

**Spring 2006  
Industry Study**

**Final Report  
*Land Combat Systems Industry***



**The Industrial College of the Armed Forces**

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Fort McNair, Washington DC, 20319-5062

## LAND COMBAT SYSTEMS 2006

**ABSTRACT:** Operation Iraqi Freedom (OIF) is proving--once again--the relevance of robust Land Combat Systems (LCS) to the success of our nation's war efforts and the survivability of our troops. Most of today's land combat systems are working well in missions for which they were not originally envisioned. Still, the LCS industry is undergoing notable change in multiple areas. First, systems like the Future Combat System (FCS) show the changing approach within the industry toward high technology, software-intensive, and networked systems of systems. Second, globalization is impacting the LCS industry, just as it does other economic sectors. The DoD needs to decide whether to fight or embrace globalization. Finally, the proliferation of partnerships, and other mechanisms, illustrate the struggle of industry players to maintain their relevance, and the DoD's struggle to maintain a healthy LCS industrial base. This year, the study team devotes considerable report space to providing field study observations, findings, and recommendations for bolstering the industry. Overall, the study team found the LCS industry to be in good shape, but not without opportunities for significant improvement.

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## PLACES VISITED

### Domestic

US Marine Corps Systems Command (MARCORSYSCOM), Woodbridge, VA  
Expeditionary Fighting Vehicle (EFV) Program Management Office, Woodbridge, VA  
Anniston Army Depot (ANAD), Anniston, AL  
General Dynamics Land Systems (GDLS), Stryker Plant, Anniston, AL  
Aberdeen Test Center, Aberdeen Proving Grounds, MD  
BAE Systems, York, PA  
Raytheon Space and Airborne Systems (SAS), El Segundo, CA  
Boeing, Huntington Beach, CA  
US Army Tank-Automotive and Armaments Command (TACOM), Warren, MI  
General Purpose Vehicles (GPV), New Haven, MI  
MTU Detroit Diesel, Detroit, MI  
General Dynamics Land Systems (GDLS) Headquarters, Sterling Heights, MI  
Joint Systems Manufacturing Center (Lima Tank Plant), Lima, OH  
Allison Transmission, Indianapolis, IN  
AM General, South Bend, IN

### International

Bumar, Warsaw, Poland  
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Steyr-Daimler-Puch Spezialfahrzeug (SDP SF), Vienna, Austria  
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## INTRODUCTION

The viability of the industrial base is inseparable from the national security of the United States (US). Private industry provides the skills, facilities, and technology to support the land combat systems (LCS) that give our US military undeniable power. If we accept these premises, then it is clear the Department of Defense (DoD) must actively manage (i.e., regulate) the LCS industry to ensure it remains responsive to changing threats, while simultaneously able to support future DoD warfighting strategies. To that end, this report represents the findings of a three-month study aimed at assessing the capabilities, health, and areas for improvement of the US-- and to a smaller degree the European--LCS industry. This report is the next in a series of annual reports on the LCS industry chartered by the Industrial College of the Armed Forces (ICAF), located at Fort Lesley J. McNair, Washington DC. This year's report devotes considerable space to field study observations, findings, and recommendations for bolstering the industry. The study team--comprised of eighteen US and international military, and DoD civilian employees--included members from every US service, as well as Finland and Egypt. This coalition-joint make-up challenged the team to avoid parochial interests and international boundaries.

The study team employed the standard process for ultimately reaching its observations and findings. This process involved literature review, domestic field visits, European field visits, comparative analysis, and finally, group consensus of the reported results. The products from the study team's efforts include a series of white papers, this report, and a summary briefing to senior DoD officials. Any shortcomings are a reflection of the compressed schedule or the study team's understanding, and not the US and European industry participants, each whom provided candid comments about the industry and open access to their capabilities and facilities.

*Our intent here is to demonstrate that while the overall LCS industry is in good health, due in part to high demand stemming from current operations and the DoD's transformation efforts, significant opportunities exist for improvement, to include initiatives both in the US and Europe.* We'll start by offering a short historical background, followed by a precise definition of what we mean by "LCS industry." Second, because one characteristic of the LCS industry is that it is highly regulated, we must explain the US government's goals and roles within the industry. Third, we'll examine current conditions within the industry using Porter's classic "Five Forces" model as a framework (1980). Fourth, we'll discuss the more prominent industry challenges and opportunities. Fifth, we devote the final third of the paper to observations, findings, and recommendations that the study team hopes will initiate a broader discussion between congressional, DoD, and industry leadership on initiatives for LCS industry improvement.

## HISTORICAL PERSPECTIVE

The 1990's were a challenging period for the defense business, as the demand for land combat systems declined along with shrinking defense budgets. This led industry partners to seek consolidations, eliminate personnel, and improve processes wherever possible in order to maintain profitability. The end result was a reduced number of suppliers available in the LCS marketplace, and even these remaining suppliers suffered from excess capacity. Conditions began to change in 1999, when the Army set a course for transformation with its vision of the Future Combat System (FCS) designed to network forces in order to provide superior mobility, battle space awareness, enhanced lethality, and survivability. The Global War on Terror (GWOT) brought further change in 2001, later manifested in Operation Enduring Freedom

(OEF) and Operation Iraqi Freedom (OIF). These current operations, the larger GWOT, and the push to transform, significantly raised the tide for the LCS industry and improved the market environment for competitors. It is this environment in which we find ourselves today.

## THE INDUSTRY DEFINED

Before engaging in meaningful analyses of the industry, we must first define what we mean by "LCS industry," and then place boundaries on that part of the LCS industry reviewed by the study team. The LCS industry--itself a subset of the overarching defense industry--contains multiple elements, to include combat and tactical vehicles, sensors, networks, small arms, clothing, ammunition, bridging systems, and so forth (i.e., virtually anything that supports the Soldier or Marine in peace and war). While all these subsets contribute to the fight, and are important in their own right, this year's study focused only on the combat vehicles and systems sector, and to a lesser degree on the tactical wheeled vehicles sector. Hence, for our purposes here, when we use the term "LCS industry," we use it loosely to refer to just these two sectors.

Throughout this report, we will refer to further breakouts within these two sectors. Hence, we must be able to mentally sort the industry in multiple ways. The tables below show three sorting taxonomies, along with their generally recognized delineations.

### *LCS Industry Sorting Taxonomies*

<i>Sort by Size</i>	<i>Sort by Purpose</i>	<i>Sort by Work Breakdown Structure</i>
Light (0 - 20 Ton)	Tactical Wheeled Vehicles (trucks and utility vehicles)	Lower tier vendors and materials
Medium (20 - 40 Ton)	Wheeled Combat Vehicles	First tier sub-system providers (e.g., engines, transmissions)
Heavy ( > 40 Ton)	Tracked Combat Vehicles	Vehicle system providers
		Lead System Integrators (LSI)

The Lead System Integrator (LSI) is a new concept for the LCS industry, and stems from the aforementioned Army flagship program, FCS, which consists of 18 separate systems, plus an integrating network, plus the Soldier for which FCS exists (i.e., this is the genesis of the often cited "18+1+1" phrase). The LSI is the contractor (Boeing in the case of FCS) charged with making the system of systems work as one--no small task. The rest of the categories are self-explanatory, but we must make several points before moving on. First, because the US LCS industry is monopsonistic (i.e., the DoD is essentially the only customer), for industrial base reasons, the DoD must preserve (1) at least one sourcing option for each category in the above table, preferably a US source, and ideally (2) competition within each category in order to drive lower cost and innovation, even if it means looking at off-shore sources. Second, for any of the three sorting taxonomies in the above tables, as we move down a column, the reliance on commercial technologies diminishes. Reliance on commercial technologies has its pros and cons, and *understanding the magnitude of reliance* goes far in explaining both prime and vendor behaviors, and the DoD's strategies for preserving each category.

## GOVERNMENT: GOALS AND ROLES

The US government plays a large role in the LCS industry because the government, in effect, is *the* industry hub. As a rule, economists prefer<sup>1</sup> minimal government interference in the

market place (i.e., a "laissez-faire" approach) because the alternative--regulation--often leads to inefficiency and excess costs (Baumol & Blinder, 2006, p. 262). Yet, this rule of thumb does *not* hold for a monopsonistic<sup>ii</sup> industry with few suppliers, such as LCS. *Hence, in addition to its obvious role as customer, the government's overarching role in the LCS industry is that of regulator.* In these roles, the government affects nearly every aspect of how the industry conducts business. The government regulates the industry to achieve four broad goals: (1) maintain the health of the industrial base to ensure its availability and responsiveness, (2) protect LCS technologies via export restrictions, (3) ensure the efficient, honest, and fair use of taxpayer dollars, and (4) channel the bulk of taxpayer defense dollars back into the overall US economy.

