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# Open for Business: Business Models for Innovation with Modular Open Systems Approaches

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## Abstract

Modular Open Systems Approaches (MOSA) build on techniques used in the commercial world to attempt to bring innovation, speed, and savings to Department of Defense (DoD) acquisition. However, while competition can be a powerful motivator, MOSA can be disruptive to those traditional defense industrial base business models that rely on the expectation of long-term production and sustainment revenue to make back corporate investments. This project undertook interviews and surveys to better understand how MOSA influences vendor incentives and what business models may best serve DoD needs going forward. MOSA's promise of enabling faster technology refresh and bringing in new sources of innovation addresses technical and operational challenges associated with 21st century great power competition and longstanding DoD difficulties in accessing commercial technology.

This project has identified three overarching challenges regarding MOSA adoption: communicating and demonstrating government commitment; developing a MOSA-enabled IP and data rights strategy; and establishing standards and interfaces. In addressing these three challenges, the government will need to employ its acquisition toolkit to take different approaches with different vendors. To better understand how to make this transition a success, this paper presents a framework for evaluating the DoD's readiness for MOSA.

## Introduction

Across multiple decades, the Department of Defense has tried to emulate the advantages of commercial sector approaches (like common standards for personal computers and telecoms) in its acquisition system, using open standards to make it possible for a range of suppliers to innovate and compete with one another while still developing compatible technology. The present drive towards Modular Open Systems Approaches (MOSA) is a central pillar in this effort, one that has been repeatedly encouraged by Congress—including in the 2017 National Defense Authorization Act, which codified a requirement to use open interfaces in major defense acquisition projects. The possibility of a shift to MOSA for defense acquisition has drawn significant interest within the defense community (Baldwin, 2019; Minor, 2017). It has the potential to increase competition among vendors, make integration of subsystems and components cheaper and easier, increase interoperability, decrease the cost of operations and maintenance, and encourage innovation.

However, the potential benefits of MOSA also carry significant implications for defense–industrial business models. By making it easier to change subsystems (and the components within them), MOSA adds uncertainty to the level and duration of the business a vendor earns when selected to provide technology on a system. Successful MOSA implementation implies a greater likelihood that a vendor's technology could be replaced, or at least recompeted for, during a system's production. It also increases the ease with which a vendor's technology can be replaced in the sustainment phase. Historically, major defense contractors receive a

significant portion of their revenue in the sustainment phase of a platform's life cycle. One reason for the substantial revenue from the sustainment period is that the long platform lifespans are vendor-locked. The government is often reliant on a single vendor for upgrading the system, integrating a component from a third party, or any variety of maintenance tasks. This vendor-lock can be reinforced by proprietary interfaces that make their owners a mandatory participant in upgrades and gives them control over the supply chain throughout the life cycle of a system. The transition to open standards alters vendors' ability to forecast future revenues, especially during sustainment, and thus has the potential to reduce returns on investment, undermining companies' business models. On the other hand, a MOSA environment brings new opportunities to the industrial base. Even incumbent suppliers benefit from some of the changes in a MOSA environment, as it can lower transaction costs and creates opportunities to acquire market share previously controlled by competitors (Scheurer & Moshinsky, 2020).

Prior scholarship on MOSA seeks to lay out the technical and business challenges from a theoretical perspective. However, as MOSA moves closer to being in widespread use, it is vital to understand the perspective of industry as they navigate this paradigm shift in their business model. This report seeks to bridge the divide between the theoretical framework for MOSA and the experiences of practitioners through of survey and interviews. The insights gleaned from this work provides an important contribution to the MOSA literature and empowers policy-makers with new information as they seek to better understand the MOSA problem set.

The government has a vital role in implementing MOSA but cannot succeed alone. Successful implementation of MOSA will require robust participation by a cadre of vendors who are ready to put down the initial investment to make their products MOSA-compatible and ultimately willing to invest in technology that leverages MOSA to provide the benefits the government desires. For this reason, industry's understanding of and concerns about MOSA—particularly its impact on the business model—is key to MOSA implementation. To investigate how companies think about their business models in a shift to MOSA, the authors of this report conducted surveys and a series of interviews, primarily with those in industry. While a wide range of projects was discussed, the interviewees and the surveyed population paid special attention to the pivotal Army aviation sector and the development of next-generation helicopter and tiltrotor platforms via the Future Vertical Lift program.

The current report identifies three key challenges as primary areas of focus for adopting MOSA in light of industry concerns. The first challenge is communicating commitment—including clarifying what objectives supported by MOSA are top government priorities, being prepared to stand by those priorities, and having a means of evaluating whether those priorities are being met. The second is clarifying government requirements for MOSA-enabled IP and data rights. This relates to understanding vendor concerns about the scope of government demands, while determining what core technical data is necessary and what boundaries can be set to give industry the room to profit on its investment. The third challenge is choosing interfaces and standards, with a particular concern for the commonality of interfaces across different platforms and the modularity of those interfaces. The project also explores the acquisition toolkit, which is not a direct focus of vendor concern but instead provides opportunities to address the challenges listed above.

This paper begins by reviewing what has already been established in the literature, with special attention to the benefits suppliers may see from MOSA. The paper then takes a look at previous MOSA research on the four cross-cutting categories mentioned above: communicating commitment, IP and data rights, standards and interfaces, and the acquisition toolkit.

The next sections of the paper focus on the interviews and surveys themselves. First, the methodology of the survey is described: a mix of 1-hour interviews and electronic surveys reaching a more widespread audience. Both approaches were performed with the participants' inputs handled on a "not for attribution" basis, to encourage robust commentary and participation. The organizational and individual demographics of the respondents are summarized to give the results context. The paper then walks through the results of the survey, broken down into six large categories:

- Big picture opinions: how vendors are inclined toward MOSA, how it affects their financial incentives, and how their business model could change to incorporate open systems. This section discusses a division identified between MOSA embracers and MOSA-hesitant respondents, sometimes within the same organization.
- The open interfaces marking the boundaries between different modular systems, along with their associated challenge: shaping which subsystems and components will be available for competition.
- Industry views on intellectual property and data rights: how they lie at the core of their business model and what rights the government may require in implementing MOSA. This is especially relevant for companies that sell to commercial customers.
- The government's MOSA readiness and supporting infrastructure, including workforce and investments, and to what extent these are seen as opportunities by industry.
- Specific acquisition approaches, such as other transaction authority (OTA) arrangements and licensing, and how they shape company incentives. This section also covers one specific acquisition controversy: the role of the system integrator.
- Industry perceptions of the outcomes achieved by MOSA projects and their sources of innovation. These outcomes are a key indicator of success from the government's perspective, but they can also reflect favorably on future opportunities for companies.

