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Industry Study

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Land Combat Systems

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LAND COMBAT SYSTEMS 2014

ABSTRACT: The United States produces and employs the premier Land Combat Systems (LCS) in the world. The LCS industry has two major segments, Tactical Wheeled Vehicles (TWV) and Combat Vehicles (CV). The TWV market is based heavily on the commercial truck market, while the CV market is reliant solely on the US government. A decade of war-driven funding has produced healthy, recapitalized vehicle fleets. This growth, followed by major defense budget cuts, has led to large excess capacity in both the government and industry. Since the TWV segment is largely commercial, the US government does not need to regulate this market to ensure a continued source of new TWVs in the future. However, for CVs, the US government must intervene to retain critical skills, targeted capacity, and continued innovation in order to ensure continued dominance for the warfighter on future battlefields.

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Domestic:

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INTRODUCTION

The current state of the US Land Combat Systems (LCS) industry is indicative of the nation's post-war environment. After 2001, wartime demand for LCS products soared to levels not seen since the Second World War. However, in recent years, this demand has declined sharply as the Iraq and Afghanistan wars have drawn to a close. A major driving factor in the current demand decline has been the reduced Department of Defense (DoD) budgets resulting from the Budget Control Act (BCA) of 2011. However, these budget implications will be increasingly accompanied by a confluence of other unrelated factors negatively affecting the LCS industry. Among these are changes in national security strategy priorities, which are associated with the Pacific Rebalance, and a shift in expected DoD mission requirements. As a consequence, there is a reprioritization of military spending away from LCS in favor of Air-Sea Battle systems, reconnaissance platforms, and systems aimed to defeat the increasing anti-access/area denial threat. In line with these new priorities, the DoD has recently curtailed major LCS development and procurement.

Since the LCS industry covers multiple segments represented by varying business models, there has been a notable difference in business strategy in light of this changing demand. Some LCS industry segments have greater commercial application because they possess less *military unique* and more dual-use components. Manufacturers in these segments are able to leverage a mixed production of commercial and military products on the same line to mitigate the decline in demand. The bulk of the LCS industry, however, is more militarily specialized without its prime contractors and key suppliers being able to operate in this manner. These firms have slowed to minimum sustainable production levels in order to keep them operating. Depots supporting LCS are in a similar situation. The level of reset and repair work necessary to meet wartime demand has all but ceased and direct labor hours have dropped significantly resulting in excess capacity. Despite this new reality, the multitude of stakeholders involved in any LCS consolidation decision makes sweeping change unlikely. Nonetheless, change is required in this post war period to maintain commercial and military organic industrial base capacity.

In order to make well-informed recommendations suitable for the current LCS environment, the 2014 LCS industry study seminar studied the DoD's requirements development, as well as budgeting and acquisition systems to better understand LCS procurement. It also conducted comparative analysis of global LCS producers, such as India and Germany, to gain an appreciation of alternative approaches and applied industry analytics to specific firms, gaining insight into where and how they fit in the LCS industry. This foundational learning set the conditions for meetings, and detailed and candid discussions with numerous government and industry LCS leaders from the US and Germany. These discussions and this foundational learning form the basis of this report.

DEFINING THE LCS INDUSTRIAL BASE

The domestic LCS Industrial Base (IB) supports three broad vehicle classes: Combat Vehicles (CV), Tactical Wheeled Vehicles (TWV), and Protected Vehicles (PV). CVs are heavily armored, integrated with complex weapons systems and sensors, and often used in fire support and field support capacities. This class is *military unique* with little to no dual-use commercial application. CVs are typically tracked, but can be either wheeled or tracked. These vehicles include tanks, infantry fighting vehicles, personnel carriers, amphibious assault vehicles, and self-

propelled artillery. The primary CV fleet within the DoD includes the M1 Abrams tank, M2 Bradley Infantry and Cavalry Fighting vehicles, Stryker family of wheeled combat vehicles, M88 Armored Recovery Vehicle, M109 self-propelled howitzer Paladin Integrated Management (PIM), Multiple Launch Rocket System (MLRS), Light Armored Vehicle (LAV), and Amphibious Assault Vehicle (AAV).

TWVs are trucks modified from commercial variants or specifically designed to meet the heavy demands of on and off-road military transportation. They have bolt on armored crew cabs and may be equipped with weapons, but these vehicles primarily serve in a combat support or combat service support role. These vehicles range in weight and capacity from light to heavy. The DoD fleet of TWVs include the High Mobility Multipurpose Wheeled Vehicle (HMMWV), the Family of Medium Tactical Vehicles (FMTV), the Medium Tactical Vehicle Replacement (MTVR), Heavy Expanded Mobility Tactical Truck (HEMTT), Heavy Equipment Transporter System (HETS), Logistical Vehicle System Replacement (LVSR) and the Palletized Load System (PLS).

PVs represent the newest class, which began with the procurement of Mine Resistant Ambush Protected (MRAP) vehicles designed as a counter to improvised explosive devices. In addition to truck features typical of TWVs, these vehicles have more robust armor protection not previously associated with support vehicles. This report limits the scope of the LCS industry study to CV and TWV classes because PV characteristics, specifically that of survivability, are now incorporated into all new vehicles. Therefore, it is expected that PVs will merge with TWVs instead of appearing as a separate sector of the LCS IB.

The size of the LCS IB, measured by its DoD funding level, expands or contracts depending on existing LCS requirements. The LCS IB, comprised of commercial firms, government enterprises and public-private partnerships, constituted $6B-$10B of annual government spending before the wars in Iraq and Afghanistan. However, with these wars came budget growth in LCS procurement and Research & Development (R&D) to $17B by FY10.[1] Added to this FY10 amount was an estimated $17B-$19B of funding required for LCS overhaul and repair work resulting in an overall LCS funding peak of $34B.[2] With the conclusion of the Iraq war and Afghanistan's drawing down, the DoD's combined procurement and R&D funding request in FY13 was $3.6B.[3] Overhaul and repair funding returned to the pre-war levels of $2.5-$3B.[4] As a result, the total FY13 funding for LCS is approximately $7B.

The scope of the LCS IB encompasses both private and organic (i.e., government) elements. As a consequence of federal laws, regulations, and political pressures, there is a geographic limit to this scope with only US based companies available to supply the DoD with LCS products. DoD management at both the product and supply chain levels prioritizes security of information and security of supply with respect to *military unique* LCS items.[5] This results in a heavy bias towards US sources of LCS end-items and components, particularly in the CV market. Therefore, prime contractors that make up the privately owned sector of the LCS IB are limited to the following domestic companies: General Dynamics Land Systems (GDLS) and BAE Land & Armaments (BAE L&A) in the CV market; and Oshkosh, AM General, Navistar, and Textron in the TWV market. Although these limits impact prime contractors that manufacture LCS end-items, international firms support the LCS IB by supplying components and sub-components further down the supply chain, or partnering with US firms on major systems development. Organic elements of the LCS IB consist of the nation's depots and arsenals. Overall, seven government depots and arsenals support Army and Marine Corps LCS programs. However, the two primary facilities that contribute to the organic LCS IB are the Anniston Army Depot (ANAD)

and Red River Army Depot (RRAD). A third component of the LCS IB is a mix of both public and private elements. Government has partnered with private firms by leasing out manufacturing infrastructure, in addition to this partnering on contracts involving remanufacturing and supply chain management. Appendix 1 contains a graphic depiction of the LCS industry structure.

CURRENT CONDITIONS AND TRENDS

Current Demand Trends – US Government

The LCS demand is heavily influenced by its primary customer, the US Government (USG), with domestic demand split between just two buyers - the Army and Marine Corps. The main factors that affect demand include DoD budgets, overseas contingency involvement, political influences, and technological developments.[6] In the near-term (linked to the current FYDP out to FY19), demand will be characterized by a general decline in defense spending. As military activity in Iraq and Afghanistan comes to a close, national budget priorities are shifting to non-DoD requirements and entitlement programs. With significant growth expected in the mandatory portion of the overall USG budget, non-DoD areas will increasingly compete with defense for an ever-smaller slice of discretionary spending. For example, the recently released 2014 QDR proposed cost-saving measures that included force structure reductions to the regular Army, from a wartime high of 570,000 soldiers, to 440,000-450,000. Sequestration cuts in FY16 may further reduce this force to 420,000.[7] Changing missions requiring less LCS capabilities is another trend that will affect future demand. An increasingly asymmetric threat landscape has been accompanied by a shift in expected DoD missions to non-LCS related operations, such as counter-terrorism, humanitarian assistance/disaster relief, international law enforcement, anti-piracy, and theater security cooperation. Exacerbating these trends is the relatively healthy condition of the current LCS vehicle fleet and its resupply stock. Following ten years of frequent fleet revitalization efforts, the average age of the CV and TWV fleet is now quite low. This will facilitate a reduced need for recapitalization and less demand for depot support. With the return of equipment and support systems to a peacetime operating environment, following years of wartime plus up, there will be a large inventory of replacement vehicles and spare part stocks available to support the anticipated requirement.

