How the Navy Is Using Open Systems Architecture to Revolutionize Capability Acquisition

The Naval OSA Strategy Can Yield Multiple Benefits

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Introduction

Given the expense of our defense acquisition programs—coupled with budget limitations stemming from the fiscally constrained environment—the Department of Defense (DoD) has prioritized attaining greater efficiencies to achieve dominant capabilities through technical excellence and innovation .[i] To achieve these goals, the Navy is applying an Open Systems Architecture (OSA)[ii] strategy that promotes open competition, cost control, innovation, and the rapid (and affordable) replacement, integration, and upgrades of capabilities to address warfighter needs. This paper describes how the Navy is shifting its efforts toward open architectures that (1) are defined and managed by government/industry consortia and (2) can be used across multiple air, surface, or subsurface platforms, instead of allowing vendors to define proprietary platforms or even contractor-/vendor-specific open architectures.

<u>Limitations with the Status Quo.</u> The Navy has long strived to attain the benefits from OSA approaches. It has historically attempted to achieve open systems by acquiring the appropriate data rights and contracting with industry to define an open system. However, allowing industry to work in isolation to define system and software architectures has generally resulted in vendor-specific product line or platform-unique solutions. These vendor-specific architectures have limited the Government's ability to bring third parties into the marketplace to add new capabilities or compete the role of system integration. Moreover, this approach has resulted in multiple, disparate, and often non-interoperable open architectures, which have yielded minimal benefits and often resulted in sole-source or single-bidder contracts.[iii]

Towards a Holistic OSA Strategy. The uncoordinated acquisition models to date have limited the benefits that can be realized through the systematic application of OSA approaches, which require a holistic, strategic approach to yield the maximum benefit by applying product-lines within and across multiple layers, subsystems, and warfighting domains. In particular, single-solution acquisition contracts will not provide the long-awaited OSA benefits of affordability, shorter program schedules, and increased warfighting capability. The complexity of advanced warfighting capabilities and their associated safety and security concerns may always make initial delivery lengthy. However, rapid capability reuse and deployment across many systems—both domestically and internationally—can achieve significant cost, schedule, and warfighting advantages.

Earlier experience with OSA approaches for the Navy has shown that investing in the initial design and development of open product-line architectures is needed to reap the system life cycle cost reduction associated with integration, obsolescence, upgrade, and technical refresh that can be provided by multiple parties. Likewise, robust and refined intellectual property strategies must be developed to ensure the Government acquires only what it needs to ensure more granular open competition and to simplify technology refresh across the life cycle of an open system. These strategies should also incentivize appropriate levels of information sharing and cooperation to avoid common tensions that exist between Government program offices and their industry suppliers.

Program officials who manage systems that were not initially design as open architectures might attempt to break a long-held vendor lock by considering costly purchases of extra license rights to monolithic or closed architectures. These actions are often applied to address some aspects of the risks associated with competing for the sustainment of the entire system. Those acquisition strategies have to address an environment where the Original Equipment Manufacturer (OEM) might have unique technical abilities to understand and maintain the system due to its lack of an open design and the dearth of widely available industry standards and published interfaces.

A holistic OSA approach, on the other hand, starts with central management of shared architectural elements by defining and managing the modules and decomposition of system capabilities. The deployment of these capabilities onto a system is then (1) enabled by the design and development of standardized hardware and software technical reference frameworks and (2) supported by a well-defined intellectual property strategy promoting open competition. These competitions can be managed in smaller risk-prudent elements and be a venue for capturing innovation arising throughout the defense industrial base.

Using a holistic approach to architect future warfighting systems will enable the DoD to address the acquisition of military platforms (e.g., ship, aircraft, submarine, ground vehicle, spacecraft), and the payload systems that go in them (e.g., sensors, command & control, combat, weapons), as separate entities. Integration services can also be established to both coordinate the delivery of systems into the platform and the integration of the components into the payload/mission systems. This comprehensive architectural strategy provides the foundation for a Navy product-line approach. Moreover, the work products produced by government or industry contributors can be provided to a capability integrator agent (which can be either Government and/or Industry) as the basis of the system design. In general, a holistic approach to architecting defense systems can be applied to help achieve the following benefits of the Navy's OSA strategy:

1. Eliminate redundant development efforts
2. Develop flexible and scalable system and software architectures
3. Tailor deployment of capabilities required to complete a particular mission
4. Deploy new capabilities to support a range of evolving missions quickly and cost effectively
5. Increase innovation across the defense industrial base
6. Avoid or break vendor-lock and improve effective competition
7. Provide a common framework for international technology transfer agreements

A Holistic OSA Strategy and Product Lines

Achieving the benefits of OSA strategy outlined above involves a holistic, multi-dimensional, and architecture-driven approach that combines (1) Capability Decomposition, (2) Technical Reference Frameworks, and (3) an Intellectual Property Strategy, as discussed below.

