

LAND COMBAT SYSTEMS INDUSTRY REPORT

Industrial College of the Armed Forces

Academic Year 2004 - 2005

ABSTRACT: The end of the Cold War initiated an era of reevaluation and transformation as national strategic leaders sought to assess and respond to changing global challenges. The U.S. Land Combat Systems (LCS) industry is an integral part of the Department of Defense's continuing transformational efforts.

After more than a decade of industry turmoil as evidenced by company downsizing and mergers, the LCS industry appears to have stabilized. For the surviving companies, the short-term economic prospects appear promising, given the few companies remaining and the high demand for land combat vehicles currently conducting operations in the Global War on Terror (GWOT). Moreover, continuing transformation efforts will potentially infuse \$2 billion per year over the next 20 years to ensure the development, production, and fielding of land combat systems capable of rapid response to virtually any corner of the globe with a minimum logistics footprint.



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INDUSTRY SPEAKERS/PLACES VISITED

Speakers:

Mr. Jerry Cothran, Defense Acquisition University
Mr. Gary Motsek, Deputy G-3 for Support Operations, U.S. Army Materiel Command
Mr. Mark Sykes, Independent Operational Evaluator, Army Test and Evaluation Center
COL Pete Fuller, USA, Project Manager, Stryker
Ms. Julia Denman, Asst. Director, Defense Capability and Management Team, GAO
Mr. Larry Junek, Senior Evaluator, Defense Capability and Management Team, GAO
Mr. Matthew Thuve, Boeing (FCS – Lead System Integrator (LSI) Contractor)
Dr. Thomas Killion, Army Deputy Assistant Secretary for Research and Technology

Domestic Travel:

United Defense, York, PA
USMC Expeditionary Fighting Vehicle Program Management Office, Woodbridge, VA
U.S. Marine Corps Systems Command, Woodbridge, VA
Anniston Army Depot, Anniston, AL
General Dynamics Land Systems Stryker Assembly Operations, Anniston, AL
Textron Land and Marine Systems, New Orleans, LA
Aberdeen Test Center, Aberdeen Proving Ground, MD
AM General, Mishawaka, IN
Allison Transmissions, Indianapolis, IN
Armor Holding, Fairfield, OH
Lima Tank Plant, Lima, OH
Program Executive Office, Ground Combat Systems, Warren, MI
Project Manager, FCS Ground Systems, Warren, MI
General Dynamics Land Systems Headquarters, Warren, MI
Detroit Diesel, Detroit, MI

International Travel:

Santa Barbara Systems, Seville, Spain
Steyr-Daimler-Puch Spezialfahrzeuge AG & Co KG, Vienna, Austria
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Krauss-Maffei-Wegmann GmbH & Co KG, Munich, Germany
Oto Melara, La Spezia, Italy
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AY 2004-2005 LAND COMBAT SYSTEMS INDUSTRY STUDY OVERVIEW

The Industrial College of the Armed Forces (ICAF), located at Fort Lesley J. McNair in Washington, D.C., prepares senior military officers and civilian officials for positions of senior leadership in the federal government. The College seeks to impart an understanding of how a nation creates military strength from the economic and societal elements of national power. A major element of the curriculum is the Industry Studies Program, which establishes a framework for each student to apply analytical techniques in assessing the state of a selected industrial sector.

The Industry Studies Program objectives include development of a strategic perspective of selected industries and their role in supporting the materiel requirements of national defense in normal and emergency conditions. The study groups complete comparative analyses of U.S. and international members of selected industries in both defense and non-defense environments, and prepare specific policy options to enhance industrial preparedness.

The Land Combat Systems (LCS) Industry Study is one of 20 industry studies. This group is comprised of three faculty members and 14 students. The study group meets as a seminar either in a classroom setting where recognized industrial, government and academic authorities are invited to speak on a broad range of topics relating to the Land Combat Systems industry, or in field study visits to government agencies, business headquarters or appropriate manufacturing facilities. The field study portion includes visits to both domestic and international industries and directly supports the group's research and analysis.

At the conclusion of the study, the seminar group prepares both a written report and an oral presentation of their findings. The report and presentation provide a comprehensive view of the overall status of the LCS industry and the resulting strategic policy implications. Consistent with the ICAF's non-attribution policy, this report presents industry composite information only, disclosing neither company specific information nor proprietary data.

For the purpose of the report, the LCS industry is defined as a subset of the larger defense industry. The LCS industry includes a broad range of warfighting vehicles, weapons, and support equipment that are manufactured by a number of commercial and defense-related companies. This paper focuses only on the ground combat vehicle segment within the industry. For clarity, the term ground combat vehicle refers to armored and lightly armored combat tracked and wheeled systems. These vehicle systems are further stratified by weight (light – less than 20 tons, medium – 20-40 tons, and heavy – over 40 tons), lethality, and survivability.¹

The following presents the Land Combat Systems Industry Study report for academic year 2004-2005. The paper begins with a brief background of the LCS industry, describing this sector in its current form. Next, it describes suppliers and provides a financial overview of the two major domestic manufacturers in the LCS industry. Further, it portrays a future view of the industry by examining the Department of Defense's transformation initiative and two important programs that will play a major role in transforming land combat systems: the Army's Future Combat Systems (FCS) and the Marine Corps' Expeditionary Fighting Vehicle (EFV). Finally, the paper closes by identifying important trends in the industry and drawing some conclusions concerning future implications for the LCS Industry.

INTRODUCTION TO THE LAND COMBAT SYSTEMS INDUSTRY

The last quarter century witnessed a dramatic evolution in the Land Combat Systems (LCS) industry. While entrenched in the Cold War doctrine of containment, the U.S. and its allies dedicated considerable national resources to building strong industrial bases capable of sustaining conventional forces in a protracted war with the former Soviet Union. In the LCS sector, both NATO and former Warsaw Pact nations emphasized high volume production of tracked and wheeled combat vehicles. Although the industry depended heavily on Department of Defense requirements, the number of manufacturers and volume of production during this time induced sufficient competition to ensure sustained innovation and efficiency were achieved in the U.S. LCS industry. This situation, however, resulted in an emphasis by industry on more profitable production while leaving the cost and risk of research and development largely to the government. Moreover, U.S. industry sought to protect its competitive advantage by lobbying for and securing strict export controls on national security technology.²

In contrast, many NATO nations made strategic national security decisions to provide government subsidies to their respective LCS companies. Confronted with low production requirements and reliance on governmental largesse, European firms within the LCS industry increasingly turned to foreign markets to augment its sales in order to derive additional capital for reinvestment and expansion. Additionally, as NATO countries established and built upon their independent production capabilities, protectionist policies made it difficult to secure the cooperation of other national LCS companies, thus negating potential gains in manufacturing efficiencies and lower costs.

