AN EVALUATION OF MATURE PERFORMANCE-BASED LOGISTICS PROGRAMS

By

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Abstract

For over fifteen years, performance-based logistics (PBL) contracting has been used to reduce weapon system sustainment costs and increase system reliability. In its simplest formulation, PBL "explicitly identifies what is required, but the contractor determines how to fulfill the requirement." Often, the most significant improvements occur relatively early on in the PBL program. Typically, PBL programs evolve along a common trajectory. With new systems, cost-reimbursement contracts are used in order to provide the government customer and the provider with a cost baseline. Once the costs, risk factors, and system failure modes and rates have stabilized, the program generally transitions to the use of fixed-price contracts where providers are paid a fixed cost or fixed rate (e.g. per hour, per mile) so long as operational readiness is achieved at the specified level(s). Over time, the provider makes improvements to its supply chain, logistics networks, operations, and the system itself in order to reduce its costs and maximize profitability. In the "terminal stage" of its evolution, the exemplary PBL is characterized by high availability, reduced inventories, and efficient sustainment processes. This research examines three PBLs that reached this stage, including one program that reverted to the use of cost-plus contracts in an attempt to reduce costs. We found that long-running PBLs continue to deliver value, high reliability, and improved performance, and that distortions to the PBL paradigm (*i.e.,* reverting to more transactional approaches) are unwarranted and may lead to unintended consequences that include higher future costs and decreased system readiness.

I. Introduction

Described by the Department of Defense (DoD) in 2001 as the "preferred approach to product support," performance-based logistics (PBL) represents a radical change in contracting for maintenance, sustainment, and other after-sales support services. In its simplest formulation, PBL "explicitly identifies what is required, but the contractor determines how to fulfill the requirement" (Macfarlan & Mansir, 2004, p. 40). DoD guidelines state that "The essence of performance-based logistics is buying performance outcomes, not the individual parts and repair actions…Instead of buying set levels of spares, repairs, tools, and data, the new focus is on buying a predetermined level of availability to meet the [customer's] objectives" (Defense Acquisition University, 2005).

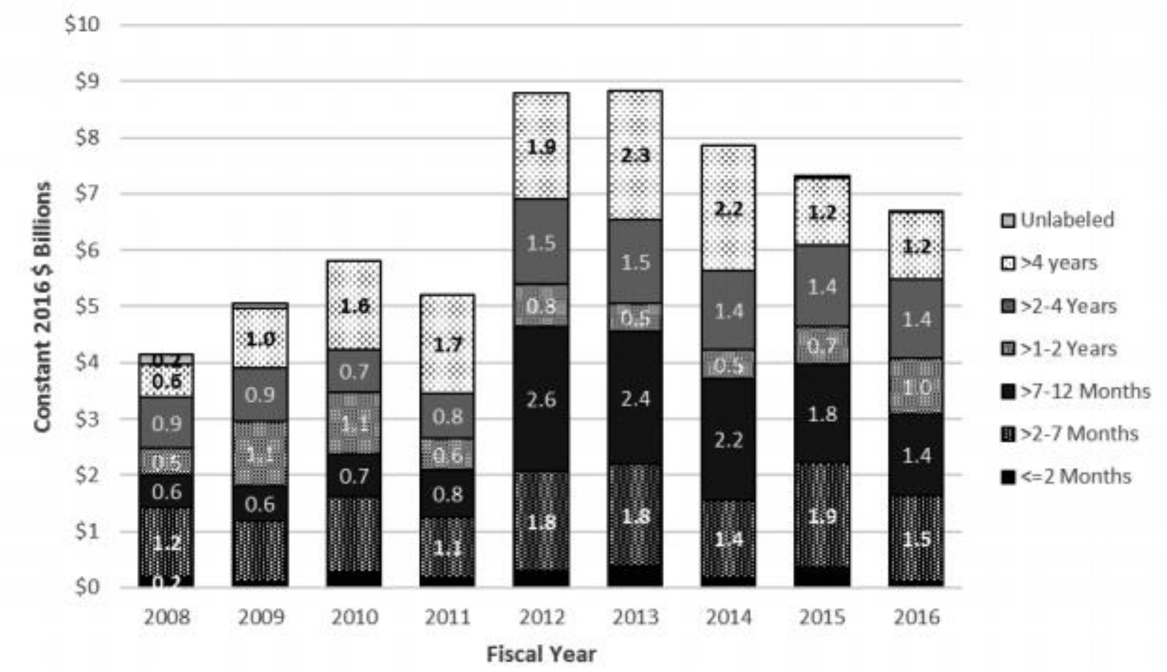

Figure 1. DoD PBL contract obligations by initial maximum duration, 2000-2016 (CSIS analysis of FPDS data).

There is now clear empirical evidence that PBL strategies, when properly implemented, can dramatically reduce system sustainment costs while improving overall reliability and performance (Guajardo *et al.*, 2011; Boyce & Banghart, 2012; Lucyshyn, Rigilano, & Safai, 2016). It is noteworthy, then, that PBL contracting is not being aggressively pursued across the DoD. The overall number of PBL programs has waned considerably since its peak in 2005, when there were over 200 programs in place compared to fewer than half this number by 2012

(Erwin, 2013). In dollar terms, PBL contract obligations have gradually declined in recent years after peaking in 2013 (Hunter, Ellman, & Howe, 2018; See Figure 1).

In the early 2000s, criticism of PBL focused on contractor reliability (Gansler, Lucyshyn, & Vorhis, 2011). Critics argued that the military places itself in a dangerous position of relying too heavily on contractors who may become unreliable in the future. Some were concerned over whether contractors would be able to perform at the same high level during contingency and combat operations, especially if deployed in theater. Military planners feared that the "lack of control due to outsourcing could…put an entire military operation at risk" if, for example, contractors were to pull out of a war zone (Singer, 2008). To date, research indicates that these concerns are largely unfounded (Lucyshyn, Rigilano, & Safai, 2016). Time and again, PBL-supported systems operating in stressful environments have met or exceeded performance requirements, contributing to mission success.

Critics, including some within government, have moved to questioning the value that is obtained through PBL, as programs mature and the benefits, in terms of both cost reduction and performance improvement, become less significant. Could it be that once the "low hanging fruit" has been picked and incremental improvements become more difficult to achieve; that reverting to traditional, transactional contracting approaches makes more sense? Selviaridis and Wynstra (2015) note that it is unclear whether "performance-based incentives in long-term contractual relationships are sustainable over time as supplier learning occurs and service improvements become marginal" (p. 3520). This report addresses this concern. Ultimately, it seeks to determine if and how product support contracts should be modified over time in order to provide continuous value to the customer.

PBL is still in its infancy. And given the fundamental change in functions and responsibilities—*e.g.*, the customer no longer manages (or in many cases even owns) inventory—it is not surprising that the optimal PBL contracting approach, specifically its development over the product deployment lifecycle (as uncertainty in support costs change), has yet to be fully examined, let alone articulated.

Report Approach

The objective of this report is to determine whether a “steady-state” PBL—one that generates continuous value to the customer—can be achieved, and if so, how to structure the optimal arrangement. This study relies primarily on structured interviews with program personnel in both the public and private sectors; the application of the academic literature (on contracting, management science, agency theory, and transaction cost economics) to PBL; and in-depth case studies of three mature PBLs.

II. Background

Over the last two decades, the DoD has focused on reducing the cost of weapon system logistics by constructing more sophisticated contracts with more favorable terms for the government (Butler, 2013). In addition, the military services are increasingly diverting their attention to sustainment costs—which are continuing to increase across the DoD—in part because the services cannot afford to replace rapidly ageing systems. The DoD has identified PBL as its preferred approach to supporting weapon system logistics.

PBL Basics

PBL contracting, when used appropriately can reduce sustainment costs relative to traditional, transactional approaches. PBL is a logistics support solution that transfers inventory management, technical support, and the supply chain function to a provider who guarantees a level of performance at the same, or reduced, cost. Instead of buying spares, repairs, tools, and data in individual transactions, the customer purchases a predetermined level of availability in order to meet the warfighter's objectives.

The optimal PBL contract is a multi-year agreement wherein the user purchases sustainment in an integrated way, to include elements of the system's supply chain. Long-term agreements allow the provider to incur up-front investment costs in the beginning stages of a PBL contract that are later offset by future cost avoidance. Whereas traditional sustainment contracts incentivize the provider to sell parts, PBL's "pay for performance" approach aligns the objectives of the service provider, with those of the customer; and motivates the provider to reduce failures and resource consumption.

As outlined in the Defense Acquisition Guidebook, a PBL's performance is measured through one or more of the following criteria.

> **Operational Availability:** Percent of time that the system is able to sustain operations tempos or is available for missions
>
> **Operational Reliability:** Measure of a system in meeting objectives set for mission success

Cost per Unit Usage: Total operating costs divided by the individual unit of measurement for a specific weapons system (flight hour, miles driven, etc.)

Logistics Footprint: Government or contractor presence required to sustain/deploy the system

Logistics Response Time: Time from logistics demand sent to completion of demands (labor, support, etc.)

A successful PBL contract relies on performance metrics that are straightforward, measurable, and achievable. Additionally, these metrics must be carefully developed and implemented, monitored, and evaluated. Continuous communication between the program office and the support provider is crucial to ensure that these metrics are negotiated and executed in a manner that will ensure successful implementation of the PBL contract (Gansler & Lucyshyn, 2014).

