Acoustic Rapid COTS Insertion (ARCI) Program Case Study

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Executive Summary

This case study provides an in-depth look at why the Acoustic Rapid COTS Insertion (ARCI) process is a successful product sustainment strategy. The case not only draws upon past data, but also upon an interview conducted with Lockheed Martin associates at the Lockheed Martin Maritime Systems and Sensors (MS2) facility, located in Manassas, VA.

The US Navy lost its acoustic superiority in the 1990's, and needed an efficient and cost-effective way of upgrading their sonar systems, under the financial constraints they were facing at the time. The Acoustic Rapid COTS Insertion process was the solution, and provided significant performance and cost-saving benefits to the US Navy.

The ARCI process is referenced in many journals and articles as a great example in the utilization of COTS (Commercial Off-The-Shelf) technology. COTS technology is a key driver for the success of this product sustainment strategy. This case looks at the benefits of COTS and open architecture, and how they have impacted the ARCI process.

A unique aspect of the ARCI process is the contract structure under which it operates. There are a total of three contracts; two with NAVSEA and one with NAVSUP. The two contracts with NAVSEA are cost-plus contracts; and the one with NAVSUP is a firm-fixed-price, fixed-fee-contract. This case examines the uniqueness of the contract structure and provides analysis of how the firm-fixed-price, fixed-fee contract is actually executed more as a cost-type contract.

Key enablers of the ARCI process are identified in the form of "best practices" and "lessons learned" that the MS2 facility and the US Navy have encountered over the 15 years of implementation. Additionally, current barriers and issues that hamper the progress of the ARCI process are identified, along with the significant cost-savings and performance benefits that the US Navy has experienced as result of the process. The case study concludes with some observations and recommendations regarding the ARCI process and its use for other product sustainment programs.

I. Introduction

The United States faces several long-term budgetary challenges. The rapidly-increasing financial burden, as "Baby Boomers" age (by 2020 the number of people in the U.S. population between the ages of 65-84 is expected to rise by nearly 50 percent), includes mandatory federal entitlement spending on programs such as Social Security and Medicare, as well as the impact of the recent healthcare reform bill. For example, during the next eight years, annual growth rates for Social Security and Medicare/Medicaid are expected to rise by roughly 4.5 to 6.5 percent, and 7 to 8 percent respectively[1]. Spending on these programs is directly tied to rising cost-of-living and healthcare costs in the United States; and has historically outpaced defense spending as a percent of GDP. Compounding this budgetary problem will be the large annual payments on the national debt, accumulated during the financial crisis of the past decade. These challenges, and the impact they will have on the domestic economy, will directly influence DoD's future budgets.

The Budget Control Act (BCA) of 2011was enacted into law on August 2, 2011 and sets caps on discretionary spending for FY 2012-2021. How these will be implemented is still uncertain, but more than likely will result in cuts to several programs that provide support to the military, including training, healthcare, quantity of weapon systems, and most importantly weapons system support, also known as product sustainment.[2]

Product sustainment is defined as the package of support functions required to maintain the readiness and the operational capability of weapons systems, subsystems, software, and support systems. It encompasses materiel management, distribution, technical data management, maintenance, training, cataloging, configuration management, engineering support, repair parts management, failure reporting and analysis, and reliability growth. Product sustainment strategies utilize capabilities of the public (organic) and private sectors; these include labor, facilities, and other assets. Product sustainment strategies

[1] Congressional Budget Office. 2007. Financing Projected Spending in the Long Run.

[2] 2012. "Comptroller: Sequestration Would Devastate Defense Spending" Web Page, [accessed 21 December 2012]. Available at http://www.af.mil/news/story.asp?id=123319134

use a variety of options and capabilities. The goal is to maximize weapons system availability and support, at the lowest total-ownership-cost.[3]

The DoD's strategy of product sustainment has evolved from the traditional transactional support concept (where spare parts and components are procured with discrete transactions) to an emphasis on a "performance-based" strategy of acquiring operational readiness outcomes.[4] One example of a successful product sustainment strategy is the US Navy's Acoustic Rapid COTS Insertion process (ARCI). This product sustainment strategy illustrates the benefits of a public-private partnership (in this case, between the US Navy and Lockheed Martin Maritime Systems and Sensors (MS2)). The implementation of the ARCI process yielded significant cost savings for the Navy, and improved performance of its sonar systems, by using Commercial-Off-The-Shelf (COTS) technology.