Capability Decomposition. A holistic approach begins with a multi-organization, mission-area engineering team responsible for performing the assignment of capabilities that decomposes system functionality into components required to execute the mission. One example of this construct is NAVAIR's Integrated Warfighting Capability (IWC) organization, which established mission-based engineering teams to analyze the “kill chain” and identify the capabilities necessary to execute the mission. The "kill chain" allows the Navy to understand the capabilities necessary to complete the mission and focus our investments to those required capabilities. The mission-area engineering team then describes the capability and high-level capabilities apart from a specific platform or system in the Mission Technical Baseline (MTB). Next, the team assigns the capabilities to the appropriate platforms and systems, which are documented in the Integrated Capability Technical Baseline (ICTB).

A commodity capability program office can then analyze the ICTB in conjunction with a multi-platform portfolio manager who has the necessary insight and authority to develop common capability roadmaps for a portfolio of systems. After achieving a solid understanding of which capabilities have common requirements across systems, these capabilities are further decomposed into discrete core capabilities. In turn, these core capabilities serve as the building blocks for developing high-level capabilities. The decomposition of these capabilities includes a description of the capability, the required functionality of the capability, its behavior and the data interoperability requirements. These descriptions can then be used to develop procurable components that perform these capabilities, which are then deployed on multiple DoD systems.

Technical Reference Framework. The second piece of a holistic approach is the development of a limited number of hardware and software technical reference frameworks or infrastructure architectures. These standardized frameworks enable the deployment of the functionality and components identified by the Capability Decomposition process described above onto the architecture using published and standardized key interfaces. Limiting the number of systematically-aligned technical frameworks helps maximize component reuse, while minimizing the use of idiosyncratic "open" architectures. The Armed Services have already embarked on instantiating these frameworks, including the Navy initiatives researching hardware open-systems approaches and the software-reliant Future Airborne Capability Environment (FACE™)[iv] Standard (Army/Navy).

Intellectual Property Strategy. The last piece of the holistic OSA approach is the adoption of a robust intellectual property (IP) strategy. Standardizing the Technical Reference Frameworks and decomposing/documenting the capabilities needed for a given system provide the acquisition community with increased options for addressing an IP strategy. Previous strategies assumed that acquiring a minimum of Government Purpose Rights (GPR) for the hardware and software within a system would improve the Government's ability to compete the product and award to a non-incumbent. These systems however, were not decomposed into discrete components that reflected warfighter capabilities. In addition, data deliverables were typically a tapestry of different data rights elements that defined large, complex, and tightly-coupled systems.

Due to the lack of effective decomposition—along with the "poison pill" of tightly-coupled proprietary elements—the Government has historically been limited in the use of delivered data to compete effectively. In particular, monolithic system architectures—exacerbated by the lack of thoughtful IP strategies—prevent subsystem upgrades through competition and create a barrier to market entry. This conventional approach presents DoD program managers with few risk-prudent options for competitive upgrades, replacing obsolete capabilities, or improving underperforming systems. It also raised the barrier to entry such that when upgrades *were* competed, they frequently resulted in single-bidder responses from the incumbent or ventures that became high risk for cost and schedule.[v] This conventional approach has not only yielded more expensive single-system upgrades, it's also discouraged consideration of more capable and innovative solutions.

An IP strategy forms the basis for acquiring the appropriate license rights for technical data that is an integral part of the acquisition strategy. These strategies identify the need to have a well-defined infrastructure and modular architecture whose capability decomposition provides program managers with the flexibility to add, remove, and replace components as the mission capabilities evolve. This flexibility also enables commercial component licensing models, where it is often beneficial to license an innovative solution and replace it cost effectively when a more capable solution is available or the technology becomes obsolete. Not only do product-line architectures and commercial licensing model leverage innovative solutions from industry, they also enable the adoption of a more robust and competitive global marketplace.

