achieved when the implementation takes into consideration future growth and ease of extending function. It is a measure of the ability to extend a system and the level of effort required to implement the extension. Extensions, or expandability, can apply to re-engineering or during runtime. Extensibility is an important dimension to be able to incorporate an asset and add to or modify its functionality.

3.4.3 Intellectual Property

To reuse software or hardware the legal rights for obtaining, using, modifying and distributing the asset must be available. This is a formal and documented explanation of the involved parties and roles, with binding statements describing any licensing mechanisms, ownership rights, restrictions, and user/consumer responsibilities related to the distribution and reuse of assets.

3.4.4 Modularity

Modularity is the degree of segregation and containment of an asset or components of an asset. For reuse to be effective the modularity needs to be at the level where changes will be made. Modularity is a software design technique that increases the extent to which software is composed from separate components, called modules. Conceptually, modules represent a separation of and encapsulation of concern, purpose, and function, and they improve maintainability, reusability, and facilitate change. Modular assets generally are easier to synthesize and extend. Modularity enhances competition during development and replacement of components throughout the life cycle.

3.4.5 Packing

Packing is the methodology and technology for assembling and encapsulating the components of a software asset. Packaging pertains to the technologies, standards, and procedures related to gathering, organizing, assembling, and compressing the parts of a software system and distributing it as a collection. Packaging is important to ensure completeness, to allow distribution, and to simplify the installation of the asset.

3.5.6 Portability

Portability is the independence of an asset from platform-specific technologies. Portability refers to two components: software consisting of source code that can be compiled for various computing platforms; software executables that can be executed on various platforms. The ability to be installed or executed on various platforms maximizes reuse potential and increases the flexibility and (re-)usability of the asset and its applications.

3.5.7 Standards Compliance

Standards compliance is the adherence of an asset to accepted technology definitions. It ensures commonly accepted criteria, models, patterns and/or specifications have been followed in the creation of a reusable asset; and at what level the asset complies with the selected acceptable standards and reference architectures. By complying with accepted standards and reference architectures, the asset has increased potential for adoption.

3.5.8 Support

Support is the amount and type of assistance available to users of the asset. Technical support exists, in the form of various communication methods with the asset's developers, documentation/knowledge bases, user communities, support level agreements, and online forums. Support includes a release strategy and plan for patches and versions that are created. Support provisions expertise to assist in maintenance, evolution, extension and issue resolution.

3.4.9 Verification and Validation

Verification and validation are the degree to which the functionality and applicability of the asset has been demonstrated. This can be realized through the provision of test material, requirements compliance, proper function, and usability (robustness). Tests are documented, results are analyzed and published, and fixes and enhancements applied. Sufficient verification and testing increase the accuracy and confidence and reduces potential risks and costs of reuse. The degree to which the functionality and applicability of the asset has been demonstrated in a similar environment increases the probability of successful reuse.

3.4.11 Reuse Use Case and Criteria-Based Trade Study Models

During Mission/Business Analysis program define the MOSA business case or mission problem or opportunity, characterize the solution space, and determine potential MOSA solution(s) that could address a problem or take advantage of an opportunity to achieve MOSA reuse benefits. The Modular Open System Approach Enhance HW- SW Use Case address the addresses the employment of MOSA design tenants, implementation strategies and metrics for measuring progress and MOSA benefits using software reuse. The NASA SW Reuse Readiness Levels Assessment Tool was adapted for the NASA paper and provides a criteria-based trade study for assessing reuse candidates.

- Modular Open System Approach Enhance HW- SW Reuse
- NASA SW Reuse Readiness Levels Assessment Tool SAH

3.6 Appendix E – Navy CANES MOSA Acquisition/Technical Refresh Strategy

The Navy Consolidates Afloat Navy Enterprise System (CANES) was an early adopter of MOSA. Their approach stressed a strategy that maximizes the following:

- Competition throughout program's lifecycle
- Competitive procurement for Engineering & Manufacturing Development (EMD)
- Down-select for Limited Deployment (LD)
- Separate Full & Open competition for Full Deployment (FD) Production Units

The CANES life cycle support approach specified:

- Design CANES Functional Baseline and CANES architecture to support MOSA
    - Ensure portability, scalability, and interoperability compatible with the CANES system architecture and existing afloat/ashore systems
- Select, integrate, and test Contractor Furnished Equipment (CFE), COTS components, and NDI components that satisfy the system requirements and the open system goals
- Design a system that can be improved incrementally without redesign of the entire system
- Develop in accordance with the NESI Implementation Framework.