Evidence pointing to this impending near-term LCS demand decline is already available. Neither the QDR nor the DoD's FY15 budget specifically mentions any LCS programs as a budget priority. In addition, the DoD has recently curtailed major LCS development and procurement, such as the Army's Ground Combat Vehicle (GCV). Of the DoD's $153.9B total acquisition budget in FY15, only $2.3B was identified for CV and TWV programs. Existing LCS contract spending has slipped from the FY10 high of 576 transactions (worth $7.1B) to only 146 transactions thus far in FY14 (worth $600M), with no sign of large procurement contracts on the horizon.[8]

Thus, firms providing LCS capabilities now compete vigorously for the few remaining LCS business opportunities and arduously lobby Congress to shape requirements to their favor. For CVs, current revenue streams include limited M1 tank remanufacturing, Stryker upgrades and remanufacturing, and M109 PIM production. For TWVs, active programs include MRAP All-Terrain Vehicle (M-ATV) production, along with completion of FMTV, HET, and HEMMT production contracts. With only a broadly defined future for new acquisition opportunities [e.g., the Armored Multi-Purpose Vehicle (AMPV), Amphibious Combat Vehicle 1.1 (ACV), and Joint

Light Tactical Vehicle (JLTV)], anticipated near-term demand for both CVs and TWVs will come increasingly from maintenance and upgrades rather than new acquisition programs.

Current Demand Trends – International

Due to these poor domestic demand expectations, US firms have increasingly looked to overseas sales as part of their overall business strategy. These opportunities involve both Foreign Military Sales (FMS) and Direct Commercial Sales (DCS) to overseas partners. In fact, since 2010, LCS firms have relied heavily on FMS contracts with Saudi Arabia and Egypt to maintain profitability. Although overseas defense budgets are dwarfed by US spending levels, and most developed nations (e.g., in Europe) have an established history of low defense spending levels, there are LCS business opportunity available in emerging markets, primarily Saudi Arabia, Kuwait, UAE, Morocco, and Iraq.

Although these emerging markets provide opportunities, they are not without obstacles and risks for US LCS manufacturers. First, dependence upon more volatile geo-political regions increases contract risk for these firms. In fact, a number of current and expected acquisition contracts that US firms are relying on for sustained operation are now in doubt. Acquisition contracts with Egypt and Morocco, recently halted by the USG, are but two examples of this. Secondly, complicated and cumbersome US export controls have hindered additional opportunities. The all-inclusive characteristics of the US Munitions List (USML) have blocked sales of *military unique* end-items, in addition to more commercially available components and parts that have been deemed military related. Finally, FMS is typically accompanied by offset requirements levied by foreign buying countries. These offsets allow foreign buyers to receive reciprocal benefit through local manufacturing and employment, while at the same time building indigenous production "know-how" and capacity. This requires significant investment on the part of US firms, and risks intellectual property spillage that could lead to a loss of competitive advantage.

In addition to these risks, there is some question as to the actual size of the available demand in these emerging markets. US firms are not the only suppliers competing for business in this sector. European defense manufacturers, who have suffered similar declines in their domestic European sales, also compete aggressively in these markets. Although US firms enjoy a combat-proven product reputation and offer superior life-cycle support, some countries may look to diversify their defense supply base beyond the US. In some LCS segments, US firms are not even well-positioned to compete in overseas markets. Because demand is most heavily affected by the LCS IB's primary customer (i.e., the USG), firms have traditionally aligned their products and strategy with US requirements. This has resulted in a competitive strategy favoring high-end performance over price. Thus, US products are typically non-competitive in emerging markets where price is the primary driver. This is particularly true in the CV market, where US firms have much more specialized product offerings. One example is the M1 tank, which is powered by a gas-turbine engine. Although this provides higher performance, it is also significantly less fuel-efficient than a traditional diesel engine and more difficult to maintain. As a result, it has difficulty competing against modern tanks powered by diesel engines such as the German Leopard II. Since TWVs are less specialized and less *military unique* (with more commercially available components), this area presents the greatest opportunity for new revenue streams. For example, AM General recently invested in right-hand drive technology while pursuing HMMWV sales

contracts in the emerging South East Asian market. But like CV sellers, US TWV firms face tough competition from numerous international competitors.

Current Supply Trends – LCS IB Supply Structure

There are principally three categories of production activities within the LCS IB:
1) Contractor Owned Contractor Operated (COCO) are privately owned and operated for-profit firms. These COCO facilities are resident within the Original Equipment Manufacturers (OEMs).
2) Government Owned Government Operated (GOGO) are production and repair facilities owned and operated by the government. These activities are resident within the nation's depots and arsenals.
3) Government Owned Contractor Operated (GOCO) are production and repair facilities owned by the government but leased to and operated by contracted OEMs in a public-private partnership. The Joint Systems Manufacturing Center (JSMC) in Lima, Ohio is an example of these activities.

Current Supply Trends - Privately Owned LCS IB

The privately owned (COCO) portion of the domestic LCS IB is comprised of OEMs, which serve primarily as system integrators for the CV and TWV markets. These OEMs provide value through the final assembly and delivery of the completed system, consisting of thousands of components sourced from hundreds of suppliers. The CV market is a duopoly consisting of two OEMs - GDLS and BAE L&A. The competition within this market structure is characterized by a small number of large multi-year contracts that typically do not involve the ability for re-compete because of high government switching costs. In this environment, the result has been a partition of the market along separate product lines. GDLS manufactures M1 Abrams and Stryker CVs. BAE produces M2 Bradley, M88 and M109 PIM. Although this partitioned market has created an overall non-competitive environment for established programs, these OEMs compete fiercely for new programs, such as the developing AMPV program. As a result of relatively low-entry barriers and less specialized technology, the TWV market demonstrates greater diversity and competition. For example, the TWV market has had more frequent changeover with respect to the list of key competitors, in addition to significant shifts in market-share between these competitors. Key competitors in this market are: Oshkosh, AM General, Navistar, and Textron. The characteristics of this market, particularly the use of less *military unique* parts, allow many of these companies to simultaneously compete in the production of commercial vehicles (e.g. Class-8 commercial trucks). Therefore, competitors within the TWV market are not as dependent on military contracts for overall sales revenue.

Faced with a declining US defense budget, both CV and TWV companies have responded by developing business strategies that allow for continued operation at minimal levels of sustainable production while maintaining the capability for potential future expansion when demand is expected to increase. This has resulted in low utilization rates, with most military specific manufacturing facilities operating at 40% (or below) of available industrial capacity.[9] TWV companies, which typically operate dual-use manufacturing facilities, have been able to offset some of this declining defense demand and low utilization with their commercial product manufacturing.[10] Additionally, both CV and TWV firms have increasingly looked to foreign sales and the secondary market (defined by lifecycle support that includes replacement parts sales, maintenance contracts, rebuilds and vehicle resets) to mitigate this downturn.

Looking to the future, most companies are investing about 6-10% of annual revenue towards R&D activities. However, in response to the recent trend of multiple LCS acquisition programs failing to reach production [e.g., Future Combat System (FCS), GCV, Crusader, and Expeditionary Fighting Vehicle (EFV)], these firms are limiting R&D activities to those areas that have direct links to validated requirements and associated funding. There are some limited examples of innovative R&D, but the erratic demand signal and fluctuating requirements from the USG works to suppress innovation rather than foster it. One recent trend witnessed since the cancellation of the GCV has been the aggressive pursuit by OEMs of new revenue streams in leveraging budget increases associated with future Science and Technology (S&T). The OEMs contend that they should have a larger portion of the Army's S&T budget because they have a higher rate of maturing technologies than the Army's S&T agencies, such as TARDEC.

The suppliers of components and sub-components much like the OEMs, have also been negatively affected by declining demand. In fact, the supply-base is currently more threatened than their OEM customers. One firm reported that the estimated cost for OEMs to qualify a single supplier is approximately one million dollars.[11] It would take 18-36 months to re-qualify all of the OEM's suppliers following a complete production shutdown.[12] Because of this risk, most OEMs actively track the health of their primary suppliers. However, this becomes increasingly more difficult further down the supply chain, where many of the suppliers at the sub-component level are small and independent companies, which limits transparency.