The paper concludes by discussing findings related to the three challenges mentioned above: communicating commitment, MOSA-enabled IP and data rights, and choosing interfaces and standards. It also investigates the potential of the acquisition toolkit to allow for diverse approaches to addressing vendor incentives.

## Background and Literature Review

MOSA and related open-system architecture topics have a multidecade history within government, which involves a mix of interwoven technical and business considerations. Much of the literature focuses on the perspective of the acquirer, both commercial and government, as well as a range of policy- and technology-focused issues. This section starts by reviewing the core concepts of successful MOSA implementation, then dives deeper into five key concepts. The first topic addresses the overarching question of what motivates vendors in a MOSA environment. The second topic covers communicating commitment to an appropriate set of MOSA objectives and being able to confirm that openness has been achieved. The third topic presents the foundational choice of interfaces and standards, along with the implications that flow from those choices. The fourth topic is intellectual property and data rights, their interaction with MOSA, and the need for openness in key areas. The last topic is the acquisition toolkit that seeks to align vendor and government incentives.

Starting with the big picture, the Government Accountability Office (GAO) studied private sector open-system successes in addition to speaking with military open-system practitioners. They asked what would be needed to achieve success with open systems and put forward a few central practices and enablers. The first was the importance of "broad industry support and

coordination" in the development and adoption of standards, in order to create demand for open systems and to drive competition for the development of software and hardware. The second factor was a "long-term commitment" by the acquirer to "develop, implement, test, and refine standards" (GAO, 2014, p. 2) Another tenet was ensuring that an acquirer has the "technical expertise" to identify which standards to employ and which interfaces to open. Responders also indicated that "knowledge sharing across all the departments" within an acquirer was important to win organizational resources and minimize necessary investments (GAO, 2014, p. 2).

**What Motivates Vendors**

The exact benefits offered by MOSA vary somewhat from source to source, but the short list includes greater competition, interoperability, easier upgrades, incorporated innovation, and savings through reuse (*DAU Acquipedia*, n.d.; Zimmerman et al., 2019). A GAO report from 2013 contrasts the benefits of MOSA to a critical depiction of typical acquisition: "Traditionally, DoD has acquired proprietary systems that limit opportunities for competition and cannot readily be upgraded because the government is locked into the original suppliers" (GAP, 2013, p. 1). When determining which incentive structure to pursue, it is important to understand why industry can be motivated to adopt MOSA despite the differences in incentive structure, particularly considering that undercutting vendor-lock could threaten certain incumbents.

Nickolas Guertin and Douglas Schmidt (2018), of Carnegie Mellon University's Software Enterprise Institute, offer three main reasons vendors are pursuing MOSA: "(1) to avoid being left behind as others find new opportunities and (2) to take advantage of new methods to improve internal corporate efficiency, as well as to (3) increase market share and increase profits."

Bob Scheurer and Ed Moshinsky (2020), co-chairs of the National Defense Industrial Association System Engineering Architecture Committee, elaborate on the efficiencies and potential sources of competitive advantage and outline seven different positive-sum benefits of adopting MOSA for suppliers:

1. More competitive products through lower cost structures
2. Faster time to market, with less development time and costs
3. Increased competition within supply chain for lower costs
4. Increased interoperability providing greater market opportunities
5. Structured upgrade paths for quicker tech refresh and longer product life spans
6. Foundation for greater commonality across products, and larger lot buys for reduced costs through modularity
7. Incentive to innovate via an improved IP policy, by allowing access to and integration of critical supplier IP while still protecting supplier business interests and investments (2020, p. 6)

Well-architected MOSA makes designing products in a complex interrelated technology ecosystem easier and enables suppliers to focus more of their efforts and resources on product quality. In addition, as point 3 above implies, suppliers often act as acquirers themselves and thus have the potential to gain some of the benefits that the DoD seeks. The points on interoperability and commonality indicate that scale is another potential supplier benefit, as the promulgation of open standards means that a product may be useful to a greater range of customers while reducing the need for modification. The potential for greater product lifespans also reduces the negative impacts for suppliers that face greater competition. If incumbent

companies can more easily refresh the technology in their product, then they can potentially steadily improve existing product lines rather than sell the same system for longer.[1]

Taken together, the two lists above show why transition to MOSA can easily build momentum—or falter due to insufficient adaptation. The efficiencies cited by Scheurer and Moshinsky (2020) become more widespread when an acquirer makes greater use of MOSA; this is also the case if multiple buyers (e.g., different military departments or allied countries) choose the same interoperable standards. Meanwhile, Guertin and Schmidt's (2018) first point suggests that this is a transition for a larger sector of vendors, and that even a vendor that finds MOSA less appealing may still adopt lest they lose access to the new opportunities that their competitors are able to exploit. Thus, the benefits of MOSA for suppliers can create a virtuous cycle, but the uncertainty inherent when implementation is first starting out can delay or potentially short-circuit the development of that cycle.

Some suppliers will seek advantage by being early adopters of MOSA. Because the DoD often employs outside vendors directly in the creation of architectures and standards and in the management of integration, these early adopters have an opportunity to distinguish themselves from competitors by offering more openness in the initial design and implementation of MOSA. Davendralingam et al. (2019) highlight the Army VICTORY program, noting "the participation of GE Intelligent Platforms (Charlottesville, VA), which supported the use of an open standards approach, seeing it as a key business opportunity since other prime vendors were focused on proprietary-based solutions"( p. 393).