The Navy solution selections and integration priorities were as follows:

- Assess impact to the overall modular open systems architecture.
- Ensure long term supportability
- Facilitate growth for future modifications
- Focus on ease of integration
- Facilitate addition of high-performance elements with minimal impact on existing systems
- Provide a viable technology insertion methodology and refresh strategy that supports application of a MOSA and is responsive to changes driven by mission and technology

The winning Northrop Grumman approach was solution was based on continuous competition throughout the CANES life cycle. Key elements in the winning bid and execution where as follows:

- Vendor neutral open, modular and scalable design
    - Used consensus open IT standards
    - Design to cost and Cost as an Independent Variable Trades
- Built Operational Prototype prior to CDR
    - All potential supplier products integrated in prototype – enabled selectable configurations
    - Demonstrated system performance with different product configurations
- Enabled continuous competition of component products for each buy
    - 80% of the Bill of material cost was in 20 products
    - Obtained up to 83% cost discounts
- Automated production loads to reduce cost and speed delivery

The Navy is continuing to accrue MOSA benefits with the evolution of the CANES system by the following:

- 20 Dec 2022 award of a 10-year multiple-award, indefinite-delivery/indefinite-quantity contract to ensure enhanced competition
    - Provide a secure afloat network for naval and joint operations, advancing the <u>use of a common computing environment</u> and mature cross domain technologies to <u>reduce the number of afloat networks and reduce the infrastructure footprint and related training, logistics and sustainment costs</u>
    - Rapid deployment to mitigate cyber security threats, keep pace with increased computing requirements for hosted applications, and support Department of Defense (DoD) directives to remove End of Life (EOL) Windows Operating Systems software from the Fleet as quickly as feasible.

    - Consolidates existing Afloat Network programs of record designed to provide an agile, responsive Common Computing Environment (CCE) and Agile Core Services (ACS) within and upon which application developers will host Command and Control, Warfare, Intelligence, Logistics, and business and education applications and services. Migration of Non-Classified Enclave (NCE) capabilities into the CANES baseline.
- CANES Application Integration effort provide common software governance, testing, processes, and tools to application developers, and conducts integration testing to confirm compatibility for hosted applications prior to fielding

3.7 Appendix F – USAF GATM MOSA Acquisition/Technical Refresh Strategy

In the late 1990s, international airspace was rapidly undergoing significant changes which required new equipage on DoD aircraft. If not addressed; the changes would have had significant operational impacts on 15,000 DoD aircraft. The $2.5B investment in these changes avoided these impacts and provided an opportunity to apply MOSA principals to achieve the following benefits:

- Reuse and increase competition to reduce cost
- Standard interfaces between modules and increased commonality
- Technology evolution roadmap scyhronized with industry
- Airspace system capacity increase
- Economic benefits of operations in optimum flight envelope
- Upgrade or elimination of the high-cost/labor intensive ground-based air traffic control (ATC)
- Air traffic service provide growth in developing countries
- Reduction in operations and maintenance (O&M) cost for ground infrastructure
- Technology substitutions for controllers and maintenance personnel
- Expanded capability in the overloaded communications networks and overused frequency spectra
- Transition from analog to digital systems

Figure 11 shows how the integrated business and technical USAF acquisition strategy employed MOSA principals to achieve benefits. More details and information are contained in Appendix G.