Although the CV and TWV markets have some supply base similarities, there are some unique supplier aspects as well. First, almost 80% of CV parts come from "directed" sources due to the very specific nature of the government requirements document.[13] This lack of ability to leverage competition among the component suppliers limits the buyer power of CV OEMs. Secondly, the CV market is especially sensitive to impacts on its most critical suppliers; those that manufacture high-tech and *military unique* components. In particular, these include specialized armor, tracked vehicle transmissions, and sensors (e.g. forward-looking infrared sights). Beyond these specific areas, however, the sensitivity of the supply chain decreases quickly at the subcomponent level. The TWV market is not as sensitive to supplier issues because it enjoys greater commonality with commercial vehicle parts.[14]

The CV and TWV market workforce is comprised of three distinct groups. The first is the engineering workforce, necessary for front-end production design and vehicle integration. This group is highly educated and displays the lowest employment transfer costs. Due to the current STEM shortage among the overall US workforce, these engineers are highly sought after by competing industries. This presents considerable intellectual capacity risk for the OEMs because much of the IB's systems integration knowledge has been developed largely in-house over the last few decades. This "tribal knowledge" could potentially be lost should these individuals depart the market and move to other industries (e.g., the automotive industry). The second group consists of the production line workers with specialized manufacturing skills that are often unique to the LCS industry. The most unique of these skills is armor welding. Welding armor is very different from typical commercial welding. The extensive qualification process and experience required makes it very difficult for OEMs to replace these workers. Therefore, keeping some minimum number of them employed with a consistent flow of work is considered to be critical by the OEMs.[15] The last group consists of the remainder of the production labor workforce. These lower skilled and unionized workers pose the lowest replacement risk to the OEMs because they are less skilled and tend to stay local when laid off during downturns. The cyclical nature of the industry makes layoffs and rehires a typical occurrence. Since LCS IB jobs pay better than other local industries, it is not

too difficult to attract these workers back during up-turns in demand. Overall, there is a positive relationship between the OEMs and their supportive labor unions. As management has attempted to position firms for expected future reductions, the unions have accepted the workforce cuts. However, these cuts to manufacturing labor are resulting in an aging workforce since union rules tend to favor organization seniority in lay-off decisions. Consequently, this lack of age and experience distribution is eliminating the depth necessary for future production.

Current Supply Trends - Government Owned LCS IB

As a part of the nation's organic LCS IB, GOGO depots are responsible for providing a core logistics capability, which consists of performing maintenance, repair, modification, and rebuild of end-items (including components, and subassemblies). There are currently seven depot facilities that make up the organic LCS IB - five Army and two Marine Corps facilities. Among those, there are three depots designated as DoD Centers for Industrial and Technical Excellence (CITE) for LCS. Anniston Army Depot (ANAD), located in Anniston Alabama, supports tracked vehicles, such as the M1 Abrams and M88 Armored Recovery Vehicle, as well as wheeled Stryker vehicles. Red River Army Depot (RRAD), located in Texarkana Texas, is the Center of Excellence for TWVs and the M2 Bradley. Letterkenny Army Depot in Chambersburg, Pa is the Center for Excellence for the HMMWV ambulance variant, MRAP, and the Avenger Air Defense System.

Competition among the government owned depots is focused on protecting individual facilities from BRAC. This is primarily done by improving infrastructure and industrial capabilities. However, there is little evidence among the depots and arsenals of aggressive business development for new revenue streams or significant competition to capture workload from other depots and arsenals. The competitive environment is stable, with well-partitioned segments and workload aligned according to individual product lines. This alignment is facilitated by the CITE construct, which leaves little ability or desire among the depots to compete for new revenue streams with workload that is currently held at other facilities. Furthermore, because of the high demand for LCS products over the last decade, there was enough workload across the LCS IB, and therefore, little incentive for aggressive competition between OEMs and depots. The OEMs focus on core competencies of engineering design, integration, and Supply Chain Management (SCM), while the depots have relied upon competitive advantages in infrastructure and skilled labor to concentrate activities exclusively on tear-down, component rebuild, and parts reclamation. However, the changing environment, with expected demand decline and low future budgets, leads to questions such as whether this segmentation is supportable in the future. That is, these factors could force COCOs to compete for traditionally depot maintenance and repair activities in order to remain in the LCS market.

Depots appear more insulated than OEMs from such minimum sustainment level and "bottom line" competitive decisions. For example, depot workload is protected by Title X, Section 2466, US Code; commonly referred to as the '50/50 rule". This law limits OEM performance of depot level maintenance to not more than 50 percent of the DoD's annual depot maintenance appropriation. This law is emblematic of the political influence that GOGOs hold in Congress. Another example of this political involvement was evident in the 2014 Appropriations Act where Congress added $150 million to the Army Working Capital Fund to allow Rock Island Arsenal (RIA) to lower its overhead cost in order to make it more competitive.[16] Despite demand trends that have forced several COCOs to reduce production overhead, or even leave the market entirely, there have been no consolidation efforts among the nations' LCS depots and arsenals. In fact, the

same number of LCS GOGO facilities that supported the US Army during the height of the Cold War, [when the Army maintained a force structure of approximately 50 Armored Brigade Combat Teams (ABCTs)], now supports a much smaller force of only 20 ABCTs. This force structure may even be reduced further under Sequestration cuts. While significant force structure reductions are currently in progress throughout the DoD, political influence and numerous stakeholders make the argument for consolidation of GOGO infrastructure a "third-rail" issue with reform unlikely.

Consequently, there is ample evidence of low utilization and excess capacity at LCS GOGO facilities. The depots have experienced a steady reduction in direct labor hours since FY11; a trend that is projected to continue into FY15. From 2008 to 2013, the workload at ANAD dropped by approximately 37 percent.[17] Other depots are projecting low utilization, reaching as little as 65% of their annual core maintenance requirement out to FY20. Despite this underutilization, GOGO facilities have continued to add capabilities and infrastructure as a means of remaining "competitive", and thus protected against closure by "BRAC proofing" their installations. Although there has been little evidence of facility overhead restructuring in lieu of recent demand decline, there is a noticeable reduction of labor among the depots. Much of the depot production workforce is unionized with collective bargaining rights that affect the depot's ability to rapidly reconfigure its workforce or change working conditions. Similar to the workforce drawdown witnessed among the OEMs, (also unionized), retention decisions are based upon worker seniority. Reductions are therefore, most heavily felt by the newest employees. This has created an aging workforce with challenges for the sustainability of expertise within the future labor force. Additionally, many permanent positions have been replaced with temporary employees who receive no benefits. This measure, originally designed to adjust for surges in depot maintenance demands, is now becoming more commonplace as a mitigation measure in response to the new demand environment. Although both GOGOs and COCOs employ union labor, based upon interviews with OEMs and Army officials, depot overhead cost and hourly rates are higher than corresponding OEM rates.[18] These higher labor rates make GOGO facilities a less economical choice. Yet, current legislation (e.g., 50/50 rule) and political pressure ensure continued work for the depots.

The supply trend for parts and materials is another area of concern within the organic LCS IB. Because SCM is not a core competency of the depots, there is limited visibility on the supply chain. Consequently, supply risk and vulnerability to supplier performance is a concern among the depots. This is of particular concern in the CV market. First, many *military unique* components are provided by a sole source OEM supplier which creates a single point of failure. Likewise, the suppliers in the upper tiers of the supply chain are heavily dependent upon DoD purchases, and as such, are most affected by fluctuations in government demand.

Current Supply Trends - Government Owned Contractor Operated LCS IB

In some areas of the LCS IB, government and private entities have found it beneficial to cooperate in GOCO arrangements. The Joint Systems Manufacturing Center (JSMC), Lima Tank Plant located in Lima, Ohio, is the only government owned production facility operated by a commercial firm (i.e., GDLS). The JSMC is comprised of a unique organizational structure that involves the Tank Automotive & Armaments Command (TACOM) owning the grounds and

facilities, the Defense Contracting Management Agency (DCMA) managing the contract and facility, and GDLS working the plant's maintenance and production operations. Since the start of the M1 tank program in the 1970s, over $1B has been spent on Government Furnished Equipment (GFE), which includes a classified armor facility and tooling machinery that is 99% government owned.[19] Originally designed and built to manufacture the M1 Abrams tank, the JSMC was also the planned production site for the Marine Corps' EFV and the Army's FCS until those programs were cancelled. As such, GDLS is the sole contractor in the facility and much of the efficiencies desired of the JSMC plan are not evident. The JSMC now only supports GDLS programs that include naval gun turrets, Stryker hulls, tank armor, and the Israeli Defense Force's Namer fighting vehicle. This arrangement allows GDLS, as the leasing contractor, to operate with great flexibility and relatively little overhead. It can take advantage of government provided facility benefits without the associated requirements and capital investment demands of ownership with respect to grounds, facilities and much of the tooling. Since under the current organizational model there is no one agency responsible for the overall management of the JSMC, there is little incentive to seek efficiencies or ensure upkeep for sustainment. This trend is exacerbated, given the decline in demand for combat vehicles. Designed with enough capacity to support its once peak production rate of over 600 tanks per year, the JSMC plans to produce just 12 tanks this coming FY.[20] As a result of these trends, the JSMC suffers from significant over-capacity, 40% plant utilization, and decaying capabilities.

