

Spring 2010
Industry Study

Final Report
Land Combat Systems Industry



The Industrial College of the Armed Forces
National Defense University
Fort McNair, Washington, D.C. 20219-5062

LAND COMBAT SYSTEMS 2010

ABSTRACT: The Land Combat Systems (LCS) industry is in transition. The war related surge in production peaked in 2009. The drawdown of forces in Iraq, a weakened economy, cancellation of the Future Combat System (FCS) and anticipated future declines in defense budgets are causes for concern about the future health of the industry. The U.S. also faces growing asymmetric security challenges. The government will need to monitor the health of the industry and its suppliers during the coming years to ensure it is fully capable of responding to future crises. New vehicle systems projections offer the LCS industry growth opportunities in the five to ten year period. The outcomes of these initiatives could alter the face of industry. Industry participants are keenly aware of the emerging challenges in the LCS market. Despite these challenges, the LCS industry will be fully capable of meeting national security requirements during the next five years.

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PLACES VISITED

Domestic:

Aberdeen Test Center (Aberdeen Proving Grounds, MD)
Allison Transmissions (Indianapolis, IN)
AM General (Mishawaka, IN)
Anniston Army Depot (Anniston, AL)
BAE U.S. Combat Systems (York, PA)
Force Protection Industries, Inc. (Charleston, SC)
General Dynamics Land Systems Hqs (Sterling Heights, MI)
General Dynamics Land Systems Anniston Operations – Stryker assembly plant (Anniston, AL)
Joint Services Manufacturing Center - Lima Tank Plant (Lima, OH)
Letterkenney Army Depot (Chambersburg, PA)
MTU Detroit Diesel (Detroit, MI)
Oshkosh Corporation (Oshkosh, WI)
U.S. Army Ground Combat Vehicle Office (USATACOM, Warren, MI)
U.S. Army Heavy Brigade Combat Team Program Office (USATACOM, Warren, MI)
USMC Expeditionary Fighting Vehicle Program Office (Woodbridge, VA)
USMC Joint Light Tactical Vehicle (JLTV) Program Office (Quantico, VA)
USMC Mine Resistant Ambush Protected (MRAP) Program Office (Quantico, VA)

International:

General Dynamics European Land Systems Steyr-Daimler-Puch Spezialfahrzeug (Vienna, Austria)
MAN Nutzfahrzeuge Österreich, Military Trucks (Vienna, Austria)
Krauss-Maffei-Wegmann (Munich, Germany)
MAN Nutzfahrzeuge, Commercial Trucks (Augsburg, Germany)
Renk Transmissions (Augsburg, Germany)
Rheinmetall-MAN Military Vehicles (Munich, Germany)
Iveco Defense Vehicles, Fiat Consortium (Bolzano, Italy)
Oto Melara (Finmeccanica) (La Spezia, Italy)

INTRODUCTION

The LCS industry is in transition. The war related surge in production peaked in 2009. The U.S. economy is recovering from recession. The government's financial outlook has changed due to rising debt and its ability to finance discretionary programs is increasingly under pressure. While the U.S. is still the world's superpower, its position is challenged by rising competitors (Brazil, Russia, India, and China (BRIC)) and the European Union (EU). The U.S. also faces growing asymmetric security challenges emanating from the so-called "arc of instability," the wide swath of highly populated, but less developed countries spanning the global tropics. Globalization, the growth of international trade and finance, and the internet add to the likelihood and potential complexity of a wide variety of conflicts around the world.

This environment highlights the importance of the LCS industry's ability to respond to national security threats. Though the industry needed time to respond to the demands of the wars in Iraq and Afghanistan, it was able to expand its production and supply chain capacity. The short to mid-term outlook for the LCS industry is a decline in production, with a recovery linked to new production programs by 2017 or 2018. Industry will face challenges to retain key skills and capabilities. The LCS industry is currently capable of meeting the national security requirements; but the government will need to monitor the health of the industry and its suppliers during the coming years to ensure it is fully capable of meeting the nation's requirements.

This report examines several factors relating to the LCS industry: its current state, challenges it faces, and its ability to respond to future needs. It also includes recommendations on how the government can improve the LCS industrial base and relations with industry. The report takes a deeper look at several issues with which the industry is grappling and looks at the European LCS industry. The report is based on academic research and analysis as well as meetings with U.S. and European manufacturers, program managers, government depots, government-owned/contractor-operated (GOCO) facilities, and testing centers of excellence.

THE INDUSTRY DEFINED

The LCS industry is a subset of the larger defense industry. Tracked and wheeled combat vehicles, protected vehicles, and tactical wheeled vehicles define the major industry products. Examples of tracked and wheeled fighting vehicles are tanks, infantry fighting vehicles, and amphibious assault vehicles. Whether wheeled or tracked, this class of vehicles is primarily designed to fight. Protected vehicles include types such as the MRAP series and Armored Security Vehicles (ASV). Tactical wheeled vehicles have the ability to operate off-road as well as on-road and consist of light, medium and heavy classes of trucks, ranging from high mobility, multi-purpose vehicles to heavy trucks.

The LCS industry encompasses establishments in both public and private sectors, including entities engaged in product development, manufacturing, integration, sustainment, and related suppliers. The top-level structure of the industry consists of end-item development, manufacturing, integration and recapitalization firms, government-owned/government-operated (GOGO) facilities, GOCO facilities, and research and development and test facilities. The second tier of the industry supplies major components to systems manufacturers, such as armoring solutions, ballistic grade aluminum and steel, armaments, off-road capable engines and transmissions, sensor and command and control (C2) suites, automotive components, and remanufactured components¹. The third level of the industry includes vendors and suppliers to

prime contractors, subcontractors and GOGO depots. Firms active in this level of the industry usually also supply goods and services to non-defense industries, including the automotive industry.

The scope of the U.S. LCS industry is global. The U.S. LCS industry designs, produces, and supports international markets through export sales, including transactions conducted through the Department of Defense's (DoD) Foreign Military Sales (FMS) program and direct commercial sales (DCS) concluded between U.S. suppliers and foreign customers. The LCS industry has demonstrated the ability to surge to meet national security requirements in response to conflicts in Iraq and Afghanistan. Buyers and users are generally governments and private military corporations. In terms of overall defense dollars, the LCS is a relatively small part of U.S. defense spending. The 2011-2012 outlook is roughly \$30-35 billion.²

CURRENT CONDITIONS

U.S. demand for LCS products has been strong in recent years, but the market is entering a period of transition with projected near-term demand tapering off. Demand associated with new vehicle production, reset and recapitalization, and fleet sustainment had been high due to operations in Afghanistan and Iraq, as well as decisions to expand the force structures of the Army and Marine Corps and to better equip reserve and National Guard units. LCS-related spending increased dramatically from less than \$10 billion in 2002 to more than \$40 billion in 2008. However, LCS-related expenditures have begun to decrease and are expected to fall further until the demand associated with new planned programs rebounds after 2017.

Strategic Environment

Evolving threats from conflicts in Iraq and Afghanistan increased requirements for military vehicles, both in terms of quantities and capabilities. The distinction between "combat vehicles" and "tactical vehicles" has blurred. There are no clear front lines in today's operations. Survivability is now a key criterion, especially with the use of improvised explosive devices (IEDs). As a result, many vehicles acquired now are protected and carry increased communication equipment.³ The additional armor and associated weight may adversely impact a vehicle's mobility, power, and transportability.⁴ The weight issue in turn drives the demand for lighter armor and vehicle structures; however these technologies are still in the research phase. The integration of new communications, connectivity and counter-IED requirements has also increased combat vehicle complexity. The conflicts in Iraq and Afghanistan have demonstrated the continued value of armor in the present national security environment. DoD's budget plans call for resetting and recapitalizing the heavy armored fleet within two years after the end of the current conflicts, instead of an earlier planned phase-out of these vehicles.⁵ DoD's cancellation of the FCS Manned Ground Vehicle (MGV) program has heightened the Army's need to rely on Abrams M1A2 tanks and Bradley Infantry Fighting Vehicles (Bradley) to retain its Heavy Brigade Combat Teams' (HBCT) capability.

The Army and the Marine Corps are pursuing the development of new vehicle platforms with capabilities reflecting the lessons learned in recent combat operations. The Army has initiated the Ground Combat Vehicle (GCV) program to develop a highly survivable infantry fighting vehicle. The Marine Corps is also continuing development of the Expeditionary Fighting Vehicle (EFV) based on its requirement for a vehicle to support forcible entry capabilities. The Army and Marine Corps are also working together on the JLTV program to develop a family of

light tactical vehicles and trailers. Other countries have initiated similar programs and there is increased demand for larger protected wheeled combat vehicles worldwide.^{6, 7}

Current Structure of the Market/Industry

Strong defense spending during the past decade has resulted in a healthy domestic LCS industry, but decreasing demands for military vehicles will impact the future health. Multiple domestic suppliers have competed to satisfy DoD requirements for combat and tactical vehicles, with some teaming with international partners. The industry has expanded its production and supply chain system to respond to strong demand for military vehicles.

DoD-owned facilities are significant actors in the industry structure. GOGO and GOCO depots play significant roles in the market, especially related to the reset and refurbishment of major systems and components, frequently through public-private partnerships (P3) with the original equipment manufacturers. DoD has also purchased major tooling to facilitate industry's ability to respond to DoD's requirements, including both public and private establishments. See the essays on engines and transmissions for further information on this topic.

The competitive structure of the market encouraged mergers and acquisitions, joint ventures, new entrants, and increased independent research and development. The new enhanced capabilities required in military vehicles, have led to mergers, acquisitions and teaming arrangements between traditional vehicle manufacturers, key component suppliers (including armor technology), and weapon systems integrators. For example, Armor Holdings bought Stewart and Stevenson to link its armoring capabilities with tactical vehicle production capabilities. BAE Systems acquired United Defense Limited Partnership (UDLP) to enter the U.S. combat vehicle market and then acquired Armor Holdings to give the group a presence in the combat and tactical vehicle markets. The essay on globalization and supply chain management provides further information.

Entry barriers in this industry are not as high as many observers previously believed.⁸ However, the specialized skills associated with designing and manufacturing armored vehicles have limited recent entrants to those with the requisite skills, the ability to partner with LCS firms, or to firms with deep pockets and a willingness to buy into the market. Significant recent entrants into the market at the prime contractor or key partner levels include start-ups (Force Protection Inc (FPI)); commercial firms (Navistar); and defense firms not traditionally active in the military vehicle market (Boeing, DRS Technologies, Lockheed Martin, Northrop Grumman, and Raytheon were each involved in the competition for the JLTV technology demonstration contract).

Vertical integration has also occurred in the industry in response to market demand for highly integrated and capable vehicle systems. Two integrated defense systems manufacturers (BAE Systems and General Dynamics Land Systems (GDLS)) and two military truck manufacturers (AM General and Oshkosh) have replaced the pre-2001 structure of two combat vehicle makers (UDLP and GDLS) and three light, medium, and heavy truck manufacturers (AM General, Stewart and Stevenson, and Oshkosh). Automotive suppliers have served as major fabrication, assembly and integration sub-contractors to support military vehicle programs. For example, on the MRAP program, Spartan Chassis acted as a subcontractor to BAE and FPI, while the Demmer Corporation served as a subcontractor to FPI and GDLS-Canada. The ability of defense companies to team with the commercial sector clearly contributed to the rapid fielding of MRAP vehicles.

