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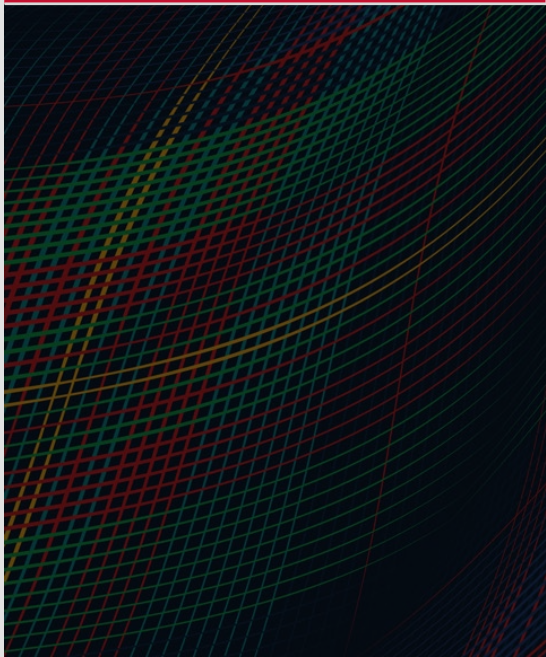

A Model for Evaluating the Maturity of a Modular Open Systems Approach

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Agenda

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- Earlier Efforts
- MOSA Maturity
- Summary

How Do You Test “Open Architectures”?

Video Clip From 2023 Acquisition Research Symposium Day 2 Keynote Address

A Model for Evaluating the Maturity of a Modular Open Systems Approach

Introduction and Context

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Introduction

We introduce a way to characterize maturity with respect to implementing a Modular Open Systems Approach (MOSA) for Department of Defense (DoD) acquisition.

- **We believe this characterization will lead to an improved evaluation method. We elaborate and comment on prior evaluation methods.**
- **We describe a hierarchy of business and technical acquisition aspects related to openness that is aligned to the Adaptive Acquisition Framework and the FY-21 NDAA.**
- **These sections together illuminate some specific requirements associated with MOSA for the DoD.**
- **We then connect those requirements with a tool that can be used to evaluate the cost of making investments in MOSA-aligned products.**

This paper builds on work by Carnegie Mellon University's Software Engineering Institute (CMU/SEI) that evaluates open architecture approaches. Particularly noteworthy is the blog post Addressing Open Architecture in Software Cost Estimation (Gagliardi et al., 2020).

Context

Broad application of a MOSA across the DoD and Military Services of the Army, Air Force, Space Force, Navy, and Marine Corps (i.e., the Services) enables effective decision making in evaluating choices among innovative alternatives and competing technologies. A key motivation for a MOSA is to enable a mechanism for inserting innovative technical solutions into the hands of the military users (i.e., warfighters) as rapidly and affordably as possible.

At its core, however, a MOSA is an architectural constraint to be balanced against other architectural constraints (such as performance, safety, security). While principles of modularity and openness can be applied broadly, when it comes to a MOSA, the real benefit occurs when the government correctly anticipates the specific pieces of technology that are likely to be upgraded/replaced over the product's lifecycle and makes the necessary investments in that technology *when the product is being developed* to facilitate those changes/upgrades, thereby proactively reducing technical debt over the lifecycle.

Unlike Thermodynamics, MOSA is NOT Everywhere!

MOSA – Features and Benefits

An effective MOSA should be implemented with (1) sound and mature technical characteristics, (2) well-reasoned and nuanced approaches to competitive dynamics, and (3) the thoughtful use of intellectual property rights in technical data.