## Survey Methodology and Respondent Demographics

The industry opinions in this project are based on a series of not-for-attribution interviews supplemented by an electronic survey sent to interviewees and to the membership of the Vertical Lift Consortium. The interviews were targeted at companies that have experience with MOSA and were reviewed by the Army to ensure that a selection of companies they regularly work with would have ample opportunity to participate. A total of 16 guided interviews lasting roughly 1 hour were conducted, some with multiple participants. Interviewees sometimes included different divisions or experts within the same larger company; in total, 10 vendors participated. The interview process also included speaking with analysts and government practitioners, and a small number of international experts were included on both the vendor and government sides.

The project further developed an extensive survey to elicit respondents' opinions on how MOSA will affect their individual work and their company's business model. This survey took two forms: a long form for those who had a "nuanced understanding" of MOSA, and a short form for those who were only generally aware of the concept. The short survey focused on the following areas: respondent and company characteristics, impressions of MOSA overall, impression of steps needed for successful MOSA implementation, and the relative importance of various MOSA initiatives to the companies. The long form for those with specific MOSA familiarity asked all of these questions but also inquired about their thoughts on how intellectual property and data rights and interfaces have worked in the past, as well as how MOSA affects their company's acquisition approach, possibility for innovation, financial incentives, and outcomes. For the ordered multiple-choice questions that are displayed on a Likert scale below, no default answer was specified, but the most negative answer in a given context was listed first. Two

[1] The NDIA suggests that a carefully balanced version of MOSA will be most successful, and that, as per the information in their report, "the NDIA expects that all stakeholders in a MOSA implementation can achieve a higher potential for success and realize both the technical and business benefits from such implementations on system development programs and deployments" (2020, p. 6).

multiple-choice and most short-answer questions were optional, enabling some respondents to skip these questions.

The survey was sent to all interview respondents, as well as to the Vertical Lift Consortium mailing list. In total, 13 responses to the short form survey and 50 responses to the long form survey were collected. The short form survey was a subset of the longform survey so those questions on the short form survey were answered by both all that completed the survey. Of the 63 completed electronic survey responses, roughly a quarter were completed by interview respondents, with the remainder coming from the Vertical Lift Consortium.[2]

**Respondent Demographics**

Given the diversity within the defense industrial base, the survey started by asking the respondents to self-classify their organization and their work.[3] Multiple respondents from the same organization—including organizations that separately participated in the interview—were allowed, even if at times classification of the organization varied between different people at the same organization. As shown in Figure 1, the two roles most represented are original equipment manufacturers (OEMs) and system integrators, who make up over half of the respondents. These categories of organizations (sometimes in partnership with one another) are the traditional platform leading primes.

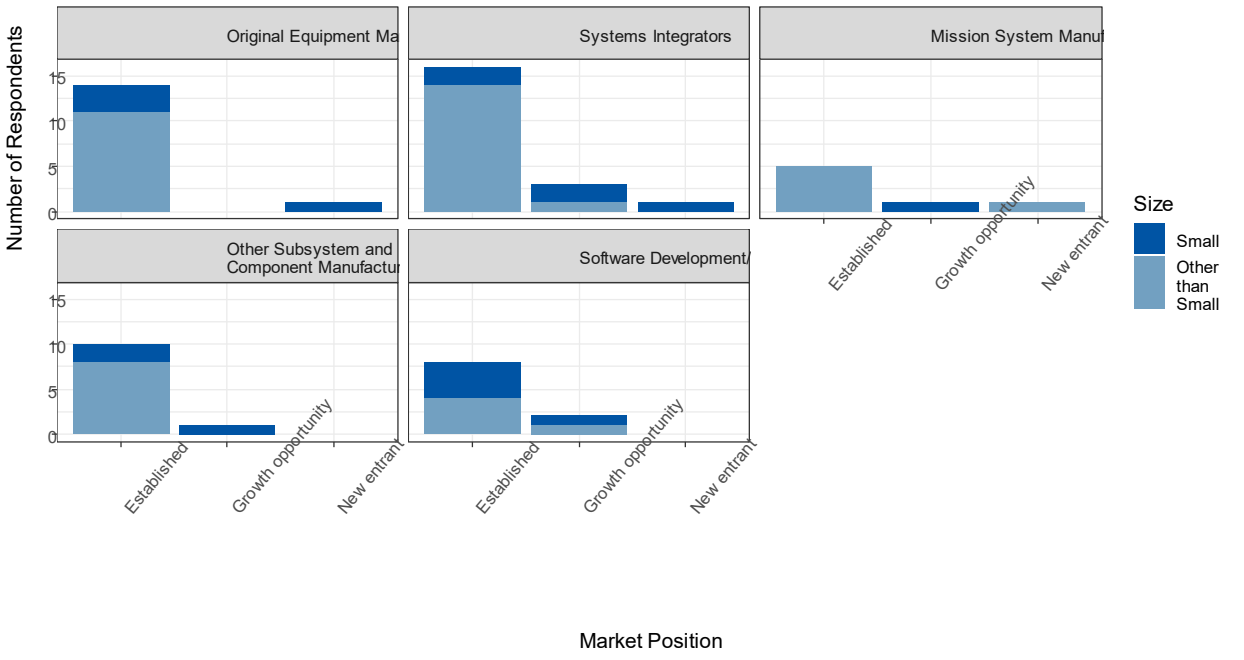


Figure 1. Industry Survey Participants Self-Classification by Organization Role and Market Position

The other three categories are key to providing modules to the platform, although vendors for complex mission systems and subsystems often have their own integration responsibilities within their domain. Most of the respondents were established companies, although there were three new entrants and seven respondents seeing substantial growth opportunities. The relative frequency of established players partially reflects an orientation of

[2] Approximately 40 additional respondents started but did not complete the survey.
[3] Analysts were asked to describe the organizations with which they were most familiar.

interviews to MOSA-experienced companies, but also suggests that even smaller vendors in consortiums often see themselves as established players. A significant minority of respondents (28.6%) were from small businesses, partly balancing the low proportion of non-traditional defense companies. Collectively, this means that the results will better capture the range of opinions among larger prime competitors than smaller or less traditional competitors. Thus, discussion of adopting commercial technology will often refer to the commercial portion of an established defense industrial base company or to the challenges of bringing in a third party's parts and services.

