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Analysis of Modular Open Systems Approach (MOSA) Implementation in Navy Acquisition Programs

07 March 2008

by

Dr. Rene G. Rendon, Senior Lecturer

Graduate School of Business & Public Policy

Naval Postgraduate School

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Abstract

This research attempts to use the Navy Enterprise Open Architecture Assessment Tool (OAAT) findings as a method for analyzing the US Navy's implementation of a Modular Systems Approach (MOSA) in its weapon systems acquisition programs.

The purpose of this research paper to provide a preliminary analysis of assessments conducted on Navy weapon system acquisition programs using the Navy Enterprise Open Architecture Assessment Tool (OAAT). The OAAT is used to assess a weapon system's "degree of openness" in terms of the open architecture maturity of that specific weapon system program and its systems. Openness refers to both business and technical characteristics of weapon systems that support modular design, interoperability, and commercial standards. A higher degree of openness both supports weapon system programs in terms of competition for development and support, as well as facilitates rapid technology insertion. Although the number of weapon system programs and system assessments analyzed in this research are minimal, this paper does provide some preliminary conclusions on the Navy's implementation of a Modular Systems Approach (MOSA) in its weapon systems acquisition programs.

Keywords: assessment, modular open systems approach, OAAT, open systems

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About the Author

Dr. Rene G. Rendon is a nationally recognized authority in the areas of supply management, contract management, and project management. He is currently on the faculty of the United States Naval Postgraduate School, where he teaches in the MBA and Master of Science programs. Prior to his appointment at the Naval Postgraduate School, he served for more than 22 years as an acquisition and contracting officer in the United States Air Force, retiring at the rank of lieutenant colonel. His Air Force career included assignments as a warranted contracting officer for the Peacekeeper ICBM, Maverick Missile, C-20 (Gulfstream IV), and the F-22 Raptor. He was also a contracting squadron commander for an Air Force pilot training base and the director of contracting for the Air Force's Space Based Infrared satellite system, and the Evolved Expendable Launch Vehicle rocket program.

Rendon has taught contract management courses for the UCLA Government Contracts program and was also a senior faculty member for the Keller Graduate School of Management, where he taught MBA courses in project management and contract management. He is a graduate of the US Air Force Squadron Officer School, Air Command and Staff College, Air War College, and the Department of Defense Systems Management College. Rendon is Level III certified in both Program Management and Contracting under the *Defense Acquisition Workforce Improvement Act* (*DAWIA*) program. He is also a Certified Professional Contracts Manager (CPCM) with the National Contract Management Association (NCMA), a Certified Purchasing Manager (C.P.M.) with the Institute for Supply Management (ISM), and a certified Project Management Professional (PMP) with the Project Management Institute (PMI). He has received the prestigious Fellow Award from NCMA, and he was recognized with the United States Air Force Outstanding Officer in Contracting Award. He has also received the NCMA National Education Award and the NCMA Outstanding Fellow Award. Dr. Rendon is a member of the ISM

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Table of Contents

I. Introduction 1

II. Background on MOSA Policy 3

III. Initial Research Findings 5

IV. Internal Assessment of MOSA Implementation 7

A. Open Architecture Assessment Tool 7

B. Business/Programmatic 8

C. Technical 9

D. Open Architecture Maturity Matrix 9

V. Assessment Results 13

A. Subsurface Domain 13

B. Air Domain 14

VI. Analysis of Assessment Results 17

VII. Areas for Further Analysis 19

VIII. Conclusion 21

List of References 23

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I. Introduction

This research continues the exploration of the use of the modular open systems approach (MOSA) as a method for implementing an evolutionary acquisition strategy in Department of Defense (DoD) programs. The background on the initial DoD and Navy policy on using a MOSA approach in defense acquisition is presented, followed by a review of the initial research findings. A discussion is then provided on the Navy's method for assessing its implementation of a MOSA approach in its acquisition programs. This discussion will focus on the use of the Naval Enterprise Open Architecture Assessment Tool (OAAT). The primary purpose of this continuing research is to provide a preliminary analysis of the results of the OAAT assessment of selected Navy acquisition programs.