PBL Advantages

When implemented, PBL shifts the focus of the government's efforts from transactions to identifying performance outcomes and assigning responsibilities. The objective is to develop accountability, instead of relying on control. With PBL, active management of the sustainment process (e.g. forecasting demand, maintaining inventory, and scheduling repairs) becomes the responsibility of the support provider. Traditional logistics support dictates processes and design specifications, which has the effect of constraining innovation and process improvement. Suppliers and equipment manufacturers are incentivized to sell more repair parts as opposed to developing and implementing reliability improvements. PBL changes the incentives for the supplier. The supplier is now incentivized to improve the reliability of systems and reduce inventories of spare parts, in order to increase profit.

The DoD is gradually moving away from its traditional hierarchical command and control structure and towards a more adaptive system that will provide the precise, agile support required for the distributed, network-centric operations. In this regard, there are four distinct advantages associated with the use of PBL contracting:

- <u>Delineates outcome performance goal.</u> The objective of PBL programs is to buy measurable outcomes based on warfighter performance requirements. They should, at the top level, be based on war-fighter performance requirements; and include only a few simple, realistic, consistent, and easily quantifiable metrics

- Ensures responsibilities are assigned. PBL metrics, when properly developed, clearly define the suppliers' responsibilities.
- Reduces cost of ownership. This reduction results from the decline in inventories, improved supply chain efficiency, replacement of low-reliability components, and increased system availability.
- Provides incentives for attaining performance goal. The PBL program should fundamentally align the interest of the supplier with that of the customer, and lead suppliers to assume greater responsibility for providing ongoing improvements to their products. PBL provides incentives for the supplier to improve design and processes and implement commercial best practices (Lucyshyn, Rigilano, & Safai, 2016).

There is ample empirical data that demonstrates that PBL, when properly implemented, produces desired outcomes in the key performance areas of availability, reliability, logistics footprint, and cost. Major systems including the C-17 and F/A-18, for instance, have all reduced sustainment costs by hundreds of millions of dollars, while other systems and subsystems such as the F-22, UH-60 avionics, and F-404 engine have seen drastic improvement in availability and cycle time (i.e. logistics response and repair turnaround; (Fowler, 2008). Empirical analysis has demonstrated that PBL contracts incentivize reliability improvements of 25% to 40%, compared to more traditional transactional approaches (Guajardo *et.al*, 2012). Other government reports (*e.g.*, Office of the Secretary of Defense, 2009), and think-tank studies have concluded that PBL offers distinct benefits that are difficult to achieve using traditional transactional approaches.

PBL Contract Trajectory

Ensuring a PBL contract is structured properly and contains the correct incentives is crucial to its long-term success. The Center for Executive Education from the University of Tennessee (2012) identified three factors inherent to a successful PBL contract:

- **Alignment:** Both the contractor and government have embraced PBL as a new form of provider-client relationship and not merely a variant of business as usual.

- **Contract Structure:** The appropriate balance of risk and asset management is achieved, an environment is established that allows for creativity and shared success, and a pricing model is utilized that considers incentive types.
- **Performance Management:** Desired outcomes and metrics for reporting and improving are established (Hunter, Ellman, & Howe, 2018).

Typically, PBL programs evolve along a common trajectory. With new systems, cost-plus reimbursement contracts followed by cost-plus incentive contracts are used to enable the government customer and the service provider to collect sufficient data to develop a cost baseline. Once the costs, risk factors, and system failure modes and rates have stabilized, the program should transition to the use of fixed-price contracts where providers are paid a fixed cost or fixed rate (e.g. per hour, per mile) so long as operational readiness is achieved at the specified level(s). Over time, the provider makes improvements to its supply chain, logistics networks, operations, and the system itself in order to reduce costs and increase profitability. A typical PBL contract pricing structure includes three components:

- Share-in-savings, to incentivize the provider to reduce overall sustainment costs
- A fee, to reward provider for meeting performance expectations
- A fixed-price or fixed-price per operating hour contract schedule, to provide payment to provider regardless of quantity of parts or services consumed (Gansler & Lucyshyn, 2017).

In the “terminal stage” of its evolution, the exemplary PBL achieves consistently high availability, and efficient maintenance processes and supply chains. The program operates at lower risk, from both a cost and technical perspective. When this stage is reached, obtaining further performance improvements and price reductions will require increasing levels of innovation, since, presumably, the “low hanging fruit” has been picked.

Since 2000, 68% of DoD PBL contract obligations have been awarded as firm-fixed-price contracts, with cost-plus-incentive and cost plus award-fee being the next common contract types (Hunter, Ellman, & Howe, 2018). As Figure 2 indicates, PBLs can be implemented at the component, subsystem, and system level.

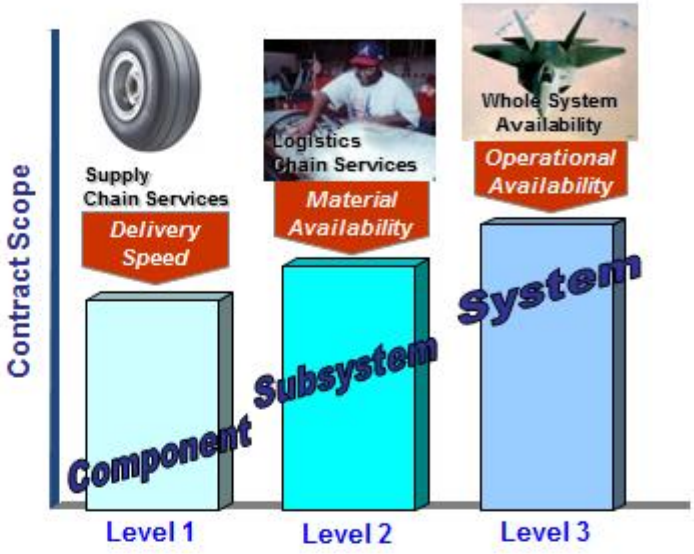

Figure 2. Level of implementation and contract scope (Gourley, 2014)

Risk, Profit, and Contract Type

Note that as the PBL matures, the contractor takes on more risk, which is reflected in the type of contract that is used (See Figure 3). As risk increases, so does the contractor's opportunity to increase profit.

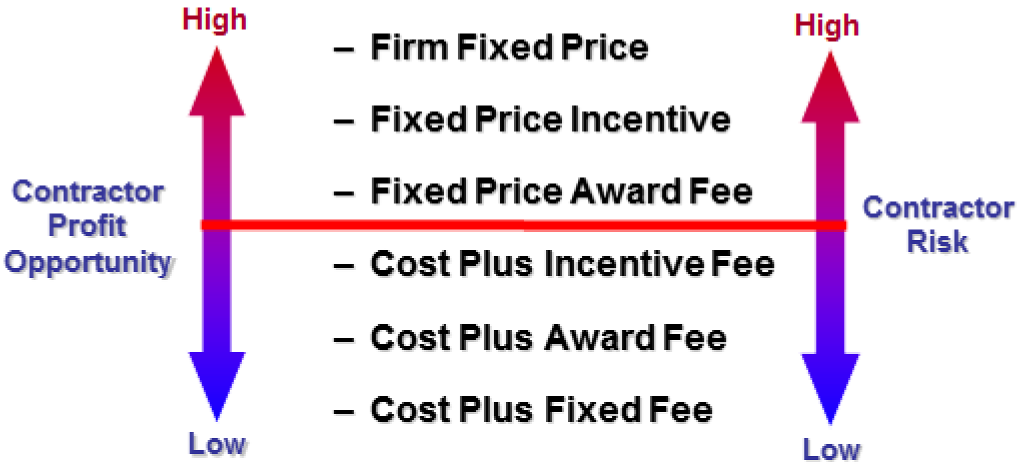

Figure 3. Relationship between contract type, risk, and profit opportunity (Gourley, 2014)

Some within government have become concerned by "excessive" profits generated by PBLs, even in instances where overall program costs have been reduced. This concern can manifest itself in disagreements between contracting officers (COs) and program managers (PMs) over the type of contract that should be used, the former asserting that cost-plus contacts should be used to constrain windfall profits.

It should be noted that the contracting officer binds the government to a contract, the legal document that specifies program requirements. In many instances, however, the CO generally does not report administratively to the PM who, of course, is responsible for overall program performance and success, including contract execution. From the CO's perspective, success is often construed narrowly. Was the contract awarded? Were protests avoided? Have costs been minimized? (National Academies of Sciences, Engineering, and Medicine, 2016). In fact, COs, at times, dictate contract type and terms to the PM, which can lead to negative program outcomes (e.g., contracts may not take advantage of some of the flexibility available in the FAR, or be of the most appropriate length[1]). Needless to say, affordably providing the required capability to the warfighter should be emphasized over minimizing profits. As stated by the DAU (2018), "the Services' primary concern is to pay less for more when compared to their current sustainment strategy, irrespective of industry profits" (p.30).

This is not to suggest that cost-plus contracts should be avoided altogether. As discussed, for new programs, a cost-plus contract may be essential to determining a cost baseline that can be used to develop future fixed-price contracts. In addition, when risk cannot be quantified or the cost of transferring the risk to the supplier "is more than the government can accept," cost-plus contracts are preferable (DAU, 2018). Cost-plus contacts may also be preferable, as the component or system approaches disposal and emphasis turns to containing the costs associated with wear-out and obsolescence. As a system approaches retirement, cost-plus contracts may allow the government to better balance costs, risk, and performance requirements. There is also some theoretical evidence indicating that cost-plus contracts may be well suited to certain types of product support programs, namely simpler ones for which the scope of work is limited. Kim, Cohen, and Netessine (2007) model how the customer observability[2] of two variables—the contractor's cost reduction efforts and spare parts inventory—affect optimal contract choice. They show that when the supplier and the customer are risk neutral, "which may be the case in

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[1] PBL contracts need to be long enough to enable the contractor to recover any investment made in product and process improvements. These contracts are, consequently, competed less frequently, which conflicts with guidance to compete frequently.