Current Supply Trends – Public Private Partnerships

Another collaborative practice involving government-private entities is the Public-Private Partnership (P3). Although P3s are not a new practice, there is evidence of increased use now as a mitigation measure for low utilization within the LCS industry. There are two primary P3 arrangements that currently support the LCS GOGOs – "work-share" and "direct". The Stryker reset effort at ANAD is an example of a work-share P3. In this case, the work is split 50/50 and the government separately funds the depot and GDLS. This P3 arrangement exists because the DoD does not own the design and manufacturing data to the Stryker. Therefore, ANAD must share workload with GDLS to get access to this knowledge. Although the two entities (i.e., GDLS and ANAD) are at the same facility, they operate separate production lines. The M2 Bradley re-build effort at BAE's facility in York, Pennsylvania is a direct P3 arrangement, where the government has contracted with BAE as the prime service provider and RRAD functions as a sub-contractor to BAE. Initial vehicle breakdown occurs at RRAD and the components are shipped to the BAE York facility for rebuild and reassembly. The objective of such arrangements is to achieve synergy by leveraging the strengths of commercial best practices and depot level maintenance capabilities. There is evidence of advantages with these arrangements. However, these P3s do have limitations. This is especially evident in the area of quality assurance and SCM. In the case of the M2 Bradley rebuild contract, BAE has little control or ability to affect the quality of components received from RRAD. Components shipped from RRAD to the BAE York facility that do not meet quality standards create workload inefficiencies for the assembly line. In a separate case involving ANAD, the outsourcing of SCM to the OEM in a P3 arrangement limited the depot's visibility of ordered repair parts.

The LCS IB supply chain faces many complex issues that are further challenged by declining demand for CV and TWVs. P3s arrangements serve as a foundation for supply chain operations for the maintenance depots. In most P3s, DLA is the initial source of supply with the OEMs filling

any repair part requisition gaps. The two main issues facing the SCM function are the impacts of Technical Data Package (TDP) ownership and quality control of repair parts sourced from the commercial industry. In the case where the OEM owns the TDP, the depots and DLA are forced to order exclusively from the OEM. This situation creates a lack of price control and competition when bidding for supply part contracts. When repair parts are ordered from the commercial industry without TDP information, there are significant concerns with technically compliant parts. DLA does not have the engineering expertise to ensure compliance with TDP requirements and typically the depots receive "will fit" or non-OEM conforming repair parts. These inefficiencies result in depots forming P3 arrangements solely with the OEM to avoid DLA related support issues and increased maintenance repair related to repair part failure issues.

COMPARISON WITH THE EUROPEAN LCS INDUSTRY MODEL

European LCS - Demand Trends

Many of the current challenges and emerging trends within the US LCS industry have been part of the European experience for more than ten years. Therefore, it is helpful to include observations from LCS producing countries within the European Union (EU).[21] From a demand perspective, the European LCS industry is witnessing an overall decline of defense related spending in Europe. Since 2007, the 27 members of the European Defense Agency (EDA)[22] have witnessed a 4.9% decline in overall defense related spending from a high of 204 billion Euros down to 194 billion Euros in 2010.[23] This new level represents only 1.6% of the EU's total GDP. The ongoing economic crisis along with renewed stress by EU members towards sovereign debt reduction and social welfare spending is putting additional downward pressure on the demand for defense related goods and services. In addition to these budget pressures, much like with the US DoD, changing mission requirements of European militaries is also having a profound effect on LCS demand. Following the end of the Cold War, and in particular since 9/11, the missions required of Europe's militaries have increasingly focused on peace keeping, crisis intervention, security operations, and counter terrorism.[24] These new mission requirements are less suited for medium and heavy armored vehicles. Another reason for this low European demand has been the post WWII environment in which the US has supported European security with security guarantees and troops. The Europeans have not had to spend as much on defense because they have relied on US spending for their defense. For instance, in 2012, US spending on defense equated to 4.4% of GDP, while the largest percentage spent by a NATO member was Great Britain at 2.5% of GDP. Likewise, the French and Germans spent 2.3% and 1.4% of GDP respectively.[25]

Because of the declining demand trend exhibited by European customers, exports to non-EU nations are playing an increasingly important role in the European LCS industry. Exports have become a critical source of revenue for sustaining the EU's LCS industry. In fact, some European producers report that sales to their national government account for as little as 30% of their defense related revenue. Therefore, increases in export demand have grown faster than the shrinking local EU demand.[26] As such, European LCS producers are focusing on expanding their export sales and reducing their dependency on domestic sales. While US LCS manufacturers design products exclusively with the DoD in mind, European manufacturers have exportability in mind from the outset of development.

European LCS - Market Fragmentation

The European LCS market displays much greater fragmentation than in the US. Europeans have traditionally favored national sovereignty and autonomy in defense related acquisition issues.[27] This has negatively affected free competition among LCS producers in that public procurement by EU members typically favors national firms. Article 346 of the Treaty on the Functioning of the European Union (TFEU) provides an exception to free trade requirements by allowing individual EU members to establish market barriers in the name of national security interest. This has resulted in nearly 28 separate EU customers with diverse regulatory frameworks and standards.[28] To help break up these stove-piped markets, the EU is increasingly encouraging free and open competition for military vehicles through the European Commission's *Directive 2009/81/EC on Defense and Sensitive Security Procurement*.[29] Yet, Article 346 and other regulatory restrictions throughout the EU continue to hinder this effort. Although consolidation has occurred within Europe, this consolidation has been limited to national LCS industries. Despite several attempts to consolidate the overall European LCS industry in order to make EU firms and products more competitive, these efforts have ultimately not succeeded due to national politics that have insured sustainment of local industrial capability, local jobs, and the investment of Euros within national borders. These obstacles have prevented economies of scale, and in so doing, negatively affected average unit cost. Thus, the LCS market in Europe is characterized overall by small and infrequent production orders of redundant products, excess capacity, and increased unit prices of LCS products.[30]

These discrete and infrequent production runs put pressure on the European LCS supply chain, often forcing second and third tier suppliers to exit the market when production has become idle. As a result, the European LCS IB is slower to respond to spikes in demand. However, Europeans have weathered several interruptions of LCS manufacturing without a complete breakdown in the supply chain. The European OEMs are able to operate in this manner because they are willing to accept a greater amount of order backlog and greater supply chain risk. They do so by holding second and third tier suppliers to a less stringent standard than US counterparts. Unlike US firms that require significant requalification of suppliers in order to mitigate supplier risk, European OEMs are more willing to accept this risk as a cost of doing business. In fact, US firms are so proactive in mitigating supplier risk that there have been several instances when OEMs have even purchased a supplier for no other reason than to prevent the supplier from exiting the market.

European LCS – Research & Development

In comparison to the US CV market, where government involvement has established dependency, there is far less concern exhibited among EU governments for maintaining a warm LCS industrial base. With this has come less direct support from government in the European LCS market and less willingness to use political influence on behalf of the OEMs in petitioning potential foreign customers. This lack of government support also applies to government funded Research and Development (R&D). Unable to use government resources to fund R&D as participants in the US CV market do, these OEMs are very reliant on Independent R&D (IR&D). Without the vast financial resources of comparable US defense conglomerates, European OEMs have not been able to source the same level of IR&D typical in the US market. As such, this disadvantage of having to compete without the ability to leverage the technology breakthroughs

that come from such IR&D has forced European OEMs towards employing simpler and more commercially available designs.

PERFORMANCE ANALYSIS

Given the structure of the LCS industry and current operating environment, a few consistent performance themes are apparent. These themes fit into two categories of LCS analysis, industrial base performance and acquisition performance. By examining the overall industry structure that affects market conduct, we can qualitatively assess resulting firm performance. This follows a qualitative root-cause analysis methodology that investigates structure, conduct and resulting performance rather than incorporating quantitative business analytics.

LCS Industry Performance - Demand Structure

The LCS market operates under a monopsonistic structure, with several sellers but only the DoD as the single customer. This relationship facilitates significant buyer power for the government during the competition phase for new programs. This has resulted in an LCS market generally characterized by concentrated demand involving a limited number of products and infrequent purchases of new vehicle models. The DoD's buyer power is further strengthened because the government, as a sovereign, both *operates in* and *regulates over* the market. Therefore, the DoD is able to dictate terms to its suppliers (i.e., CV and TWV producers) and shape the market with purchasing decisions and acquisition policy. This is especially true in the CV market where firms provide exclusively *military unique* products, and as such, are more heavily reliant on the government for top-line sales. This is less true of TWV producers who sell in commercial as well as defense markets.

Yet, despite seemingly excessive buyer power, there is also a LCS market paradox. Although LCS suppliers initially have very little market power and compete intensely for new programs, these same companies gain considerable power upon contract award as the sole-source provider because of the large switching costs for the DoD that result in contracts typically of long-term duration. These switching costs are particularly an issue, when the government has less information than the seller because it lacks rights to the design and manufacturing data referred to in DOD parlance as the Technical Data Package (TDP). The DoD faces "supplier lock" unless it is able to buy the design and manufacturing data (via the TDP) and competently maintain that data. In so doing, this affords the ability to re-compete the contract among other suppliers at some future date if demand is sufficiently large to justify the cost of a new competition.[31] One example of this occurred when Oshkosh was able to win a re-competed contract against the incumbent supplier (BAE) because the government owned the TDP rights. Although this has proven successful in the TWV market, the complexity of CVs has made this option less viable in the CV market.