Despite these different approaches, the U.S. and its NATO partners managed to achieve commonality and interoperability across a wide array of land combat systems, particularly with respect to fuel and ammunition. Even so, the national LCS industries significantly contributed to the Cold War victory of the U.S. and its NATO allies over the Soviet Union and the Warsaw Pact.

U.S. LCS Trends

When the Berlin Wall fell in November 1989, it signaled not only the end of the Cold War but also a reevaluation of the United States' national security and military strategy. From 1992 to 2001, the Department of Defense significantly reduced the funding of its major weapons systems acquisition programs, taking what has become known as a *procurement holiday*. This reduction in U.S. defense spending proved challenging for the defense industry and perhaps, hit the LCS sector the hardest.

Aware of the impact that declining military spending would have on the industry, former Secretary of Defense William J. Perry gathered top executives from major defense contractors in July 1993. Dubbed the *Last Supper*, Perry urged these defense contractors to merge and consolidate their collective capabilities because future defense spending plans were insufficient to maintain previous production rates. Moreover, Perry pushed for increasing application of dual-use technology in order to mitigate risk for defense contractors. He also directed reforms to the existing DoD acquisition process to take advantage of best commercial practices in industry to induce more competitive pricing and stimulate product innovation.³

At the beginning of the new millennium, it appeared that the U.S. industrial base had adjusted correctly to the new market realities. In the armored combat-tracked vehicle segment of the LCS industry, a dozen manufacturers merged to become two – General Dynamics Land Systems (GDLS) and United Defense Limited Partnership (UDLP). On the armored combat-wheeled vehicle side, the three primary suppliers remaining are GDLS, UDLP, and Textron. With adjustments to the LCS industry made during this period, GDLS and UDLP have become the predominant force in the domestic land combat systems marketplace.

GDLS has been the sole producer of the Army's main battle tank (M1 Abrams Tank) for over three decades. Although new tank production for U.S. forces has ceased, foreign sales and cooperative ventures with Saudi Arabia, Egypt, Kuwait, South Korea and most recently Australia has enabled GDLS to maintain its profitability and position as manufacturer of the world's premier tank. The recently awarded contracts for the Army's Stryker Program and the Marines' Expeditionary Fighting Vehicle (EFV) have further positioned the firm to compete for additional opportunities, especially with respect to the Army's Future Combat System (FCS) Program.

On the other hand, UDLP is the industry's foremost manufacturer of medium weight combat vehicles. As the industry leader in track suspension systems for combat vehicles, UDLP was adversely affected by both the Army's cancellation of the Crusader Program and its decision to award the lightweight combat vehicle program (Stryker) to GDLS. Nevertheless, foreign ventures with Turkey and Saudi Arabia along with significant rebuild/remanufacturing contracts from the U.S. Government keep UDLP viable but far from its previous full-rate production tempo.

The U.S. LCS industry now appears stable but further contractions could force future consolidation and ultimately constrict competition. However, the relatively new entry into the industry of Textron with its Armored Security Vehicle (ASV) indicates that capable manufacturers can still fill a niche where a need exists in this sector. In the long-term though, the strength and growth of the domestic market may hinge on U.S. firms' ability to leverage foreign markets either through company mergers or cooperative ventures rather than relying on new entries into the marketplace. See Appendix A for U.S. LCS programs and manufacturers.

European LCS Trends

The LCS industry in Europe similarly downsized in the face of reduced defense spending and force structure reductions. Although France, Great Britain, and Spain recently announced targeted increases in defense spending, the trend in Europe is one of reduction and restraint. Given constricting markets at home, the European Union (EU) defense industrial base, like that in U.S., has turned increasingly toward international sales in the hopes of not only strengthening their profitability but also of becoming a more formidable competitor to U.S. LCS firms. Increasing, the affects of globalization have European competitors no longer viewing the U.S. LCS market as the sole domain of U.S.-based companies. To compete with the U.S., European companies continue to consolidate but still face many challenges. While U.S. productivity surged over the last 20 years, European productivity slowed. For instance, between 1995 and 2002, the gross domestic product per capita rose 7.2% in the EU, while in the U.S.; the figure has remained steady at 16.2%.⁴ Given its low production volumes, the European LCS

industry has been unable to sustain capital investment, therefore suffering from the effects of plant and equipment obsolescence, production inefficiency, and under utilization of manufacturing facilities.

While many European LCS companies experience most of these effects, certain firms have aggressively pursued new business opportunities in the international market to offset the domestic lag in combat vehicle orders. Iveco DVD, located in Bolzano, Italy, has expanded its sales of Light Multirole Vehicles (LMV) and Armored Fighting Vehicles (AFV) to other NATO (35%) and non-NATO (15%) countries.⁵ Its Panther 4x4 LMV has been sold to the United Kingdom to meet the British Army's need for a Future Command and Liaison Vehicle (FCLV) while the Centauro, an 8x8 tank destroyer AFV, has been sold to the Spanish army. Each vehicle can be manufactured in many variants to satisfy customer requirements, adding increased flexibility to meet their operational needs. Further, as part of the Fiat Consortium, idle manufacturing facilities does not appear to afflict Iveco's operations as with many American and European LCS manufacturers. Other commercial Fiat vehicles are produced side-by-side with Iveco's military-related systems when defense orders decline, thus maintaining the company's production base.⁶

Another leading European LCS manufacturer relying on export business is Oto Melara (Finmeccanica). In 2004, export sales alone accounted for one-third of its total sales.⁷ With its defense production facility based in La Spezia, Italy, Oto Melara is an acknowledged leader in designing and manufacturing naval and land ordnance and weapon control and firing systems. In collaboration with Iveco DVD, Oto Melara has designed and produced a modular family of turrets used principally on the Dardo Infantry Fighting Vehicle (IFV), Centauro tank destroyer, and the Ariete Main Battle Tank (MBT). Along with the export of its 76mm Super Rapid Fire Naval Gun to the United States, Norway, and Malaysia, the Consortium Iveco Fiat-Oto Melara (CIO) exports its current line of combat vehicles primarily to Spain, the United Kingdom, and other international customers.⁸

Krauss-Maffei Wegmann (KMW) is a privately held LCS manufacturer headquartered in Munich, Germany. As the noted designer and manufacturer of the Euro Leopard 2 and various other light armored combat vehicles (i.e., Mungo, Dingo, etc.), KMW relies heavily on its export sales – almost 70% as of 2004.⁹ Currently, the Leopard 2 is being built under license by Santa Barbara Sistemas (GDELCS) for the Spanish Army while 170 new tanks are being built in Greece for the Greek army.