The products from each dimension of the holistic approach described above form the basis of a flexible, extensible, composable, and scalable system and software architecture for warfighting platforms. These products are described in the Integrated Warfighting Capability Package (ICWP), which can be used by the LCI to better manage the system design over the life cycle of the warfighting platform. Figure 1 shows a notional flow for establishing the holistic architecture approach within a DoD acquisition organization.

OSA Product Line Benefits

Establishing a holistic OSA approach that culminates in open capabilities derived as a product line is non-trivial. The end result, however, provides significant value for both the Navy and the warfighter. These benefits will be driven primarily by the consolidation of platform-unique architectures into an open product-line architecture defined and managed by Government/Industry consortia that will enable:

1. Common capabilities to be reusable across multiple platforms
2. Competition throughout the lifecycle for components of payload systems
3. Competition throughout the lifecycle for integration services (including assignment of Government labs in selected instances).
4. Consolidation of Government development and test lab infrastructure
5. Markets that are currently vendor locked to be opened (foreign and domestic)
6. The science and technology community to focus on the innovative capabilities
7. The international cooperation initiatives to focus on the innovative capabilities
8. Improved commercial data rights licensing strategies
9. Consolidation of contract actions for redundant capability
10. The ability to integrate emerging capabilities affordably
11. Cross-Service common capability reuse and interoperability

12. International common capability reuse and interoperability

These benefits are crucial to sustaining warfighting dominance of the U.S. and its allies. In the present fiscal environment, the acquisition community must make a cultural shift away from sole-source, platform-unique solutions and adopt a holistic OSA approach to deliver the most capability across the DoD cost-effectively and preserve the relevance—and effectiveness—of the warfighter.