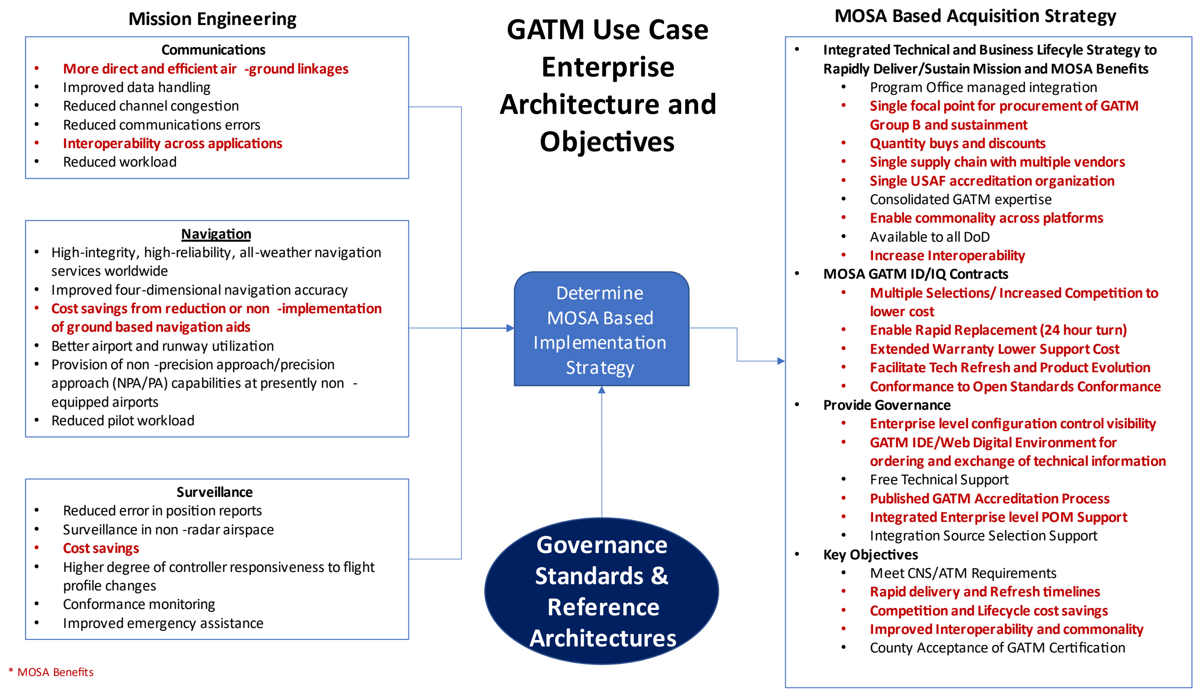


Figure 13– USAF GATM Acquisition Strategy and Benefits

3.8 Appendix G – Army PEO Aviation MOSA Guidance

The Army PEO Aviation is an exemplar example for implementing MOSA at the enterprise level. They have published guidance and are implementing an enterprise MOSA governance and management approach through their MOSA Transformation Office. Figure 12 provides and overview of their transformation process.

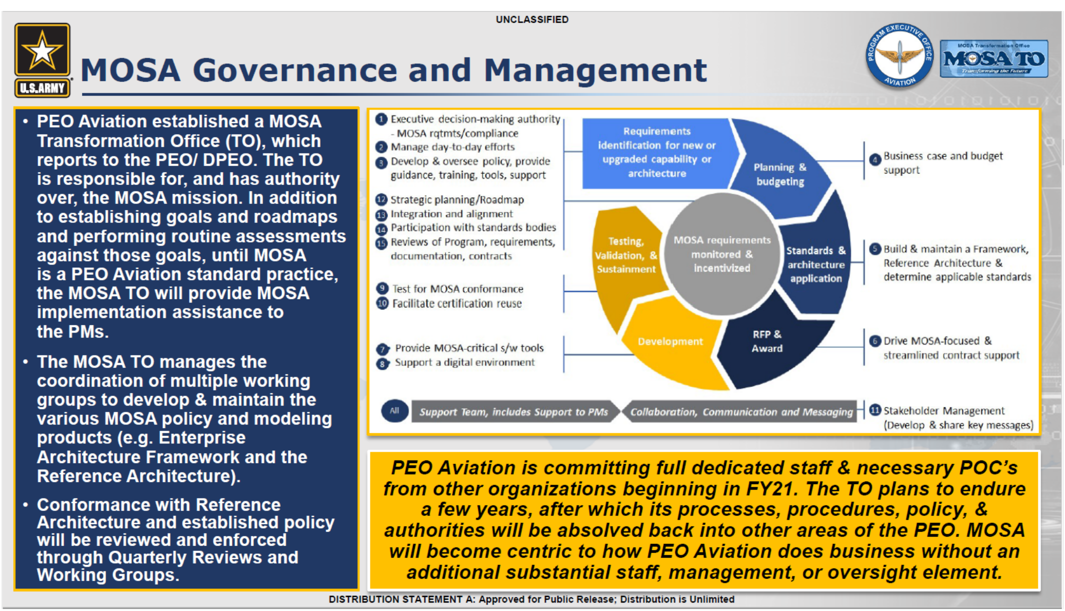


Figure 14 - PEO Aviation Governance and Management PEO Aviation MOSA Implementation Guide Skinny, August 2021

More importantly, PEO Aviation has clearly defined the MOSA objectives for all PEO Aviation Acquisition Program. Figure 13 provides the PEO Aviation MOSA definitions and objectives.