While EU LCS manufacturers seek to expand their international markets, the U.S. consistently acts to protect defense technology from being proliferated to undesirable nations. European firms regard these U.S. export control policies as protectionist and, indeed, many seek out partnership arrangements to circumvent U.S. restrictions. A good example is the European Union's attempt to sell military hardware to China. The French and Germans are leading a campaign within the EU to repeal the arms embargo placed on China 15 years ago because of China's human rights violations associated with Tiananmen Square.¹⁰ If successful, this move could inaugurate market opportunities for an industry struggling to remain solvent.

Despite formidable challenges, consolidation and expansion of international markets appear to be the order of the day for EU-based LCS companies. For example, BAE System's acquisition of the United Kingdom's armored vehicle manufacturer Alvis (who also owns Vickers) and their most recent announcement to acquire American-based

United Defense Limited Partnership clearly signals an intent to get a piece of the foreign market – even if that foreign market happens to be located in the United States.

THE DOMESTIC LCS MARKET CHARACTERISTICS

The Land Combat Systems (LCS) industry occupies a unique position within the existing U.S. manufacturing base with significant implications for national security. The industry operates in a distinctive market environment that challenges profits, production, and long-term viability. Further, from an economist's perspective, the LCS industry reflects a monopsonistic marketplace – that is, one buyer (government) and few suppliers.

With the defense budget exceeding \$400 billion per year, the U.S. Government clearly represents the largest demand force within the LCS industry.¹¹ Maintaining a competitive environment among suppliers optimizes defense spending, but the system itself often works against such optimization. As is the nature of government procurement programs, weapons system acquisitions are highly politicized, often leading to inefficiency. Although research, development, and production may span decades, there are no long-term commitments to defense spending because Constitutional requirements, as well as Congressional language, often limit contract lengths to one year. With relatively short production runs, economies of scale are not possible, causing the government to ultimately purchase higher-priced products manufactured on inefficient production lines. Finally, when a selected LCS system is of foreign design, the U.S. Government often mandates *Americanization* of the weapon system's configuration. This contributes further to production inefficiencies and counters the ongoing globalization of the LCS's industrial base.

Together, these characteristics not only defy economic norms of a demand-side monopoly, they generate an extremely challenging environment to LCS manufacturers. The government acquisition system strives for the *best bang for the buck* but simultaneously works against this goal through governmental inefficiencies and political stresses. These bi-polar extremes add to the U.S. LCS industry's challenges and the painful environment in which LCS suppliers must seek profit. However, to ensure long-term success, many LCS suppliers have expanded their production efforts into other manufacturing sectors. By diversifying into other markets, LCS manufacturers become less reliant on an unstable monopsony environment for survival.

U.S. MARKET FORCES INFLUENCING THE LCS INDUSTRY

There are three primary forces currently influencing the U.S. LCS market. First is the transition of the U.S. Army from a threat-based planning to a capabilities-based planning construct. The fall of the Iron Curtain brought about a paradigm shift in defense planning – from a force structure designed to counter the former Soviet threat to a capabilities-based plan that meets the challenges of a multi-polar international environment. The U.S. Army's recent cancellation of the Crusader Program and adoption of the wheeled Stryker vehicles mark the initial steps toward a lighter, more flexible and responsive land force structure. This shift in planning models also brings significant challenges. The Army's new Brigade Combat Teams (BCT) that employ mostly wheeled Strykers and HMMWVs initially lacked the defensive armor required when threatened by unanticipated insurgent forces in Iraq. The time-critical demand for additional defensive measures became a

searing political issue with many Americans perceiving that U.S. soldiers were in combat equipped with substandard equipment.¹² In reaction, several LCS manufacturers reported various problems with ramping-up to a wartime surge capability sufficient to meet battlefield demands.

Sustainment is the second factor exerting influence on the LCS market. With the limited number of new LCS acquisition programs over the last 25 years, sustainment of legacy systems often represented the greatest opportunity for new sales in the LCS market. For instances, most vehicles returning from action in Southwest Asia require significant overhauls to *reset* or return the equipment to operational capability. The reset market helps bridge the gap in defense system procurement and maintains the U.S. defense industrial base. Additionally, initiatives for improving the sustainability of land combat systems have recently been introduced to the industry – Performance-Based Logistics (PBL) and Contractor Logistics Support (CLS) concepts.

PBL uses an acquisition strategy that concentrates on performance-based metrics designed to reduce program costs throughout the life cycle of the equipment. Its focus is on procuring a capability that produces specific outcomes. It is therefore more concerned with ends than with means. Program managers structure PBL contracts to support warfighters' requirements for supported systems. Department of Defense Instruction 5000.1 establishes PBL as DoD's preferred approach for product/logistics support for all new acquisition programs.

To date, no major LCS program has fully implemented PBL as part of its acquisition strategy; however, two vehicles are in the process of developing metrics to support the implementation of PBL. First, the Army's Stryker Program Management Office is working to define the metrics to support a PBL strategy (See Appendix B for a synopsis of a special PBL study conducted by students of the AY2005 LCS Industry Study for the Stryker Program Manager). The second program is the Marine Corps' Expeditionary Fighting Vehicle (EFV). The Marine Corps is taking a deliberate approach in the development of its strategy. They envision some type of interim support package in the early years of product fielding while fully developing the metrics set for use in a full-scale PBL contract. Since no LCS product approaching the magnitude of Stryker or EFV is under a PBL contract, the full implications and promise of this sustainment option are yet to be determined; however, the Government Accountability Office (GAO) has nevertheless touted its potential if it is properly implemented. As of this writing, PBL appears to offer the possibility of significant cost savings. The upside notwithstanding, DoD would be wise to carefully review its PBL implementation policies, as they will greatly affect the sustainment costs of future land combat systems and the industry's health as a whole.

Contractor Logistics Support (CLS) is a sustainment concept first introduced by DoD approximately ten years ago. It has been used extensively to provide or augment a variety of logistics functions such as dining facilities, installation housing and depot-level maintenance. Usually provided on a long-term basis, CLS applications in the LCS sector include such functions as determining the requirements for spare and repair parts, engineering services and equipment maintenance. In comparison to PBL, CLS is not a new concept although the extensive use of contractors providing maintenance support on the battlefield is now becoming the standard method of operation.

The most visible example of CLS in the LCS industry is the Army's use of GDLS technicians in Iraq to perform all the maintenance on Stryker vehicles. From the

beginning of the operation, the Army knew that the commercial-off-the-shelf Stryker would require significant external support from contractors. Moreover, since the vehicles were rapidly fielded and sent to the Iraqi theater of operations, the Army had no choice but to use GDLS technicians to perform maintenance and repair. In the case of Stryker, since the Army does not plan to create Military Occupational Specialties (MOS) for maintenance personnel, the CLS requirement may remain for some time or at least until a PBL strategy is fully developed.

