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Lean Six Sigma Implementation for Military Logistics to Improve Readiness

by

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Lean Six Sigma Implementation for Military Logistics to Improve Readiness

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Abstract

In general, during the lifecycle of a weapon system, a significantly larger amount of money gets spent on operating and maintaining the system than on acquiring it. Hence, efficient logistics systems, including transportation, inventory management, modifications and maintenance activities, are critically important for containing the lifecycle costs of weapon systems and for maintaining the highest level of military readiness given the extant fiscal constraints. This paper describes Lean Six Sigma (LSS), a strategically important and proven logistics initiative for both reduced lifecycle costs and improved readiness.

With aging weapon systems, the US Department of Defense is facing ever-increasing military expenses to maintain military readiness. Hence, the Department of Defense is keenly interested in implementing Lean Six Sigma in all the services. We begin this paper by providing an overview of military logistics and discussing the critical concepts of readiness and cycle-time. Thereafter, we present an overview of Lean Six Sigma methodologies—including Lean production and Six Sigma, and describe the experience in implementing Lean Six Sigma in the Army, Navy and Air force. The paper ends with a discussion of the managerial guidelines for successfully implementing Lean Six Sigma.

Keywords: Lean Six Sigma, Lean Production, Six Sigma, Military Logistics, Readiness, Lifecycle Costs

Introduction

Three essential factors to maintaining strong military power and readiness are well-trained troops/ well-educated officers, reliable high-tech weapon systems, and well-designed logistics systems to support troops and improve the readiness of the weapon systems. In purchasing weapon systems, program managers widely use acquisition costs as the primary, and at times the only, criteria for decision-making. However, in general, during the lifecycle of a weapon system, a significantly larger amount of money gets spent on operating and maintaining the system than on acquiring it. Hence, efficient logistics systems—including transportation, inventory management, modifications and maintenance activities—are critically important for containing the lifecycle costs (LCC) of weapon systems and for maintaining the highest level of military readiness given the extant fiscal constraints. This paper will describe Lean Six Sigma (LSS), a strategically important and proven logistics initiative for both reduced lifecycle costs and improved readiness.

Two major components of LCC are *Acquisition* costs and *Operations and Maintenance* (O&M) costs. Acquisition costs include such items as research, development, test and evaluation, program management, engineering design, initial spare parts, manufacturing and production, facilities and construction, and initial training. O&M costs, on the other hand, include such cost categories as labor, materials, and overhead, operations, scheduled and unscheduled maintenance, training, replacement and renewal, transportation, system/equipment modification, technical data collection, documentation and database management, energy and facility usage, and disposal costs. Without question, the logistics systems have a great deal of influence on the size of O&M costs.

It is difficult to generalize the percentage of money spent on operations and maintenance of a typical weapon system. Some literature points out that the O&M costs contribute to 60% of the total lifecycle cost on average (DAU, 2006), while other sources estimate these costs to be as high as 80% of the total (Cost Analysis Improvement Group, 1992). In any event, with the Service Extension Program (SEP) that many weapon systems are experiencing these days, the percentage of the total lifecycle cost spent on O&M is simply becoming larger. Most weapon systems were originally designed for a lifecycle of 20+ years, but some have been stretched to last as long as 50 years. In the case of B-52 aircraft, for example, the lifecycle is expected to extend to 80 years, in which case the O&M costs expect to form as much as 90% of its lifecycle cost (Parker, 1999).

With aging weapon systems, the US Department of Defense (DoD) is facing ever-increasing O&M costs. The DoD is, therefore, keenly interested in applying Lean Six Sigma methodologies to cut down O&M costs. Experiences of the private sector in implementing Lean Six Sigma illustrate that the methodology is as effective in improving business processes as it is in improving the manufacturing processes. Thus, successful implementation of LSS methodologies would also reduce acquisition costs by improving acquisition and contracting processes. Hence, in this paper we will discuss Lean Six Sigma and its application in the military. This paper is organized as follows: in Section 2, we provide an overview of military logistics and discuss the critical concepts of readiness and cycle-time. In Section 3, we describe background material for LSS methodologies. Section 4 includes examples of LSS implementation in the US Army, the US Navy and the US Air Force. In Section 5, we conclude the paper by presenting managerial guidelines and by discussing the challenges present in implementing LSS in the military.