The key benefits of a MOSA-based implementation include the following:

- **Enhance competition by employing open architectures with severable modules, allowing open competition of architectural functions/system components.**
- **Facilitate technology refresh by enabling delivery of new capabilities or replacement technology with minimal impact on system design.**
- **Incorporate innovation by ensuring operational flexibility to configure and reconfigure available assets to meet rapidly changing operational requirements.**
- **Enable cost savings/cost avoidance through reuse of technology, modules, or components from any qualified supplier across the acquisition life cycle.**
- **Improve interoperability by allowing changes and updates to severable software and hardware modules independently**

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Congressional Direction and Military Services Guidance

FY-21 NDAA Section 804

(a) Modular Open System Approach Requirement. — ***All (MDAP and "other") defense acquisition programs*** *shall be designed and developed,* ***to the maximum extent practicable****, with a* ***modular open system approach*** *to enable* ***incremental development*** *and* ***enhance competition****,* ***innovation****, and* ***interoperability****.*

Taken in aggregate, the message in this legislation is clear:

- The technical architecture should be built on a set of standards that are open and available to any qualified provider.
- A modular construct for weapon systems must comport to business practices that facilitate the government's ability to choose alternatives in a competitive environment.
- Complete details of the interfaces that characterize the interaction between the modules must be made available to the government and can be provided to competitors in a related market.
- Modular designs and related interfaces will be subject to government verification and validation.
- Sharing information that represents the fire of innovation, which is the principal driver of competitive market dynamics, must be preserved.

Tri-Services Memo (Jan. 2019) and Services Guidance

"…further development of Modular Open Systems Approach (MOSA) standards in areas where we lack them is vital to our success. As such, MOSA supporting standards should be included in all requirements, programming and development activities for future weapon system modifications and new start development programs to the maximum extent possible.

"In an effort to formalize our approach to MOSA, Service Acquisition Executives will publish specific implementation guidance for our acquisition programs… requirements and programming functions will ensure MOSA is reflected in our requirements and programs to ensure our future weapon systems can communicate and share across domains."

- Army PEO Aviation MOSA Transformation Office has published significant materials to help their acquisition programs and is providing direct support to help their programs improve their MOSA footprint.
- Air Force Materiel Command has produced a Modular Open Systems Guidebook
- OUSD(R&E) has taken a leadership role, standing up several Tiger Teams, and continuing to build a MOSA community of practice

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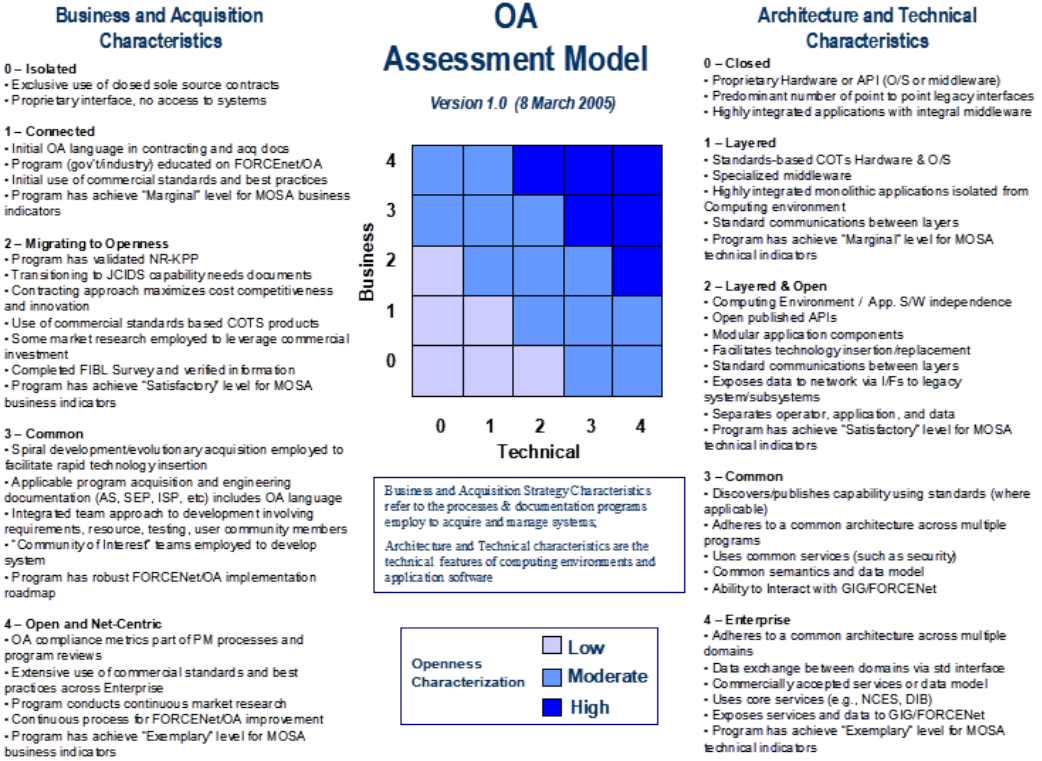
MOSA Assessment Methods Through the Years

