PROGRAM MANAGER'S GUIDE

OPEN SYSTEMS JOINT TASK FORCE

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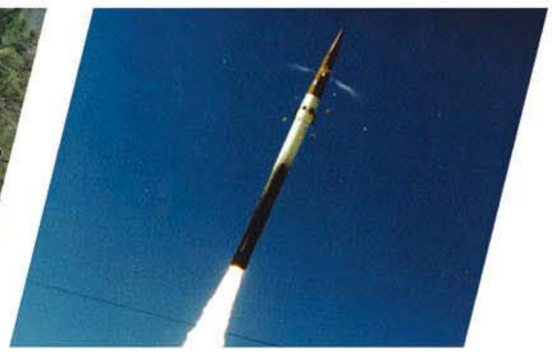
Version 2.0 | September 2004

PROGRAM MANAGER'S GUIDE

A Modular Open Systems Approach (MOSA) To Acquisition

OPEN SYSTEMS JOINT TASK FORCE



Fielding affordable and interoperable combat capabilities

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

www.acq.osd.mil/osjtf

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Foreword

The Open Systems Joint Task Force (OSJTF) prepared this guide to provide program managers, system engineers, contracting officers, and the entire program team the tools required to implement a Modular Open Systems Approach (MOSA). This guide will enable new and legacy programs to realize the DoD vision of making MOSA an integral part of any acquisition strategy to achieve affordable, evolutionary, joint combat capability. The key questions this guide will answer are:

- What is MOSA?
- Why is it important?
- How should MOSA be planned for and implemented?
- How will MOSA implementation be gauged and assessed?
- How will MOSA implementation issues be adjudicated?

Please go to **http://www.acq.osd.mil/osjtf** for more information.

Executive Summary

A Modular Open Systems Approach (MOSA) is both a business and technical strategy for developing a new system or modernizing an existing one. It is an integral part of the toolset that will help DoD to achieve its goal of providing the joint combat capabilities required for 21st century warfare, including supporting and evolving these capabilities over their total life-cycle. DoDD 5000.1 states that, "Acquisition programs shall be managed through the application of a systems engineering approach that optimizes total system performance and minimizes total ownership costs. A modular, open-systems approach shall be employed, where feasible."

This approach is an enabler to achieve the following objectives:

- *adapt to evolving requirements and threats*
- *promote transition from science and technology into acquisition and deployment*
- *facilitate systems integration*
- *leverage commercial investment*
- *reduce the development cycle time and total life-cycle cost*
- *ensure that the system will be fully interoperable with all the systems which it must interface, without major modification of existing components*
- *enhance commonality and reuse of components among systems*
- *enhance access to cutting edge technologies and products from multiple suppliers*
- *mitigate the risks associated with technology obsolescence*
- *mitigate the risk of a single source of supply over the life of a system*
- *enhance life-cycle supportability*
- *increase competition*

Application of MOSA is consistent with sound system engineering principals; however it requires a different mindset as the SE process is executed during the design of a system and then repeated throughout the life-cycle of that system. Application of MOSA is most effective when implemented within an Integrated Product and Process Development (IPPD) environment. Moreover, MOSA implementation is dependent on continuous market research.

As shown in Figure 1 below, MOSA is characterized by modular design, key interfaces, and the use of open standards for key interfaces where appropriate.

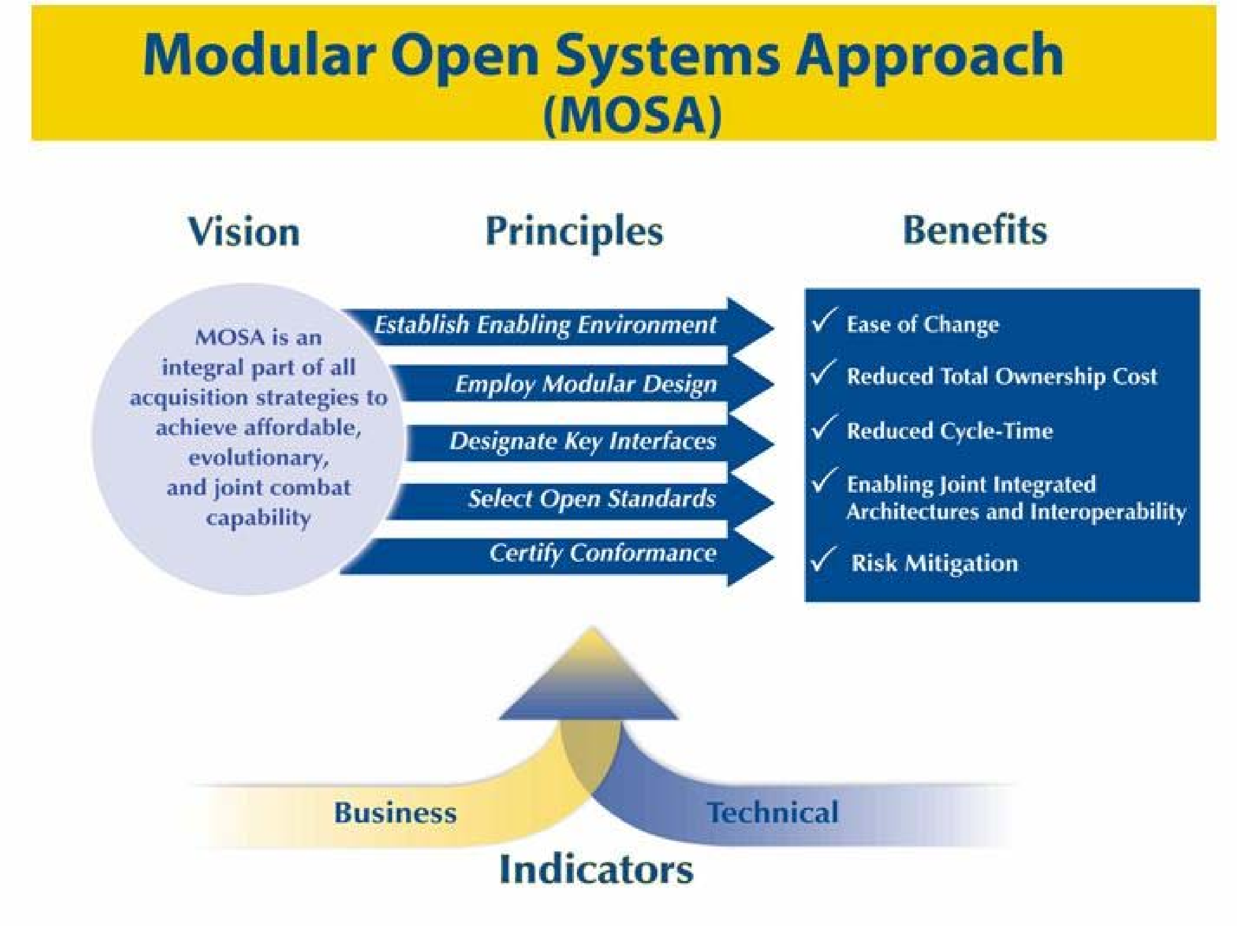

Figure 1: Modular Open Systems Approach (MOSA)

The Open Systems Joint Task Force (OSJTF) has developed a set of indicators that have been incorporated as MOSA implementation questions in an assessment tool called MOSA PART; which is a DoD adaptation of the Program Assessment and Review Tool (PART) originally prepared by the Office of Management and Budget. MOSA PART may either be used for self-assessment by program managers, or be utilized by acquisition executives to recognize when an acquisition program is following MOSA. When MOSA indicators are taken into account and adhered to by an acquisition program, there can be a level of confidence that such program has effectively implemented MOSA.

MOSA Principles

Introduction

As previously described, a Modular Open Systems Approach (MOSA) is both a business and technical strategy for developing a new system or modernizing an existing one. It is a means to assess and implement, when feasible, widely supported commercial interface standards in developing systems using modular design concepts. MOSA is also a significant part of the toolset that will help meet DoD's goal of providing joint combat capabilities required for 21st century warfare, and supporting these evolving capabilities over their total life-cycle.