Finally, transformation looms as the third and largest force in shaping the current and future LCS market. The DoD's Transformation Program is a shift from a linear, evolutionary force development model to a skip-generation development process. Rather than investing in legacy systems that step towards a network-centric capability, the Army's transformation philosophy seeks to pass over evolutionary systems in favor of directly fielding a network-centric force. The Future Combat Systems (FCS) Program represents the Army's transformational effort towards a mobile, flexible, and networked force. FCS, as developed by Boeing and SAIC under the Lead System Integrator (LSI) concept, consists of a new family of advanced vehicles with a robust information network. At an estimated cost of over \$130 billion, FCS is the Army's most expensive weapons program ever conceived and relies heavily on unproven technologies, leading many critics to challenge the initiative's fiscal viability.¹³

Overall, the LCS industry is an unpredictable monopsony that forces its suppliers to continually deal with uncertainty and risk. The market's volatile supply and demand relationship generate an unstable environment that challenges LCS companies' long-term success and profitability. The U.S. Government drives the domestic LCS market as both the largest consumer and by severely limiting sales of the industry's products to international customers owing to security prohibitions. Diverse forces, ranging from political influences to evolving force capabilities, will continue to shape the U.S. LCS market's characteristics far into the future.

HEALTH OF THE CURRENT DOMESTIC LCS INDUSTRY

The following section briefly examines the health of the Land Combat Systems industry's two predominate domestic leaders, focusing specifically on production capabilities and the firms' financial health. Discussion is limited to General Dynamics Land Systems (GDLS) and United Defense Limited Partnership (UDLP).

General Dynamics Land Systems' (GDLS) Capabilities

General Dynamics is one of largest companies in the world and is the recognized market leader in the ground combat vehicle sector. Headquartered in Falls Church, VA, the company employs over 70,000 people around the globe with 2004 sales exceeding \$19 billion across its four main market segments: marine systems, combat systems, aerospace and, information systems and technology.¹⁴ General Dynamics further divides the combat systems segment into four additional divisions: Land Systems, European Land Combat Systems, Ordnance and Tactical Systems, and Armament and Technical Products. It is within the Land Systems and European Land Systems divisions that ground combat vehicles are produced and sold to the U.S. military and other international customers. Its European Land Combat Systems consists of MOWAG AG Kreuzlingen,

Santa Barbara Sistemas, and Steyr Spezialfahrzeug. In 2003, these firms integrated into the larger European Land Systems business unit.

General Dynamics Land Systems (GDLS) provides a full spectrum of land and amphibious combat systems and subsystems worldwide. GDLS's core competency lies in its design and systems integration, advanced production techniques, and innovative life cycle support. Headquartered in Sterling Heights, MI, GDLS employs 7,800 people in 11 states, generating approximately 23% of General Dynamics' annual sales in 2004.¹⁵ The GDLS combat vehicle product line consists of the following systems:

- Abrams Main Battle Tank (MBT)
- Wheeled Combat Vehicles – Wheeled combat vehicles constitute the largest segment of the Land Systems business. These products include the following:
 - The Light Armored Vehicle (LAV)
 - Stryker – A LAV variant adopted by the U.S. Army in 2000. The Stryker represents an interim vehicle solution for the Army as they transform toward a lighter more mobile force, pending the operational fielding of FCS.
 - Fox Nuclear Biological Chemical Reconnaissance System
- Expeditionary Fighting Vehicle (EFV) under development for the U.S. Marine Corps to replace the legacy AAV system. It remains the Marine Corps' highest ground combat vehicle priority.
- Future Combat Systems (FCS) Program – During the program's System Development and Demonstration Phase, GDLS is collaborating to develop manned ground combat vehicle variants and other FCS advanced technologies.

Through a combination of company-owned, leased, and government-owned facilities, GDLS maintains sufficient capacity to fulfill current production requirements. In fact, the firm currently carries considerable excess capacity and facilities (particularly at its overseas production facilities) that could be used to meet surge production and ramp-up requirements if needed. Although GDLS incurs the overhead cost associated with excess capacity, it attempts to offset it with production efficiencies. Assisting the company in this regard are the benefits GDLS derives from using a number of Government-Owned, Contractor- Operated (GOCO) facilities. The Joint Systems Manufacturing Center in Lima, OH, and the Anniston Army Depot in Anniston, AL are two such facilities.

Although GDLS tries to minimize fixed costs by using GOCO facilities, the company also infuses capital investments into its manufacturing and production processes. These investments are targeted typically at the integration of the latest technology and state-of-the-art machines, tools, and processes.

With respect to manufacturing certifications, techniques and initiatives, GDLS leads the U.S. LCS industry. They have implemented lean manufacturing techniques in their plants to eliminate waste and reduce production and assembly times while increasing quality. The company relies heavily on engineering modeling and simulation techniques to improve design, product development, and production processes. GDLS's quality management system is ISO 9001 registered, SEI Level V certified, and it continually seeks to integrate new technologies and welding techniques into their production processes.¹⁶ Finally, GDLS's use of progressive management techniques (e.g., balanced scorecard) and supply chain information technology improve customer satisfaction while minimizing production costs.

Financial Analysis of General Dynamics

At the corporate level, General Dynamics is a profitable and well-managed defense firm. The overall financial strategy of the company is to focus on earnings, cash flow, and return on invested capital. A strong balance sheet and other financial statements support this approach. The company's profit margin for 2004 was solid while its Return on Equity (ROE) was a very respectable 108% – considerably higher than the industry's average of 13%. The company's ability to generate income on owned assets was also formidable in 2004. The bulk of the company's revenue is derived from its domestic and international defense business, representing 81% of total sales in 2004.¹⁷ The company achieved \$19.2 billion in gross sales for 2004 – an increase of 17% from 2003. Net income increased by 22%, climbing to \$1.23 billion or up from \$1 billion in 2003.¹⁸ GDLS attributes the majority of its recent growth to its corporate acquisitions and operating performance of its Combat Systems and Information Systems and Technology Divisions.

The Combat Systems Division performed extremely well for General Dynamics in 2004, accumulating revenues of \$4.4 billion. This represents 23% of General Dynamics' total revenue and an increase of 10% from 2003. Net earnings increased by 18% to \$522 million.¹⁹ The key programs fueling GDLS's earnings growth include vehicle sales, product enhancements and after-market support connected to wheeled systems – particularly Stryker, LAV, FOX NBCRS and, the M1 Abrams tank (rebuilds upgrades and replacements). Current defense funding and contracts related to the Army's transformation initiatives and the Global War on Terrorism (GWOT) have favorably affected the firm's revenue position. Among these are Future Combat Systems (FCS) and the Marine Corps Expeditionary Fighting Vehicle (EFV). Driven by increased sales in Leopard tanks, the Pandur, Piranha, and the Ulan Infantry Fighting Vehicle, its European Land Combat Systems Division also experienced equally impressive performance.²⁰ Based on the firm's global business, future growth expectations, and other financial data, it appears General Dynamics is positioned well to continue to lead the LCS sector and be a major player in the overall defense industry.