Military Logistics

Military Logistics support deals with *everything* required to provide warfighters with the *right stuff* at the *right time* at the *right place* at the *right cost.* The goal of military logistics support is to maintain the highest possible level of readiness, commonly expressed as operational availability: $Ao = \frac{MTBM}{MTMB + MDT} = \frac{uptime}{uptime + downtime}$, where MTBM is the mean time between maintenance, and MDT is the maintenance down time—which includes repair time and administrative and logistics delay times. Intuitively, operational availability is the fraction of time a weapon system is operational or mission capable. Clearly, operational availability can be improved by increasing MTBM (i.e., increasing reliability) and/or decreasing MDT (i.e., reducing repair or cycle-time). Thus, the two key issues to improve weapon systems readiness are reliability improvement and cycle-time reduction.

From Little's Law (Little, 1961), reducing repair or cycle-time reduces pipeline inventory directly, and leads to significant savings in inventory costs. The relationship between repair or cycle-time and inventory levels is critically important (yet, troublesome) in the military because it crosses physical, organizational, and financial barriers. Inventory managers strive to consolidate and minimize stocks of piece-parts to free-up resources for other priorities. They also seek to get quick turnaround on repairable components in order to minimize pipeline inventory. However, stockout of spare parts or consumable components results in delays in repair processes and, eventually, serious readiness degradation. Cycle-time reduction in a military logistics channel (repair depots, intermediate-level maintenance, inventory control points, and supply centers) also means that more weapon systems are available in the field or fleet. On the other hand, increased cycle-time causes a vicious cycle of deteriorating military readiness. For instance, poor logistics support (e.g., lack of spare parts, personnel, and/or training) increases the cycle-time, which in turn decreases readiness, *Ao*. Therefore, the warfighters are forced to satisfy mission requirements with a fewer number of mission-capable weapon systems, resulting in stress on those fewer mission-capable systems. Due to this stress, more system failures occur, which in turn generate more workload at repair facilities. Thus, the repair turnaround time can become even longer. And the vicious cycle can go on.

The following simple example explains the importance of cycle-time reduction in military logistics. Suppose that the US Navy has 800 F/A-18 Hornet aircraft, each of which costs $50 million, and that the Standard Depot Level Maintenance (SDLM) is done every 4 years. If the MDT is one year, the readiness, *Ao,* will be 4/(4+1) = 0.8. Thus, only 80% of 800, or 640, aircraft will be mission-capable on average since an aircraft would be available for mission for four years (and at the depot for one year) out of every five years. This also means 160 aircraft will be non-mission capable at any given time. If the MDT can be reduced to 6 months, *Ao* will be 0.889; or, only 89 instead of 160 aircraft will be at the depot for maintenance at any given time. It is equivalent of having 71 additional aircraft (worth more than $3.5 billion) in the fleet. On the other hand, if having 640 mission-capable aircraft available is adequate, it would mean reducing the fleet size by 80 aircraft and freeing up $4 billion expenditure for other purposes. See Kang, Gue and Eaton (1998) for a cycle-time reduction case study at a Navy depot.

The Department of Defense and its services have many on-going initiatives to cut down maintenance cycle-time to improve military readiness. The Navy has been working on the *Sea Based Logistic*s to cut down distribution time by supporting "customers" on shore directly from the sea by eliminating "Iron Mountains" (middlemen) in the supply-chain management context. Likewise, since 1995, the US Army has implemented *Velocity Management* (Dumond et al., 2001) which focuses on improving the speed and accuracy with which materials and information flow from factories to fox holes. The US Air Force has implemented *Agile Logistics,* and the US Marine Corps, *Precision Logistics* for cycle-time reduction.

More recently, all branches of the US military, Army, Navy and the Air Force, are actively applying *Lean Six Sigma* methodology to their various activities to reduce cycle-time and to reduce maintenance expenses. We will describe the details of current initiatives of Lean Six Sigma in the military services in Section 4.