MOSA is an enabler that supports program teams in the acquisition community to 1) design for affordable change, 2) employ evolutionary acquisition and spiral development, and 3) develop an integrated roadmap for weapon system design and development. Basing design strategies on widely supported open standards increases the chance that future changes will be able to be integrated in a cost effective manner. Designing a system for affordable change requires modularity. An evolutionary acquisition strategy provides a foundation that meets existing needs while providing the capability to meet evolving requirements and threats. An integrated roadmap is a tool for detailing the strategy to deliver a weapon system that is capable, upgradeable, affordable, and supportable throughout its planned life-cycle. MOSA supports achieving the following:

- *reduced acquisition cycle time and overall life-cycle cost*
- *ability to insert cutting edge technology as it evolves*
- *commonality and reuse of components among systems*
- *increased ability to leverage commercial investment*

MOSA Principles Explained

The realization of MOSA benefits is dependent on adherence to five major principles, namely; establishing a MOSA enabling environment, employment of modular design, designation of key interfaces, use of open standards for key interfaces, where appropriate, and certifying conformance. These principles lay the foundation for identification of a set of indicators that could be used by acquisition executives and program managers to assess the progress of implementing MOSA in acquisition programs.

Principle 1: Establish an Enabling Environment

To adhere to this principle, the PM must establish supportive requirements, business practices, and technology development, acquisition, test and evaluation, and product support strategies needed for effective development of open systems. Assigning responsibility for MOSA implementation, ensuring appropriate experience and training on MOSA, continuing market research, and proactive identification and overcoming of barriers or obstacles that can potentially slow down or even, in some cases, undermine effective MOSA implementation are among the supportive practices needed for creating an enabling MOSA environment.

Principle 2: Employ Modular Design

Partitioning a system appropriately during the design process to isolate functionality makes the system easier to develop, maintain, and modify or upgrade. Given a system designed for modularity, functions that change rapidly or evolve over time can be upgraded and changed with minor impact to the remainder of the system. This occurs when the design process starts with modularity and future evolution as an objective. Modular designs are characterized by the following:

- Functionally partitioned into discrete scalable, reusable modules consisting of isolated, self-contained functional elements
- Rigorous use of disciplined definition of modular interfaces, to include object oriented descriptions of module functionality
- Designed for ease of change to achieve technology transparency and, to the largest extent possible, makes use of commonly used industry standards for key interfaces

Principle 3: Designate Key interfaces

The focus of MOSA is not on control and management of all the interfaces within and between systems. It will be very costly and perhaps impractical to manage hundreds and in some cases thousands of interfaces used within and among systems. As shown in Figure 2, MOSA manages the interfaces by grouping them into key and non-key interfaces. It distinguishes among interfaces that are between technologically stable and volatile modules, between highly reliable and more frequently failing modules, and between modules with least interoperability impact and those that pass vital interoperability information. Key interfaces should utilize open standards in order to produce the largest life-cycle cost benefits.

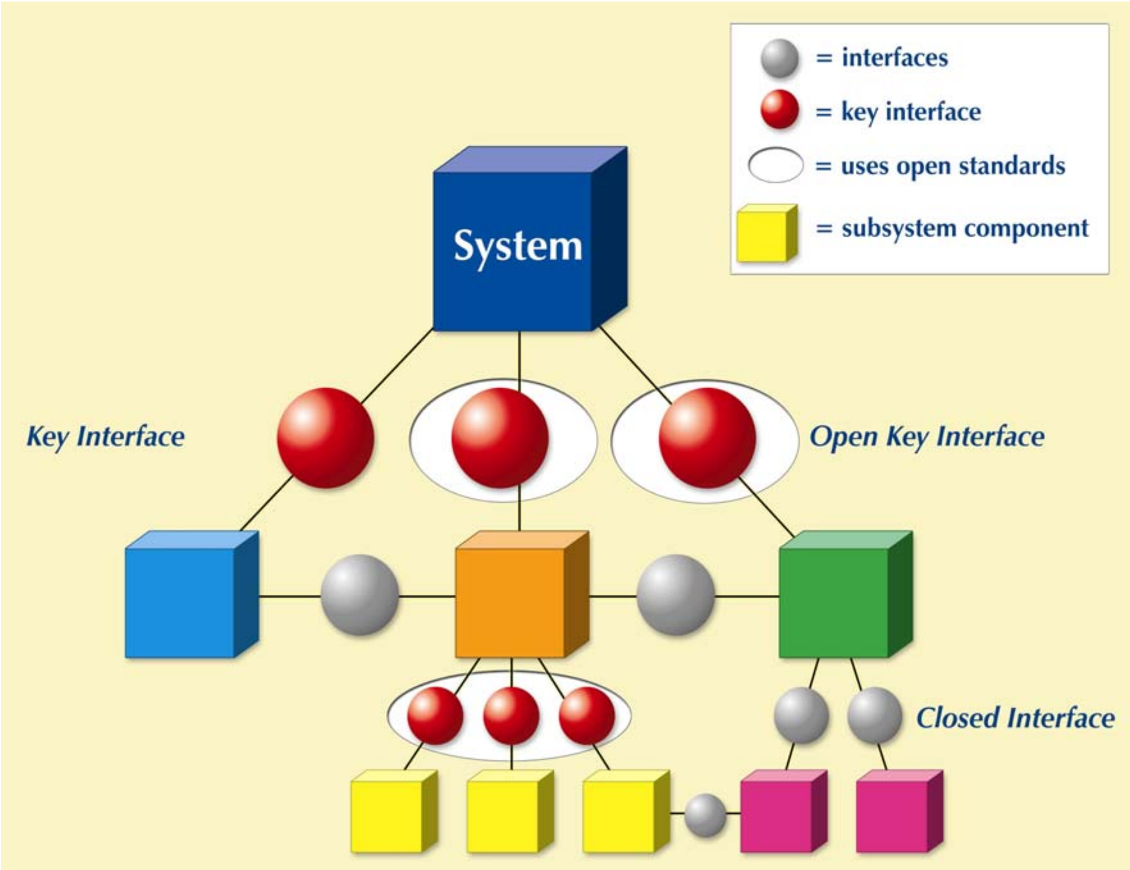

Figure 2: Types of System Interfaces

Principle 4: Use Open Standards

Interface standards specify the physical, functional, and operational relationships between the various elements (hardware and software), to permit interchangeability, interconnection, compatibility and/or communication, and improve logistics support. The selection of the appropriate standards for system interfaces should be based on sound market research of available standards and the application of a disciplined systems engineering process.

In order to take full advantage of modularity in design, interface standards must be well defined, mature, widely used, and readily available. In general, popular open standards yield the most benefit to the customer in terms of ease of future changes to the system and should be the standards of choice. However, there are situations where proprietary standards are the correct choice.

Standards should be selected based on maturity, market acceptance, and allowance for future technology insertion. As a general rule, preference is given to the use of open interface standards first, the de facto interface standards second, and finally government and proprietary interface standards.

Open standards allow programs to leverage commercially funded or developed technologies and to take advantage of increased competition. They also allow faster upgrade of systems with less complexity and cost. Bottom line, systems can be fielded that are more affordable.

Principle 5: Certify Conformance

The program manager, in coordination with the user, should prepare validation and verification mechanisms such as conformance certification and test plans to ensure that the system and its component modules conform to the external and internal open interfaces allowing plug-and-play of modules, net-centric information exchange, and re-configuration of mission capability in response to new threats and technologies. Open systems verification and validation must become an integral part of the overall organization change and configuration management processes. They should also ensure that the system components and selected commercial products avoid utilization of vendor-unique extensions to interface standards and can easily be substituted with similar components from competitive sources.

Putting MOSA Into Practice

A Modular Open Systems Approach (MOSA) is both a business and technical strategy for developing a new system or modernizing an existing one. As a business strategy, it enables program teams to build, upgrade and support systems more quickly and affordably. These benefits may be realized by leveraging the commercial sector investment in new technology through the use of corresponding commercial products available from multiple sources. As a technical strategy, MOSA is focused on a system design that is modular, has well defined interfaces, is designed for change and, to the extent possible, utilizes widely supported industry standards for key interfaces. As with any other approach, MOSA implementation should be based on upfront planning. To be most effective, the preparations for applying MOSA must be initiated early in the program and acquisition planning. Figure 3 depicts the essential elements and the supportive technical and business practices needed for effective MOSA implementation.