The majority of respondents included aircraft in their focus, while a near-majority also included electronics, comms, and sensors. This again reflects the focus on FVL-relevant vendors and the Vertical Lift Consortium, but it does show that respondents have a wide range of focus areas. While the interviewees (and the respondents writ large) most frequently were focused on FVL and Army programs more broadly, cited experience with MOSA projects included all three military departments.

Looking at the individual responsibility and expertise of respondents, engineers and program managers were the most common respondents, with government relations and contracting officials being a distant third. The two analysts were experts that study MOSA programs and industry rather than being vendors themselves. In their individual responsibilities, over 60% of the respondents dealt with an even mix of hardware and software, and among the remaining, more dealt with hardware than software. This sample has extensive knowledge of MOSA, with nearly four fifths having at least a nuanced understanding and more than half of respondents having direct professional experience or outright expertise.

## Frameworks and Crosscutting Patterns

This report suggests several key challenges that MOSA presents for the business case of a mix of suppliers in the defense industry. This section outlines how these challenges are related to the Army's stated goals for MOSA, how these goals are related, and how a determination might be made across acquisition priorities. It concludes with recommendations to address each challenge in the report.

The areas of focus identified in the report are communicating commitment to MOSA, developing an IP strategy that benefits from MOSA, and achieving commonality of standards and interfaces. Each of these challenges has been discussed at length in the above sections, but is briefly summarized again below:

- **Communicating Commitment to MOSA.** Companies communicated multiple related concerns:
    - Communication: Vendors, especially the MOSA hesitant, want to know the government's priorities regarding MOSA, in order to guide investments and to build the case for tailored IP and data rights.
    - Commitment: For MOSA embracers, a chief concern is that the government will accept defections from stated MOSA commitments, undercutting their process reforms. For both embracers and the hesitant, consistency between leadership's vision for the "big idea" of MOSA and the staff officers managing implementation is a key prerequisite for achieving lasting change.
    - Follow-Through: The government will have to effectively judge compliance with standards at the start and throughout the life of a program. This can involve competition to judge integration speed, cross-vendor feedback mechanisms, and accessible conformance testing facilities.

- **IP and Data Rights.** Companies expressed concern that the government "wants it all" regarding IP and data, including commercial IP and IP stemming from vendor investments. In many cases, flexibility on IP below the interface level would address these concerns. Business-model impacts for interfaces and architectures are more challenging. Deeper interfaces implicate more sensitive data rights.
- **Standards and Interfaces:** Companies had different preferences over the extent of modularity, with some seeing disruption to existing products and business approaches and others seeing new opportunities for competition and innovation. Regardless of the extent of modularity, cross-platform commonality is a key incentive with substantial room for improvement.

A fourth cross-cutting topic is the **acquisition toolkit**. This is not a challenge in the same manner as the other three, in that it was not a direct source of concern; instead, applying a diverse mix of contracting approaches has the potential to help tune business models to address these challenges.

Table 1 connects each of the key challenges laid out in this report to larger problems the Army seeks to address. The three middle columns in the table each represent one of the challenges to successful MOSA implementation. The rightmost column covers options provided by the acquisition toolkit. The rows of the table represent ways to address the cross-cutting topic that would also aid in addressing larger Army goals. Because not every challenge will affect every goal, and because these goals may trade off against each other, this table allows for prioritization across the MOSA challenges laid out in this report, based on which goal the Army wants to prioritize. For example, if the Army's priority is accelerating development timelines, this analysis suggests that IP and data rights will not have a large impact on this goal, but that communicating commitment by incentivizing faster integration and achieving commonality in standards and interfaces will make a bigger difference.

Table 1. Connection between Army Goals and Key Business Case Challenges Identified in This Report

| **Army Goals** | **Communicating Commitment to MOSA:** *Successfully communicating commitment to MOSA means...* | **IP and Data Rights:** *Successfully implementing a MOSA-enabled IP and data rights strategy means...* | **Standards and Interfaces:** *Successfully implementing standards and interfaces means…* | **Acquisition Toolkit:** *The acquisition toolkit can aid in addressing these challenges by...* |
|---|---|---|---|---|
| Design a system architecture | Convincing involved actors that the Army will not change the system later to decrease prices in the short term. Achieving a common understanding of underlying goals across both government and industry; reinforced by evaluations and testing approaches. | Determining necessary IP and data rights for technical baseline; being prepared for upfront prices to acquire them. | Encouraging cross-platform adoption. Deciding which features of MOSA and other acquisition priorities are most important, to guide choice of architecture depth.<br><br>***Key Trade-off: Extent of Modularization* | Exploring contracting approaches that consider openness when determining what proposals offer the best value. More experimentally, exploring rewarding future integration successes and wider reuse of interface, including licenses and royalties. |

| **Army Goals** | **Communicating Commitment to MOSA:** *Successfully communicating commitment to MOSA means...* | **IP and Data Rights:** *Successfully implementing a MOSA-enabled IP and data rights strategy means...* | **Standards and Interfaces:** *Successfully implementing standards and interfaces means…* | **Acquisition Toolkit:** *The acquisition toolkit can aid in addressing these challenges by...* |
|---|---|---|---|---|
| Develop new capabilities | Sharing a roadmap for future system development through working groups. | Encouraging investment by allowing industry to retain below-interface IP, while preserving open interfaces. | Enabling new and growing vendors to offer and be competitive in providing new capabilities.<br><br>***Key Trade-off: Extent of Modularization* | Allowing for more iterative development of requirements. Employing rapid contracting approaches, especially for software. |
| Maintain stable budgets for mission system development and deployment | Taking enabling measures to ensure that openness is maintained over time. | Lowering risk for government and vendors by allowing more tailored IP solutions while preserving options for future competition. | Setting realistic expectations for industry to support investing in capability development. | Enabling acquisition tool planning that enables successful budget execution. Balancing upfront costs and life-cycle costs through approaches such as minimum orders or commercial licensing. |
| Accelerate development timelines | Employing competitive measures that test integration speed and incentive openness on the integrator side. | Maturing tailored data rights requirements for more rapid agreements with industry and clarity in expectations. | Achieving greater commonality in interfaces or adherence to commercial standards. | Lowering time to contract, especially for software development. |
| Address fluctuations and uncertainties in order quantities | Setting priorities across the entire system to ensure that initial requirements are credible. | Addressing “can I still sell this” industry concerns beyond the initial platform. | Adopting standards widely, and across platforms, to mitigate investment risk through larger sales opportunities. | Diversifying acquisition approaches using ones that address risk tolerance, such as minimum order and time options. |
| Incorporate Software | Establishing a conformance process that is clear and viable, making it easier and less costly to integrate software. | Developing licenses that give access for key government purposes, including ease of replacement and cybersecurity, while addressing industry concerns that source code may be transferred to competitors. | Creating a common digital backbone that should improve the ability to incorporate software.<br><br>***Key Trade-off: Extent of Modularization* | Licensing software and easing the shift for vendors traditionally reliant on hardware sales. |