Levels of Maintenance

We can use the US Navy's aviation maintenance system to understand how military maintenance logistics are typically conducted. The Naval Aviation Maintenance Program divides maintenance into three levels: organizational level (O-level), intermediate level (I-level), and depot level (D-level), which are similar in structure to multi-echelon logistics support systems of commercial firms (e.g., Blanchard, 2004) or other services. To achieve economies of scale in maintenance equipment and personnel, levels of maintenance are made progressively more capable, with D-level being the most capable. However, the longer turnaround time at D-level also increases the work-in-process and requires more spare parts to maintain the desired readiness level.

O-level maintenance is performed at the site and typically involves simple repairs or the replacement of modular components. I-level maintenance involves more difficult repairs and maintenance, including the repair and testing of modules that have failed at the O-level. I-level maintenance for Navy aircraft is done at Aircraft Intermediate Maintenance Departments (AIMDs) ashore in naval air stations or afloat in aircraft carriers. D-level maintenance activities, called Naval Aviation Depots (NADEPs), ensure the continued flight integrity and safety of airframes and related flight systems throughout their service lives. This involves performing maintenance beyond the capabilities of the lower levels, usually on equipment requiring major overhaul or rebuilding of end-items, subassemblies, and parts. The Navy operates three NADEPs in the US (North Island, CA; Cherry Point, NC; and Jacksonville, FL) and fleet repair facility sites in Italy and Japan.

The repair cycle begins when an unserviceable repairable is turned for maintenance, and it ends when the item is recorded on the inventory control point records as being ready-for-issue (RFI). Repair cycle-time includes shipping and processing time, accumulation time, repair time, time awaiting parts, and delivery time. Unserviceable items may remain in storage for extended times for various reasons.

Readiness and Inventory Management

Aviation readiness is measured by computing fully mission-capable (FMC) rates. The FMC rate indicates the operational availability of the aircraft in a unit—that is, the fraction of aircraft that are mission capable at any arbitrary time. When aircraft are partially mission capable or not mission capable, it is because of either maintenance or supply problems.

Aviation items, especially repairables, are very expensive to maintain. For example, each aircraft carrier carries onboard an Aviation Consolidated Allowance List (AVCAL) consisting of consumable and repairable items and subassemblies required to support the Air Wing for 90 days of wartime operations. A typical AVCAL consists of tens of millions of line items valued at hundreds of millions of dollars. Repairable items represent only 10% of the total line items, but 90% of the total value of the AVCAL (USS Independence Shipboard Uniform Automatic Data Processing System Report 008, 1991, July 26).

Material readiness demands spare parts, but fiscal constraints have put pressure on the Navy to reduce inventory levels at AIMDs and stock points. The two-part solution is easier said than done: select a “better” mix of spares and reduce repair cycle-time. Both tend to improve readiness for a given cost or achieve the same readiness for lower cost.

The relationship between spares/inventory levels and cycle-time is a key to understanding how to achieve higher readiness at lower cost. Kang (1993) shows the diminishing marginal utility of spare parts, implying that additional spare parts beyond a certain threshold level will not improve readiness. Those additional spare parts, once they are turned in after failure, will simply increase the work-in-process or inventory at repair facilities. Spares levels and repair cycle-time must be considered together when attempting to improve material readiness (see Kang & Gue, 1997).

During the past 30 years, the military has been implementing spares methodologies based on the readiness-based METRIC models such as those described in Sherbrooke (1992). Rather than the traditional approach to inventory problems that minimize holding and ordering costs for individual items subject to a service level, readiness-based models seek to maximize *Ao* for multiple items directly and simultaneously, subject to a budget constraint. It is possible to measure *Ao* for a specific component, such as an aircraft engine, as opposed to measuring *Ao* for the aircraft itself. An improvement in *Ao* for the engine will provide some marginal improvement in Ao for the aircraft. But this improvement will not be one-to-one: large improvements in engine availability may yield only trivial improvements in aircraft availability, depending not only on the failure rate of the engines, but on the performance and availability of all the other critical components of the aircraft. The readiness-based models are important to military systems because they treat all of the critical components in a weapon system together in order to achieve the singular objective of maximizing the *Ao* of the weapon system. Implementation of these models requires detailed, accurate information about the reliability of components, but the rewards have been worth the effort in many systems. For example, Sherbrooke (1992) reports inventory investment being cut nearly in half, with no degradation in readiness, during a test for the Air Force. Hale (1994) also shows significant inventory savings in the Navy after implementing readiness-based models.