The DoD regulates the health of the LCS industry to maintain a "reliable, cost-effective, and sufficient" (AICR, 2006) LCS industrial base. As Baumol & Blinder note, an unregulated market does not "readily provide public goods, such as national defense" (2006, p. 308). OIF is proving, in spades, the value of a robust--if not redundant and at times underutilized--industrial base. The DoD maintains LCS industry health using multiple tools.<sup>iii</sup> First and foremost, the DoD attempts to be a predictable customer because "stable, robust DoD funding is the primary factor in sustaining...industrial capabilities" (AICR, 2006). The DoD shows commitment to private industry by forecasting multiple years of demand in the annual President's Budget (PB) submittal to Congress. Second, to simultaneously preserve a healthy *organic* system, the DoD maintains a core depot maintenance capability and ensures at least 50% of the depot-level work is completed by federal employees, as required by 10 U.S.C. 2466 (AOIB, 2005). To comply with this so-called "50/50 law," depots and private industry forge innovative partnering relationships that maintain the health of the public-private LCS industrial base, while also preserving a surge capacity. We shall have more to say--both positives and negatives--about partnerships later. Third, to prevent LCS vendors from exiting the market, the DoD employs measures that transfer risk from the vendors to the DoD, to include "cost-plus" development contracts, government-owned contractor-operated (GOCO) facilities that reduce the need for large capital investments, multi-year contracting, progress payments for work not completed, and fast and reliable bill payments. Finally, when all else fails, the DoD<sup>iv</sup> can assess vendor and capability areas, and makes deliberate investments to preserve the vendor or capability, if necessary (White, 1996a).

At the same time the DoD attempts to *maintain* a healthy LCS industry via stable and predictable demand, the DoD also regulates (i.e., reduces) external LCS demand by implementing export restrictions via the International Traffic in Arms Regulations<sup>v</sup> (ITAR) (GB, 2005). While export restrictions run counter to the DoD's own efforts to bolster demand, they are necessary for protecting critical LCS capabilities. Vendors must obtain an export license<sup>vi</sup> from the Department of State to sell items on the US Munitions List; most LCS items *are* on the list, to include tanks and military trucks (USML, 2005). Yet, the DoD recognizes the value in approving export requests because exports provide quality weapons to our allies, strengthen the LCS domestic industry, reduce overhead rates for US procurements, improve ally relationships, improve the overall US trade imbalance, and assure ally interoperability.

The third form of regulation relates to being good stewards of taxpayer dollars by ensuring the LCS procurement system is efficient, honest, and fair. For example, the DoD employs the Federal Acquisition Regulations (FAR) and other DoD directives that require<sup>vii</sup> competition,<sup>viii</sup> to include anti-competitive assessments<sup>ix</sup> related to proposed defense industry mergers and acquisitions (White, 1996b). To further ensure efficiency and honesty, the DoD requires LCS contractors to employ auditing tools--such as cost accounting systems (e.g., Earned

Value Management Systems, or EVMS)--and allow in-plant DoD auditors and oversight.

Finally, the government prefers to channel the bulk of taxpayer defense dollars back into the overall US economy, from whence it came, for obvious reasons. The Buy American Act, which places limits on US government purchases of foreign supplies (Lorell, 2002), is the principal means for assuring the bulk of DoD LCS dollars stay within the US. Additionally, the Berry Amendment requires (see Appendix A for a complete description of Berry Amendment requirements), among other things, that the DoD procure specialty metals "melted in steel manufacturing facilities located within the United States" (DFARS, 2004). Titanium, a specialty metal that falls under the Berry Amendment provisions, is of particular significance to the LCS industry because its use is becoming more prevalent and primes have been citing difficulties in obtaining it at affordable prices, causing many in industry to call for Berry Amendment reform.

## CURRENT CONDITIONS

Porter's "Five Forces" model (1980, p. 4) offers a framework for capturing the current conditions within the LCS industry as they relate to the primary industry stakeholders.<sup>x</sup> For our purposes, we shall modify Porter's model<sup>xi</sup> and examine four areas: industry competitors and competitive determinants, suppliers, demand (i.e., Porter's buyers), and potential entrants.

### Industry Competitors and Competitive Determinants

#### *Combat Vehicle (Tracked and Wheeled) Competitors*

Two armored combat vehicle prime contractors predominately support the DoD: BAE Systems (Land and Armament Ground Systems Division), and General Dynamics Land Systems (GDLS), a division of General Dynamics Corporation. The tracked armored combat vehicles produced by these two companies include the M1 Abrams tank, M2/3 Bradley infantry fighting vehicle, M109 self-propelled howitzer, M88 recovery vehicle, M9 armored combat earthmover, M113 family of vehicles, as well as other systems such as the Marine Corps Amphibious Assault Vehicle (AAV) and Expeditionary Fighting Vehicle (EFV). While tracked armored combat vehicles are designed to traverse the harshest terrain, wheeled armored combat vehicles are lighter and easier to transport, maintain, and support. The primary wheeled armored combat vehicles produced by BAE Systems and GDLS include the family of Light Armored Vehicles (LAV) and the Stryker family of vehicles.

Both BAE Systems and GDLS share a large role in FCS. Of the eight FCS Manned Ground Vehicles (MGVs), BAE Systems has development leadership for five MGVs, while GDLS has the remaining three. However, because there is common development work across the eight MGVs, the FCS program opted to *equally* split the dollarized development workload. This solution cleverly keeps both contractors actively "in the game." Of note, because neither contractor is assured of being selected for the production contract, the DoD can expect competition to remain keen between BAE Systems and GDLS. Given that FCS holds the bulk of future Army procurement funds, both contractors will need to win production rights.

#### *Tactical Wheeled Vehicle Competitors*

Hardened or armored tactical wheeled vehicles (TWV) have dramatically risen in importance on today's battlefield. The three major domestic competitors include Stewart & Stevenson, Oshkosh Truck Corporation, and AM General. The Army's current TWV fleet is

composed of the M915 series of trucks, Palletized Load System (PLS), Heavy Equipment Transporter (HET), Heavy Expanded Mobility Tactical Truck (HEMTT), Family of Medium Tactical Vehicles (FMTV), and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) fleet of vehicles, as well as their associated trailers (Erwin, 2006).

Similar to the BAE and UDLP merger last year, the tactical wheeled vehicle market is now working through a period of consolidations. Armor Holdings recently announced plans to acquire Stewart & Stevenson. Armor Holdings, headquartered in Jacksonville, Florida, is acquiring Stewart & Stevenson in order to obtain the FMTV and increase their market share in the LCS industry. This \$755 million deal, while not yet final, will make Armor Holdings the US Army's number one defense contractor for armored tactical wheeled vehicles (Hannaford, 2006). Stewart & Stevenson's closest competitive rival is Oshkosh Truck Corporation, which makes the heavier HET, HEMTT and PLS line of trucks. AM General produces the HMMWV. All three TWV competitors are on solid footing as current suppliers of tactical wheeled vehicles for the DoD. Oshkosh may be in the best long-term position because they have a healthy commercial truck line, which helps immunize them against defense budget slow downs.

During the next several years, the Army will be evaluating new truck design concepts as part of a program called Future Tactical Truck System (FTTS). Truck manufacturers Stewart & Stevenson, Oshkosh Trucks, and AM General received contract awards for the first phase of FTTS, which was essentially limited to developing and modeling concepts. Interestingly, Lockheed Martin and International Truck and Engine succeeded in winning the second phase of FTTS to demonstrate select concepts. Ideally, what is learned under FTTS will be folded into a new program to replace the Army and Marine Corps fleet of HMMWVs. This new program, while not yet approved for start, is currently being dubbed the Joint Light Tactical Vehicle (JLTV). If JLTV becomes reality, the competition will again be open to all, though Lockheed Martin and International Truck and Engine may have a significant competitive advantage based on their work under FTTS Phase 2. AM General may be in the most need of a JLTV win because their revenues are almost completely generated from the HMMWV family. In that sense, the DoD should expect AM General to aggressively pursue JLTV.

### *Consolidations*

As mentioned, both the combat vehicle segment and the tactical wheeled vehicle segment have seen the continuing effects of mergers and acquisitions. If this trend continues, we should expect competitive forces to contract, perhaps to an undesirable state. Some in the industry speculate there may be one more major round of mergers in the overall defense industry, although it is difficult to ascertain how given there are already very few players. Appendix B provides a snapshot of consolidations within the US and Europe over the past 15 years.

### *Strategic Alliances: Depot and Corporate Partnerships*

Another recent trend affecting competition is the increase in partnering agreements between government depots and the major LCS competitors. For years, DoD installations--like Anniston Army Depot (ANAD)--were thought to be incompatible with private industry due to conflicting motives, operations, and cultures. However, this has proven to be incorrect. ANAD has entered into over 30 fruitful public-private partnerships (PPPs) with industry leaders (AAD, 2005). Partnering is a business alliance that ideally optimizes the best practices and resources of the private and public sectors in the execution of many defense-manufacturing programs. For example, GDLS and ANAD partner together on programs such as Abrams upgrades, Fox

upgrades, and Stryker final assembly. These partnering initiatives include work-share programs, facility use agreements, and reimbursable contract actions (GDLS, 2006).

The DoD must carefully *balance* the affects of partnering on competition. On one hand, partnering inhibits competition because it appears to allow "work for all." On the other hand, partnering can allow more than one competitor to "stay in the game," thereby *maintaining* future competition. The recent proliferation of partnering might suggest the LCS industry is now out of balance. To that end, in the Challenges and Opportunities section of this paper, we shall discuss partnering further; specifically, we shall assess whether partnering has gone too far.