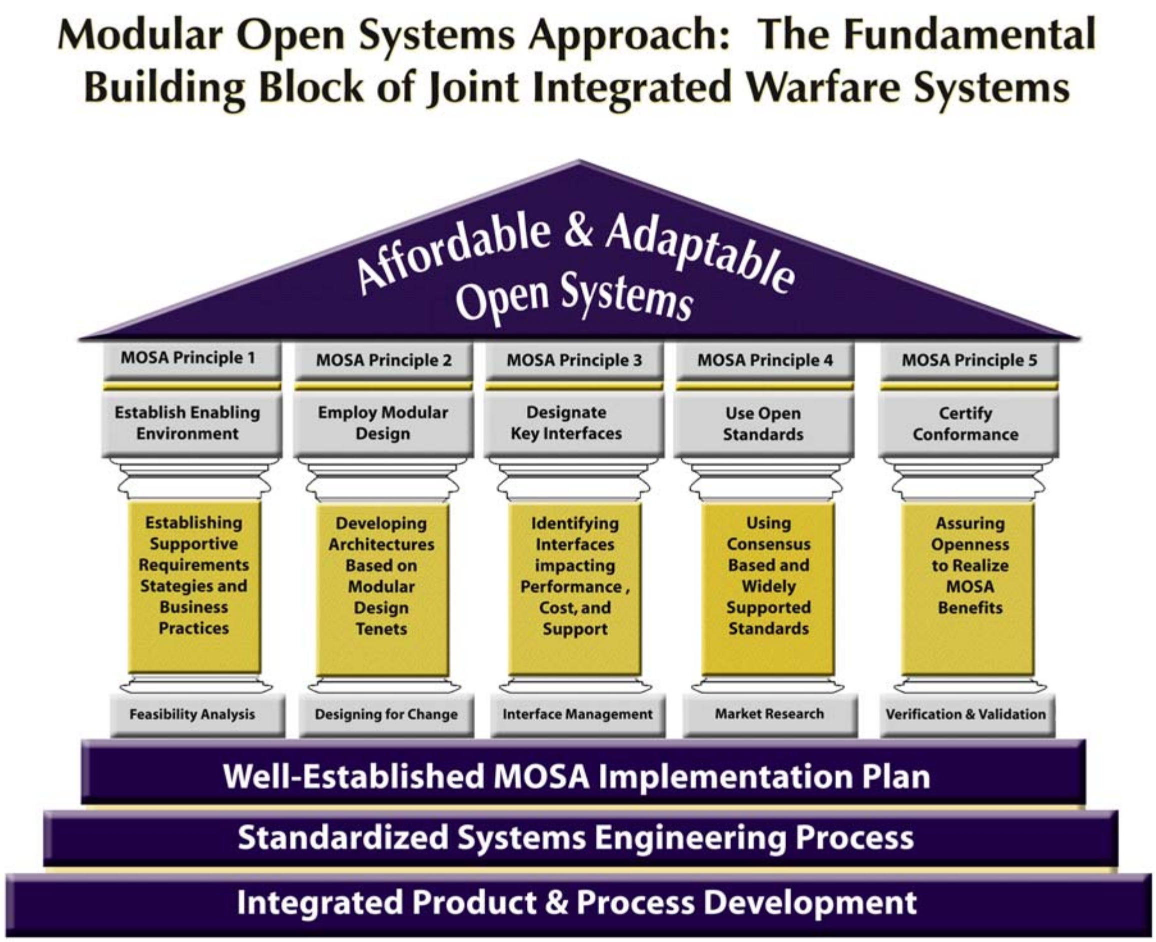

Figure 3: The MOSA Framework

As shown in Figure 3, effective implementation of MOSA requires employment of an Integrated Product and Process Development (IPPD) team approach, application of a sound systems engineering process, establishment of a MOSA implementation plan, and capitalizing on five proven MOSA principles: establishing enabling environment, employing modular design, designating key interfaces, selecting open standards, and certifying conformance to such standards.

The preferred strategy for applying MOSA is to employ an IPPD team comprised of government and industry representatives. The IPPD team should include all of the stakeholders involved in the acquisition, deployment, and employment of the system. The actual make up of an IPPD team is the responsibility of the program manager. At a minimum, an IPPD team should include those who require, specify, design, build, test, operate and maintain the system. The responsibilities of the IPPD team include establishing a tailored approach for implementing MOSA, identifying acquisition objectives and operational capabilities that lend themselves to the use of open systems, gathering and analyzing previous lessons learned, analyzing market research findings and other responsibilities relating to MOSA implementation.

The effectiveness of MOSA is also largely determined by the degree to which it is an integral part of a sound systems engineering (SE) process. We recommend incorporating MOSA into the SE process because it is during this process that MOSA has the greatest impact on the systems design and therefore the greatest benefit to the users of resulting products. Programs and contractors are encouraged to use SE standards such as EIA 632: Processes for Engineering a System, ISO 15288: Systems Engineering – System Life Cycle Processes or IEEE 1220: Standard for Application and Management of the Systems Engineering Process9 as the foundation for applying MOSA.

The MOSA implementation plan is a roadmap with specific objectives, tasks, principles, and milestones for putting MOSA into practice. The MOSA implementation plan should describe (1) how MOSA fits into a program's overall acquisition process and strategies for technology development, acquisition, test and evaluation, and product support; (2) what steps a program will take to analyze, develop, and implement a system or a system-of-systems architecture based on MOSA principles; and (3) how the program intends to monitor and assess its MOSA implementation progress.

The MOSA implementation plan should, at a minimum address the following five major tasks:

I. Identify and analyze capabilities and strategies that could most effectively be pursued by open system design solutions.
II. Assess the feasibility of open systems design solutions
III. Establish performance measures to assess MOSA implementation progress
IV. Use MOSA principles to develop an open architecture
V. Identify and resolve MOSA implementation issues and report the unresolved issues to Milestone Decision Authority.

For the remainder of this Guide, we will describe each of these tasks in greater detail.

I. Identify and Analyze MOSA Enabled Capabilities and Strategies

Program managers should identify specific operational and performance capabilities, and strategies for technology development, acquisition, test and evaluation, and product support that could be most effectively be enabled by using open systems design strategies. For example, the Program Management Office (PMO) could capitalize on open systems characteristics such as standardized interfaces and modular architectures to enhance joint combat capabilities, and support such evolving capabilities over their total life-cycle. The PMO could also select an open system solution if the warfighters require the ability to field innovative technologies as they become available to meet emerging threats and incorporate warfighter lessons learned in a timely fashion. Modular and scalable architectures could also be the preferred design choice if capabilities must be fielded in time-phased increments, and when the warfighter demands quick integration, interoperability, and reconfiguration of systems and their modules.

There are many acquisition strategies, operational capabilities, and performance requirements that lend themselves to the use of open systems in a program. The following list is a sample:

- Evolutionary acquisition and spiral development
- Operational requirements specified in an incremental manner over time.
- Requirements that place great emphasis on long-term sustainment and affordability, or establish affordability as the basis for fostering greater program stability.
- The ability to constitute and reconfigure functionally compatible forces and systems.
- Digitized battlefield or heavy reliance on digitized battlefield conditions to create operational capabilities.
- Receiving and disseminating command and control data in real time
- Seamless, high speed, digital information exchange among diverse warfighting elements.
- Overarching capabilities for a mission area that form a system of systems or family of systems.
- Reprogramming of software modules and communication networks where software reuse and increased flexibility is required.
- Integrated and modular communications and navigation capability.
- Application of an integrated approach for adding and facilitating the incorporation of future capabilities and advanced technologies with minimum impact on existing systems.
- Requirements that are defined in terms that enable and encourage offerors to supply commercial and non-developmental item equipment and call for minimizing the risks associated with being captive to specific products or sources.
- Future growth capabilities and performance characteristics that will be highly dependent on continuous use of emerging technologies such as computer, communication, surveillance, and navigation technologies.
- Interoperable joint service solutions and development of integrated architectures that must comply with open standards across different platforms.

- Modular contracting strategies

II. Assess the Feasibility of Open Systems Design Solutions

Open systems solution should not be pursued blindly. The PMO should make a business case for using open systems solutions. They should use a dynamic business case analysis model and apply market research findings to evaluate the appropriateness and feasibility of open systems. The model should take into consideration the changes in technology and threats to evaluate the total life cycle costs of designing the system as an open rather than a closed system. The PMO should conduct market research to identify technologies, standards, and compliant products needed for fulfilling capabilities and strategies identified at the preceding step. The review of technologies and standards will assist the PMO in the identification and assessment of risk areas with substantial impact on development, operation, and sustainment of a system over its life cycle. The PMO shall report to the MDA, in the context of the program Acquisition Strategy, the findings of the business case analysis used to justify non-compliance with the DoD MOSA policies and the potential economic impact on total ownership cost and risk to technology maturation and insertion over the service life of the system.