What results from this is an industry that has had two somewhat distinct business models and performance records. The more commercially involved TWV OEMs have been more successful in operating with competitive market efficiency because they have greater flexibility with less government direction. This is in contrast to CV OEMs, which follow business models that are heavily focused on government requirements and dependent upon its continued support. Consequently, they have become more specialized, more government controlled, and thus, less free to compete in an open market environment. Deemed more critical to the national defense, the CV market draws higher levels of regulation and government intervention. The government

exercises this control to preserve technological advantage on the battlefield. However, this desire clashes with contradictory attempts by the government to maximize buying power through greater competition. Since these CV producers must follow more restrictive procurement methods and are in most cases directed to specific suppliers, they are often denied by the government from competing with sales outside of the DoD. As a result, these companies have become less efficient in a classic "defense industry" structure. Government dependence coupled with declining DoD budget trends has resulted in an environment of "opportunity compression" where CV producers, left with *nothing-to-lose,* have been driven to atypical behavior among industry participants.[32] The increasing occurrence of contract "protests" is but one example of this desperate behavior. Continued pressure and increasing desperation among these firms is likely to result in a greater frequency of this type of behavior which is contrary to the public good.

As with most defense markets, the competitive factors that are associated with LCS sales to the DoD involve much more than core competencies in engineering, production, and performance. They require considerable skill in bidding contracts and navigating in a highly regulated environment. Most companies lack this experience and find great difficulty in successfully operating in such an environment. This is particularly true among TWV market participants that are typically commercial entities (i.e., non-traditional defense companies) with much of the business culture residing in the civil and commercial segments. Therefore, such companies are at a disadvantage relative to the big defense conglomerates in an era of demand down-turn and consolidation. This offers new opportunities for these defense conglomerates that currently may not be in the LCS market, but are politically savvy with greater influence in Washington D.C. to team up with LCS producers in joint-ventures that compete for future LCS programs. The predicted market environment may drive this to become a more frequent occurrence in the future.

LCS Industry Performance - Capacity and Utilization

Much like demand structure that has resulted in varying business models and market competitiveness between CV and TWV OEMs, a number of these same factors similarly affect overhead cost management. A general characterization of the CV industrial base is that over capacity has resulted in low utilization and high unit costs in order to cover excessive infrastructure. Yet interest groups and intense constituent politics make it difficult for Congress and the DoD to take actions that would allow consolidation of either private OEMs or government entities (i.e., the GOGOs and GOCO). For example, a proposed merger in 1997 of GDLS and United Defense (which BAE bought in 2005) was dropped because of antitrust concerns and opposition from Pennsylvania Senators that threatened Congressional action to hold up the deal. Awareness of this political reality has resulted in a collective opinion within this market that the government will not let the CV industrial base go dormant, and therefore, market demand will return. This supposition is reinforced by recent Congressional action that went against DoD budget requests by funding additional M1 Abrams production at the JSMC. Consequently, there is little incentive to drive Lean production or efficiencies that reduce cost. By commercial standards, the CV manufacturers have not been producing at an economically efficient rate for some time. The JSMC is a $1B and 1.6M sq-ft facility with only 40% utilization of its manufacturing floor space.[33] Likewise, GDLS's Anniston Stryker assembly line currently only produces at 20% of its designed rate.[34] A similar environment exists among the government owned entities. The depots leveraged wartime expenditures to expand their plant and operations, even though they never reached full

capacity during the height of the wartime demand. Since 2003, ANAD has made $640M in capital investments to modernize facilities and equipment, yet these capabilities are extremely underutilized with production lines nearly at idle.[35]

With more component and system-level crossover between commercial and defense products, TWV firms are able to use existing manufacturing capacity more efficiently. Reacting to current demand, TWV firms have employed Lean operating processes in a variety of ways to reduce inventory on the manufacturing floor, integrate military-commercial production lines, and tailor an able labor force that flexes with production. This is driven by the fact that TWV OEMs operate in the more competitive commercial market, and therefore, must find cost-saving efficiencies to survive. The depots (and to a lesser extent the government subsidized CV OEMs) operate on a completely different business model. They don't manage *cost* as much as they manage *workload*.

Analysis of Acquisition Performance

In determining acquisition success, the Honorable Frank Kendall, Under Secretary of Defense, Acquisition, Technology and Logistics said that the "ultimate measure of performance is providing effective systems to the warfighter that are suitable for fielding, at costs that are affordable, while ensuring taxpayers' money is spent as productively as possible."[36] However, because this definition is too general for the purposes of this study, this report defines a successful acquisition outcome as a program that survives the Concept Definition (CD) and Engineering & Manufacturing Development (EMD) acquisition phases and enters production. Over the last 25 years, LCS program acquisition has witnessed mixed results with a number of cancelled or deferred programs, along with some notable (albeit fewer) successes. Appendix 2 summarizes the results of recent LCS acquisition programs that have not met this success criterion, and provides some distinguishing program characteristics as potential underlying causes.

One factor driving performance involves contract structure. Despite DoD acquisition reform initiatives in recent years which direct greater use of fixed-cost contracts to incentivize better contractor performance, cost-plus contracts are more typical in LCS acquisitions during the CD and EMD acquisition phases. This places all of the cost and schedule risk on the government because poor management or program deficiencies, in cost or schedule liability, ultimately come back to only the government. Thus, there is little incentive for the contractor to drive program efficiencies. Yet, when less mature technologies are involved (which has been a consistent trend among many LCS programs), fixed-cost contracts are unworkable for contractors because they involve too many technology development unknowns. What limited acquisition success stories are available have been associated with programs containing more commercial availability, and thus more mature technology. These programs have employed acquisition strategies that solicited vendors to submit commercial based systems at a fixed price. This was made feasible because it occurred once the technology and cost were well understood (usually upon entering EMD). In one program, this was even successfully used somewhat earlier in the CD phase. In that case, contractors were provided performance feedback and allowed to be part of the conduct of the test prior to the government's independent evaluation. This had many benefits. Among them, it created a level playing field for competition, greatly increased communication between the government and industry and most importantly, limited government liability, placing the onus on the contractor to control cost.

Another factor that has played a role in the success or failure of LCS acquisitions has been requirements development. There is currently a lack of professionalization among Requirements Officers beyond on-the-job training opportunities. Without specific training in this field regarding requirements generation and acquisition processes, requirements decisions are left exclusively to officers with only an operational background. These officers typically have a great deal of practical knowledge regarding the use of the systems and technologies in the field, but lack critical knowledge regarding the level of technical maturity or the cost and time necessary to develop that technology. This knowledge is now resident only within the Army and Marine Corps acquisition commands. Yet, these organizations are often times not involved until much later in the process, after basic requirements have already been determined.

What has resulted is an ever-increasing trend of stated requirement changes during execution, without regard for the effects such changes have on cost and schedule risk. Closely related to this result is a trend of increasing program scope (known as "requirements creep") regarding Key Performance Parameters (KPPs). This has been done in a good faith effort to ensure the *warfighter* receives all the capability that he could possibly need. Rather than taking an incrementally designed "good enough" approach, by upgrading vehicles at some future date when the technology has sufficiently matured, these KPPs are written as all-inclusive capability requirements that significantly affect acquisition cost and schedule. Some argue that incremental improvements increase the difficulty of vehicle fleet configuration management, leading to a mix of vehicle types in service. This impacts operator and maintenance training in addition to logistical support (i.e., parts supply). However, evidence suggests that excessively long acquisition schedules that result from such lofty requirements have resulted in configuration issues in any event. This is due to a mix of legacy vehicles and upgraded vehicles of the same model that have received necessary life extensions with accompanying upgrades.

Another complication involves the test community and its role in the acquisition process. Vehicle testing, as the last step in the acquisition process before production, has been perceived to be an impediment to successful outcomes due to seemingly extensive and sometimes unrealistic standards. Complex leading-edge technology requirements have contributed somewhat to this because the very nature of such complexity makes for more costly testing. However, the greatest contributing factor can be linked to a lack of early involvement of the test community in the program acquisition. What could be considered a valid performance requirement may be extremely difficult or expensive to verify during developmental or operational test. Earlier involvement of the test community during the requirements development process would facilitate early identification of such issues, and allow program managers to mitigate them by modifying the requirement or verifying it by some other means. If this is done up front in the LCS acquisition process, both schedule delay and increased cost could be avoided later in the program. This model has been executed during the early acquisition of the JLTV with some promising results.

OUTLOOK

This report has established the current and near-term industry trends and evaluated LCS industry and market performance. It will now examine future long-term demand and offer recommendations for improving the industry. The DoD's potential long-term demand can be categorized into three alternate future scenarios.