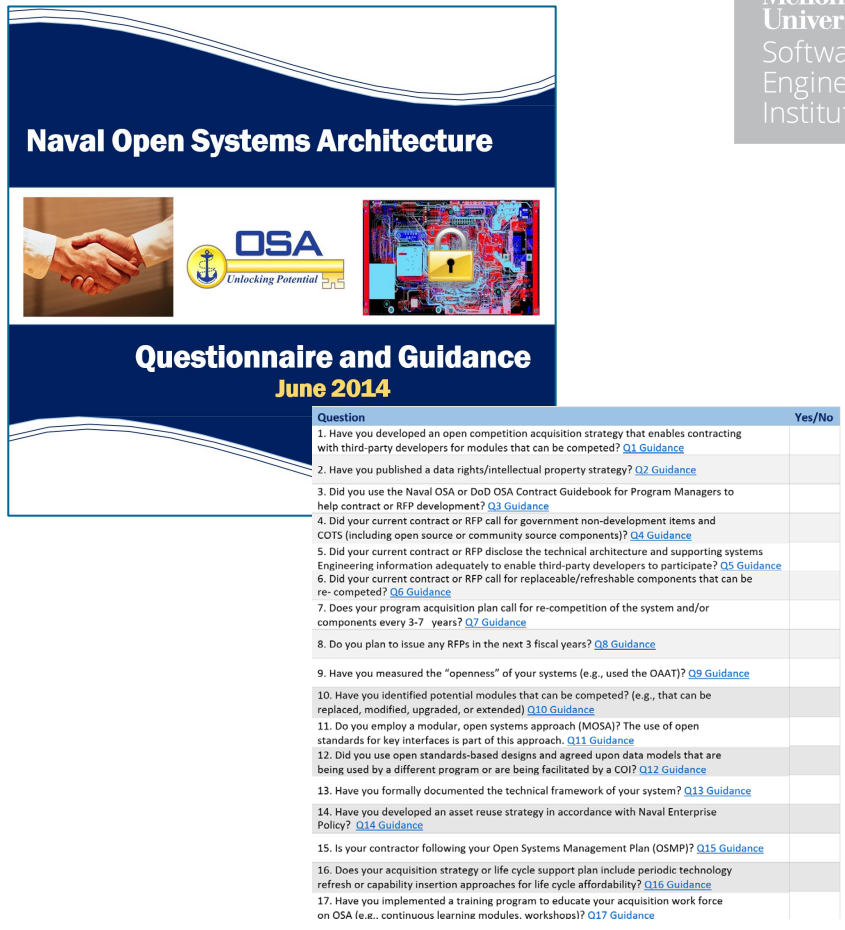
Surveys

Name	Date Range	Comments	Key Artifacts
Modular Open Systems Approach, Program Assessment and Rating Tool (MOSA PART):	1997-2004	Voluntary participation, preliminary effort	
Open Architecture Assessment Tool (OAAT):	2005-2013	Evolution from MOSA PART, defined two axes of “openness” – business and technical 64 Questions – 50/50 split	Open Architecture Assessment Model
NOA Questionnaire	2014-2016	17 Questions – 8 Business, 8 Technical, 1 Workforce	NOA Questionnaire