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II. Background on MOSA Policy

DoD 5000.1 states that, "a modular open systems approach shall be employed where feasible" (Under Secretary of Defense (AT&L), 2003, May 12a; 2003, May 12b). Furthermore, in April 2004, the USD (AT&L) issued a memorandum stating, "all programs subject to milestone review shall brief their program's MOSA implementation status to the Milestone Decision Authority (MDA) to determine compliance" (Under Secretary of Defense (AT&L), 2004, April 5). This USD (AT&L) memo also directs program managers to brief the result of their Program Assessment and Rating Tool (PART) assessments at all major milestone and program reviews (Under Secretary of Defense (AT&L), 2004, April 5).

Later that year, the Office of the USD(AT&L), Director of Defense Systems, issued instructions for MOSA implementation and identified the Open System Joint Task Force (OSJTF) as the DoD lead for MOSA. This memo also identified MOSA as, "an integral part of the toolset that will help DoD achieve its goal of providing the joint combat capabilities required in the 21st century, including supporting and evolving these capabilities over their total life-cycle" (Under Secretary of Defense (AT&L), 2004, July 7).

In addition, in August 2004, Assistant Secretary of the Navy (Research, Development & Acquisition) (ASN (RDA)) issued a policy statement that developed a single Navy-wide Open Architecture to account for Surface, Air, Submarine, C4I, and Space domain unique requirements. That memo also assigned PEO IWS overall responsibility and authority for directing the Navy's OA Enterprise effort. An OA Enterprise Team comprised of OA domain leads, ASN, OPNAV, and SYSCOM representatives was chartered and led by PEO IWS. The Team collectively oversees the development and implementation of the processes, business strategies, and technical solutions which support cross-Enterprise requirements in addition to domain-specific needs. The Enterprise Team will also define an overarching OA acquisition strategy and develop guidance that addresses incentives, intellectual

property issues, contracting strategies (i.e., integrator's vs. prime's), and funding alternatives (ASN (RD&A), 2004).

Finally, in a 23 December 2005 letter, Deputy Chief of Naval Operations (Warfare Requirements and Program) established the Navy-wide requirement for OA and laid out the priorities on which it wants Naval OA to focus. The letter, "establishes the requirement to implement Open Architecture (OA) principles across the Navy Enterprise." It establishes the OA Council (OAC) of representatives of N6/N7 Division Directors to work with the OAET on the requirements. The letter directs the OAC, PEO IWS 7.0, and the OAET to focus assessment priorities in support of the following capabilities: Track management, Combat ID (CID), Data fusion, Time-critical Targeting & Strike, and Integrated Fire Control (IFC).

III. Initial Research Findings

The purpose of the initial MOSA research was to explore both the use of the modular open systems approach (MOSA) as a method for implementing an evolutionary acquisition strategy, as well as the implications of using such an approach on the contracting process.

Although the phases of the contracting process are the same for MOSA-based program as they are for non-MOSA-based programs, this research found that the specific activities conducted and documents developed during the execution of these contracting phases have a direct influence on the success of a MOSA-based program. For example, the various options for allocating roles and responsibilities between the government and the contractor for the various steps in the acquisition process will influence the amount of "openness" in the program and the contractor's motivation for meeting the desired level of openness.

This research indicated that the greater degree of jointness in acquisition roles and responsibilities, as well as the greater degree of contractor-developed acquisition documents, led to a higher level of openness.

This initial research also identified early involvement and participation by industry in developing requirements and acquisition strategy as key factors in successful MOSA-based programs. Program offices managing a MOSA-based programs should conduct extensive market research and industry conferences to achieve this contractor involvement. A best-value contract strategy that is tailored to emphasize technical performance in open-based systems and COTS systems is also a critical factor in meeting higher levels of openness in MOSA-based programs. A contract strategy which involves developing source-selection evaluation factors specifically weighted to emphasize an open systems approach will be critical for MOSA-based programs.

The structure of the contract of a MOSA-based program is as important as its acquisition strategy.

This research identified the use of incentive-fee, award-fee, and award-term contract incentives as integral to the success of MOSA-based programs. These incentives, if structured appropriately, are effective tools for motivating and incentivizing contractors to achieve higher levels of openness in the design and development of systems.

Finally, the consistent and aggressive use of the contractor past-performance information system, as well as the development and establishment of lessons-learned programs and best practices will be essential as more and more MOSA-based programs are initiated. As contractors performing work on MOSA-based programs begin to realize that the DoD is insistent on using open systems in developing its major weapon systems, they should begin to dedicate the required resources to this method of developing weapon systems.