Table 2 MOSA Readiness Framework

| Category | Dimension | High Readiness | Low Readiness |
|---|---|---|---|
| Communication and Commitment | Government and broad industry communication about achievable first iterations and future roadmaps | • MOSA part of system engineering<br>• Informed by industry input | • Lack of clarity on which MOSA goals are integral to system<br>• Government and industry talk past each other |
| | Sustained government commitment to MOSA objectives and a credible MOSA funding model | • Competition by best value and contract incentives tied to openness<br>• Budgets support iteration within a program and cross-program investments | • Government awarding contracts that undercut MOSA standards for other benefits<br>• Absence of metrics for MOSA goals in execution |
| Enabling Environment | DOD and service enterprise investments in MOSA enablers | • Support from above<br>• Encouraging adoption of widespread open standards | • Programs face MOSA challenges alone<br>• Initiating new bespoke approaches |
| | Government engagement with key enablers and cross-platform standards development that builds and sustains consensus with industry | • Wide range of industry stakeholders engaging in the standards development process | • Limited interaction between industry and government<br>• A few vendors dominate the process at the expense of others |
| | Acquisition and sustainment workforces' business and technical expertise | • Widespread understanding backed by effectively deployed experts track larger MOSA concepts and meet MOSA goals | • Experts are rare within organizations<br>• Solutions are applied that run contrary to leadership direction |
| Business Models | Business models that incentivize defense-industrial base transition | • Diverse mix of contracting approaches that use a variety of incentives to meet MOSA goals | • Contracting approaches that disproportionately rely on significant profits during the sustainment period |
| | Expansion of the supplier base and inclusion of commercial technology | • New vendors competing for modules<br>• Reduction in the bifurcation between the military and commercial markets | • Low level of engagement in DoD standards process<br>• Lack of knowledge or interest in contracting opportunities |

The solutions to these three MOSA challenges and the employment of the acquisition toolkit are not independent. Picking an interface standard is unlikely to have any influence on outcomes if the commitment and follow-through measures are not sufficient to ensure that the implementation is open in practice. Likewise, failing to tailor IP approaches will almost preclude successfully finding ways to incorporate commercial technology. The depth of interfaces should be shaped by larger MOSA and system objectives, such as the use of multifunction shared

computing resources, and it in turn will shape what IP and data rights are necessary for the architecture. Addressing any one of the three challenges well will make the others easier, but entirely neglecting one will undercut attempts to address the others. The final section of the report outlines several ways that the government might do this. However, even if these requirements are met, many of the Army's stated goals for MOSA will falter if the challenges of commitment, conformance, and incorporating technology are not addressed as well.

### MOSA Readiness Framework

In a parallel effort to the industrial survey covered in this report, the authors created MOSA readiness framework shown in Table 2 (Sanders & Holderness, 2021). This framework suggests metrics for considering the government's readiness for MOSA's coordination problems.

## Discussion

### Communicating Commitment

Open system adoption is a coordination problem offering shared benefits for government and industry, but it also carries transition costs and risks. "Communication" here is used broadly—strategic outreach and conferences are directly relevant, but the bigger picture is demonstrably taking steps that demonstrate both commitment and the capability to follow through. Effective coordination has multiple aspects: vendor participation in standards, adoption of interfaces, and implementation of open-source business process reforms; vendors investing in and proposing technologies of interest; vendors providing feedback and sharing knowledge to shape effective approaches; and vendors being discouraged from behavior and proposals that would fail to achieve openness.

**Vendors, especially MOSA-hesitant ones, desire to know the government's MOSA-related priorities for them to guide their investments and build their case for tailored IP and data rights arrangements.** There is some risk here that defining goals and priorities too narrowly may foreclose future options that are compatible with larger MOSA principles but are not the focus of today's leaders. However, that risk is balanced by the opportunity to show how MOSA goals fit into the larger program and enterprise goals, and how they will stick around even when trade-offs must be made in development.

Use cases are one such mechanism for communication. These are scenarios that depict how the MOSA characteristics of a project are to come into play to achieve desired goals. Moving from a broad goal, like providing competition and technology insertion, to a use-case example of how a new mission system module may be incorporated provides more detail for vendors, but it remains goal-focused in a way that does not need to be highly prescriptive to be effectively communicated.

**For MOSA embracers, a chief concern is that the government will fail to enforce MOSA.** During the present FVL competition phase, this could mean accepting a proposal that offered a lower front-end price but fell short on openness goals. Further on in the life of a system, this might mean accepting an exciting module that withholds key information or otherwise fails to conform. In either case, accepting a solution that is putatively "close enough" could undermine the openness of a system in ways that manifest over time in exchange for a short-term benefit. This fear has some basis in the multidecade history of open system policy goals, which have often lost out to proprietary systems in practice.

Those that raised this concern emphasized its importance to their incentives, but in broader terms they had positive views of Army commitment. Upfront work on standards, and steps such as the creation of the Architecture Collaborative Working Group, were seen as

important sign of intended follow-through. Excess detail in requirements was widely agreed to be a risk, but suggestions as to what was necessary varied, with some arguing for mandating chosen standards and others suggesting that specifying the open interfaces was more important.