[3] U.S. Department of Defense. DoD Weapons System Acquisition Reform Product Support Assessment, Washington, DC: United States Department of Defense; 2009, pg. 7
[4] Ibid, pg. 8

II. ARCI Background

In response to the collapse of the Soviet Union (and with it the end of the Cold War), the U.S. defense budget was significantly reduced, along with a reduced emphasis on the Navy's anti-submarine warfare capability. As a result, the Navy's submarine force lost ground in its ability to acoustically detect and track foreign submarines during the decade of the 1990's. At the same time, other nations continued to develop submarines that used advanced quieting technology, making them even more difficult to detect. In order for the Navy to regain its ability to track adversary submarines, new systems would have to be developed, or the existing systems would have to be upgraded with improved processing capabilities.

Consideration of COTS and Open Architecture

During the same timeframe, (and following the integrated circuit trends predicted by Gordon Moore[5]), there were dramatic increases in computing power, and huge growth in commercial computer applications, thus driving up the volume and decreasing the prices. The private sector capitalized on the rapid pace of advancements in IT capabilities, leveraging the improved performance and reduced cost, to significantly improve productivity. Faced with reduced budgets, and the requirement to upgrade their sonar system, the Navy began to examine the possibility of using commercial technology to upgrade their sonar systems. The "term of art" for commercially-available technology is "Commercial-Off-The-Shelf" (COTS), i.e. software or hardware that is commercially available for sale, lease, or license to the public, and requires little or no unique government modifications to meet the needs of the procuring agency.[6]

The use of commercial technology was not a new concept, as there were examples of its use as far back as the 1970s. In 1994, then Secretary of Defense, William J. Perry, advocated the replacement of MIL-SPECS and MIL-STDS with performance and

[5] Moore made the observation that over the history of computing hardware, the number of transistors on integrated circuits doubles approximately every two years.
[6] Gansler, Jacques and William Lucyshyn. 2008. Commercial-Off-the-Shelf (COTS) Doing It Right September 2008, pg. IV

commercial specifications[7], and was instrumental in setting the policy emphasizing the use of commercial technologies.[8] The consideration and use of commercial technology was enacted into law in 1994, as part of the Federal Acquisition Streamlining Act (FASA). FASA not only clarified the definition of commercial items, but also mandated the use of COTS in the procurement of government items (wherever applicable).

When compared to the costly and often inefficient (small quantity) alternative of developing unique systems based on military specifications, using COTS products offered many advantages. These included the opportunities to reduce development time, insert new technology faster, and reduce lifecycle costs. When coupled with the adoption of an open systems architecture, the use of COTS allowed for greater flexibility in hardware and software use. An open systems architecture uses non-proprietary software and hardware, and, as a result, is "open" to using various components from a variety of vendors, without having to develop specific interfaces for proprietary software/hardware. Simply put, devices and programs run together as one system; however, they can be upgraded independently–a true "plug-and-play" capability. As a result, the upgrades do not compromise the overall functionality or performance of the system.

In an effort to evaluate the potential of using COTS and open architecture, the Navy issued two "Small Business Innovative Research (SBIR)" requests for proposals. This research examined the concept of porting existing sonar system software into commercial hardware, and the use of open systems architecture capable of handling real-time processing needs of sonar systems. The results of the research led to the development of the Multi-Purpose Processor (MPP), which demonstrated the ability to run sonar system software on commercial processing hardware, within an open systems architecture. It also demonstrated that the increased processing power that resulted from the use of

[7] Based on comparative cost, performance, and reliability data received by the "Packard Commission" (President's Blue Ribbon Commission on Defense Management, June 1986)
[8] Perry, William. Memorandum from Secretary of Defense to Secretaries of the Military Departments, et al., Specifications & Standards – A New Way of Doing Business. June 29, 1994

COTS technology was a viable option in improving the signal processing capabilities of the sonar system.[9]

A New Upgrade Process is Developed

With the results of the SBIR research in hand, the NAVY first tried to implement the COTS technology upgrade through their existing sonar upgrade programs, which proved to be unsuccessful. However, in 1995, fresh off the heels of these unsuccessful upgrade programs, the Naval Sea Systems Command (NAVSEA) decided that a restructuring was needed to all of their existing sonar upgrade programs. They wanted to take advantage of the COTS-based Multi-Purpose Processor potential, but at the same time, work within their budgetary constraints. NAVSEA pooled all of the funding available for the independent upgrade programs into an all-encompassing process that utilized COTS technology with the already developed MPP. Under this approach, a broader upgrade process was feasible which resulted in a new sonar system upgrade process. This new process was named "Acoustic Rapid COTS Insertion" and was implemented in November of 1997.[10]

