International Council on Systems Engineering
A better world through a systems approach

A Model-Based Framework for Assessing MOSA Value Delivery in DoD Acquisitions

Richard Wise
Alton Schultheis
Christopher Zeoli

INCOSE International Symposium 2025 | Ottawa, Canada

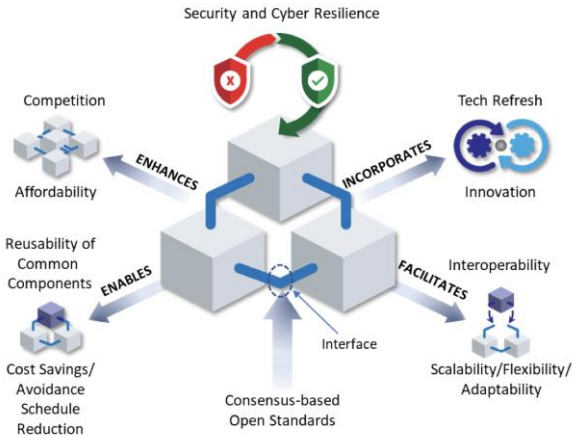
Your participation please…

- **Imaginary Estates Homeowners Association Rules and Regulations**
  - **Article III: Pet Ownership**
    - **Section 8: Pet Requirements**
      - **Subparagraph 9: Each homeowner shall own a cuddly pet.**




Which example is compliant to the regulation?

MOSA: Modular Open Systems Approach

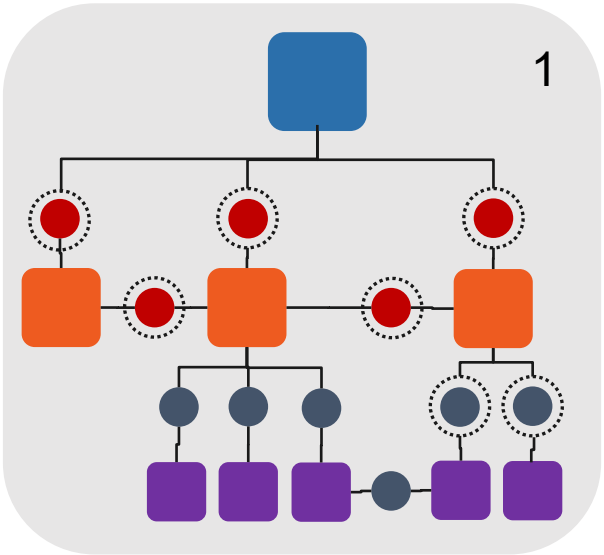


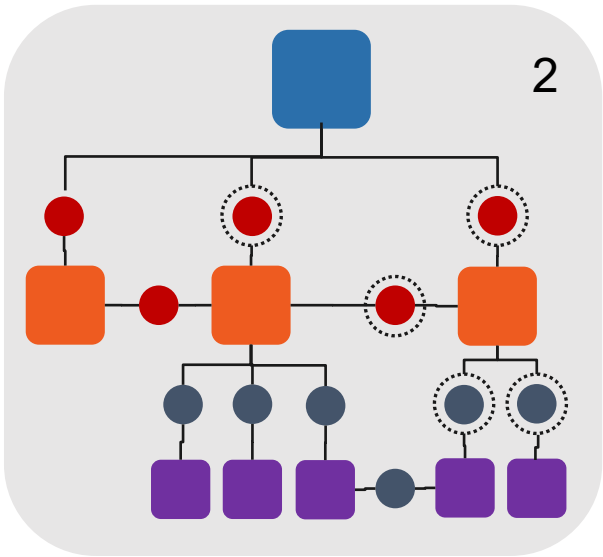
A Modular Open Systems Approach (MOSA) "is an **integrated business and technical** strategy to achieve competitive and affordable acquisition and sustainment over the system lifecycle."

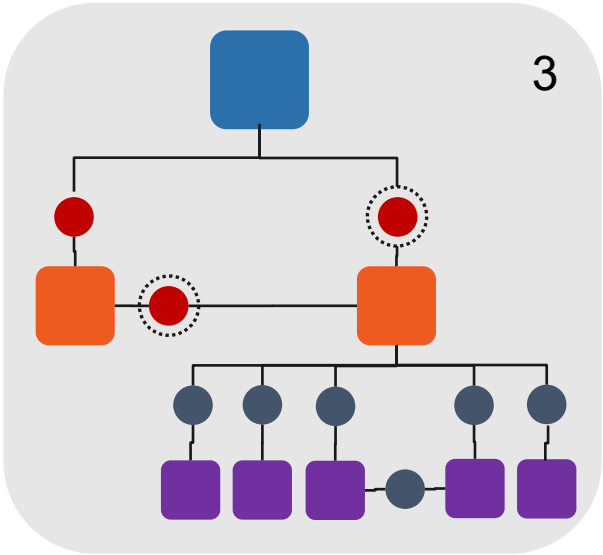
Mandated by **10 USC §4401**: Major defense programs shall be designed and developed, to the **maximum extent practicable**, with a modular open system approach - enabling modularity, innovation, and interoperability.

(*Modular Open Systems Approach – DoD Research & Engineering, OUSD(R&E)*, n.d.; *Modular Open Systems Approach (MOSA) - AcqNotes*, n.d.) (Office of Systems Engineering and Architecture, 2025)

Which MOSA Implementation is Compliant?





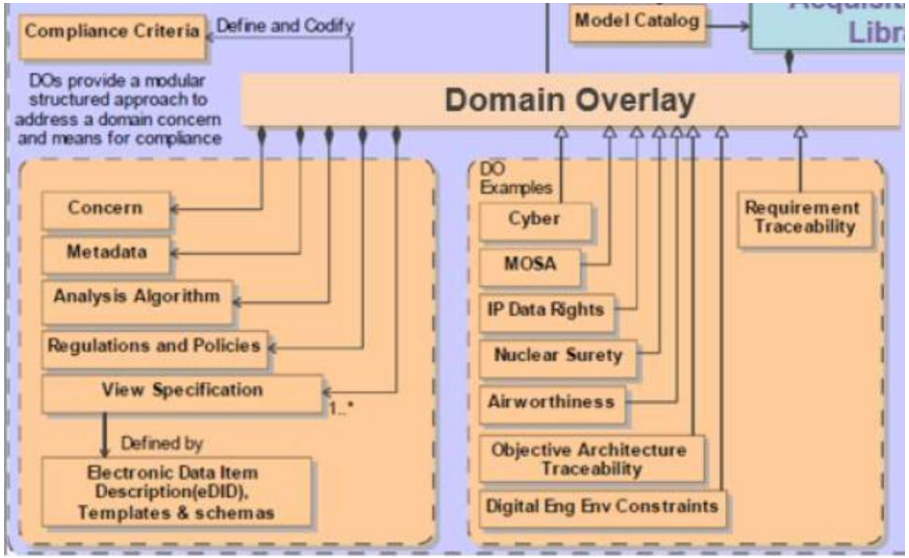


MOSA
- Major System Platform
- Major System Component
- Component

OSA
- Key Interface
- Interface
- Open Interface

(*Zimmerman et al., 2019*)

Domain Overlay

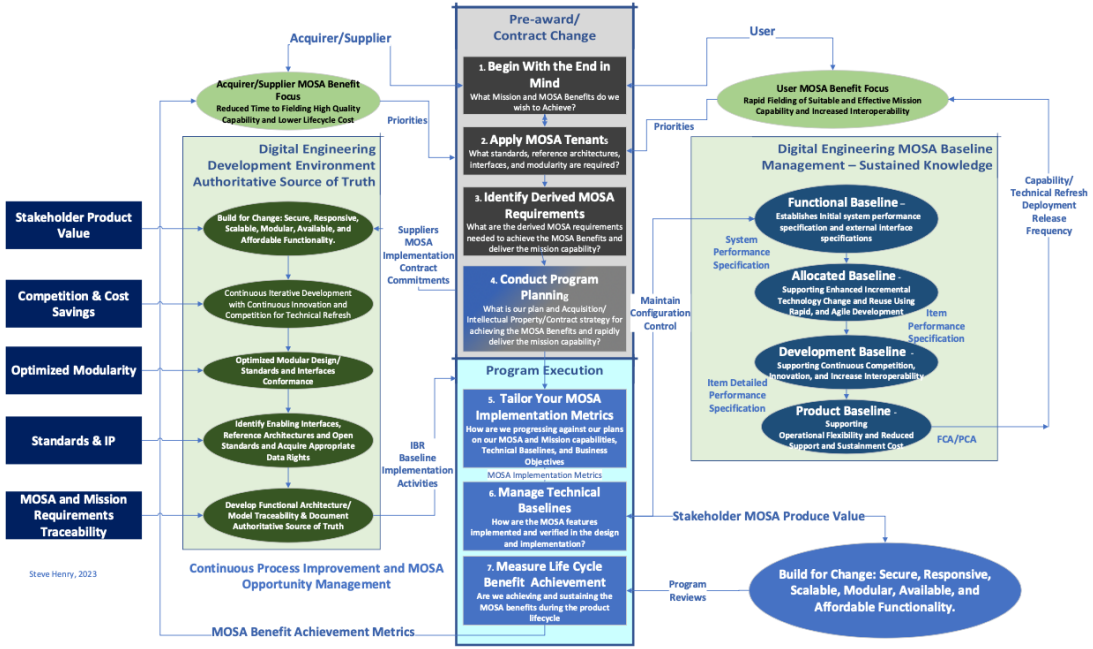


- Part of Model-Based Acquisition RFP
- A collection of constructs needed to support analysis for a domain specific concern using a standardized approach.
- Characteristics:
  - Usually has associated regulations, governance that can be treated as pseudo requirements or constraints
  - Cross-cutting both viewpoints/rows & aspects/columns
  - Supports specific analysis associated with a Domain-Specific concern
  - Can be created independent of a specific solution architecture description
  - Can be applied or removed from a specific architecture description without impacting the AD, hence an overlay

OMG Standards Development Organization

(Hart & Anderson, 2022; Hart & Hause, 2023)

Effective MOSA Implementations



- Seven step process for measuring MOSA life cycle benefit achievement.
- Define and Plan
- Measure and Monitor
- Execute and Manage

What Gets Measured and Acted Upon Gets Done

(Henry et al., 2023)

“Value can be defined as the ‘benefit that is derived by an organization’s stakeholder while interacting with that organization.’ Value is fundamental to everything that an organization does. In fact, **the only reason an organization exists is that it provides value** to one or more stakeholders.”

