AN OPEN SYSTEMS APPROACH TO SUPPORTABILITY

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ABSTRACT

The open systems approach is both a technical approach to weapons systems engineering and a preferred business strategy that is becoming widely applied by manufacturers of large complex systems. Today, legacy systems continue to be developed with their own, often unique, and frequently closed designs, making upgrade or modification difficult over their expected lifetimes (20 to 40 years). Also, reduced procurement budgets and the increased dominance of commercial technology cause DoD acquisition managers to increasingly rely on commercial markets for affordable product development and support. For the most part, however, DoD weapons systems managers still risk relying on unique products provided by a single supplier at high non-competitive prices with little opportunity for technology insertion or product support by other suppliers. Life cycle supportability of weapons systems is seriously impacted by the continued use of closed designs. This paper discusses the use and application of open systems concepts and design principles to provide weapons systems that more readily accommodate changing technology to achieve system cost, schedule, and performance benefits by promoting multiple competitive sources of supply within the commercial marketplace. Open systems concepts and design principles also offer the potential to greatly improve supportability of such systems over their service lifetimes.

WHAT IS THE OPEN SYSTEMS APPROACH?

The open systems approach is an integrated technical and business strategy that defines key interfaces for a system (or piece of equipment) being developed. Such interfaces generally are best defined by formal consensus (adopted by recognized industry standards bodies) specifications and standards. However, commonly accepted (de facto) specifications and standards (both company proprietary and non-proprietary) are also acceptable if they facilitate utilization of multiple suppliers.

The use of de facto specifications and standards takes advantage of the fact that firms, particularly those in the commercial arenas, frequently develop hardware, software and systems standards of the design and fabrication of computing, telecommunications, display, sensing, and signal processing systems. Whether consensus or de facto standards are used to describe interfaces, the benefits only accrue if products from multiple sources are economically possible. Although the most common emphasis is on electronic systems, the open systems approach is widely applicable, from fasteners and light bulbs to jet engines.

An effective open systems architecture will rely on physical modularity and functional partitioning of both hardware and software. Physical modularity and functional partitioning should be aligned to

facilitate the replacement of specific subsystems and components without impacting others. The subsystems and components described by the systems design should be consistent with the system repairable level. Subsystems and components below the repairable level will normally not be under government configuration control. Therefore, repairs below the repairable level, if required, will be by the supplier. If the hardware and software is effectively partitioned, processing hardware can be replaced with new technology without modifying application software. Additionally, application software can be modified without necessitating hardware changes.

As a preferred business strategy, the open system approach is becoming widely applied by commercial manufacturers of large complex systems. It has the attention of DoD management who have mandated its use by DoD systems developers to maintain continued superior combat capability affordably. System designs incorporating open systems concepts and principles more readily accommodate changing technology to achieve cost, schedule, and performance benefits by promoting multiple sources of supply and technology insertion.

OPEN SYSTEMS IN WEAPONS SYSTEMS ACQUISITIONS

The adoption of open systems in systems acquisition is a pragmatic reality. The confluence of technological trends, business trends, fiscal constraints, and evolving threats has forced the government to recognize that systems can no longer be acquired and supported with traditional methods. Ideally, the logistician would prefer to hold a system configuration constant for its' projected lifetime, procure a lifetime's worth of spares and provide operational support. Unfortunately that situation does not exist. Contemporary acquisition strategies are incorporating plans for modernization, just-in-time spares, horizontal technology insertion, single process initiative, performance specification, CAIV, IPPD, et al that leverages industry's creativity and efficiency. The support system will be affected by this too. Some support functions will benefit from open systems. Some support functions will have challenges.

The open systems design approach allows a weapon system program office to achieve and maintain combat superiority in today's challenging acquisition environment. The design process is focussed on lowering the entire life-cycle costs of weapon systems in contrast to current practice in which a disproportionate focus is placed on the short-term goal of having the lowest development costs. The ability of the open systems design approach to improve life-cycle supportability is becoming an even more important issue as DoD limits the number of new weapon systems procurements and extends the life of the systems currently fielded.