[9]Guertin, N.H., R.W. Miller. A-RCI–The Right Way to Submarine Superiority. Naval Engineers Journal March 1998, pg. 25
[10] Ibid

III. ARCI Process

Overview

The objective of the ARCI process is to enable a faster, more efficient process to upgrade submarine sonar systems, using COTS technology and open system architecture. The ARCI process consists of "Technology Insertions"(hardware upgrades) every two years, and "Advanced Processing Builds" (APB) (software upgrades that contain new or enhanced capabilities) that occur on an annual basis. Within this process, not all submarines are upgraded upon release of each new tech insertion. Individual submarines are only upgraded every four to six years, using this two-year tech insertion cycle. For example, a tech insertion released in 2012, would be retrofitted into submarines that had their last tech insertions in 2008. This schedule allows for the submarines with the oldest systems to be upgraded with the latest technology. In addition to the hardware upgrades, the annual cycle of the software upgrades can occur two to three times between two technology insertions.

The ARCI process is comprised of a four-phased approach, with each phase providing improved signal processing capability to a specific part of the sonar system. This approach was adopted as a way of overcoming the limited funding in the procurement budget, while also shortening the time from technology development to fleet use, which, in the past, typically took several years.[11]

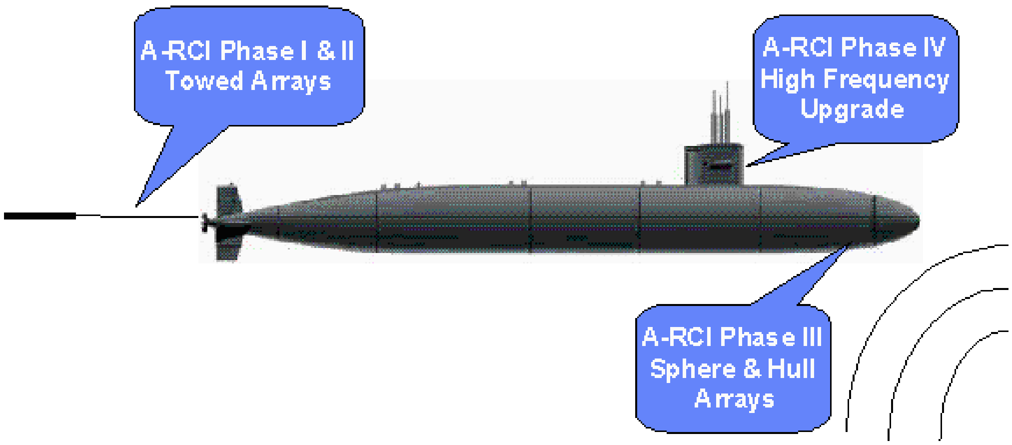

Figure 1: Note, the sonar hardware is not replaced, just the computer components that are used to process the sonar signals.

Figure 1above depicts the Virginia Class Sonar System, and the system components that are getting hardware/software upgrades in each phase. With this phased approach, more submarines were able to benefit sooner from the use of COTS technology. Furthermore, with this phased approach, feedback from the fleet was received sooner, and was used to guide future developments.

Implementation

The first implementation of the ARCI process involved a combination of custom and COTS circuit cards, to provide the necessary processing power. To minimize software development, COTS operating systems and hardware drivers were used to their maximum extent. However, the custom cards proved difficult to program and were also prone to failure. Additionally, the COTS signal processing cards were very specialized; they required specific operating systems, with very limited driver support. The non-standard implementation of the COTS products within the sonar systems, made it very hard to get vendor support, or to leverage lessons learned from applications in the

[11]Ibid

commercial sector. Moreover, since the ARCI program was a "small player" in this segment of the COTS market, getting proper support was hit-or-miss, depending on the severity of the problem. As a result, obtaining the required vendor software/hardware support during integration and testing proved to be a significant challenge.[12] The lesson learned from this first implementation was to use hardware and software components that were more commonly used. This proved to be significant in reducing the number of failures, as well as in getting better support from the vendors. This switch represented the start of the technology insertion process.[13]

The first two technology insertions eliminated the use of the custom cards, and provided improved display performance. This change reduced system cost, improved system reliability, and also facilitated software programming. The software could now be written in a higher-level language, i.e. the use of assembly language code was no longer needed. This freed up time, allowing programmers to develop better code, and debug problems, instead of worrying about the hardware interfaces.

With each new technology insertion, the signal processing capabilities increased due to the advancements in the commercial technology. The process expanded from what was simply a single sonar sensor and processor, to a complex "system of systems" that includes all sensors, ship's navigation, combat/fire control, and ship monitoring functions.