Business Architecture Body of Knowledge (BIZBOK)

BUSINESS ARCHITECTURE GUILD

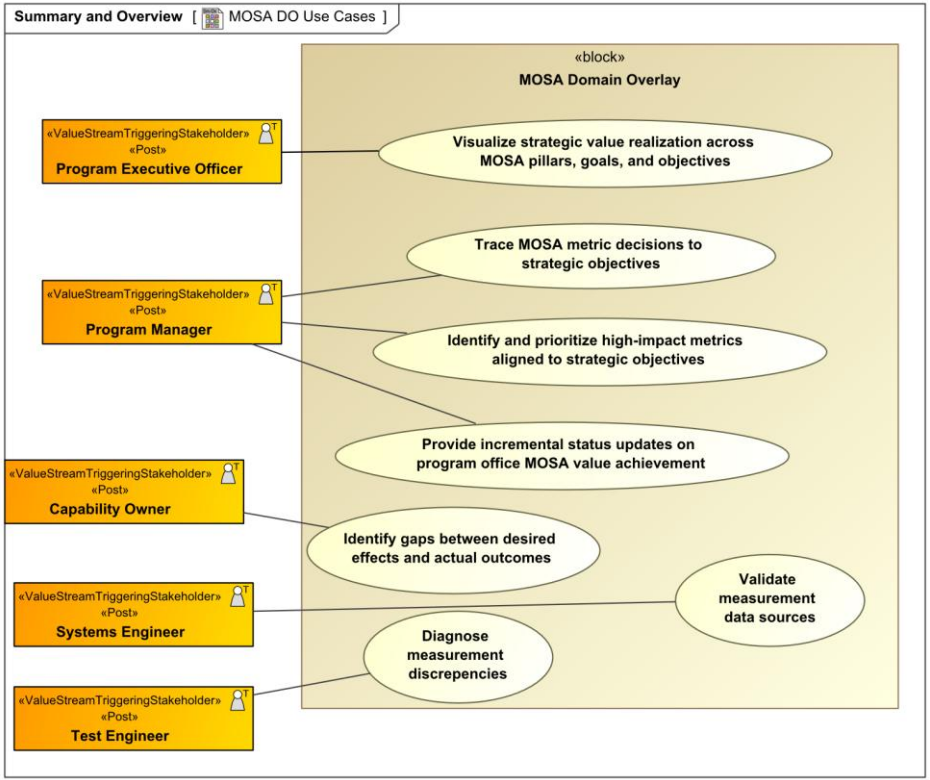
MOSA Compliance: Delivering What Matters

MOSA compliance isn't just about maximizing modularity or opening all interfaces.

Under 10 U.S.C. § 4401, *"to the maximum extent practicable"* means decomposing the MOSA pillars into measurable benefits that can be achieved within programmatic and organizational constraints.

When a program demonstrates it is meeting defined benefits that are traceable to the MOSA pillars - and doing so within constraints, i.e., **delivering value** - it establishes a strong, defensible case for compliance with both the law and its intent.

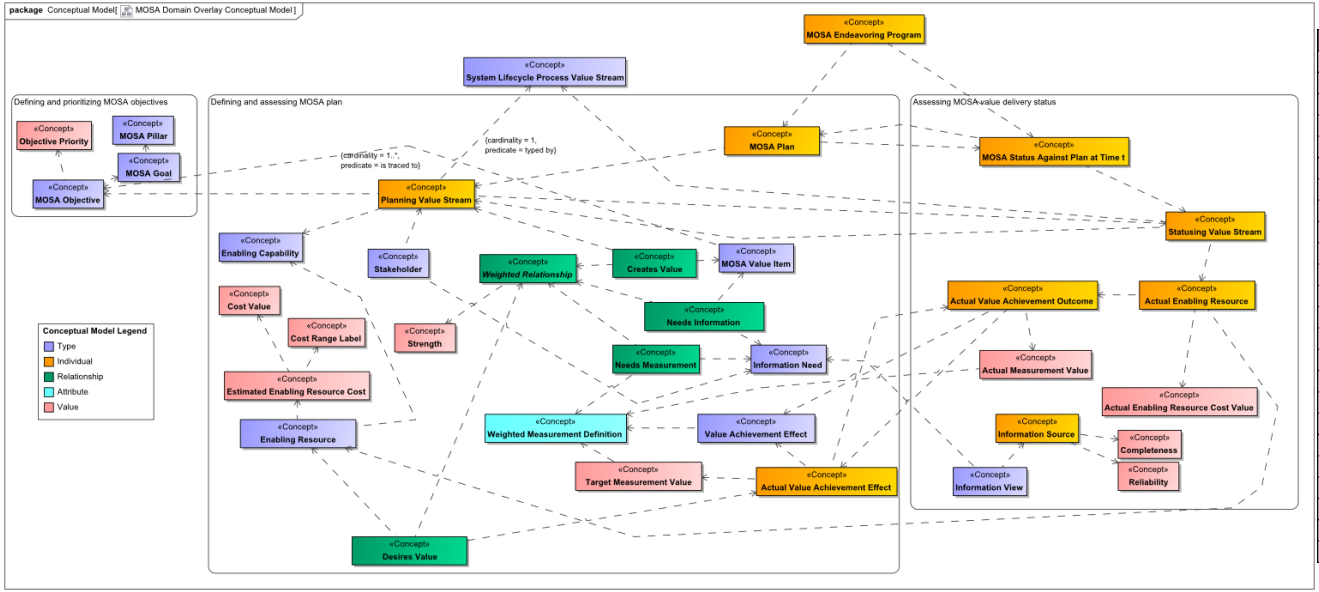
MOSA Domain Overlay Use Cases



- **Executive (PEO):** Uses the MOSA DO to trace strategic value realization and ensure alignment with goals, objectives, and MOSA pillars.
- **Program Management (PM):** Leverages planning and status views in the MOSA DO to identify execution risks and resource misalignments.
- **Operational (Capability Owner):** Applies the MOSA DO to detect gaps between desired effects and actual outcomes.
- **Engineering (Systems/Test Engineer):** Relies on diagnostic views in the MOSA DO to assess measurement integrity and verify data source reliability.

MOSA Domain Overlay Conceptual Model

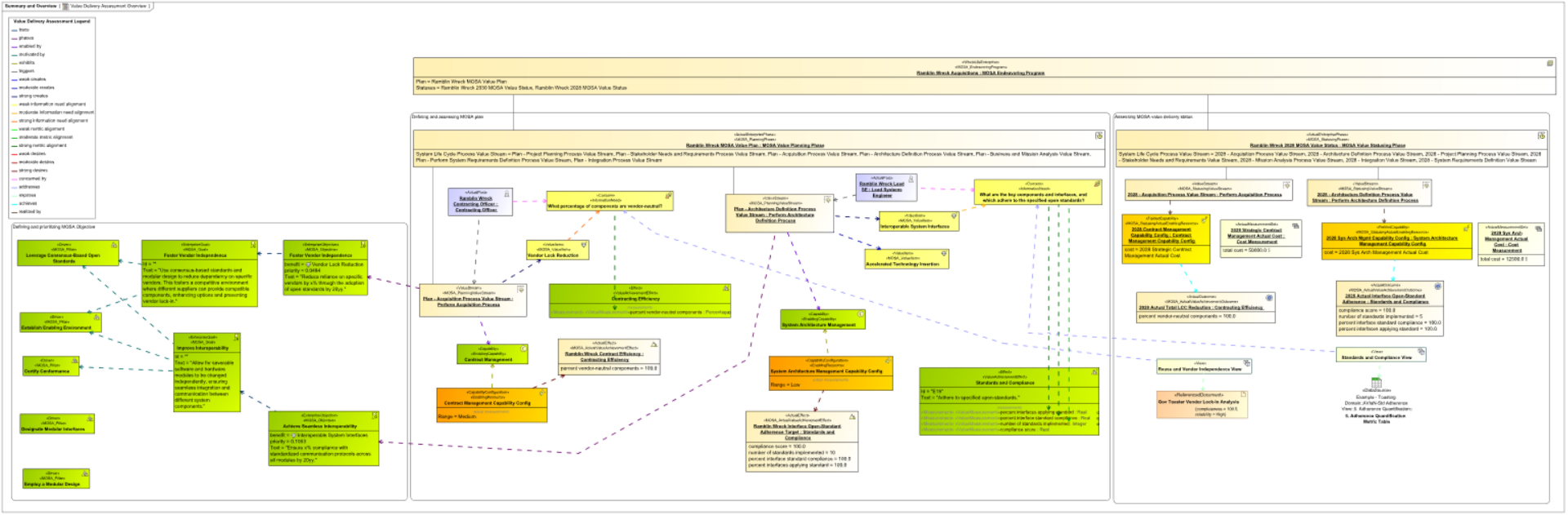
An informal, lightweight ontological framework enables implementation of the MOSA Domain Overlay in a modeling language - supporting validation rules, traceability, and query-driven analysis.