It is a fact of today's acquisition environment that DoD is no longer the dominant force in the technological market place. Moreover, as the DoD procurement budget has been drastically reduced, DoD no longer has the luxury of technology dominance, funded by seemingly unlimited budgets. In prior decades, DoD weapons systems requirements drove development of new products and new technology. In the today's environment the opposite is true; commercial demand drives product and technology development. However, DoD can now take advantage of commercial

innovation, research and development to drive down its cost of developing, acquiring and maintaining weapon systems, leveraging the commercial investment to make the most of a shrinking defense budget. An open systems approach, using open interfaces supported by commercial and non-developmental components, can substantially facilitates this leveraging.

Most of today's legacy weapons systems were developed with their own, often unique and frequently closed, infrastructures, making upgrade or modification over their expected lifetimes (20 to 40 or more years) both problematic and expensive. The impact of reduced budgets and increased dominance of commercial technology made this approach to development obsolete. Acquisition managers now have to rely on commercial markets for affordable product development and support. However, as DoD's role shifts from technology producer to technology consumer, weapon systems will be based more on commercial products, whose design is not controlled by DoD and whose lifetimes are much shorter and more volatile than the weapons systems they support (e.g., years vs. decades). This, of course, presents an interesting logistics challenge.

Application of the open systems approach is being applied to legacy systems as well. Legacy systems usually have size, space, power, cooling and shape factor constraints. For these systems, the open systems approach provides form-fit-function interface (F3I) solutions within existing packaging, power, and environmental constraints. In such cases, the open systems solution frequently requires less system resources by using newer, more efficient technologies. The open systems approach is similar to F3I except that the open systems approach emphasizes choosing interfaces that are broadly accepted in the marketplace to allow for as many suppliers as possible over the long term.

For weapons systems acquisitions the issue is not just cost: continuance of our military superiority may depend on reduced technology insertion cycle times. In a global market, everyone, including our potential adversaries, will gain increasing access to the same commercial technology base. The military advantage goes to the nation that captures the latest commercially available technologies, incorporates them in weapon systems, and fields them first. Moreover, since coalition operations with our allies place a premium on interoperability, it is essential that our systems be compatible and capable of being sustained through a common logistics support structure. Open systems specifications and standards promote standard interfaces and interoperability with our friends and allies.

As a result of this changing acquisition environment, DoD finds itself with few alternatives but to drastically alter the way it develops, produces and supports its weapon systems. It is neither economically nor technologically feasible to continue traditional closed design approaches. DoD has been compelled to move towards a more open weapon systems design alternative.

Open Systems are Important to Supportability

There are a number of benefits for the customer who has pursued an open system design. There is more component and interface commonality which should provide greater ease in maintenance. Modernization of the open system is expected to take less time and money. The

open system may also afford more organizational repair, thereby increasing operational availability.

A system that has successfully integrated the aspects of an open architecture into its design will be well situated for inserting new technology, especially technology from the commercial sector. Typically, an open system will be populated with commercial components that have been widely used throughout the market. Successful commercial products will usually enjoy superior support, which should be of benefit to the DoD, especially in supply support. As the DoD supports the system, it will enjoy reduced pricing from competitive sourcing, supply efficiencies through multiple sources, and vendors will be more responsive competing for government business. Availability of supply support will be improved because of multiple sources and the supply and demand created by commercial market.

Open systems are less likely to require military unique special test equipment. They can be expected to be tested with commercial off-the-shelf equipment which may already exist in the support system possibly eradicating any necessity for additional test equipment altogether.

Open systems may reduce some operator and maintenance training. The rationale for that supposition is based upon familiarity of common products. That is; if one piece of test equipment is common between many other systems, retraining is not required for technicians who are cross-training to maintain other systems.

Extending the rationale above, maintenance of new systems may not require additional facilities, or modification of existing facilities as has happened in the past. If new systems were designed to test on equipment that already exists, then there is the possibility that maintenance could all occur in existing government facilities or use existing commercial facilities.

An open systems approach is designed to facilitate the use of widely accepted, standard products-from multiple suppliers in DoD weapons systems. In addition, if the architecture is defined by specifications and standards used in the private sector, the DoD can be one of many customers to leverage the benefits of the commercial marketplace. Thus, DoD can leverage the competitive pressures that motivate commercial companies to reduce prices, and introduce new products developed with internal resources.