Beyond the MOSA embracers, a wider pool of vendors underlined the importance of commitment to the programs that contain MOSA. The logic here is straightforward: when a program is delayed and shrunk—or worse, canceled—many of the investments made in it will see greatly reduced returns. The success of the larger efforts of transitioning to MOSA depends in no small part on the success of the present crop of programs that are mandated to implement it.

**There are opportunities for industry to demonstrate its ability to implement MOSA goals beyond thresholds.** Setting threshold requirements to encourage openness is part of the incentive picture, but many aspects of openness will not be pass-fail. Developing metrics to measure MOSA alignment is highlighted in the literature as a prerequisite for setting appropriate incentives for vendors. In terms of competitive evaluation, some MOSA embracers suggested that past performance and best-value criteria for openness could be used to set apart those that could deliver an architecture that would provide a greater savings in the long term.

Any metrics and incentives chosen will come with some controversy and vendor feedback. For example, past performance may be less applicable to non-traditional vendors or fail to account for decisions on the government side. Nonetheless, one promising approach emerged during the interviews. New hardware and software integration will regularly be a key MOSA priority and one which a broad range of primes express confidence in their ability to execute. When prototypes are sufficiently advanced and developed standards are in place, integration “shoot-offs” are one way to put this confidence to the test. Under this approach, the government would furnish software or hardware products that conform to the pertinent open standards and give the relevant integrator the opportunity to demonstrate how quickly and effectively these can be incorporated into their system. One system integrator did warn that some level of communication between the integrator and the module provider may be necessary.

Sustaining commitment does not end when winning vendors are chosen, but instead it should be tracked throughout the life of a program. Testing the speed of integration has value post-competition as a means of evaluating the sufficiency of openness and available technical data and artifacts. In one international example, an architecture intended for wide deployment is being tested by a third party taking on the role of integrator. In this particular example, the vendor committed to make additional artifacts available if the previous IP and data rights scope was insufficient to enable integration. Specially-negotiated license arrangements may benefit from similarly being tied to goals rather than to static predictions of what IP and data rights would be required.

### IP and Data Rights

For a plurality of vendors, IP and data rights are the top concern regarding MOSA. The incentives are most pertinent when vendors are bringing technology they also sell in the commercial market, with regards to front-end investments, and for sustaining investment. The open interfaces themselves are only part of the discussion, which expands to grapple with the question of the contours of vendor IP under MOSA and what incentives this creates for investments.

**A common industry concern is that government “wants it all,” even IP developed at private expense or when not in support of a clear goal.** Vendors often argued that accommodation could be reached on a range of more limited transfers, with in-field

maintenance and depot arrangements as commonly cited examples. This complaint precedes MOSA, but the switch to open interfaces and the rearranging of existing business models brings it to the fore. Concerns were diffuse, but two areas received repeated attention: transfer of IP to competitors and computer source code. Transfer to a competitor might happen intentionally (for example, as part of substituting a new system integrator for sustainment) or unintentionally (as a consequence of greater openness) if not accompanied by protective measures. The government's desire for computer source code, without being accompanied by a license, was repeatedly raised in the electronic survey.

**Especially for commercial products, industry wants to know "can I still sell this?"** MOSA brings opportunities to adapt existing technologies to a new system, although this can raise questions about whether the ability to sell the underlying technology is affected, especially when the government is paying for the adaptation. For example, would a commercial avionics package adapted for use in a military helicopter come under export control regulations? For software sales, one vendor raised the question of whether a sale would be a one-off and afterwards available to any part of the government.

**MOSA has the potential to enable a diverse mix of IP and data rights approaches.** Building on an approach proposed by Guertin and Schmidt's (2018) framework, it is possible to determine what IP and data rights are necessary by thinking of the system in two tiers. The first tier is the fundamental necessities in the architecture, standards, and infrastructure that are the foundation of MOSA. Industry does have concerns—sometimes vehement ones—in this area that will be challenging to finesse. Clear explanations of goals and developing plans that will lead to cross-platform adoption has aided this step in one international case. However, wise choices and a willingness to bear some upfront costs will be critical.

With that foundation in place, MOSA can then enable a diverse mix of IP and data rights strategies for the replaceable portions of system. These modules will be "grey boxes," not truly opaque black boxes, as information about their workings will be required for successful integration. However, the option to turn to a new vendor means that as long as any module conforms with the larger standards, there is much more room to reach a range of IP and data rights approaches that are appropriate to the vendor, the need they are meeting, and the mix of investment. A range of vendors independently raised this point in tandem with their IP and data rights concerns. This is the realm where acquisition approaches, such as software licenses, that give vendors something to hold on to and that reward investments can be experimented with at lower risk of future vendor-lock. The MOSA goals the government seeks for a project may change and evolve over time in ways that cannot be predicted in advance, even by the best tailored arrangement, but the availability of competition means that departing from arrangements that are no longer suitable is a viable option.

**Business model impacts for interfaces and architectures are more challenging. Deeper interfaces implicate more sensitive data rights.** While MOSA is quite compatible with leaving "grey boxes" preserved for vendor investment, the size of those boxes depends on the choices of interface and standards. What might be a single package under one architecture could be broken into multiple components in another, or divided between hardware and software in yet another. Under deeper interfaces, what once was internal to a subsystem may now openly flow across components, including those made by different vendors. For example, under CMOSS, a box containing a radio and antenna would be broken up, with key capabilities placed on hardware cards and the antenna itself used as a pooled resource serving multiple functions (Strout, 2021). However, for a mission system manufacturer, this might mean that offering a commercial product would be unappealing, as it would involve breaking up a subsystem sold to the larger market as a whole. Likewise, commercial technology—notably software—may have special licensing requirements that can be preserved when they are part of

a large subsystem but which may not be compatible with them being a module in their own right. On the other hand, more granular interfaces can also open up opportunities for a range of vendors, including software developers and component manufacturers. While special licensing or other acquisition approaches may be necessary for some non-traditional vendors, these should be compatible with the MOSA-enabled IP and data rights diversity discussed above.