[2] Kim, Cohen, and Netessine define an "observable" variable as one "that is verifiable and hence can be specified in a contract" (p. 1849).

practice if the customer and the suppliers are well-diversified corporations" the combination of a "fixed payment and a performance component" (*i.e.*, a typical PBL contract) is optimal, provided that the contractor's cost reduction efforts and inventory levels are unobservable (p. 1857).

Reliability and Ownership

The reliability of a system appears to be correlated with the ownership of spare parts. That is, when the supplier owns a larger portion of spare parts, reliability is higher. Kim, Cohen, and Netessine (2011) found that "the full benefit of a PBC [performance-based contracting] strategy is achieved when suppliers are transformed into total service providers who take the ownership of physical assets" (p. 1).

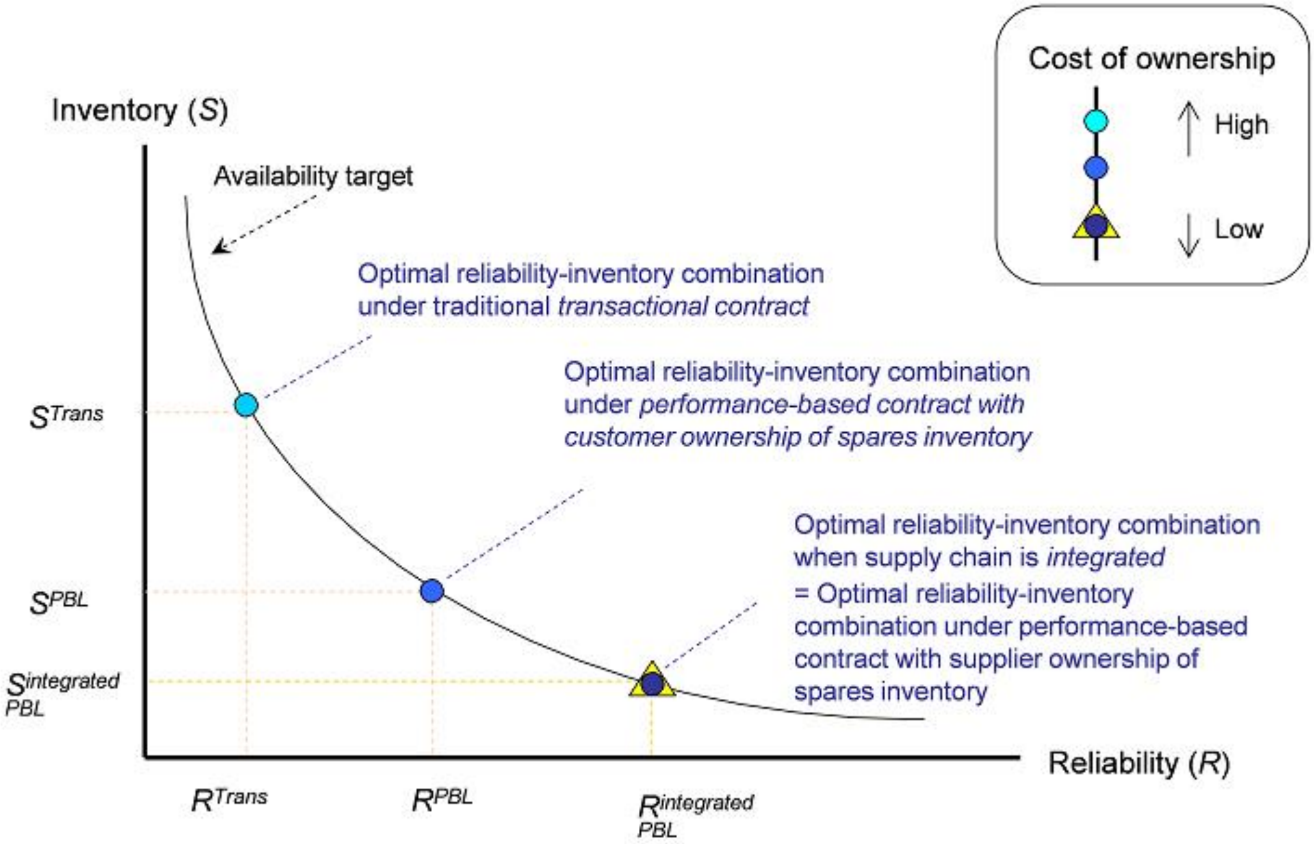

Figure 4. Relationship between contract type, spare asset inventory, spare asset ownership, and reliability (adapted from Kim, Cohen, & Netessine, 2011)

Figure 4 shows the relationship between contract type, spare asset inventory, spare asset ownership, and reliability. The graph indicates that when non-performance based contracting strategies (transactional contracts) are used; reliability remains low with suppliers relying more heavily on a larger inventory of customer-owned spare parts to maintain the system. When non-performance contracting strategies are used, suppliers are not incentivized to improve reliability.

Under fixed-price PBL contracting strategies, the optimal combination of reliability and inventory shifts away from inventory and toward improved reliability. In other words, the supplier makes investments in reliability (process, schedule, or technology), thereby obviating the need for a large parts inventory. The optimal combination shifts even farther to the right when spare parts are owned by the supplier. The graph reveals that although reliability and inventory are, in effect, substitutes—either can be increased to meet system availability requirements—cost of ownership is lowest under a PBL contracting strategy where spare parts are owned by the supplier. Kim, Cohen, and Netessine assert that when the supplier owns all spare parts, "the supply chain becomes coordinated." They conclude that "Our analysis supports a DoD recommendation for transforming suppliers into total service providers of support services who, under the PBL arrangement, assume complete control of service functions, including asset ownership" (p. 1). At present, industry practice is for the customer to own spare assets "while the supplier decides on target stocking levels of spares and recommends to the customer a budget of spares acquisitions to achieve these levels."

Stryker: A cost-plus PBL

When Stryker brigades supported by a PBL contract first deployed to Iraq, Army officials reported operational readiness rates averaging 96% from October 2003 through September 2005 (GAO, 2006). In addition, the Army consistently noted that contractors were providing impressive levels of support and according to a 2006 GAO report, more knowledgeable and efficient than their military counterparts with regard to the specifics of the Stryker vehicles (GAO, 2006).

From a cost perspective, however, contract performance is less clear. In 2012, The DoD Inspector General asserted that the follow-on contract's continued use of a sole metric (readiness) in combination with a high-ceiling, cost-plus contract unduly incentivized the contractor to accumulate significant excess inventory valued at $335.9 million (DoD IG, 2012). The Army responded that the excess inventory could be attributed, in part, to contractor improvements in reliability, and that the spare parts would be used eventually, albeit at a slower pace than anticipated (DoD IG, 2012).

Given the Army's heavy reliance on Stryker during the Iraq War, changing operational tempos, and the lack of historical cost data, the use of a cost-plus fixed fee contract (as opposed to a fixed-price contract) was well-founded. However, it appears that the Army could have implemented better cost controls, perhaps by tying the fixed fee to an agreed-upon cost-per-mile metric.

It should be emphasized that these relationships hold only when fixed-price contracts are used. PBL arrangements that use cost-plus contracts can provide suppliers with the perverse incentive to accumulate spare parts, if those parts are customer owned (see the inset above).

III. Long Term PBLs

In this section, we provide an in-depth examination of three mature, long-running, PBL programs: The High-Mobility Artillery Rocket System, better known as HIMARS, the Navy Aviation Tires Program, and the Apace helicopter's Modernized Target Acquisition Designations Sight (M-TADS) system. The HIMARS PBL supports two major subcomponents, the Launcher-Loader Module and the Fire Control System. The Apache PBL provides subsystem-level support.

HIMARS

HIMARS is the latest addition to the military's multiple-launch rocket system (MLRS) family. Designed with the purpose of engaging and combatting artillery, trucks, air defense, light armor and personnel carriers; it was a lighter, more mobile variation on the MLRS M270A1, with some common components. In addition to supporting troop and supply concentrations, HIMARS has been in constant demand by both the Army and the Marine Corps, (as well as foreign governments) since the production of its first prototype in 1999.

The HIMARS launcher is an impressive weapon that has continuously exceeded its operational readiness expectations. Initially developed through an advanced concept technology demonstration (ACTD) program by Lockheed Martin Missile and Fire Control in 1996, HIMARS has been referred to as "the most advanced artillery system in the U.S. arsenal." Following their successful deployments during Operation Iraqi Freedom, HIMARS launchers have become indispensable to the arsenals of both the Army and Marines.

A Brief History

Originally conceived to meet the need for a lighter, rapidly deployable rocket launcher – HIMARS is a wheeled, agile, rocket and guided missile launcher fixed to a five-ton armored truck (Gansler & Lucyshyn, 2014). Owing to its wheeled chassis and lightweight design, the system can be easily transported by C-130, allowing it to be deployed to previously inaccessible areas at a moment's notice (Lockheed Martin, 2011). The HIMARS system has been internationally recognized for its highly efficient and innovative features, including the ability to take aim at a target in under 16 seconds, and rapidly move away from the launch site once a missile is released. In addition, its fire controls system, electronics, and communications units are interchangeable with its heavier, tracked, predecessor, the M270A1.

Following the ACTD in 1996, Lockheed Martin was awarded an engineering and manufacturing development (EMD) contract for six launchers (and later an additional two launchers) in 2000 (Army-Technology, 2015). Not long after, in 2003, "the U.S. Army and Marine Corps signed a contract for the low-rate initial production (LRIP) of 89 launchers for the Army and four for the USMC" (Army-Technology, 2015). As the U.S. role in overseas conflicts grew in the mid to late 2000s, the need for HIMARS units grew, as outlined in Figure 5.