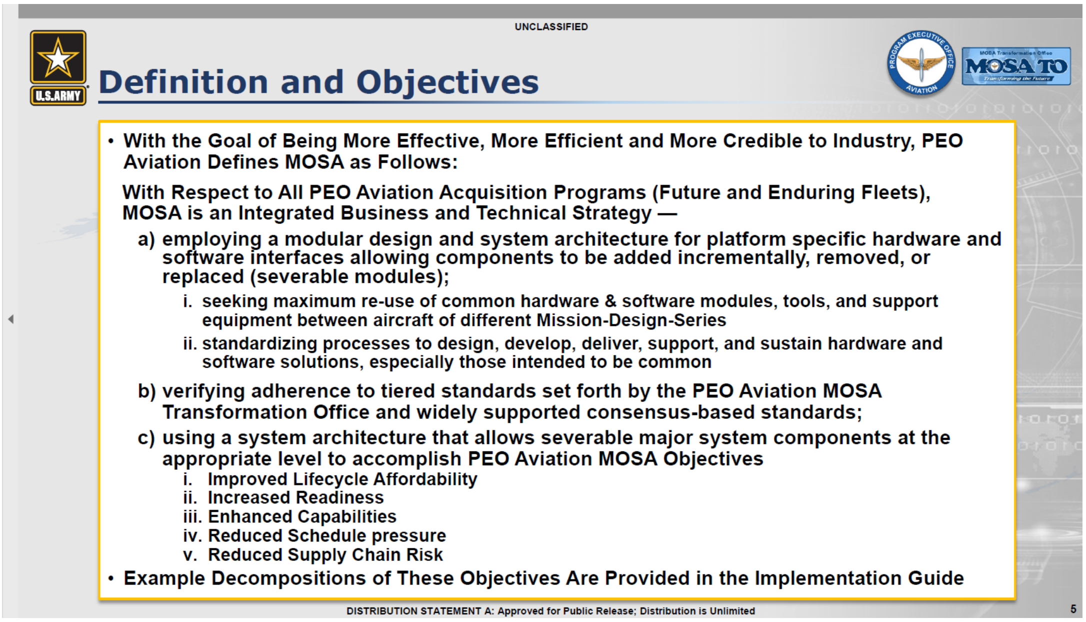


Figure 15 - PEO Aviation MOSA Definitions and Benefit Objectives

The following are links to Key PEO Aviation's MOSA guidance/information.

- PEO Aviation MOSA Implementation Guide Skinny
- MOSA Transformation Office
- PEO Aviation's Modular Open Systems Demonstration

3.9 Appendix H – Systems Engineering Technical Review Questions

The IEEE 15288.2 defines the DoD expectations for major technical reviews. It is an excellent resource to guide program planning efforts in all disciplines. However, remember the standard is tailorable so different programs may not do all of the activities. As proactive leaders, we should always be looking ahead to assess our risks and identify opportunities. This can be done by selecting leading indicator metrics and by asking probing questions in regards to planned activities leading to each major program event. To prototype a construct, we have reviewed the IEEE 15288.2 expectations and developed questions that assess our readiness for each technical review. The following are questions directed at the following reviews/knowledge points: SRR, SFR, PDR, CDR, TRR, PRR, and Sustainment Reviews. In addition, we have added technical review questions for ready for Operational Test, Production Readiness, and Sustainment Reviews. While technically driven, the answers to these questions can have profound impacts on other disciplines in the program office.   As we each reflect on our own programs, what other questions should we be asking from your discipline? Appendix H identifies MOSA tailored information needs for each technical review.

3.10 Appendix I – System of Systems Interoperability and Mission Integration

The Modular Open Systems Approach (MOSA) Reference Frameworks in Defense Acquisition Programs recommends providing a business case for achieving MOSA-related benefits, to include: enhanced competition and innovation, significant cost savings or avoidance, schedule reduction, opportunities for technical upgrades, increased interoperability, including system of systems interoperability and mission integration, and other benefits during the sustainment phase of a major weapon system. Figure 14 identifies key information needs and metrics for implementing system of systems interoperability and mission integration.