United Defense Limited Partnership's (UDLP) Capabilities

United Defense Limited Partnership (UDLP) is the other dominant player in the U.S. LCS industry. Although not as large as GDLS, UDLP nonetheless is a global leader in the design, development, and production of ground combat vehicles, artillery, naval gun systems, and precision munitions. The company has produced over 100,000 combat vehicles and weapon systems for the U.S. military and other worldwide customers.²¹ Headquartered in Arlington, VA, UDLP employs 7,900 people, achieving over \$2.2 billion in sales in 2004.²² Incorporated in 1997, the company is organized into two main product and service divisions: Defense Systems and Ship Repair and Maintenance. The Defense Systems Division is organized into four main business segments: Armament Systems, Ground Systems, Steel Products, and International. UDLP generates ground combat vehicle sales through its Ground Systems Division. The one exception is the M113 infantry carrier, which is managed by the Steel Products Division. The Ground Systems Division, headquartered in York, PA, houses the company's primary ground combat vehicle production facility.

UDLP expanded over time through domestic and international mergers. In 2000, the company acquired Bofors Defence, located in Sweden. In 2002, they bought United States Marine Repair, a leader in ship repair and maintenance. Other acquisitions include: CERCOM (March 2004), a supplier of lightweight ceramic armor, and Kaiser Compositenk (Feb 2004). UDLP also has joint ventures in Turkey and Saudi Arabia and participates in co-production programs with Egypt, Malaysia, and other foreign allies.²³

Historically, UDLP's ground combat vehicle niche was the development and production of tracked-vehicle systems. With the inception of the FCS Program, the company has expanded into the wheeled-vehicle arena by developing and manufacturing variously configured, wheeled FCS prototype vehicles. Perhaps the company's most recognized product is its family of Bradley Fighting Vehicles, which has proven its combat performance in both Operation Desert Storm (ODS) and in Operation Iraqi Freedom (OIF). Other ground combat vehicles the company has produced or is developing include:

- Family of M113 vehicles (armored personnel carrier)
- M109A6 Paladin Howitzer
- M992A2 Field Artillery Ammunition Support Vehicle (FAASV)
- The Family of Assault Amphibious Vehicles (AAV7A1) used by the Marine Corps since the early 1970s and the recently recapitalized AAV RAM/RS vehicle.
- M88A2 HERCULES (Heavy Equipment Recovery Combat Utility Lift and Evacuation System)
- M993 Carrier is based on the BFV System. This vehicle system is used for U.S. Army's MLRS, also supporting its armored maintenance, medical treatment, and C2 requirements.
- M9 Armored Combat Earthmover (ACE)
- M8 Armored Gun System (light tank)
- FCS Family of Vehicles. UDLP is scheduled to develop the Non-Line-Of-Sight (NLOS) Cannon System and four other FCS-manned ground vehicle systems, including the infantry carrier, NLOS-Mortar, medical and the maintenance and recovery vehicles.

Similar to GDLS, UDLP also has excess production capacity in its Defense Systems and Ship Repair/Maintenance facilities. In fact, UDLP is using some of the extra capacity in its Marine Repair segment to execute a \$90 million contract to manufacture add-on armored kits for the Army's combat vehicles operating in Afghanistan and Iraq. The excess capacity has proved beneficial in accommodating the increased volume and demand generated from OIF requirements but will be difficult to maintain over the long-haul without an increase in production contracts and additional LCS sales.

UDLP considers its technology, manufacturing, and production processes a core competency. The company has made considerable investments in lean manufacturing techniques and state-of-the-art tools and processes in order to make production and assembly operations more efficient. The lean investment appears to be successful, with UDLP attributing its higher profit margins to the efficiencies achieved on production contracts.²⁴

To remain a market leader in the LCS industry, UDLP relies heavily on modeling and simulation and technology innovation to improve product design, development, and integration. Modeling and simulation also help identify production and design problems early, assisting in the reduction of development time and improving the overall quality of the product. Further, these techniques improve production processes and assess design changes on key performance parameters such as weight, survivability, range, etc. UDLP integrates innovative solutions to improve ground combat vehicle survivability and supportability. For example, UDLP's experience with band track systems, advanced composite materials, and hybrid electric power supplies has ensured the company a solid position within the LCS industry.

UDLP's quality management system is ISO-9001 certified while its software development teams are operating at a Level 3 Rating on the Software Capability Maturity Model.²⁵ UDLP continues to be a global leader in total life cycle product development and systems integration.

Financial Analysis of United Defense Limited Partnership (UDLP)

UDLP remains a profitable defense-manufacturing firm. In 2004, the company increased sales by 11.7% to \$2.29 billion. Net income increased from \$140.6 million in 2003 to \$166.1 million for 2004.²⁶ Both sales and net income have trended positively since 2001. The company's balance sheet and income statements in comparison to the industry are respectable and its profitability and liquidity ratios are above the industry's average. However, cash flow is one concern that could constrain future growth and the flexibility to conduct near-term capital investments. Current backlog figures have been steady but do not indicate any substantial growth in sales for the short-term.

The firm attributes most of its recent revenue growth to the performance of the Ship Repair and Maintenance segment of its business. Sales growth in the Defense Systems segment is fueled and maintained primarily by the company's legacy ground combat vehicle product line. The most significant ground combat vehicle revenue generator has been the Bradley Family of Vehicles (BFV). In 2003, the BFV produced \$293 million in sales and achieving \$369 million total sales in 2004.²⁷ This growth in sales has been driven by the Army's operational demands (Operation Iraqi Freedom) for which Congressional funding continue to be appropriated in order to pay for maintenance recapitalization requirements and combat attrition. Funding for BFV technology upgrades also keeps a portion of UDLP's production lines busy as evidenced by a recent contract award for \$143 million (April 2005) to upgrade and re-manufacture 55 fully digitized Bradley A3 models. UDLP's other legacy combat vehicle products continue to generate significant sales and post-production support. Foreign Military Sales (FMS) have also been an important source of revenues on which the company relies to help maintain its industrial capacity through lean production years.

In the short-term, UDLP will continue to generate sales from its LCS legacy product line and its Ship Repair and Maintenance business activity. The firm's long-term health and profitability is directly linked to the Army's Future Combat Systems (FCS) Program. As mentioned, UDLP is teaming with Boeing/SAIC (as the joint Lead System Integrator) and GDLS to design and develop manned-ground vehicle systems for FCS. UDLP will design and develop five of the eight FCS ground vehicles. The FCS contract represents long-term production and post-production support opportunities for UDLP. With the

cancellation of the Crusader Program and the loss of the Stryker competition to General Dynamics, the FCS contract is critical to UDLP's financial health and its ability to maintain its manufacturing base.