Subject - Predicates
Actual Enabling Resource contains 1 Actual Enabling Resource Cost Value.
Actual Enabling Resource achieves 1..* Actual Value Achievement Outcome.
Actual Enabling Resource typed by 1 Enabling Resource.
Actual Measurement Value typed by 1 Weighted Measurement Definition.
Actual Value Achievement Effect is compared to 1..* Actual Value Achievement Outcome.
Actual Value Achievement Effect contains 1..* Target Measurement Value.
Actual Value Achievement Effect typed by 1 Value Achievement Effect.
Actual Value Achievement Outcome contains 1..* Actual Measurement Value.
Actual Value Achievement Outcome compares to 1 Actual Value Achievement Effect.
Actual Value Achievement Outcome instantiates 1 Measures.
Actual Value Achievement Outcome is informed by 1..* System Artifacts.
Actual Value Achievement Outcome typed by 1 Value Achievement Effect.
Creates Value target 1 MOSA Value Item.
Creates Value source 1 Planning Value Stream.
Creates Value specializes 1 Weighted Relationship.
Desires Value target 1 Actual Value Achievement Effect.
Desires Value source 1 Enabling Resource.
Desires Value specializes 1 Weighted Relationship.
Enabling Capability supports 1..* System Life Cycle Value Stream.
Enabling Resource exhibits 1 Enabling Capability.
Enabling Resource is characterized by 1 Estimated Enabling Resource Cost.
Enabling Resource desires 1..* Target Effect.
Estimated Enabling Resource Cost contains 1 Cost Range Label.
Estimated Enabling Resource Cost contains 1 Cost Value.

MOSA Value Delivery Assessment Pattern

A UAF pattern linking value delivery to MOSA pillars - enabling programs to demonstrate objective-driven, defensible compliance.

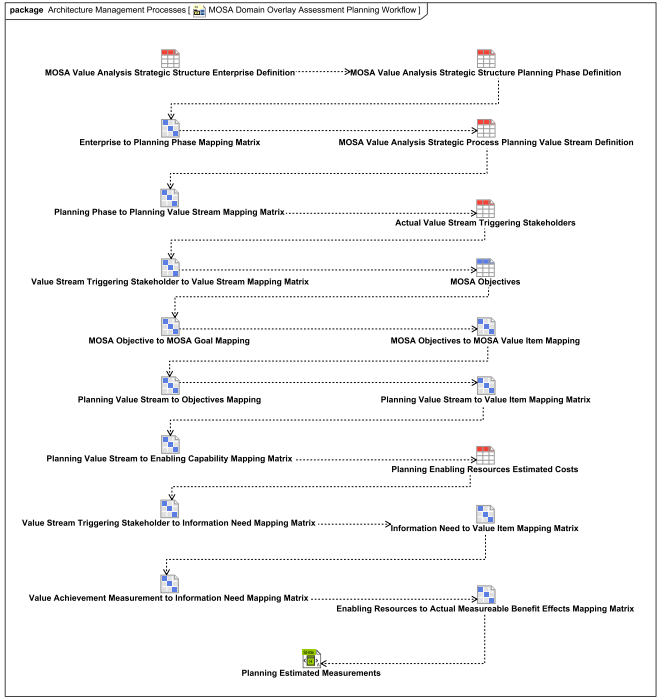


MOSA Assessment Model Building

A set of guided workflows, accessible through fit-for-purpose views, to support program-specific MOSA Domain Overlay development

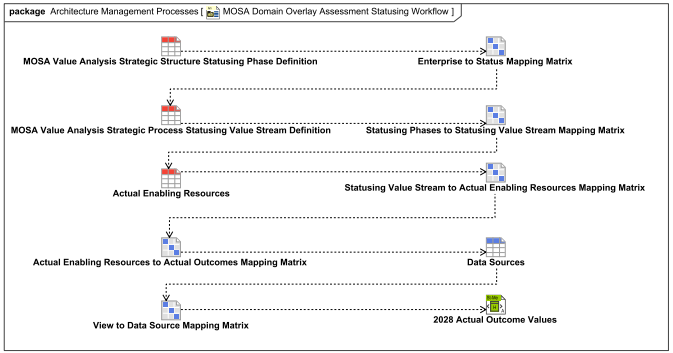
Plan

- Identify and prioritize MOSA goals, objectives, and benefits
- Map to objectives to ISO 15288 System Lifecycle Management Process value streams
- Identify business capabilities and resources necessary to realize objectives
- Flow down objective priority to benefits (value items), information needs, and measurements
- Set target values for measurements and estimated costs



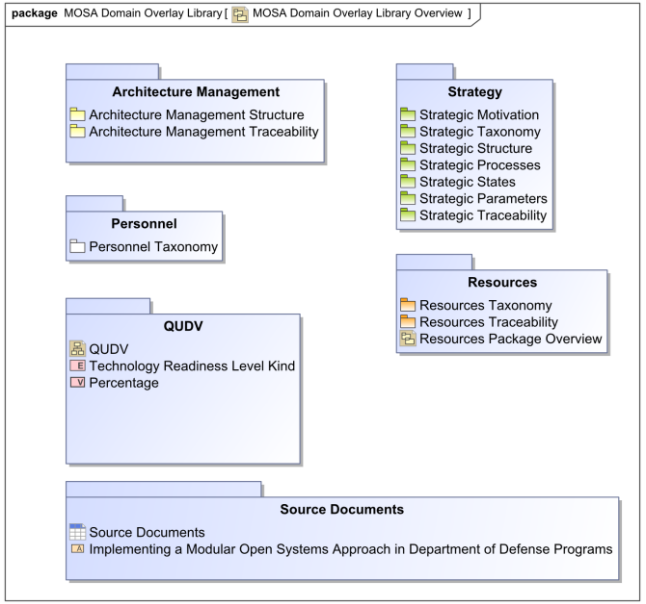
Status

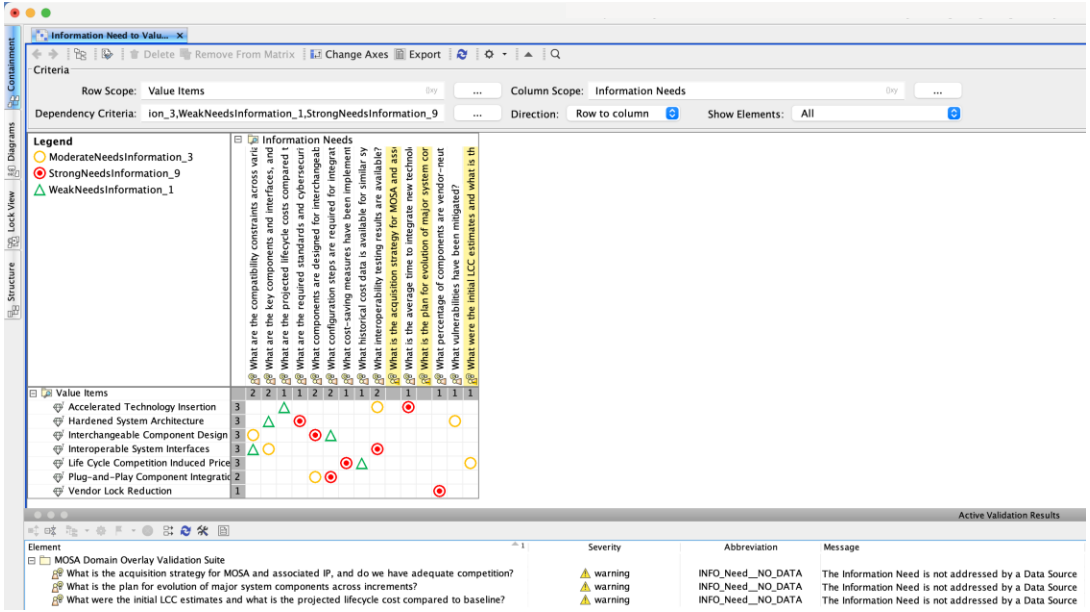
- Map architecture to assess to MOSA Domain Overlay
- Identify artifacts, e.g. system architecture elements or programmatic artifacts to measure
- Assign actual resource costs and measurement values



MOSA Assessment Model Building, continued

A reusable library and built-in validation rules ensure fast, accurate, and model development