Some Graphics



(Image: OAAT User's Guide V3.0, OAET)



(Image: U.S. Navy)

OUSD(R&E) MOSA Assessment Efforts

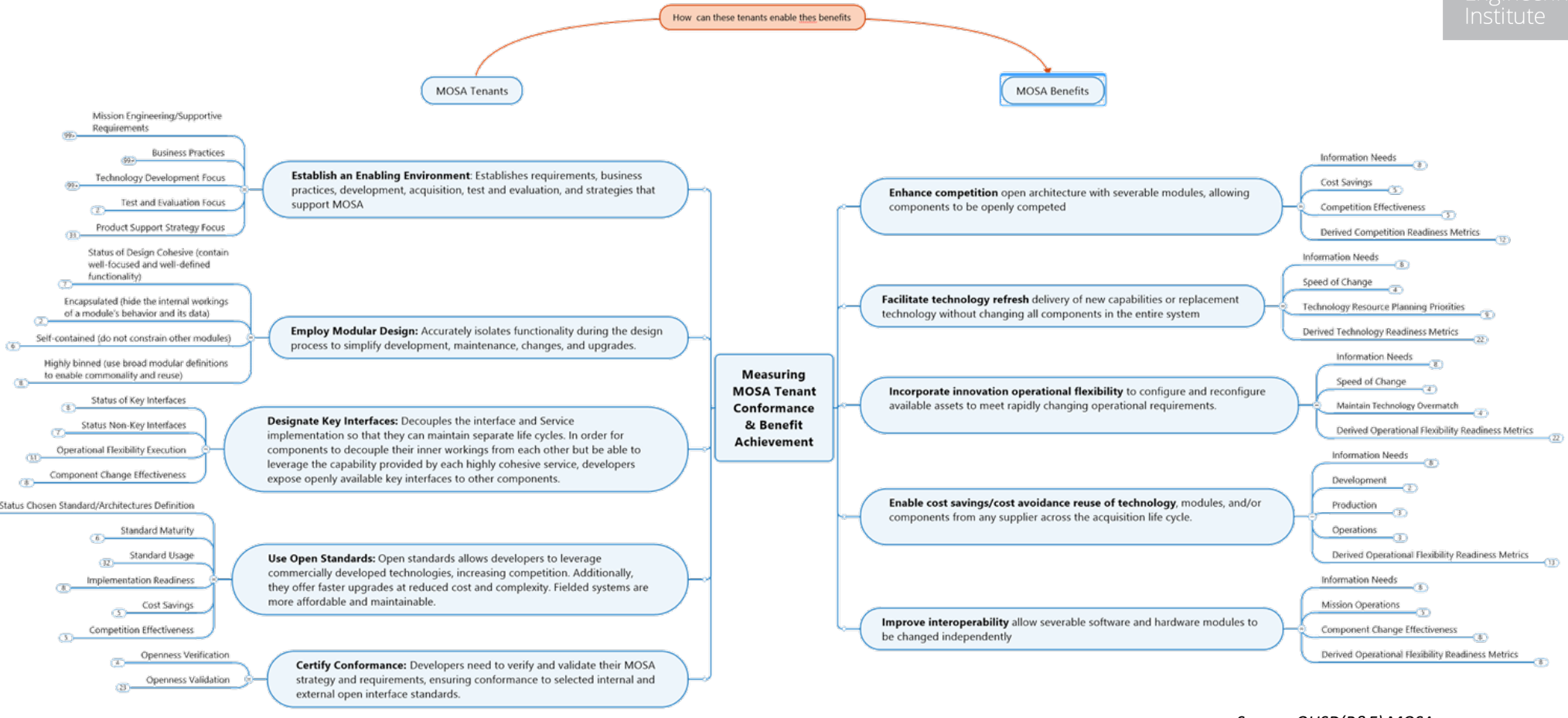
FY-21 NDAA is an enhancement to the FY-17 and FY-15 NDAAs that established MOSA as part of public law for MDAPs. Prior requirements were mandated by DoD 5000.