Perhaps the most significant issue related to UDLP's financial health is its possible acquisition by BAE Systems-North America, Inc. The proposed merger was approved unanimously by UDLP's board of directors and is currently being reviewed by the Federal Trade Commission and Antitrust Division of the Department of Justice. If approved, UDLP will become a wholly owned subsidiary of BAE (United Kingdom) and its common stock will no longer be traded on the public exchange.²⁸ Final approval is expected by mid-year 2005. Presently, it is not entirely clear how this merger will shape the domestic and international LCS industry. However, the merger will likely increase competition for General Dynamics' European Land Systems and potentially create new foreign markets for UDLP's ground combat vehicles and associated technologies. The extent to which BAE can exploit this, however, depends on how much and what kind of technologies U.S. governmental policies will allow to be exported. For the moment, this proposed merger represents another example of market consolidation and globalization as BAE Systems attempts to add to its competitive advantage and increase its presence in the U.S. LCS market.

U.S. GOVERNMENT'S FUTURE DIRECTION

In assessing the LCS industry, an analysis of the future direction of the primary customer, the U.S. Government, is necessary. This analysis will encompass three aspects: the ongoing transformation of the Department of Defense and, due to its transformation, the impact on the future direction of the U.S. Army's and the U.S. Marine Corps' land combat system programs.

Impact of Transformation

Transformation means changing and integrating tactics, techniques, procedures, and warfighting capability in order to enhance dominance on the battlefield. It includes better training and cooperation with allies, improving relationships within the Department of Defense (DoD) and other governmental agencies. As it will require creativity and innovation, transformation also means leveraging new technologies and developing new doctrine. The Army's transformation relies upon its Future Combat Systems (FCS) and Brigade Combat Teams (BCT). For the Marine Corps, it hinges on the V-22 Osprey and Expeditionary Fighting Vehicle (EFV). For the Navy and Air Force, their transformation centerpieces are Littoral Combat and Sea Basing Ships and the F-22 Raptor and Joint Strike Fighter, respectively.

The two primary goals for America's military transformation are to take into consideration reaction time for force deployments to zones of instability (short-term) and to meet new commitments and operational demands throughout the world (long-term).²⁹ As the nation moves towards the realization of these strategic goals, there are two questions that must be asked: 1) Can America afford to pay for transformation and, 2) What impact will transformation have on America's industrial base?

Transformation will significantly affect not only how the nation prepares for and fights future wars but it also will affect each uniformed service's budget as well as LCS

manufacturers. New materiel solutions will provide state-of-the-art land combat systems for the Army and Marine Corps and provide communication networks heretofore unseen in modern warfare. However, it will not come cheaply. As costs for Medicare, Medicaid, and Social Security rise, there will be trade-offs between domestic requirements and spending on the national defense – the classic economic debate of guns versus butter. For now, the checkbook seems wide-open. Transformation will also have a major impact on LCS industry producers, either introducing additional competitors to an already exclusive market or driving the industry to a government-supported monopoly.

The most formidable obstacle for transformation is not the intellectual capability to produce new technologies but rather funding. The total transformation cost across the services comes with a staggering price tag of \$239 billion for procurement programs from Fiscal Year 2005 through Fiscal Year 2009.³⁰ Indeed, the DoD budget rose precipitously from \$290 billion in 2000 to \$402.6 billion in 2005.³¹ Alone, the Stryker's contract allows for the production of 2,400 vehicles at a total cost of \$6 billion.³² FCS program costs are already setting records for the most expensive LCS program ever procured at an estimated \$133 billion (current procurement lags behind the Joint Strike Fighter at \$244 billion). More significantly, the cost for FCS is already up 45% from the original estimate of \$92 billion.³³ The Marine Corps' EFV price tag is currently \$7.6 billion for 1000 vehicles.

The cost to acquire transformational capabilities continues to grow and is taking a toll on services' budgets in terms of opportunity costs. The Army canceled other programs to pay for the initial startup for the Stryker Program and is leveraging funding provided through Congressional supplemental appropriations for Operation Iraqi Freedom. Without it, the Army would find it quite difficult to transform. Meanwhile, the Marine Corps has mortgaged much of its future procurement dollars to pay for the EFV. Budget challenges will likely either reduce the EFV procurement quantity or stretch out the program, ultimately increasing the total cost as well. Transformation is expensive and, though there appears to be plenty of money now, indications are beginning to appear that may suggest it will not always be so.

The impact of transformation on LCS manufacturers is no less threatening. When it comes to new production of land combat systems, GDLS surpasses its nearest competitor (UDLP) by more than a 3 to 1 ratio. GDLS not only manufactures heavy and medium land combat systems, but the firm is also a top producer in the shipbuilding, aircraft, and advance technology industries. This compares to UDLP who employs only 7,900 and books sales of \$2.2 billion.³⁴ GDLS's comparative advantage lies as the sole producer of America's Abrams main battle tank, the Army's Stryker vehicle fleet, and the Marine Corps' EFV. Although each company bid on the Stryker and EFV programs, GDLS won both competitions.

The redirection of the Army towards Stryker Brigade Combat Teams has had serious consequences to UDLP. In order to fund this, the Army canceled three major land combat legacy programs that included the Grizzly, Wolverine, and Crusader Programs, all of which UDLP designed and developed. As a result, UDLP immediately lost market share in land combat systems production, billions in revenue, and thousands of jobs. Consequently, UDLP cut its work force by 70% and now operates at only 35% of its full production capacity. Its current business has been reduced to rebuilding weapon systems such as the Bradley Fighting Vehicle, the Armored Combat Excavator, the M88 Recovery Vehicle, and the Marine Corps' Amphibious Assault Vehicle (AAV). UDLP

has no major U.S. LCS vehicles currently in production and no firm DoD contracts to produce any other new LCS weapon systems in the near future.

UDLP may rebound as the Army enters the System Development and Demonstration Phase for its FCS Program. The Lead System Integrator (LSI), Boeing Company and SAIC, has awarded design of FCS vehicles to both GDLS and UDLP. As part of the contract award, UDLP will design the Infantry Carrier Vehicle, the Future Maintenance and Recovery Vehicle, the Medical Vehicle, and the Non-Line-of-Sight (NLOS) Cannon and Mortar variants. UDLP's FCS System Development and Demonstration contract is worth over \$2.5 billion, with production implications exceeding \$60 billion over the life of the program. This all bodes well for UDLP but there has been discussion of canceling the FCS vehicle portion of the program in order to save \$17 billion in budget authority through 2010 and \$56 billion through 2015 relative to the 2005 Future Years Defense Program. This would be a heavy financial blow from which UDLP might not recover. The Department of Defense has thus created a potential situation that may result in GDLS receiving all of the LCS vehicle production thereby driving UDLP out of the industry.