IV. Internal Assessment of MOSA Implementation

The focus of this follow-on research is to explore the effectiveness of the implementation of MOSA in Navy acquisition programs. This research will include investigating the results of MOSA-internal assessments, specifically the results of the Navy's Open Architecture Assessment Tool (OAAT). The results of this research will prove beneficial to senior Navy officials by providing data points on MOSA implementation by analyzing the consistency of MOSA compliance status and internal assessments for specific Navy acquisition programs.

A. Open Architecture Assessment Tool

The Open Architecture Assessment Tool (OAAT) is a tool designed to assist Navy program managers in assessing the degree of "openness" of their programs. It aligns to the Open Architecture Assessment Model (OAAM) as approved by ASN(RDA) and provides a reproducible and objective method of conducting program assessments. Specifically, the OAAT is an analytical tool that evaluates responses to a set of interrelated questions to provide program officers with an objective and evidence-based assessment of the degree that a program exhibits openness along two axes: Business/Programmatic and Technical. The degree to which openness is implemented is presented in terms of business/programmatic and technical criteria. The OAAT assessment score summary provides a summary of the ratings for each of the evaluated areas (See Figure 1).

Business Areas	Technical Areas
Open Systems Approach	**Design Tenet: Interoperability**
Open Architecture	**Design Tenet: Maintainability**
Open Modular Design	**Design Tenet: Extensibility**
Interface Design and Management	**Design Tenet: Composability**
Treatment of Proprietary Elements	**Design Tenet: Reusability**
Open Business Practices	**General Design Tenet**
Peer Review Rights	
Technical Insertion	
Commercial Standards	
Compliance	

Figure 1. Ratings of Evaluated Areas

B. Business/Programmatic

The business/programmatic dimension criteria include questions that address: Open Architecture, Modular Open Design, Interface Design and Management, Treatment of Proprietary Elements, Open Business Practices, Peer Review Rights, and Technology Insertion. The programmatic questions refer to the processes and documentation employed to acquire and manage systems. The programmatic areas measured include the following (Naval Open Architecture Enterprise Team, 2006):

- Minimization of modifications to open standards that limit flexibility
- Scope of unique development
- Limitation of impact of proprietary solutions on openness
- Requirements compliance with JCIDS
- Requirements compliance with Interoperability and Supportability references
- Spiral development
- Exportation of reusables, flexibility/openness
- Prime System Integrator competitive assignment

C. Technical

The technical dimension criteria cover the essential OA design tenets of *Interoperability, Composability, Reusability, Maintainability and Extensibility.* The technical questions refer to the technical features of computing environments and application software. The technical areas measured are described below (Naval Open Architecture Enterprise Team, 2006):

> **Interoperability**: How readily can the program's separate systems exchange information and appropriately utilize each other's functional capabilities?
>
> **Maintainability**: What architectural characteristics address obsolescence and provide for timely technology refresh, fixes, and upgrades?
>
> **Extensibility**: Does the program follow a well-defined System Engineering process for implementing capability extension?
>
> **Composability**: Are the program's systems capable of being highly modular and having minimal dependencies (loosely coupled) so they can be readily combined with other modules to provide new types of functionality?
>
> **Reusability**: Are the assemblies that are candidates for reuse readily available, certified for reliability and performance, and easily obtained for reuse?
>
> **MOSA**: What is the program's level of MOSA Compliance?

The answers to the Business/Programmatic and Technical questions are summarized to provide an overall score of the percent total of the answered questions against the total possible score. This is the number that is used to plot on the appropriate dimension or axis of the OAAT matrix, which will be discussed next.

D. Open Architecture Maturity Matrix

The OAAT provides an OA assessment matrix that displays the program's current state with respect to business and technical degrees of openness. Each of these areas (business and technical) is rated on a scale of 0 to 4. (See Figure 2.)