### *Funding Levels*

Supplemental funding resulting from current operations and the overarching GWOT provided a big boost to LCS contractors and their depot partners. This increased workload helped employ excess capacity, improved efficiency, and greatly increased the overall health of the industry. However, there is considerable concern in the industry that a drawdown of current operations will be accompanied immediately by a funding contraction. Such a defense spending decrease will likely enhance the competitive forces, as the few remaining competitors push hard to secure the remaining dollars. While enhancing competition is certainly desirable, like partnering, the DoD must monitor industry behaviors once funding levels begin to decrease. For example, in order for FCS to succeed, the two MGVP providers, BAE Systems and GDLS, must continue to exist and collaborate in the face of an increase in overall competition and a decrease in funding. Similarly, the DoD must ensure potential JLTV bidders remain in the industry--or be prepared to source the HMMWV replacement from offshore.

### Suppliers

Like other defense industries, the LCS industry draws from a large list of suppliers. However, the key first-tier subsystem provider base, most notably for engines and transmissions, is somewhat thin. Many of these first-tier suppliers, such as Allison Transmission and MTU Detroit Diesel, draw the majority of their revenue from the commercial market. For this reason, the DoD should not expect these suppliers to forever see a business case for remaining in the military market. Uncertainty regarding future budgets further exacerbates the problem.

Thus far, the Army and Marine Corps have been able to maintain their first-tier suppliers, primarily because of supplemental funding. However, out-year funding, in the absence of supplemental funding, places the DoD at risk. The DoD must work to stabilize future funding profiles for their key suppliers by implementing all available tools (e.g., multi-year contracts, expanded share of repair and overhaul work<sup>xii</sup>).

### Demand

The Army and Marine Corps generate requirements, and subsequently demand, by analyzing existing capabilities against expectations and direction established in senior level planning guidance. Further, because there is some overlap in their equipment needs, they work together via the Army-Marine Corps board to de-conflict duplicative requirements. While this "textbook" process runs, the so-called "Iron Triangle"--metaphorically formed by the combined actions and reactions of the DoD, congress, and industry--provides external "corrections" along the way that impact the eventual demand as viewed by the industry.

Acquisition is a political and bureaucratic process. Different factors motivate each member of the Iron Triangle to exert influence. The DoD approves the requirements it views are best for national defense. Yet, the DoD often changes its mind regarding what programs it needs in the future, leaving industry to "war-game" possible demand futures. The congress exerts influence to balance national security with their constituent's needs, or because they view a program's health differently than does the DoD. For example, some in Congress are calling for the DoD to decide by September 2008 whether to continue with the FCS program (John & Roque, 2006), even though the program is not due for a milestone decision. The industry exerts influence to secure future profits for their shareholders. As such, the industry's behaviors at times run counter to service requirements or acquisition strategies (e.g., full and open competition).

This demand environment results in a substantial level of uncertainty across the LCS industry for all stakeholders, DoD included. Hence, it is no surprise industry is reluctant to invest company funds in recapitalization and internal research and development efforts. That said, current equipment usage rates, coupled with large Army and Marine investment accounts, have raised significantly the potential for new entrants, a subject to which we now turn.

### Potential Entrants

Significant barriers to entry exist in the LCS industry because of the tremendous capital investment required. The major defense contractors not currently involved at the systems level--Lockheed Martin, Northrop Grumman, and Raytheon--may yet follow Boeing's path. Boeing made a strategic decision to give up being just a component manufacturer for LCS in order to become a system designer for the Army. Entry options for the others might include the acquisition of niche companies from Europe or the US in order to win an Army or Marine Corps future development program. With the Army and Marine Corps potentially infusing \$2 billion a year over the next 20 years, LCS is certainly a lucrative market. Lockheed Martin has already started this strategy with the acquisition of UK-based HMT Vehicles Ltd., to manufacture under license four-wheel drive and six-wheel drive trucks in the US. Lockheed Martin intends to incorporate HMT designs into its US programs, such as FTTS--more on that shortly.

Although not a new entrant per se, another player worth mentioning is Textron Inc., a \$10 billion multi-industry company with 44,000 employees in 40 countries. Textron found its way to the US LCS market with its Armored Security Vehicle (ASV). This indicates that capable manufacturers can still fill a niche need. Textron is now on contract to deliver nearly 1,000 ASVs to the US Army. Textron is also a licensed manufacturer of the Dingo 2 All Protected Vehicle from Krauss-Maffei Wegmann (KMW) of Germany.

The US truck company International Truck and Engine, better known for its commercial trucks, recently entered the military market. US Army Tank-Automotive and Armaments Command (TACOM) awarded International a contract to provide vehicles to the Afghanistan National Army. The Army also selected International to compete to re-engine the HMMWV.

As mentioned, the Army also recently selected Lockheed Martin and International Truck and Engine as the only two contractors for FTTS Phase 2. Both will build demonstrator armored vehicles that assess key technologies and future Army concepts. Of note, the two companies are not traditional suppliers of light and medium tactical vehicles. Yet, they are among the companies that have developed state-of-the-art technologies applicable to future combat needs.

Finally, no new entrant discussion would be complete without mentioning General Purpose Vehicles (GPV). GPV is attempting to penetrate the wheeled combat vehicle and

armored tactical wheeled vehicle arenas with its 4x4, 6x6, 8x8, and 10x10 family of vehicles. This system of vehicles shares many components and subassemblies, thereby reducing the logistical footprint. It appears GPV wishes to avoid being a large-scale producer by licensing their designs to other companies for production instead. GPV's strategy to design but not enter full production highlights the key barrier to entry of the LCS industry: large capital investment.

## **CHALLENGES AND OPPORTUNITIES**

The study team noted numerous challenges to and opportunities for improving how the DoD acquires and sustains land combat systems. Let's consider the five that stood out most: the growing use of partnerships, new methods of support, the European LCS industry as a model, the Lead System Integrator concept, and the new emphasis on armor.

### Growing Use of Partnerships

Proponents tout partnerships as an opportunity to leverage the best of the public and private sectors, while maintaining the industrial capabilities of both. To realize these benefits, both congress and the DoD have been encouraging Public-Private Partnerships (PPPs) (GAO, 2003). The LCS industry has answered the call. With a few years of partnership experience behind us, it is time to assess whether any mid-course corrections might be needed.

A public private partnership is an agreement between an organic depot and private industry to perform work or use facilities and equipment. Three typical types of partnerships exist. The first applies to the use of government facilities, equipment, and personnel to perform maintenance or support the production of goods for the private sector. The second leverages joint capabilities, and includes a work sharing arrangement for facilities or personnel. The third, and most commonly used at depots today, involves private companies leasing government facilities or equipment as part of a contract to deliver a service to the government (DUSD, 2006).

The need for partnerships arose when program managers developed an appetite for contractor performance-based maintenance contracts under Contractor Logistics Support (CLS) arrangements. Because CLS contracts still require core and 50/50 law compliance, partnership held promise for having a CLS contract while also complying with these laws. Congress responded by providing the basis for establishing partnerships in Title 10 U.S.C. 2474.

The LCS industry in recent years has experienced an explosion of partnerships touted to save money, leverage the best of industry, and preserve the industrial base. Indeed, the study team noted partnerships in a variety of shapes and sizes. For example, ANAD and GDLS formed a partnership to perform M1 upgrades; ANAD disassembles the hull, demilitarizes the turret, overhauls subassemblies, and then ships everything to GDLS in Lima, Ohio for re-build. The Stryker vehicle final assembly is an example of a facilities usage partnership, again between ANAD and GDLS. ANAD provides the facilities, while GDLS performs final assembly. The Marines' HEMTT partnership involves Albany Depot performing engine removal and MTU Detroit Diesel performing the engine repair work. Finally, though not strictly a PPP, the recent 50/50 work-split decision on FCS MGVs appears to be grounded on the same rationale, namely leveraging the best of breed and preserving the industrial base.

The study team noted several concerns that deserve reflection. First, some partnerships involve extensive long-distance hand offs and transportation costs. Second, at times the value-added by each stop does not justify the added overhead, especially when either end of the partnership can often accomplish the entire job. Third, it seems doubtful that either the depot or

contractor would prefer such odd workflows if given a choice. Fourth, formal PPPs, as well as government endorsed contractor teaming arrangements, can hinder competition, efficiency, and innovation, and if left unchecked, hold potential for collusive behaviors. While partnerships hold promise, the DoD might consider re-assessing the rule set for implementation. Partnerships that duplicate capability, or arbitrarily and equally split work at two different and distant locations should be examined closely. It is not clear the benefits of preserving a larger industrial and job base exceed the efficiencies that might otherwise be gained by pushing for more competition.

### New Methods of Support

Contractor maintenance on the battlefield of OEF and OIF has been well tested--and largely found to be successful. An issue, then, worth considering is whether its use ought to be expanded. We may not have a choice, given that the rising complexity of land combat systems almost mandates that contractors support them--both during war and in garrison. To get an idea on what future challenges the LCS industry can expect, let's examine recent experiences on the Stryker program, after first defining some terms.

The DoD defines CLS as the performance of maintenance or materiel management functions for a DoD system by a commercial activity historically done on an interim basis until systems support can be transitioned to an organic capability. Current policy now allows for the provision of system support by contractors on a long-term basis (USAIG, 2004), for those services not coded as "core." In the traditional CLS application (i.e., non-PBL), the more equipment breaks, the more work there is to do, and the more profit available for industry. In this case, traditional CLS provides little incentive to the contractor to maintain a high operational readiness rate (ORR)--in fact, ironically, the contractor gets more work when the ORR declines.