Lean Six Sigma

Penchant for process improvement is inherent in human nature; even our distant ancestors discovered a better way to start fire, make arrowheads and spears, or build shelters (Dershin, 2004). Early improvements probably came about through trial and error and took hundreds (if not thousands) of years to become part of the human skill set. Almost up to the modern times, such improvements were the carefully guarded secrets of the select few. However, the fast pace of modern commercial/industrial economy has given rise to the structured problem-solving methodologies for process improvement that are well understood by and available to all.

Two major approaches for structured problem solving emerged separately in the 20th century and have come to be known as “Lean” and “Six Sigma” methodologies. Lean improvements focus on process speed and waste removal, while Six Sigma, like its predecessor Total Quality Management (TQM), focuses on the removal of process defects and the reduction of process variability. Ironically, Six Sigma and Lean have often been regarded as rival initiatives. Lean enthusiasts note that Six Sigma pays little attention to anything related to speed and flow, while Six Sigma supporters point out that Lean fails to address key concepts like customer needs and process variation. To some extent, these are valid arguments. Yet, they have been more often used by the practitioners to promote the choice of one versus the other approach. However, today’s need for an even higher level of competitiveness than that achieved through implementing either methodology has now convinced practitioners that these two approaches are synergistic, and there is benefit to be realized by blending the two. Therefore, in the new millennium, we are witnessing the emergence of Lean Six Sigma (George, 2002; Nash, Poling & Ward, 2006).

Lean and Six Sigma are two different bodies of knowledge. The Six Sigma is all about locating and eliminating root causes of process problems. The Six Sigma tools, such as the “the five whys,” are designed to find the root cause/s of the problems and build models of cause and effect. The process is then redesigned with the root cause/s eliminated.

Lean is different. As popularized by Womack and Jones (2003), the Lean roadmap is one of successive refinements to improve the overall process through the following steps (Apte & Goh, 2004):

- Specify value in the eyes of the customer
- Identify the value stream and eliminate waste
- Make value flow at the pull of the customer

- Involve and empower employees
- Continuously improve in the pursuit of perfection.

Since Lean Six Sigma is a synergistic blending of Lean Production and Six Sigma methodologies, we will present a brief overview of these two methodologies.

Lean Production

Lean can be defined as a set of principles and tools that helps us eliminate process activities that don't add value, and create "flow" in a process (Dennis, 2002). A Lean process is defined as one that uses only the absolute minimum of resources to add value to the service or product. Lean manufacturing can also be viewed as a management philosophy focusing on reduction of the eight types of wastes (Human Talent, Over-production, Waiting time, Transportation, Processing, Inventory, Motion and Scrap) in manufacturing or service processes ("Lean Manufacturing," 2006). By eliminating waste (muda), quality is improved, production time is reduced, and cost is reduced. Lean "tools" include continuous process improvement (kaizen), "pull" production process (by means of kanban) and mistake-proofing (poka-yoke). Lean, as a management philosophy, is also very focused on creating a better workplace through the Toyota principle of "respect for humanity."

Origins of Lean Production can be traced to the Scientific Management principles of Frederic Taylor (1911) and to the practical genius of Henry Ford (Levinson, 2002). But the principles of Lean Production were more fully embodied in its recent incarnations: Just in Time Systems and Toyota Production System (Ohno, 1988). The term Lean Production was coined by Womack, Jones and Roos (1991) in their best seller, *The Machine that Changed the World*. The book chronicles the transitions of automobile manufacturing from craft production to mass production to lean production. "Theory of Constraints (TOC)" popularized by Goldratt and Cox (1992) in their novel *The Goal* is also typically used in implementing Lean production. Simply put, TOC involves identification and use of the bottleneck (i.e., the constraint) of the system to set the operational pace of the system's components and to achieve a synchronous flow so as to maximize the throughput (i.e., the money-making potential) of the system.