A key enabler for the periodic technology insertions is the use of Multipurpose Transportable Middleware (MTM). The MTM is a set of software utilities that separates the software applications from the hardware and network protocols and allows for high-speed data transfers between applications. With this separation, hardware is upgraded without impacting the software code that is running within the sonar system. Leveraging the functionality of the MTM, technology insertions took less time, and were less

[12]Kerr, Gibson. 2004. A Revolutionary Use of COTS in a Submarine Sonar System. The Journal of Defense Software Engineering. November 2004.
[13]Ibid

expensive. The technology insertion is the basis upon which APB's (Advanced Processing Builds) are delivered. Their compatibility with the technology insertions allow for a smoother system wide upgrade and testing. This allows for reduced cost in current ARCI development, production, and support.[14]

Use of COTS and Open Architecture

The Navy's decision to move forward with COTS technology and open systems architecture proved to be an efficient means of upgrading the sonar systems, while also getting away from the use of proprietary software. This transition proved to be very beneficial for the following reasons:

- The time and cost to develop system upgrades was significantly reduced. Rapid system updates via technology insertions and advanced processing builds allowed for the sonar system to keep pace with the rapid pace of technical evolution.
- The sonar systems were able to be upgraded at all levels, independently, without interfering with existing protocols, equipment, or procedures.
- Vendor "lock-in" was eliminated, at all system levels.

[14] Ibid

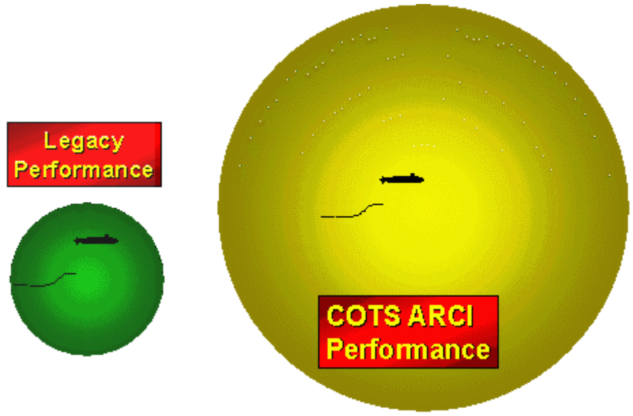

Figure 2. Illustrates the performance improvement with the ARCI process

As illustrated graphically in figure 2 above, the implementation of COTS products improved signal processing for legacy sonar systems while maintaining commonality among the parallel development efforts for the newer sonar systems. The legacy sonar systems were able to operate at a greater range, and with faster processing capabilities due to the COTS technology.[15]

[15]Scott, Richard. 2006. Open for Business: A New Model for Submarine Warfare. Jane's Navy International. Mar 1, 2006

IV. Contracts with the US Navy

The ARCI process also brought about another shift in the Navy's product sustainment approach for these sonar systems. The legacy support strategy depended on the Naval Supply Systems Command (NAVSUP) stockpiling spare parts bought from the vendors, and/or repairing failed components returned from the fleets. Additionally, NAVSUP was responsible for developing the technical documentation and providing the necessary training. NAVSUP was also responsible for obsolesce management of the system components. NAVSUP made sure that the parts were available from the vendor, and, if not, NAVSUP would have its engineers redesign the components using alternative available parts. In some cases, NAVSUP would buy enough spares to ensure availability for the life of the system. With this type of support strategy, costs became a huge burden, and, at times, the Navy stockpiled parts that were never used.

In an effort to improve the product sustainment strategy, the Navy looked to the private sector. They partnered with Lockheed Martin Maritime Systems and Sensors (MS2), forming a public-private partnership. NAVSEA contracted with Lockheed Martin to provide (as required) engineering services and production (these were in two separate cost-plus contracts). Additionally, NAVSUP contracted with Lockheed Martin to manage the supply side of the ARCI process (fill requisitions for replacement parts and for part repairs), with a firm-fixed price contract.

NAVSEA

The two contracts with NAVSEA function differently, yet are a complement to the NAVSUP contracts, in terms of providing efficient product sustainment. One contract is the production contract; the main task is for Lockheed Martin to develop, and construct the racks that house the servers aboard the submarine. These are then shipped out to the fleet where they are installed, and the servers are mounted.