Industry has pursued active independent research and development programs to upgrade and enhance the capabilities of existing vehicles, such as the Abrams, Bradley, High Mobility Multi-purpose Wheeled Vehicle (HMMWV), and Stryker.⁹ Industry is also developing new models in response to identified Army and Marine Corps requirements, such as the GCV, Marine Personnel Carrier (MPC), and the JLTV. In addition, industry is investing research funds in the areas of active/semi-active suspensions, hybrid-electric drives, command, control, communications, computers and information (C4I) systems, robotic systems, and lightweight armoring solutions.

Business strategies employed by the industry's key firms

Major LCS firms have adopted different strategies to succeed in the LCS market. For example, BAE has become an increasingly global company, relying largely on mergers and acquisitions around the world to obtain needed technologies and skills.¹⁰ Through its acquisitions and other investments, BAE has established centrally managed "home markets" in a number of countries, which the firm hopes to use to build new business opportunities. In contrast, GDLS has focused its U.S. establishments on developing and producing products for the U.S. market (or for export through DoD's FMS program), and generally pursued international opportunities through independently operating international units that it has acquired. GDLS has limited its capital investments, and has tended to lease facilities, often through P3 arrangements (e.g., its operations at the Anniston Army depot and at the GOCO facility in Lima, Ohio).

There is significant collaboration among firms in the LCS industry in addition to competition.¹¹ For example, BAE and Navistar are partners in the JLTV programs, but were competitors in the most recent Family of Military Tactical Vehicles (FMTV) competition. Firms understand the importance of safeguarding trade secrets in the development of relationships with partners and suppliers, especially considering that such firms may be competitors for other projects. Industry participants also recognize that partnerships can also foster future competitors, including foreign companies that leverage knowledge and experience obtain through co-development and offset programs with U.S. LCS firms and their suppliers to become competitors in the international market for all classes of combat vehicles.

After years of conflict, industry orders peaked in 2009 and are now declining.¹² The February 2010 *Quadrennial Defense Review Report* (QDR) outlines the expectation that defense procurement budgets will fall in the near term, but expresses the hope that funding to reset and recapitalize the fleet will continue two years past the end of the current conflicts. Industry participants are keenly aware of the emerging challenges in the LCS market.

OUTLOOK

As the conflicts in Iraq and Afghanistan wind down, the short to mid-term outlook for the LCS industry is a decline in production, with a recovery by 2017 or 2018. The FY 2011 Presidential Budget has only \$1.7 billion proposed for combat vehicle procurement. This figure is significantly down from annual amounts during the last decade. Some sources suggest that industry revenues could decrease by as much as 10 percent per year from 2010 to 2014.¹³ Production of newly manufactured vehicles will diminish over the next two years with little prospect for new vehicle production opportunities until 2017, at the earliest. War-related reset and refurbishment of vehicles returning from Iraq and Afghanistan will wane in the next few

years, but may be the bridge industry needs to take it through tough times. Domestic and international sales are likely to be very volatile and uneven, making revenues unpredictable for the first half of the decade, though they could grow slightly as the recession ends and economies strengthen.¹⁴

These factors will combine to create a “bathtub” effect from 2013 to 2017. Demand will steadily decline then bottom out in the middle of the decade before increasing toward the end of the decade. This will create management challenges for firms to retain qualified staff, maintain research and development investments, and make the necessary infrastructure investments to maintain a competitive advantage within the LCS industry. The effects may vary depending on lifecycle phase. That is, the effect on science and technology (S&T) and product development will likely be very different from the effect on production or sustainment. While, the overall long-term outlook is stable, the short-term fiscal stresses in the next five to seven years are likely to result in more industry consolidation, further eliminating the historical distinction between combat and tactical vehicle manufacturers. The key challenge will be maintaining a robust LCS industry during the coming financial trough to preserve capacity and skilled labor to meet future needs.

S&T

The S&T budget outlook is somewhat positive for the near-term and more positive for the long-term. The Army has maintained S&T budgets at pre-war levels but pulled most of the last decade’s cutting-edge technologies forward to support the war effort. This has created a huge gap in leap-ahead technologies for the next decade. Army S&T programs over the next decade will likely be oriented on long-term payoff technologies such as lightweight structures, robotics, and survivability enhancements. The tasks ahead should keep the LCS technology base healthy in the future.

Product Development

Product development is a critical defense industrial base skill. Engineering, Research and Development (R&D) and complex system integration skills are enablers for a viable LCS capability over the next decade. New programs such as the GCV and the JLTV are now in technology development, and the MPC is entering concept exploration. If all goes as planned, the GCV will begin production in 2018. The MPC, along with other potential development opportunities for Abrams, Bradley, M109 Paladin (M109 PIM), Stryker and EFV product improvements later this decade will also provide much-needed product development opportunities. If most of these programs come to fruition, there should be sufficient design and development opportunities to preserve critical engineering expertise. If these new programs do not materialize, the arts and sciences of combat vehicle design in the United States will suffer.

Production

The outlook for new vehicle production declines over the next five to seven years, but should improve at the end of the decade as the GCV, JLTV, MPC, Namer, or other vehicles go into full rate production. Existing new and remanufactured vehicle production is expected to finish several years before these new programs are to begin. The Army recently notified Congress of a request to stop purchasing HMMWV’s in 2011. New Stryker manufacture and the Abrams M1A2 System Enhancement Program will be complete by 2011. MRAP and MRAP-All Terrain Vehicle (M-ATV) production will finish by 2012. Bradley A3 upgrades will be the last

to finish in 2013. FMTV, Medium Tactical Vehicle Replacement (MTVR), and Heavy Tactical Vehicles (HTV) truck production will continue but at low production rates.

As current production winds down, there will be intense competition for additional work. Each opportunity could become existential for LCS firms. While no decision has been made, there is a possibility that Stryker could replace some of the aging, flat-hulled M113 Family of Vehicles (FOV) in Stryker Brigades. Acceleration of the M109 PIM and HMMWV recapitalization are both possibilities. The Namer should enter production in 2012 or 2013. There is a high likelihood of Abrams M1A3 and Bradley FOV upgrades as the Army continues its transformation. Any of these would help to smooth out the 2013 to 2017 bathtub effect. New production programs such as GCV, MPC, JLTV, and EFV, absent any major decreases in force structure, should begin to pick up in 2017-2018.

Increased advocacy for P3 arrangements is likely to create more sharing opportunities with defense depots. The P3 strategy has already proven highly successful for GDLS on the Stryker production contract. The GDLS work share with Anniston Army Depot (ANAD) on the Stryker reset contract almost certainly contributed to their success in that effort. A winning strategy for potential bidders on any new production program will likely include a P3.

Sustainment

Finally, while the sustainment outlook in the near term (one to five year period) will remain strong as vehicles return from Iraq and Afghanistan, the five to ten year outlook is challenging. DoD asked Congress to continue funding war-related reset activities for at least two years following the end of operations. As that is completed, reset and recapitalization is then likely to return to low levels. Service life extension programs are likely for Abrams, Bradley and, possibly the HMMWV. Lower production rates and smaller quantities, however, are likely to affect the LCS supply chain. Decreased demands for new or remanufactured vehicles could cause specialty parts providers to go out of business or move on to other markets before new production picks back up in 2017-2018. Several new firms, for example, entered the LCS industry through the MRAP program. These firms have since been largely unsuccessful in securing additional military vehicle contracts. Without a new production or sustainment contract, these firms may not have a long-term presence in the LCS industry.

Outlook Summary

With the current recession and growing national debt, the Congress will no longer be able to sustain large increases in the defense budget. DoD, in anticipation of declining budgets, rising vehicle costs, and gaps in the production stream, has begun to make tough choices about the required mix of vehicles. Unplanned procurements of vehicles such as the MRAP and M-ATV complicate future acquisition plans as Congress and Secretary Gates have instructed the services to incorporate MRAPs into the fleet. Due to cost constraints, the Army and USMC are looking at a mixed fleet of high and low capabilities for the long-term. Budget reductions coupled with increased demands for unmanned vehicles could negatively affect the manned vehicle fleet.

The lack of new opportunities in the near term could leave a consolidated LCS market to a few major survivors. However, new vehicle systems, such as the GCV, JLTV, and MPC offer growth in the five to ten year period. The outcomes of these production contracts could alter the face of industry, as could a major change in numbers of vehicles required. Despite these significant challenges, the LCS industry is fully capable of meeting national security requirements during the next five years. The U.S. government will need to monitor the health of

the industry and its suppliers during the coming lean years to ensure it is fully capable of responding to future crises.

CHALLENGES

The LCS Industry Study Seminar observed substantial concern from government and industry alike regarding the transition from a wartime operating tempo to a period of diminished demand. In several cases, coping strategies were under development. The current economic situation coupled with the vacuum left in the wake of the cancelled FCS program and reforms, e.g. the Weapons Systems Acquisition Reform Act (WSARA) present uncertainty that impairs both government and industry's ability to plan. As a result, the Seminar found the following challenges to be most significant: assessing how much industrial capacity is needed and supportable; maintaining the current force structure; reacting to potential policy adjustments associated with WSARA; and the political nature of weapons system acquisition.

Assessing Industrial Capacity

The outlook for the LCS industry creates challenges in sustaining the capabilities to support each major activity within the product lifecycle. While industry was able to meet production demands while employing only a single shift, supply chain capacity was a limiting factor. It is imperative that the U.S. Government understand how changes in demand may drive industry structure and capacity so DoD can minimize impacts to the U.S. national security posture.

With multiple new products in development (e.g., the EFV, GCV, MPC, JLTV and M109 PIM) and several more under consideration for the near future (e.g., Abrams, Bradley, and Stryker upgrades), there appears to be sufficient development work available to support the current market structure. Assuming these opportunities come to fruition, the ability to preserve the two primary domestic combat vehicle design teams (BAE and GDLS) appears to be a reasonable expectation and critical design and engineering experience should remain strong. In addition, other firms are seeking to enter and compete in this market, including some domestic firms teamed with experienced foreign LCS suppliers.

Although the overall level of activity within the industry is expected to remain higher than experienced in the 1990s, the Seminar recognized that a decrease in demand will pressure industry players to right-size production and sustainment activities. Recent acquisition reform initiatives coupled with a lack of insight into DoD's acquisition priorities presents uncertainty and complicates industry decision-making. Even if current expectations are that new systems will replace old systems in roughly equal numbers, declining DoD budgets and price growth associated with new systems may result in quantity reductions and hence a mismatch in anticipated production capacity.

Additionally, this transition period presents challenges to DoD in addressing the right mix of private versus public (depot) work share for production and sustainment activities. In recent years, Congress and DoD have encouraged P3s between industry and the depots in order to leverage the best of the public and private sectors, while maintaining the capabilities of both. The Seminar noted that while in some cases these partnerships lead to more effective capacity utilization, other arrangements yield inefficiencies as a result of the time and cost associated with shipping subassemblies from one location to another. Compliance with the 50/50 rule for depots coupled with Original Equipment Manufacturer (OEM) ownership of Technical Data Packages

(TDPs) for newer equipment (e.g., ASV, Stryker, MRAP/M-ATV and current versions of Abrams and Bradley) complicates these arrangements and future right-sizing decisions. Production and sustainment strategies for future competitions such as GCV, MPC, and JLTV must also be considered. DoD should use source selection factors to encourage bidders to use existing facilities (government and private) rather than invest in new facilities.

Retaining a highly skilled workforce during periods of decreased production and uncertainty presents a challenge to industry and depots alike. Unless special arrangements are in place to support the retention of critical skills during this transition period, entities will likely reduce labor costs to ensure future viability. Often skilled workers such as ballistic welders, assemblers and more technical workers such as engineers leave the industry when laid off and never return. See the essay on labor market issues for more information.