MOSA has been "on the radar" of OUSD for 10-15 years. A Modular Open Systems Working Group (MOSWG) was established in 2016.

In 2018, the MOSWG stood up a Tiger Team to survey the use of MOSA in Defense Acquisition programs. In 2021, the Tiger Team reported that ***"although it had identified general criteria for assessing the effectiveness of MOSA compliance, it had not agreed on specific criteria that would be applicable across all Service and program types."***

The MOSWG decided to require the Services to explicitly connect their tailored assessment criteria to the 5 MOSA "pillars" or "Tenets".

Example



Source: OUSD(R&E) MOSA Assessment Criteria – May 2022

Army PM FARA – Open Systems Verification Demonstration -1

The Army (2022-23) planned a series of open system verification demonstration (OSVD) events to assess the degree to which the FARA contractor's designs met the Army's MOSA standards.

The Army had provided a set of MOSA scenarios to the contractors as part of the acquisition Government Furnished Information (GFI). The demonstration was to verify the Government could replace a major system component with the following constraints:

- by using nothing but the contractor's TDP,
- using an independent third party to implement the component replacement, and
- performing the work in the contractor's Systems Integration Lab (SIL).

Army PM FARA – Open Systems Verification Demonstration -2

Much more involved assessment than anything prior:

- Expected that there would be training required to get the independent third party up to speed
- Early demonstrations were “simple”, once fluency was established with the contractor SIL and development environment, things got more complicated

We believe this type of assessment provides direction to becoming the “gold standard” for MOSA assessment, but more experience with performing it is needed.

The opportunity to collect data (e.g., effort, issues, lessons learned) regarding the experience of making the change is unparalleled. A standard set of measures must be developed to support this type of assessment.

Unfortunately, the FARA acquisition was canceled in February 2024. The OSVD results have not yet been published.

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MOSA Maturity

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MOSA Does Not Happen By Accident

MOSA requires a deliberate effort by an organization to accomplish specific objectives for their products.

How do we know that:

1. our organization possesses the knowledge and skills needed to develop a strategy to acquire products following MOSA principles, and
2. our source selection process will produce a contractor that correctly applies the MOSA principles to the design and integration of our products?

Is it simply adequate for a project to satisfy the measurement criteria of a particular assessment? Or are there other indicators of an organization's experience with MOSA that would provide more insight for an organization?

A MOSA Maturity model could be used to help define and assess the competencies of both the acquirer and the contractor and could incorporate the pro forma approaches that have been attempted over the past twenty years.

Some Qualitative Indicators

For the Contractor:

- How models are used (e.g., data models, MBSE) in the design
- How the interfaces are documented
- How much due diligence was spent on MOSA (i.e., effort spent performing trade-off analyses where MOSA was one of the criteria)
- Experience with product lines and product line governance

For the Acquirer:

- Experience with product lines and product line governance
- Elaborated scenarios (or use cases) that illustrate the intent of the MOSA
- Existence of data models that are used in the product domain
- Experience with model-based methods for specifying requirements
- Standard measures for how to characterize the MOSA implementation

Maturity of Data and Interfaces -1

The Tri-Service MOSA Memo and the FY-21 NDAA make clear that interoperability is based on the interfaces between major elements, the standards on which those interfaces are built, and the intelligible structure to the data so that the products can be mixed and matched across a diverse set of military capabilities.

As the use of a module (be it in a system, a platform, or a product) is expanded to other areas, portability and multi-context interoperability are predicated on the ability to consume and provide information in other arenas or domains. Interface documentation, including clarity of semantics and syntactics, is then critical to achieving the objectives of a MOSA strategy.