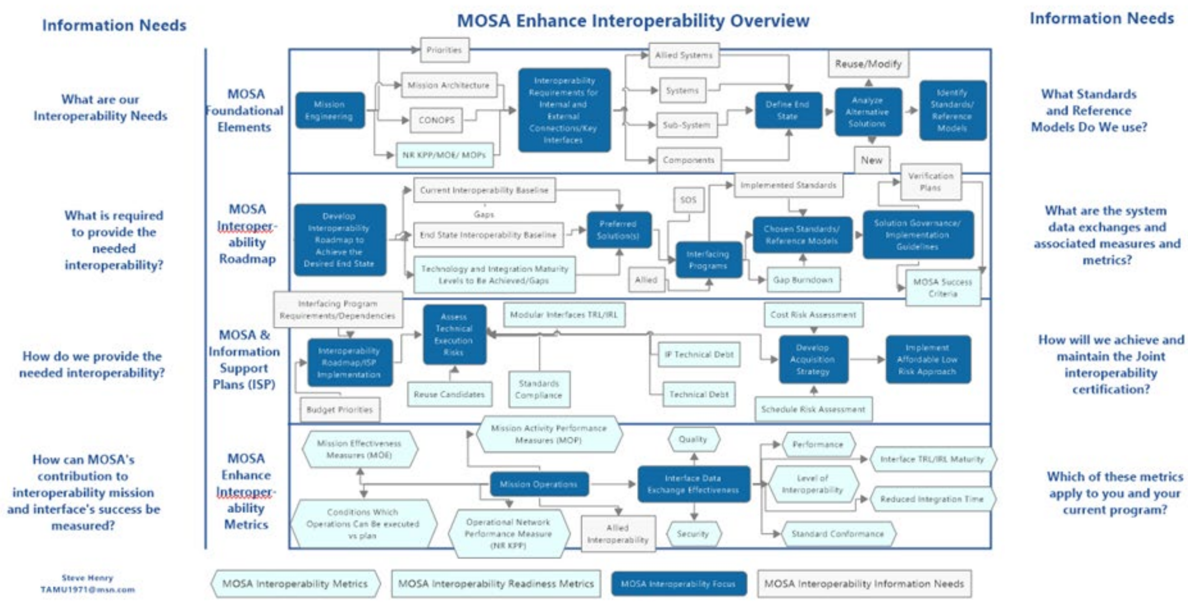


Figure 16 - MOSA Enhance Interoperability Overview

3.11 Appendix J - Methods and Assessment Criteria to Quantitatively Evaluate MOSA

Appendix J describes methods, MOSA implementation strategies and assessment criteria to quantitatively evaluate MOSA in designs, tech approach and business strategies during planning and source selection. The appendix also includes sample statement of work (SOW) and instruction to offeror section L and M examples. The intent of appendix is to enable quantitatively evaluation(s) of MOSA offerings to choose a partner that can effectively collaborate with the acquirer and deliver the desired MOSA benefits at acceptable risk within the program constraints.

3.12 Appendix K - MOSA Enhance Competition Strategy and Metrics

Figure 15 provides an approach to enhancing competition on program by implementing MOSA attributes. The figure shows four swim lanes with key information needs and decision points. The process can be started at any time during the system life cycle. The process will always start with Mission Engineering. Always start with the end in mind. What mission and MOSA benefits are required. Figure 5, Effective MOSA Implementations – What Gets Measured and Acted Upon Gets Done, outlines a 7-step process of implementing MOSA. The first 3 swim lanes in Figure 15 complement and provide more detail on Figure 5 steps 1-4. Swim lane 4 support Figure 5 steps 5-7 and focuses on the effectiveness of the competitive strategy over time.