At the heart of Lean is the determination of value. Value is defined as form, feature or function for which a customer is willing to pay. The processes that do not add value are deemed waste. The Lean framework is used as a tool to focus resources and energies on producing the value-added features while identifying and eliminating non-value added activities. Processes in Lean are thought of as value streams. Lead-time reduction and the flow of the value streams are the major areas of focus in Lean. *Value-stream mapping* helps teams understand the flow of material and information in creating and delivering the product or services being offered to the customer by the organization.

In summary, in its current implementation, the Lean methodology:

- Provides tools for analyzing process flow and delay times at each activity in a process,
- Emphasizes *Value-stream Mapping,* which centers on the separation of "value-added" from "non-value-added" work with tools to eliminate the root causes of non-valued activities and their cost,
- Uses Theory of Constraints as its integral element to identify bottlenecks and achieve a synchronous flow in the system,

- Recognizes and attempts to eliminate 8 types of waste/non-value-added work: defects, inventory, over-production, waiting time, motion, transportation, processing, and human talent, and
- Creates workplace organization through *Five S* methodology consisting of sort, straighten, sustain, sweep, and standardize.

Six Sigma

Six Sigma is a management technique that aims to develop and deliver near-perfect products and services. The primary goal of Six Sigma is to improve customer satisfaction (and, thereby, profitability) by reducing and eliminating defects. In this case, the defects may be related to any aspect of customer satisfaction: product quality, delivery performance, and product cost. Six Sigma is targeted at reducing variation in a business processes. It can also be a great way to permeate the culture of continuous improvement in an organization.

The term "Six Sigma" refers to a statistical construct that measures how far a given process deviates from perfection. A level of Six Sigma (about 3.4 defects per every million items) represents the highest level of quality: virtually all products and business processes are defect-free. It should be noted that most companies today function at only a three or four sigma level and lose 10-15% of their total revenue due to defects. Thus, a typical company stands to benefit significantly from implementing Six Sigma.

Six Sigma originated in 1986 with the efforts of Bill Smith, a senior engineer and scientist at Motorola (McCarty, 2004). It was originally used to improve manufacturing processes at Motorola. While Six Sigma has its roots in the total quality management (TQM) approach of the 1980s, today it is much more than that. It is now being used across a wide range of industries, including banking, insurance, telecommunications, construction, healthcare, and software. Interestingly, the methodology gained industry-wide acceptance in the mid-90s when Jack Welch, CEO of GE, successfully launched it within the entire company (General Electric, 2006) and began vouching for the billion-dollar benefits realized by GE through the use of Six Sigma methodology. For instance, in 1999 alone, GE reported that it saved $2 billion using Six Sigma principles.

In Six Sigma applications in service-sector industries, the program implies going beyond the highest quality level targeted in the manufacturing process. For example, an average of 3.4 errors in every one million financial transactions would not be acceptable to a financial institution. Six Sigma now has much broader meaning. Simply put, Six Sigma:

- Emphasizes the need to recognize opportunities and eliminate defects as defined by customers,
- Recognizes that process variation hinders our ability to reliably deliver high-quality services,
- Requires data-driven decisions and incorporates a comprehensive set of quality tools under a powerful framework for effective problem solving, and
- Provides a highly prescriptive cultural infrastructure effective in obtaining sustainable results.

In any improvement project, utilization of a well-defined improvement procedure is critically important. The most commonly used standard improvement procedure in Six Sigma is DMAIC (Define, Measure, Analyze, Improve and Control). DMAIC is a structured, disciplined, rigorous approach to process improvement consisting of the five phases, in which each phase is linked logically to the previous phase as well as to the next phase. A detailed description of these phases can be found in Stamatis (2004) and Rath and Strong (2006).

In terms of the tools and techniques used for process improvement, there is only a marginal difference between Six Sigma and the Total Quality Management approaches. But what sets Six Sigma apart from TQM, which is perhaps the most important reason behind the success of Six Sigma, is the establishment of organizational infrastructure for ensuring continuous process improvement. Thus, Six Sigma should be ideally viewed as a management system that integrates strategic objective and measurement systems development, and provides the guidance for project prioritization and governance. It is a performance-management system to drive a more focused execution of the overall business strategy. The essential premise of the Six Sigma Management System is that there is a leadership team in place whose members are willing and capable of engaging in a disciplined, team-based process of continuously monitoring real-time organizational performance metrics and then taking action in the form of project reviews. The team engages in frequent dialogue regarding performance related to customer and market requirements as well as performance related to critical improvement projects. As a result of these efforts, an organization-wide dialogue is created that drives top-to-bottom focus on daily execution and a culture of continuous improvement.