III. Establish Metrics to Assess MOSA Implementation Progress

In order to arrive at a system that exhibits open system characteristics, it is critical to have a set of measures or attributes indicating that these characteristics will be present as the system is being developed and when the system is complete. Establishing MOSA specific performance measures or at a minimum incorporation of MOSA principles in the program's performance measures is essential for realization of MOSA benefits. Program managers should use specific performance measures to gauge the progress on implementing MOSA, and ensure timely, efficient, and effective MOSA implementation. For example, the percentage of key interfaces defined by open standards could be used as a metric to measure the degree of system openness. Another example will be the percentage of obsolete modules in a system as a metric to measure the degree of system obsolescence. Other examples are the number or percentage of modules that can change without major system redesign; the percentage or actual total life cycle cost savings/avoidance attributable to compliance with MOSA principles; and number of latest technologies successfully migrated to a program as a result of adherence to MOSA principles.

IV. Use MOSA Principles to Develop an Open Architecture

Effective MOSA implementation is contingent upon proactive adherence to five major MOSA principles (please see Figure 1). These principles are essential parts of MOSA implementation plans and are fundamental to the design and implementation of open architectures. These guiding principles of MOSA are based on the experiences of programs that have implemented MOSA. Together, they are considered to be the minimum set of best business practices required for an effective application of MOSA. The first principle deals with creating an enabling environment characterized by supportive requirements, strategies, and business practices. The second principle is concerned with using modular design tenets to develop a robust architecture. The third principle focuses on designation of key interfaces so that we can distinguish among interfaces that are between technologically stable and volatile modules, between highly reliable and more frequently failing modules, and between modules with least interoperability impact and those that pass vital interoperability information. The fourth principle addresses the use of open standards for key interfaces, and the last principle pertains to certifying conformance to assure realization of open systems benefits.

For the remainder of this section, we will focus on describing these five MOSA principles. We will also address the MOSA indicators and briefly describe the tasks performed to effectively apply them in the overall system acquisition and SE process activities.

Principle 1: Establish an Enabling Environment

The first MOSA principle lays the foundation for establishing supportive requirements, business practices, and technology development, acquisition, test and evaluation, and product support strategies needed for effective development of open systems. Following is a list of type of supportive practices needed:

a. Existence of program requirements and system level functional and performance specifications that permit open systems development and will not impose design-specific solutions.
b. Presence of configuration management processes that encompass changes to key interfaces and corresponding standards over the system life cycle.
c. Existence of program staff with training or relevant experience in MOSA concepts and implementation.
d. Assignment of responsibilities for implementing MOSA. The PM should lead the efforts for MOSA implementation and should vigorously enforce the DoD MOSA policies and ensure that the PMO and contractors are aware of those policies and responsibilities for implementing them, understand MOSA concepts, and are familiar with the program MOSA implementation plan.
e. Program management and acquisition planning efforts conducive to MOSA implementation. The program's Systems Engineering Plan and strategies for technology development, acquisition, test and evaluations, and product support should all be supportive of MOSA implementation. For example, the Technology Development Strategy should emphasize the application of an open architecture so that the planned technology spirals or increments will be more effectively and affordably integrated. It should also emphasize that the prototype units that will be produced and deployed during technology development capitalize on open architecture attributes and benefits. The program's Systems Engineering Plan should encourage adherence to MOSA principles to ensure that the system is functionally partitioned into discrete, scalable, and reusable modules consisting of

isolated, self-contained functionally cohesive, interchangeable, and adaptable elements.

f. Effective identification and mitigation of barriers or obstacles that can potentially slow down or even, in some cases, undermine effective MOSA implementation.
g. Application of state of the art and widely used standard reference models and architectural frameworks adopted by the industry.
h. Continuing market research and analysis. Programs should establish a process for continuous market research to:

   - Analyze commercial market capabilities and future market and technology trends.
   - Collect and evaluate data on available and emerging interface standards to determine whether or not they are applicable to their particular system.
   - Assess the breadth of open and de facto standard compliant products to determine if suppliers will continue to produce or support the standards selected.
   - Help in partitioning the system into modules based on widely-supported commercial interfaces.

It should be noted that since there is no single best approach for implementing MOSA; therefore, every program should establish its own approach tailored to their specific acquisition strategy and program requirements.

Principle 2: Employ Modular Design

Modular design provides for expansion or functional reconfiguration through the incorporation of replaceable modules. A simple example is that of a desktop computer. The functions may include word processor or graphics applications depending on the software modules installed. Similarly, other functionally may be easily added by installing a new hardware module such as a modem. These functions are possible because sufficient aspects of the corresponding system interfaces are well defined so that designers of individual modules can do their work independently. Under the ideal situation, multiple product choices are available that can be inserted with minimal integration.

The first step in design of a new system is to partition the system into functions and identify the functional elements that should be modularized. The process then proceeds to decomposing higher-level functions into lower-level functions, identifying interfaces (e.g., internal and external), and finally to allocating performance from higher to lower-level functions. This process is repeated to define successively lower level functional and performance requirements, thus defining modular architectures at ever-increasing levels of detail.

For a legacy system, the focus will be on gathering information on the existing or as-built design, and performing the essential modular partitioning and mapping of services and interfaces to known functions and capabilities. To assess the appropriateness of a modular standards-based architecture, several items such as design specifications, interface control documents, functional specifications, and known standards profiles for an existing system may be reviewed. Knowledge of the other respective systems/subsystems that must be interfaced is derived from the existing requirement documents.

IPPDs must use modularity principles (maximal cohesiveness of the functions and minimal coupling among elements) to convert functional architectures to design architectures. They need to group and regroup components that perform a single independent function or single logical task into modules. They must also use desirable attributes such as low coupling, high binding (cohesion), and low connectivity to do the grouping required for modularity. Decoupling modules eases development risks and makes future modifications easier. High binding (similarity of tasks performed within the modules) allows for use of identical or like components or for use of a single component to perform multiple functions. Low connectivity (relationship among internal elements of one module to those of another module) is desirable because it reduces design and test complexity.

IPPDs should also prototype the system, subsystems, and components to demonstrate the integration of the system using the proposed modular decomposition. They should also use prototypes to demonstrate standards and standards-compliant products. Final products should not be selected at this time and the IPPD should demonstrate that potential interface standards and specifications will achieve required system performance.

Principle 3: Designate Key Interfaces

A key interface is an interface for which the preferred implementation uses an open standard to design the system for affordable change, ease of integration, interoperability, commonality, reuse or other essential considerations such as criticality of function. The IPPD should evaluate the system modules using the characteristics listed above to designate an interface as a key interface. The IPPD should recursively apply the evaluation characteristics to the top-level design components/modules and their sub-modules until all key interfaces are designated.

Programs must determine the level of implementation (e.g., subsystem, system, system-of-systems) at and above which they aspire to maintain control over the key interfaces and would like these interfaces to be defined by widely supported and consensus based standards. To establish the desired level of control, programs must review the results of market analysis on the availability of open standards for selected key interfaces and assess the impact of a chosen level of control on long-term viability and affordability of the system. Defining the level of interface control too low may limit efficient technology insertion, while defining the level too high may lead to the use of proprietary interfaces for major system components resulting in limited supplier support. Programs should use a business case analysis to justify the use of open standards for such interfaces at desired levels of implementation.

Programs may use Work Breakdown Structures (WBS) developed from the design architecture or a reference model to designate key interfaces. Reference models are perhaps the best means for designating key interfaces. IPPDs should first determine whether there is an existing reference model they can use, or if they need to develop one appropriate to the concept(s) under consideration. A technical reference model (TRM) provides a high level, generalized system view of the weapon system family. Generally speaking, a TRM:

- Is a common high-level communications vehicle for system stakeholders. It embodies the earliest set of design decisions about the system. These decisions are the most difficult to get right, the hardest ones to change and have the most far-reaching effects downstream.
- Forms the organizational plan for development of a modular, open system. It establishes a context for understanding how disparate technologies and standards relate to each other. Done well, a reference model is a high-level vehicle for incorporating existing or planned components.