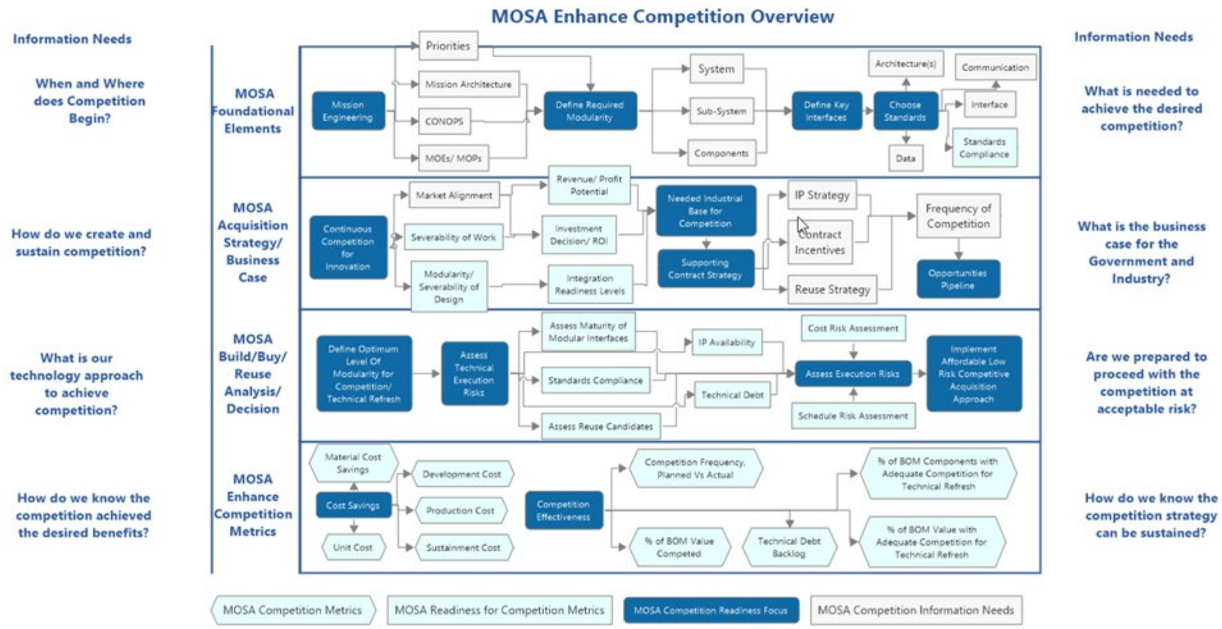


Figure 17 - Approach for Implementing Enhance Competition With MOSA

4.0 Key MOSA References

4.1 Statutory

- **10 USC 4401: Requirement for modular open system approach in major defense acquisition programs**
- **10 USC 4402: Requirement to address modular open system approach in program capabilities development and acquisition weapon system design**
- **10 USC 4403: Requirements relating to availability of major system interfaces and support for modular open system approach definitions**
- **10 USC 3771: Rights in technical data: regulations**
- **10 USC 3772: Rights in technical data: provisions required in contracts**
- **10 USC 3774: Major weapon systems and subsystems: long-term technical data needs**
- **10 USC 3775: Definitions**
- **10 USC 2222: Defense business systems: business process reengineering; enterprise architecture; management**
- **10 USC 2223: Information technology: additional responsibilities of Chief Information Officers**
- **10 USC 2224: Defense Information Assurance Program**

4.2 Policy

- **DOD DIRECTIVE 6200.04 Force Health Protection (FHP)**

- **DOD DIRECTIVE 7045.14 The Planning, Programming, Budgeting, and Execution (PPBE) Process**
- **DOD 7000.14-R Department of Defense Financial Management Regulation (DoD FMR)**
- **CJCSI 5123.01I 30 October 2021 CHARTER OF THE JOINT REQUIREMENTS OVERSIGHT COUNCIL AND IMPLEMENTATION OF THE JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM**
- **JCIDS Manual 30 October 2021 MANUAL FOR THE OPERATION OF THE JOINT CAPABILITIES**
- **DOD INSTRUCTION 4120.11 MOBILE ELECTRIC POWER SYSTEMS (MEPS)**
- **DOD INSTRUCTION 4120.24 DEFENSE STANDARDIZATION PROGRAM**
- **DOD INSTRUCTION 5205.83 DOD INSIDER THREAT MANAGEMENT AND ANALYSIS CENTER (DITMAC)**
- **DOD INSTRUCTION 8330.01 INTEROPERABILITY OF INFORMATION TECHNOLOGY, INCLUDING NATIONAL SECURITY SYSTEMS**
- **DOD INSTRUCTION 8310.01 INFORMATION TECHNOLOGY STANDARDS IN THE DOD**
- **DOD INSTRUCTION 8420.02 DOD SATELLITE COMMUNICATIONS**
- **DOD INSTRUCTION 5000.01 THE DEFENSE ACQUISITION SYSTEM**
- **DOD INSTRUCTION 5000.02 OPERATION OF THE ADAPTIVE ACQUISITION FRAMEWORK**
- **DOD INSTRUCTION 5000.88 ENGINEERING OF DEFENSE SYSTEMS**
- **DOD INSTRUCTION 5000.73 COST ANALYSIS GUIDANCE AND PROCEDURES**
- **DOD INSTRUCTION 5000.75 DEFENSE BUSINESS SYSTEMS**
- **DOD INSTRUCTION 5000.80 MIDDLE TIER ACQUISITION**
- **DOD INSTRUCTION 5000.82 ACQUISITION OF INFORMATION TECHNOLOGY**
- **DOD INSTRUCTION 5000.83 TECHNOLOGY AND PROGRAM PROTECTION TO MAINTAIN TECHNOLOGICAL ADVANTAGE**
- **DOD INSTRUCTION 5000.84 ANALYSIS OF ALTERNATIVES**
- **DOD INSTRUCTION 5000.86 ACQUISITION INTELLIGENCE**
- **DOD INSTRUCTION 5000.85 MAJOR CAPABILITY ACQUISITION**
- **DOD INSTRUCTION 5000.87 SOFTWARE ACQUISITION**
- **DOD INSTRUCTION 5000.89 TEST AND EVALUATION**
- **DOD INSTRUCTION 5000.90 CYBERSECURITY FOR ACQUISITION DECISION AUTHORITIES AND PROGRAM MANAGERS**
- **DOD INSTRUCTION 5000.91 PRODUCT SUPPORT MANAGEMENT FOR THE ADAPTIVE**
- **DOD INSTRUCTION 5000.95 HUMAN SYSTEMS INTEGRATION IN DEFENSE ACQUISITION**
- **DOD INSTRUCTION 5010.44 INTELLECTUAL PROPERTY (IP) ACQUISITION AND LICENSING**
- **AIR FORCE INSTRUCTION 63-101/20-101 INTEGRATED LIFE CYCLE MANAGEMENT**
-