Future Demand Scenarios

Scenario 1: "*The Bathtub*": The most optimistic scenario, referred to as "*the bathtub*", is characterized by a 5-6 year funding low, followed by a return to previous elevated levels. Program life extensions and upgrades to older systems, such as M1 Abrams and HEMTT, will be accompanied by new production contracts, such as JLTV and AMPV. This scenario is based on historical precedent, where spending recovery has typically followed post-conflict drawdown to pre-war spending levels. Some government and many industry leaders interviewed expect that this will occur early in the 2019 period, once a solution to the BCA has been implemented.[37] The challenge during this period will be for the DoD to estimate the funding that is required to modernize and sustain current vehicle fleets. Another challenge without new program starts, such as the cancelled GCV, is that most legacy LCS vehicles have no remaining growth margin available in Size, Weight & Power or Cooling (known as SWAP-C). CV market production will recover in FY19 with an estimated $5.5B for AMPV, Bradley Engineering Change Proposal (ECP) and Abrams modernization.[38] Meanwhile, the TWV segment will complete JLTV development and transition to production by this recovery start date.

Scenario 2: "*The Waterfall*": The most pessimistic scenario incorporates further reductions of the total sequestration defense budget with further force structure re-shaping. Declining LCS budgets, with no predictable return to pre-war spending levels, will result in a future environment that is represented as an LCS budget "*waterfall*." The BCA mandates cuts to future DoD budgets by $487B in the next decade.[39] To protect manpower and readiness, both the Army and Marine Corps will continue to shortchange LCS programs for an indeterminate period. Meanwhile, operation and sustainment budgets will be reduced according to reduced readiness requirements. Hence, depot maintenance and working capital funds will be sized according to operational tempo, without well-structured modernization schedules, resulting in workload level that is at an all-time low. Industry firms will need to increase pressure on Congress and the DoD for depot work shares and assistance in gaining access to overseas markets. The arbitrary defense reductions under this scenario and lack of strategic vision will increase uncertainty and pessimism for the industry. Ultimately, certain firms will be forced to exit the CV and TWV markets.

Scenario 3: "*The New Normal*": The final alternative future scenario follows the decline and bottom lull of the "*bathtub*" scenario. However, instead of the expected full recover of that scenario, a much milder spending recovery is anticipated that will stabilize at significantly lower budget levels with only small incremental growth to LCS spending. This "*new normal*" in demand level becomes a permanent operating reality with budgets closer to the bottom of the fiscal "*bathtub*." This scenario represents the continuing fiscal demands of DoD accounts (outside of LCS) with permanent reductions to force structure. DoD investments will continue to focus on *phase zero* shaping systems and forces. LCS procurement budgets here will likely grow no higher than the near minimum sustainment levels of $1.5 billion annually for CV and no more than $1 billion for TWV. It will most likely induce a consolidation of large firms and key suppliers, or force them to exit the market entirely. DoD and Congress will battle over a balance between desired minimum production that maintains capability without crowding-out other DoD priorities, with the political influence of constituency groups.

Increased uncertainty, reduced demand, and a greater risk burden borne by the industry will inhibit technological gains. In most current cases, industry development focuses on science and technology (S&T) application that is targeted to take proven technology to a higher level of

performance. As a consequence, it is unlikely that revolutionary technological breakthroughs necessary to sustain US technical superiority would be achieved in the future.

CONCLUSIONS

With an understanding of the current conditions and resulting industry performance, this report offers the following major conclusions about its current state and outlook. These conclusions are by no means all-inclusive, but highlight the key issues that affect the CV and TWV markets.

LCS Demand Effects

After reaching a peak in demand and production during the wars in Iraq and Afghanistan, the decline since 2010 has been significant. This decline is the result of a number of factors in addition to the end of combat operations. This has primarily been a consequence of the BCA budget cuts. However, future LCS budgets will be increasingly affected by the strategic shift to the Asia-Pacific, projected Army and Marine Corps force structure reductions, and decreased long-term DoD budgets under the "*new normal*" future outlook discussed earlier. Furthermore, during the *high budget* era of the last decade, a great majority of the CV and TWV fleet was refurbished following its return from deployment. This now leaves the DoD with a relatively young LCS fleet in a high state of readiness, further reducing the demand for new acquisitions. Due to these trends, a greater portion of future demand in both the CV and TWV markets is expected to come from maintenance and upgrades rather than new programs. This will lead to even greater competition for the remaining few new start "winner take all" contracts, such as AMPV, Marine Personnel Carrier (MPC), and JLTV.

Export of LCS Products

With decreased domestic demand, OEMs are now increasingly looking towards international sales to weather the downturn. However, demand from international sales will not fully make-up for domestic market decline. This is due to a number of reasons. The US is the largest customer by far within the global LCS market. Therefore, it is improbable that demand from a few friendly markets (which are also affected by the same budgetary pressures) will be able to effectively offset US reductions. In addition, US LCS products will go up against steep global competition. European and Asian military vehicle firms along with indigenous suppliers will be competing for these same contracts. Since US makers of CVs and TWVs design and market their vehicles exclusively for the DoD, these products compete on high-end performance with less regard for price, whereas emerging markets are much more price-oriented as part of selection criteria. These "high-end" American products may therefore be uncompetitive due to price and complexity. Likewise, international sales are often hampered by diplomatic obstacles and offset requirements. Fear of security risks and intellectual property losses will make it difficult for many of these products to be marketed beyond only a few international partners. Despite recent export restriction reforms, industry leaders have noted that more needs to be done as they have yet to experience the expected benefits from such reforms.

Overcapacity and Low Utilization

As demand declines, managing the LCS industry will be difficult with many trade-offs to be considered. Among them will be balancing the risk of reviving a dormant LCS industry during some future national emergency versus the current consumption of DoD budgets with wasteful overhead. The questions of how much risk is acceptable and whether DoD and Congress can mitigate those risks will make up much of the LCS industry debate in the coming years. These difficult questions are further complicated by the equities of numerous stakeholders that make any management decision seeking consolidation for efficiency more difficult to implement.

The recent demand decline without a corresponding reduction in CV production infrastructure has led to low utilization and large overcapacity. This has increased costs for vehicle repairs and upgrades in order to cover unnecessary overhead. As we look to future demand and budget expectations, maintaining duplicative commercial and government CV production facilities with overlapping capabilities is unsustainable. The challenge for the government will be to determine the minimum level of production capability necessary for the CV market from which the nation can ramp up production when needed. Recent public-private partnership trends involving supply chain management and manufacturing work-share show promise to alleviate some of these issues. Yet, a new vision of CV production is required that realistically balances the required number of OEMs, with depots and other government owned CV production facilities.

Although the health of the CV market is more fragile and dependent upon government support, the TWV market demonstrates greater resiliency. In the TWV market, firms have employed various means to remain profitable. Lean management initiatives along with the diversification that is already resident within their business models as commercial manufacturers, has allowed these firms to counter the dip in military sales. With less control exercised by the government, TWV suppliers have been more flexible in adjusting work capacity to meet demand. Some firms have even left the market entirely when profits were not sufficient to support the business case to remain. Since the TWV market is more commercial in nature and has lower entry barriers, this market will require less attention by the DoD. As demand ebbs and flows, new entrants and already established TWV suppliers will be available to meet the DoD demand. The successful surge production of MRAP is a testament to this capability.

Importance of maintaining critical skills

Despite this decrease in demand and continued drawdown across the industry, some critical skills must be maintained to ensure continued competitiveness and mitigate national security risks. Engineering core competencies involving front-end design and systems integration are of particular importance for the industry, especially with the *military unique* designs associated with CVs. Likewise, production knowledge and skill-sets that involve more specialized manufacturing are another area of concern for the industry. One of the skills most at risk is armor welding. LCS Hull and armor welding is not comparable with commercial welding techniques, and therefore, requires government support. If not maintained, requalifying such skills would be costly and time consuming.

Lessons of the European Model

The European LCS industry offers a glance at an alternative model. This is instructive because many of the current trends along with the projected "*new normal*" outlook for the US LCS

industry has been the European reality for some time. Consequently, there are many lessons that the European experience can provide. European LCS firms, operating under continued austere conditions with little government support, have been forced to adapt. In this environment, they have adjusted their manufacturing model to do shorter and discrete production runs with periodic production stoppages. Although this leads to increased costs and longer lead times for orders, these firms have shown the ability to successfully operate under these challenges. Additionally, European governments do not normally directly fund technology and product development, but instead, evaluate off-the-shelf capabilities for purchase. This leads firms to do more IR&D in order to remain competitive. Additionally, European firms design systems with export in mind from the outset. This enables competition in the high-end European and Middle East markets as well as offer lower-cost solutions to the developing world.