The DoD describes Performance-Based Logistics (PBL) as the process of identifying a level of performance required by the warfighter, and then negotiating a performance-based arrangement between the government and the vendor or government facility to provide long-term total system support for a weapon system at a fixed level of annual funding (GAO, 2005). In simple terms, PBL procures outcomes, not products or services. As such, there is a high incentive under PBL for industry to maintain high ORRs.

The Stryker program entered into a PBL-based CLS contract with GDLS to perform all Stryker depot and field maintenance. This innovative contract requires GDLS to maintain a 90 percent ORR. How does this work in the field? A Stryker Brigade Combat Team (SBCT) includes roughly 1,200 Soldiers augmented by 185 contractors. Soldiers perform only preventative maintenance checks and services, while the contractor performs *everything* else. The Stryker CLS effort has had both successes and challenges.

The primary success of the Stryker CLS story is the tremendous ORR during combat. In Iraq, the contractor can normally return vehicles in a near-catastrophic state back to duty within 48 hours, thereby allowing the SBCT to maintain an overall ORR greater than 90 percent. This is an incredible success, given the SBCT area of operation (AO) exceeds 2,500 square kilometers. No other family of vehicles sustains the same level of performance in similar environments.

Stryker maintenance has also faced several challenges. First, the Army sometimes "hands over" Stryker vehicles that have been modified for reasons of operational necessity. When the Army turns in an altered vehicle for battle damage repair, by contract GDLS must restore it to its unaltered configuration. For example, on the Stryker Mortar Carrier (MC) variant, some commanders remove the vehicle-mounted mortar system so the vehicle could be used as a troop carrier. When an MC variant sustains battle damage, the contractor must return it to its original

configuration, even when the mortar system cannot be located. Future PBL CLS LCS contracts must contain provisions for handling such unauthorized field modifications.

Second, contractor personnel subject themselves to safety risks when operating in the AO. To date, GDLS has not had difficulty getting employees to volunteer. If that situation changes because of the intensity of a conflict, the Army will be challenged to sustain initial fighting in the absence of contract support and with diminished organic skills. According to Kallock & Williams (2004), at the beginning of the Iraq war, some units were in continuous combat for 21 days without receiving a single repair part. The ingenuity of America's Soldiers and Marines once again came through. But, as LCS become even more complex, that may not happen next time. These challenges notwithstanding, the Stryker program proves that CLS, particularly its PBL implementation, should be considered for other land combat systems.

### European LCS Industry as a Model

Europe and the US differ sharply in how they develop land combat systems. While the US LCS industry *undeniably* develops and fields world-class systems, and may be operating as intended, it is also *undeniably* slow and expensive. Therefore, the European model may hold promise for improving upon the US system. To that end, let's compare and contrast the two to determine what features of the European system the US might wish to leverage. The table below compares the two national industries along eight relevant dimensions.

	<b>US</b>	<b>Europe</b>
Market structure	Monopsony	Export-driven
R&D financing source	DoD (largely)	Contractor (largely)
Risk tolerance	High	Low
R&D budgeting method	Cost plus	Fixed price
Solutions	Unique	Commercial off the Shelf (COTS)/ Military off the shelf (MOTS)
Ability to pay a premium	High	Low
Engine emission standards	Exempt	Euro-2, and higher later
Field support	Contractor	Organic

For the US, these dimensions relate to an abundance of financial resources available to the single customer, the DoD. Because of the DoD's relatively large budgets, the DoD can afford to finance development programs that employ high risk and immature technologies. To do such programs, contractors require the DoD to assume the risk, and therefore they prefer cost plus type contracts. The net result is that the DoD tends to develop unique, leading-edge solutions and is willing to pay a price premium to be the world's technology leader. Though the DoD espouses using Cost as An Independent Variable (CAIV) principles, in practice the DoD generally compromises on performance only as a last resort. Consistent with that theme, DoD combat vehicle engines are exempt from US vehicle emission standards. Complying with emission standards requires different designs, or add-on scrubbing sub-systems, both which reduce the engine power per volume ratio and steal available real estate from other, more mission-related purposes. Finally, because US systems are becoming complex, the need for contractor support in the battlefield continues to rise, as the Stryker program discussed earlier shows.

In contrast, European defense budgets do not support pushing technology beyond the state of the art. Because the contractors often must finance the development themselves, they tend to rely on more-proven, lower risk technologies (i.e., Technology Readiness Level (TRL) 6

to 7, using US vernacular). Hence, they develop LCS under fixed price arrangements. Because the European contractors drive the bulk of their revenue from exports, they tend to generate fully developed solutions, and then market and compete them (i.e., COTS/MOTS). One goal of the European Defense Agency (EDA) is to minimize duplicate development efforts, and competitions based on fully developed products (Tigner, 2006). Additionally, European land combat systems must meet the same European emission standards, currently "Euro-2," as other vehicles. Once Europe adopts "Euro-4" emission standards, LCS contractors will likely be forced to use vehicle space for additional emissions reducing sub-systems.

Given the success of the US military machine, and as long as US worldwide commitments and large budgets remain, it is unlikely the US model will change. However, the DoD might consider applying a variation of the European model to select programs that do not require uncompromised performance. The study team envisions future LCS developed under a mix of cost plus and fixed price instruments, thereby achieving the best of both models.

### Lead System Integrator (LSI) Concept

FCS is an Army initiative to build a brigade-sized structure that is, from the beginning, designed as a System of Systems (SOS). This SOS combines Families of Systems (FOS)--such as Manned Ground Vehicles (MGVs), Unmanned Ground Vehicles (UGVs), and Unmanned Air Vehicles (UAVs)--via a sophisticated network and largely common software and hardware. The intent is to enhance situational awareness, decrease target acquisition time, decrease sensor-to-shooter times, and allow a brigade to fight at a time and place of their choosing. Overall, this \$160 billion program, involving 23 prime and support contractors, will spin out FCS technology into 18 Brigade Combat Teams (BCTs), and then beginning in 2014, start fielding full FCS brigades, ending in the late 2020s, with a total of 35+ fully fielded and networked brigades.

As mentioned earlier, the Army's decision to use an LSI for FCS program management is a first within the LCS industry. However, the selection of the Boeing/Science Applications International Corporation (SAIC) as the LSI team has been somewhat controversial. The Congressional Research Service identifies two of the main criticisms of this decision as "the Army's potential lack of control over the program and Boeing's past ethical difficulties." (Feickert, 2005). The real thrust of the criticism over the Army's lack of control is that Boeing has too much control over subcontracting decisions and funds distribution. The study team did not find this to be the case. The FCS "One Team," which included the Army as a key team member, evaluated subcontractor proposals and made best value source selections, resulting in zero protests. This best value source selection process is a success story in how the government and contractor can successfully work together.

However, the study team sensed that the FCS LSI arrangement has caused tension between the FCS MGV subcontractors. Part of this tension might be because the two principal experts in the US LCS industry are now working for a company new to the LCS arena. Although FCS is only in the System Design and Development (SDD) phase, the subcontractors appear anxious about their role in production and Boeing's ability to influence that decision.

### New Emphasis on Armor

Prior to OIF, few of the DoD's tactical wheeled vehicles, to include the HMMWV, were up-armored. Once insurgent tactics evolved, commanders quickly realized their shortcomings in armor protection. Units in theater in 2003 and early 2004 resorted to using cut steel, sheet metal, scrap from damaged equipment, and whatever else they could find to add protection, leading to

the phrase “hillbilly armor.” Two problems arose from these makeshift solutions.

First, they were largely untested--and in some cases did more harm than good. In response to the casualties coming from Iraq, Congress pressured the DoD to resolve the shortfall in armor solutions (Hodge, 2005). Second, the added weight of the hillbilly armor greatly increased the wear and tear on vehicle brake, suspension, and transmission systems--and also degraded overall vehicle performance. This added weight, coupled with a high operational tempo, can wear a vehicle out 12 times faster than in garrison (HASC, 2006).

The DoD now has an established Long Term Armor Strategy (LTAS). The LTAS is an Army-led joint service initiative to establish a common set of ballistic standards, materials, and armor applications to best support TWVs and other equipment. For example, the LTAS established common requirements for TWV armoring kits. Future armor protection will be applied in two "layers," called the A-kit and B-kit. The A-kit affixes to the sub frame and undercarriage, while the B-kit contains removable panels common throughout the fleet of TWVs. Additionally, B-kits can be tailored for varying threat levels (Gourley, 2004).

As the DoD looks to develop future TWVs (e.g., the JLTV program), affordability will quickly become a challenge. For example, today's HMMWVs range in price from \$50 - 150 thousand, depending on the variant--and that is for a vehicle whose chassis and other parts were not designed for extensive armor weight. We can expect the future HMMWV replacement, whose design will trade mobility for much higher survivability, to be much higher in price. The question, then, becomes can the DoD afford to replace its large TWV fleet with vehicles having much more sophisticated design features? Given recent actions by congress, they may not have a choice. If that is the case, in the future we can expect TWV programs will secure a larger share of the DoD LCS budgets than in the past, perhaps to the detriment of increased firepower.

## **OBSERVATIONS**

In addition to the aforementioned challenges and opportunities, the study team noted other LCS industry trends that merit reflection. The study team does not imply these are problems requiring solutions. Rather, we leave it to senior decision makers to assess whether each observation reflects the system as it is intended to operate, or are issues requiring action.