Data Normalization Through Architecture Views

Architecture views normalize diverse artifacts into stakeholder-relevant insights

#	Name	Addressed Information Need	Stakeholder	Related Measurement	Supporting Information Artifact
1	Cost Savings Tracking View	What are the projected lifecycle costs compared to baseline? What historical cost data is available for similar systems? What cost-saving measures have been implemented and how do current LCC estimates compare to previous systems?	Financial Analyst Program Manager Contracting Officer	-LCC reduction gap : Percentage -overall cost of ownership : currency[USD] -missed early detection savings : currency[USD] -reuse savings shortfall : currency[USD] -maintenance savings gap : Percentage	Gov Toaster Cost Analysis Requirements Description Gov Toaster LCC Analysis Report Gov Toaster Vendor Lock-In Analysis
2	Design and Engineering View	What are the compatibility constraints across variants? What components are designed for interchangeability and support plug-and-play integration? What configuration steps are required for integration?	System Engineer Integration and Test Engineer Software Engineer	-number of compatibility exceptions : Integer -number of interoperability issues : Integer -percent non-interchangeable components : Percentage -percent non plug-and-play components : Percentage -complexity of integration tasks : Real -average integration time : time[days] -integration time per component : time[hours]	Gov Toaster Technology Readiness Assessment Gov Toaster Open System Architecture Assessment 5. Adherence Quantification Metric Table
3	Integration and Interoperability View	What is the average time to integrate new technologies and what barriers exist to rapid prototyping and deployment? What components are designed for interchangeability and support plug-and-play integration? What configuration steps are required for integration? What interoperability testing results are available?	Program Manager System Engineer Software Engineer Integration and Test Engineer	-average integration time : time[days] -integration time per component : time[hours] -count of unresolved integration and business barriers : Integer -percent non-interchangeable components : Percentage -percent non plug-and-play components : Percentage -complexity of integration tasks : Real -interoperability test failure rate : Real -number of interoperability issues : Integer -percent interface standard non-compliance : Real	Gov Toaster Interoperability Certification Gov Toaster Open System Architecture Assessment Gov Toaster System Integration Assessment Report
4	Reuse and Vendor Independence View	What components are designed for interchangeability and support plug-and-play integration? What percentage of components are vendor-neutral?	System Engineer Software Engineer Integration and Test Engineer Program Manager	-percent non-interchangeable components : Percentage -percent non plug-and-play components : Percentage -percent non vendor-neutral components : Percentage	Gov Toaster Vendor Lock-In Analysis Gov Toaster Open System Architecture Assessment
5	Risk and Security View	What are the required standards and cybersecurity requirements? What vulnerabilities have been mitigated?	Cybersecurity Engineer System Engineer	-number of vulnerabilities identified : Integer -remaining risk after mitigation : Real	Gov Toaster Cybersecurity Compliance Matrix Gov Toaster Mission-Based Cyber Risk Assessment Gov Toaster RMF Security Authorization Package
6	Standards and Compliance View	What are the key components and interfaces, and which adhere to the specified open standards?	System Engineer Software Engineer	-percent interfaces not applying standard : Real -percent interface standard non-compliance : Real -percent non vendor-neutral components : Percentage	5. Adherence Quantification Metric Table Gov Toaster Open System Architecture Assessment Gov Toaster Cybersecurity Compliance Matrix

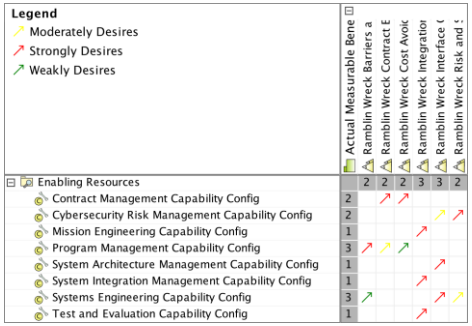
Prioritizing What Matters

Objectives are traced to value items via value streams, which vary in strength of value creation. Value items map to information needs, and those to measurements—each step weighted using a 9-3-1 scale. This cascade enables traceable, prioritized measurement of value.

Enabling resources are similarly mapped to desired effects to assign responsibility and cost.

Objective to measurement priority flow-down

Resource influence on measured outcomes



Data into Insight

Stakeholder-specific equations convert normalized data into actionable insights across executive, program, operational, and engineering levels.

Executive

- Aggregates weighted performance and cost
- Applies penalty for cost overruns
- Binary value achievement: Yes/Partial/No

$$\text{Score} = \frac{\sum w_i \cdot \left(\frac{d_i - a_i}{d_i}\right)}{\sum w_i} \cdot \min\left(1, \frac{C_{\text{estimated}}}{C_{\text{actual}}}\right)$$

Program Management

- Scores enabling resources by cost and measurement priority
- Normalized risk ranking: Low / Medium / High

$$\text{Risk Score}_{ER} = \sum_j c_j \cdot \bar{w}_j \cdot p_j$$

Operational

- Compares desired vs. actual performance
- Highlights weighted performance gaps

$$\Delta_m = d_m - a_m$$

Engineering

- Evaluates data completeness and reliability
- Computes data risk weighted by measurement priority

$$\text{Data Risk} = P \cdot \left(1 - \frac{C}{100}\right) \cdot \left(\frac{9}{R}\right)$$

Framework in Action

A notional toaster upgrade scenario illustrates how structured value assessment leads to actionable insight into MOSA compliance.

Scenario

Upgrade fielded toasters to meet operational and compliance needs

#	Motivating Pillar	Traced To	Name	Text	Benefit	Priority
1	Pillar–1 Establish Enabling Environment Pillar–5 Certify Conformance	Goal–5 Enable Cost Savings/Cost Avoidance/Schedule Reduction	Achieve Cost Savings and Schedule Reduction	Reduce development and testing costs by x% through component reuse within the next y years.	Life Cycle Competition Induced Price Reduction from Life Cycle Cost Target(s)	0.0484
2	Pillar–1 Establish Enabling Environment Pillar–4 Leverage Consensus–Based Open Standards Pillar–5 Certify Conformance	Goal–1 Improve Interoperability	Achieve Seamless Interoperability	Ensure x% compliance with standardized communication protocols across all modules by 20yy.	Interoperable System Interfaces	0.1053
3	Pillar–1 Establish Enabling Environment Pillar–2 Employ a Modular Design Pillar–3 Designate Modular Interfaces Pillar–4 Leverage Consensus–Based Open Standards	Goal–6 Enable Plug–and–Play Capability	Enable Plug–and–Play Capability	Ensure x% of modules can be integrated and replaced within 24 hours by 20yy.	Plug–and–Play Component Integration	0.1053
4	Pillar–1 Establish Enabling Environment Pillar–2 Employ a Modular Design Pillar–3 Designate Modular Interfaces Pillar–4 Leverage Consensus–Based Open Standards	Goal–7 Ensure Interchangeability	Ensure Interchangeability of Components	Achieve x% compatibility of components from different vendors by 20yy.	Interchangeable Component Design	0.1053
5	Pillar–1 Establish Enabling Environment Pillar–4 Leverage Consensus–Based Open Standards	Goal–10 Foster Vendor Independence	Foster Vendor Independence	Reduce reliance on specific vendors by x% through the adoption of open standards by 20yy.	Vendor Lock Reduction	0.0484
6	Pillar–1 Establish Enabling Environment	Goal–4 Incorporate Innovation	Promote Rapid Innovation	Reduce the time required to reconfigure system capabilities by x% within the next y years.	Accelerated Technology Insertion	0.1053
7	Pillar–1 Establish Enabling Environment Pillar–4 Leverage Consensus–Based Open Standards Pillar–5 Certify Conformance	Goal–13 Strengthen Security and Cyber Resilience	Strengthen Security and Cyber Resilience	Apply security patches and updates to x% of modules within h hours of release.	Hardened System Architecture	0.0211
8	Pillar–1 Establish Enabling Environment Pillar–2 Employ a Modular Design Pillar–3 Designate Modular Interfaces	Goal–9 Support Scalability	Support Scalability of Systems	Ensure systems can be scaled up or down by x% within m months of operational need.	Interoperable System Interfaces	0.1053

Primary Goals:

- Interface Standardization: Ensure compatibility with standard-issue bread slices and control systems
- Modularity: Enable plug-and-play components (e.g., heating coils, crumb trays) for rapid maintenance and upgrades

Secondary Enhancements:

- Faster, more consistent toasting
- Remote initiation and monitoring via secure satellite link

MOSA Adoption:

- Focused on interchangeability and component-level flexibility
- Other pillars (e.g., cybersecurity, lifecycle affordability) are considered but not prioritized

Business Benefits:

- Reduced vendor lock-in through standardized, swappable modules
- Increased operational uptime via modular maintenance
- Competitive sourcing enabled by open interfaces

Target Values

Values maximizing interface standardization, compliance, modularity, and integration.