Six Sigma identifies five key organizational roles for its successful implementation ("Six Sigma," 2006):

- *Executive Leadership* includes CEO and other key top management team members. They are responsible for establishing a vision for Six Sigma implementation.
- *Champions* are responsible for the Six Sigma implementation across the organization in an integrated manner.
- *Master Black Belts*, identified by Champions, act as in-house, full-time, expert coaches for the organization on Six Sigma initiatives.
- *Black Belts* operate under Master Black Belts to apply Six Sigma methodology to specific projects. They devote 100% of their time to Six Sigma. They primarily focus on Six Sigma project execution, whereas Champions and Master Black Belts focus on identifying projects/functions for Six Sigma.
- *Green Belts* are the employees who take up Six Sigma implementation along with their other job responsibilities. They operate under the guidance of Black Belts and support them in achieving the overall results.

Please note that there exists a large variation in the way the above roles are defined and utilized within the Six Sigma implementations in different enterprises and that specific training programs are available to train people to fulfill these roles.

Lean Six Sigma

As noted earlier, the process improvement methods of Lean and Six Sigma have been practiced separately for many years. However, in recent years, practitioners have come to realize that the two methodologies are, in fact, dependent on each other for greater success. For example, it is impossible to run a process with minimum waste or at a dependable capacity if individual process steps are highly variable. On the other hand, one can carefully study the complex processes, looking for root causes using elegant statistical techniques, and never make improvements in cycle-time or productivity that can be obtained from value-stream analysis.

To the extent Lean and Six Sigma approaches have their own strengths and weaknesses, the specific action plan to be followed in effectively implementing Lean Six Sigma (for example, Lean first followed by Six Sigma later or vice versa) is dependent on the nature of the situation at hand. For example, the problems related to accuracy and/or completeness are usually addressed best by the tools of Six Sigma; consequently, those tools should be introduced first. However, if the customer needs quick results, and if the problem is related to timeliness or productivity, Lean should be implemented first with an understanding that deep and complex problems will be solved only by the subsequent use of the Six Sigma tools.

In summary, Lean and Six Sigma are rich bodies of knowledge and are mature methodologies for solving a broad variety of process-related problems. Each methodology has its own approach to process improvement and its own tool set. Although Lean and Six Sigma methodologies can be mastered independently, they can and should be implemented together to realize the full benefits of process improvements by any organization.

Examples of Lean Six Sigma Implementations in the Military

The combination of Lean Thinking and Six Sigma has proven to be a very effective tool in the private sector. The success realized by top companies such as Toyota and GE has inspired the use of Lean Six Sigma in the US Department of Defense (DoD). Although the DoD has implemented a number of process-improvements methodologies with varying degrees of success in the past decade, it has begun to explore the potential of implementing Lean Six Sigma throughout the entire DoD only recently. The early results are very promising. As the lean Six Sigma mindset continues to grow among the DoD community and both the Lean and Six Sigma practices become more commonplace, the equipment and personnel available to the DoD will provide considerably more capability per taxpayer dollar than ever before. We discuss below some examples of Lean Six Sigma implementations in the US Army, Navy and the Air Force.

Army Implementations

Faced with the expectations of a shrinking defense budget, the Secretary of the Army Francis Harvey signed an order in March of 2005 that would implement Lean Six Sigma across the entire service. Currently, several organizations within the Army are implementing Lean Six Sigma and are enjoying remarkable results.

The Red River Army Depot Repair Facility is one such organization (Donnelly, 2006). In implementing Lean Six Sigma, the Red River Depot has made many changes to its HMMWV repair line, such as: forming an assembly-line process, using time-managed intervals to control the flow of work, organizing employees based on experience and proficiency, cleaning up and improving the overall work environment, stocking more and better quality parts to reduce stock-outs, and training employees to ensure there is no break in continuity on the assembly line. Improvement efforts have resulted in the ability to turn out 32 mission-ready HMMWV's a day, compared with three a week in 2004. The Lean process has also lowered the cost of repair for one vehicle from $89,000 to $48,000. Some of the biggest improvement ideas have come from the front-line employees themselves.