HIMARS Timeline, 2004-2011	
January 2004	Second LRIP awarded • 25 launchers for the Army, 1 for the USMC
January 2005	Third LRIP awarded • 37 launchers for the Army, 1 for the USMC
November 2004	Initial operational test & evaluation (IOT&E) completed • Three prototype launchers used successfully for Operation Iraqi Freedom
June 2005	HIMARS enters service with 27th Field Artillery, 18th Airborne Corps at Fort Bragg • July 2007 – 2nd Battalion, 14th Marine Regiment deployed to Iraq
December 2005	First full-rate production contract
January 2007	Lockheed awarded contract for an additional 44 launchers for the Army, and 16 for the USMC
2008	HIMARS completes "255 out of 257 dry-fire missions and 17 out of 17 live-fire missions for a 99.2% and 100% success rate, respectively ("XM142", 2008) (Gansler & Lucyshyn, 2014)
January 2009	Contract placed for 57 launchers for the Army, and 7 for the USMC
March 2009	HIMARS launchers successfully fired two advanced medium-range air-to-air missiles
June 2010	BAE systems awarded $24 million contract for 63 HIMARS launchers • November 2010 – additional $16.3 million contract with US Army Tank Automotive and Armaments Command to supply 44 more HIMARS launchers
January 2011	$139.6 million contract between Army and Lockheed Martin for 44 combat-proven HIMARS • Total launchers = 375
September 2011	Army received its 400th HIMARS launcher

Figure 5. HIMARS Program Timeline (Army-Technology, 2015)

Since its introduction into the force in 1998, HIMARS has proven its value through both peacetime forcible-entry exercises and on operational deployments in the U.S. Central Command (CENTCOM) area of responsibility (Russo & Hilbert, 2008).

Program Description

The Lockheed Martin HIMARS program office is headquartered in Dallas, TX, where numerous program functions are executed; these include program management, depot repair coordination, inventory control, contracting with suppliers, design interface, and database maintenance. The program database tracks the location of each launcher, including each spare part, indicates whether the part is functional, and provides its status with regard to the repair process. The DoD’s internal logistics systems rarely achieve this level of visibility for most weapon systems, often leading to ordering redundancy, misplaced orders, and an incomplete picture of program operations.

The program also employs 31 field service representatives (FSRs) that operate with deployed units stateside and overseas. In-theater maintenance work is performed primarily by soldiers, while the FSRs facilitate the supply process by overseeing numerous functions (Hawkins, 2009). These functions include

- supply, receipt, storage, issue, inspecting, packaging, and shipping, of subsystems and components;
- data collection and recording (maintenance actions, supply transactions, operating hours, munitions status [deployment and garrison]);
- system fault isolation using a variety of either built in or stand-alone test equipment;
- replacement of assemblies, as required;
- provision of technical assistance and support (both launcher and automotive); and
- provision of an interface for “reach back” engineering support, enabling the rapid resolution of problems.

Given the level of sophistication provided by the Lockheed Martin’s database and logistics networks, the FSRs are able to streamline and simplify the repair process for launchers. As a result, early in the PBL program, Lockheed Martin was able to reduce the number of diagnostic test units provided to each battalion, from six to one. In fact, soldiers operating the system in theater need only remove and replace defective line-replaceable units.

Perhaps one of the greatest benefits is the provision of limited depot-level repair capability at each battalion, where repair work is provided by the FSR. Referred to as the capability to "Fix Forward," some 50% of all HIMARS repairs are performed on location by the FSRs, eliminating wait times and significantly reducing costs. Moreover, the FSRs are trained to test and replace circuit card assemblies (CCAs), rather than the LRUs in which they are housed, which reduces the overall logistics footprint and lowers costs —only the CCAs need to be shipped. This in-the-field repair capability has also significantly improved deployed launcher availability. According to interviews with Lockheed Martin officials, FSRs voiced few concerns over their work environments, safety, or civilian status within the battalion, with several volunteering to return, for a follow-on tour.

PBL Strategy

The Army awarded the first HIMARS PBL contract to Lockheed Martin for $96 million, in February 2004 (Gansler & and Lucyshyn, 2006). The four-year contract (one base year and three option years), referred to as Life Cycle Contractor Support (LCCS) ended in December 2007. At this point, the Army had acquired 195 HIMARS launchers; and the Marines had acquired 40. Given its increasing inventory of HIMARS, the existence of a successful partnership between the Army and Lockheed Martin, and the cost benefits that derive from economies of scale, the Marines sought to support its launchers through LCCS upon completion of the initial contract.

Accordingly, the second contract (LCCS II), a three-year contract (one base year with two option years) worth $90 million, was awarded in January 2008 to support both the Army and Marines' systems. The shorter duration of LCCS II reflected significant risk associated with unknown launcher production quantities and price fluctuations for component spares (Gardner, 2008). A third PBL contract, for $158 million, termed Life Cycle Launcher Support (LCLS), extended HIMARS sustainment through December 2013 for services and through December 2014 for hardware.

The initial PBL strategy relied on firm-fixed-price contracts with performance incentives[3] for stateside operations, and cost-plus fixed-fee contracts for overseas contingency operations (Gardner, 2008). This strategy provided strong cost reduction incentives as well as the flexibility to meet overseas operational requirements. Moreover, the fixed-price is tied to an OPTEMPO category, with each vehicle assigned to a price category based on anticipated usage.

The LCCS/LCLS contracts tasked Lockheed Martin with the full support responsibilities for the performance-based product support of the HIMARS and MLRS M270A1 launchers' fire control systems, as well as the HIMARS launcher-loader module (Gardner, 2008). The commonality of support for the two platforms allowed the Army and later, the Marines, to take full advantage of the potential economies of scale in order to reduce costs (DoD, 2006).

The LCCS/LCLS concept represented a significant evolution from the original M270 MLRS strategy, according to which the majority of tasks (e.g. initial provisioning, inventory management, war reserve stock, repair and overhaul, depot maintenance, etc.) were provided with organic support. LCCS/LCLS, on the other hand, represents an ideal partnership, one in which the contractor assumes responsibility for providing technical support, and user training, in order to meet performance objectives; while, at the same time maximizing existing Army depot and acquisition infrastructure, relying on military personnel to operate and repair the system.

Based primarily on data collection provided by Lockheed Martin during the initial contract, the LCCS team was able to make a number of changes to the LCCS II contract that would reduce future ownership costs. Notably, the team determined that the usage hours for the launchers varied significantly between active Army units and National Guard units (OSD, 2009). In an

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[3] A fee was paid to the contractor on a quarterly basis provided that the performance requirements were met.

effort to reduce future costs, the less-used units were categorized under a lower operational tempo, which led to a reduction in needed support. Accordingly, Lockheed Martin and the DoD negotiated the LCCS II contract to reflect the anticipated savings derived through the reduction in operational tempo. These savings turned out to be considerable. In 2007—the final year of LCCS I—costs associated with operational tempo totaled $12.4 million; in 2009, these costs had declined to $3.8 million, for a total cost avoidance of $8.6 million.

Initially, the PBL contained three contract metrics: system readiness, response time for part delivery, and repair turnaround time. System readiness was required to be maintained at or above a specified percentage (92% for LCCS I; 90% for LCCS II); however, this requirement was not included in the third contract.[4] With regard to the second metric, the contract required that response time for mission capable parts deliveries fall within a specified range a certain percentage of the time, depending on the type of part. For overseas operations, the response time ranges were extended to provide the flexibility necessary to meet fluctuations in demand that might arise in unpredictable operating environments (DoD, 2006). The LCCS II contract, for example, required that response time be less than 48, 72, or 96 hours for U.S. based operations, depending on the part (each of which is assigned to an Issue Priority Group), 92%, 91%, and 90% of the time, respectively (OSD, 2009). For overseas operations, the response time had to be less than 96, 120, or 144 hours (OSD, 2009; See Figure 5)

Issue Priority Group	Requirement	Percentage Required
1	48 hours (CONUS) 96 hours (OCONUS)	>92%
2	72 hours (CONUS) 120 hours (OCONUS)	>91%
3	96 hours (CONUS) 144 hours (OCONUS)	>90%

Figure 5. Response time requirement for mission capable parts delivery

The third metric, repair turnaround time, specified the time period for completing LRU repairs. The contract required that LRU repairs be completed within a certain number of days a certain percentage of the time as defined by five “bands” (See Figure 6). This requirement was measured

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[4] During this time period, the government sought generally to reduce the number of metrics used in PBL contracts to improve program outcomes and, in the specific case of HIMARS, eliminate the incentive fee tied to the readiness requirement, which was seen as redundant in light of the incentive fees tied to the other two requirements.

on a quarterly basis. As the figure shows, a majority of the repairs (65%) had a required repair turnaround time of less than 35 days.

Band	**Repair Turnaround Time**	**Requirement (percentage of total repairs)**
Band 1	1-7 days	≥18%
Band 2	8-35 days	≥47%
Band 3	36-80 days	≤27%
Band 4	81-90 days	≤8%
Band 5	91 days	1%

Figure 6. Turnaround time requirement for LRU repair

PBL Performance

The HIMARS PBL program achieved success early on, reaching a 99% average system readiness rate, with no launcher out of service for more than 24 hours through 2015 (Gansler & Lucyshyn, 2014). With regard to the other two metrics, response time for mission capable deliveries and repair turnaround time, the program also performed extremely well. The CONUS average for mission capable delivery stood at 14 hours, the OCONUS average at less than one hour. Field repair turnaround time averaged 1.2 days and vendor repair turnaround averaged 34 days.

The HIMARS program also tracked reliability through mandated field analysis reports, monitoring the mean time between system aborts (MTBSA) and mean time between essential function failures (MTBEFF). Figure 7 illustrates HIMARS units' reliability between 2005 and 2015. Note that reliability among deployed Army units, as measured by both MTBSA and MTBEFF, climbed significantly during 2009 and 2010, before stabilizing at levels that continue to exceed average reliability across all units. The peaks in reliability correspond with peaks in the number of operational hours for deployed units (*i.e.*, 3rd quarter 2009 and 1st quarter 2010).