Although the success of FCS depends in part on competitive market forces to drive innovation, efficiency, and cost, losing UDLP to the domestic LCS industry might possibly cause the Army to default to the Stryker built by GDLS. This adds a different dimension to the future of the LCS industry, having only one major manufacturer of armored land combat vehicles. Can America afford only one producer, even if it is a premiere company such as GDLS? One can argue that only with competition can the government ensure it will receive the best product quality at an optimum price – now and in the future.

The Army's FCS Program

Discussion of the Army's future plans would be incomplete without a discussion of its flagship transformation program – Future Combat Systems. The Future Combat Systems (FCS) is not merely a new land combat system; it is a system of systems, which consists of an integrated network, the soldier, and eighteen separate classes of equipment ranging from armed robotic vehicles to sophisticated command and control vehicles.

The combination of these systems will fundamentally change the way the Army is organized and how it will fight. As envisioned, the synergy of these networked components will allow the Army to enhance its warfighting superiority while replacing force of mass with the strength of information technology. Increased situational awareness will be used to offset the need for heavy armor to provide system survivability. Consequently, each of the manned combat systems is to weigh only one-third as much as the heavily armored M1 Abrams tank. This weight savings will enable the FCS-equipped forces to be more agile, more deployable, and more sustainable. The network will enhance system survivability, lethality, and versatility. In developing and ultimately fielding FCS, the Army faces multiple risks. Among these are management, contract, budget, technology, and requirement risks.

The complexity of the FCS system of systems and the sheer magnitude of what must be developed, procured, and integrated make the program the largest procurement action ever executed by the Department of the Army. It inherently entails management risk. Failures in bringing other large-scale development programs to fruition supported the Army's assertion that it required assistance to make FCS a success. To resolve this

problem, the Army did not award a production contract, but instead issued a contract for a Lead System Integrator (LSI). As the LSI, Boeing and SAIC were charged with developing a systems' architecture, defining requirements, selecting appropriate technologies, issuing subcontracts, and managing the overall program – all tasks normally performed by government acquisition professionals.³⁵

Thus far, the LSI concept has proven to have both advantages and disadvantages. As the Army had hoped, the LSI has been able to jump-start the program by bringing large numbers of personnel to the program through expeditious and flexible subcontracting. Unfortunately, these benefits have been counterbalanced by complaints from both the Army and LSI subcontractors. Army personnel have complained that they have lost control of the program because the LSI has created such a bureaucracy that it is nearly impossible to determine where decisions are made. Even in cases where the appropriate forum for decision-making can be found, government personnel are severely outnumbered and are simply overwhelmed. The LSI has developed an extensive network of integrated project teams (IPTs) and sub-IPTs to work FCS issues. In most cases, the IPTs are co-chaired by the LSI and the government. This co-chair relationship has severely reduced the government's ability to affect the program. While it is true that the Army cannot manage every aspect of FCS, it should retain decision authority over important issues. Reorganizing each IPT, with a government official as the chair, would help the government regain control of important program decisions.³⁶

As for contract risk, the Army finds itself unable to mandate desired management changes because of the current contract it has with the LSI. To empower the LSI, the Army chose to forgo standard contracting vehicles that are subject to the Federal Acquisition Regulation (FAR). Instead, the Army is using a type of contract instrument known as Other Transactions Authority (OTA). OTA contracts are typically used for small developmental contracts, especially those involving small companies and focusing more on research than on system procurement.

This type of contract instrument seemed logical at the outset of the FCS Program because it allowed the Army to team with the Defense Applied Research Program Agency (DARPA), an activity that exploits the freedom afforded by OTA contracts. In addition, this contractual instrument was selected because the Army's motivation was to develop a concept for the FCS and the FCS-equipped forces as opposed to a detailed platform development and prototype production effort. However, even after the program moved out of the Concept Technology Development Phase in May 2003, the Army maintained this contract vehicle for System Development and Demonstration. The obvious advantage was the flexibility it allowed the LSI in rapidly issuing subcontracts to achieve program objectives. However, government officials soon complained that the LSI had so much flexibility that it lost oversight of the subcontracts and their requirements.

The Army's position has changed within the last several months. After receiving pressure from Congress, the Army decided to transition to traditional Federal Acquisition Regulation (FAR)-based contracting methods. While this move will introduce some inefficiency into the process, it will ensure fairness in contracting and allow the government to exert more control over the program.³⁷ Additionally, transition to FAR-based contracting will invoke provisions of the Truth in Negotiations Act and Procurement Integrity Act, providing important safeguards during system acquisitions.³⁸

Even beyond management and contract risk, budget risk is a major concern within both the DoD and Congress. FCS is the most expensive procurement program ever initiated by the Army. Originally projected to cost \$92 billion, the cost has now risen to over \$130 billion. Other programs within the Army have already seen fiscal cuts in order to fund the FCS Program. Even ardent Congressional supporters of Army transformation have balked at the skyrocketing costs. Added to the ever-climbing costs to recapitalize and replace equipment worn out in Operation Iraqi Freedom (OIF) and the \$48 billion the Army wants for its Modular Force Initiative, FCS may soon prove to be unaffordable. According to the Government Accountability Office (GAO), FCS could potentially consume 65% of the Army's System Development and Demonstration Procurement Budget and 35% of its Research and Development Budget next fiscal year.³⁹

These costs do not include additional funds needed for FCS complementary systems or for plans to *spin-out* advanced technology to the current force. It is unlikely that the Army will be able to continue to fence FCS Program funds. Already, money has been reallocated for other Army priorities. Additionally, as operational requirements reduce in Iraq, Congress' willingness to provide supplemental funding for Army operations will wane. As such, the Army undoubtedly will be required to reassess its budget priorities and develop a more affordable FCS Program. One way to accomplish this is by deferring procurement of the manned ground platforms. While the Army recently postponed this part of FCS until 2014, a further delay could allow for technology maturation and further reduce costs. Likewise, with only the development of the network, sensors, and unmanned platforms, the Army could obtain the functionality it needs without new manned ground combat platforms.