**Standards and Interfaces**

**Depth of interfaces is a dividing line. More granular interfaces may bring benefits for multifunctionality and more advanced components, but the MOSA-hesitant see integration risks and a loss of incentive to invest.** Carrying over from the last point under IP and data rights, the extent of the advantages of greater modularization was a point of disagreement. For some vendors and other interviewed experts, more modular interface approaches are desirable, as they allow for greater multifunctionality and more rapid insertion of technologies such as sensors or processors rather than tying them to the refresh cycles of the larger subsystem. Multifunction components have the potential to reduce size, weight, and power (SWaP) by reducing duplication. For some vendors, including ones with mixed feelings on MOSA, a more modular architecture may be their best chance to be competitive for a system where an established vendor has been taking a leading role on the subsystem in question. For the skeptics, including many MOSA-hesitant respondents, more granular interfaces did raise concerns about IP and data rights and their incentives to invest, but other concerns were also cited. Namely, a more modular system does mean a greater integration role for some mix of the system integrator and the government. One related concern is the need to be clear about who is responsible for the performance of different parts of the system when a failure comes out of interactions rather than a single module.

**Widely adopted standards and interfaces expand the potential market and are a key incentive.** When a technology works with one platform employing a common standard, MOSA greatly speeds the development time and lowers the cost of bringing that technology to a new platform with compatible standards. As vendors incorporate a standard into their businesses processes, future opportunities to employ it are also made easier. This commonality also can result in a module having a diverse portfolio of potential customers and thus being less affected by volatility in any individual program. Multiple respondents, including those expressing hesitancy about the downsides of more granular standards, noted that market size was a key positive incentive. This was not a universal sentiment; some standard choices or implementation will bring controversy, but there is a clear upside to increasing standard reuse, which was reinforced in the vendor survey regarding the anticipated advantages to vendors of allowing part reuse.

**Standard-setting bodies and other coordinating groups are vital feedback mechanisms and benefit from openness with allied countries.** Standards commonality could put the brakes on the ability to incorporate new technology if the standards were static. Happily, the bodies instituted for industry to discuss standards, as well as other coordinating mechanisms such as software interface control working groups, were seen as venues both for shaping future developments and for the government to provide roadmaps for future intentions. The diversity of approaches in industry provides an opportunity to vet ideas that may run the risk of undermining openness (even if they would be advantageous to a company) by bringing them to bodies like the Architecture Collaborative Working Group. One challenge raised by some international interviewees was that some standards are partially classified, and that some consortiums can limit participation only to the U.S. subsidiaries of international companies. The FACE standard does better in this area than some other DoD standards, but this is an area where classification and no-foreign limitations should be used sparingly, as allied adoption of

standards can be advantageous for interoperability and for exports—besides which, cross-national embrace of standards further increases their potential for reuse.

**Adopting or following commercial open standards where possible is desirable but requires upfront thinking on cybersecurity.** Some commercial standards, such as ethernet and the defense industry–focused OpenVPX, were given as examples already in use. The automotive industry was favorably cited for its success in adopting open systems; in the aerospace sector, some respondents, especially MOSA embracers and analysts, cited open integrated modular avionics architecture and efforts in Europe as models worth greater study and adoption. Adoption where possible and hewing closely when wholesale adoption was not possible was seen as a worthy goal, but also one that would require deliberate effort to implement and that would face complications—such as the risk of obsolescence, as industry sometimes switches standards entirely. Additionally, one skeptic on this idea raised concerns that standard update cycles might mean that attempts at partial adoption would just lag perpetually behind. Cybersecurity, also raised outside of the commercial standards context, was cited as an important front-end issue rather than something that could be added later.

**Enterprise mechanisms to build commonality are a good investment.** The most important benefits of MOSA can vary from one program to another. However, the interest of individual programs can be in conflict with that of the larger enterprise. Upfront decisions need not only consider prices years in the future, but also questions of commonality. As more programs settle on a single standard, the potential benefits and incentives for industry accrue. However, particularly for legacy programs, the costs and compromises of adopting a potentially widespread approach may make bespoke approaches win out.

While vendors will have strong opinions about what standards and approaches will win out, the advantages of working at the enterprise level were uncontroversial. The survey showed enterprise-wide governance and policy was the most favored of the options presented. Here, approaches by Army PEO Aviation garnered some praise. Likewise, cross-service coordination was seen as desirable but more of an aspiration than a topic where progress was being made.

**Assigning responsibility for integration and considering airworthiness certification is worth upfront attention.** A range of vendors, especially system integrators, argued that a set of conforming modules was not seen as sufficient to ensure a successful system. End-to-end integration, especially during development, was widely seen as a coordination-intensive challenge and one that would require trade-offs that go beyond enforcing and updating standards. Determining who is responsible for the performance of different parts of the system as well as the extent of government integration responsibility will be important for ensuring that accountability and authority are aligned. As a related issue, airworthiness certification and approaches that enable updates that do not endanger the larger certification are also worth early consideration. One analyst argued that incremental certification, as employed in open integrated modular avionics, is a plausible path forward.[4]

### Acquisition Toolkit

The acquisition toolkit is different than the prior categories of findings because it is more contextual and less shaped by the transition to MOSA. Many of the considerations raised apply to larger adaptable acquisition concerns, in particular for software acquisition, although proper use of the acquisition toolkit has the potential to help address the aforementioned challenges.

[4] For example, see Daniel P. Schrage and William Lewis, "It Is Time for Army Aviation to Move to a Development Assurance Approach for Including Open Integrated Modular Avionics" (presented at the Vertical Flight Society's 76th Annual Forum & Technology Display, Virginia Beach, VA, 2020), 12.

**The contracting approach often has an "indirect" relationship with MOSA, and traditional industry is comfortable working with a range of mechanisms.** While other transaction authority and single-award indefinite delivery vehicles were both favorably rated, most interviewees did not emphasize any particular mechanism as necessary. Instead, for those that spoke to considerations such as cost-based or fixed-price contracting, the emphasis was often placed on the phase of contracting and the certainty of the requirements at that time.

**Contracting may be more central for non-traditional participants.** Fixed-price approaches are more associated with examples of commercial technology adaption, suggesting that dynamics for non-traditional vendors in the other parts of the acquisition system apply here as well. Likewise, other transaction authority (OTA) approaches were supported but not universally favored. For traditional vendors, OTAs do bring the potential for greater speed and flexibility, but also often involve cost-sharing requirements.