RECOMMENDATIONS

The following recommendations are limited to what can realistically be achieved in the current political environment, with the understanding that without support from the many LCS stakeholders little can be changed. A broad consensus is necessary. Yet, in some cases, difficult decisions resulting in both winners and losers will have to be made to sustain competitiveness.

New Vision for the CV Industrial Base

The unsustainable overcapacity described throughout this study requires a new vision. This includes the development of a strategy that manages the CV industrial base as a regulated industry in order to maintain capabilities at an affordable cost. Instead of attempting to prop up two separate CV firms with both design and production capabilities, the government should maintain design competition but consolidate production and depot level maintenance in fewer facilities by encouraging use of joint ventures and public-private partnerships.

The DoD should not attempt to subsidize all capabilities of the CV firms, but instead focus on the few critical skills in front-end engineering design and manufacturing processes that are deemed most at risk. This targeted approach should also be applied to the supply chain. Instead of an OEM centric focus, the DoD should concentrate support efforts on key second and third tier suppliers of *military unique* items that have the greatest supply risk (e.g., sensor and optics suppliers).

For production, a review of the JSMC management structure is recommended in order to increase efficiency and allow facility use by multiple contractors. First, an independent third-party contractor should have oversight of the facility. This would provide one organization with the responsibility, authority and accountability that would ensure efficient operation and sustainment of the facility and tooling. Secondly, when future CV contracts are awarded, they should include incentives or direction to manufacture in this facility, as opposed to building new facilities that add to overhead. If the JSMC were given the same legal authority as depots now have to open facilities up to commercial leasing arrangements, excess capacity could be better utilized. Furthermore, consolidation of depot level work at either ANAD or RRAD would reduce overhead and ensure a steadier workflow across multiple vehicle platforms. Although this would be the hardest recommendation to pass without considerable stakeholder buy-in, the industry cannot support the number of depots and arsenals presently servicing LCS.

Requirements Reform

Early communication between the acquisition process stakeholders (i.e., requirements development, acquisition strategy, and test) is the foundation of any good program. However, despite the fact that all of these processes are interrelated, they are typically treated as separate because they are assigned under different organizations. In setting program requirements, it is critical that all three communities work together to ensure that requirements are well understood, involve sufficiently mature technology, and can be tested effectively and efficiently. Efforts should be made to incentivize earlier and more frequent communication between these entities beginning while requirements are being developed.

Although requirements development often sets the terms for success or failure of an LCS program, there is a lack of sufficient training for Requirements Officers. Efforts should be taken to professionalize these positions, similar to what was previously accomplished with the Acquisition Corps. At a minimum, there should be a process of more formalized training in both requirements and acquisitions prior to serving in these assignments. This would support a better recognition and understanding of technology maturity, cost of requirement, and affordability implications among future Requirements Officers.

Role of S&T in Maintaining Competitive Advantage

As production decreases, it will become increasingly important to maintain front-end design and development skills through the continued support of design teams. This can be accomplished by revising the manner in which S&T budgets are spent. For example, S&T budgeting should be used to support both government and commercial efforts that are focused on leap-ahead technology at the component level. These funds could also provide OEMs with new revenue streams associated with prototype development. However, these efforts should be exclusively focused on future development and not directly connected to existing acquisition programs. This requires close coordination and ongoing communication between the S&T community and the acquisition world.

APPENDIX 1: LCS Industrial Base Structure

LCS Industrial Base Structure

Industry
New Work
Government

First Tier Contractors & Government Entities

Combat Vehicle Producers and/or Integrators
BAE US Combat Systems
General Dynamics Land Systems (GDLS)
Tactical Wheeled Vehicles
AM General / Oshkosh Defense
Freightliner / Navistar Defense
Potential New Entrants: LM, Boeing, SAIC

New Work
Up Grades
USMC AAV Tracked Amphib CV: BAE, GDLS or SAIC
Abrams Upgrade: GDLS or Depot
Bradley Upgrade: BAE or Depot
HMMWV Recap TWV: AM General or Depot
New Starts
JLTV Army/USMC TWV: AM General, LM or Oshkosh
USMC ACV 1.1/ MPC: US / EU Partners
Army AMPV Tracked CV: BAE or GDLS
Army Future CV R&D: BAE, GDLS, LM, Raytheon, SAIC

Depots (GOGO)
Anniston AD
Red River AD
MCLB Albany

Lima Tank Plant GOCO
JSMC [GDLS]

Second Tier Subcontractors & GFE Providers

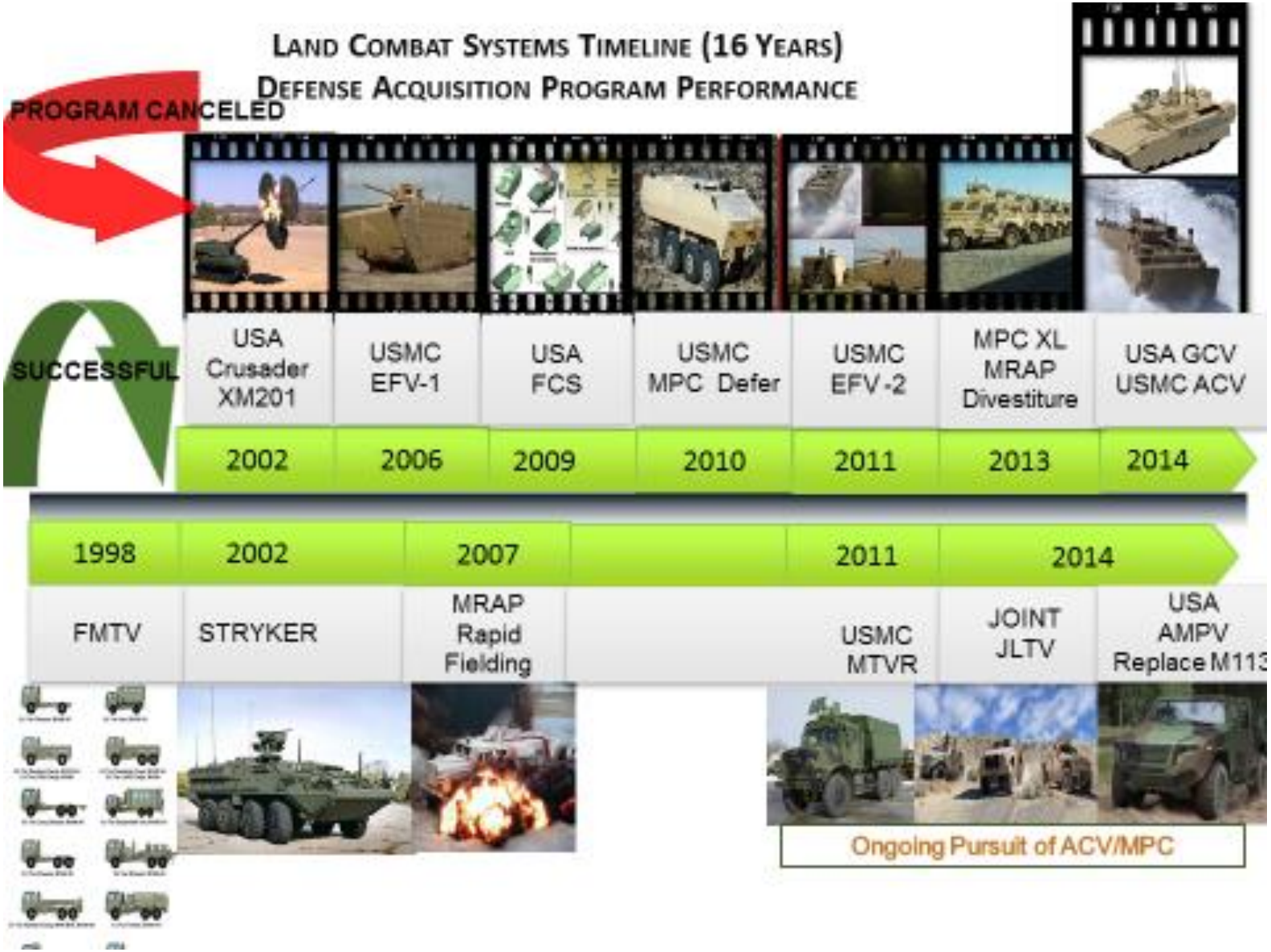
- TWV is a commercial supply chain, CV is predominantly military unique with DoD direction

Steel /Alum	Armor Solutions	Engines	Trans	Automotive	Sensors/Wpns	Component Rebuild	Arsenals	Supply Chain Mang
Alcoa, DOE, Kaiser Arcelor Mittal, Evraz Oregon Algoma Steel Off-Shore	BAE S&S Ceradyne IBD Oran Plasan Sasa	Caterpillar Cummins Honeywell Tognum MTU/	Allison L-3 Twin Disc	Axletech C E Niehoff Cushman Goodyear, Meritor Michelin, Titan	Boeing, DRS Lockheed Northrop Raytheon Textron	Anniston AD Red River AD	Rock Island, IL Watervliet, NY (M1 gun barrels)	DLA AMC