### **Observation: Politics Sometimes Drives Demand**

The LCS industry, like other defense industries, is highly politicized. The "Iron Triangle" consisting of industry, the DoD, and Congress must work as partners, while preserving their unique roles. This political process--to include lobbying, demands for perfect armoring solutions from parents, and so forth--at times drives demand in unexpected ways. For example, the political process bolstered funds for HMMWV production and Abrams overhauls, and also set a requirement for rapid *and comprehensive* armoring of soldiers and vehicles.

### **Observation: Globalization Does Not Bypass the LCS Industry**

Globalization impacts the LCS industry just as it does other sectors of the US economy. LCS primes increasingly turn to non-US sources for both parts and production line tooling. For example, 10% of the EFV is sourced from off-shore (primarily driven by the MTU-supplied engine). Additionally, MTU Detroit Diesel--far and away the market leader for defense-related diesel engines--draws heavily from a European vendor base. Another interesting globalization twist is the foreign acquisition of US LCS supplier plants. For example, the Committee on

Foreign Investments in the United States (CFIUS) just approved the purchase of Doncasters Group Ltd.,--to include its plant in Georgia that produces turbine engine parts for the Abrams tank--by Dubai International Capital LLC (Bluestein, 2006). These trends will likely continue and do not necessarily require a change to the Buy American legislation.<sup>xiii</sup> However, if production tooling continues to move off-shore, that conclusion may no longer hold.

**Observation: Power of Global Mergers is Not Fully Tapped**

Mergers and acquisitions further cloud the meaning of globalization and the need for Buy American legislation. For example, in 2005 MTU (Germany) acquired Detroit Diesel, which was then acquired by EQT, a Swedish investment banking company; and BAE Systems (UK) acquired United Defense Limited Partnership (UDLP).<sup>xiv</sup> In the case of BAE, they are now a global defense company, with business units covering the sea, air, and land mediums. Yet, the requirement for complex firewalls undermines the potential synergies of these global mergers.

**Observation: Expect Software Integration to be Challenging**

LCS systems have become software intensive. As an extreme example, the Army estimates FCS will have 34 million source lines of code (SLOC), some 7 times more than the F-22A fighter program, which itself struggled to achieve stable software. Analogous to past aircraft industry actions, LCS prime contractors are developing software integration laboratories (SILs) to deal with this new environment. The LCS industry should expect its software integration efforts to be difficult and uncertain, and build cost and schedule estimates accordingly.

**Observation: Concern Exists that Today's Needs May "Delay" the Future**

There is some level of uncertainty regarding whether the Army can continue to pay for OIF-related costs, while modularizing today's Army and developing FCS. The Marines face a similar challenge. The Army and Marines desire supplemental funding to continue for two years after OIF ends. Yet, some predict the DoD or Congress will ramp down spending immediately. If so, the Army and Marines may be forced to trade away investments in the future in order to reset and modularize the force today. This uncertainty about the future fuels systemic instabilities that discourage investments in physical and human capital.

**Observation: Sustainment Work is Becoming Increasingly Valuable**

Sustainment contracts make up a growing revenue source for LCS contractors. For example, Stryker sustainment provides 20% of all GDLS revenue. As a result, in the future we can expect industry to aggressively compete first for the production contract, with an expectation the winner will then have an advantage at being selected for the post-production support contracts.

**Observation: Benefits of Depots Extend Beyond Just "Core"**

The existence of government depots, such as ANAD, adds benefit beyond ensuring a core depot capability. ANAD provides competition for nearly every LCS prime and first tier vendor (e.g., Allison). Such competition increases alternatives and results in more efficiency and innovation, even within companies (e.g., GDLS chose ANAD for Stryker finally assembly rather than the Joint Systems Manufacturing Center (JSMC)). Additionally, depots provide an invaluable surge capability, as proven during OIF.

**Observation: Interstate Supplier Base Lowers Cost and Bolsters Support**

Internet-based technologies and improved supplier management allow LCS primes to draw from a multi-state supplier base that offers quality at a competitive price, while assuring broad support from many members of Congress.

**Observation: Industry is Creatively Managing its Workforce**

Multiple industry players employ innovative human resource strategies that allow them to hire qualified employees, manage average workforce age, and be good neighbors within their communities. For example, ANAD works with the local high school to offer internships and a path to be regular employees and Aberdeen Test Center (ATC) offers internships to college engineering students. In the case of ANAD, they are considered the employer of choice in their region and have even hired manufacturing experience away from others (e.g., the Honda plant).

**Observation: Co-located Competitors Compete for and Share Employees**

Co-location of depot and contractor programs can cause the two entities to compete with each other for the local workforce. This is especially prevalent at ANAD, where GDLS performs final assembly of the Stryker, while drawing from the same labor pool as ANAD. Co-location also offers benefits, in that the competitors can tap into each other's workforce--using partnering and other contractual arrangements--for surge needs.

**Observation: Tactical Vehicles Must Incorporate Some Combat Vehicle Traits**

Today's tracked and wheeled vehicles operate in environments--and carry unplanned armor payloads--for which they were not originally designed. On the whole, these vehicles are proving their inherent robustness for these new missions. Yet, because there is no longer a "rear area" in the historical sense, the lines are now blurred regarding what is a tactical vehicle and what is a combat vehicle. In the future, all vehicles may be required to be combat vehicles to some extent. For example, the proposed HMMWV replacement, called the Joint Light Tactical Vehicle (JLTV), will emphasize combat vehicle traits at least as much as utility vehicle traits. This will require trading mobility for enhanced survivability and vehicle modularity in the future.

**Observation: Buying TDPs Does Not Assure Quality Re-Procurements**

Ownership of Technical Data Packages (TDPs) does not assure the DoD can procure systems and parts of Original Equipment Manufacturer (OEM)-like quality from non-OEM vendors. A prime example is the Allison X1100 transmission for the Abrams tank family. The government procurement process tends to trade off quality for cost when re-procuring parts, or is unable to assemble the parts using sufficient quality standards, in spite of owning the TDP. In that light, the DoD must carefully consider buying TDPs for complex systems, and improve its supplier qualification standards when it *does* decide to buy TDPs for re-procurement purposes.

**Observation: FCS LSI Strategy is Changing the Industry Structure**

FCS will shape the future of the LCS industry because it affects nearly every industry vendor. In fact, FCS is shaking up the structure within the industry because primes of the past (e.g., BAE and GDLS) are now subcontractors to the LSI (Boeing). This new structure drives new behaviors that must be monitored in the near term until they are better understood.

**Observation: FCS Budgeting Strategy Holds Both Risk and Reward Potential**

The FCS concept and budgeting strategy bundles 18 programs plus two major integrations into a single, large program. This strategy offers multiple advantages (keeps pressure on the LSI to build an integrated solution, retains integrity of the FCS concept of operations, and, perhaps, makes the budget easier to defend) and disadvantages (provides larger target for cuts, reduces spending insight for congress, and holds 18 plus programs--and their associated contractors--hostage to total program success and the Army's ability to defend the overall program). The Army must continue to explain FCS to all stakeholders and keep *future* programs that tap into the FCS network as separately budgeted items in order to maintain an explainable cost baseline.

**Observation: Innovations are Often Led by "Second Rank" Primes**

Having Boeing, a non-traditional LCS prime, lead the Army's flagship FCS program is consistent with how breakthrough technological innovations occur in the aerospace industry. A RAND study found that aerospace technological innovations are almost always led by "second rank" prime contractors<sup>xv</sup> (Hebert, 2005). For example, Lockheed Martin and Northrop Grumman led the Air Force into the stealth age (F-117, F-22 and B-2), at the chagrin of previous industry leaders McDonnell Douglas and General Dynamics (F-15 and F-16).

**Observation: Managing Obsolescence Will Rise in Importance**

As FCS demonstrates, land combat systems are becoming increasingly networked, and therefore dependent on electronics and software. Because these components are based heavily on commercial technologies, and DoD's production rates alone are too low to keep these commercial parts in production, parts obsolescence will likely be a large challenge. Additionally, without a well-crafted *and funded* obsolescence management plan, systems like FCS can expand into having multiple hardware and software configurations, further complicating supportability.

**Observation: FCS Acquisition Strategy for Production Has Pros and Cons**

The Army's FCS MGV strategy to compete production is an effective method for keeping both BAE and GDLS innovative, efficient, and hungry (i.e., they are not assured of producing the MGV variants for which they have design responsibility). This strategy is not without precedent. For example, UDLP developed the Paladin vehicle, and even produced the LRIP units, yet lost the production contract to the FMC Corp.<sup>xvi</sup> However, because FCS is a family of systems, with a separate LSI, the DoD must accept that this strategy may also discourage full and open sharing amongst the LSI and the two MGV developers during the SDD phase.

**Observation: Program Interdependencies Require Thoughtful Management**

FCS reliance on feeder programs, such as the Joint Tactical Radio System (JTRS), makes it--and other LCS programs--vulnerable to forces outside its control. Feeder program delays will likely result in some combination of increased cost, delayed performance (e.g., if JTRS falters, FCS will revert to a backup, but less capable, "wireless router" system), and delayed fielding. Future LCS programs must craft mitigation plans to manage these interdependencies.