**Software licensing deserves more attention and use, especially for source code access, but will bring complexities.** Licensing arrangements that pay for regularly updated software as a service, rather than traditional waterfall software acquisition, can be well suited to an iterative approach, with ongoing investments after reaching initial capacity. Respondents noted that this approach was applied in the commercial sector, often by their own companies. Particularly if the IP and data rights largely rested with the government, vendors argued that the incentives to make ongoing investments would be reduced. That said, licensing will require developing additional government expertise, and commercial licenses are often explicitly not designed for military use. In addition, the IP and data rights aspect of licensing involves complexities separate from payment structure, as the government may need sufficient access to trace faults while limiting what source code could be seen by competitors. In parallel, internal government software capacity may bring additional options—if also greater responsibility and talent demands on the government side. To some MOSA-hesitant vendors, depots are less of an IP and data rights concern and diverse acquisition models may include open-source approaches alongside greater use of commercial style.

**Diversity of methods can help round out restraints in other areas.** Choices regarding standards and interfaces benefit from cross-platform adoption, and while different sorts of platforms and mission sets may benefit from different priorities and metrics, this tuning should be weighed against commonality. As a result, while the extent of modularity may differ across platform areas and there will be some variety from one system to the next, standards and interfaces will be shaped by higher-level choices and will be a better fit for some vendors than for others. While the requirements set by an open interface apply to all vendors using it, greater diversity is possible for IP and data rights arrangements, dramatically so within modules. That said, work such as system integration, the design of open interfaces, and the open aspects of modules themselves offers less flexibility. Specially-negotiated licenses may allow for some tailoring in those areas, but maintaining commitment to the openness of the system is vital. The acquisition toolkit may be of lesser importance to the more challenging factors, but it also provides an opportunity for tuning when other aspects are fixed.

This diversity of approach suggested that extra acquisition workforce attention should be devoted to the hard cases, in particular system integration, where MOSA is changing both the business model and the nature of the responsibility. One possibility raised in interviews and at the Acquisition Research Symposium would be a royalty model where, for example, successful integration of additional vendors and technologies could reward the developer of an open interface even though they did not retain an IP interest (Tate, 2021).[5] In a follow-on survey,

5 Comment at the 48-minute mark. Tate also proposed a system of two proposals, one with vendor-preferred data rights and one with government-purpose rights, to better understand the underlying problem and incentives needed.

royalties and similar licensing approaches were widely thought to be both relevant to and to enhance the appeal of MOSA projects. More conventionally, the literature emphasized the development of metrics based on MOSA goals and tying contract incentives to these metrics. Within arrangements such as IDIQ vehicles, success might be tied with time extensions rather than be viewed as a strictly financial benefit. That said, some vendors interviewed were more worried about downside risk, especially in cases where order numbers may fluctuate for reasons that they have little influence over. When vendors are bringing key commercial or other heavily invested technology, it may be appropriate to offer minimum duration or quantity guarantees, especially where technology refresh cycles are slower. In follow-on interviews, such guarantees were supported, but not seen as a panacea. Vendors may be able to offer lower unit costs based on cost curves achievable with the guaranteed quantities, but may be unwilling to include further savings based on unit counts they are at risk of not selling.

## Conclusions

### MOSA Changes to the Business Model

Efforts to transition to MOSA are longstanding, but urgency is growing due to the mounting difficulty of high technology great power competition reinforced by congressional mandates. The start of a major program, such as the Army's Future Vertical Lift, represents an irreplaceable opportunity to apply standards and open interfaces. However, MOSA implementation faces a range of difficult business and technical choices and is only part of a larger industrial base management and program development picture. This report assists policy-makers and analysts by documenting the sometimes clashing views of industry, aiming to inform the development of business models that will be able to align incentives between DoD priorities and vendor interests. Success means that government and industry solve a coordination problem; this will be iterative and increase the adaptability of individual programs and the acquisition system as whole. Ongoing communication and feedback will be necessary to sustain progress, and this report assists that process by helping customers and vendors to understand one another—and to understand the prerequisites of transitioning to a system that, while still competitive, offers new opportunities and efficiencies for those eager to innovate.

To successfully carry out a transition to MOSA, the Army will face three parallel but interlinked challenges: communicating commitment, developing a framework for IP and data rights, and choosing and building consensus on standards and interfaces. Collectively, addressing these challenges will require understanding the government's own priorities in implementing MOSA, building the government's MOSA infrastructure in the form of MOSA-savvy personnel and MOSA resources, making prudent choices on IP, establishing standards and interfaces informed by a range of industry input in an ongoing dialogue, and demonstrating a willingness to bear short-term cost to achieve longer-term gains.

There is a range of industry opinions on MOSA that vary by industry position and function, sometimes even among different business units within diversified companies. Even within those traditional defense industry players most comfortable with the DoD's existing approach to system design, there are a mix of opinions about MOSA. It is clear that there is a critical mass of support for MOSA in industry, enough to make success achievable. However, there is also enough MOSA hesitancy to undermine the effort if the government makes poor implementation choices or loses its commitment to the effort. Overall, this mix of genuine MOSA support from some traditional industry players and the potential for inclusion of non-traditional players through MOSA does present an opportunity to use competition to encourage MOSA adoption. Sustaining and communicating commitment is critical to ensuring that threshold levels of openness are achieved and maintained. Ultimately, MOSA implementation will lead to a substantial reshaping of defense supply chains that will necessarily evolve over time.

Addressing intellectual property and data rights is not just a matter of resolving all of these issues upfront, but of taking advantage of the benefits offered by MOSA to ensure that industry has appealing business models in a more competitive MOSA environment. Finally, the choice and development of standards and interfaces will require difficult trade-offs and will benefit from achieving commonality both within portfolios, such as PEO Aviation, but also throughout the DoD and beyond. Across these challenges, the acquisition toolkit can assist in making the transition to MOSA appealing—both through the application of traditional acquisition judgment and through the application of adaptable approaches that aid in aligning the incentives of a variety of businesses with those of the government.

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