The open systems approach facilitates the use of lower cost, high performance weapons system, subsystems and components, mostly built to commercial specifications and standards. The open systems approach does not imply that only consumer grade products should be used. However, some commercial environments are as demanding as military environments, and commercial products that function in these environments will also function in the military environment. In any case, all open systems designs still must meet military requirements.

An open systems approach also mitigates the risk of obsolescence due to shortened technology cycle time. Obsolescence risk is significant because technology cycle time, sometimes on the order of months, far outpace weapon system development cycle time, which is typically 8 to 15 years. By the time a system is fielded, supporting technologies are often outdated—the U.S. military cannot afford to be 3 or 4

technological generations behind what is available to the commercial market. Open systems designs, using commercially-supported interface standards permitting upgrade at a relatively low cost, specifically address issues of affordability and supportability associated with long lived system by facilitating evolutionary upgrade with new technology. Generally, this results in superior combat capability over the total system life cycle, usually at a lower cost to the government.

The system design flexibility inherent in the open system approach, and the more widespread availability of conforming commercial products, mitigates potential problems associated with a diminishing defense-dependent manufacturing base. Finally, life cycle costs are reduced by a long-lived, standards based architecture that facilitates upgrades by incremental technology insertion, rather than by large-scale system redesign.

The open systems approach can have a profound effect on the life cycle cost of a system. Program managers can have access to alternative sources for the key subsystems and components to construct DoD systems. DoD investment early in the life cycle is reduced since at least some of the required subsystems or components are likely to already be available, or being developed without direct DoD investment. Production sources can be competitively selected from multiple competitors.

OPEN SYSTEMS ISSUES IN SUPPORTABILITY

DoD acquisition is going to open systems! The logistics community is going to be presented with the accomplished fact of open systems that they must maintain and supply. They will have to deal with the open systems now being developed. Though, as stated above, this provides benefits and opportunities, it also presents challenges.

It is essential to also identify supportability issues that are begot by the open systems approach. Additional planning, market research, testing, and data management will become necessary in order to assure operational availability, system reliability, and quality assurance.

Commercial industry is underwriting the development costs and controlling configuration of many of the subsystems and components in an open system. If the vendor unilaterally chooses to make a product improvement, that is their right. It was a business decision. No permission is necessary from the government. Market dependency issues are:

- Quality assurance–recognizing changes as they occur, and testing to assure compliance to performance and quality.
- Configuration management–documenting changes to specifications, drawings, and parts lists as they are integrated into fielded units (configuration control). Tracking changes in the field (status accounting).
- Data management – documenting changes to technical manuals, technical orders, and training materials.

An open systems approach tends to focus the systems engineering process on developing system designs which consider life-cycle support requirements up front and that support system evolution throughout the system's life. The application of open systems designs is a common sense approach that has substantial promise as an

approach to meet DoD's continuing need to support weapons systems over increasingly long life cycles in an environment of decreasing resources. In a time when the development of a complex system can span several generations of the faster moving technologies, open system architectures offer the tantalizing prospect of facilitating performance upgrades at affordable costs for the life cycle of the system.

In 1996, DoD issued a revised directive DoD 5000.2-R that instructs program managers to employ open systems as a design consideration in defense systems engineering. This directive was subsequently revised and strengthened with Change 3 in March 1998. However, DoD program managers must exercise some care and judgment in their application of the open systems approach. It does not represent a new approach that replaces and makes obsolete previous approaches to engineering complex systems. Moreover, managers should not simply implement an open standard without careful consideration of where (in the system hierarchy) it makes sense to impose standards nor should they simply grasp for a commercial item solution, whether or not the solution leads to the benefits of open systems architectures. Such actions may encourage program managers to declare that they are achieving open systems attributes, whether or not the system design is well thought out to take full advantage of the benefits that the open systems approach offers. This may give the appearance of achieving open systems architectures but, in fact, such shortsighted decisions work against the long-term viability of the system.

In addition, open systems interfaces must be managed more rigorously than in previous practice. An interface specification or standard is inherently a performance standard, is used as such by industry, and must be recognized as such in DoD. System partitions must not violate the interface, unilaterally extend it, or define it so that it is no longer compliant with the standard. At the start of production, the open systems requirements are published, thus identifying the market opportunities for suppliers.