Supply chain health is critical to the well being of the LCS industry. The Seminar found that the global supply chain supporting the domestic LCS industry has been able to meet the incredible demands placed on it to support Operations Enduring Freedom and Iraqi Freedom. However, the economic downturn is having a negative impact on some small businesses in the supply chain. Industry reported that some of their suppliers are having trouble obtaining financing and others are not able to generate enough revenues to remain in business. All industry OEMs indicate that converting from high wartime to lower peacetime production and sustainment rates will require intensive monitoring of the capacity and responsiveness of the supply chain for military unique as well as commercial components, rather than strictly relying on the Defense Priorities and Allocations System (DPAS) to ensure that the domestic industrial base prioritizes DoD-related orders.

LCS Equipping Trends in Army Brigade Combat Teams

With the recession and growing national debt, defense officials anticipate tough choices ahead. The Army is facing increasing growth in equipping requirements associated with expanding the force and rapid integration of new capabilities to meet the needs of the Warfighter. From 2003 to 2011, the number of items authorized on unit Modified Tables of Organization and Equipment grew by over 100 percent.¹⁵ The cost to fully equip a HBCT has grown from \$1.148 billion in 1999 to \$1.273 billion in 2008; the Infantry Brigade Combat Team from \$253 million in 1999 to \$609 million in 2008; and the Stryker Brigade Combat Team (SBCT) from \$561 million in 1999 to \$1.814 billion in 2008.¹⁶ Significant equipment cost increases occurred with the decision to convert seven HBCTs to SBCTs. The cost for this conversion was nearly \$4.662 billion.

DoD will face significant budget challenges in the future related to incorporating multiple MRAP variants into combat formations, rapidly developing and fielding the GCV and JLTV, and continuing the Brigade Combat Team (BCT) modernization. The cost to equip the suite of Army BCTs will continue to increase incrementally each year due to modernization, application of lessons learned from recent conflicts, and incorporation of promising technologies via rapid acquisition processes.

Effects of WSARA

In recent years, Congress and DoD have approved laws or policies intended to improve performance in system acquisition. These laws and policies may have a profound impact on the structure of the industry and the behavior of its participants. The areas these initiatives address include cost and schedule management and improved competition throughout the product

lifecycle. Key areas of emphasis include: the elimination of organizational conflicts of interest (OCI); restrictions on the use of lead systems integrators (LSI); increased acquisition of TDPs; a reduction in sole-source contracting; a greater reliance on mature technology early in a program; improved cost estimating during the early stages of an acquisition; the use of prototype competition; more requirements stability; and increased use of fixed priced development contracts. These initiatives create uncertainty for both industry and DoD and could certainly cause adjustments in business strategy and industry structure. Specific influences on the industry and observations are included in the essay on the WSARA.

Political Influence in Weapon System Development and Production

The Seminar also noted that some industry representatives believe that political efficiency and lobbying are crucial not just to the profitability of their firms but also, quite possibly to their existence. During this period of declining demand and uncertainty, members of industry are likely to step up efforts to advocate programs and projects supporting their corporate interests to both DoD and Congress.¹⁷

GOVERNMENT GOALS, ROLES, AND RECOMMENDATIONS

Goals

The government's goal is to foster a competitive domestic industrial base for land combat systems that provides war-winning capability via economically sustainable investments. Land combat capabilities should provide superior capabilities, be adaptable as adversary tactics change, and they need to be supportable over distance and time. Lastly, the acquisition of these capabilities must be affordable, which requires a competitive domestic industrial base that is structurally organized to maximize capability per dollar invested, and access to reliable foreign suppliers offering competitive products.

To achieve this, DoD must maintain a S&T program to ensure U.S. military systems maintain a technological edge over potential adversaries wherever possible and programs to pursue international cooperation and collaboration where appropriate. DoD must also ensure maintenance of development expertise, production knowledge, and capital capacity, adequate for military needs. The industry structure must balance affordability and capacity to fill surge requirements needed to counter unexpected national security threats.

Roles

Implicit in the government's role to organize, train, and equip military forces is a responsibility to manage the LCS industrial base by setting policy, prescribing requirements, and providing resources. DoD is a monopsony buyer of land combat systems, which empowers it to make structural decisions for the LCS industry that would ordinarily be left to free-market forces in competitive, commercial markets.

DoD and Congress jointly determine requirements and funding, which drive the total dollars expended and number of vehicles purchased. This defines the size and make-up of the overall market. Defining system capabilities influences product features, technology and price, which influence profitability, workforce demographics and size of individual firms. Acquisition policy shapes conduct that influences competition and entry/exit barrier for firms. Since DoD owns a significant amount of industry capital and is also a participant in the industry through S&T centers, production and sustainment facilities it shapes performance, e.g. P3 arrangements.

To support the industrial base and supply chain, DoD needs to develop a force modernization strategy and generate stable requirements for systems. Additionally, DoD should preserve the nation's capacity to design, develop, produce, and sustain a war-winning land combat capability and leverage the global LCS market. To further these goals, the Seminar proposes the following recommendations.

Recommendations

- 1) DoD should publish an LCS modernization plan with stable requirements. The strategy should rely on the QDR for guidance and be constrained to reflect realistic funding projections. The plan should consider the entire force and the desired capabilities within the joint operating environment. The plan should prioritize requirements and provide planning guidance both to DoD and to industry to manage industrial capacity in the future.
- 2) The U.S. Government should implement the export control reform initiative outlined in April 2010 in order to enhance the ability of U.S. industry participants to pursue foreign defense sales and international defense industrial collaboration and to motivate increased U.S. innovation. Exports of weapon systems lower overhead costs for DoD and help maintain production facilities and workforce expertise to satisfy current and future requirements. Exports also promote interoperability between U.S. forces and those of friends and allies. Implementing the export control reform initiative should reduce foreign anxieties associated with sourcing weapon systems, components, and technologies from U.S. suppliers and facilitate greater international teaming arrangements.
- 3) DoD should engage in LCS industrial base planning at the strategic level to allow public and private sector market participants to determine the appropriate level of capacity necessary to satisfy projected requirements. DoD should promote policies that encourage and enable public facilities to compete against each other and private entities for LCS work, e.g. update carry-over policies so depots can use money over the Fiscal Year (FY) boundary, fund capitalization accounts, and lower overhead rates by separately funding war reserve capacity that is excess to peacetime needs. DoD should encourage depot use by highlighting P3 opportunities in solicitations. The Seminar believes there is unnecessary excess production capacity in the LCS industrial base. For example, military unique powertrain production is redundant at two locations. Whether consolidation should be at Allison's Plant 14 or at ANAD is beyond the scope of this paper. We also recommend DoD revisit the 2005 Base Realignment And Closure recommendation to close Red River Army Depot (RRAD) as a means of right-sizing capacity.
- 4) DoD should institutionalize lessons learned associated with surging production to meet urgent operational requirements, including the challenges faced by industry in ramping up production (supplier base, labor, quality controls, etc.) and successful strategies to mitigate those challenges. In addition, DoD should assess the tools used to support the surge, including the Priority Allocation of Industrial Resources Task Force and authorities provided by the Defense Production Act, and institutionalize best practices that could be used to support future surges.
- 5) The U.S. Government should strengthen dialogue with the EU and Europe's leading defense supplier nations (Letter of Intent-6) to coordinate efforts to minimize the adverse effects of offsets on U.S. and European defense companies, including those in the land combat systems

ESSAYS ON MAJOR ISSUES

Throughout the study period, the Seminar had the opportunity to discuss numerous issues with key industry participants. While many of these issues have been briefly addressed in previous sections of the paper, the following sections present more detailed information to further support the Seminar's analysis, recommendations, and conclusion.

Globalization and Supply Chain Management

The LCS industry is operating in an increasingly global market environment. Many LCS OEMs and supply chain leaders are seeking teaming and partnering arrangements across national boundaries to reduce costs and increase sales via international markets. Affordable shipping rates, telecommunication rates, and lower aggregate manufacturing costs are key elements fostering growth in globalization. In short, globalization allows LCS firms to enter new markets and increase profits.

Global companies are an important part of the DoD LCS industrial base. BAE and MTU Detroit Diesel are examples of global companies serving as important suppliers to the DoD. DoD is not the sole military customer for either BAE or MTU, which view the world as their customer base and develop home-market strategies to sell their products in many countries.¹⁸ Other LCS OEMs and suppliers make sales on the global market via Direct Commercial Sales, FMS and equipment sustainment programs. A number of tier-one automotive suppliers that manufacture sub components for light and medium tactical wheeled vehicles have moved manufacturing offshore to gain entry to exploding commercial automotive markets in the BRIC.¹⁹ Bypassing the exchange rate is another advantage for offshore manufacturing, one firm visited aims for a 50/50 split in euros and dollars to mitigate risks over the long run due to exchange rate volatility.²⁰

International regulations regarding the transfer of defense technology complicates global manufacturing of defense products. In order to market defense products outside the U.S., International Traffic in Arms Regulations (ITAR) requires LCS OEMs to apply for licenses for technology exported from the U.S. Unfortunately, ITAR also complicates cooperative technology development with foreign partners. While OEMs are willing to apply for export licenses in order to compete in the global defense market, foreign anxieties with U.S. export

controls may reduce the attraction of partnering with U.S. suppliers, thus reducing U.S. competitiveness.

The global LCS marketplace is maturing. Both the US and its friends and allies benefit when they can share information, collaborate, and develop LCS platforms together. Globalization helps the nation meet Warfighter requirements at the lowest cost and helps U.S. industry remain profitable and viable in the LCS marketplace.

Managing the LCS Supply Chain

Supply chain health is critical to the well being of the LCS industry. When converting from low peacetime to high wartime production rates for the Iraq War, industry unanimously agreed that supply chain management was the key to successfully meeting increasing demand. Supply chain issues were often the limiting factor in production capability and required intensive management to ensure an adequate supply of components, in addition to relying on the DPAS to expedite shipments from domestic suppliers.

Prior to the war effort, OEMs placed pressure on their suppliers to cut costs and lean out excess capacity due to low production requirements. In some cases, suppliers with extremely low volume left the market completely. During the high operational tempo of the Iraq War, the supply chain was required to expand its capacity and OEMs had to seek out and qualify new vendors for components no longer produced because of low peacetime demands.

The supply chain at all tiers must be capable of supporting surge production requirements. The trend within industry is for OEMs to out-source an increasing amount of components and fabrication work. The Seminar noticed that an increasing number of steel casting procurements are from BRIC countries, a result of globalization. However, some OEMs still rely on regional vendors to provide castings to meet just-in-time production.²¹

The LCS, commercial heavy truck, and construction equipment industries share a large quantity of automotive supply chain components. These commercial industries are consumers of the same raw materials, such as aluminum and steel, which are critical to LCS production. When LCS demands increase during bullish commercial periods, such as 2004-2008, the LCS industry must compete with commercial users for supply chain capacity, although defense related orders do receive priority based on the DPAS from domestic suppliers. When commercial demand is low, LCS OEMs find it easier to leverage commercial supply chain capacity.

LCS Industry Supply Chain Concerns

Parts production from a cold start takes disproportionately long. During a surge, military unique engines, transmissions, and gun tubes have lead times in excess of a year. Utilizing long-term contracts would eliminate 120-180 or more days of acquisition lead-time associated with starting new contracts at the beginning of a surge. Parts obsolescence for older and out of production configurations of equipment such as the M1A1 Abrams Integrated Management is a concern. A number of OEMs are utilizing obsolescence managers intensively to work with vendors on timely delivery, quality, and configuration of parts for low density and out of production platforms.