- Provides a framework for breaking out the system and applying standards. Well-formed reference models exhibit modularity. The reference model provides a framework for how to apply standards, particularly, how to identify interfaces that are key to achieving system technical and business goals.

Reference models provide a high-level view of the system modularity and the interfaces between those modules. Figure 4 is an example of how a reference model might depict the functional parts comprising systems belonging to an aircraft. It demonstrates decomposition of the overall weapon system's mission into a smaller number of simpler functional building blocks. Each functional building block can be similarly decomposed. The selection of particular functional entities represents the initial design decisions for how the weapon system will be engineered. Here, modularity in design is facilitated by aligning functional partitioning with physical modularity where modularity is used to facilitate the replacement of specific subsystems and components without impacting other parts of the system. The boundary or interface between each building block pair is defined by the services provided over that interface.

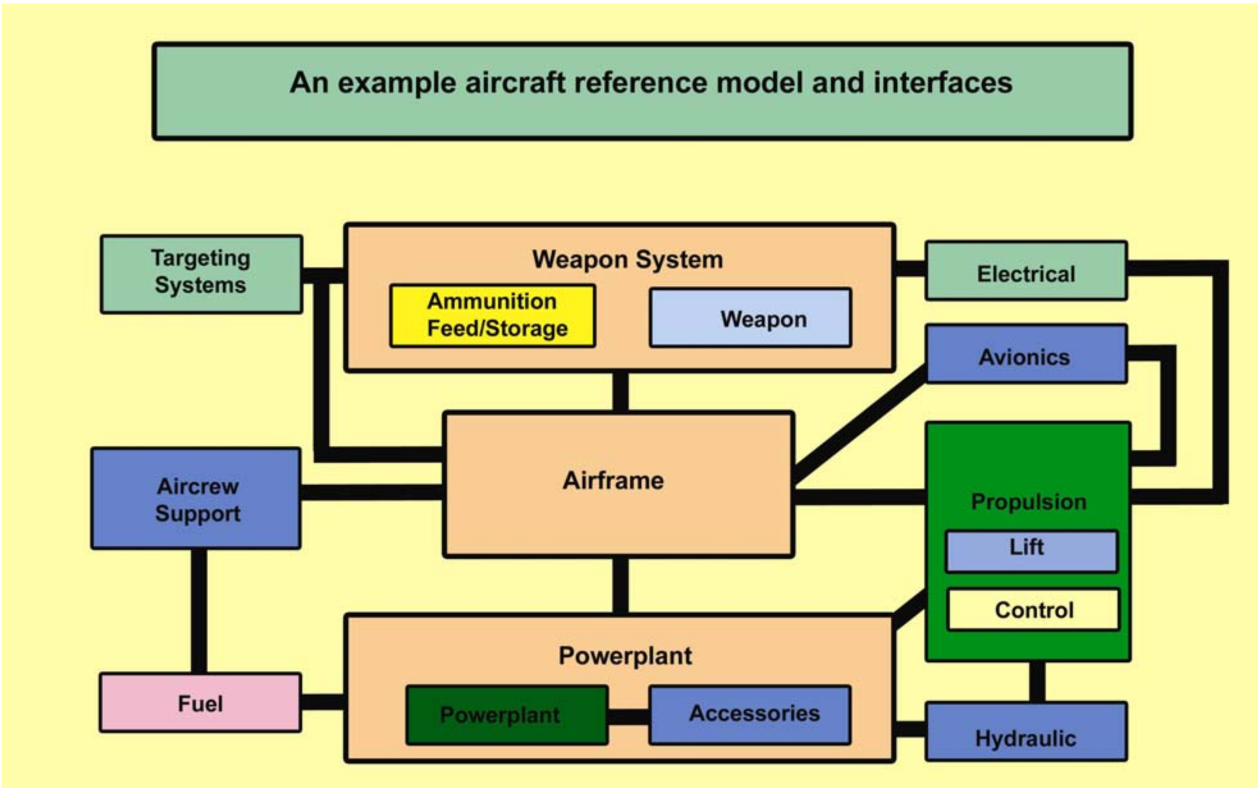

Figure 4: An Aircraft Reference Model

Principle 4: Use Open Standards

Once key interfaces are identified, the next task for the program team is to determine whether or not it is feasible to use an open interface standard for each of the key interfaces. In MOSA, the fact that an interface has been designated as a key interface means that the preferred implementation would employ an open interface standard. This does not mean that the final implementation for every key interface will always use an open standard. There will be times when the best decision is to use a proprietary standard. This decision is left to the program manager. The following factors may be considered by the IPPD in using open standards for key interfaces:

- Overall acquisition strategy (e.g., the likelihood that the technologies/engineering for full capability still need to be developed and whether or not the longer-term requirements are stable or addressed as evolving increments.)
- The degree of dependency on rapidly evolving technology and the technology readiness level for the components or items at both ends of an interface
- The intensity and magnitude of risks associated with a proprietary interface standard
- Need for minimizing integration risks over the life of the system
- Need to take advantage of competition throughout the life cycle
- Need for design flexibility, modularity, and interface control
- Availability, maturity, verification, and accreditation of standards for an interface
- Support strategy (e.g., the extent of market acceptance and availability of products that comply with a selected standard)

Key interfaces should be examined very carefully to insure that the use of an open standard is both feasible and appropriate based on performance and business objectives. As previously mentioned, the aim of MOSA is not to make all the internal and external system interfaces open. There are significant advantages to using open interface standards; however they should only be used if it makes sense within the context of the performance and business objectives of the particular program. The utilization environment of a system also has some open system implications. The physical environment may also necessitate modification of commercial products because they may not withstand the humidity, temperature, vibration, and electromagnetic environments in a weapon system. Long term supportability and maintainability may also be impacted if unique proprietary interface standards are employed in the system resulting in dependency on a sole source and possibly costly maintenance for the life of a system. The size and weight of products in the system under development may impose restrictions on use of commercial interface standards and products. But, the benefits gained from the isolation of the function for future change may far outweigh any disadvantage of using a proprietary interface standard due to utilization environment constraints. If the use of an open standard is not appropriate at a given time, the program should continue to look for future opportunities within the system to take advantage of benefits of using open standards. As a general rule, system developers should only use open standards when it makes business and technical sense.

Interfaces may be controlled through interface management. Interface management identifies, develops, and maintains the external and internal interfaces necessary for system operations. It also ensures that system elements are compatible in form, fit, and function. Interface management may also include establishing an Interface Control Working Group, which among other things may establish the Interface Control Documentation.

Once standards are selected for the appropriate key interfaces, the IPPD also needs to develop a method of verification or conformance to the interface specification itself. IPPDs need to verify claims made by vendors that their products comply with certain interface standards and their respective profiles. Test suites should be developed to ensure conformance of selected commercial items and non-developmental items to appropriate interface definitions.

Principle 5: Certify Conformance

The program manager, in coordination with the user, should prepare validation and verification mechanisms such as conformance certification and test plans to ensure that the system and its component modules conform to the external and internal open interfaces allowing plug-and-play of modules, net-centric information exchange, and re-configuration of mission capability in response to new threats and technologies. Such plans must become an integral part of the overall organization change management process. As systems evolve through spiral development and in response to changes in requirements and technologies, external and internal interfaces will most likely change which necessitates proactive conformance and integration tests. The conformance test and certification plans should ensure that the system components and selected commercial products avoid utilization of vendor-unique extensions to interface standards and can easily be substituted with similar components from competitive sources.