Sub-Tier Vendors/Suppliers

- TWV: Large, diverse, commercial (automotive) supply chain – influenced by global market forces
- CV: Military unique supply chain influenced by security of supply & information (ITAR) needs
- Supply chain Influenced by govt policy (i.e. small biz & minority set asides) & political sourcing

APPENDIX 2: LCS Acquisition Program Performance



APPENDIX 3. Acronym List

AAV	Amphibious Assault Vehicle
ABCT	Armored Brigade Combat Team
ACE	Armored Combat Earthmover
ACV	Amphibious Combat Vehicle
AMPV	Armored Multi-Purpose Vehicle
ANAD	Anniston Army Depot
BAE	British Aerospace Engineering Systems
BCA	Budget Control Act
BBP	Better Buying Power
BRAC	Base Realignment and Closure
CITE	Center of Industrial and Technical Excellence
COCO	Contractor Owned Contractor Operated
CONUS	Continental United States
CV	Combat Vehicle
CVIB	Combat Vehicle Industrial Base
DCMA	Defense Contracting Management Agency
DCS	Direct Commercial Sales
DIB	Defense Industrial Base
DLA	Defense Logistics Agency
DoD	Department of Defense
EU	European Union
EDA	European Defense Agency
EMD	Engineering Manufacturing Development
EFV	Expeditionary Fighting Vehicle
FCS	Future Combat System
FMS	Foreign Military Sales
FMTV	Family of Medium Tactical Vehicles
FY	Fiscal Year
FYDP	Future Years Defense Program
GCV	Ground Combat Vehicle
GDLS	General Dynamics Land Systems
GFE	Government Furnished Equipment
GOCO	Government Owned Contractor Operated
GOGO	Government Owned Government Operated
HEMTT	Heavy Expanded Mobility Tactical Truck
HET	Heavy Equipment Transporter
HMMWV	High Mobility Multipurpose Wheeled Vehicle
IB	Industrial Base
IR&D	Independent Research and Development
ITAR	International Trade in Arms Regulation
JLTV	Joint Light Tactical Vehicle
JSMC	Joint Systems Manufacturing Center
KPP	Key Performance Parameter

LAV	Light Armored Vehicles
LCS	Land Combat Systems
LVSR	Logistical Vehicle System Replacement
MLRS	Multiple Launch Rocket System
MPC	Marine Personnel Carrier
MRAP	Mine Resistant Ambush Protected
MTVR	Medium Tactical Vehicle Replaceent
NATO	North Atlantic Treaty Organization
OCO	Overseas Contingency Operations
OEM	Original Equipment Manufacturer
P3	Public-Private Partnership
PEO	Program Executive Office
PIM	Paladin Integrated Management
PLS	Palletized Load System
PM	Program Manager
PV	Protected Vehicle
QDR	Quadrennial Defense Review
RFP	Request for Proposal
RRAD	Red River Army Depot
SCM	Supply Chain Management
S&T	Science and Technology
TACOM	Tank-Automotive & Armaments Command
TD	Technology Development
TFEU	Treaty on the Functioning of the European Union
TDP	Technical Data Package
TWV	Tactical Wheeled Vehicle
USMC	United States Marine Corps
USML	US Munitions List
WSARA	Weapon Systems Acquisition Reform Act

ENDNOTES

[1] *Annual Industrial Capabilities Report to Congress* (Washington, D.C.: Under Secretary of Defense for Acquisition, Technology and Logistics, October 2013), http://www.acq.osd.mil/mibp/docs/annual_ind_cap_rpt_to_congress-2013.pdf.

[2] Ibid.

[3] Ibid.

[4] Ibid.

[5] Note: Security of information involves protection of military technology while security of supply is associated with a desire to minimize dependence on foreign sources of supply for defense related items.

[6] Brandon Ruiz, *IBIS World Industry Report, 33699b, Tank and Armored Vehicle Manufacturing in US* (IBISWorld, December 2013), www.ibisworld.com.

[7] *Quadrennial Defense Review 2014* (Washington, D.C.: Dept of Defense, 2014), IX.

[8] NOTE: data does not include all TWV and CV related spending, i.e. depot work and repair parts. USASpending.gov, Summary LCS Spending, http://www.usaspending.gov/search?form_fields=%7B%22search_term%22%3A%22land+combat+systems%22%2C%22recip_state%22%3Anull%2C%22recip_congdist%22%3Anull%2C%22recip_country%22%3Anull%2C%22spending_cat%22%3A%5B%22c%22%5D%2C%22dept%22%3A%5B%229700%22%5D%7D, (accessed 28 April, 2014).

[9] Eisenhower School, Land Combat Systems Industry Study, Field Studies Brief, April 16, 2014 and March 14, 2014.

[10] Eisenhower School Land Combat Systems Industry Study, Field Studies Brief, February 28, 2014.

[11] Eisenhower School, Land Combat Systems Industry Study, Field Studies Brief, March 14, 2014.

[12] Ibid.

[13] Eisenhower School, Land Combat Systems Industry Study, Field Studies Brief, March 14, 2014 and April 18, 2014.

[14] Eisenhower School Land Combat Systems Industry Study, Field Studies Brief, February 28, 2014.

[15] Eisenhower School, Land Combat Systems Industry Study, Field Studies Brief, March 14, 2014 and April 17, 2014.

[16] "Kirk Highlights Bipartisan Efforts to Enhance Public-Private Partnerships, Keep Jobs at the Arsenal | Mark Kirk | Senator for Illinois," August 26, 2013, http://www.kirk.senate.gov/?p=press_release&id=846.

[17] Peter Buxbaum, "Depot Maintenance," October 9, 2013, http://www.kmimediagroup.com/military-logistics-forum/432-articles-mlf/depot-maintenance-1/5110-depot-maintenance.

[18] Eisenhower School, Land Combat Systems Industry Study, Field Studies Brief, April 17, 2014.

[19] Eisenhower School, Land Combat Systems Industry Study, Field Studies Brief, April 16, 2014.

[20] Ibid.

[21] Note: For the purposes of this report, the terms EU, Europe, and European are used synonymously.

[22] Note: The EDA is made up of all European Union members except Denmark.

[23] Jessica Duran and Antonio Corral, *Study on the Perspectives of the European Land Armament Sector: Final Summary Report* (IndustriAll European Trade Union, November 14, 2012), 17, http://www.industriall-europe.eu/sectors/defence/2012/INFF_E3779_Final%20Summary%20Report_v03-EN.pdf.

[24] Ibid., 11.

[25] Central Intelligence Agency, "'Country Comparison: Military Expenditures.' The World Factbook," accessed April 21, 2014, https://www.cia.gov/library/publications/the-world-factbook/rankorder/2034rank.html.

[26] Jessica Duran and Antonio Corral, *Study on the Perspectives of the European Land Armament Sector: Final Summary Report*, 60.

[27] Ibid., 11.

[28] "Eisenhower School Land Combat Systems Industry Study, ICBE-6, Jan 27, 2014" (Washington, D.C., January 27, 2014).

[29] "Defence Procurement - European Commission," accessed April 21, 2014, http://ec.europa.eu/internal_market/publicprocurement/rules/defence_procurement/.

[30] Jessica Duran and Antonio Corral, *Study on the Perspectives of the European Land Armament Sector: Final Summary Report*, 59.

[31] Note: Because of the cost of qualifying a new supplier, re-competing a TDP is not practical for procurements involving small to mid-size quantities. A re-compete strategy is most beneficial for programs with substantial production that occurs over many years (e.g., FMTV and JLTV).

[32] Eisenhower School Land Combat Systems Industry Study Discussions.

[33] Eisenhower School Land Combat Systems Industry Study, Field Studies Brief, April 16, 2014.

[34] Eisenhower School Land Combat Systems Industry Study, Field Studies Brief, April 17, 2014.

[35] Eisenhower School Land Combat Systems Industry Study, Field Studies Brief, February 3, 2014.

[36] *Performance of the Defense Acquisition System 2013 Annual Report* (Washington, D.C.: Office of the Under Secretary of Defense, Acquisition, Technology and Logistics, June 28, 2013), iv, http://www.acq.osd.mil/docs/Performance%20of%20the%20Def%20Acq%20System%202013%20-%20FINAL%2028June2013.pdf.

[37] James Drew, Olga Belogolova, and Tony Bertuca, "House Armed Services Committee Tallies Acquisition Program Pluses, Minuses. InsideDefense.Com's SitRep," accessed April 21, 2014, http://search.proquest.com.nduezproxy.idm.oclc.org/docview/1520919795?accountid=12686.

[38] Ibid.

[39] Richard Kugler and Linton Wells, *Strategic Shift Appraising Recent Changes in U.S. Defense Plans and Priorities* (Washington, D.C.: Center for Technology and National Security Policy Institute for National Strategic Studies National Defense University, 2013), 86.

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