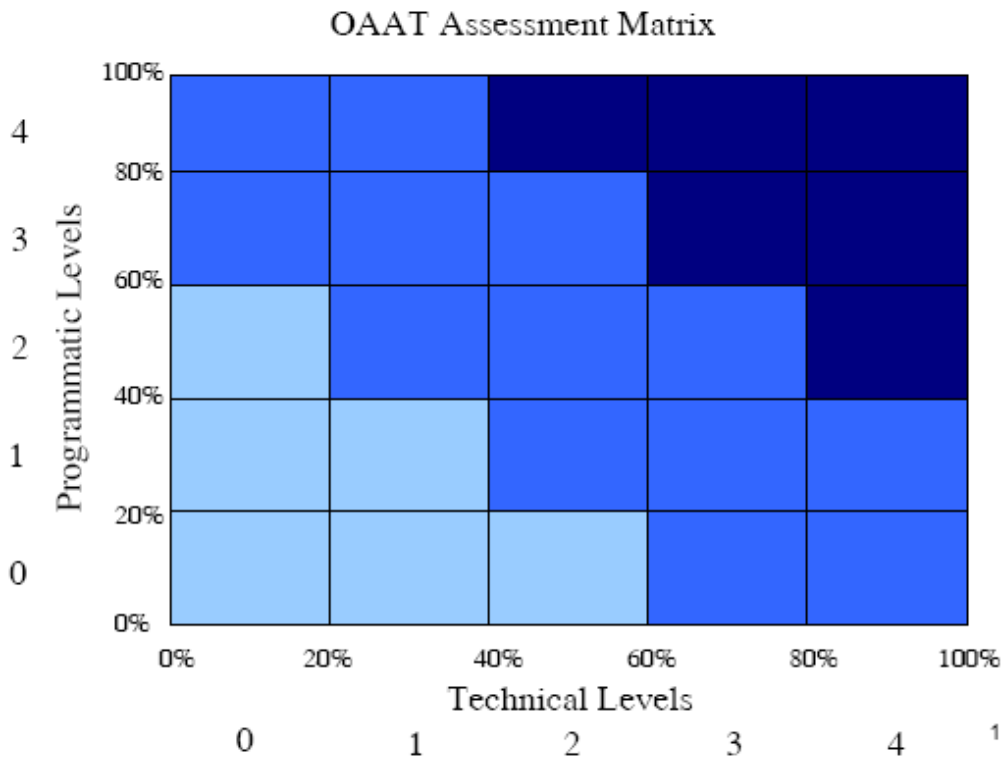

Figure 2. Open Architecture Maturity Matrix

The scores for these two dimensions are plotted on the OA Assessment Model, which provides a graphical depiction of the current state of OA maturity and also identifies the progression towards higher levels of openness. The results of the OAAT assessment are then be used by the program manager to help improve the program with respect to Naval Open Architecture.

Using the Open Architecture Maturity Matrix, a program's degree of openness can be rated using the programmatic and technical levels as shown in Figure 3 below.

Programmatic Levels	Technical Levels
4: Open and Net-Centric	4: Enterprise
3: Common	3: Common
2: Migrating to Openness	2: Layered & Open
1: Connected	1: Layered
0: Isolated	0: Closed

Figure 3. Rating Levels

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V. Assessment Results

The primary purpose of this continuing research is to provide a preliminary analysis of the results of the OAAT assessment of selected Navy acquisition programs. This research reviewed the OAAT assessment results from two different Navy domains—Subsurface and Air. It should be noted that some of these assessments were conducted using the initial OAAT before the addition of the MOSA PART questions, so some of these scores may not include the MOSA assessment. Additionally, the names of the specific programs and units of assessment have been deleted since they were not cleared for public release.

A. Subsurface Domain

Figure 4 reflects the assessment results of eight programs within the Subsurface domain. As illustrated in Figure 4, four of the eight programs are rated at Level 3 or higher in both the Technical and Programmatic categories, reflecting High levels of openness. Additionally, two programs are rated at the Medium level of openness, and the remaining two programs are rated at the Low level of openness.