**Observation: Plant Facilitization Does Not Always Require DoD Funds**

AM General facilitized their HMMWV plant strictly via AM General funds. This is in contrast to other LCS industry plants that typically have a mix of government-furnished property (GFP) and contractor property. This arrangement encourages AM General to conduct its own business case

for each piece of new production equipment, taking in to account expected future DoD orders. With the help of the HMMWV multi-year procurement contracts, AM General has been able to drive down production costs, and share fixed costs with the commercial H1 vehicle, to the benefit of the DoD and AM General's own profit margin. The MTU Detroit Diesel off-highway engine line has no GFP either. The DoD might consider studying the conditions that allowed these arrangements to form for application to other programs.

**Observation: Partnership Count and Type Are On the Rise**

Partnerships between primes, vendors, and depots--to include nearly every conceivable combination and type of partnership--are on the rise. The ANAD-Honeywell partnership to overhaul the M1 turbine engine appears to be a solid partnership model because it does not duplicate, or arbitrarily and equally split work, at two different locations. Honeywell provides the overhaul kits and on-site engineers at ANAD, while ANAD overhauls the engines.

**Observation: Diesel Engines Are Diverging From Commercial Counterparts**

At a time when much of the LCS industry is attempting to leverage commercial technologies, the diesel engine defense industry<sup>xvii</sup> is diverging from its commercial counterparts because high power, smaller size, low infrared signatures, and durability are more important than lower emissions and their associated low sulfur diesel fuels.

**Observation: Armor Test Process May be Slowing Innovations**

Upstart companies with innovative armoring solutions do not have timely access to government-recognized ballistic testing. Further, when companies *can* get their designs tested, the results are often not shared across projects, causing some testing to be repeated.<sup>xviii</sup> This "barrier to entry" adds cost and may be inhibiting needed solutions from reaching the field.

**Observation: Barriers to Entry are Surmountable**

New entrants<sup>xix</sup> are attempting to penetrate the US LCS industry. For example, General Purpose Vehicles (GPV) offers credible and innovative tactical and light wheeled combat vehicles, Lockheed Martin is attempting to broach the tactical truck market, and Northrop Grumman or Boeing could choose to partner with a European firm, such as KMW or Iveco, to build a future tactical truck. In this last example, the US firm might provide the labor and parts, while the foreign firm provides the technical data package and engineering support (i.e., analogous to US production of the FMTV and Stryker family of vehicles).

**Observation: Seemingly Unique Requirements Can Drive LCS Costs**

The Marines proposed MAGTF Expeditionary Family of Fighting Vehicles (MEFFV) program, designed to replace the LAV and M1A1 fleet and complement the EFV, appears similar to the FCS program in purpose and concept of operation (i.e., both are networked ground systems). Such similarity suggests duplicated effort. Should the MEFFV program become reality, this may be an area for joint development, at least for the network architecture.

**Observation: Affects of 2005-2006 LCS Industry Consolidations are Unclear**

In 2005-2006, consolidation activity included BAE Systems acquiring UDLP, Armor Holdings potentially acquiring Stewart & Stevenson, and MTU acquiring the off-highway part of Detroit Diesel. It is too early to assess the affects of these consolidations on industry competition.

**Observation: Offsets are a Necessary Part of the European LCS Business Model**

In order to compete and win, European defense contractors accept that they must establish a production facility (usually final assembly) and establish a supplier base within the acquiring nation, or assure the acquiring nation of some percentage of export business, often in unrelated industries. Oddly, some of these "offset" arrangements even exceed the contract price. This trend shows the importance to the selling nation of keeping their defense industry viable, and the required politics within the acquiring nation needed to convince their constituency to spend national funds on defense items. Of note, this is analogous to what foreign contractors often must do to secure contracts with the DoD.

**Observation: The European Wheeled Combat Vehicle Segment is Saturated**

Contractors within Europe compete heavily, usually across national boundaries, within the wheeled combat vehicle segment. A quick market survey uncovers multiple capable vehicles, to include Patria's Armored Modular Vehicle (AMV), Steyr's Pandur I/II, Mowag's Piranha, KMW's Boxer, the Iveco/Oto Melara consortium's Centauro and Puma, and GIAT's VBCI. Further, these vehicles are not highly differentiated, leaving the contractors to compete on price, offsets, or some other non-performance factor. It is likely that market forces will drive some of these competitors into mergers and partnerships, and perhaps others into exiting the market.

**Observation: US and European Tactical Wheeled Vehicle Segments are Healthy**

US tactical wheeled vehicle contractors--e.g., Stewart & Stevenson, Oshkosh, and AM General--market primarily to the defense and specialty (e.g., fire trucks) markets, while European tactical wheeled vehicle contractors--e.g., MAN and Iveco--generate most of their revenue from the commercial truck markets. Regardless of this difference in approach, the industrial base for tactical wheeled vehicles in both the US and Europe is healthy and about the right size.

**Observation: State-Owned European Contractors are Progressing Well**

State-owned defense contractors, such as the Bumar Group and Wojskowe Zakłady Mechaniczne Siemianowic (WZMS), continue to make excellent progress in developing and marketing LCS. For example, WZMS teamed with Patria of Finland to build a manufacturing capability and supplier base within Poland to produce the Wolverine for the Polish Army.

**Observation: Fully Globalized Divisions within Europe Benefit from US Ties**

General Dynamics (GD) acquired Steyr of Austria, Mowag of Switzerland, and Santa Barbara Sistemas of Spain to become a full spectrum global LCS provider. GD grouped these European companies under an umbrella division called GD European Land Combat Systems, and kept them separate from their US GDLS division. These European companies receive benefits from being part of the mass of a larger US contractor. For example, having the financial solvency of GD behind them helped Steyr successfully win the Portugal wheeled combat vehicle program.

**FINDINGS AND RECOMMENDATIONS**

While the health of the LCS industry appears strong, much of that strength stems from the extended operations in Iraq.<sup>xx</sup> In effect, OEF/OIF-related supplemental funding is masking symptoms of potential industry troubles. Additionally, other non-operations related concerns

(e.g., FCS cost) exist. The DoD needs to take steps *now* to maintain long-term industry health. To that end, this section includes a set of findings and recommendations worthy of consideration.

**Finding: Industry Capacity Exceeds Need for Tracked Vehicles**

Industry capacity for tracked armored vehicle reset, overhaul, and upgrades residing within BAE Systems, ANAD, and the JSMC exceed DoD requirements, even during surge conditions such as the peak of OIF. For example, the JSMC currently operates considerably under capacity, suggesting an unnecessary overhead burden.

*Recommendation: Explore options for gaining efficiencies, while maintaining the industrial base and preserving a reasonable surge capacity. Possible options include (1) divesting JSMC to the private LCS industry, thereby incentivizing efficiencies, (2) seeking legislation to allow commercial, non-defense related, use of portions of JSMC, and (3) re-distributing workload across these three, and other Army and Marine LCS facilities and depots, such that same-system work resides at a single facility.*

**Finding: Acquisition Strategy for FCS MGV Production is Unclear**

The FCS MGV program does not appear to have a clear acquisition strategy for production or sustainment. Relative to non-LSI programs at this stage of development, this may not seem alarming. Yet, the LSI may be making daily decisions based on a tacit assumption that their level of involvement in production and sustainment will be the same as it is in SDD--certainly a valid assumption. In this case, the LSI's collection of daily decisions, over time, could make the government's production and sustainment acquisition strategy decisions foregone conclusions.

*Recommendation: Determine the acquisition strategies for FCS production and sustainment, and then convey those decisions to the LSI (and perhaps even the first tier FCS vendors). This will help manage the expectations of the entire FCS industrial base, which is largely also the LCS industrial base, so they may make related strategic business decisions. Waiting is a course of action, but may result in a fait accompli.*

**Finding: Titanium Strategies are Affecting Program Costs and Schedules**

The LCS industry expressed concern with the ability to obtain affordable Titanium in order to maintain production schedules or meet cost goals.

*Recommendation: Assess whether Titanium sourcing difficulties are founded, or simply just industry resistance to paying US market-based prices. If industry complaints are valid, then the DoD should consider developing a department-wide precious commodity management plan. Elements of such a plan might include overseas procurement and an associated Berry Amendment waiver, or a new form of long-lead funding for securing department-wide (or at least agency-wide) bulk precious resources that are not necessarily tied to a single program. Completing this commodity management plan will be doubly important if FCS opts to use Titanium armor. Of note, the DoD sent a proposal to Congress in April 2006 that would ease the Berry Amendment Titanium restrictions (Matthews, 2006), which if accepted, may make this finding self-healing.*

**Finding: Transmission Industrial Base is Shallow**

The LCS industry is susceptible to a single point failure in that its key transmission supplier (i.e., Allison, the free world's largest producer of tracked combat vehicle transmissions and maker of all US LCS transmissions except those used on the Bradley Fighting Vehicle and HMMWV) is not securing business at an economically sensible level--even during OIF. The net results are high costs and availability concerns for programs using Allison transmissions (e.g., EFV).<sup>xxi</sup>

*Recommendation: Continue developing the DoD's long-term transmission strategy to ensure the integrity of all, or part, of Allison Plant 14, while maintaining a core depot capability. Alternatively, the DoD should consider (1) securing a second source for LCS transmissions to drive competition into this sector, perhaps looking off-shore, and (2) leveraging commercial transmissions in all non-Abrams applications.*

**Finding: Multi-Program GOCOs Lack Methods to Re-Capitalize**

Government-owned Contractor-Operated (GOCO) facilities, such as JSMC, have limited ability to re-capitalize aging manufacturing equipment because individual programs resist paying costs not directly traceable to their program. As a result, there is no advocate for GOCO infrastructure improvements. Though not a strict GOCO, Allison Plant 14, which is loaded with antiquated Government Furnished Property (GFP), suffers from the same malady: more than one defense transmission program uses Plant 14, yet no single program wishes to bear new equipment costs.