The Seminar observed at least three instances where industry made statements that DLA had issues supplying parts that meet OEM and government quality, configuration, and schedule requirements. OEMs indicated that they are better postured to leverage the supply chain and manage these components.²²

The recession and ongoing financial troubles of the “Big Three” affect the industry’s supply chain. Many vendors serve both markets, with some facing acute financial problems. OEMs must intensively manage their vendor base.²³

ITAR’s effect on limiting collaboration and sales hinders U.S. competition in a global market. OEMs must request licenses to partner with and export technologies to foreign/allied LCS leaders.

The supply chain is the most tenuous element in the LCS industry. Firms indicate that trust and open communications with suppliers are critical for successful operations. When necessary, OEMs are providing management assistance, financial assistance, or acquiring critical suppliers in order to remain viable players in the LCS market. While the LCS supply chain is productive and responsive, potential budget cuts will make reliance on global and dual suppliers (commercial and military unique) critical and could affect supply chain support to industry.

Engine Market

Structure and Health of the Industry

DoD buys from a healthy, competitive industry that consistently demonstrates the ability to meet its requirements. The market structure is highly concentrated and has significant barriers to entry. However, observations of the market, level of competition, and availability of high-quality products leads us to conclude that the diesel engine industry is sufficiently robust and competitive on both performance and price. Despite this overall health, the military diesel engine market demands significant attention by DoD in the very near-term as it faces implementation of new Environmental Protection Agency (EPA) emissions standards.

Emissions standards which caused a divergence between on-road and off-road engine designs, are a major force in the market. When EPA-mandated standards increased for on-road vehicles while off-road standards remained static the required technologies diverged and split the market. An EPA emission standards increase for the off-road market could create another split in the market, this time between off-road and military unique applications. DoD’s reliance on logistical efficiency gained through the “single-fuel-on-the-battlefield” doctrine (Jet Propellant-8 (JP-8)) will drive this split.

Impending Decision Required by DoD

Emissions standards heavily influence diesel engine technologies. The progressively tougher standards have forced changes to fuel and engine design. The off-road engine standards come on-line in 2010 with full implementation by 2014 and we expect it to force a technology divergence between commercial and military engines as commercial technologies become incompatible with JP-8. Several factors led DoD to the single-fuel doctrine but what is most relevant now is that its fuel distribution and storage systems are optimized for this approach.

At this point there are two courses of action, both create significant implications for DoD acquisition and sustainment of ground vehicles and have potential market structure implications. First, DoD could change nothing, continuing to purchase old technology engines under the National Security Exemption and related waivers² and continuing to burn JP-8 in all land systems. This approach preserves the single-fuel doctrine but makes all of DoD’s engines military-unique losing the efficiencies and technology advancements gained by using commercial technology.

Alternatively, DoD can abandon the single-fuel doctrine and switch engines to EPA-compliant engines that burn ultra low sulfur fuel. This retains DoD’s ability to leverage

commercial production economies of scale and overhead burden sharing. These may result in long-term cost savings but are countered by upfront switching costs in logistics force structure and vehicle system redesign.

In summary, the short-term view is a healthy, competitive diesel engine industry where DoD is able to leverage commercially-driven innovation and volumes to share cost burdens and remain on the cutting-edge of technological advancement. However, those conditions are at risk beginning this year. DoD must recognize this and take action to prevent another example of high-cost, military-unique solutions that burden the taxpayers and potentially rob our Warfighters of operational capability on the battlefield.

Transmission Market

Structure and Health of the Industry

The heavy-duty transmission²⁴ market is overwhelmingly dominated by a single firm, Allison Transmissions, with estimated market-share of 90 percent domestically and 80 percent internationally. Despite this domination by Allison, eight other firms have successfully gained footholds in the military market²⁵. Of those, only three are U.S. firms.

DoD relies heavily on commercial transmissions for many of its systems. As a small quantity buyer, DoD gains significant price advantages by leveraging the commercial market. Lean, high-volume production lines, shared development costs with commercial customers, and leveraging Allison's extensive service network all serve to control prices. Alternatively, the government's low-quantity demand diminishes its buying power. It surrenders leadership in influencing innovation and product lifecycle decisions and loses configuration control during a 30 to 40 year military lifecycle (commercial lifecycles are typically 10 to 15 years).

The greatest opportunity for competition is in leap-ahead technologies associated with electric or other hybrid drive systems. As this technology matures and becomes more competitive with traditional propulsion systems there is potential for new entrants to gain significant market share and industry leadership. The dominant firms are investing heavily in these technologies and fighting to preserve their positions as suppliers of choice for DoD.

What does the future hold?

Declining procurement budgets and recent cancellation of major U.S. Army programs have squeezed revenues for new production and are increasing demand for rebuild and remanufacture of combat systems. Extending the life of transmissions has increased emphasis on the sustainment segment of the business. This serves to keep production lines active, sustain critical skills, and provide revenue to the industry. Doing this efficiently for military-unique transmissions is particularly challenging because they have virtually no parts or components in common with commercial models and are therefore not a good fit to share commercial production lines or supply chains.

A significant by-product of the low volumes of military-unique transmission production is the cost of sustaining Allison Transmission's Plant 14.²⁶ It is primarily capitalized with government furnished tooling and machining sufficient to produce 90 transmissions per month.²⁷ They currently produce three to five new transmissions per month in addition to rebuilds. Exacerbating the issue is the redundant capability established at ANAD. There are instances where national security concerns rightfully override economic efficiencies, but there is an opportunity to significantly improve the efficiency without risking national security. DoD should consolidate these activities into a single location.

European LCS Industry

The European Commission (EC) and the EDA are pursuing initiatives to create a more integrated European defense market.^{28,29} Many countries in Europe have traditionally sought to limit purchases of defense items from foreign nations based on national security considerations, preferring to rely on domestic sources whenever possible. Multilateral trade agreements, including Article 346 of the treaty on the functioning of the EU, include exceptions for national security.³⁰ Brussels' recent actions to assert competency over defense procurement will challenge current national government-industry relationships in Europe, although the full impact of these initiatives on European and U.S. industry will not be clear until the new initiatives are fully implemented.

Current Environment

The EU is striving to build an integrated European defense industrial and technological base. Europe's defense market today consists of 27 national markets in the EU framework. In the land combat industry, there are multiple European combat vehicle suppliers, including firms in Austria, Germany, Finland, France, Italy, Spain, Sweden, Switzerland, Turkey, and the United Kingdom. The European land combat industry has experienced some consolidation since the end of the Cold War, including national and cross-border mergers and acquisitions. However, industry observers argue that further consolidation and rationalization is necessary in light of the significant number of firms still active in the market, redundant product lines, excess capacity, anticipated decline in demand, and constrained defense budgets.^{31,32}

There are significant political issues associated with the prospects for further consolidation in the industry. National markets are frequently supplied by "national champions," many of whom have government ownership or control. A key question is whether a government will be willing to lose a domestic manufacturing capability in light of the associated national security, industrial base, and employment implications. The U.K. Ministry of Defence's *Armoured Fighting Vehicle Sector Strategy* highlighted the U.K.'s continued focus on obtaining "long-term value for money" and the country's willingness to rely on foreign suppliers to satisfy future requirements.³³ However, this philosophy is not widely shared across Europe.

There is significant collaboration and cooperation among European firms at the national and international level through joint ventures and other strategic alliances that could facilitate a new wave of restructuring.³⁴ European firms have also teamed with U.S. companies to compete for U.S. programs.³⁵ Current industrial collaboration could lead to more industry-initiated mergers and acquisitions (e.g., 2010 MAN/Rheinmetall military wheeled vehicle joint venture), but governments would need to play a role in promoting and approving cross-border mergers and acquisitions, especially if the transactions involve state-owned or state-invested firms or the creation of a "European" land combat system group similar to EADS.³⁶

Recent EU Regulatory Developments

Three recent EU initiatives serve as the foundation for building an integrated European defense market by increasing market access, restricting offset practices, and facilitating intra-EU trade in defense goods and technologies.

The EC's DPD gives EU members until August 2011 to amend national laws to align defense trade with EU rules.^{37 38} The intent of the directive is to increase intra-European defense

cooperation and collaboration by promoting open and transparent competition through common procurement rules and by limiting sole-source and non-competitive awards to national firms.³⁹ The EC anticipates that national governments will award most defense contracts pursuant to the directive once it is implemented.⁴⁰

The EC argues that offsets are inconsistent with EU rules.⁴¹ Although the directive does not specifically forbid offsets, the directive includes provisions on subcontracting that prevent a government from imposing local suppliers on contractors bidding for a project (a standard offset practice).^{42 43} The EDA's 2008 Code of Conduct on Offsets also restrains the use of offsets by requiring that offsets not exceed the value of a contract, that offsets not be the most significant selection criteria, and that foreign suppliers be given flexibility in developing offset packages.⁴⁴ EDA members must implement the code in October 2010.⁴⁵ The expectation is that after implementation of the DPD, the EDA code will apply only when Article 346 is invoked.⁴⁶

The EU also approved a new export control directive in October 2009 to facilitate the transfer of defense items within the EU.⁴⁷ This directive establishes a harmonized intra-European export licensing system administered by national authorities, replacing the current national approaches that do not differentiate requests to export defense items to EU members and non-EU members. Member states will have two years to implement this directive.⁴⁸

Implications of the EU Regulatory Developments on Europe and the United States

The new directives and the offset code will have a significant impact on the structure, conduct, and performance of national regulatory and government controls related to defense procurements and intra-EU export controls, changes that will challenge traditional government-industry relationships. These initiatives and market forces may promote further consolidation and rationalization in the land combat industry. Key issues in the future will be how national governments implement the directives and the offset code into national laws and regulations and how frequently EU members invoke Article 346 in defense procurements.

Complying with the procurement directive will significantly impair the ability of national governments to award contracts to remaining national champions or other preferred suppliers (including potentially U.S. suppliers) without full and open competition unless there is a strong justification for invoking Article 346.^{49 50} Restricting support to national champions and the use of offsets may also require the development of new policies to support domestic industrial development, rather than continuing to link such activity with defense programs, and an increased reliance on foreign sources of supply.

On the other hand, the focus on full and open competition should provide competitive LCS suppliers with new business opportunities throughout the EU without having to rely on investing in a market as a business entry strategy. The DPD also gives firms the ability to challenge national procurement practices through EU authorities. Restricting the use of offsets should provide prime contractors with more flexibility to source components from their preferred suppliers, as opposed to nurturing companies in a customer's country to satisfy offset requirements. The new transfer directive will also benefit industry by reducing the administrative burden associated with intra-EU trade. These two directives may encourage LCS manufacturers to expand their pool of potential suppliers beyond their national borders in a search for "best value" suppliers.

The EU initiatives have implications for U.S. industry and DoD. The DPD does not contain "Buy European" preferences, but rather allows member states to decide whether to allow non-EU member firms to bid for procurements covered by the directive. U.S. firms would be

allowed to bid for additional business opportunities based on DoD's existing bilateral reciprocal defense procurement agreements with 14 EU members.⁵¹ U.S. firms may also benefit from the restraints on offset requirements. In addition, the advent of more competitive and innovative European defense firms may benefit DoD by increasing its potential supplier base if European land combat system firms increasingly pursue business opportunities in the U.S. market, as prime contractors or teamed with U.S. firms.