The Interface Documentation Maturity Levels (IDML) model was developed to establish a progression of characteristics needed to address how to develop interfaces that support a MOSA strategy (Hand et al., 2018).

graphic used with permission from Skayl

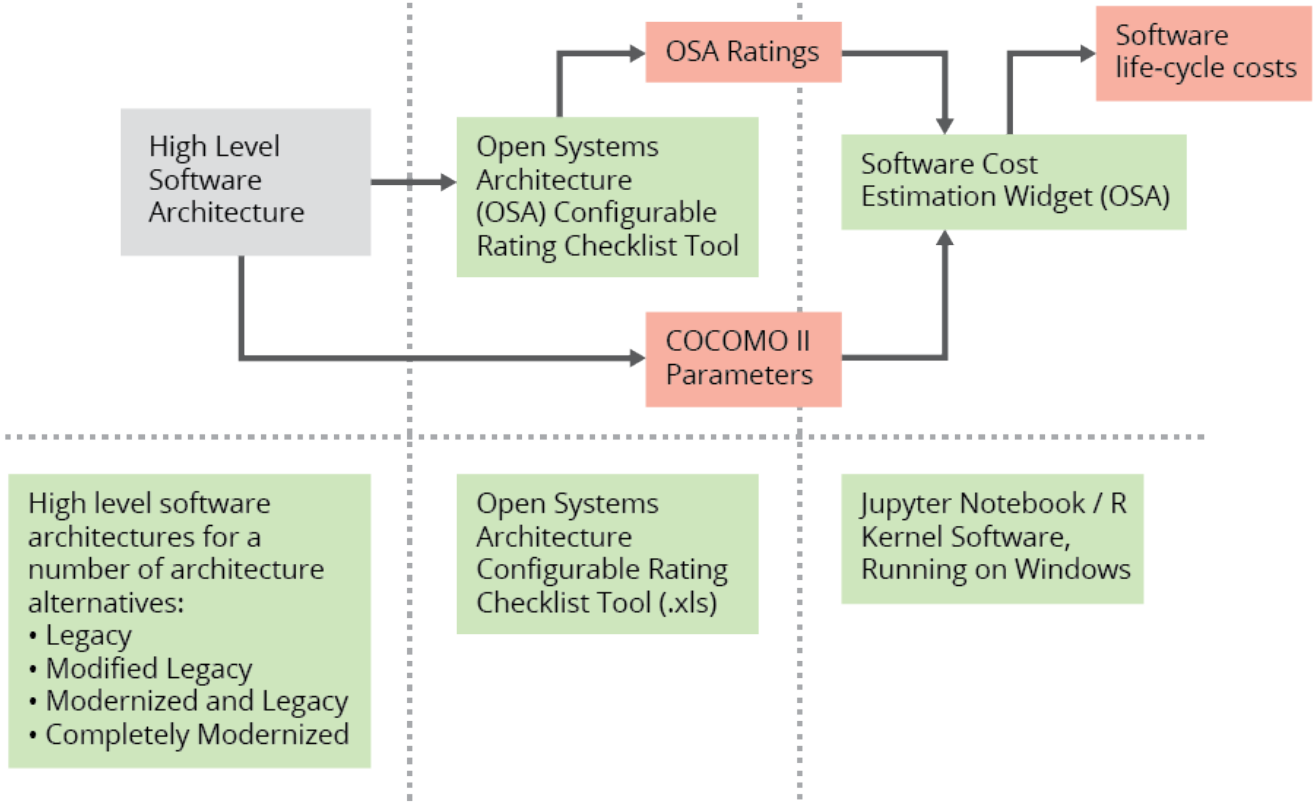
Software Attributes Trade-off Tool (SWATT) -1