#	Realizing Objectives	Enabled Value Streams	Classifier	cost.range : Cost Range Kind	cost.total cost : currency[USD]	Desired Effects	Value Measurements	Target Values
1	Obj-10 Foster Vendo	Plan – Acquisition Process Value Stream : Perform A	**Contract Management Capability Config**	Medium	60000 $	Ramblin Wreck Cost Avoidance Target : C Ramblin Wreck Contract Efficiency : Contr	-reuse savings shortfall : currency[USD] -missed early detection savings : currency[USD] -LCC reduction gap : Percentage -maintenance savings gap : Percentage -overall cost of ownership : currency[USD] -percent non vendor-neutral components : Percentage	0.0 0.0 0.0 0.0 300000.0 0.0
2	Obj-4 Promote Rapid Obj-7 Ensure Intercha Obj-6 Enable Plug-an	Plan – Stakeholder Needs and Requirements Proces Plan – Perform System Requirements Definition Proc	**Cybersecurity Risk Management Capability Config**	Medium	30000 $	Ramblin Wreck Risk and Security : Risk an Ramblin Wreck Interface Open-Standard	-number of vulnerabilities identified : Integer -remaining risk after mitigation : Real -percent interfaces not applying standard : Real -percent interface standard non-compliance : Real	10 3.0 0.0 0.0
3	Obj-9 Support Scalab	Plan – Business and Mission Analysis Value Stream :	**Mission Engineering Capability Config**	Low	15000 $	Ramblin Wreck Integration and Interoper	-percent non plug-and-play components : Percentage -integration time per component : time[hours] -average integration time : time[days] -complexity of integration tasks : Real -percent non-interchangeable components : Percentage -number of compatibility exceptions : Integer -interoperability test failure rate : Real -number of interoperability issues : Integer	0.0 2.0 10.0 3.0 0.0 3 0.0 1
4	Obj-5 Achieve Cost Sa	Plan – Project Planning Process Value Stream : Perfo	**Program Management Capability Config**	Low	30000 $	Ramblin Wreck Barriers and Challenges T Ramblin Wreck Cost Avoidance Target : C Ramblin Wreck Contract Efficiency : Contr	-count of unresolved integration and business barriers : Integ -reuse savings shortfall : currency[USD] -missed early detection savings : currency[USD] -LCC reduction gap : Percentage -maintenance savings gap : Percentage -overall cost of ownership : currency[USD] -percent non vendor-neutral components : Percentage	3 0.0 0.0 0.0 0.0 300000.0 0.0
5	Obj-1 Achieve Seamle	Plan – Architecture Definition Process Value Stream	**System Architecture Management Capability Config**	Low	15000 $	Ramblin Wreck Interface Open-Standard	-percent interfaces not applying standard : Real -percent interface standard non-compliance : Real	0.0 0.0
6	Obj-13 Strengthen Se	Plan – Integration Process Value Stream : Perform In	**System Integration Management Capability Config**	Medium	60000 $	Ramblin Wreck Integration and Interopera	-percent non plug-and-play components : Percentage -integration time per component : time[hours] -average integration time : time[days] -complexity of integration tasks : Real -percent non-interchangeable components : Percentage -number of compatibility exceptions : Integer -interoperability test failure rate : Real -number of interoperability issues : Integer	0.0 2.0 10.0 3.0 0.0 3 0.0 1
7	Obj-6 Enable Plug-an Obj-4 Promote Rapid Obj-7 Ensure Intercha	Plan – Perform System Requirements Definition Proc Plan – Stakeholder Needs and Requirements Proces	**Systems Engineering Capability Config**	Medium	30000 $	Ramblin Wreck Interface Open-Standard Ramblin Wreck Barriers and Challenges T Ramblin Wreck Risk and Security : Risk a	-percent interfaces not applying standard : Real -percent interface standard non-compliance : Real -number of vulnerabilities identified : Integer -remaining risk after mitigation : Real	0.0 0.0 10 3.0
8	Obj-13 Strengthen Se	Plan – Integration Process Value Stream : Perform In	**Test and Evaluation Capability Config**	High	30000 $	Ramblin Wreck Integration and Interopera	-percent non plug-and-play components : Percentage -integration time per component : time[hours] -average integration time : time[days] -complexity of integration tasks : Real -percent non-interchangeable components : Percentage -number of compatibility exceptions : Integer -interoperability test failure rate : Real -number of interoperability issues : Integer	0.0 2.0 10.0 3.0 0.0 3 0.0 1

Resource cost estimate and range

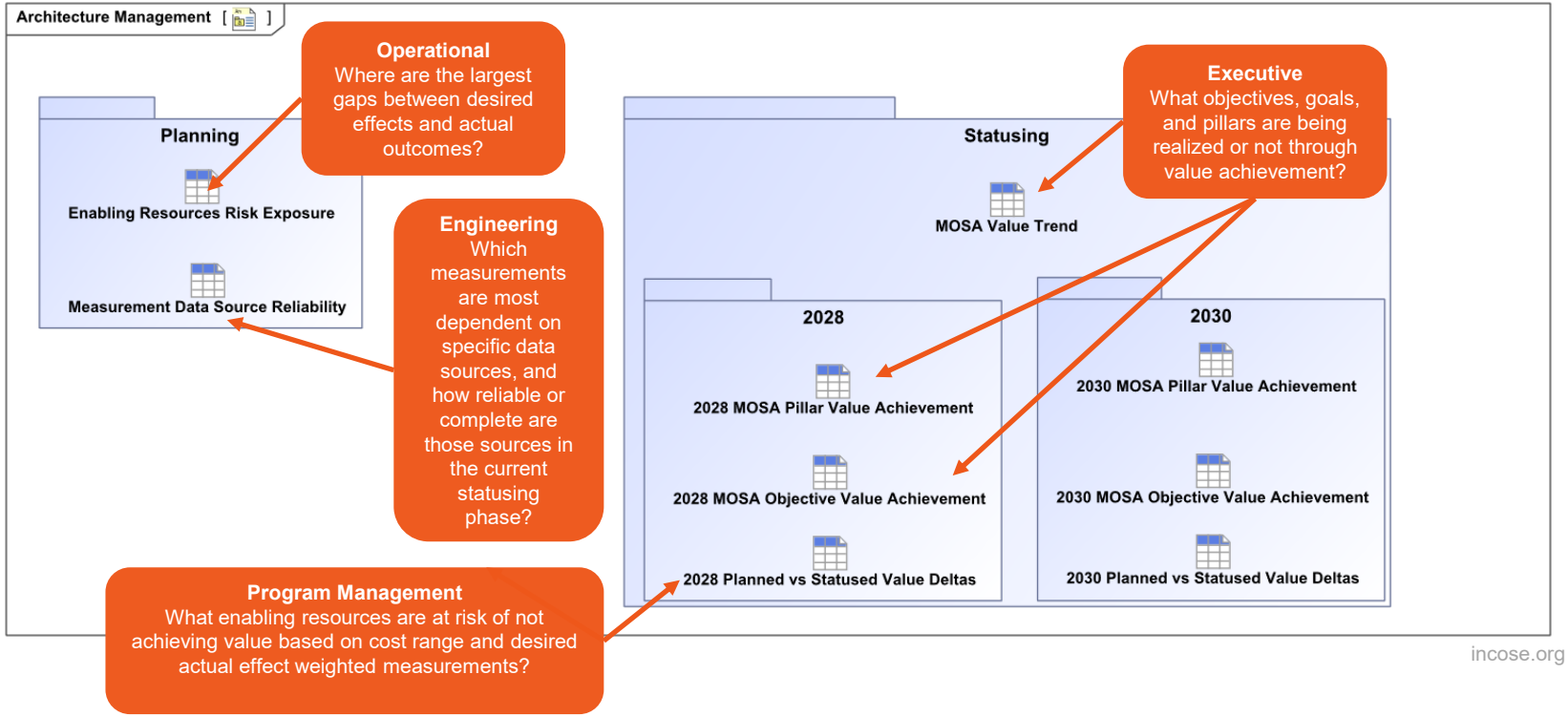
-integration time per component : time[hours] 2.0
-average integration time : time[days] 10.0
-complexity of integration tasks : Real 3.0
-percent non-interchangeable components : Percentage 0.0

Lower values are better

-percent interfaces not applying standard : Real 0.0
-percent interface standard non-compliance : Real 0.0

MOSA Dashboard

Model-based views tailored to stakeholder-specific concerns, enabling monitoring and sustainment of MOSA value delivery across planning and execution phases.



Measurement Data Source Reliability

Supports engineering-level concerns by tracing measurements to their data sources and computing a data risk score based on completeness, reliability, and measurement priority.