V. Identify and Resolve MOSA Implementation Issues and Report the Unresolved Issues to Milestone Decision Authority

MOSA is characterized by an enabling environment, employment of modular design, designation of key interfaces, use of open interface standards and certification of conformance. In order to arrive at a system that exhibits these open system characteristics, it is critical to establish a procedure to assess MOSA implementation progress, identify the implementation issues, and satisfactorily resolve such issues. The procedure should be based on a set of measures or attributes indicating that the characteristics associated with each MOSA principle will be present as the system is being developed and when the system is complete. These measures or attributes are intended for consideration and use by acquisition executives, program managers and IPPD teams responsible for implementing MOSA to assure the achievement of MOSA benefits. The OSJTF has developed a set of indicators, in the form of MOSA implementation questions (please refer to Appendix C), to help assess the extent to which MOSA is implemented in an acquisition program, and also to identify actual or potential MOSA implementation issues. These questions are representative of the actual questions used in the MOSA Program Assessment and Review Tool (PART), which is an automated analytical tool that relies on objective, data evidence-based judgments to assess and evaluate MOSA implementation. The MOSA PART is an adaptation of the OMB Program Assessment Rating Tool (PART), which is a questionnaire designed to provide a consistent approach to rating programs across the Federal government. The responses to the questions, provided on the MOSA Implementation Questions tab of the PART, will be evaluated to determine the overall implementation level of MOSA, identify actual and potential implementation issues, and determine individual areas where improvements might be made. The evaluation results are shown in the Assessment Report tab of the PART. Program managers can use either MOSA PART or other tools to identify specific MOSA implementation issues that their Integrated Product Team must address and satisfactorily resolve. In case such issues can not be resolved at the lower level, program managers must report them to the Milestone Decision Authority for final resolution.

The MOSA PART can be found on the Open Systems Joint Task Force website at http://ww.acq.osd.mil/osjtf.

Programs should proactively identify the problems, obstacles and issues they encounter in implementing their MOSA. They can use a variety of means (e.g., the MOSA PART questions; market research findings; doctrine, organization, training, materiel, leadership and education, personnel and facilities (DOTMLPF) implication assessments; MOSA specific metrics; etc.) to discover potential problems, obstacles, or barriers toward MOSA implementation. For example, the marketing research can point to the fact that an emerging open standard for a key interface may not be matured by the time predicted, or the test suits for its conformance testing may not be available when needed. Under this circumstance, the program may not have any other choice but to use a de-facto or proprietary standard for that interface to resolve the issue. The programs should undertake the following procedure to effectively deal with a major MOSA implementation issue (problem, obstacle, or barrier):

1. Use appropriate means to discover MOSA implementation problems, obstacles, and barriers.
2. Analyze and document the problems, obstacles, or barriers, and the circumstances surrounding them.
3. Address the identified problems, obstacles, or barriers via the Integrated Product Team (IPT) process and focus on resolving them at the lower IPT levels. For example, propose a migration plan to attain future openness.
4. Present the identified problems, obstacles, or barriers as issues to the MDA only when unresolved at a lower level. The issues must be reported to the MDA in the context of a summary within the program acquisition strategy. The summary should describe the potential economic impact of the issue (e.g., using closed interfaces) on total ownership costs and the risk to technology maturation and insertion over the service life of the system. The summary should also describe the potential impacts of the issue on the ability to integrate and/or retrofit earlier increments with later increments, and the effects on integrating the system with other systems within a system of systems context.

APPENDIX A

DEFINITIONS

Note: Unless stated otherwise, these terms of reference are defined by the Open Systems Joint Task Force (OSJTF).

Architecture
The organizational structure of a system or component, their relationships, and the principles and guidelines governing their design and evolution over time. *(IEEE 610.12)*

Commercial Item
The CI definition can be found in *Federal Acquisition Regulation (FAR) Subchapter A General, Part 2, 2.101 Definitions at http://www.arnet.gov/far/*

Component
A product that is not subject to decomposition from the perspective of a specific application. (*ISO 10303-1*)

Closed Interfaces
Privately controlled system/subsystem boundary descriptions that are not disclosed to the public or are unique to a single supplier.

De facto standard
A standard that is widely accepted and used but that lacks formal approval by a recognized standards organization. *(FED-STD-1037C)*

Design Architecture
An arrangement of design elements that provides the design solution for a product or life cycle process intended to satisfy the functional architecture and the requirements baseline. *(IEEE 1220)*

Domain
A grouping of related items within a certain area of interest.

End Product
The portion of a system that performs the operational functions and is delivered to an acquirer. *(IEEE 1220)*

Evolutionary Acquisition
Evolutionary acquisition is the preferred DoD strategy for rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in increments, recognizing, up front, the need for future capability improvements. The objective is to balance needs and available capability with resources, and to put capability into the hands of the user quickly. (DoDI 5000.2 approved May 12. 2003)

Functional Architecture
An arrangement of functions and their sub-functions and interfaces (internal and external) that defines the execution sequencing, conditions for control or data flow, and the performance requirements to satisfy the requirements baseline. *(IEEE 1220)*

Interface
The functional and physical characteristics required to exist at a common boundary or connection between systems or items. *(DoD 4120.214-M)*

Interface Standard
A standard that specifies the physical, functional, and operational relationships between various elements (hardware and software), to permit interchangeability, interconnection, compatibility and/or communications.

Interoperability
The ability of systems, units, or forces to provide data, information, materiel, and services to and accept the same from other systems, units, or forces, and to use the data, information, materiel, and services so exchanged to enable them to operate effectively together. *(DoDD 5000.1)*

Intraoperability
The ability to (1) interchange and use information, services and/or physical items among components within a system (platform, program or domain) and (2) support the common use of components across various product lines.

Joint Integrated Architecture
An architecture that establishes the basis for rapidly acquiring affordable and evolving joint warfighting capabilities through collaborative planning, analysis, assessment, and decision making.

Key Interface
A common boundary shared between system modules that provides access to critical data, information, materiel, or services; and/or is of high interest due to rapid technological change, a high rate of failure, or costliness of connected modules.

Modular Design
A design where functionally is partitioned into discrete, cohesive, and self-contained units with well-defined interfaces that permit substitution of such units with similar components or products from alternate sources with minimum impact on existing units.

Modular Open Systems Approach
An integrated business and technical strategy that employs a modular design and, where appropriate, defines key interfaces using widely supported, consensus-based standards that are published and maintained by a recognized industry standards organization.

Module
An independently operable unit that is a part of the total structure. (Merriam-Webster)

Open Architecture
An architecture that employs open standards for key interfaces within a system.

Open Standards
Standards that are widely used, consensus based, published and maintained by recognized industry standards organizations.

Open System
A system that employs modular design, uses widely supported and consensus based standards for its key interfaces, and has been subjected to successful validation and verification tests to ensure the openness of its key interfaces.

Proprietary Standard
A standard that is exclusively owned by an individual or organization, the use of which generally would require a license and/or fee.

Reference Model
A structure which allows the modules and interfaces of a system to be described in a consistent manner.

Spiral Development
A process for implementing evolutionary acquisition within which the end-state requirements are not known at program initiation but are refined through continuous user feedback, demonstration, and risk management so that each increment provides the user the best possible capability.

Stakeholder
An enterprise, organization, or individual having an interest or a stake in the outcome of the engineering of a system. *(EIA-632, Annex A)*

Standard
A document that establishes engineering and technical requirements for products, processes, procedures, practices, and methods that have been decreed by authority or adopted by consensus. *(EIA-632, Annex A)*

Subsystem
A grouping of items that perform a set of functions within a particular end product. *(EIA-632, Annex A)*

System
A combination of two or more interrelated pieces of equipment (or sets) arranged in a functional package to perform an operational function or to satisfy a requirement. *(Defense Acquisition Glossary of Terms, Jan 2001)*

System Architecture
The composite of the design architectures for products and their life cycle processes. *(IEEE 1220-1998)*

Weapon System
An item or set of items that can be used directly by warfighters to carry out combat or combat support missions to include tactical communication systems. *(DoDI 5000.2)*

APPENDIX B

Applying MOSA in a Request for Proposal

I. Introduction

This document contains examples of language suitable for use in an RFP and supporting documents to facilitate the application of a Modular Open Systems Approach (MOSA) by offerors. The language examples are intended to be stand-alone generic statements that provide effective ways of addressing modular open systems in a particular context. You should select the examples that are useful in your particular situation. The examples are intended to be tailored, as appropriate, to meet specific program requirements.

II. Examples of Open System Language

A. Executive Summary or Cover Letter Language

Many contracting activities issue RFPs with a cover letter or executive summary that tells potential offerors about the requirement that needs to be satisfied and what matters most to the government. Identifying modular open systems as a key interest or goal, in the cover letter or executive summary, emphasizes to potential offerors that MOSA is important to the government. Here are examples of modular open systems language that may be appropriate in a cover letter or executive summary:

- *Provide for a system that allows for interoperability and cost effective incremental upgrade over the entire life cycle of the system without dependence upon a single source.*
- *Deploy a system characterized by life-long viability, a standard-based and robust architecture, and capability to insert new technology based on the cycle rates of the ensuing technologies in system components.*
- *Build a system that can be improved incrementally without redesign of the entire system or large portions thereof.*

B. Statements of Objectives (SOO) Language

A SOO is an excellent tool for conveying to the offerors the main objectives of the acquisition. As offerors prepare their proposals they can concentrate on ensuring that they meet or exceed all of the objectives stated in the SOO. If a SOO is being used, the following examples of objectives may be used.