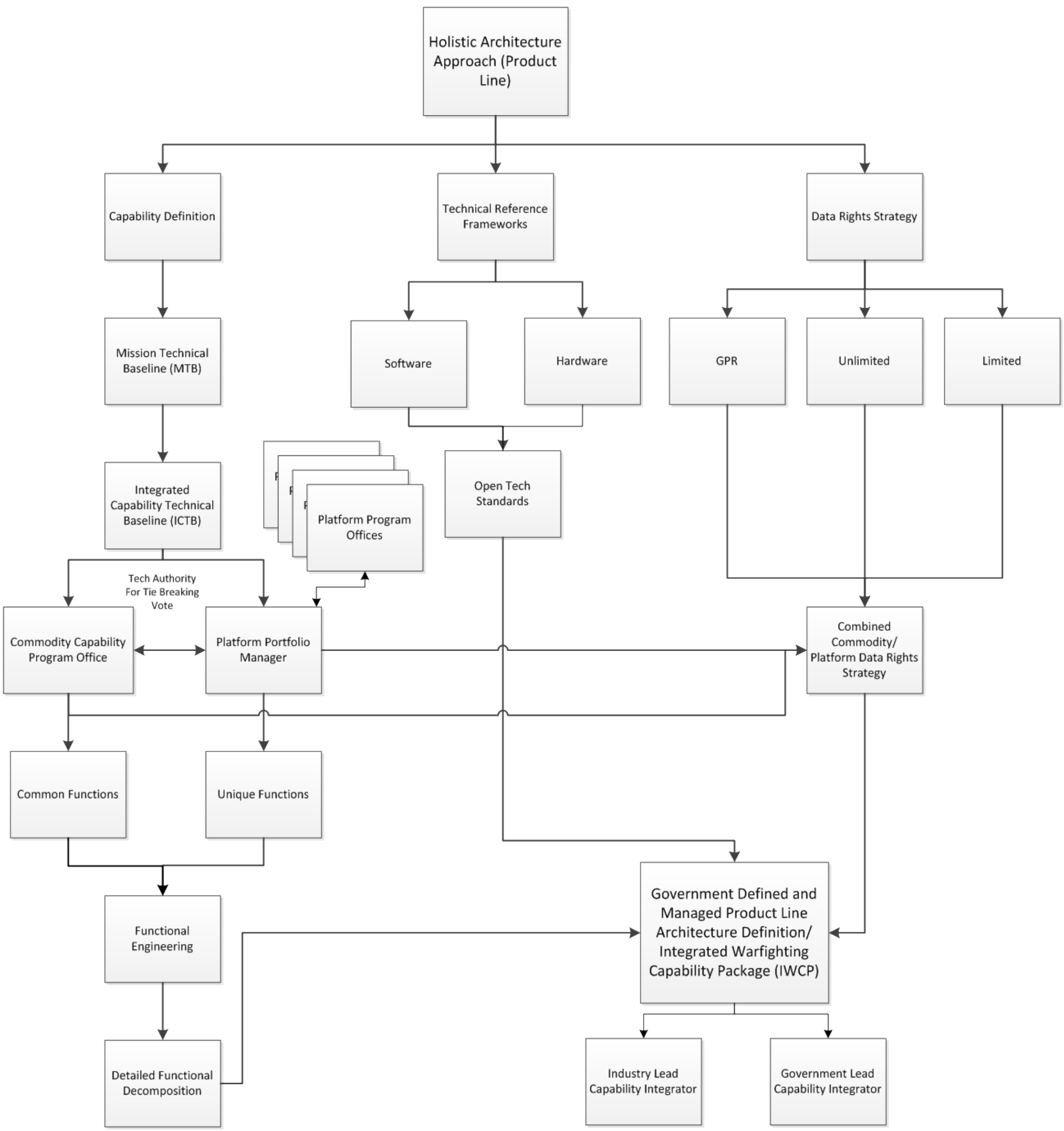

Figure 1: Holistic OSA Flow Diagram

OSA Product Line Challenges

Several leadership challenges exist in establishing a holistic open OSA approach and instantiating a capability-based product line. The hardest challenge to overcome is the significant acquisition and organizational cultural shift that must occur. The defense acquisition community has been primarily focused on single-platform solutions, which results in stove-piped acquisitions.[vi] Organizational processes need to shift toward focusing on the capabilities needed to perform a mission and which of those capabilities are common across multiple platforms. This shift may move program managers (PMs) out of their traditional comfort zones since it requires them to assume risk to a program for the benefit of another program. As such, the PM needs to be incentivized to assume this shared risk. Program managers and acquisition leadership will need to accept a shared risk across programs to reap significant cost avoidance with minimal schedule or performance risk.

Another challenge is identifying the up-front funding source to appropriately invest in maturation of the product-line architectures that embody Technical Reference Frameworks. The decision must be made to provide this funding to an independent common capability program office or to tie it to an early adopting program. Both options come with drawbacks that need to be resolved:

- *Segregated accountability*. Funding an independent capability program office isolates the funding, which could segregate accountability of the capability from the integrating platforms. This segregation may lead to a perceived restriction of technical and financial trade space over a single program office authority, but better enable multi-platform trade space decisions for common capabilities.
- *Restrictive platform reuse*. If the development of the product-line architecture is tied to an early adopting program, the lead platform will maintain perceived trade space. However, the platform requirements of the early adopting program may heavily influence or bias the common-capability architecture requirements, resulting in an overly restrictive solution hinders systematic reuse since it does not meet the requirements of other platforms.

Despite these drawbacks, the Navy cannot afford "business as usual," which is currently the development of vendor-unique “stove-piped” architectures, which lock programs into a small number of system integrators, each devising proprietary point solutions that are expensive to develop and sustain over the lifecycle. Resource sponsors, commodity capability program managers, and platform portfolio managers should therefore work together to strategically coordinate investments that ensure maturation of product-line architectures that are suitable to their domains. This coordination allows the mitigation of shared risk, thereby ensuring programs are successful, relevant, and sustainable well into the future.

The last major challenge is developing an acquisition workforce with the right knowledge, skills, and abilities (KSAs) to manage a holistic product-line approach. Today's cultural focus and acquisition alignment is around platform-unique solutions, where each systems bring its own networks, computers, displays, software, and operators. The Navy therefore needs to increase its skill set to architect, design, develop and maintain each of the pillars of this holistic approach. It also needs to train personnel in all career fields with skills related to software and hardware product-line management, including program managers, portfolio managers, architects, engineers, logisticians, test engineers, contracts and data-rights specialists. Moreover, the Navy may need to reach into the defense industrial base to recruit the workforce with the necessary KSAs to help influence the current organizational culture by providing valuable insight and lessons learned for establishing and maintaining product lines.

International Technology Transfer Program

The DoD is not the only national defense organization attempting to benefit from the instantiation of OSA in their respective organizations. Alignment of OSA strategies across allied nations could benefit the existing and future technology transfer agreements by allowing the sharing of innovative technologies between nations more affordably and effectively.