Other Army facilities boast similar progress as the result of Lean Six Sigma methodologies. Pine Bluff Arsenal in Arkansas reduced its repair cycle-time by about 90% and increased its production rate by about 50% on M-40 protective gas masks. Letterkenny Army

Depot in Pennsylvania has saved $11.9 million in the cost of building the Patriot air-defense missile system. In the Corpus Christi Army Depot, the overhaul time for one T700 helicopter engine was reduced by 64%. These depots improved the consistency of their repair operations by increasing the mean time between the engine overhauls from 309 hours to over 900 hours and improved the return to field accuracy to above 90% (Moorman, 2005).

Despite these early successes, the long-term, future and the resulting benefits of Lean Six Sigma are far from certain. Ultimately, the key ingredient for the successful implementation of Lean Six Sigma is not simply an order from the top, but the ability of commanders to change the organization's culture and convince the soldiers and employees that Lean Six Sigma does work and that it is worth the effort. The Red River Depot has taken a small, yet interesting, step to change the culture of the organization by posting a black cutout figure of a soldier with a helmet and rifle with a sign affixed to it that reads, "We build it as if our life depends on it. Theirs do!" This is to serve as a reminder that their job is about more than a paycheck, and the better they can do their job, the more lives they can save.

Navy Implementations

The *AIRSpeed* program is perhaps the best known implementation of Lean Six Sigma in the US Navy. As stated by the Secretary of the Navy Donald Winter in a memorandum in May 2006, "Lean Six Sigma (LSS) is a proven business process that several elements of the Navy and Marine Corps have initiated including training over 500 Black Belts and 1500 Green Belts who have facilitated 2800 events and projects. These activities have averaged a 4:1 return on investment." The following examples demonstrate some success stories in the implementation of *AIRSpeed*.

a. In October 2005, Naval Air Warfare Center (NAWC) accounting practices yielded an annual savings of $176.9K, with an additional anticipated saving of $146.3K in waste elimination.
b. Since April 2004, Aviation Intermediate Maintenance Division (AIMD) Whidbey Island reduced J-52 aircraft engine repair time from 468 hours to 233 hours and reported significant inventory and operating cost savings. Since February 2006, AIMD Patuxent River has seen increased savings due to a 10% inventory reduction and a reallocation of 166 hours of full-time employees.
c. In June 2006, Naval Aviation Systems Command's (NAVAIR) PMA offices began replicating successes of other PMA offices, including one office that saw an estimated $163K/year savings due to reducing processing time from the 240-days average to a predicted average of 15 days.

The successes are due, in large part, to the training received by the employees that emphasizes the use of DMAIC (Define, Measure, Analysis, Improve and Control) methodology for process improvement. *AIRSpeed* attempts to create an enterprise-wide, continuous process-improvement environment through the incorporation of commercial business practices. The goal of *AIRSpeed* is to operationalize cost-wise readiness across the Naval Aviation Enterprise.

There are five anticipated long-term benefits of *AIRSpeed*:

1. Reduce total cost of Naval Aviation by reducing inventory, manpower and operating expenses.
2. Support the Fleet Response Plan by providing aircraft Ready for Tasking (RFT).

3. Integrate the Maintenance and Supply Support System to provide seamless support to the Fleet.
4. Improve logistics and maintenance response by reducing cycle-time and the logistics footprint.
5. Place ownership and accountability at the appropriate levels.

Air Force Implementations

Over the next several years, the Air Force (AF) is expected lose approximately 40,000 personnel. This loss of manpower means airmen must work smarter and leaner. Senior AF leadership has decided to utilize the Lean Six Sigma strategy to accomplish this. Accordingly, the USAF has created a new program office, Air Force Smart Operations 21 (AFSO21), at the Pentagon with Brig. Gen. S. Taco Gilbert as the Director of the AFSO21 Office (Lopez, 2006).