Conversely, the EU export control directive may encourage European firms to increasingly team with European suppliers unless the Administration's ongoing review of the U.S export control systems significantly eases European anxieties with sourcing systems, components, and technologies from the United States. U.S. firms that previously benefited from sole-source awards in Europe will also face competition due to the new focus on competition. U.S. industry is also likely to face even more competition from European suppliers internationally as European LCS suppliers seek export sales to compensate for the loss of preferential status in their domestic markets.

It is clear that these European initiatives will require significant amendments to the national regulatory structures in place for defense procurements and export controls, changes that will impact current government-industry relationships in Europe. These initiatives should benefit firms that offer competitive products. The key challenge to achieving a truly integrated European defense market will be overcoming the domestic political interests that will seek to continue to support national champions and preferred suppliers, promote domestic economic development through defense programs, and preserve domestic employment.

Weapons Systems Acquisition and Reform Act

During the last five years, Congress and DoD enacted a number of laws intended to improve DoD's performance in buying defense systems improving defense acquisition.⁵² These laws and policies will influence the organizational structure of the industry and the behavior of its participants. Some changes attempt to influence the structure of the industry and incentivize certain forms of conduct while others attempt to regulate conduct directly.

Organizational Conflict of Interest (OCI)

OCI requirements set forth in WSARA are affecting industry organization. Some firms have already divested themselves of activities that could create the most obvious types of OCI, e.g. one subsidiary develops a statement of work on which the parent company would bid. Industry is generally supportive of this reform and believes it will result in government decisions that are driven by greater objectivity and competitive forces. Industry, however, is concerned about how far OCI will go in affecting the organization of their firms and business practices. Firms are concerned that they might be forced to reduce the degree of vertical integration in their firms or forgo using inside suppliers for some contracts. Some firms are concerned that this will reduce the flow of information necessary for good systems integration. Some system integrators argue that inside suppliers can more easily exchange sensitive information with design engineers than outside suppliers who are often owned by competitors. Some firms believe that limits on vertical integration are necessary to ensure that system integrators are picking the best of the best and not letting business interests degrade the system integration function. Generally the implications are greatest for LCS firms whose vertical integration includes not only platforms but C4ISR mission systems such as sensors.

Technical Data

The WSARA favors government ownership of TDP's. Competition associated with new programs should provide competitive TDP pricing. The intent is to increase the ability of the government to compete future product buys and end the reliance on sole source follow-on contracts. Since sustainment funding is generally 70 percent of life cycle cost, government ownership of TDP's should yield savings on product and sustainment buys and allow greater depot involvement in system rebuild or upgrades. The 2009 FMTV reprocurement is an example where TDP ownership yielded better prices through competition.

However, there may be costs associated with government TDP ownership. Maintaining accurate TDP's is critical to system management and the Army may need to set up an organization to conduct TDP configuration management. These skills have decayed in the government for complex weapons systems. Purchasing TDP's for complex systems or systems already in sustainment may be cost prohibitive. The government must analyze the benefits and costs of procuring TDP's at the level needed for depots to participate in the rebuild or upgrade process and the potential to conduct competition for spare and repair parts.

Sole-Source Contracting

WSARA's effort to expand full and open competition is changing the LCS industry; justification and approvals for sole source contracts are becoming more difficult. As an example, operation of the JSMC facility may be competed rather than continuing GDLS's sole source contract. Additionally, plans to award a sole source contract for the Enhanced Capability Vehicle 2 (ECV 2) were stopped. While some programs may make sense to remain sole source, the trend is toward greater competition.

Technological Maturity

The WSARA strives to reduce risk and cost by demanding greater technology maturity during the Technology Development (TD) phase and the Engineering and Manufacturing Development (EMD) phase.⁵³ The GCV TD requires Technology Readiness Levels (TRL)⁵⁴ of 5 and 6 for TD and TRLs of 6 and 7 for EMD. This should result in a technology integration effort rather than a technology development effort. The acquisition strategies for the JLTV and GCV are examples of the impacts on new programs.

Prototype Competition

WSARA requires competitive prototyping prior to a Milestone B decision, with a waiver process based on affordability.⁵⁵ Competitive prototyping is already occurring in the LCS industry. The JLTV program has three firms developing competitive prototypes as opposed to EFV which did not. Using competitive forces to incentivize contractor performance in the TD phase of a program should lower program risk and cost.

Firm Fixed Price Development Contracts

Most developmental programs use cost reimbursable contracts. Firm Fixed Price (FFP) contracts should incentivize contractors to meet cost goals. This reduces government risk, but raises contractor risk, especially when dealing with immature technologies and unstable or differing interpretations of requirements. Firms have expressed the concern with the government's poor record of stabilizing requirements and therefore consider fixed price contracts

during development a problem. Bidders will likely compensate with higher bids to decrease their risk.

Labor Market

Workforce training, skills, and retention are areas of concern to private industry and government. A flexible and well-trained workforce is critical to maintaining a competitive advantage. Maintaining core skills are necessary to the long-term health of the LCS industrial base as a whole. The critical skills that require sustainment in the long term are combat vehicle design engineering (including R&D), systems integration skills, and ballistic welding.⁵⁶ These skills do not generally reside in the commercial sector. A highly skilled welder is only the starting point for training someone in ballistic welding, certification in more advanced techniques requires additional years of experience. Workers experienced in designing and assembling highly complex weapons systems and components represent critical job skills necessary for a competitive capability. When the workforce contracts, seniority usually determines who stays. Those employees will likely retire within the next decade. The displaced younger employees will leave the LCS industry for other jobs and are not likely to return.

The Seminar observed that the conduct of a union workforce creates different performance outcomes across the industry. Generally, labor and management realize that the relationship is symbiotic and they cooperate for mutual benefit, profit for the company, and jobs for the workers. Companies and facilities with a strong entrepreneurial focus driven by competition exhibited more of these behaviors than those with limited competition or sole source situations. However, one firm cited labor inflexibility as a key factor that drove their decision to move to a new location with a non-union workforce.

Overall, training and maintaining a skilled workforce are keys to competitiveness and the long-term health of the LCS industry.

Depots and the JSMC

Congress established depots as a means to retain an organic government capability to meet military requirements. The goal is to ensure a core capability under government control to perform major maintenance and repair on weapon systems. Currently, depots and commercial firms find themselves competing for increasingly limited opportunities to perform depot maintenance work. Congress influences utilization of depots by providing language in the annual NDAA that limits the services to utilizing no more than 50 percent of their annual depot maintenance budgets for contracted maintenance. This structural condition, combined with contractor ownership of TDP's has fostered the creation of P3's within the depot maintenance arena. Service Secretaries designate depots as Centers for Industrial and Technical Excellence (CITE) and provide authority to the head of each CITE to enter into partnerships. Work performed by a contractor at a CITE pursuant to a partnership is not counted against the 50 percent limitation.⁵⁷ While depots and private firms view these partnerships as a win/win, they may not create economic efficiencies. The depots benefit by gaining access to technical expertise and skills provided by their private partner and workload that helps reduce overhead costs. The private firms benefit by using the depot's facilities, reducing capitalization costs, getting access to a trained workforce or cheaper labor rates and retaining a lucrative share of the sustainment and recapitalization workload.

Depots are public entities that provide numerous jobs and have a significant economic impact on their local communities. Therefore, they are affected by political decisions and Federal rules and regulations to a greater extent than their private counterparts. Politics often play a strong role in determining where work is performed regardless of excess capacity at other sites. For example, all work on the Bradley fighting vehicle is performed at RRAD even though there is sufficient capacity to perform the work at ANAD. A private firm with two repair facilities both operating below capacity would most likely close one down and shift all work to the other because it is more efficient. The Army is unable to do this easily because of the political considerations. While P3's claim to reduce taxpayer costs by leveraging existing, government-owned infrastructure, there is a potential that political rather than economical considerations drive decision-making.

Working capital funds and one-year appropriations challenge depot management. This funding expires annually on 30 September, creating spikes in orders at the end of the FY. This creates the problem of fund carryover. Depots are not allowed to carry more than a small amount of funds from one FY to the next. If larger amounts of funding could be carried over into the next FY, the depots would be able to smooth out their workload and use funds to achieve economies of scale in material purchases.

The JSMC in Lima, OH is the only GOCO facility in the LCS industry. It is managed by Defense Contract Management Agency (DCMA), funded by PM-HBCT, and operated by GDLS. The commander (assigned to DCMA) is only responsible for contract management and contractor performance and has no operating budget. No one is responsible for holistic management of the facility, industrial base management, or long term planning and work loading. JSMC may benefit by becoming an AMC managed facility.

CONCLUSION

The LCS industry is in transition. The surge in production peaked in 2009, the economy is recovering from recession and the government's rising debt and its ability to finance discretionary programs is increasingly under pressure. Rising competitors and growing asymmetric threats challenge the U.S. position. Given this environment, the LCS industry must be capable of responding to national security threats, both now and in the future.

The short to mid-term outlook for the LCS industry is a decline in production, with a recovery in 2017 or 2018. Industry will face challenges to retain key skills and capabilities. The LCS industry is currently capable of meeting the national security requirements. However, DoD will need to monitor the industry and its suppliers during the coming years to ensure it is fully capable of responding to future crises.

The report examined the current state, challenges, and ability to respond to future needs of the LCS industry. While the long-term outlook is stable, the short-term fiscal stresses in the next five to seven years are likely to result in more industry consolidation. The key issue will be maintaining a robust LCS industry and supply chain to meet future needs. To that end, the paper provides policy recommendations to promote a strong LCS industrial base capable of satisfying U.S. national defense requirements.

ANNEX A. Unmanned Ground Vehicles

DoD should begin formal review and planning regarding the current, near and far term impacts Unmanned Ground Vehicles (UGV) will have on the LCS industry. UGVs are a capability that could significantly impact future LCS force structure, doctrine and industry dynamics. UGVs are following a path of exponential technology advances, rapid acquisition and low barriers to entry for industry, more balanced state of life-cycle management and normalized market forces. This movement indicates UGVs are no longer a DoD “science project” and will soon mature as a game changing force multiplier requiring focused DoD attention and management.

Requirements and Policy

Congress passed a law directing increased use of unmanned systems as a consequence of emerging capabilities offered by advances in technology, as well as a growing concern for lack of coordination and management of unmanned programs.⁵⁸ DoD responded to Congress by publishing the FY 2009 – 2034 Unmanned Systems Integrated Roadmap (the Roadmap), as well as chartering the Joint Ground Robotics Enterprise (JGRE) office within OSD. However, the Roadmap and the JGRE charter are focused on unmanned systems as a singular capability and not how UGVs could affect traditional, manned LCS’s.

These policies also reflect a shift in favor of unmanned systems over manned systems. It represents a turning point with respect to both acceptance of the technology as militarily viable and infers integration of unmanned systems with current and future military doctrine. Equally, the policy reflects a potential for increased funding, leading to heightened activity by acquisition agencies and the supporting industrial base.⁵⁹

UGVs in Transition

Several factors drove UGV entry into military operations, such as technology advances; urgent needs; available funding; and a niche industry racing to keep up with a fast moving market. Trends show UGVs will soon transition into a more stable environment of maturing technologies; structured acquisition management; competitive budget cycles; and normalized market forces. As this transition continues, debates may ensue whether a particular task can best be performed by a UGV vice a manned LCS. DoD program and budget drills will compare the costs of recruiting, training, sustaining, equipping and employing ground troops to the declining costs of UGVs. This transition signals that UGVs are becoming players in mainstream capabilities development and a competitor for decreasing defense dollars.

Industry in Transition

Unmanned ground vehicles are transitioning to a more stable acquisition process in DoD. Industry firms that can adapt and find robotics opportunities in the domestic market will have an advantage over firms with narrower strategies. As more systems are employed in military theaters, user experience will guide future UGV development and requirements generation. While some UGV capability planning is underway, DoD is still catching up after a decade of fragmented planning efforts. DoD must take the initiative to consider the future impacts of UGVs on the LCS industry.