OPEN SYSTEMS SUPPORTABILITY CHALLENGES

The issues of quality assurance, configuration management, and data management present these challenges:

- How to anticipate product line changes – market research and analysis to predict how product trends will affect supply support (associated to quality assurance, configuration management and data management). Challenge is adjusting existing (or programming new) resources to accomplish the increased activity in this area.
- Test and evaluation of new and improved components in the open system – assessing how product changes conform to system requirements for performance and quality (associated to quality assurance and data management). Challenge is adjusting existing resources to accomplished more test and evaluation.
- Updating the specifications, manuals, drawings, et al – maintaining currency in detail specifications, maintenance manuals, and parts lists (associated to data management and configuration management). Challenge is adjusting existing resources

- Updating training – adjusting materials and facilities for training currency (associated to data management). Challenge is adjusting resources to meet training needs.
- Estimating cost impacts due to product line changes – conducting extensions of market research to predict how market trends will affect support costs and programming support budgets (associated with quality assurance, configuration management and data management). Challenge is programming resources to satisfy your supply support, training, and maintenance needs.

Open systems design approaches offer considerable benefits in terms of life cycle support, affordability, and timely technology insertion. The approach also carries with it some substantial differences in the way that systems will be managed and supported. Since by its nature open systems designs will involve increased use of commercial and non-developmental items in systems architectures, the government will necessarily have to plan for significant differences in the way systems are managed from a technical perspective. These differences cut across almost every aspect of weapons systems management, and while space prohibits an exhaustive treatment, examples impacting supportability include the following:

- Standards based architectures lessen the degree of control that DoD can expect to exert. Changes, fixes, and updates will likely be under the vendor's control. This can have a significant impact on system support.
- Standards evolve with time. It is difficult to project the extent to which a given standard will endure. It is equally challenging to determine when to move from one standard to the next.
- Standards based architectures tend to change the focus of systems engineering from design to integration. The challenge is to achieve performance requirements without detailed control over the component design specification.
- An item, once integrated, may affect other system parameters. Commercial and non-developmental items make testing an on-going and continuing activity to verify that items can integrate successfully into systems.
- The use of commercial and non-developmental items requires that support concepts be developed early in the acquisition cycle.

While this is hardly an exhaustive list, it makes the point that open systems design approaches introduce new issues into the management weapons systems programs throughout their entire life cycle. There are many potential benefits, but, likewise, there are challenges and problems that the manager must be alert to anticipate and overcome.

SUMMARY

The objective of open systems acquisitions is to provide the warfighter the most effective weapon systems possible. An open systems approach to systems engineering facilitates this throughout the life of the system. The open systems approach is a new way of doing business and an important part of ongoing acquisition reform initiatives. Beyond that, however, the open systems approach is a smart way to do business. Hard pressed to maintain the

superiority of the U.S. military systems within severe budget constraints, DoD program managers need the flexibility of open systems to leverage the creativity and competitive pressures of the commercial marketplace. Open systems designs provide an opportunity to achieve affordable designs, which can more readily accommodate changing technology to achieve system cost, schedule, and performance benefits by promoting multiple competitive sources of supply within the commercial marketplace. Open systems concepts and design principles also offer the potential to greatly improve supportability of such systems over their service lifetimes.

The DoD acquisition community has begun the process of developing weapon systems with the open system approach. The logistics community should be aware that as these systems enter the operations and support phase, they will present opportunities for benefits and challenges that must be addressed. There are benefits that come from leveraging commercial practice.
There are opportunities that allow additional benefits if there are changes in the way business is done. There are challenges that can only be met by reconsidering how logistic support is performed in DoD. If these challenges go unmet the lifecycle benefits from the open systems approach will not be realized and support problems will be generated. This paper has mentioned some of the benefits, opportunities, and challenges that will have to be dealt with. Though certain of these issues have similarities with current processes used for COTS and NDI, there is a significant difference: open system requires continual assessment of what is current in the commercial sector and how it relates to the support of the specific system, subsystem, or component. The problem for the logistics community is how should this be done, and how does it impact the different functions of logistics.

More open systems information and reference materials are available on the Open Systems Joint Task Force home page on the Internet at http://www.acq.osd.mil/osjtf