4.3 MOSA Related Guidance

- **DoD Engineering of Defense Systems Guidebook**
- **DoD Systems Engineering Guidebook**
- **Department of Defense Systems Engineering Plan (SEP) Outline, V 4.1**
- **MIL-HDBK-61B - Configuration Management Guidance [ASSIST]**
- **DI-MGMT-82099 - Open Systems Management Plan (OSMP) [ASSIST]**

- **DI-SESS-82007B - Configuration Item (CI) Documentation Recommendation [ASSIST]**
- **DI-SESS-82333B - Acquisition and Sustainment Data Package (ASDP) Configuration Status Accounting (CSA) Information [ASSIST]**
- **DI-SESS-81694 - Engineering Database and Configuration Management Information (EDCMI) [ASSIST]**
- **DI-SESS-80858D - Supplier's Configuration Management Plan [ASSIST]**
- **DI-SESS-81343A NOT 2 - Information Security (INFOSEC) Boundary Configuration Management Plan [ASSIST]**
- **DI-MGMT-81776 NOT 2 - Configuration Data Management Database-Open Architecture (CDMD-OA) CDMD-OA Metric Report [ASSIST]**
- **ACMP-1 ED.2 - NATO REQUIREMENTS FOR THE PREPARATION OF CONFIGURATION MANAGEMENT PLANS [ASSIST]**
- **ACMP-6 ED.2 - NATO CONFIGURATION MANAGEMENT TERMS AND DEFINITIONS [ASSIST]**
- **ACMP-7 ED.2 - NATO CONFIGURATION MANAGEMENT - GUIDANCE ON THE APPLICATION OF ACMP 1- 6 [ASSIST]**
- **ACMP-2000 ED.A - POLICY ON CONFIGURATION MANAGEMENT [ASSIST]**
- **ACMP-2009 ED.A(1) - GUIDANCE ON CONFIGURATION MANAGEMENT [ASSIST]**
- **ACMP-2100 ED.A(1) - CONFIGURATION MANAGEMENT CONTRACTUAL REQUIREMENTS [ASSIST]**
- **QSTAG-2117 - INFORMATION MANAGEMENT BASELINE STANDARD [ASSIST]**
- **STANAG-4159 ED.2(1) - NATO MATERIEL CONFIGURATION MANAGEMENT POLICY AND PROCEDURES FOR MULTINATIONAL JOINT PROJECTS [ASSIST]**
- **STANAG-4427 ED.3 - CONFIGURATION MANAGEMENT IN SYSTEM LIFE CYCLE MANAGEMENT - ACMP-2000 EDITION A & ACMP-2009 EDITION A & ACMP-2100 EDITION A [ASSIST]**
- **EIA-649-1 - Configuration Management Requirements for Defense Contractors [ASSIST]**
- **EIA-649-C - Configuration Management Standard [ASSIST]**
- **SAE-GEIA-HB-649A - Configuration Management Standard Implementation Guide [ASSIST]**
- **MIMOSA-OSA-EAI-2004 - Mimosa Open Systems Architecture for Enterprise Application Integration (OSA-EAI) Standards [ASSIST]**
- **ARMY-VICTORY-001 NOT 1 - Vehicular Integration for Command, Control, Communication and Computers, Intelligence Surveillance, and Reconnaissance and Electronic Warfare (C4ISR/EW) Interoperability (VICTORY) [ASSIST]**
- **JOINT-UXS-002 NOT 1 - Modular Open Systems Approach (MOSA) Portfolio-Hardware Open Systems Technologies (HOST), Future Airborne Capability Environment™ or Face™, Sensor Open Systems Architecture or SOSA™, Unmanned Systems (UXS) Control Segment (UCS), and Open Mission Systems (OMS) [ASSIST]**
- **JOINT-GRA-003 NOT 1 - US Air Force Modular Open Systems Approach (MOSA) Portfolio [ASSIST]**
- **DI-MGMT-82170 NOT 1 - Maintenance and Material Management/Open Architecture Retrieval System (3M/Oars) Database Transaction Report [ASSIST]**
- **AEP-104A(1) - NATO DEFENSIVE AIDS SYSTEMS (NDAS) OPEN ARCHITECTURE [ASSIST]**
- **ANEP-50 ED.1 - SHIPBOARD OPEN SYSTEM ENVIRONMENT [ASSIST]**
- **ANEP-53 ED.1 - EXTENSION TO SHIPBOARD OPEN SYSTEM ENVIRONMENT INTERFACE [ASSIST]**