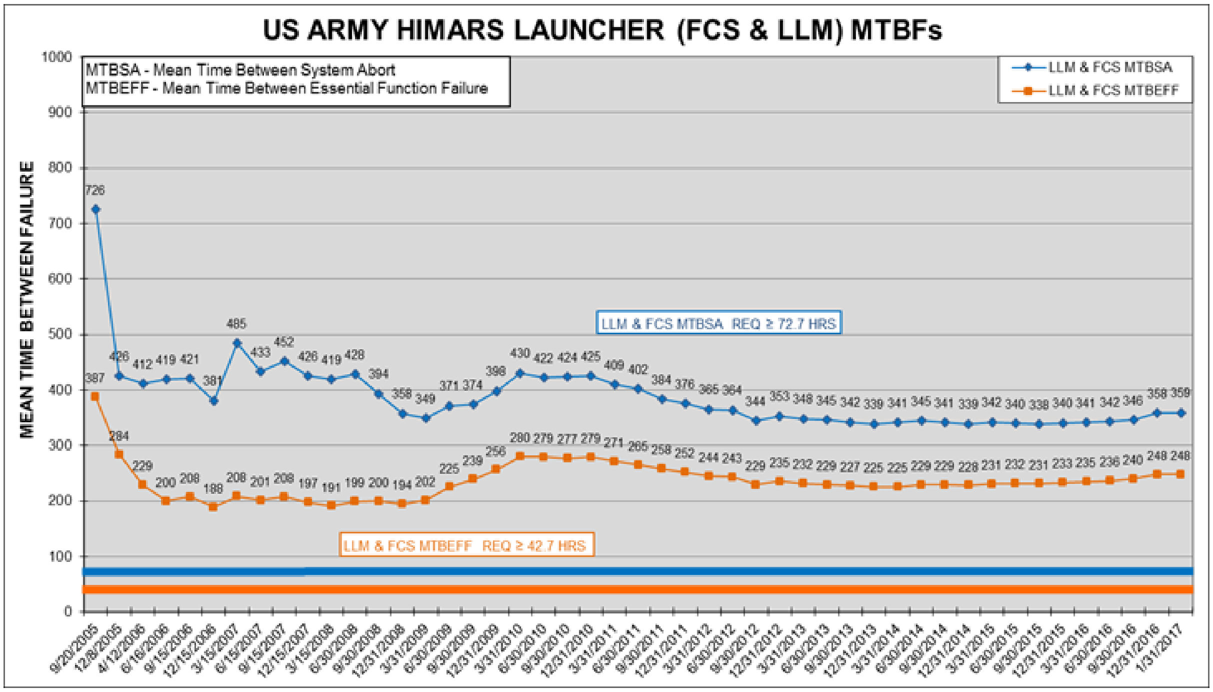

Figure 7. HIMARS Field Reliability
Note. The information in the chart came from Lockheed Martin, 2017)

Transition to cost-plus contract

Despite the program's success, in 2014 the DoD transitioned to the use of a cost-plus fixed fee contract, transferring much of the inventory management function from the contractor to the government, in an effort to further reduce costs through more direct government control. The five-year contract (one base year and four option years) extends support for HIMARS through 2018. Contractor personnel have suggested that the government-contracting officer pressed for the transition, in an effort to constrain costs. The program continues to use the response time and turnaround time requirements. The response time (customer wait time[5]) requirement remains unchanged from the previous contract, whereas the repair turnaround time[6] requirement was modified to specify two bands as opposed to five. As with the previous contracts, 65% of repairs had a required repair turnaround time of 35 days, or less.

Unlike the previous fixed-price contracts, this contract specifies "stock objectives" and other inventory and operational constraints that the contractor is not permitted to exceed. This, of

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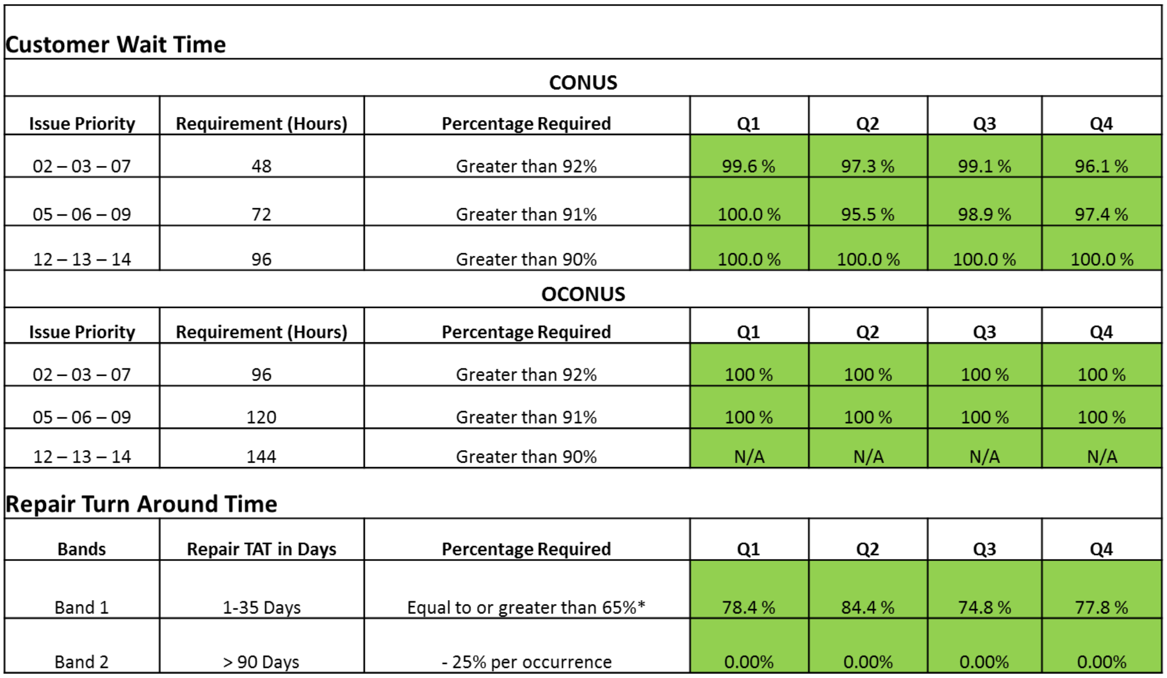
[5] Customer Wait Time – The number of hours that LCLS has from the moment an FSR submits a requisition until when that item requested is in the hand of the requesting echelon.
[6] Turn Around Time – The action of repairing an Line Replaceable Unit (LRU) to Condition Code A (serviceable - issuable without qualification) within the allotted time period.

course, limits the contractor’s flexibility to leverage economic efficiencies when buying spares, and virtually eliminates the incentives to invest in program improvements, doing away with one of the primary benefits of performance-based contracts. Because the program shifts most of the risk back to the government, some suggest that the program is a PBL “in name only.”



Customer Wait Time

CONUS

Issue Priority	Requirement (Hours)	Percentage Required	Q1	Q2	Q3	Q4
02 – 03 – 07	48	Greater than 92%	99.6 %	97.3 %	99.1 %	96.1 %
05 – 06 – 09	72	Greater than 91%	100.0 %	95.5 %	98.9 %	97.4 %
12 – 13 – 14	96	Greater than 90%	100.0 %	100.0 %	100.0 %	100.0 %

OCONUS

Issue Priority	Requirement (Hours)	Percentage Required	Q1	Q2	Q3	Q4
02 – 03 – 07	96	Greater than 92%	100 %	100 %	100 %	100 %
05 – 06 – 09	120	Greater than 91%	100 %	100 %	100 %	100 %
12 – 13 – 14	144	Greater than 90%	N/A	N/A	N/A	N/A

Repair Turn Around Time

Bands	Repair TAT in Days	Percentage Required	Q1	Q2	Q3	Q4
Band 1	1-35 Days	Equal to or greater than 65%*	78.4 %	84.4 %	74.8 %	77.8 %
Band 2	> 90 Days	- 25% per occurrence	0.00%	0.00%	0.00%	0.00%

Figure 8. HIMARS Program Results FY 2017

One of the key questions government officials must ask is whether the new arrangement satisfies objectives of reducing cost, while meeting the requirement for HIMARS availability; both in the present and in the future. It may very well be that the government is, at present, receiving sufficient value, and taking on what it considers acceptable risk. Indeed, contractor personnel stated that the government has been able to take advantage of the “residual setup” established under the previous contacting arrangements, in effect relying on the same proven processes and expertise, albeit in a more transactional environment in which spare parts procurement is constrained, ostensibly to reduce program costs.

The program continues to perform well; response time and turn-around time remain well above the requirement and reliability has remained consistent (See Figure 8). During the initial contracts, Lockheed Martin and its subcontractors had invested over $10 million in design improvements, process changes, equipment and facilities to improve reliability and reduce costs.

This resulted in a high level of system availability; reducing support requirements overall and enhancing mission success. The inertia from these improvements have enabled the continued high level of the programs performance and cost reductions. According to contractor personnel, DoD costs per launcher are less in 2018 than they were in 2005; the total price of the LCLS support contract in 2018 is less than it was in 2006, even though the 2018 LCLS program currently supports 643 launchers, compared to the 286 launchers in 2005. The question is whether the same processes, level of detail, amount of effort, program improvements, cost reductions, and forward-looking approach can be preserved in a cost-plus environment over the long term.