ANNEX B. Rapid Acquisition of MRAPs and M-ATVs

Rapidly evolving urgent operational needs originating from a combat theater highlight the necessity of the defense acquisition system and defense industrial base to respond to emerging and changing requirements. As U.S. forces in OIF transitioned from a traditional force on force scenario to counterinsurgency and stabilization operations, our adversaries adjusted as well. The enemy adapted with IED's targeting U.S. tracked and wheeled vehicles. The immediate need for a survivable platform capable of mitigating the effects of IEDs would test the agility of DoD and industry to rapidly acquire a materiel solution.

DoD utilized a tailored rapid acquisition strategy in lieu of the standard deliberate approach to quickly deliver a highly survivable vehicle to theater. The MRAP program relied heavily on minimal operational requirements, mature technologies, Commercial Off-the-Shelf (COTS) products and a concurrent approach to producing, testing and fielding MRAPs.⁶⁰ This accelerated process challenged our acquisition system and industrial base to respond to urgent need requirements resulting from wartime operations.

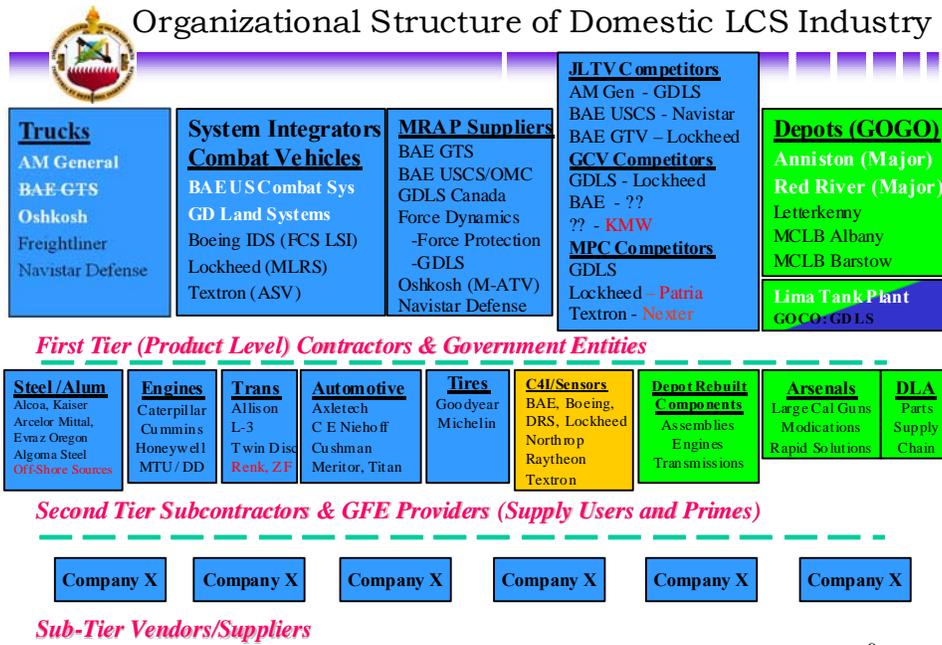
The MRAP relied heavily on proven technologies that promoted the rapid acquisition of vehicles utilizing existing defense and commercial industrial bases and resources. Industry increased production by engaging in teaming and licensing arrangements among competing manufactures. Of the five primary vendors, FPI teamed with GDLS to combine resources leading to increased productivity while GDLS-Canada teamed with BAE and Demmer to produce an improved version of its existing MRAP variant, the RG-31. To augment fabrication, integration and assembly functions, GDLS and BAE entered into P3's with defense industrial base facilities at Anniston and Letterkenny Army depots. The teaming strategies among commercial enterprises combined with P3 activities greatly expanded industrial capacity by leveraging resources to meet an uncompromising production schedule.

DoD designated MRAP as the most important acquisition program with a "DX" rating under DPAS and granted waivers from statutory restrictions on obtaining critical resources such as steel from foreign sources. Requirements were simple, clear and kept to a minimum. The use of proven technologies coupled with a concurrent approach to production; testing and fielding greatly streamlined the acquisition process. DoD retained the responsibility for final integration of mission equipment packages (radios and jammers) that reduced risk and helped deliver vehicles at a rapid pace. To maintain the momentum throughout the program, Congress provided stable funding that proved the crucial factor in setting conditions for success. Finally, personal involvement and attention from senior DoD leaders helped eliminate resource constraints in meeting the required production schedules.

Lessons Learned

The MRAP program is a case study on DoD's development of new acquisition strategies to meet immediate and evolving requirements. The use of a rapid acquisition in lieu of a deliberate acquisition process coupled with unprecedented Congressional and DoD support greatly contributed to the programs overall success. The availability of funding combined with an existing materiel solution based on COTS and non-developmental items allowed for the rapid procurement of vehicles to meet a compressed, aggressive and firm fielding timeline. Future fulfillment of urgent Warfighter needs should focus on speed and flexibility to achieve rapid materiel solutions.

ANNEX C. Organisation of the Domestic LCS Industry



Endnotes

¹ Remanufactured components are parts and major assemblies repaired and reconditioned after harvesting during tear down of major end items.

² Frost and Sullivan, *US DoD FY 11 Budget*, N787-16, March 2010.

³ Tactical wheeled vehicles are now armored to resist small arms, IED blasts and explosively formed projectile (EFP) attacks. Most are equipped with communications equipment, counter measure devices for defeating IEDs, Blue Force Trackers, the Boomerang anti-sniper system, and the Common Remotely Operated Weapon Station (CROWS). Chassis and drive trains are upgraded to carry the additional weight. The EPA recognizes that “tactical vehicles” are now “combat vehicles” now that they carry armor.

⁴ A USMC 900-man infantry battalion now has 800 radios, whereas in the past it only had 80. Grace V. Jean, “Marine Corps Faces Gap in Ground Tactical Vehicles,” *National Defense*, February 2010, pp. 32-33.

⁵ The Marine Corps expects to spend \$10 billion per year on vehicle reset. Grace V. Jean, “Marine Corps Faces Gap in Ground Tactical Vehicles,” *National Defense*, February 2010, pp. 32-33. Resetting and even recapitalizing and upgrading existing vehicles are cheaper than producing new vehicles, usually costing approximately 80% of a new vehicle. Information from Sydney J. Freedberg, “The Army Looks Beyond Afghanistan,” (*National Journal*, December 12, 2009), http://www.nationaljournal.com/njmagazine/nj_20091212_4983.php.

⁶ E.G., the German *Puma*, Israeli *Namer* armored personnel carrier (APC); Korean *K2 & K21*, Turkish *Atlay*, Indian T-90 tank.

⁷ E.G., 20-ton C-130 deployable Wheeled Combat Vehicles (WCVs) are proving not to be sufficiently survivable for many users; highly survivable WCVs generally are in 30-ton range (Piranha V & Boxer).

⁸ *Full spectrum defense firms* created as result of defense industry mergers in 1990s have deep pockets to finance entry into new product markets if profitable opportunities exist (e.g.: JLTV partnerships and the MPC bid).

⁹ E.G., AM General is continuously improving the HMMWV while competing for the JLTV. Firms are spending heavily on the JLTV competition, just as they had for the M-ATV contract. Textron has developed improved Armored Security Vehicle (ASV) with “MRAP II” survivability.

¹⁰ The number of major defense companies dropped from 130 to five over the past decade due to mergers and acquisitions. From Leslie Wayne, *The Shrinking Military Complex; After the Cold War, the Pentagon Is Just Another Customer*, (New York: New York Times, February 27, 1998), <http://www.nytimes.com/1998/02/27/business/shrinking-military-complex-after-cold-war-pentagon-just-another-customer.html?pagewanted=all>.

¹¹ The largest U.S.-based LCS integrators are General Dynamics Land Systems and BAE U.S. Combat Systems. Textron is a minor player and manufactures the Armored Security Vehicle (ASV). Oshkosh Defense is currently the largest maker of U.S. military trucks and also manufactures the M-ATV and some MRAP models. Other truck makers include: BAE Global Tactical Systems, Freightliner, and Navistar Defense. AM General continues to produce HMMWVs and will seek to reset, recapitalize, and offer new upgrades as its production run ends. Four teams are competing for the Marine Personnel Carrier contract: BAE-Iveco Defense Systems, GD Land Systems, Lockheed-Patria, and Textron-Nexter. The three remaining JLTV competitors are: AM General-General Dynamics Land Systems, BAE-U.S. Combat Systems-Navistar, and BAE-Global Tactical Systems-Lockheed. Protected vehicle suppliers include: BAE Global Tactical Systems, BAE U.S. Combat Systems, BAE-OMC (South Africa), GDLS-Canada, Force Dynamics (GDLS and Force Protection), Navistar Defense, and Oshkosh Defense. Industry relationship can be quite tangled. Boeing IDS, Lockheed & Raytheon were all prime competitors for JLTV. Raytheon was a sub to Boeing LSI on Future Combat Systems (FCS) (Raytheon is a ground sensor integrator). Lockheed is developing a ground sensor for Raytheon.

¹² E.G., the figures below demonstrate the varied status of current Bradley program from its low production levels before 2003, through the peak, and approaching an estimated real drop by 2012: 2002 – about 300; 2007 – 813; 2008 – 942; 2009 – 1424; 2010 – 959; 2011 – 540; 2012 – 150

¹³ Ian MacGowan, “Tank & Armored Vehicle Manufacturing in the US”, IBISWorld Industry Report (IBISWorld Number 33699b, 2009), 7-8.

¹⁴ *Ibid.*, 19.

¹⁵ Headquarters, Department of the Army, G-8, *The Army Equipping Strategy White Paper*, 29 September, 2009, 1.

¹⁶ January 2010 SACS.

¹⁷ Examples are Bradley upgrade, M1A3, HMMWV ECV 2.

¹⁸ Home-market business strategies exist when a company manufactures and utilize the supply chain in countries where they sell products. Home-market strategies allow the host countries to participate in cost-share arrangements allowing the host country to benefit from jobs produced from products that are sold in the countries LCS market.

¹⁹ Efraim Levy, CFA, Auto Analyst, Standard & Poor's, "Industry Surveys – Autos & Auto Parts" (New York: Equity Research Service, 2009), 5.

²⁰ MTU/Detroit Diesel is building a manufacturing plant in South Carolina to increase capability, lower manufacturing cost and produce more engines in the U.S. versus Germany. Producing engines in the U.S. allows MTU/Detroit Diesel to procure raw materiel, pay employees, and sell products in dollars vs. euros. The company saves approximately 3% of net profits by bypassing exchange rates.

²¹ MTU Detroit Diesel, a global company, is procuring steel castings from BRIC countries while Allison Transmissions rely on local and regional vendors for transmission castings.

²² DLA contracted AM General to provide the bill of materiel for the HMMWV recapitalization line at Letterkenny Army Depot (LEAD). As the OEM, AM General was successful in meeting the Up-Armored HMMWV surge requirements and leaning forward to procure armor and steel for upgrades and production.

²³ GDLS is utilizing Dunn and Bradstreet reports as a tool to monitor DIB vendor base. AM General is utilizing a financial consultant to assess the health of their major supplies.

²⁴ Transmissions for military tracked combat vehicles are called "power-trains". The cross-drive design used for combat vehicle power-trains integrates the traditional transmission functions along with steering and braking functions making these power-trains military unique.