The DoD's International Science and Technology Engagement Strategy[vii] seeks to enhance interoperability and collaboration with allied nations through the exchange of innovative technologies. Its ultimate goal is to accelerate research and development programs and leverage emerging global opportunities to enhance the capabilities of the U.S. and our allied partners while gaining economic efficiencies. Applying a product-line approach among allied nations could allow the international partners to quickly and affordably reach the goals of the international engagement strategy.

Alignment of a product-line architecture approach is already underway through the Technology Transfer Cooperative Program (TTCP)[viii] between the United States, Canada, United Kingdom, Australia, and New Zealand. Through the multinational collaboration and coordinated investment within the TTCP Aerospace Systems Group (AER) Technical Panel 7 (TP-7), a standardized approach to mission systems OSA is being developed. Once this alignment has matured, other allied nation technology transfer groups and organizations can utilize the agreed upon product-line architecture to affordably and rapidly develop, integrate and test new technologies, while ensuring multinational integration and interoperability.

Pockets of Ongoing OSA Efforts

Several pockets of OSA efforts are ongoing throughout the DoD. These efforts must be brought together and collectively mandated to realize the benefits of the holistic approach discussed above. By leveraging efforts already underway and coordinating investments across services and allied nations, a product line can be established. Examples of these efforts include hardware open system approaches, the FACE Standard, Joint Common Architecture (JCA), Unmanned Aerial System (UAS) Control Segment (UCS), and TTCP. The Navy's mission engineering organization's efforts, coupled with a sustained push by NAVAIR leadership for a cultural shift toward OSA and commonality, will ensure success.

The hardware open system approaches being pursued by Naval Air Systems Command (NAVAIR) and Georgia Tech Research Institute (GTRI) are intended to provide requirements and guidance for developing open hardware computing systems for hardened military use. Their approach's core tenets promote upgradeability, expandability, sustainability, and component reuse. A joint NAVAIR and Army Aviation influenced effort is the FACE Technical Standard and corresponding business practices. The FACE initiative establishes a technical and business ecosystem to enable open software architectures, software portability and reuse, and ease software integration efforts resulting in decreased costs and fielding schedules for DoD software aviation capabilities.

The Army's Joint Common Architecture (JCA) is defining and describing the low-level capability decomposition to be incorporated into future Army helicopter programs. These capabilities would be deployed on the FACE architecture as building blocks in a manner that forms the capabilities necessary to execute the Army's mission threads. The Office of the Secretary of Defense has commissioned the UCS Technical Society to design and document a standardized functional decomposition of UAS Control Station (UCS) services. The UCS functional decomposition standard will be used to develop and deploy modular capabilities onto control stations based on the mission needs of the UAS that is being controlled. The UCS-defined modular ground station capabilities have been deployed on a FACE-enabled architecture during a recent airborne demonstration, showcasing the feasibility of a holistic architecture approach.

The international alignment efforts being performed under the TTCP organization will take the current OA efforts from each of the partner nations and align them to develop a singular architectural approach enabling development of common technologies in collaboration with member nations. Likewise, NAVAIR has championed a true cultural shift in strategic thinking by establishing a mission-level engineering organization, the IWC, to analyze and define the kill chain. This analysis is being used to flow capability-based requirements down to the commodity and platform programs for acquisition. NAVAIR has also embraced several of the other OSA efforts, which have begun to pull together a holistic approach to OSA by strategically linking these efforts with the mission engineering organization to establish and mature a product-line architecture for use on future naval aviation platforms. Through this cultural shift, NAVAIR is advantageously positioning itself to realize the benefits of the holistic approach in the future.

Summary

When applied properly, OSA practices can increase affordability and reduce time to field, while providing an increase in capability to the warfighter. A holistic approach to OSA using capability decompositions with central management of common functionality, standardized hardware and software technical reference frameworks, and a cohesive data rights strategy will yield these benefits. The Navy must realign its investments to establish, mature, and maintain the pillars of product lines and Technical Reference Frameworks. While this realignment may seem daunting, pockets of success are appearing, which can be leveraged and combined to form the holistic architecture strategy. Although the challenges of cultural change are significant, the benefits of future technological and financial efficiencies far outweigh the risks and costs of maintaining the current acquisition status quo.

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