*Recommendation: DoD ought to consider a single funding line for all GOCOs (i.e., much like is done for Major Range and Test Facility Bases (MRTFBs)). This would allow GOCOs to compete for recapitalization projects from a pooled appropriation. Just as at an MRTFB, each program would be required to fund its own direct costs. Alternatively, if the DoD does not wish to modernize the GOCOs, then the DoD should consider divesting them. For example, GDLS might consider purchasing JSMC given they are the only contractor operating there. In fact, GDLS is already investing in capital for JSMC, with some 10% of JSMC equipment now owned by GDLS.*

**Finding: Industry Craves Requirements and Funding Stability**

The need for requirements and funding stability echoes across the industry. Instabilities prevent (1) the formation of strong long-term vendor relationships, (2) vendors from making company investments in infrastructure to reduce costs, (3) lower prices and assured availability, and (4) proper management and training of the workforce at contractor facilities and government depots.

*Recommendation: Seek new ways of providing stability. Possibilities include (1) expansion of multi-year contracting, (2) assurance of a minimum funding baseline, with agreed upon allowable funding "deviation bars," and (3) disciplined requirements freeze points. Implementation of this recommendation is perhaps the most daunting--many in the past have tried to solve this problem. Any effort will require Congress, DoD, and industry to jointly work the solution.*

**Finding: Rationale for and Methods of Partnering Not Always Clear**

Public-Private Partnerships (PPPs) continue to grow and offer multiple advantages, to include (1) preservation of a wide industrial base and expertise, (2) mechanism for complying with depot

core and "50/50" laws, (3) capacity for surge, and (4) flexibility. Additionally, the types of partnerships continue to proliferate, such as (1) facility usage, (2) work share, (3) depots contracting with contractors, (4) contractors providing technical support, and virtually every other combination. Still, questions remain regarding the reasons for some partnerships, as well as the need for new contracting methods. The Bradley Fighting Vehicle refurbishment program is perhaps the most extreme example, with the Red River Depot partially disassembling the vehicles, BAE's Fayette County PA facility finishing disassembly, and then BAE's York PA facility performing the re-assembly. The M1 Abrams reset and refurbishment process is similar.

*Recommendation: The DoD must ensure partnerships do not exist solely to preserve jobs, which can lead to uncompetitive behaviors on the part of the depots and the contractors, and higher costs. Second, new contracting methods should be explored to allow contractors to sign contracts with the depots, thereby eliminating the need for TACOM to be an intermediary. This would drive the depots to be responsive to their actual customer--the contractor in this case--and allow the contractor to be accountable for delivering a finished product to their customer--TACOM. In this sense, the depots would effectively be a directed subcontractor. For this to work, the DoD should develop tools to incentivize the depots and give "teeth" to the contractor-depot "contract." For example, the contractor could complete a modified Contractor Performance Assessment Report (CPAR) on its depot suppliers. Of note, this relationship can also work in reverse, when the contractor supplies parts or kits to the depot. For example, ANAD receives X1100 transmission re-build kits from Allison via a TACOM-Allison contract. In this case, ANAD should receive funding from TACOM, and then contract directly with Allison, which would make Allison more responsive to ANAD.*

### **Finding: Export Policies Limit Full Exploitation of Common Development**

US export policies limit the ability to (1) reap benefits from common development and (2) share information with allies. For example, because BAE Systems (US) is prohibited from sharing data and technology with BAE (UK), some development work must be done twice on the US FCS and UK Future Rapid Effects System (FRES) programs, despite program similarities. The FRES program is balking at US technology because they cannot secure the TDPs needed for long-term sustainment. The UK's reticence stems from recent experiences on the Joint Strike Fighter Program (JSF). The net result is an increase in cost and lack of ally interoperability.

*Recommendation: Global leadership requires global participation. Congress, DoD, Department of State (DoS), and Department of Commerce (DoC) should work together to modify laws that restrict information exchange on programs between like-minded nations, thereby strengthening alliances, improving US LCS systems, enhancing the US industrial base, and improving ally interoperability.*

## **CONCLUSION**

Overall, the LCS industry is healthy, but much of that health stems from supplemental funding. The study team concluded that this large influx of emergency funding--so large that it doubles the DoD's programmed LCS investment funding--is masking a larger problem that will emerge once these supplemental appropriations end. The need to armor all future tactical

wheeled vehicles will only place further strain on LCS budgets. Hence, the DoD needs to take steps to use its resources much more efficiently. To that end, the study team offers the enclosed meaningful opportunities, observations and recommendations. While they may cause discomfort, each is worthy and workable. We must work past the discomfort and we must start now.



Appendix A

**Berry Amendment as Codified in DFARS 225**

**225.7002 Restrictions on food, clothing, fabrics, specialty metals, and hand or measuring tools.**

**225.7002-1 Restrictions.**

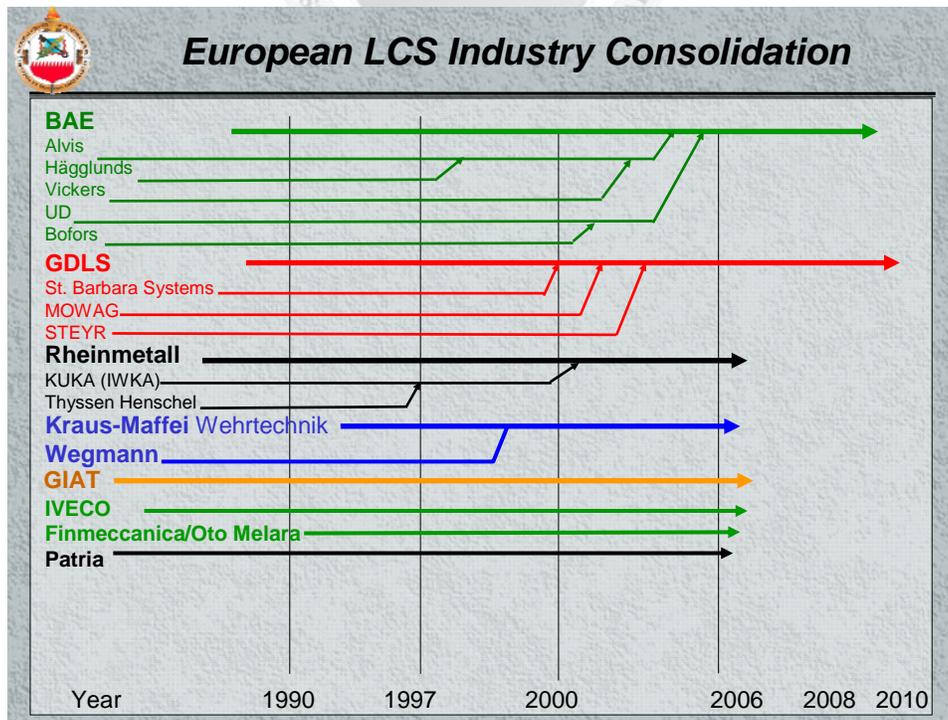
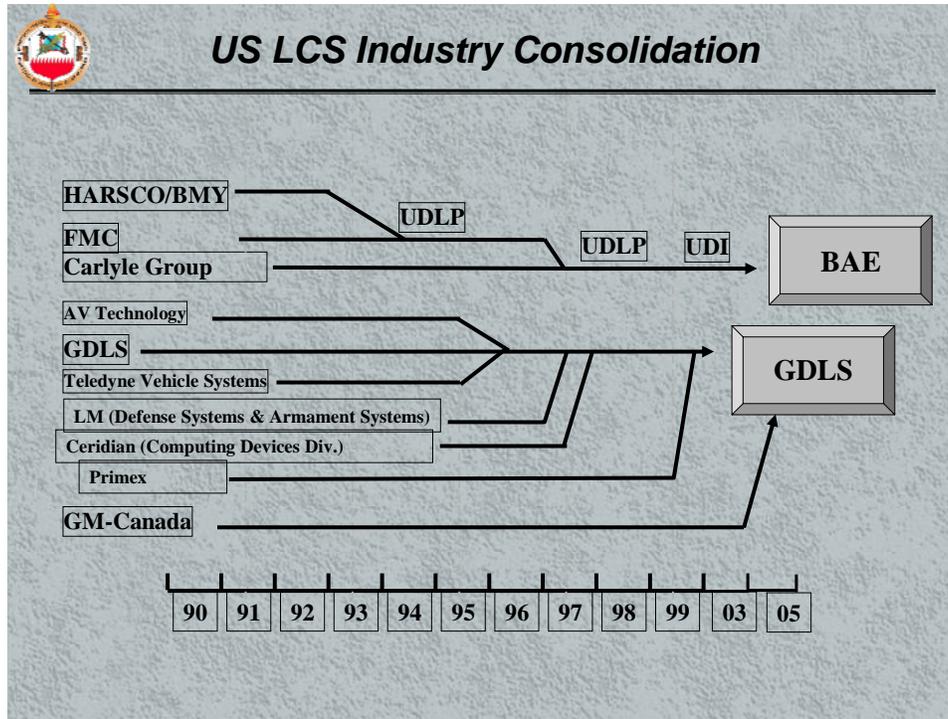
The following restrictions implement 10 U.S.C. 2533a. Except as provided in subsection 225.7002-2, do not acquire--

(a) Any of the following items, either as end products or components, unless the items have been grown, reprocessed, reused, or produced in the United States:

- (1) Food.
  - (2) Clothing.
  - (3) Tents, tarpaulins, or covers.
  - (4) Cotton and other natural fiber products.
  - (5) Woven silk or woven silk blends.
  - (6) Spun silk yarn for cartridge cloth.
  - (7) Synthetic fabric or coated synthetic fabric, including all textile fibers and yarns that are for use in such fabrics.
  - (8) Canvas products.
  - (9) Wool (whether in the form of fiber or yarn or contained in fabrics, materials, or manufactured articles).
  - (10) Any item of individual equipment (Federal Supply Class 8465) manufactured from or containing any of the fibers, yarns, fabrics, or materials listed in this paragraph (a).
- (b) Specialty metals, including stainless steel flatware, unless the metals were melted in steel manufacturing facilities located within the United States.
- (c) Hand or measuring tools, unless the tools were produced in the United States.