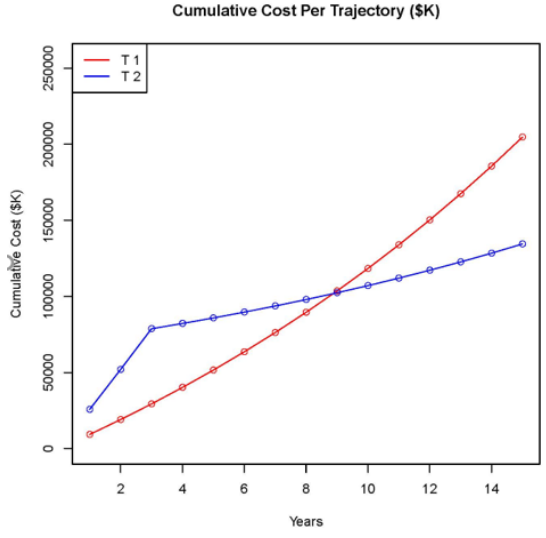
The SEI developed a tool that enables a program to perform an open systems architecture assessment on a selected software architecture and then provide cost estimation inputs, including assessment ratings, to a standard software cost estimation program. This tool goes into greater depth of the characteristics of MOSA; it examines a product through the lens of a separate Units of Assessment and addresses the following:

- **Modularity**: System architecture key components are encapsulated, cohesive, self-contained, and loosely coupled
- **Interface Standards**: A widely available document exists that specifies interfaces, including services provided/required, protocols, message and data formats, etc.
- **Layering and Tiers**: A software abstraction provides separation from other software packages and technology
- **Open and Accessible Standards**: Key interfaces are based on open and accessible standards that are widely used, consensus based, published, and maintained by recognized communities of interest

Modeling the Effects of Software-Related Decisions on Early System Cost Estimates: Experience Report from the Software Attributes Trade-off Tool (SWATT) Project

Software Attributes Trade-off Tool (SWATT) -2





Cost Assessment of Adopting MOSA vs. Staying the Course Using the Open Systems Architecture Configurability Rating Checklist Tool

Open Systems Architecture Configurability Rating Checklist Tool

MOSA Maturity Model

Following is a blend of (1) the legislative requirements from Congress with (2) the acquisition policy needs of the DoD to create a hierarchy composed of criteria that address the business needs and technical discipline MOSA requires for a product, system, or platform. We continue to assert the need to evaluate the framework of the technical architecture to be as important as the management of the acquisition approach to achieve the objectives of MOSA.

“The model” is instantiated as a set of scenarios, broken into three tiers, ranked by importance, and split along the dimensions of business and technical characteristics. We can use these scenarios to assess how well the MOSA goals are being met, which can be informed by evidence-based measures and logic tests.

The Maturity Model “Levels” -1

	Business	Technical
Mature	Is the module’s **performance** documented in a digital model that can be used for the competition of existing capabilities?	Can a different module replace an existing module **within a day** with the same or fewer integration errors?
	Is there an intellectual property strategy that has been validated against the newest data rights legislation, including a preference for Program Purpose Rights?	Can modules be upgraded or replaced quickly either directly or by technicians in the field?
	Are the **interfaces of the module**, system, or platform published (either in a digital model or in a document) and made available to any qualified organization?	Is the **software environment made up of an open platform** (e.g., containerization construct or micro-service architecture) that is widely published and available to any qualified competitor?
Growing	Can a new module be added to a product to improve its fielded performance (i.e., innovation) **within a week** of completing integration testing?	Does the interface of the module have well-defined and published semantics and syntactics (i.e., data model) for interoperability that are addressable by any other defense program?
	Is the technical architecture for the current design **documented in a digital model** and made available to any qualified party?	Is there sufficient documentation or a digital model so that the role of the system integrator can be competed or subsumed by the government **with minimal effort**?
		Is there sufficient documentation or a digital model for a module so that the role of the product provider can be competed or subsumed by the government with minimal effort?