One would anticipate that the contractor would be reluctant to make any additional investment in the program, without a reasonable expectation of getting a return on their investment. As might be expected, contractor investment and surge capacity have indeed decreased following the transition to a cost-plus contract. According to contractor personnel, the program has not procured an LRU in five years. And, with a depleted spare parts inventory that is constrained by the contract, availability may not be able to keep pace with demand, should requirements dictate an increased operational tempo.

In addition, although the costs associated with spare parts procurement may accrue more slowly under the current contract, they will likely end up being higher when compared to previous arrangements that permit more cost-effective parts procurement (*e.g.,* “bulk buys”). In other words, the program may no longer be able to capture economies of scale to the same extent.

The government has yet to release a Request for Proposals to continue HIMARS support beyond 2018. Contractor personnel believe that the government intends to ask for a one-year extension to bridge the existing contract as it continues to assess how support will be provided over a longer period, and a RFP for the new contract is released.

Navy Tires

In 2001, the Navy Inventory Control Point (NAVICP), had already used PBL to transform other supply chains, improving performance and reducing costs, and turned their focus to aircraft tires (Mahandevia, 2006). NAVICP was a Command responsible for more than 400,000 items of supply, and had an inventory valued at $27 billion, with $4.2 billion in annual sales. As of July 2011, NAVICP was replaced by the Naval Supply Systems Command Weapon Systems Support (NAVSUP WSS). The mission of NAVSUP WSS is to "provide the Navy, Marine Corps, Joint and Allied Forces program and supply support for the weapons systems that keep our Naval forces mission ready" (NAVSUP, 2014). It should be noted that NAVSUP WSS only enters into a PBL contract after assessing and concluding that a PBL contract cost would be equal to or less than traditional support. Overall, NAVSUP WSS PBL contracts have reduced costs by 3.9 percent (The Naval Aviation Enterprise Air Plan 2013).

A Brief History

Traditionally, NAVICP treated aircraft tires as a commodity; they bought them in bulk, and then stored them until they were needed. This resulted in a large on-hand inventory (approximately 60,000 tires) that may or may not have had the right mix of tires for the fleet. This inventory was maintained through small contracts for individual types of tires, which were awarded to a variety of manufacturers (OSD, 2012). The unintended consequence of this short-term acquisition process was to send erratic signals to the industrial base, resulting in less than optimal production runs, higher cost raw material sourcing, and longer lead-times. In addition, distribution services were provided by organic military resources, often with delays; in effect, operational units had to maintain a retail inventory. This resulted in higher overall costs to the fleet.

Program Description

The Navy developed a strategy to transition the provision of aircraft tires to a component level PBL. This strategy was implement in 2000, and has resulted in a dramatic improvement in the availability of the required aircraft tires, with significant reduction in cost.

Initial Contract

In May 2000, NAVICP issued a Request for Proposal (RFP) for a PBL contract to manufacture and deliver naval aircraft tires to all U.S. Navy, Marine Corps and foreign military sales customers (NAVICP, 2000). A firm-fixed-price contract was competitively awarded in April 2001 to Michelin Aircraft Tires Corporation (MATC), Greenville, S.C. to manage the Navy's aircraft tire program. This contract had a five-year base with an estimated value of $67.4 million, supporting all 23 types of tires that the Navy used (NAVICP, 2001). This contract had two five-year options, and the resultant 15-year value for the contract was $261.5 million (PBL Award Summary 2011). The first five-year option was exercised in July 2005, with an award of almost $92 million to MATC (DoD, 2005). The second five-year option was awarded in June 2010 and was valued at over $101 million (Military Industrial Complex, 2010). This contract ended in January 2016.

This initiative was the first time the DoD contracted out for the support for new and repairable tires. MATC was prime contractor for the program as well as the manufacturer and supplier of the tires. MATC maintained responsibility for requirements forecasting, inventory management, retrograde management, storage, and transportation (Mahadavia, Engel, & Fowler, 2006). MATC subcontracted with Lockheed Martin to provide the supply chain services. These services included demand forecasting, order fulfillment, and inventory management. In addition, Lockheed Martin also managed the commercial carriers (Bland & Bigaj, 2003).

As part of their contract task, Lockheed Martin provided a service center that was available 24/7, called the Lifetime Support Command Center (LSCC). This center controlled all requisitions and maintained a real-time requisition status with web-based access, and was electronically interfaced with Michelin, the two warehouses, and through the Navy with the Naval Air Stations, Marine Corp Air Stations, carriers, and Landing Helicopter Assaults and Landing Helicopter Docks. This data along with shipping status and product support information was provided to Michelin to maintain their internal systems (Gansler & Lucyshyn 2006; Mahadavia, Engel, & Fowler 2006; Bland & Bigaj 2003).

The ambitious contract requirements were as follows:

- 95 percent on-time fill rate
    - 48 hours (2 days) within the continental United States (CONUS)
    - 96 hours (4 days) outside the continental United States (OCONUS)

- Reduce retail inventories to a 90-day operating level (Bland & Bigaj, 2003)
- Achieve and maintain a surge capability at a rate of up to twice the monthly demand rate of each tire type (Bland & Bigaj 2003; DoD, 2005).

The Michelin-Lockheed Martin team developed internal metrics to measure performance to achieve the 95 percent on-time delivery requirement. These included dock-to-stock time in warehouse, inventory accuracy, order fill time, and carrier performance (Bland & Bigaj 2003).

The program shipped its first tires on July 9, 2001. Prior to this PBL contract, tire availability was 81 percent. As of 2011, backorders dropped from 3,500 to zero, and logistics response time dropped from 60 days to under 2 days in CONUS and under 4 days OCONUS. As of 2011, the average customer wait time was 32.1 hours CONUS and 59.5 hours OCONUS, and on-time performance rates were 98.5 percent – well exceeding the contract requirement of 95 percent on-time (PBL Award Summary 2011). These results were achieved during surge periods – supporting Operation Enduring Freedom and Operation Iraqi Freedom – with no reported impact to the fleet customer.

Follow-on Contract

The follow-on firm-fixed price contract was competitively awarded to Lockheed Martin by the NAVSUP WSS, in February 2016. This contract had a base period of performance of 3 years, with two 6-month options, at a total value of $131.3M. The Navy estimated a total cost avoidance of $24.3M, with this contract. As the prime contractor, Lockheed Martin has Michelin as a subcontractor, along with other tire manufacturers, such as Goodyear, to meet specific Navy requirements. The contract requirements were consistent with the initial contract, and through 2016 Lockheed Martin exceeded the on-time delivery metric of 95% with an on-time delivery of 98.2% CONUS and 98.7% OCONUS.

This high level of material availability provided by these PBL contracts enabled the Navy to completely draw down its former stockpile of wholesale tires from 60,000 tires to zero. By eliminating the Navy’s wholesale tire inventory, 280,000 cubic feet of storage space in the distribution depots were made available. This high level of availability and consistently reduced delivery timeframes significantly reduced the need for local retail customer inventory levels; these were reduced by 66%, with a value of $1.7M. The Navy also reduced total ownership costs by handing off the responsibility for retrograde pick-ups and disposal of scrapped tires. Additionally, the quick retrograde pick-up time, of 3.4 days on average, eliminated the need for the labor and storage costs associated with retrograde tire management. By reducing wholesale/retail inventory and eliminating retrograde pick-up, the program demonstrated the Navy's improved inventory management.

Lockheed Martin's best-in-class logistics support system (the LSCC) also allowed the contractor to notify the NAVAIR program manager with shipment dates and serial numbers in order to locate and quarantine any tires already out of the warehouses. This program demonstrated the benefit that the Navy received from a long-term contract based on performance from the private investment in product and process improvements, that results in cost-savings and improved support to the warfighter.

AH-64 Apache

The AH-64 Apache was conceptualized as a high-powered, tank-killing, attack helicopter, capable of repelling conventional ground forces during a soviet invasion of Europe. Still an essential part of the Army's fleet today, the primary mission of the Apache is to perform armed reconnaissance and conduct rear, close, and shaping missions, including deep precision strikes.

Since its inception, the Apache has accumulated over 3.9 million flight hours, with operational deployments during Desert Storm, Operation Iraqi Freedom, and Operation Enduring Freedom, and Operation Inherent Resolve in Iraq. Although the first AH-64 was delivered to the Army five years before the fall of the Berlin Wall, the Apache remains the Army's primary and most advanced attack helicopter. Central to the Apache's mission is the Target Acquisition and Designation Sight/Pilot Night Vision Sensor (TADS/PNVS) system, nicknamed the "eye of the Apache."

A Brief History

The first generation of the TADS/PNVS system was fielded by the Army in 1983. The system, which comprises two sub-systems, enables Apache pilots to fly at low altitudes in total darkness and poor weather. The TADS/PNVS system also provides a capability that allows the co-pilot to identify and engage hostile targets (Yenne, 2005).

In 2003, Lockheed Martin was awarded a production contract for an upgraded, modernized version of TADS/PNVS. The M-TADS/PNVS, also known as the "Arrowhead," is an "advanced electro-optical fire control system that AH-64D/E Apache helicopter pilots use for targeting and pilotage in day, night and/or adverse-weather missions" (Lockheed Martin, 2015). The updated version is projected to lower sustainment costs by 50% over the system's expected 40-year life span (Lockheed Martin, 2015).

Prior to the initial TADS/PNVS PBL contract, the sustainment cost for the Apache's sensors systems averaged $218 million per year. Product support functions were performed organically, with Lockheed Martin providing 'repair and return' services on a transactional basis (DoD, 2013).

Both the original TADS/PNVS and M-TADS are designed around the concept of the Line Replaceable Module (LRM). Technicians remove and replace faulty components directly, restoring the system to service quickly. The faulty component is sent for repair off-site. The LRM concept has been shown to reduce the cost, volume, and weight of spares holdings (Curtiss-Wright, 2016). The LRM design allowed technicians to remove and replace faulty equipment on the flight line. Intermediate-level maintenance of faulty components was performed at the division or corps level, while depot-level maintenance was performed either at the then Martin Marietta depot facility in Orlando, Florida, or at subcontractor facilities (Robbins & McIver, 1994).