#	Name	Relative Weight	Data Source	Average Completeness	Average Reliability	Data Risk
1	average integration time	0.1183	Gov Toaster Technology Readiness Assessment Gov Toaster Open System Architecture Assessment 5. Adherence Quantification Metric Table Gov Toaster Interoperability Certification Gov Toaster System Integration Assessment Report	80.0	5.0	High (0.043)
2	complexity of integration tasks	0.0717	Gov Toaster Technology Readiness Assessment Gov Toaster Open System Architecture Assessment 5. Adherence Quantification Metric Table Gov Toaster Interoperability Certification Gov Toaster System Integration Assessment Report	80.0	5.0	High (0.026)
3	count of unresolved integration and business barriers	0.0944	Gov Toaster Interoperability Certification Gov Toaster Open System Architecture Assessment Gov Toaster System Integration Assessment Report	88.0	5.0	High (0.021)
4	integration time per component	0.1031	Gov Toaster Technology Readiness Assessment Gov Toaster Open System Architecture Assessment 5. Adherence Quantification Metric Table Gov Toaster Interoperability Certification Gov Toaster System Integration Assessment Report	80.0	5.0	High (0.037)
5	interoperability test failure rate	0.0881	Gov Toaster Interoperability Certification Gov Toaster Open System Architecture Assessment Gov Toaster System Integration Assessment Report	88.0	5.0	High (0.020)
6	LCC reduction gap	0.0192	Gov Toaster Cost Analysis Requirements Description Gov Toaster LCC Analysis Report Gov Toaster Vendor Lock-In Analysis	98.0	5.0	Low (0.001)
7	maintenance savings gap	0.026	Gov Toaster Cost Analysis Requirements Description Gov Toaster LCC Analysis Report Gov Toaster Vendor Lock-In Analysis	98.0	5.0	Low (0.001)
8	missed early detection savings	0.026	Gov Toaster Cost Analysis Requirements Description Gov Toaster LCC Analysis Report Gov Toaster Vendor Lock-In Analysis	98.0	5.0	Low (0.001)
9	number of compatibility exceptions	0.0324	Gov Toaster Technology Readiness Assessment Gov Toaster Open System Architecture Assessment 5. Adherence Quantification Metric Table	82.0	5.0	Medium (0.011)
10	number of interoperability issues	0.0989	Gov Toaster Technology Readiness Assessment Gov Toaster Open System Architecture Assessment 5. Adherence Quantification Metric Table Gov Toaster Interoperability Certification Gov Toaster System Integration Assessment Report	80.0	5.0	High (0.036)
11	number of vulnerabilities identified	0.0038	Gov Toaster Cybersecurity Compliance Matrix Gov Toaster Mission-Based Cyber Risk Assessment Gov Toaster RMF Security Authorization Package	89.0	2.0	Low (0.002)
12	overall cost of ownership	0.0122	Gov Toaster Cost Analysis Requirements Description Gov Toaster LCC Analysis Report Gov Toaster Vendor Lock-In Analysis	98.0	5.0	Low (0.001)
13	percent interface standard non-compliance	0.0299	5. Adherence Quantification Metric Table Gov Toaster Open System Architecture Assessment Gov Toaster Cybersecurity Compliance Matrix Gov Toaster Interoperability Certification Gov Toaster System Integration Assessment Report	83.0	5.0	Medium (0.011)
14	percent interfaces not applying standard	0.0201	5. Adherence Quantification Metric Table Gov Toaster Open System Architecture Assessment Gov Toaster Cybersecurity Compliance Matrix	85.0	5.0	Low (0.006)
15	percent non plug-and-play components	0.0994	Gov Toaster Vendor Lock-In Analysis Gov Toaster Open System Architecture Assessment Gov Toaster Interoperability Certification Gov Toaster System Integration Assessment Report Gov Toaster Technology Readiness Assessment 5. Adherence Quantification Metric Table	80.0	5.0	High (0.036)
16	percent non vendor-neutral components	0.0295	5. Adherence Quantification Metric Table Gov Toaster Open System Architecture Assessment Gov Toaster Cybersecurity Compliance Matrix Gov Toaster Vendor Lock-In Analysis	85.0	5.0	Medium (0.009)
17	percent non-interchangeable components	0.0994	Gov Toaster Vendor Lock-In Analysis Gov Toaster Open System Architecture Assessment Gov Toaster Interoperability Certification Gov Toaster System Integration Assessment Report Gov Toaster Technology Readiness Assessment 5. Adherence Quantification Metric Table	80.0	5.0	High (0.036)
18	remaining risk after mitigation	0.0013	Gov Toaster Cybersecurity Compliance Matrix Gov Toaster Mission-Based Cyber Risk Assessment Gov Toaster RMF Security Authorization Package	89.0	2.0	Low (0.001)
19	reuse savings shortfall	0.026	Gov Toaster Cost Analysis Requirements Description Gov Toaster LCC Analysis Report Gov Toaster Vendor Lock-In Analysis	98.0	5.0	Low (0.001)

Planned vs Statused Value Deltas

Addresses operational concerns by comparing actual and target measurement values, computing weighted deltas, and highlighting performance gaps.

Actual values represent the measurement of value delivery by the enterprise at a specific point in time within a given statusing phase.

#	Measurement	Type	Target Value	Actual Value	Delta	Relative Weight	Weighted Delta
1	average integration time	time[days]	10	11	-1	0.1183	▼ -0.11830944066627284
2	complexity of integration tasks	Real	3	3.5	-0.5	0.0717	▼ -0.035831251378252785
3	count of unresolved integration and business barriers	Integer	3	4	-1	0.0944	▼ -0.09442193974743764
4	integration time per component	time[hours]	2	2.5	-0.5	0.1031	▼ -0.05156824133615906
5	interoperability test failure rate	Real	0	95	-95	0.0881	▼ -8.37207865760614
6	LCC reduction gap	Percentage	0	2	-2	0.0192	▼ -0.03834266043305256
7	maintenance savings gap	Percentage	0	2	-2	0.026	▼ -0.052080021467532565
8	missed early detection savings	currency[USD]	0	1000	-1000	0.026	▼ -26.040010733766287
9	number of compatibility exceptions	Integer	3	5	-2	0.0324	▼ -0.06487684951560779
10	number of interoperability issues	Integer	1	4	-3	0.0989	▼ -0.2968198560506292
11	number of vulnerabilities identified	Integer	10	8	2	0.0038	▲ 0.00756810229314695
12	overall cost of ownership	currency[USD]	300000	310000	-10000	0.0122	▼ -121.77112457456823
13	percent interface standard non-compliance	Real	0	25	-25	0.0299	▼ -0.7484410798593981
14	percent interfaces not applying standard	Real	0	40	-40	0.0201	▼ -0.8058295332671477
15	percent non plug-and-play components	Percentage	0	30	-30	0.0994	▼ -2.9824061880339756
16	percent non vendor-neutral components	Percentage	0	25	-25	0.0295	▼ -0.738494412153599
17	percent non-interchangeable components	Percentage	0	35	-35	0.0994	▼ -3.479473886039638
18	remaining risk after mitigation	Real	3	2.5	0.5	0.0013	▲ 6.306751910955792E-4
19	reuse savings shortfall	currency[USD]	0	5000	-5000	0.026	▼ -130.20005366883143

Inconsequential improvements

Enabling Resource Risk Exposure

Addresses program management concerns by ranking enabling resources based on their cost range and the weighted priority of their desired effects, highlighting those at greatest risk of not achieving value.

High-risk due to desiring effects related to high-priority objectives

#	Realizing Value	Enabling Value Stream	Exhibits Capability	Name	Cost Range	Desires	Desired Actual Achievement Effect Average Relative Weights	Risk Exposure	Risk Ranking
1	Interchangeable Component Design Vendor Lock Reduction	Plan – Acquisition Process Value Stream : Perform Acquisition Process	Contract Management	Contract Management Capability Config	Medium	Ramblin Wreck Cost Avoidance Target : Cost Avoidance Ramblin Wreck Contract Efficiency : Contracting Efficiency	0.0219 0.0295	0	Low
2	Interchangeable Component Design Accelerated Technology Insertion Plug-and-Play Component Integration	Plan – Stakeholder Needs and Requirements Process Value Stream : Perform Stakeholder Needs and Requirements Process Plan – Perform System Requirements Definition Process Value Stream : Perform System Requirements Definition Process	Cybersecurity Risk Management	Cybersecurity Risk Management Capability Config	Medium	Ramblin Wreck Risk and Security : Risk and Security Ramblin Wreck Interface Open-Standard Adherence Target : Standards and Compliance	0.0025 0.025	0.0164	Low
3	Accelerated Technology Insertion Plug-and-Play Component Integration	Plan – Business and Mission Analysis Value Stream : Perform Business and Mission Analysis Process	Mission Engineering	Mission Engineering Capability Config	Low	Ramblin Wreck Integration and Interoperability Targets : Integration and Interoperability	0.0889	1	High
4	Life Cycle Competition Induced Price Reduction from Life Cycle Cost Target(s)	Plan – Project Planning Process Value Stream : Perform Project Planning Process	Program Management	Program Management Capability Config	Low	Ramblin Wreck Barriers and Challenges Targets : Barriers and Challenges Ramblin Wreck Cost Avoidance Target : Cost Avoidance Ramblin Wreck Contract Efficiency : Contracting Efficiency	0.0944 0.0219 0.0295	0.0814	Medium
5	Accelerated Technology Insertion Interoperable System Interfaces	Plan – Architecture Definition Process Value Stream : Perform Architecture Definition Process	System Architecture Management	System Architecture Management Capability Config	Low	Ramblin Wreck Interface Open-Standard Adherence Target : Standards and Compliance	0.025	0.0095	Low
6	Hardened System Architecture Vendor Lock Reduction	Plan – Integration Process Value Stream : Perform Integration Process	System Integration, Assembly, Test, and Checkout	System Integration Management Capability Config	Medium	Ramblin Wreck Integration and Interoperability Targets : Integration and Interoperability	0.0889	1	High
7	Interchangeable Component Design Plug-and-Play Component Integration Accelerated Technology Insertion	Plan – Perform System Requirements Definition Process Value Stream : Perform System Requirements Definition Process Plan – Stakeholder Needs and Requirements Process Value Stream : Perform Stakeholder Needs and Requirements Process	Systems Engineering	Systems Engineering Capability Config	Medium	Ramblin Wreck Interface Open-Standard Adherence Target : Standards and Compliance Ramblin Wreck Barriers and Challenges Targets : Barriers and Challenges Ramblin Wreck Risk and Security : Risk and Security	0.025 0.0944 0.0025	0.0979	Medium
8	Hardened System Architecture Vendor Lock Reduction	Plan – Integration Process Value Stream : Perform Integration Process	System Integration, Assembly, Test, and Checkout	Test and Evaluation Capability Config	High	Ramblin Wreck Integration and Interoperability Targets : Integration and Interoperability	0.0889	1	High

MOSA Pillar Value Achievement

Addresses executive level concerns and provides a summary of which MOSA pillars, goals, and objectives are being realized in a specific statusing phase.