²⁵ Allison's eight competitors in the military market are L3, Twin Disc, Renk, David Brown Engineering, Perkins, ZF Friedrichshafen, and Mitsubishi. Renk is Allison's primary competitor in the worldwide tracked, combat vehicle power-train market while ZF Friedrichshafen battles it in the wheeled vehicle market.

²⁶ Plant 14 is a facility within the Allison Transmissions complex in Indianapolis, Indiana. It is equipped to produce the power-trains (X1100) for M1 Abrams tanks and the Expeditionary Fighting Vehicle (USMC). Currently its X1100 production is exclusively focused on the remanufacture of power-trains, the production of rebuild kits which it sells to Anniston Army Depot, and kits for sale to Egypt for M1s built there.

²⁷ U.S. Army TACOM is currently about halfway complete with a \$40 million tooling upgrade in Plant 14 that aims to make the plant more efficient at the lower volumes.

²⁸ European Commission Press Release, *Public Procurement: new Commission guidelines on defence contracts* (December 7, 2006), http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm, March 17, 2010.

²⁹ European Defence Agency, *The Code of Conduct on Offsets* (October 24, 2008), <http://eda.europa.eu>, March 1, 2010. Romania elected not to sign the code. Norway has signed the code even though it is not an EU member.

³⁰ European Union, "Article 346 of the Consolidated Version of the Treaty on the Functioning of the European Union," *Official Journal of the European Union* (March 30, 2010), <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:083:0047:0200:EN:PDF>, April 16, 2010.

³¹ Stephanie Frey, "Collaboration: The Way ahead for European Land Systems Producers?" *Military Power Revue der Schweizer Armee*. no. 1 (2009): 36-37.

³² The European defense expenditures have begun to decline. See European Defence Agency, *Defence Data 2008* (2009), 2, 15, <http://eda.europa.eu>, March 17, 2010; European Defence Agency, *European-United States Defence Expenditure in 2008* (2009), 2, <http://eda.europa.eu>, March 17, 2010; and Datamonitor, *Defense Spending in Europe* (March 2010), 12.

³³ United Kingdom Ministry of Defence, *Armoured Fighting Vehicle Strategy* (June 2009), 1-4, <http://www.mod.uk>, March 17, 2010. The Ministry of Defence stated that while it was critical to have the capability to maintain, overhaul, and repair its armored vehicles domestically, the ministry stated it was willing to rely on foreign suppliers to produce vehicles provided that those suppliers transferred the design information and knowledge necessary for British depots and industry to support and upgrade the vehicles.

³⁴ Christopher Foss, "Ground masters: European land systems part one – Germany," *Jane's Defence Weekly*. May 8, 2009, <http://www.search.janes.com>, March 17, 2010. E.g. this article notes that the two leading German combat vehicle manufacturers (Krauss-Maffei Wegmann and Rheinmetall) often form strategic alliances to pursue German and international orders. In addition, Rheinmetall has teamed with the French firm Panhard and the Swiss firm GDELS MOWAG on occasion, while Krauss-Maffei Wegmann has teamed with the Italian firm Iveco.

³⁵ For example, Lockheed Martin Press Release, "Lockheed Martin and Patria Join Force for Marine Personnel Carrier Offering (October 18, 2007)," <http://www.lockheedmartin.com/news>, April 2, 2010.

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- ³⁶ Rheinmetall AG, “Rheinmetall and MAN Nutzfahrzeuge from joint venture for wheeled military vehicles” (January 12, 2010), <http://www.rheinmetall.de>, February 22, 2010.
- ³⁷ European Commission Press Release, *New Directive on defence and security procurement enters into force* (August 25, 2009), http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm, March 17, 2010.
- ³⁸ European Union, “Directive 2009/81/EC of the European Parliament and of the Council of 13 July 2009 on the coordination of procedures for the award of certain works contracts, supply contracts and service contracts by contracting authorities or entities in the fields of defence and security, and amending Directives 2004/17/EC and 2004/18/EU,” *Official Journal of the European Union* (August 20, 2009), <http://Eur-Lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:216:0076:0136:EN:pdf>, March 20, 2010.
- ³⁹ Department of Commerce/U.S. Commercial Service, *European Union: EU Defence Procurement Directive* (August 2009), 1. <http://www.export.gov>, March 1, 2010.
- ⁴⁰ Department of Commerce/U.S. Commercial Service, *European Union: EU Defence Procurement Directive* (August 2009), <http://www.export.gov>, March 1, 2010. The new directive includes provisions requiring multiple bidders and sections addressing security of supply and security of information in contract award criteria. The directive prohibits the award of a production contract to a company involved in an earlier research and development phase without a new competition. National government conduct will be challengeable before the European Court of Justice. However, contracts supporting international cooperative programs are outside its scope.
- ⁴¹ Offsets include a range of industrial compensation arrangements that foreign governments require as a condition of the purchase of defense articles and services.
- ⁴² European Commission Press Release, *Defence Procurement – Frequently Asked Questions* (August 28, 2009), http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm, March 17, 2010. The EC has stated that offsets “. . . stand in direct contrast to the [EU] Treaty. Consequently, Directive 2009/81/EC can neither allow nor regulate them.” The EC has set the stage through the directive where offset requirements could be challenged before the European Court of Justice.
- ⁴³ Department of Commerce/U.S. Commercial Service, *European Union: EU Defence Procurement Directive* (August 2009), 4-5. <http://www.export.gov>, March 1, 2010. The directive also states that a prime contractor is entitled to choose its subcontractors for up to 70 percent of the value of the contract, but that a government buyer can require that the remaining 30 percent be performed by subcontractors, unrelated to the prime contractor, selected competitively.
- ⁴⁴ European Defence Agency, *The Code of Conduct on Offsets* (October 24, 2008), <http://eda.europa.eu>, March 1, 2010. The stated intent of the code is to gradually reduce reliance on offsets, to increase transparency regarding offset policies and practices, and to redirect offsets, when required, towards activity that supports the development of a European technological and industrial base.
- ⁴⁵ Department of Defense, *Report of the Interagency Team on Consultations with Foreign Nations on Limiting the Adverse Effects of Offsets in Defense Procurement* (November 2009), 4-5, in Department of Commerce, *Offsets in Defense Trade (14th Study)* (December 2009), <http://www.bis.doc.gov/defenseindustrialbaseprograms>, February 1, 2010.
- ⁴⁶ Department of Defense, *Report of the Interagency Team on Consultations with Foreign Nations on Limiting the Adverse Effects of Offsets in Defense Procurement* (November 2009), 4-5, in Department of Commerce, *Offsets in Defense Trade (14th Study)* (December 2009), <http://www.bis.doc.gov/defenseindustrialbaseprograms>, February 1, 2010.
- ⁴⁷ European Union, “Directive 2009/43/EC of the European Parliament and of the Council of 6 May 2009 simplifying terms and conditions on transfers of defence-related products within the Community,” *Official Journal of the European Union* (October 6, 2009), <http://Eur-Lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:146:0001:0036:EN:pdf>, March 20, 2010.
- ⁴⁸ Department of Commerce/U.S. Commercial Service, *European Union: Reform of Arms Transfers in the EU* (August 2009), 1, 5, <http://www.export.gov>, March 1, 2010.
- ⁴⁹ European Commission Press Release, *New Directive on defence and security procurement enters into force* (August 25, 2009), http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm, March 17, 2010.
- ⁵⁰ European Commission Press Release, *Public Procurement: new Commission guidelines on defence contracts* (December 7, 2006), http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm, March 17, 2010.
- ⁵¹ 48 Code of Federal Regulations 225.872 (2009), *Contracting with qualifying country sources*. DoD has signed reciprocal defense procurement agreements with the following EU members: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

⁵² Weapons Systems Acquisition Reform Act, Public Law 111-23, 22 May 2009 (Library of Congress) http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:s454enr.txt.pdf (accessed 3 April 2010).

⁵³ Weapons Systems Acquisition Reform Act, Public Law 111-23, 22 May 2009 (Library of Congress) http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:s454enr.txt.pdf (accessed 3 April 2010).

⁵⁴ TRL 5 & 6 state component and subsystem have validation in a relevant environment TRL 7 raises that to an operational environment.

⁵⁵ Weapons Systems Acquisition Reform Act, Public Law 111-23, 22 May 2009 (Library of Congress) http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:s454enr.txt.pdf (accessed 3 April 2010).

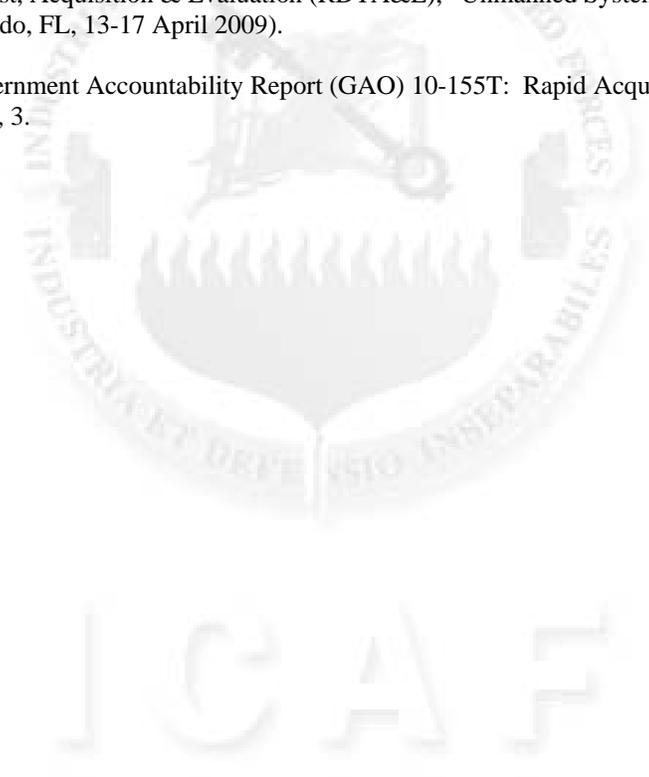
⁵⁶ The Seminar observed the impact of inexperienced product development engineers during a site visit. The skill loss was a cause for delay in a weapon system under development.

⁵⁷ Sec 342 of the NDAA for FY 2002 and sec 334 of the NDAA for FY 2003 amended 10 USC 2474 creating an exemption to the 50 percent limitation in 10 USC 2466(a) ("50-50 rule") on contracting for depot maintenance.

⁵⁸ Three of the most important pieces of legislation that influence unmanned system investments are: (1) Public Law 106-398 Section 220 (2001 NDAA). (2) Public Law 109-163 Section 261 (2006 NDAA), and (3) Public Law 109-364 Section 941(2007 NDAA). (Robin Laird, "Evolving U.S. Department of Defense (DoD) Unmanned Systems Research, Development, Test, Acquisition & Evaluation (RDTA&E)," Unmanned Systems Technology XI, Defense Security Symposium, Orlando, FL, 13-17 April 2009).

⁵⁹ Ibid.

⁶⁰ Michael J. Sullivan, Government Accountability Report (GAO) 10-155T: Rapid Acquisition of MRAP Vehicles (Wash, D.C. October 2009), 3.