A 1994 RAND report analyzing logistics support for the Army's high-tech weapons found that the Army overstocked certain TADS/PNVS LRMs and understocked others. The report concluded that the inefficiencies in intermediate-level maintenance would have limited repair capability to only 25% of all received platforms during a large-scale operation. The report attributed this limitation to the absence of prioritization mechanisms at critical repair facilities. In an effort to improve logistics efficiency, the DoD transitioned to a PBL in 2007.

Program Description

Since 2007, Lockheed Martin has provided sustainment for the AH-64 Apache Helicopter's M-TADS/PNVS system through a series of three PBL contracts. The PBL program consists of three major functions: repair operations, logistics operations, and continuous improvement areas. Together, these functions established a system of continuous improvements supporting the Apache sensors and covered complete post-production supply chain management, including inventory management, maintenance, modifications, procurement, repairs, and spares planning of fielded systems. In 2013, the PBL supported over 670 aircraft in 27 battalions worldwide, including multiple forward operating bases (DoD, 2013).

Repairs are performed at five special repair activities (SRAs). The largest of these is the Letterkenny Army Depot Partnership in Pennsylvania, which repairs 29 of the 53 LRMs on the M-TADS system. The partnership employs 14 personnel (six government and eight Lockheed Martin) Other SRA locations are located in Arizona, Texas, Alabama, and Florida (Lockheed Martin, 2016).

The second function, logistics operations, comprises U.S.-based depot support facilities and contractor supply support activities (CSSAs) located at domestic and overseas U.S. military installations and within close proximity to deployed Army units. The depot support facilities oversee the following functions: management of government-owned, contractor-managed assets; distribution of repair parts to SRAs; packing, handling, shipping, and transportation; and operation of storage facilities. The CSSAs consist primarily of forward-deployed Lockheed Martin-staffed support teams. In 2013, CSSAs had a presence in Afghanistan, Iraq, Germany, South Korea, and Kuwait (Lockheed Martin, 2016). The CSSAs serve as an information conduit between Army units and Lockheed Martin’s global support network. The CSSAs process repair orders, ensuring timely transportation of new parts from SRAs to deployed units.

Finally, the continuous improvement function of the PBL consists of a dedicated team of Lockheed professionals that do demand planning, and work to improve reliability and maintainability as well as obsolescence management. The team relies on specialized IT tools, including an asset management system that “provides data necessary to identify and implement corrective actions and proactively push improvements into the field” (DoD, 2013). Among its numerous functions, the team investigates new failure trends; reviews reliability predictions to determine current and future needs; and develops low impact, and easy-to-implement solutions to recurring or emerging logistics or technical challenges.

PBL Strategy

The PBL has relied on firm fixed-price contracts that are tied to the number of flight hours. The program has established nine flight bands, each of which is designated by a maximum number of annual flight hours. The nine bands are separated by approximately 20,000 hours; band 1 has a maximum of 87,000 hours, band 10 a maximum of 240,000 (Lockheed Martin, 2016). Thus, the Army would pay the maximum annualized value of the contract during years in which Apache flies between 220,000 and 240,000 miles. This structure is ideally suited to heavily-deployed systems, such as the Apache. It provides the contractor with the traditional incentives associated with fixed-price contracts, translating to higher levels of innovation, reliability, and availability; at the same time, the contract is sufficiently flexible—the Army pays for actual usage—to support changes in operational tempo and accommodates multiple deployments (for instance, by establishing new deployed CSSA locations as needed).

The first four-year contract (one base year and three one-year options) was valued at approximately $380 million; in 2012, a similar follow-on contract valued at $375 million was awarded (Lockheed Martin, 2012). A third, five-year, PBL contract (one base year and four one-year options) was awarded in 2016. The contract was valued at $424 million, and represents a price reduction of 10% over the previous contract (Lockheed Martin, 2016).

Program performance is measured in terms of supply availability (SA). Lockheed Martin is contractually obligated to meet a minimum availability requirement of 85%. In other words, the requested part must be received by the requesting Army unit within the required timeframe 85% of the time. This timeframe varies depending on the type of part and the location of the requesting unit. There are three issue priority groups (IPG-1 is the highest priority; IPG-3 is the lowest) and two location categories, in-country and deployed. The program relies on this matrix to meet supply availability requirements. IPG-1/deployed have the shortest timeframe requirement, IPG-3/in-country have the longest (Lockheed Martin, 2016). As with the contract structure itself, the supply availability requirement injects flexibility into the program and aligns contractor priorities with those of the Army.

Prior to awarding the 2016 contract, the Army sought to reduce costs by extending the in-country IPG-1 timeframe requirement, from two to four days. Although this change resulted cost reduction, the savings were not large. The parts inventory stayed at the same level, because the lead-time to procure parts still exceeded the required timeframe, so the change only affected transportation costs.

PBL Results

Under the initial contract, Lockheed successfully slashed sustainment costs for both sensor systems and improved supply availability primarily through improvements in supply chain and obsolescence management. Lockheed has lowered logistics and maintenance costs by leveraging data tracking for health and maintenance indicators to improve demand forecasting, determining appropriate inventory levels, and by ensuring the optimal locations of supply activities.

Figure 9. M-TADS/PNVS Parts Availability (Breter, 2013)

Between 2007 and 2013, SA for MTADS/PNVS averaged 97%, well above the 85% requirement. Figure 9 illustrates annual availability by IPG between 2007 and 2011, followed by Monthly availability between January 2012 and May 2013. Notably, a high level of availability was maintained between 2011 and 2013 when Apache reached its peak OPTEMPO of over 200,000 flying hours per year. In 2012, 96,000 hours were accumulated in Afghanistan alone. The other 115,000 hours were accumulated at locations in Kuwait, Germany, Korea, and CONUS locations (Lockheed Martin, 2016). The program has prioritized the availability of deployed units, which between 2012 and 2013, averaged 99%. As of August 2018, , the PBL continues to exceed the required performance, and has a proven supply availability rate of over 99 percent, the result of efficiencies gained in supply chain management, valued engineering services, depot level maintenance, and retrograde infrastructure.

Lockheed professionals working within the continuous improvement function have developed numerous solutions that have increased mean time between system failures (MTBF) by 70% compared to the pre-PBL period. Often “simple fixes” such as redesigned screws that strip less easily; a protective guard that prevents damage to exposed machinery; and improved airflow gaskets have all served to drastically improve reliability, durability, and overall performance. In addition, Lockheed has been successful in drastically increase the annual retrograde rate—i.e. the rate at which repairable parts are transported to depots for repair, in preparation for those parts to be placed back into the supply chain—reducing the number of spares and the overall logistics footprint required to store and maintain them (See Figure 10).

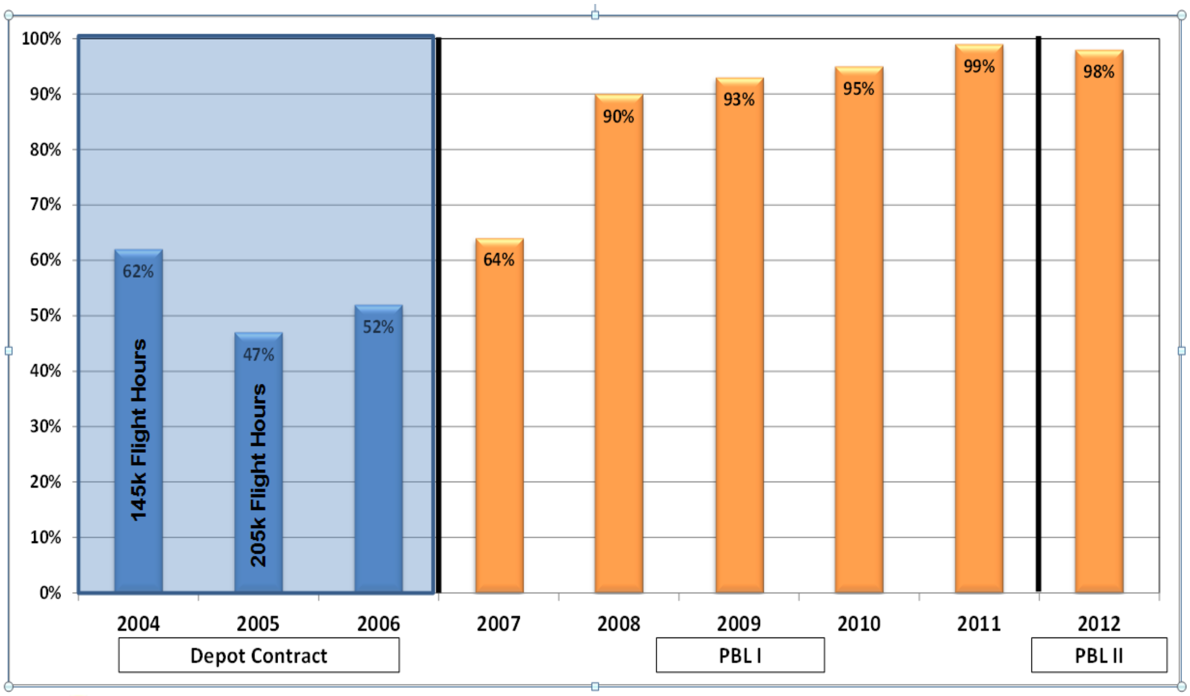


Figure 10. M-TADS/PNVS Retrogrades by Year (Breter, 2013)