The Offeror shall use modular open systems approach to:

1. *Facilitate development of a modular architecture and allow for affordable intraoperability*
2. *Ensure that the system design is sufficiently flexible and robust to accommodate changing technology and requirements*
3. *Facilitate integration with other systems and use of commercial products from multiple sources both in the initial design and in future enhancements*
4. *Enable technology insertion as currently available commercial products mature and new commercial products become available in the future*

5. *Allow for affordable support*
6. *Allow continued access to technologies and products supported by many suppliers (a broad industrial base which does not restrict available sources to the detriment of competition)*

For systems that tend to evolve and improve with time:

> *System design enables technology insertion as currently available commercial products mature and new commercial products become available in the future.*
>
> ***or***
>
> *Enable incremental system improvements through upgrades of individual hardware or software modules with newer modular components without redesign of entire systems or large portions thereof.*

If technology obsolescence is a risk that must be managed:

> *Mitigate the risks associated with technology obsolescence, being locked into proprietary technology, and reliance on a single source of supply over the life of the system.*

An overall objective to take advantage of the benefits of MOSA:

> *Build the system based on modular hardware and software design, choosing commercially supported specifications and standards for selected interfaces (external, internal, functional, and physical) products, practices, and tools.*

C. System Requirements Documents Language

The offerors are more likely to use MOSA as a suitable business and technical strategy for building systems when modular open systems attributes are embedded in performance/operational requirements. The following modular open systems language may be used in requirements documents such as the Capability Documents (e.g., ICD, CDD, and CPD), System Specifications, Technical Requirements Document (TRD), Performance Work Statement (PWS), Statement of Work (SOW), etc:

> *The Offeror shall use a modular open systems approach to evaluate the appropriateness of implementing a modular design strategy for building systems. A primary consideration in selection of equipment to meet the design functionality shall be the impact to the overall modular open systems architecture. A modular open systems approach and analysis of long term supportability, interoperability, and growth for future modifications shall be major factors in the Offeror's final selection of equipment and integration approach. All the systems components shall facilitate future upgrades and permit incremental technology insertion to allow for incorporation of additional or higher performance elements with minimal impact on the existing systems.*
>
> *The architectural approach shall provide a viable technology insertion methodology and refresh strategy that supports application of a modular open systems approach and is responsive to changes driven by mission requirements and new technologies.*

> *The Offeror shall develop a detailed modular design and integration that includes but is not limited to the following aspects: interoperability, intra-operability, upgradeability, reconfigurability, transportability, software standards, interface standards, long term supportability, sources of supply and/or repair, business strategies, and other entities that affect application of a modular open systems approach.*
>
> *For those portions of hardware, firmware, or software that are driven to proprietary and/or closed system architectures by mission specific requirements, a hardware/firmware/software partitioning or other design features to mitigate the system level impacts shall be provided*
>
> *The Offeror shall provide an orderly, planned approach to address migration of proprietary or closed system equipment or interfaces to a modular design when technological advances are available.*
>
> *The Offeror's modular design and integration shall preclude long term dependence on closed or proprietary interface standards, technologies, products, or architectures. Secure or classified data systems shall also conform to the modular design approach as much as practical. The design shall provide sufficient growth and open interface standards to allow future reconfiguration and addition of new capabilities without large-scale redesign of the system.*

D. Section L Language

Section L includes instructions for the offeror to incorporate information that evaluators will need to assess their MOSA against the evaluation criteria. The language examples that follow are intended to be stand-alone examples of "Instructions for Proposal Preparation" that might serve this purpose. Each example is not applicable to every case – you should select the examples that are useful in your particular situation.

> *The proposal shall describe how the Offeror's modular open systems approach will cause the Offeror to implement an integrated business and technical strategy that employs:*
>
>> *(1) a modular design and, where appropriate, (2) defines key interfaces using (3) widely-supported, consensus-based (i.e., open) standards that are published and maintained by a recognized industry standards organization.*
>
> *In describing the modular open systems approach, the proposal shall include:*
>
> - *Plans for integrating the systems internally and with external system*
> - *Identification of the means for ensuring conformance to widely used consensus standards (i.e., open standards) and profiles throughout the development process, and an explanation of how the modular open systems approach supports benefits such as reconfigurability, portability, interoperability, technology insertion, vendor independence, reusability, scalability, and commercial product based maintainability*

- *A description of how the technical approach ensures having access to mature as well as the latest technologies by establishing a robust, modular, and evolving architecture based on widely used consensus standards*
- *A description of how the design concept supports modular open systems approach principles*
- *A description of the strategy for maintaining the currency of technology (e.g., through COTS insertion, technology refresh strategies, and other appropriate means).*
- *Identification of processes for:*
  - *isolating functionality through the use of modular design.*
  - *identifying key interfaces.*
  - *selecting open standards for key interfaces.*
  - *specifying the lowest level (e.g., subsystem or component) at and below which they intend to control and define interfaces by proprietary standards and the impact of that upon their proposed logistics approach.*
  - *evaluating modular open systems baseline standards, defining and updating profiles, evaluating and justifying new and vendor unique profiles.*
  - *validating implementation conformance to selected profiles.*
  - *managing application conformance to selected profiles.*
  - *training in use of profiles.*

The Offeror shall specify how they plan to use a modular open systems approach as an enabler to achieve the following objectives:

- *Adapt to evolving requirements and threats*
- *Accelerate transition from science and technology into acquisition and deployment*
- *Facilitate systems reconfiguration and integration*
- *Enhance modularity*
- *Leverage commercial investment in new technologies and products*
- *Reduce the development cycle time and total life-cycle cost*
- *Achieve commonality and reuse of components within a system (if commonality is a requirement)*
- *Maintain continued access to cutting edge technologies and products from multiple suppliers*
- *Mitigate the risks associated with technology obsolescence, being locked into proprietary technology, and reliance on a single source of supply over the life of a system*
- *Enhance life-cycle supportability*

When the RFP is requesting proposals that will involve the modernization of legacy systems, one or more of the following language examples may be useful.

- *The Offeror shall clearly demonstrate the modular design strategy in all aspects of the system upgrade. In addressing the requirements specified, the proposal must demonstrate how the modular design strategy applies, and the effect it will have on the system upgrade. The proposal shall also provide documentation to support the rationale for a decision to integrate a proprietary or closed system hardware and/or software functions within the proposed system.*
- *The proposal shall describe the orderly planned process to address migration of proprietary or closed system equipment or interfaces to a modular open systems design when technological advances are available or when operational capability is upgraded. The proprietary or closed systems implementation shall also be reflected in the Offeror's system level life cycle cost estimates.*
- *The modular design approach shall either mitigate or partition the proprietary or closed systems implementation to avoid out-year supportability issues and diminishing manufacturing sources and sources of repair through the selection of open standards for identified key interfaces.*

E. Section M Language

Listed below are indicators you may use as part of the evaluation criteria calling for application of MOSA:

1. Modular Design Indicators

1.1 Identification of specific acquisition objectives (e.g., affordability, ease of change, leveraging commercial investment in new technology, etc.) and operational capabilities (e.g., ease of integration, interoperability, etc.) directly or indirectly dictate the use of open systems in your program.

1.2 A system architecture characterized by modular design.

1.3 The degree to which the program risk management strategy and MOSA complement each other.

1.4 Justification of modular open system design via business case analysis (e.g., cost/benefit analysis, market research findings, etc.).

2. Key Interface Indicators

2.1. Proactive management of system interfaces.

2.2. Identification of key system interfaces based on the module characteristics (e.g., criticality of function, ease of integration, change frequency, interoperability, commonality, etc.).

2.3. Appropriate designation of open standards for key system interfaces.

3. Open Standards Indicators

3.1. Feasibility studies to assess the use of open standards for key interfaces.

3.2. Application of a standards selection process that gives preference to open standards.

3.3. Standards selection for key interfaces is based on application of specific criteria (e.g., DoD mandate, industry consensus, market support, prime contractor recommendation, etc.).