The other contract is for engineering services; this contract provides a variety of development and training efforts for fleet personnel. Under the engineering support contract, Lockheed Martin MS2 is responsible for creating the Interactive Electronic

Tech Manual (IETM) for the sonar system. The system's IETM provide documentation for the fleet to use in the case of repairs, as well as understanding the technical design. IETMs also allow sailors to interact with a 3-D representation of the equipment. Fleet personnel can drill down from the highest levels of the sonar system to the lowest level, where they can get part numbers and vendor information, when repairing or replacing an item. The MS2 facility prides itself on the development of these training manuals, citing it as an excellent training tool for the fleet personnel.[16]The training provided includes:

- Dockside refresher training provided when swapping out a submarine's crew.
- Dockside difference training, provided to train sailors on the differences between the systems they were trained on at the learning center, and the ones that are currently installed on their specific submarine.
- A variety of classroom training, provided to educate sailors on the latest technology insertions and software upgrades. All of these training classes take place at the MS2 facility -- on an "as required" basis

NAVSUP

The contract with NAVSUP requires Lockheed Martin to fulfill requisitions and perform part repairs via a mini-stock point located at the MS2 facility. In addition to these tasks, Lockheed Martin also provides support on the "rip-outs" of the older equipment, which are sent back to the facility, and the installation of the new equipment. The contract between NAVSUP and Lockheed is a firm-fixed price contract. However, in the way it is being implemented by NAVSUP, it performs very much like a cost-reimbursement contract.

[16]Rodriguez, Alex. Personal Interview. Lockheed Martin Maritime Systems and Sensors. Manassas, Va. 27, July, 2012

The Federal Acquisition Regulation (FAR)[17] defines cost reimbursement types of contracts, as those that:

> "*…provide for payment of allowable incurred costs, to the extent prescribed in the contract. These contracts establish an estimate of total cost for the purpose of obligating funds and establishing a ceiling that the contractor may not exceed (except at its own risk) without the approval of the contracting officer*."

With this contract type, the contractor is reimbursed for all allowable cost, up to the contract ceiling.

On the other hand, the FAR defines a Firm Fixed-Price (FFP) contract as those that[18]:

> "*…provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss….The contracting officer may use a firm-fixed-price contract in conjunction with an award-fee incentive and performance or delivery incentives when the award fee or incentive is based solely on factors other than cost."*

Clearly, with a FFP contract the maximum risk and full responsibility for all cost and profits is placed upon the contractor.

The following is a brief summary of the process NAVSUP uses to contract for this support. First, NAVSUP solicits, and MS2 proposes a firm fixed-price contract, for a 6-month period of performance. In their proposal, the proposed price is based on Lockheed's historical forecasts of demand and unit cost; they make sure that it is a price that is reasonable and comfortable for all parties. This contract is not definitized, while Lockheed performs the work of requisition fills and part repairs. Near the end of the 6-month period, based on the actual costs for parts and repairs incurred, the contract is definitized. The fee is then calculated, nominally, 11-12% of their actual cost. Furthermore, Lockheed shares all their cost data with NAVSUP, so that NAVSUP can verify all forecasted and actual costs.[19]

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[17] 2007. Federal Acquisition Regulation (FAR), Subpart 16.301-1
[18] 2007. Federal Acquisition Regulation (FAR), Subpart 16.202-1
[19] Rodriguez, Alex. Personal Interview. Lockheed Martin Maritime Systems and Sensors. Manassas, Va. 27, July, 2012

Based on how it is being implemented, this firm fixed-price behaves very much like a cost-reimbursement contract. Moreover, this practice, with its abbreviated six-month period of performance, creates an unnecessarily high transaction cost, for both the Navy and Lockheed–they are virtually in an endless cycle of proposal, evaluations, and negotiations. So perhaps some longer-term reimbursement contract should be considered.

Cost Savings Initiatives

Lockheed Martin has also introduced cost saving initiatives. One example was the process of reusing system parts removed, during the tech insertion cycle, from the newer boats, to fulfill requisitions for older systems, still deployed. In an effort to maintain efficient product sustainment, during tech insertions, the older parts are ripped out and put back in the lab for testing. Once they are tested (and repaired, if required), they are put back on the shelf; if a requisition from an older boat comes in regarding the same part, then the refurbished part is sent out for reuse. . This process reduces NAVSUP's cost, since the contract primarily pays for the testing of parts. This process of reuse is a concept that Lockheed Martin came up with in order to provide better sustainment for the boats with older systems, and to reduce costs.

Another cost saving effort was the approach of borrowing replacement parts off the production line. When a part fails and Lockheed gets the requisition, but has no spare available, Lockheed personnel borrow one off the production floors and exchange it for the failed part. When the failed part is received, it is repaired and put back on the production floor, as a replacement to one that was sent out. This is another example of Lockheed working to produce a more efficient product sustainment process.