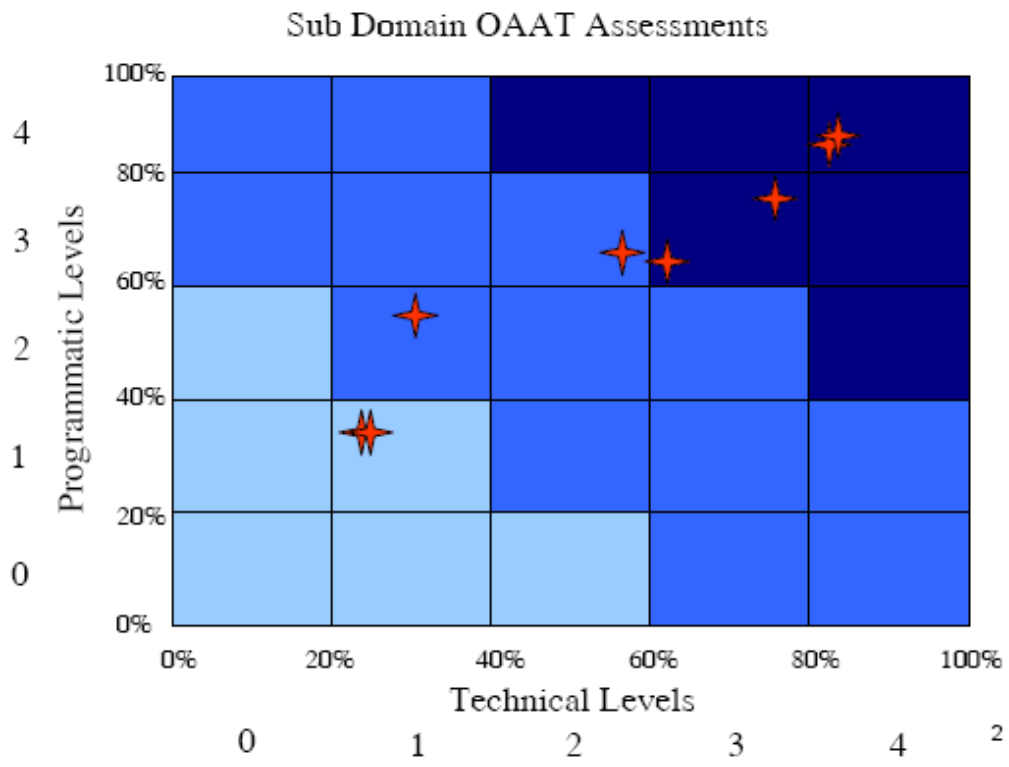

Figure 4. Subsurface Domain OAAT Results

It should be noted that some of these assessment were conducted using the initial OAAT before the addition of the MOSA PART questions, so some of these scores may not include the MOSA assessment.

B. Air Domain

Figure 5 reflects the results of 24 assessments in the Air Domain. These assessments were conducted on either total aircraft or specific systems.

In the case of an aircraft assessment, aircraft scores are either the weighted average of individual system scores, or they are reflective of the overall avionics architecture. Some systems in aircraft were weighted more important for example, the computing environment would be weighted more important for an aircraft such as the E-2 Hawkeye compared to the H-60 Black Hawk helicopter. In addition, not

every system in an aircraft was assessed. The assessment decision was determined by the appropriate program manager. Aircraft with complex architectures (i.e. those with multiple missions or those with multiple sensors) were generally broken out by systems, while simple aircraft architectures (limited to flight systems, navigation, etc.) were assessed in their entirety.

In the case of a system assessment, the systems selected for separate assessment were determined by the programs to be key components of the avionics architecture. The system scores were weighted and calculated to an aircraft score. For instance, almost all aircraft have the same radio. It was assessed once, and its score was weighted based on each aircraft's architecture (the importance of the radio to mission execution). The weighted value was then averaged with other components to create the reported aircraft score.