- **STANAG-4250 ED.2 - NATO Reference Model for Open Systems Interconnection - Part 1: General Description [ASSIST]**
- **STANAG-4250-1 ED.2 - NATO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTION - (PART I) : GENERAL DESCRIPTION [ASSIST]**
- **STANAG-4255 ED.1 - NATO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTION - LAYER 5 (SESSION LAYER) SERVICE DEFINITION [ASSIST]**
- **STANAG-4256 ED.1 - NATO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTION - LAYER 6 (PRESENTATION LAYER) SERVICE DEFINITION [ASSIST]**
- **STANAG-4258 ED.1 - NATO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTION - SPECIFICATION OF ABSTRACT SYNTAX NOTATION 1 (ASN.1) [ASSIST]**
- **STANAG-4259 ED.1 - NATO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTION - ENCODING RULES FOR ASN.1 [ASSIST]**
- **STANAG-4265 ED.1 - NATO Reference Model for Open Systems Interconnection - Layer 5 (Session Layer) Protocol Specification [ASSIST]**
- **STANAG-4266 ED.1 - NATO REFERENCE MODEL FOR OPEN SYSTEMS INTERCONNECTION - LAYER 6 (PRESENTATION LAYER) PROTOCOL SPECIFICATION [ASSIST]**
- **STANAG-4781 ED.1 - NATO DEFENSIVE AIDS SYSTEMS (NDAS) OPEN ARCHITECTURE - AEP-104 EDITION A [ASSIST]**
- **PROGRAM MANAGERS GUIDE TO DIGITAL AND AGILE SYSTEMS ENGINEERING PROCESS TRANSFORMATION, SERC-2022-TR-009, 14 Sep 2023**
- **IEEE 15288-2023 – Systems and software engineering – System life cycle processes**
- **IEEE 15288.1 - Application of Systems Engineering on Defense Programs**
- **IEEE 15288.2 - Technical Reviews and Audits on Defense Programs**
- **Best Practices for Using Systems Engineering Standards (ISO/IEC/IEEE 15288, IEEE 15288.1, and IEEE 15288.2) on Contracts for Department of Defense Acquisition Programs**
- **Department of Defense (DoD) Digital Engineering Fundamentals**
- **Early Manufacturing and Quality Engineering Guide**
- **DoD Open Systems Architecture for Program Managers, V1.1**
- **DOD CAPE COST ESTIMATING GUIDE, V1**
- **DoD CAPE OPERATING AND SUPPORT COST-ESTIMATING GUIDE**
- **OUSD(R&E) MOSA Assessment Criteria**
- **OUSD(R&E) Review of MOSA Tools and Practices**
- **OSD R&E Modular Open Systems Approach (MOSA)Reference Frameworks in Defense Acquisition Programs**
- **Defense Standardization Program, Modular Open Systems Approach (MOSA)**
- **DAU Systems Engineering Brain Book**
- **DAU Integrated Product Support (IPS) Elements Guidebook**
- **DAU Technical Reviews and Risk Assessments**
- **National Defense Industrial Association Systems Engineering Architecture Committee NDIA Modular Open Systems Approach, Considerations Impacting Both Acquirer and Supplier Adoption**
- **Guidance for e-Program Designations**

- AIR FORCE MATERIEL COMMAND (AFMC) GUIDEBOOK FOR IMPLEMENTING MODULAR OPEN SYSTEMS APPROACHES IN WEAPON SYSTEMS
- Airforce Data Rights Guidebook
- Acquiring and Enforcing the Governments Data Rights in Technical Data and Computer Software Under Department of Defense Contracts: A practical Handbook for Acquisition Professionals, 9th Edition
- Army ASALT Comprehensive Architecture Strategy (CAS)
- Army PEO Aviation MOSA Implementation Guide Skinny
- Army PEO Aviation MOSA Information Package
- Army PEO Aviation MOSA Quick Guide
- Naval Open Architecture Contract Book
- MANUAL FOR THE OPERATION OF THE JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM
- DI-MGMT-82099, DATA ITEM DESCRIPTION (DID): OPEN SYSTEMS MANAGEMENT PLAN
- COST ESTIMATING AND ASSESSMENT GUIDE, Best Practices for Developing and Managing Program Cost
- Schedule Assessment Guide Best Practices for Project Schedules

4.4 Metrics Specifications and Definitions

- Continuous Iterative Development (Agile) Measurement Framework
- Digital Engineering (DE) Measurement Framework
- SYSTEMS ENGINEERING LEADING INDICATORS GUIDE, V 2.0
- SE Brain Book - DAU Technical Risk Assessments
- DAU Life Cycle Sustainment Outcome Metrics