The AF already has several examples of AFSO21 at work. AF Materiel Command has applied AFSO21 and returned 100 aircraft to duty, as well as reduced C-5 maintenance time by 50%. USAF Europe (USAFE) applied AFSO21 practices—they reduced the number of telephone operators by approximately 16% and saved the command $2.4 million (Lopez, 2006). The AF has also begun implementation of Lean Six Sigma concepts to their contracting activities. The goal is to reduce the cycle-time required to award a contract in support of new operational requirements. The Global Hawk team followed the Lean Thinking concepts to break down the contracting process into a value stream. They identified steps that do not add value and eliminated them. By eliminating those unnecessary steps, the process times in three steps of the contracting process were cut by 37%, 40% and 73%!

Managerial Implications

The experiences in implementing Lean Six Sigma in the military have uncovered several valuable lessons and managerial guidelines. They are briefly presented below.

Active support of senior leaders is a necessity.

- Articulate clearly the need for change.
- Commit to the change—make it last through leadership turnover.
- Change and accountability should be driven from the top.
- Actions speak louder than words—participate in the effort.

Initial successes are critically important.

- Carefully choose initial projects.
- Assign high-potential employees to those projects.
- Provide financial and personnel resources to ensure success.
- Initial successes turn the skeptics into believers.

Emphasize continuing education and training.

- Deploy 1% of workforce as full-time Black Belt plus Green Belts, Champions, etc.

- Black Belts should be selected from “future leaders of the organization.”
- Create Master Black Belts to take over training at all levels.
- Senior organization leaders must be trained and engaged in project selection.
- Include Productivity Improvement Training in Leadership Development Programs.

Monitor the Lean Six Sigma projects.

- Assign concrete goals to project leaders and hold them accountable for project results.
- Provide stable funding to ensure long-term success.
- Demand validated return on investment; Keep score in public.
- Promote a philosophy that it is OK to save a dollar and give it up—it’s not your money.
- Middle management is likely to provide the most resistance—actively manage their participation (increase the ratio between those that get it and those that don’t).

The LSS methodology was developed in the private sector. To the extent the competitive environment, the organizational culture, and the nature of operational challenges are different in private-sector firms than in the Department of Defense, it is essential that the LSS methodology be suitably modified in its implementation in the military. We discuss below a set of issues that must be addressed in implementing LSS in the military.

Experience indicates that the success of Lean Six Sigma depends on employee empowerment and participative management. Since the military is traditionally organized and managed as a strict hierarchy, implementing LSS is a challenging task. Also, frequent rotation and movement of officers in their assignments is a common practice in the military. This creates a possibility that the procedures and culture created by one officer in implementing LSS can be disrupted when s/he is replaced by another officer.

In the military, the employees may enthusiastically embrace LSS implementation initially, but it is difficult to maintain that enthusiasm towards LSS in the long-run without proper incentive systems. Private-sector organizations can give financial incentives to employees to reward their contributions to process-improvement efforts. However, it is almost impossible to give such monetary incentives in the military due to the governmental rules and regulations. Hence, an alternate non-monetary incentive system, for example, for career enhancement or for better promotion opportunities, must be investigated.

Another area to be carefully studied regarding implementing LSS in the military is to understand the fundamental nature of military operations. Lean Six Sigma methodologies were originally designed for manufacturing assembly systems in which the demands are known or predetermined. As we move closer to a *foxhole* from a *factory*, the overall magnitude of uncertainty in demand, supply, and environment increases significantly. Military planners must fully keep in mind that the demand and supply are uncertain in many military applications; hence, LSS must be selectively implemented in different parts of the military in different ways. For example, supply officers may be *encouraged, but not required,* to apply Lean and just-in-time concepts to reduce inventory in military operational environments; such should not be required due to the inherent nature of uncertain demand and the potentially heavy penalty of stockouts that would cause readiness degradation and potential losses of human lives.

Finally, we wish to point out that while the issues identified above are important and must be carefully analyzed by military planners, approaches for dealing with them can be developed. Moreover, the benefits of reduced lifecycle costs and improved readiness that can be realized from implementing Lean Six Sigma are simply too great. Hence, we believe that implementing Lean Six Sigma in the military is a strategically important logistics initiative and recommend that it be undertaken under full steam.

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