Not achieving value means **non-compliance.**

#	Name	Planned Goals	Planned Objectives	Value Streams in Status Phase	Status Value Stream Achieving Value	Achieving Value
1	Certify Conformance	Goal–1 Improve Interoperability Goal–5 Enable Cost Savings/Cost Avoidance/Schedule Reduction Goal–13 Strengthen Security and Cyber Resilience	Obj–1 Achieve Seamless Interoperability Obj–5 Achieve Cost Savings and Schedule Reduction Obj–13 Strengthen Security and Cyber Resilience	2028 – Architecture Definition Process Value Stream : Perform Architecture Definition Process 2028 – Project Planning Process Value Stream : Perform Project Planning Process 2028 – Integration Value Stream : Perform Integration Process	✘ No (2028 – Architecture Definition Process Value Stream) ✘ No (2028 – Project Planning Process Value Stream) ✘ No (2028 – Integration Value Stream)	✘ No
2	Designate Modular Interfaces	Goal–6 Enable Plug–and–Play Capability Goal–7 Ensure Interchangeability Goal–9 Support Scalability	Obj–6 Enable Plug–and–Play Capability Obj–7 Ensure Interchangeability of Components Obj–9 Support Scalability of Systems	2028 – System Requirements Definition Value Stream : Perform System Requirements Definition Process 2028 – Stakeholder Needs and Requirements Value Stream : Perform Stakeholder Needs and Requirements Process 2028 – Mission Analysis Process Value Stream : Perform Business and Mission Analysis Process	✘ No (2028 – System Requirements Definition Value Stream) ✘ No (2028 – Stakeholder Needs and Requirements Value Stream) ✘ No (2028 – Mission Analysis Process Value Stream)	✘ No
3	Employ a Modular Design	Goal–6 Enable Plug–and–Play Capability Goal–7 Ensure Interchangeability Goal–9 Support Scalability	Obj–6 Enable Plug–and–Play Capability Obj–7 Ensure Interchangeability of Components Obj–9 Support Scalability of Systems	2028 – System Requirements Definition Value Stream : Perform System Requirements Definition Process 2028 – Stakeholder Needs and Requirements Value Stream : Perform Stakeholder Needs and Requirements Process 2028 – Mission Analysis Process Value Stream : Perform Business and Mission Analysis Process	✘ No (2028 – System Requirements Definition Value Stream) ✘ No (2028 – Stakeholder Needs and Requirements Value Stream) ✘ No (2028 – Mission Analysis Process Value Stream)	✘ No
4	Establish Enabling Environment	Goal–5 Enable Cost Savings/Cost Avoidance/Schedule Reduction Goal–4 Incorporate Innovation Goal–1 Improve Interoperability Goal–6 Enable Plug–and–Play Capability Goal–7 Ensure Interchangeability Goal–9 Support Scalability Goal–10 Foster Vendor Independence Goal–13 Strengthen Security and Cyber Resilience	Obj–5 Achieve Cost Savings and Schedule Reduction Obj–4 Promote Rapid Innovation Obj–1 Achieve Seamless Interoperability Obj–6 Enable Plug–and–Play Capability Obj–7 Ensure Interchangeability of Components Obj–9 Support Scalability of Systems Obj–10 Foster Vendor Independence Obj–13 Strengthen Security and Cyber Resilience	2028 – Project Planning Process Value Stream : Perform Project Planning Process 2028 – Stakeholder Needs and Requirements Value Stream : Perform Stakeholder Needs and Requirements Process 2028 – Architecture Definition Process Value Stream : Perform Architecture Definition Process 2028 – System Requirements Definition Value Stream : Perform System Requirements Definition Process 2028 – Mission Analysis Process Value Stream : Perform Business and Mission Analysis Process 2028 – Acquisition Process Value Stream : Perform Acquisition Process 2028 – Integration Value Stream : Perform Integration Process	✘ No (2028 – Project Planning Process Value Stream) ✘ No (2028 – Stakeholder Needs and Requirements Value Stream) ✘ No (2028 – Architecture Definition Process Value Stream) ✘ No (2028 – System Requirements Definition Value Stream) ✘ No (2028 – Mission Analysis Process Value Stream) ✘ No (2028 – Acquisition Process Value Stream) ✘ No (2028 – Integration Value Stream)	✘ No
5	Leverage Consensus–Based Open Standards	Goal–1 Improve Interoperability Goal–6 Enable Plug–and–Play Capability Goal–7 Ensure Interchangeability Goal–10 Foster Vendor Independence Goal–13 Strengthen Security and Cyber Resilience	Obj–1 Achieve Seamless Interoperability Obj–6 Enable Plug–and–Play Capability Obj–7 Ensure Interchangeability of Components Obj–10 Foster Vendor Independence Obj–13 Strengthen Security and Cyber Resilience	2028 – Architecture Definition Process Value Stream : Perform Architecture Definition Process 2028 – System Requirements Definition Value Stream : Perform System Requirements Definition Process 2028 – Stakeholder Needs and Requirements Value Stream : Perform Stakeholder Needs and Requirements Process 2028 – Acquisition Process Value Stream : Perform Acquisition Process 2028 – Integration Value Stream : Perform Integration Process	✘ No (2028 – Architecture Definition Process Value Stream) ✘ No (2028 – System Requirements Definition Value Stream) ✘ No (2028 – Stakeholder Needs and Requirements Value Stream) ✘ No (2028 – Acquisition Process Value Stream) ✘ No (2028 – Integration Value Stream)	✘ No

Cost-Benefit Tradespace

Lower desired, target values or invest more in enabling resources?

#	Classifier	Name	cost.range : Cost Range Kind	cost.total cost : currency [USD]
1	Contract Management Capability Config	Planning Contract Management Capability Config	Medium	60000 $
2	Cybersecurity Risk Management Capability Config	Planning Cybersecurity Risk Management Capability Config	Medium	30000 $
3	Mission Engineering Capability Config	Planning Mission Engineering Capability Config	Low	15000 $
4	Program Management Capability Config	Planning Program Management Capability Config	Low	30000 $
5	System Architecture Management Capability Config	Planning System Architecture Management Capability Config	Low	25000 $
6	System Integration Management Capability Config	Planning System Integration Capability Config	Medium	90000 $
7	Systems Engineering Capability Config	Planning Systems Engineering Capability Config	Medium	45000 $
8	Test and Evaluation Capability Config	Planning Test and Evaluation Capability Config	High	30000 $

Relaxed target values

#	Name	Measure	Metric
1	Barriers and Challenges		
2	Ramblin Wreck Barriers and Challenges Targets		
3	count of unresolved integration and business barriers	3	Integer
4	Contracting Efficiency		
5	Ramblin Wreck Contract Efficiency		
6	percent non vendor-neutral components	0	Percentage
7	Cost Avoidance		
8	Ramblin Wreck Cost Avoidance Target		
9	LCC reduction gap	0.75	Percentage
10	maintenance savings gap	0.75	Percentage
11	missed early detection savings	500	currency[USD]
12	overall cost of ownership	305000	currency[USD]
13	reuse savings shortfall	1000	currency[USD]
14	Integration and Interoperability		
15	Ramblin Wreck Integration and Interoperability Targets		
16	average integration time	10	time[days]
17	complexity of integration tasks	3	Real
18	integration time per component	2	time[hours]
19	interoperability test failure rate	1	Real
20	number of compatibility exceptions	3	Integer
21	number of interoperability issues	2	Integer
22	percent non plug-and-play components	0	Percentage
23	percent non-interchangeable components	0	Percentage
24	Risk and Security		
25	Ramblin Wreck Risk and Security		
26	number of vulnerabilities identified	10	Integer
27	remaining risk after mitigation	3	Real
28	Standards and Compliance		
29	Ramblin Wreck Interface Open-Standard Adherence Target		
30	percent interface standard non-compliance	0	Real
31	percent interfaces not applying standard	0	Real

Targets unchanged – achievable through increased funding

MOSA Value Trend

Provides a high-level snapshot of value achievement across value streams and enabling resources over time.