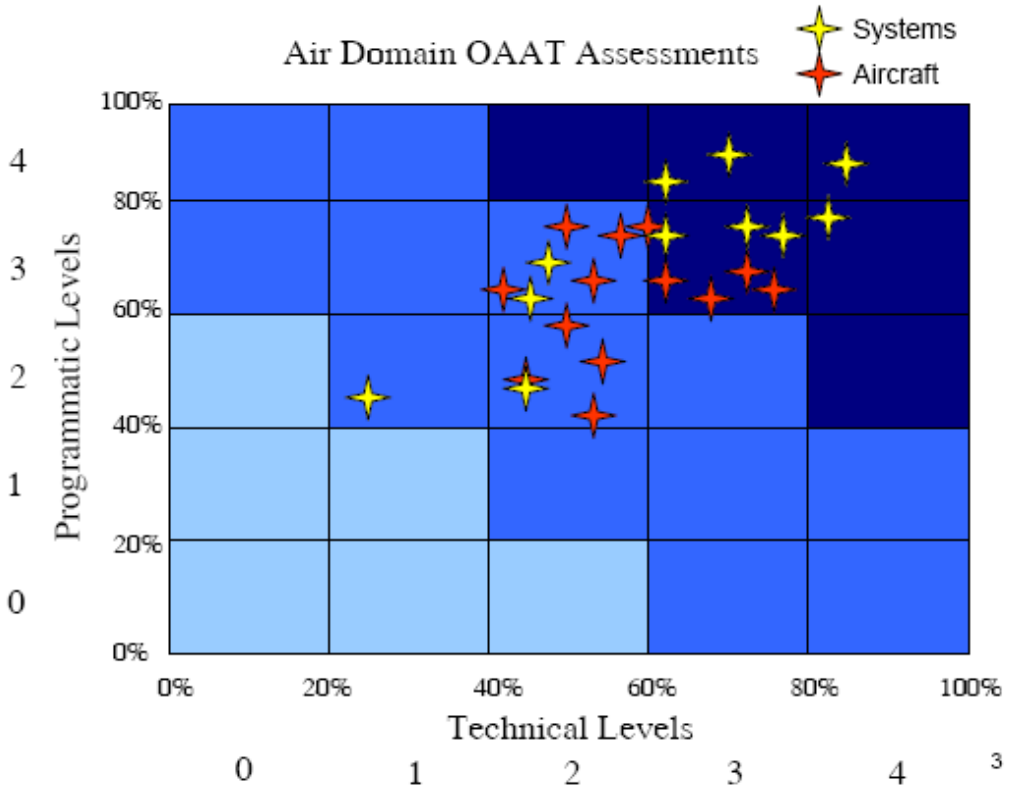

Figure 5. Aircraft Domain OAAT Results

As reflected in Figure 5, the majority of both aircraft and systems are rated at least at Level 2 Technical and Level 2 Programmatic, with almost half of the assessments rated at least Level 3 in both Technical and Programmatic.

Of the 13 aircraft programs assessed, only 4 were rated at Level 3 Technical and Level 3 Programmatic. The remaining 9 aircraft programs were rated at Level 2 Technical and either Level 2 or Level 3 for Programmatic.

Of the 11 systems that were assessed in the Air Domain, 7 were rated between Level 3 and Level 4 Technical and Level 3 and Level 4 Programmatic. The remaining 4 systems were rated between Level 1 and Level 2 Technical and between Level 2 and Level 3 Programmatic.

VI. Analysis of Assessment Results

Although data from only two domains were received in this research (out of a total of six domains solicited for data—Surface, C4I, Space and Marine Corps did not provide any data), the assessment results can be analyzed to reach some preliminary qualitative conclusions.

Approximately half (16 of the 32) of the total assessments conducted (Subsurface and Air Domains) were rated at the High level of openness. Fourteen of the total assessments were rated at the Medium level of openness, and two assessments were rated at the Low level of openness. Based on these assessment results, it can be seen how the Open Architecture Assessment Tool (OAAT) can be effectively used to assess a program's (aircraft or system) level of openness.

With the assessment results, program managers can then use the OAAT to determine which categories, Business/Programmatic or Technical, need additional emphasis in order to increase the program's level of openness. For example, programs that are rated Low in business/programmatic may need additional emphases placed on using an open systems approach, modular design, managing interface design, proper treatment of proprietary elements, using open business practices, and so forth. On the other hand, programs that are rated Low in the technical category may need additional emphasis placed on the design tenets of interoperability, maintainability, extensibility, composability, reusability and so forth.

Additionally, the OAAT can be used, not only for assessing levels of openness on an "as is " basis , but also for assessing a level of openness on a "to be" basis. That is, the OAAT can be effective in developing a road-map for a program's strategy for achieving a specific level of openness for the weapon system or sub-system. Through periodical assessments, the program manager can gage the progress in achieving the desired level of openness for the program. Of course in this application, a program decision must be made concerning the desired level of

openness, given the typical project constraints of cost, schedule and performance. Once that desired level of openness decision is made, the Program manager can then use the OAAT and periodic assessment results as a road-map for achieving that level of openness.

In addition to supporting program managers, the OAAT can also support the Milestone Decision Authority (MDAs) in assessing the program's compliance with current DoD Open Systems policy. As directed by the April 2004, USD (AT&L) memorandum, "all programs subject to milestone review shall brief their program's MOSA implementation status to the Milestone Decision Authority (MDA) to determine compliance" (Under Secretary of Defense (AT&L), 2004, April 5). It would seem that MDAs would want to take advantage of the OAAT assessment results as a gauge for determining compliance with USD(AT&L) policy. Obviously, programs that are assessed as rating on the low end of the OAAT matrix may not be meeting the intent of the open systems approach policy. MDAs should be asking for current OAAT assessment results of the programs during the major milestone program reviews.