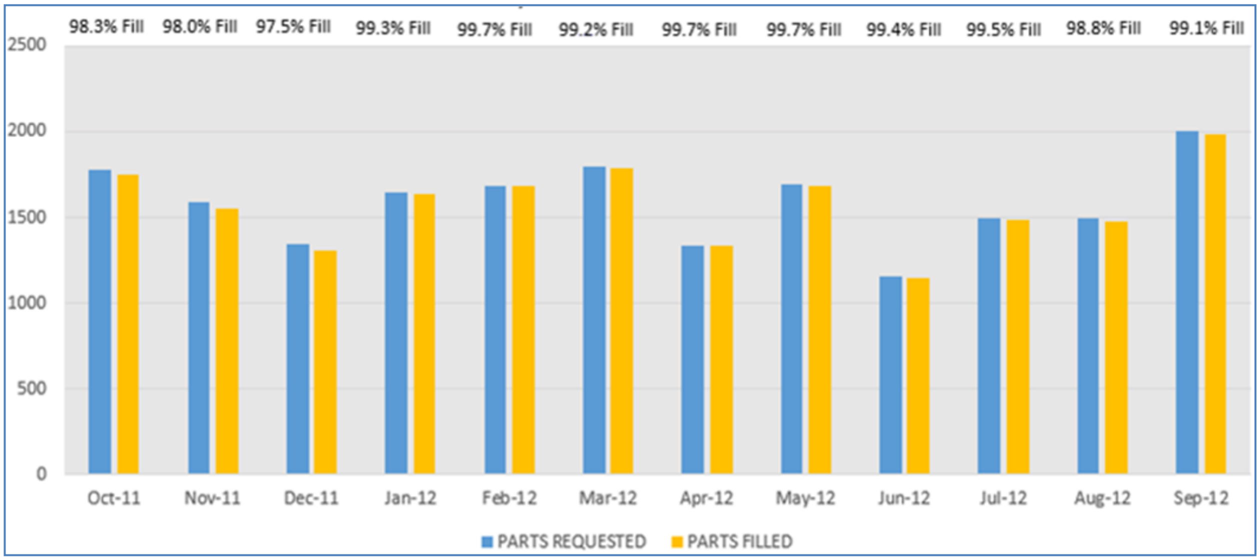


Figure 11. M-TADS/PNVS Depot Repair Parts Availability (Breter, 2013)

The program also exceeded 99% availability for depot repair parts (See Figure 11). The PBL contract has been credited with improving fleet readiness, reducing average flying hour cost and reducing the Army's long-term inventory investment. Over the course of the initial PBL contract, depot-level repairable costs were reduced by 18%, supply inventory replenishment costs were reduced by 40%, and mean-time between maintenance actions reduced by 9.6% (OSD, 2012).

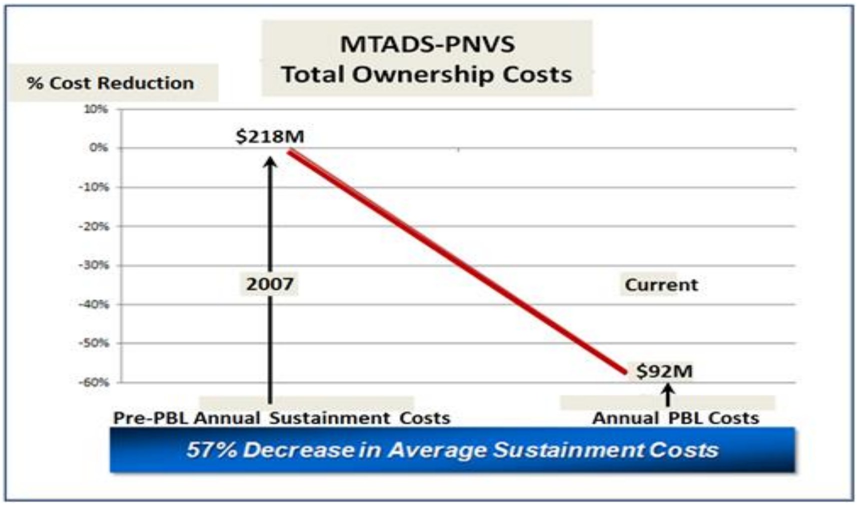


Figure 12. MTADS/PNVS Total Ownership Costs (Breter, 2013)

As mentioned previously, annual sustainment costs prior to the implementation of PBL totaled $218 million per year. In 2013, costs totaled $92 million, a drop of 58% (See Figure 12). Other accomplishments include the mitigation of 759 obsolescence and diminishing manufacturing cases since 2007 resulting in $104.2 million in cost avoidance, the reduction of the maintenance support footprint, and a decrease of over 1,000 maintenance man-hours per year through increased materiel reliability (OSD, 2012). These efficiencies enabled the government to negotiate a price reduction of approximately 10 percent, reflected in the most recent contract awarded in 2016. In light of the program's continued success, sustained high availability, and gains in affordability, the contractor team is optimistic about the program's future.

IV. Recommendations and Conclusion

Long-running PBLs have the potential to continue to deliver value, high reliability, and improved performance. Based on our examination of the PBL construct and our evaluation of three successful PBL programs, we offer the following recommendations.

Recommendations

1. Promote the use of PBL as a proven support strategy for weapons systems, throughout the life-cycle.

PBLs generally perform better than traditional support mechanisms. However, support within the DoD for PBL has appeared to wane in recent years. However, the benefits of PBL contracts continue to accrue as systems age; even with older systems, technological refresh and modernization initiatives create new opportunities to improve products and processes and reduce costs.

PBL contracts may also be perceived as being more expensive than support provided through a more traditional, transactional approach. Indeed, the price that an operational unit pays for a part may appear to increase as its reliability improves; this is because the operational unit's portion of the contract payment is allocated over the total number of parts provided within a given period. When aggregated at the fleet level, costs decrease as reliability improves.

The DoD should renew its commitment to the expansion of PBL in order to improve weapon system operations and reduce costs. This will require increased support from senior DoD officials and Service leaders to ensure that PBL is employed, when developing product support strategy and arrangements.

2. Ensure the acquisition workforce is educated and trained to execute successful PBL contracts.

Developing and implementing successful PBL arrangement requires a different skillset, than that required for contracting for transactional product support. Critics suggest, perhaps rightly, that PBL arrangements can be more challenging to develop and manage than the more traditional transactional contracts. Specifically, the acquisition workforce often does not have a thorough understanding of how to structure contracts with the appropriate the incentives, penalties, and the contract types to motivate industry to provide superior support, while reducing costs. Accordingly, the acquisition workforce must be trained in the appropriate use of PBL contracts, and how to structure them with suitable metrics and incentives to achieve program objectives.

3. Structure PBL contracts appropriately.

PBL contract type should be structured to reflect the current phase of the system's life-cycle. When a system is mature and characterized by relatively low levels of uncertainty, both operational and technical, alignment of contractor and government objectives are optimized with fixed-price PBL contracts. These arrangements promote the greatest performance improvements and cost-reduction, higher levels of innovation, shift program risk to the contractor, and result in enhanced reliability. These contracts generally rely on a small number of performance metrics that directly support the stated outcomes; these help ensure transparency and accountability.

a. Ensure proper alignment of government objectives with provider incentives.

An appropriate PBL program uses the contract structure and incentives to align the objectives of the customer (the government), with those of the support provider, leading to a win-win scenario. The incentives should generally include a combination of rewards and penalties. Rewards can include financial payments and contract extensions for achieving cost and/or performance objectives. Penalties can come into play if the support provider fails to achieve the program outcomes, and can include reduced fees and/or contract options that are not exercised. An inappropriate structure can create perverse incentives, and result in undesired or unintended consequences.

Again, the acquisition workforce must have a good understanding of what motivates businesses, to ensure that the contractual incentives will achieve the desired outcomes.

b. Consider scalability and usage requirements in developing the product support strategy.

There are various strategies to build some flexibility into PBL contracts to account for changes in how systems are used. If these strategies are not used, the results can be suboptimal. For example, under the previous HIMARS PBL contracts, the fixed price was tied to OPTEMPO category, with each vehicle assigned to a price category based on the customer's *anticipated* usage. In the event that vehicles are "underused," the government customer may feel as though he is overpaying. On the other hand, M-TADS, tied the fixed price to actual usage (*i.e.*, flight hour). When possible, PBL contracts should tie price to actual system usage.

c. **Use contract length to incentivize suppliers to improve reliability and reduce costs**. The Navy tires and M-TADS PBLs show that contracts of longer duration can incentivize suppliers to invest in reliability improvements, thereby reducing future costs. Generally, PBL contracts of shorter duration will not incentivize significant contractor investment, since the contract must be long enough for the contractors to recoup their investments (otherwise they will not invest). Accordingly, future performance improvements and price reductions may not be realized.

Conclusion

As defense budgets continue to shrink, and operations and maintenance costs for weapon systems continue to rise, the DoD must heighten its focus on affordability and efficiency when it comes to new and existing weapon programs. With PBLs vast array of benefits, when properly structured, these contracts have the potential to dramatically reduce the costs of procuring and sustaining weapon systems, while incentivizing higher levels of performance throughout the system’s life-cycle. As we continue to face new and evolving global threats, the demand for superior and highly reliable technology is now more crucial than ever. Although its benefits have been consistently proven throughout the years, PBL is still not being aggressively pursed throughout the DoD.

From a theoretical standpoint, the power of PBL lies in affording the provider the discretion and flexibility to select the optimal mix of inventory levels, maintenance activities, and technology upgrades in order to meet performance requirements. The case studies suggest that mature PBL programs are capable of exceeding performance and cost requirements. Shifting one or more of these functions to the government customer distorts the PBL paradigm and may, over time, lead to reductions in performance, innovation, and cost savings—if not in the short term, than in later iterations of the contract.

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