Bibliography

- Assistant Secretary of the Army for Financial Management and Comptroller. *FY 2011 President's Budget Highlights*. Washington, DC: U.S. Army. February 2010.
- Barbosa, Mark Col. NDIA Tactical Wheeled Vehicles (TWV) Conference. U.S. Army G-8. February 8, 2010.
- “Change of the guards: European Land Systems Part 2 – the UK.” *Jane's Defence Weekly*. June 22, 2009. <http://www.search.janes.com>.
- “Coming together: German defence industry.” *Jane's Defence Weekly*. October 29, 2009. <http://www.search.janes.com>.
- Cowan, Gerrard and Foss, Christopher. “BAE Systems win French Army VHM contract.” *Jane's Defence Weekly*. December 24, 2009. <http://www.search.janes.com>.
- Datamonitor. *Defense Spending in Europe*. March 2010.
- Department of Commerce/U.S. Commercial Service. *European Union: EU Defence Procurement Directive*. August 2009. <http://www.export.gov>.
- Department of Commerce/U.S. Commercial Service. *European Union: Reform of Arms Transfers in the EU*. August 2009. <http://www.export.gov>.
- Department of Defense. *2010 Quadrennial Review*. Washington, DC: Department of Defense. February 2010. <http://www.comw.org/qdr/fulltext/1002QDR2010.pdf>.
- Department of Defense. *Fiscal Year 2011 Budget Request, Section Three: FY2011 Program Acquisition Costs by Weapon System*. Washington, DC: Department of Defense, February 2010. http://comptroller.defense.gov/defbudget/fy2011/FY2011_Weapons.pdf
- Department of Defense. “Report of the Interagency Team on Consultations with Foreign Nations on Limiting the Adverse Effects of Offsets in Defense Procurement (November 2009).” In Department of Commerce. *Offsets in Defense Trade, 14th Study*. December 2009. <http://www.bis.doc.gov/defenseindustrialbaseprograms>.
- Dwyer, Mr. *Recapitalization*. Washington, DC: U.S. Army Materiel Command. October 5, 2009
- Erwin, Sandra I. “Defense Dept. Forecasts Greater Use of Robots in Ground Combat”. *National Defense*, Apr 2009, Vol. 93, Iss. 665.
- Erwin, Sandra I. “Army, Marines, Mull over Options to Modernize Truck Fleet,” *National Defense*, February 2010. See www.nationaldefensemagazine.org.
- Erwin, Sandra I. “Pentagon Must Avert ‘Points of Failure’ in Supplier Base, Says Industrial

Policy Chief.” *National Defense*. January 2010.
<http://www.nationaldefensemagazine.org/archive/2010/January/Pages/PentagonMustAvert%20%80%98PointsofFailure%20%80%99inSupplierBase,SaysIndustrialPolicyChief.aspx>.

Erwin, Sandra I. “To Defense Industry, the Future Looks Uncomfortably Unfamiliar.” *National Defense*. April 2010.
<http://www.nationaldefensemagazine.org/archive/2010/April/Pages/FutureLooksUncomfortablyUnfamiliar.aspx>.

European Commission Press Release. *Public Procurement: new Commission guidelines on defence contracts* (December 7, 2006).
http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm.

European Commission Press Release. *New Directive on defence and security procurement enters into force* (August 25, 2009).
http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm.

European Commission Press Release. *Defence Procurement – Frequently Asked Questions* (August 28, 2009). http://ec.europa.eu/internal_market/publicprocurement/dpp_en.htm.

European Defence Agency. *A Strategy for the European Defence Technological and Industrial Base* (May 14, 2007). <http://eda.europa.eu>.

European Defence Agency. *Defence Data 2008*. 2009. <http://eda.europa.eu>.

European Defence Agency. *European Defence Agency Ministers Call for More Cooperation on Armoured Fighting Vehicles*. (May 23, 2005). <http://eda.europa.eu>.

European Defence Agency. *European-United States Defence Expenditure in 2008*. 2009.
<http://eda.europa.eu>.

European Defence Agency. *The Code of Conduct on Offsets*. October 24, 2008.
<http://eda.europa.eu>.

European Security and Defence Assembly. *European armored vehicles: current programs: report submitted on behalf of the Technological and Aerospace Committee (Document A/2034)*. June 2009.

European Union. “Article 296 of the Treaty Establishing the European Union.”
<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:12006E296:EN:HTML>.

European Union. “Consolidated Version of the Treaty on European Union,” *Official Journal of the European Union* (March 30, 2010). <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:083:0013:0046:EN:PDF>.

European Union. “Consolidated Version of the Treaty on Functioning of the European Union,”

Official Journal of the European Union (March 30, 2010). <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:083:0047:0200:EN:PDF>.

European Union. “Directive 2009/43/EC of the European Parliament and of the Council of 6 May 2009 simplifying terms and conditions on transfers of defence-related products within the Community,” *Official Journal of the European Union* (October 6, 2009). <http://Eur-Lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:146:0001:0036:EN:pdf>.

European Union. “Directive 2009/81/EC of the European Parliament and of the Council of 13 July 2009 on the coordination of procedures for the award of certain works contracts, supply contracts and service contracts by contracting authorities or entities in the fields of defence and security, and amending Directives 2004/17/EC and 2004/18/EU,” *Official Journal of the European Union* (August 20, 2009). <http://Eur-Lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:216:0076:0136:EN:pdf>.

“Executive Overview: Unmanned Ground Vehicles and Systems”, *Jane’s Defence Information Group*, Jan 2010

Foss, Christopher. “Ground masters: European land systems part one – Germany.” *Jane’s Defence Weekly*. May 8, 2009. <http://www.search.janes.com>.

Framework Agreement between the French Republic, the Federal Republic of Germany, the Italian Republic, the Kingdom of Spain, the Kingdom of Sweden and the United Kingdom of Great Britain and Northern Ireland Concerning Measures to Facilitate the Restructuring and Operation of the European Defence Industry. 2000. <http://www.grip.org/bdg/g1014.html>.

Freedberg, Sydney J. “The Army Looks Beyond Afghanistan.” *National Journal*. December 12, 2009. http://www.nationaljournal.com/njmagazine/nj_20091212_4983.php.

Frey, Stephanie. “Collaboration: The Way ahead for European Land Systems Producers?” *Military Power Revue der Schweizer Armee*. no. 1 (2009): 28-39. “FY2009 – 2034 Unmanned Systems Integrated Roadmap”. The Pentagon, Washington D.C., April 6, 2009.

Government Accountability Office. *Defense Acquisitions: Department of Defense Needs a Unified Strategy for Balancing Investments in Tactical Wheeled Vehicles*. Washington, DC: U.S. Government Printing Office. September 28, 2009. (GAO-09-968R Tactical Wheeled Vehicles). www.gao.gov/new.items/d09968r.pdf.

Government Accountability Office. *Defense Depot Maintenance: More Comprehensive and Consistent Workload Data Needed for Decisionmakers* (Letter Report, 05/21/96, GAO/NSIAD-96-166). www.fas.org/man/gao/ns96166.htm.

Government Accountability Office. *Defense Industry: Consolidation and Options for Preserving Competition*. Washington, DC: GAO. April 1998. (Letter Report, 04/01/98, GAO/NSIAD-98-141). www.fas.org/man/gao/nsiad98141.htm.

Hasik, James. *The Armies After FCS*. Canada: Hasik Analytic LLC. December 28, 2009. www.jameshasik.com/weblog/2009/12/the-armies-after-fcs.html

Headquarters, Department of the Army, *A Statement on the Posture of the United States Army 2010*, February 19, 2010.

Headquarters, Department of the Army, G-8, *The Army Equipping Strategy White Paper*, 29 September 2009.

Headquarters, Department of the Army, *Army Transformation Report to the Congress of the United States, Improving the capabilities of Soldiers to conduct full-spectrum joint operations and defend the Nation in the 21st Century*, February 7, 2007.

Headquarters, Department of the Army, *Mine Resistant Ambush Projected (MRAP) Allocation Plan Army Campaign Plan, Decision Point 147*, DAMO-FM, March 4, 2010.

Headquarters, Department of the Army, U.S. Army War College, *How the Army Runs, 2009-2010*.

Ian MacGowan, "Tank & Armored Vehicle Manufacturing in the US", IBISWorld Industry Report (IBISWorld Number 33699b, 2009)

Jean, Grace V. "Marine Corps Faces Gap in Ground Tactical Vehicles." *National Defense*. February 2010. See www.nationaldefensemagazine.org.

Johnson, Kimberley. "EFV setbacks concern House panel." *Marine Corps Times*. July 1, 2007. http://www.marinecorpstimes.com/news/2007/06/marine_efv_070630/.

Krepinevich, Andrew F., Center for Strategic and Budgetary Assessments (CSBA), *Strategy for the long haul, an Army at the crossroads*.

Lennox, Robert MG. *Setting Conditions for the Future*. Washington, DC: U.S. Army, Army QDR Office. Powerpoint presentation for AUSA Conference 2009.

Lockheed Martin Press Release. "Lockheed Martin and Patria Join Force for Marine Personnel Carrier Offering." October 18, 2007. <http://www.lockheedmartin.com/news>.

"NDIA Corporate Index of Capabilities for 2009", *National Defense Magazine*, August 2009, p. 139 ; and "Jane's 2010 Composite Listing of World UGV Providers", *Jane's Defence Information Group*, Jan 2010. [Http://search.janes.com](http://search.janes.com)

Nones, Michele. "A New Bi-continental Approach to Transatlantic Defence Cooperation." *The International Spectator*. No. 2 (June 2007).

Ripley, Tim. "UK troops begin training on STK Warthog." *Jane's Defence Weekly*. January 26, 2010. <http://www.search.janes.com>.

Rheinmetall AG. "Rheinmetall and MAN Nutzfahrzeuge from joint venture for wheeled military vehicles." January 12, 2010. <http://www.rheinmetall.de>.

Shipe, Richard. *US-EU Combat Vehicle Comparison*. Industrial College of the Armed Forces. (Unpublished slide).

Siegel, National Public Radio: *Calculating the Cost of the War in Afghanistan*, interview with various financial experts, National Public Radio, October 29, 2009.

<http://www.npr.org/templates/transcript/transcript.php?storyId=114294746>

Singer, P.W. *Wired for War: The Robotics Revolution and Conflict in the 21st Century*. New York, NY. : Penguin Group, 2009.

Stockholm International Peace Research Institute. *SIPRI Yearbook 2009: Armaments, Disarmament and International Security*. New York: Oxford University Press, 2009.

"The outlook for a European defense industrial base." *Jane's Industry Quarterly*. October 13, 2009. <http://www.search.janes.com>.

"2009 Annual Defence Report: Europe." *Jane's Defence Weekly*. December 14, 2009. <http://www.search.janes.com>.

United Kingdom Ministry of Defence. *Armoured Fighting Vehicle Strategy*. June 2009. <http://www.mod.uk>.

United Kingdom Ministry of Defence. *Defence Industrial Strategy Defence White Paper*. December 2005. <http://www.mod.uk>.

United Kingdom Ministry of Defence. *New contract for more armored fighting vehicles*. March 22, 2010. <http://www.mod.uk>.

U.S. Army. *The Army Equipping Strategy*. Washington, DC: U.S. Army G-8. 2009. PowerPoint Presentation. https://www.g8.army.mil/pdf/Army_Equipping_Strategy.pdf

U.S. Army. *The Army Tactical Wheeled Vehicle Investment Strategy*. Washington, DC: U.S. Army G-8. October 30, 2009.

US Department of Defense, Office of the Assistant Secretary of Defense, (Public Affairs), *DOD News Briefing with Secretary Gates from the Pentagon*, News Transcript, April 6, 2009.

Wayne, Leslie. *The Shrinking Military Complex; After the Cold War, the Pentagon Is Just Another Customer*. (New York: New York Times, February 27, 1998), <http://www.nytimes.com/1998/02/27/business/shrinking-military-complex-after-cold-war-pentagon-just-another-customer.html?pagewanted=all>.