Name	Value	Status Value Streams Achieving Value	Actual Enabling Resources Achieving Value
Ramblin Wreck 2028 MOSA Value Status	✗ No	✗ No (2028 - Acquisition Process Value Stream) ✗ No (2028 - Architecture Definition Process Value Stream) ✗ No (2028 - Project Planning Process Value Stream) ✗ No (2028 - Stakeholder Needs and Requirements Value Stream) ✗ No (2028 - Mission Analysis Process Value Stream) ✗ No (2028 - Integration Value Stream) ✗ No (2028 - System Requirements Definition Value Stream)	✗ No (2028 Contract Management Capability Config) ✗ No (2028 Sys Arch Mgmt Capability Config) ✗ No (2028 Program Management Capability Config) ✗ No (2028 Cybersecurity Risk Management Capability Config) ✗ No (2028 Systems Engineering Capability Config) ✗ No (2028 Mission Engineering Capability Config) ✗ No (2028 System Integration Management Capability Config) ✗ No (2028 Test and Evaluation Capability Config)
Ramblin Wreck 2030 MOSA Value Status	✓ Yes	✓ Yes (2030 - Acquisition Process Value Stream) ✓ Yes (2030 - Architecture Definition Process Value Stream) ✓ Yes (2030 - Integration Value Stream) ✓ Yes (2030 - Mission Analysis Process Value Stream) ✓ Yes (2030 - Project Planning Process Value Stream) ✓ Yes (2030 - Stakeholder Needs and Requirements Value Stream) ✓ Yes (2030 - System Requirements Definition Value Stream)	✓ Yes (2030 Contract Management Capability Config) ✓ Yes (2030 Sys Arch Mgmt Capability Config) ✓ Yes (2030 System Integration Management Capability Config) ✓ Yes (2030 Test and Evaluation Capability Config) ✓ Yes (2030 Mission Engineering Capability Config) ✓ Yes (2030 Program Management Capability Config) ✓ Yes (2030 Cybersecurity Risk Management Capability Config) ✓ Yes (2030 Systems Engineering Capability Config)

Conclusion

- A **Modular Open Systems Approach (MOSA)** is *"an integrated business and technical strategy to achieve competitive and affordable acquisition and sustainment over the system lifecycle."*
- **Value delivery and measurement** provide a practical lens for assessing MOSA compliance.
  - *"What gets measured gets managed; what's measured and acted upon gets done."*
- The **MOSA Domain Overlay (DO)** offers **defensible, justifiable metrics** and **target values** to:
  - Optimize MOSA value
  - Assess value achievement across the system lifecycle
- Originally developed for MOSA, the framework is **generalizable** for enterprise-wide value measurement.
- **Next Steps**
  - Expand validation rules to improve model consistency
  - Apply the framework to additional acquisition scenarios
  - Grow the library of goals, objectives, benefits, resources, and measurements
  - Strengthen semantic relationships for enhanced traceability
  - Improve information discovery across lifecycle phases

Acknowledgements

Laura Hart, OMG Model-Based Acquisition Managed Community, Co-Chair.

Steve Henry, NDIA SE Division, Architecture Committee, Consultant.

Let's connect

Richard Wise
Senior Research Engineer

e richard.wise@gtri.gatech.edu

Alton Schulteis
Research Engineer I

e alton.schultheis@gtri.gatech.edu

Christopher Zeoli
Senior Research Engineer

e christopher.zeoli@gtri.gatech.edu

References

- Business Architecture Guild. (2023a). *A Guide to the Business Architecture Body of Knowledge (BIZBOK Guide)* (Version 12.0). https://view.businessarchitectureguild.org/MBXxHC
- Business Architecture Guild. (2023b). Section 2.4: Value Mapping. In *A Guide to the Business Architecture Body of Knowledge (BIZBOK Guide)* (p. 141).
- Geier, N. (2022). *OUSD(R&E) Review of MOSA Tools and Practices*.
- Hart, L., & Anderson, R. (2022). *OMG UAF Model-based Acquisition Analytic Viewpoint Overlays (AVO)*.
- Hart, L., & Hause, M. (2023). *1. Model-Based Acquisition (MBAcq): Uniting Government and Industry around a Common Standard*. https://incose.onlinelibrary.wiley.com/doi/epdf/10.1002/iis2.13078
- Henry, S., Scheurer, B., Bradley, J., & Raygan, R. (2023). *MOSA Implementation Considerations, Information Needs and Metrics*. National Defense Industrial Association.
- "ISO/IEC/IEEE 42010: Conceptual Model." Accessed: May 22, 2024. [Online]. Available: http://www.iso-architecture.org/42010/cm/
- *Modular Open Systems Approach – DoD Research & Engineering, OUSD(R&E)*. (n.d.). Retrieved March 14, 2024, from https://www.cto.mil/sea/mosa/
- *Modular Open Systems Approach (MOSA)—AcqNotes*. (n.d.). Retrieved March 14, 2024, from https://acqnotes.com/acqnote/careerfields/modular-open-systems-approach
- National Defense Industrial Association. (2023). *Modular Open Systems Approach, Implementation Challenges and Opportunities*.
- Object Management Group, *Unified Architecture Framework (UAF) Domain Metamodel*, formal/22-07-03, Jul. 2022. [Online]. Available: https://www.omg.org/spec/UAF/1.2
- *Office of Law Revision Council, United States Code*. (n.d.). OLRC Home. Retrieved March 15, 2023, from https://uscode.house.gov/browse/prelim@title10/subtitleA/part5/subpartF/chapter327/subchapter1&edition=prelim
- Zimmerman, P., Ofori, M., Barrett, D., Soler, J., & Harriman, A. (2019). Considerations and examples of a modular open systems approach in defense systems. *The Journal of Defense Modeling and Simulation*, *16*(4), 373–388. https://doi.org/10.1177/1548512917751281

Abstract

Overview. Various agencies in the Department of Defense (DoD) are supplementing or transforming their acquisition process to a model-based approach, specifically submission of a Model-Based Request for Proposal (RFP) Package by a DoD program office and response from a supplier in the form of a Model-Based Proposal. However, there is no standard approach for creating either. The Model-Based Acquisition User Group Community within the Object Management Group (OMG) is addressing this gap by standardizing approaches, patterns, and reference architectures in the context of Model-Based Acquisitions to aid in the creation of Model-Based RFPs and Model-Based Proposals. Additionally, this effort includes the assessment or evaluation of a solution architecture description as part of a Model-Based Proposal. This assessment, known as a Domain Overlay, addresses various engineering domain concerns, such as Modular Open Systems Approach (MOSA), Cyber Security, and Nuclear Surety. The first concern to be standardized through a Domain Overlay is assessing the compliance of an architecture with MOSA statutes, policies, and regulations.

Problem. Developing a system architecture that embodies MOSA principles is not an easy task. MOSA is defined as “an integrated business and technical strategy to achieve competitive and affordable acquisition and sustainment over the system lifecycle.”
DoD programs must comply with U.S.C Title 10 §4401, which codifies MOSA into law, as well as many other related and derived statutes, policies, and guidance. The blessing and the curse of how the law is written results in the determination of “maximum extent practicable” and how to assess compliance of an architecture being left up to the program.

MOSA principles, such as design modularity and interface standardization and openness, are key in assessing MOSA compliance of an architecture. However, an architecture with higher modularity and openness isn’t always better. The technical decisions made to achieve high modularity and interface openness can sometimes compromise competitive and affordable lifecycle sustainment. Conversely, a pragmatic MOSA approach that balances technical and business decisions can result in effective, affordable, and sustainable systems. Therefore, compliance depends on transparent business and technical decisions that achieve and sustain the desired MOSA benefits. Acquisition programs need a clear approach to measure success and ensure compliance with MOSA law.

Approach and Methods. In collaboration with the Model-Based Acquisition User Group Community and the NDIA Systems Engineering Division Architecture Committee, work is underway in the development of a MOSA Domain Overlay to aid acquisition programs in the assessment of how well a program, inclusive of RFP and solution architecture models, applies MOSA principles and ultimately complies with U.S.C Title 10 §4401 by leveraging business architecture concepts and principles. From this perspective, any assessment of MOSA compliance is specific to how the program and its organization wants to optimize the value proposition, i.e. benefit against cost, of a MOSA. The selection of the specific types of metrics and assignment of target values to assess how effectively an organization is in delivering the MOSA value proposition is highly contextual and requires defensible justification meaning a framework is needed that unifies business and technical considerations.

The MOSA Domain Overlay is a repeatable model-based framework compatible with MBSE languages and practices. Key components of the framework include:

- An ontology defining business and technical concepts and their relationships necessary for measuring value delivery.
- A project assessment model pattern based on the Unified Architecture Framework (UAF), implementing the ontology as a business architecture.
- A library pattern for reusable elements such as objectives, benefits, capabilities, and resources, and traceability relationships between them.
- Methods for normalizing program artifacts, such as architecture models, cost estimates, and risk registers, into common, unambiguous views.
- Algorithms for calculating MOSA value delivery across organizational levels.
- Guided workflows, accessible via fit-for-purpose views, to support program-specific overlay development.
- Tool-specific validation rules to ensure consistent creation and application of the overlay.
- Dashboards for monitoring and sustaining MOSA value delivery, with drill-down insights.

This presentation will demonstrate the framework’s utility through a notional acquisition scenario and show how it addresses the challenges of MOSA compliance within DoD acquisition programs.