Appendix B

US and European Consolidation History



## Appendix C

### **Acronyms**

AAV – Amphibious Assault Vehicle  
 AICR – Annual Industrial Capabilities Report to Congress  
 AMV – Armored Modular Vehicle (AMV)  
 ANAD – Anniston Army Depot  
 AO – Area of Operation  
 ASV – Armored Security Vehicle  
 ATC – Aberdeen Test Center

BAE – British Aerospace  
 BCT – Brigade Combat Team

CAIV – Cost as an Independent Variable  
 CFIUS – Committee on Foreign Investments in the United States  
 CLS – Contractor Logistics Support  
 COTS – Commercial off the Shelf

DFARS -- Defense Federal Acquisition Regulation Supplement  
 DoC – Department of Commerce  
 DoD – Department of Defense  
 DoJ – Department of Justice  
 DoS – Department of State  
 DTC – Developmental Test Command

EDA – European Defense Agency  
 EFV – Expeditionary Fighting Vehicle  
 EPLRS – Enhanced Position Location & Receiving System  
 EVMS – Earned Value Management System

FAR – Federal Acquisition Regulation  
 FCS – Future Combat System  
 FMTV – Family of Medium Tactical Vehicles  
 FOS – Family of Systems  
 FRES – Future Rapid Effects Systems  
 FTC – Federal Trade Commission  
 FTTS – Future Tactical Truck System

GAO – General Accountability Office  
 GD – General Dynamics  
 GDLS – General Dynamics Land Systems  
 GFP – Government Furnished Property  
 GOCO – Government-owned Contractor-operated  
 GPV – General Purpose Vehicles

GWOT – Global War on Terror

H1 – Hummer 1

HEMTT – Heavy Expanded Mobility Tactical Truck

HET – Heavy Equipment Transporter

HMMWV – High Mobility Multi-purpose Wheeled Vehicle

ICAF – Industrial College of the Armed Forces

ITAR – International Traffic in Arms Regulations

JLTV – Joint Light Tactical Vehicle

JSF – Joint Strike Fighter

JSMC – Joint Systems Manufacturing Center

JTRS – Joint Tactical Radio System

KMW – Krauss-Maffei Wegmann, Munich, Germany

LAV – Light Armored Vehicle

LCS – Land Combat Systems

LSI – Lead System Integrator

LTAS – Long Term Armor Strategy

MAGTF – Marine Air Ground Task Force

MARCORSYSCOM – Marine Corps Systems Command

MC – Mortar Carrier

MEFFV – Marine Expeditionary Family of Fighting Vehicles

MGV – Manned Ground Vehicle

MOTS – Military off the Shelf

MRTFB – Major Range & Test Facility Base

MTU – Motoren & Turbinen-Union

OEF – Operation Enduring Freedom

OEM – Original Equipment Manufacturer

OIF – Operation Iraqi Freedom

ORR – Operational Readiness Rate

PBL – Performance – Based Logistics

PLS – Palletized Load System

PPP – Public Private Partnership

SAIC – Science Applications International Corporation

SAS – Space and Airborne Systems

SBCT – Stryker Brigade Combat Team

SDD – System Design & Development

SDP SF – Steyr-Daimler-Puch Spezialfahrzeug

SIL – Systems Integration Laboratory

SLOC – Source Lines of Code  
SOS – Systems of Systems

TACOM – Tank-Automotive and Armaments Command  
TDP – Technical Data Package  
TRL – Technology Readiness Level  
TWV – Tactical Wheeled Vehicle

UAV – Unmanned Aerial Vehicle  
UGV – Unmanned Ground Vehicle  
UDLP – United Defense Limited Partnership  
UK – United Kingdom  
US – United States  
USC – United States Code  
USML – United States Munitions List

WZMS – Wojskowe Zakłady Mechaniczne Siemianowic Slaskich



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## Endnotes

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<sup>i</sup> While economists, in general, prefer unregulated markets, they *do* recognize circumstances where regulation might be justified. See, for example, Baumol & Blinder (2006, p. 262).

<sup>ii</sup> Strictly speaking, a monopsony has only one customer. Many US defense contractors sell to foreign states, subject to export restrictions. Still, the preponderance of their revenues stem from sales to the DoD.

<sup>iii</sup> The DoD has many tools for dealing with shortcomings in the LCS industrial base. See page 7-8 of the Annual Industrial Capabilities Report to Congress (AICR, 2006) for a description of some of these tools.

<sup>iv</sup> Additionally, the congress can assess capability areas and strategic sectors, and pass legislation to preserve the capability or sector. The Berry Amendment is one such example. This law, enacted in 1941, states that defense firms cannot use foreign-produced specialty metals, such as Titanium, as well as certain textiles (MTN, 2006). Some prime contractors claim deleterious effects resulting from the Berry Amendment because domestic sources have neither the capacity nor the willingness to keep up with the demand for Titanium.

<sup>v</sup> The ITAR is the mechanism for implementing the Arms Export Control Act (GB, 2005). The ITAR controls exports and imports of defense articles and services.

<sup>vi</sup> It is interesting to note that contractors actively work the foreign component of demand, as the Department of State receives 50,000 defense-related export requests each year (GB, 2005).

<sup>vii</sup> At times, competition is not possible for a variety of reasons (e.g., one qualified source, urgent and compelling need). Under these circumstances, the DoD uses a well-established competition waiver process that results in a sole-source contract.

<sup>viii</sup> Of note, the decision to split evenly the FCS MGV development work share between BAE and General Dynamics Land Systems (GDLS) maintains competition because there is no assurance of a production contract for either contractor. This delayed production decision is a clever acquisition strategy that keeps both contractors in the LCS game, while also incentivizing them to become innovative and efficient in their designs.

<sup>ix</sup> Strictly speaking, the DoD does *not* approve or deny merger or acquisition requests. Rather, the DoD conducts assessments, and then provides input to the ultimate arbiters, the Federal Trade Commission (FTC) and Department of Justice (DoJ) (White, 1996b).

<sup>x</sup> This report does not purport to examine *every* industry stakeholder or contractor. Due to the limited timeframe for the study, such a treatment is well beyond the scope of the study team's charter and budget.

<sup>xi</sup> We will not be examining Porter's fifth force, substitutes, because the process for considering substitutes to LCS is well established within the DoD's Planning, Programming, Budgeting, and Execution System (PPBES). Under PPBES other DoD capabilities (e.g., air, sea, space, intelligence, and so forth) compete annually for part of the DoD budget, and in that sense, act as substitutes to LCS.

<sup>xii</sup> Allowing contractors a larger share of repair and overhaul work may require a change to the 50/50 legislation.

<sup>xiii</sup> The Buy American Act contains exemptions that allow the DoD to source parts from certain (e.g., NATO) countries. In many cases, the sources from which US LCS contractors wish to use are already exempt.

<sup>xiv</sup> With this acquisition, BAE Systems is now the 6th largest defense contractor operating in the US.

<sup>xv</sup> Because Boeing is a relative newcomer to the LCS industry, in effect we label them "second rank."

<sup>xvi</sup> Of note, UDLP later acquired this portion of the FMC Corp. and re-gained Paladin production.

<sup>xvii</sup> This trend was noted at both MTU Detroit Diesel and AM General's engine plant, General Engine Products.

<sup>xviii</sup> The armor industry is facing difficulties getting armor samples tested. Multiple suppliers are competing to get access to limited test facilities, with the chance of getting test time being greater only when the test is a government-sponsored test (versus manufacturer sponsored). And, test results collected at different test centers are not readily recognized, and in some cases discarded altogether, regardless of

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the protocol used. Finally, the Developmental Test Command (DTC) will not provide government-funded test results to the contractors, unless the funding activity authorizes release. This prevents the contractors from using the test data to validate performance as part of a proposal for other programs, forcing repeat testing and creating delays and additional cost.

<sup>xix</sup> By "new entrants," we mean non-traditional LCS suppliers, not necessarily new start companies. Such new entrants may be active US defense or European contractors who have no previous experience in US LCS.

<sup>xx</sup> For example, Stryker vehicles normally average 2,000 miles per year, but are averaging 10 times that during OIF.

<sup>xxi</sup> Of note, the FCS program did not choose Allison as its transmission supplier. Rather, FCS chose a BAE transmission.