Finally, as more programs (weapon systems and sub-systems) throughout the DoD are assessed using the OAAT, a database of assessment results can be established as a repository for use in developing lessons learned and best practices related to designing systems to meet a higher level of openness. The database can be organized by types of systems (aircraft, ship, C4I, space …) to be used in comparing levels of openness and sharing of best practices and lessons learned in achieving those levels of openness. In addition, as the database of assessed programs grows, data mining techniques can be used to compare program acquisition costs and their relationship to higher levels of openness. This information can be useful in making determinations of desired levels of openness, given the constraints of project cost, schedule, and performance.

VII. Areas for Further Analysis

Although this research effort did not generate sufficient data to provide rigorous analysis of the assessment results, this report does provide a preliminary conclusion of the usefulness of the OAAT in assessing the level of openness of DoD weapon system programs. As more OAAT assessment results are generated and added to this research, further analysis can be conducted to determine any relationships between a program's degree of openness and its level of technology maturity, phase of the acquisition lifecycle, and type of program (non-developmental versus developmental). In addition, as more OAAT assessment results are generated and added to this research, further analysis can be conducted to determine any relationships between degrees of openness for weapon system platforms (such as aircraft, ship, and ground vehicle) versus sub-systems (such as navigational, communication, avionics, and propulsion). With this additional data, higher granularity and more rigorous analyses can be conducted.

Finally, it would be beneficial to analyze the effectiveness of the implementation of MOSA in Navy acquisition programs by investigating three different facets of MOSA-based programs: 1) The results of OAAT assessments of specific weapon system acquisition programs, 2) The status of USD(AT&L) MOSA policy compliance as presented in Milestone Decision Authority (MDA) review briefs, and 3) The results of award-fee determinations on OAAT-assessed programs. This further analysis should specifically compare the results of OAAT assessment results on specific DoD acquisition programs with the status of MOSA implementation reported to MDAs (Reference USD(AT&L) memo, 5 April 2004, requiring "all programs subject to milestone review shall brief their program's MOSA implementation status to the Milestone Decision Authority to determine compliance.") and with the results of contract award-fee determinations on MOSA-based programs that have award-fee incentives in their contracts. (Award fees were identified as a characteristic of successful MOSA-based contracts in the initial

MOSA research. See Rendon, 2005). The purpose of this additional analysis would be to determine if the OAAT assessment results are being provided to the MDA during milestone reviews, and also to determine if weapons system acquisition programs assessed at higher degrees of openness are paying higher award fees to contractors. Thus, this further analysis would provide insight into the implementation of MOSA in acquisition programs by comparing the status of MOSA compliance in MDA review briefs, the results of internal MOSA assessments on those Navy acquisition programs, and the results of contract award-fee determinations for those acquisition programs; it would also determine if any conclusions can be made on the effectiveness of MOSA implementation in Navy acquisition programs. The results of this research will prove beneficial to senior Navy officials by providing data points on MOSA implementation by analyzing the consistency of MOSA compliance status, assessments, and award-fee results for specific Navy acquisition programs.

VIII. Conclusion

The purpose of this research was to analyze the results of past OAAT assessments of selected Navy weapon systems and sub-systems. The original vision was that the OAAT assessment results would be widely accessible from the domain program offices to support this research. However, since only two Navy domains had responded to a request for OAAT assessment results, this research focused specifically on the Subsurface Domain and Air Domain programs, and generally on how the OAAT assessment results could be used in supporting the DoD's policy for using an open systems approach.

The preliminary research on the assessment results for the Sub and Air Domain programs indicated that approximately half of the total assessments conducted for both the Subsurface and Air Domains were rated at the High level of openness. Fourteen of the total assessments were rated at the Medium level of openness, and two assessments were rated at the Low level of openness.

Based on these general assessment results, it can be seen how the Open Architecture Assessment Tool (OAAT) can be used to effectively assess a program's (aircraft or system) level of openness. In addition, using the OAAT, program managers can determine which areas, Business/Programmatic or Technical, need additional emphasis in order to increase the program's level of openness. The OAAT can also be effective in developing a road-map for a program's strategy for achieving a specific level of openness for the weapon system or sub-system. The OAAT can be, and should be, used by Milestone Decision Authorities (MDAs) in assessing the program's compliance with current DoD Open Systems policy. Finally, it is proposed that a database of assessment results be established as a repository for use in developing and sharing lessons learned and best practices related to designing weapon systems and sub-systems to meet a higher level of openness.

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