Although Lockheed has separate contracts with NAVSEA and NAVSUP, the contracts complement each other and result in an improved product sustainment process. Certain cases exist where this complement is demonstrated. In the case of technology insertions, new parts are used by NAVSEA while the old parts, received from NAVSEA, are used by NAVSUP to fulfill requisitions from older boats with older systems. This helps

NAVSUP’s contracting efforts in that fewer parts are included in their forecasting, and costs are reduced due to the limited amount of new parts needed.

In another case, design changes, initiated by NAVSEA, feed into the NAVSUP contract because of the specific part(s) that are needed for the new design. This provides for a better understanding of what to include in their forecast during contract negotiations. Furthermore, money is saved from buying excessive amounts of parts that could potentially go unused or become obsolete, as was the case with the past method of stockpiling parts.

All of these cost saving initiatives improve the task of managing 40 different configurations in over 65 submarines.

V. Findings

Benefits of ARCI Process

The ARCI program has resulted in significant benefits to the Navy. The Navy was able to upgrade submarine sonar systems, within the existing budgetary constraints, and they were able to achieve commonality among the sonar systems in all submarines. Not only did they save time and money under this program, but they also leveraged the latest technical advances for their sonar systems. The Navy reduced its development costs from $1.5 billion dollars, based on the legacy MIL-SPEC system, down to $100 million dollars--a reduction of 93% using COTS technology. Furthermore, the shipset cost was also reduced by 89%, from $90 million to $10 million. The ARCI sonar program was now able to purchase system equipment from several vendors, ensuring that a continuous price competition exists.[20]

Another analysis of the cost saving benefits to the Navy, conducted by the Naval Postgraduate School[21], released the following breakdown:

> *"In addition to improving sonar system performance, ARCI generated large cost savings by reducing budget allocations across SCN, OPN, O&MN, RDT&E, and MilCon by over 50% ($7.6 billion to $3.6 billion) when the 1983-1993 budget allocations are compared to the 1996-2006 allocations. These savings reflect a reduction in Development and Production by a factor of six and a reduction in Operating and Support costs by a factor of eight. ARCI also realized over $25 million in cost avoidance for logistics support, including:*
>
> - *Over $1 million in technical manuals,*
> - *Over $2 million in direct vendor delivery,*
> - *Over $19 million in interactive, multimedia instruction, and*
> - *$3 million in outfitting spares reduction."*

Not only did the ARCI process result in cost saving benefits to the Navy, but the performance of the sonar systems also increased significantly. Specifically, the signal

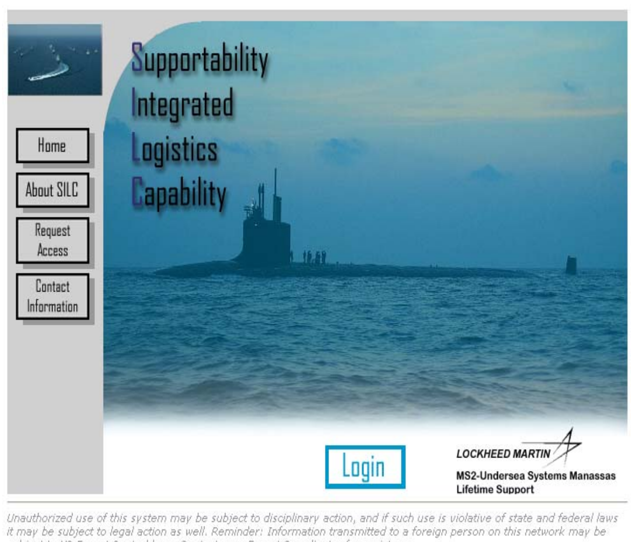
[20]Kerr, Gibson. 2004. A Revolutionary Use of COTS in a Submarine Sonar System. The Journal of Defense Software Engineering. November 2004

[21] Ford, N. David and John T. Dillard. 2009. Modeling Open Architecture and Evolutionary Acquisition: Implementation Lessons from the ARCI program for the Rapid Capability Insertion Process. 6th Annual Acquisition Research Symposium of the Naval Postgraduate School: Volume II: Defense Acquisition in Transition. 22, April, 2009: 217

processing capabilities of the sonar systems increased by a factor of 50X, over the past 15 years, while using the ARCI process. Moreover, the upgrade frequency increased greatly. Before the implementation of ARCI, the upgrade process took from 5-8 years; now, with ARCI that number has been reduced to a maximum of two years for hardware; with annual software upgrades. The end result was that the Navy was able to regain its acoustic superiority.