The Maturity Model “Levels” -2

	Business	Technical
Compliant	Can an existing module (e.g., major system component) be integrated into a different domain **within a month** of a new domain being identified?	Is a module sufficiently **decoupled from an interface standard** so that it can be repurposed or upgraded to use a different interaction mechanism?
	Is there an open competition acquisition strategy that enables nonincumbents to compete and win as alternative providers?	Can an existing module be upgraded to operate in a new environment or a different warfighting domain **within three months** of that new domain being identified?
	How often is the incumbent’s implementation of an **Open System Management Plan** validated by an independent third party?	Are the modules sufficiently decoupled from their execution platform so that an update to hardware or other infrastructure can be **performed in a week**?
	Can a module be incrementally changed and deployed with known effects to other modules it interacts with?	Can a module be replaced with an alternative either for programmatic reasons or improved performance?
Progressing	Can an existing module (e.g., component in a major system platform) be added, removed, or replaced throughout the lifecycle?	Can the module execute without coincident execution of other specific weapon systems or components?
		If the module has sensitive timing needs, is there a validated model of the interaction with other related modules that others can use to evaluate replacement alternatives?

The Maturity Model “Levels” -3

	Business	Technical
Early	How often are the members of the systems, development, and operations teams provided with training on the implementation of a MOSA?	How often are the members of the systems, development, and operations teams provided with training on the implementation of a MOSA?
	Can modules of a system or platform be severed from its original deployment for use in other contexts?	Does the module construct exist across implementation domains of electrical, mechanical, fluidic, optical, radio frequency, data, networking, or software elements?
None	How many modules of the system will be competed in the next three to seven years?	Can a product roll back to an older safe state if a replacement becomes unstable or inoperable?

Why This Approach is Different

MOSA is an evolving practice in both depth and breadth. The details matter, and measures that address needed change can inform progress. Using a scenario-based approach facilitates the evolution of the methods, while the characteristics of what is to be achieved remains somewhat stable. Any product, system, or platform can be evaluated by starting with basic levels and elevating the characteristics of what constitute both the technical and business steps to achieving the goals of a MOSA.

Enablers

The following activities should be put into place to facilitate a set of MOSA maturity measurements that inform leadership and elevate best practices for all programs:

- Develop a set of proposed measures against selected products, programs, and platforms to baseline the nature of MOSA maturity. Have those measures independently verified.
- Use that baseline to inform changes to the measures prior to full deployment to all programs.
- Capture those validated measures as inputs to the DoD and Services.
- Develop and deploy a set of matching DoD and Services policies that require all programs of record, including programs that operate under larger acquisition category arrangements, to perform the new assessment. Have a third party validate the responses.
- Perform a data analysis to identify needed next steps and evaluate efforts that best meet the spirit and the letter of the law and policy.
- Report the findings to Congress to show progress against its requirements.

Barriers

If there is not a requirement for assessing all DoD programs with respect to their implementation of MOSA, only those who expect to get a great score will perform the assessment, and enterprise value will not be achieved.

Performing independent validation is a lesson learned from the limited utility of the results from the OAAT and MOSA PART, however:

- independent validation requires a cadre of competent MOSA validators, and
- other maturity models (e.g., CMMI) struggled with qualification of the independent validators and, depending on how the validator was contracted (by the government or by the contractor), maintaining their independence.

Summary

The fundamental point of this paper is that there is a spectrum of MOSA competency exhibited by acquisition and development organizations and we should be able to characterize the differences

Prior methods for measuring MOSA have had challenges, with low thresholds for demonstrating “compliance”

Newer methods, that are more rigorous, are emerging

All of these methods would benefit from a common, comprehensive set of measures that demonstrate the effects of modularity and openness

Our approach, scenario-based with quantitative performance measures should provide good insight, but needs to be implemented and validated

The MOSA community is growing

- OUSD(R&E) continues to provide excellent resources
- New opportunities for collaboration on MOSA have arrived: MOSA Industry and Government Summit, 17-18 June 2024, National Harbor, MD

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