Additionally, does the Offeror's proposal provide the User with the ability to:

- *quickly interconnect, reconfigure, and assemble existing forces, systems, subsystems, and components?*
- *interchange and use information, services and/or physical items among components within a system?*
- *interchange and use information, services and/or physical items among systems within an integrated architecture, platform, domain, or a DoD Component?*
- *support reuse of software and the common use of components across various product lines?*
- *transfer a system, component, or data, from one hardware or software environment to another?*
- *adapt hardware or software to accommodate changing work loads?*

The following list of language should be selected to correspond with specific requirements or instructions provided to the offerors in prior sections of the RFP.

- *Does the Offeror's information technology architecture support interface requirements analysis, evolution of system capabilities, and selection of modular and open systems-based software and hardware?*
- *How consistent is the Offeror's overall sustainment strategy and execution approach with the modular open systems approach?*
- *How well does the proposal demonstrate that the modular design approach, plans for technology insertion, and sustainment strategy are consistent with the modular open systems requirements/objectives in Section C?*
- *How does the Offeror's system design satisfy the requirement for a modular design approach that uses consensus standards adopted by recognized standards organizations and/or widely-used commercial standards for key interfaces within the system?*
- *Is the Offeror's design process or systems engineering approach capable of achieving the following modular open systems objectives:*
  - *Enhance interoperability and the ability to integrate new capabilities without redesign of entire systems or large portions thereof*
  - *Enable rapid reconfiguration of systems and forces*
  - *Adapt to evolving threats and technologies by managing to the natural upgrade cycles of technologies used in a system*

  - *Improve life-long supportability and reduce total cost of ownership via continued access to multiple sources of supplies and services*
  - *Allow incremental system improvements through upgrades of individual hardware or software modules with newer modular components*
- *Does the Offeror's design approach achieve identified modular open system benefits such as higher performance, life-long supportability, reduced total ownership costs and development cycle time, lower risks associated with technological obsolescence and dependency on a single source of supply, and other requirements such as integrability, scalability, and portability?*
- *Does the Offeror have a plan to manage the impact of changing requirements and evolving technology on system's ability to continue to satisfy improved capabilities over time?*
- *Does the Offeror's design approach propose to define interfaces in sufficient completeness and detail such that selected element(s) can be replaced and/or modified in a competitive environment with minimal modifications to other system elements while maintaining equal or improved system performance and capability?*
- *Does the Offeror's approach comply with modular open systems objectives/requirements such as continued access to multiple suppliers and improved performance through affordable modernization?*
- *Does the Offeror's test and evaluation planning contain means for testing the conformance to open standards to ensure the openness of key interfaces throughout the system life cycle?*
- *Does the Offeror's approach contain capabilities to easily and quickly update, revise, and change the system as threats or technologies evolve?*

These are just a few examples of language that can be used to formulate a tailored MOSA for meeting the business and technical objectives of your program. These statements can be documented in your acquisition planning process and throughout all of your program and contractual documentation. Once you have decided on how to apply MOSA to your program, you will be able to lay a clear trail that starts with acquisition planning and can be traced from your objectives to requirements to evaluation criteria and throughout execution of the program.

APPENDIX C

Modular Open System Approach (MOSA) Implementation Questions

The OSJTF has developed the following set of indicators, in the form of MOSA implementation questions, to help assess the extent to which MOSA is implemented in an acquisition program, and also to identify actual or potential MOSA implementation issues. These questions are representative of the actual questions used in the MOSA Program Assessment and Review Tool (PART), which is an automated analytical tool that relies on objective, data evidence-based judgments to assess and evaluate MOSA implementation. The MOSA PART is an adaptation of the OMB Program Assessment Rating Tool (PART), which is a questionnaire designed to provide a consistent approach to rating programs across the Federal government. The MOSA PART can be found on the Open Systems Joint Task Force website at http://www.acq.osd.mil/osjtf.

SECTION A: BUSINESS INDICATORS

Question A1: To what extent is MOSA incorporated into the program's acquisition planning?

Question A2: To what extent did the program plan for its implementation of MOSA?

Question A3: To what extent is the program's MOSA implementation based on systems engineering principles and processes?

Question A4: To what extent are responsibilities assigned for implementing MOSA?

Question A5: To what extent is the program staff trained on, or have relevant experience in MOSA concepts and implementation?

Question A6: To what extent does the program's configuration management process encompass changes to key interfaces and corresponding standards?

Question A7: To what extent have program requirements been analyzed, and refined as needed, to ensure that design-specific solutions are not imposed?

Question A8: To what extent do the system level functional and performance specifications permit an open systems design?

Question A9: To what extent are modular, open system considerations included as part of alternative design analyses?

Question A10: To what extent are mechanisms established to migrate key interfaces that are proprietary or closed to key interfaces that are open?

Question A11: To what extent are MOSA principles reflected in the program's performance measures?

SECTION B: TECHNICAL INDICATORS

Question B1: To what extent is the system's architecture based on related industry or other standard reference models and architectural frameworks?

Question B2: To what extent is an architectural description language used to define system modules and interfaces?

Question B3: To what extent does the system's architecture exhibit modular design characteristics?

Question B4: To what extent is the system's architecture capable of adapting to evolving requirements and leveraging new technologies?

Question B5: To what extent has the criteria for designating key interfaces been established?

Question B6: To what extent has the program designated key interfaces?

Question B7: To what extent has the program assessed the feasibility of using open standards for key interfaces?

Question B8: To what extent have standards selection criteria been established that give preference to open interface standards?

Question B9: To what extent are open standards selected for key interfaces?

Question B10: To what extent are validation and verification mechanisms established to assure that system components and selected commercial products conform to the selected interface standards?

Question B11: To what extent do system components and selected commercial products conform to standards selected for system interfaces?

Question B12: To what extent do system components and selected commercial products avoid utilization of vendor-unique extensions to interface standards?

Question B13: To what extent can system components be substituted with similar components from competitive sources?

APPENDIX D

Modular Open Systems Approach (MOSA) Acquisition Strategy Template

INSTRUCTIONS: Below is a proposed template for programs to use for addressing MOSA in their acquisition strategy. Programs are encouraged to tailor the following recommended text to better correspond with their overall program and acquisition strategy. The tailorable text is highlighted in ***italics***, unless otherwise noted.

[*Insert Acquisition Strategy Section No.*] Modular Open Systems Approach (MOSA)

The **[*Insert Program Name*]** will employ a modular, open systems approach as an integrated acquisition and technical strategy. This approach is an enabler to achieve the following objectives:

[*Please select from the following list and include all that apply to your program*]

- ***adapt to evolving requirements and threats***
- ***promote transition from science and technology into acquisition and deployment***
- ***facilitate systems integration***
- ***leverage commercial investment***
- ***reduce the development cycle time***
- ***reduce the total life-cycle cost***
- ***ensure that the system will be fully interoperable with all the systems with which it must interface, without major modification of existing components***
- ***enhance commonality and reuse of components among systems***
- ***enhance access to cutting edge technologies and products from multiple suppliers***
- ***mitigate the risks associated with technology obsolescence***
- ***mitigate the risk of a single source of supply over the life of a system***
- ***enhance life-cycle supportability***
- ***increase competition***
- ***facilitate modular contracting***

The systems architecture selected for the **[*Insert Program Name*]** will ensure continued access to emerging technologies and products, and will prevent sole dependence on proprietary technology through the implementation of modular design principles and the use of open standards for key system interfaces.

The candidate system will be assessed at appropriate milestones and depending on program maturity and applicability, the design of the relevant sub-systems (i.e., structural, mechanical, hydraulic, electrical, electronic and computing) of the **[*Insert System Name*]** will be based on MOSA principles. The system architecture selected will have the following characteristics:

- application of publicly available standards specifications, and protocols which are established and maintained through a consensus process, preferably by an internationally-recognized governing group
- well-defined, widely-used, non-proprietary interfaces, services and formats
- employment of modular design principles (e.g., cohesion, encapsulation, decoupledness, etc) that facilitate component replacement and the addition of new capabilities
- upgradeable modules that enable the incorporation of additional or more-capable components with minimal impact, requiring little or no changes to the overall system

The standards selected for external interfaces will be consistent with system architectures of peer and higher level systems (e.g., System of Systems architectures), among and within which the **[*Insert System Name*]** is expected to function and interact.