Lessons Learned

In the 15 years, the ARCI process has evolved, capturing lessons learned and implementing them in a truly evolutionary process. Lockheed's driving force for lessons learned is fleet feedback. Because of the fleet feedback they have received over the years, several new processes have been introduced to reflect the fleet's needs. One example is the in-house sustainment portal, called Supportability Integrated Logistics Capability (SILC^{TM}).



The portal is easily customizable, at a low cost; the developers have the ability to respond anytime when it comes to customizing the portal for a specific fleet need, or to add some unique function that could further improve the sustainment process. One example deals with providing capabilities using data capture fields. The Lockheed staff was requested by users in Palm Beach to have the capability to monitor reliability growth and Failure Reporting, Analysis and Corrective Action (FRACAS). This request was completed on the SILC portal in a week, with data capture fields present for the fleet to do their work.

The SILC portal is also used to capture IETM comments, do configuration management, and parts management. It is connected to a data repository, which is used to push out IETM updates, and also provides data mining capabilities. Using this tool allows users to follow the entire replenishment process in real time. The data that stakeholders can see includes: platform system details, including configuration; system health reports, maintenance trend analysis (e.g. failure rates for parts); supply support demand; total asset visibility (TAV); requisition process (real time data); pending requests for requisitions; real-time report lookup; and maintenance and training material.[22]

Another product, developed as a result of the lessons learned, is the capability for secure chat, within the Customer Support Center. The secure chat serves as a way for someone to contact a technical expert, or get routed to an expert, in order to get help in troubleshooting a problem. The secure chat has reduced the time it takes for shipboard troubleshooting from days to hours. It enables distance support, and reduces operational maintenance. The secure chat provides the sailors the reach back capability; there is always someone available to provide them the support they need.

Finally, Lockheed Martin developed the fleet support lab, as a result of the lessons learned process. Lockheed employees were asking for better times to do system level testing on repaired parts, instead of the 3am-6am time-frame available in the development lab. The Lockheed employees asked for improved access, and, as a result, the fleet support lab was developed by Lockheed Martin. The end-result was improved support, based on greater availability to the required equipment.

[22]Gansler, Jacques and William Lucyshyn. 2006. Evaluation of Performance Based Logistics, Naval Postgraduate School Acquisition Case Series. August 2006

Best Practices

Several best practices have contributed to the success of the ARCI process. These practices have provided transparency across the entire process, resulting in a relationship based on trust and honesty—ultimately strengthening the public-private partnership. These best practices illustrate the type of public-private partnership that should be developed in other product sustainment programs.

- **Integrated Teams**

One of the most significant is the practice of using integrated teams. These consisted of Lockheed Martin engineers, designers, subcontractors, management, and Navy personnel. In practice, the entire team is involved in the design, development, testing, the rack&stack of the systems, and the packing&shipping when the product is complete. A shared mindset, of doing what's best for the fleet, is prevalent among all team members. Getting help from the production floor to filling requisitions or making sure that the rip-outs do not damage a part, so it can be reused for future requisitions of legacy systems, are examples of a unified team working toward one goal. Lockheed's efforts in engaging the fleet has created a trust factor among the fleet knowing that it will get support whenever it's needed; and in an efficient manner.

- **Acoustic Maintenance Training Representatives (AMTR)**

These training representatives are deployed to provide onsite fleet training support for maintenance on the submarine. The AMTRs meet with the fleet sailors and train them to maintain the system that is currently installed. The goal is to improve the sailor's ability to maintain the shipboard systems. Of course, if there is an issue with the system that fleet operators cannot fix, the AMTR is available to fix existing problems that are beyond the scope of the training. Lockheed currently has AMTRs deployed to five different locations. The goal is to increase that number to have seven AMTRs deployed.

- **The ARCI process**

The ARCI process is implemented by several different submarine program offices and helps drive commonality among the submarine programs. This commonality makes it easier for hardware selection and software development. With the ARCI process, you are not bound by the "rice-bowl" mentality; focusing on your own section, and making sure it is good, while disregarding the overall effect of the common goal. Furthermore, the Logistics Management System allows for better tracking and traceability of the system and more defined data because the information is concerning one type of system. Simply put, the ARCI process provides a common operational picture.

- **Training**

Training for the fleet is provided at the MS2 facility. They train the fleet on the latest technology that will be shipped to the boats. The Navy personnel come out and do test runs on their specific systems, to make sure it is fully operational. Maintenance demonstrations, where Navy personnel participate in a troubleshooting scenario, are also conducted. The objective is to test the IETM's to ensure they are written well enough to help the user troubleshoot the given scenario. The demonstrations also make sure that the quality of training that is given to the fleet personal is adequate enough for proper product sustainment purposes. In a recent example, a successful test was conducted by the sonar-imaging program. During the test, a troubleshooting scenario was provided to see if the fleet personal were able to use the IETM they were given; along with applying the training they had received. The fact that the employees of the MS2 facility have labs for testing, creating the necessary manuals, doing development, and providing engineering support only adds to the success of the sustainability process for the submarines.

- **Co-development**

Lockheed personnel work alongside the engineers and Navy onsite team when developing products. An example they gave us was the development process of their IETM. The IETM is developed in stages with everyone’s input. There is a light version, go to sea version, and final version--these are developed and released in an iterative fashion. This iterative working structure coupled with a co-development strategy provides for a well-developed IETM in support of better product sustainment.

VI. Conclusion

Current Barriers and Issues

The ARCI process has proven itself as an efficient product sustainment strategy; however, existing barriers and issues, which the process needs to overcome, slow further improvement.

- **Lack of in-depth Failure Data**

The Naval Undersea Warfare Center (NUWC) currently controls the database storing failure data. This data can be utilized for better forecasting and maintenance of older systems. NUWC uses this data for repair of the older systems on the older boats, thus limiting Lockheed Martin's ability to compete for this work.

- **Current Contract Structure**

The current contract structure is as an issue because of the continuous cycle of proposal writing and contract negotiations, every six months. This cycle creates unnecessarily high transaction costs. Additionally, the contract is not definitized until after the end of the six-month period; often requiring Lockheed to perform the work under an undefinitized contract.

- **Budget Constraints**

The budget on Lockheed's engineering services contract has been reduced from $11to$6 million, while the amount of work has not changed. Though this represents the idea of doing more for less, it is becoming more difficult to provide proper support, long-term. A recent example of that happened when Lockheed had to pull an entire IETM update, based on the funding that they were being provided. Instead of four full updates, they gave the customer the option of three updates, since the funding provided was not enough to cover the fourth. This feeds into documenting APB updates, because one boat will have the software upgrade, but will not have the latest manual capturing this upgrade.

- **Obsolescence Management**

MS2 is lacking an effective process in tracking and managing obsolescence of the parts their systems use. Currently, Lockheed assumes a more reactive approach to obsolescence management, as opposed to a proactive approach. An example of an effective process used to manage obsolescence, which Lockheed has favored,[23] resides in Moorestown, NJ. In Moorestown, there are people solely dedicated to diminishing manufacturing services (DMS) monitoring. They are proactive in their approach of monitoring the status of the system parts and contacting the manufacture to get the latest information regarding the life of the part. Once this was done, they would upload the information into a database that housed all of the data, providing a complete history of their system by parts. Every 2 months, a color-coded health report would be generated, detailing the status of each part, and providing the engineers a clearer picture of where to concentrate their efforts.

- **Part Numbering**

Currently, a part that is used in multiple programs may have various numbers assigned to it. As a result, this causes confusion for the fleet technicians when it comes to ordering the right part for replacement. Finding ways of streamlining the process of part numbering is an issue that needs to be addressed. This can prove to be beneficial for the fleet and Lockheed Martin.

[23]Rodriguez, Alex. Personal Interview. Lockheed Martin Maritime Systems and Sensors. Manassas, Va. 27, July, 2012.

Recommendations

The ARCI process is an example of a successful product sustainment strategy for the US Navy. The success of the process derives from leveraging the benefits of a public-private partnership. Through the practices of co-development, team integration, and training, the ARCI process has been successful in strengthening the public-private partnership between Lockheed Martin and the Navy; enabling a stronger foundation of honesty and trust. This type of relationship should be championed across all of the DoD's product sustainment programs.

The Navy achieved its goal of efficiently upgrading the submarine's sonar system through the ARCI process, and thus regained acoustic superiority. Through the ARCI process, the Navy successfully transitioned from the use of MIL-SPECS and proprietary technology to embracing the cost-effective use of COTS technology. Due to this transition, they have experienced significant cost saving benefits in the areas of training, development, and system upgrades; as well as significant performance improvements

The ARCI process can serve as a template for future product sustainment strategies. With the possibility of future budget cuts in 2013, the need for a cost-effective product sustainment strategy is paramount. Program managers continually face the situation of improving performance with declining budgets, and should look to the ARCI process as a possible solution. As demonstrated by the US Navy, the ARCI process is an example of how to effectively mitigate the backlash of reduced funding; while achieving the goal of maximum weapon systems availability and performance at the lowest total ownership cost.

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