Even if all the funds requested by the Army were available, FCS faces significant risk of not meeting its system requirements. Some of this risk can be attributed to an aggressive schedule. Even delaying the manned ground vehicles to 2014 has not completely mitigated the technology challenges for the program. Of over 50 technologies critical for FCS fielding, GAO reports that only one is sufficiently mature. The GAO report maintains that the Army was overly optimistic when it developed the FCS schedule, compressing every phase of the acquisition process including research and development, system design, fabrication, and testing. Particular areas of risk include development of lightweight materials, band track, water generation capabilities, autonomous operation, and software. Of particular note, the FCS software is likely to require 34 million lines of code – more than double that of the Joint Strike Fighter.⁴⁰ Moreover, FCS functionality relies on over 150 complementary systems in varying stages of development. The Joint Tactical Radio System (JTRS) is one of those systems. The Army recently ordered a work stoppage for JTRS because the program was not meeting its requirements. Like FCS, the Army is restructuring the program to capitalize on near-term achievable objectives while pushing back technologies that are more difficult. Failure of JTRS to deliver its advertised capabilities could leave FCS without a centric network system that is crucial to its functionality.⁴¹

Additional technological risk can be attributed to the many competing requirements the Army has placed on FCS. The FCS Operational Requirements Document (ORD) contains over 500 detailed requirements on nearly 1,000 pages. Typically, Army ORDs are 10 pages or less. The requirements of this ORD are so numerous and specifically defined, that the LSI has had to develop a complex system to track the requirements to ensure none are overlooked. These numerous requirements have resulted in increased

program costs and, in some cases, are likely to be mutually exclusive. Trying to meet all the requirements in survivability, lethality, agility, deployability, and sustainability may simply not be achievable.

What impact does FCS have for the LCS industry? Some have argued that a further delay of production contracts will hurt the industrial base. There is no doubt that the projected \$130 billion FCS Program is a tremendous boon for LCS defense contractors. However, arguments that the FCS Program and its manned-ground vehicles in particular, are necessary to sustain our nation's defense industrial base are overstated. In fact, the largest contracts let by the LSI to date have gone to traditional defense contractors, all of whom were well positioned before initiation of the FCS Program.⁴² Awardees include the top five defense contractors, each with government contracts totaling between \$8 and \$20 billion in 2004 alone, as well as others listed in the top 100 defense contractors. Of the 21 major LSI subcontractors, only four are not top 20 defense contractors.⁴³ They include irobot, Austin Info Systems, Textron, and UDLP. However, none of these companies depends solely on FCS to maintain their liquidity. Indeed, irobot has established markets in both commercial and industrial robot applications. Whereas, Austin Info Systems produces C4ISR systems for the Army, Navy, Marine Corps, and Air Force and Textron is a \$10 billion company that is well diversified in both the defense and commercial marketplaces. Of all the companies involved, only United Defense Limited Partnership appears to have its future viability linked to the Future Combat Systems Program. However, BAE Systems-North America (UK), currently the twelfth largest federal contractor, recently announced its planned acquisition of UDLP. This, coupled with the Army contracts UDLP has already received to recapitalize Bradleys, M113s, and M88s as a result of OIF OPTEMPO, should place the company on a firm financial footing in the short-term even without FCS funding.

USMC Future Plans

Similar to the Army, no discussion of DoD's transformation would be complete without examining the U.S. Marine Corps' flagship transformational program – the Expeditionary Fighting Vehicle (EFV). The Marine Corps intends the EFV to replace the Amphibious Assault Vehicle (AAV) as its primary combat vehicle for transporting Marines on land and from ship to shore. The EFV satisfies many operational requirements, which will provide increased capabilities compared to the AAV and will improve ship-to-shore movement, allowing the Marine Corps and the Navy to more effectively implement operational maneuver from the sea (OMFTS). The EFV will transport 18 Marines and a crew of 3 over water at speeds of 29 miles an hour.

The basic design is a hull propelled by two water jets. On land, the EFV will achieve speeds of 45 miles an hour, with cross-country mobility equal to an M1 Abrams tank. The EFV will have sufficient ballistic protection to defeat rounds up to 14.5mm or fragments from 155mm artillery shells. It also has improved mine-blast protection and a nuclear, chemical, and biological defense system. The EFV is the U.S. Marine Corps' only LCS Acquisition Category (ACAT) I program. The technology to meet requirements is mostly mature and has been successfully demonstrated. However, of primary concern to the program is the proper operation of the Hull Electronics Unit (HEU). This particular vehicle subsystem suffered three serious failures in December

2004, causing the operator to shut down and restart the vehicle. The water-testing phase of the program was subsequently stopped and awaits the go-ahead to resume testing.

In 1996, General Dynamics Land Systems beat UDLP for the EFV development contract. It was a cost-plus, award fee contract with a value exceeding \$7.6 billion. The EFV is currently in the System Development and Demonstration (SDD) Phase. Although production has been delayed from a Fiscal Year 2005 start-up, the system will ultimately be produced at General Dynamics' Joint Systems Manufacturing Center in Lima, OH, and will continue through Fiscal Year 2018.

As with all high visibility programs, the EFV is an inviting target for funding raids. It was recently reported that the EFV program will bear the brunt of program funding cuts as the Marine Corps shapes its future year budgets to preserve many smaller programs, some of which are integral to sustaining current operations in Iraq. Significant program cuts would have the effect of delaying the EFV's Initial Operational Capability (IOC) date by at least two years. Program cuts could also result in the Marine Corps purchasing 253 fewer vehicles than originally planned, thus effectively raising the price of the remaining vehicles.

THE LCS INDUSTRY'S FUTURE DIRECTION

After a period of much downsizing, mergers, and turmoil, the LCS industry appears to have stabilized, at least for the time being. Although surviving companies have been left with fully depreciated manufacturing capabilities, the short-term economic prospects for the industry are promising given the few companies remaining and the high demand for land combat systems to conduct current operations in Iraq and Afghanistan. Moreover, the inescapable move toward transformation in both the Army and the Marine Corps will potentially infuse over \$2 billion a year over the next 20 years into the LCS industry. In the meantime, the two dominant players in the domestic LCS industry, GDLS and UDLP, exist primarily on reset and remanufacture of the current inventory as well as new vehicle production in the case of Stryker for GDLS.

Meanwhile, a significant trend in the LCS industry is the impact of globalization. Not only have Americans seen large U.S. defense corporations consolidate the domestic industry through mergers, they have also witnessed a reduction in worldwide competition among LCS manufacturers due to the global acquisition of foreign land combat system companies. U.S. defense companies have always sought access to global markets; however, U.S. trade policies and laws make this difficult. By acquiring foreign land combat companies, U.S. firms like General Dynamics (GD), which purchased MOWAG AG in Switzerland, Santa Barbara Sistemas in Spain, and Steyr Spezialfahrzeuge in Austria, or United Defense (UDLP), which acquired Bofors Defense in Sweden, are able to gain access to foreign buyers without going through the drawn-out U.S. Foreign Military Sales (FMS) approval process. Additionally, in a unique turn of events, BAE Systems of the United Kingdom recently moved to acquire UDLP in order to gain competitive advantage and increase its access to the U.S. market. The impact of this proposed acquisition is yet to be determined, but the trend of mergers and acquisitions are likely to continue because industry and market access are extremely expensive due to the huge associated sunk costs involved. One possible benefit that can result is the increased interoperability and improved cooperation within the NATO Alliance as the full affects of globalization are realized.

Another developing trend is one that is quite out of the ordinary: the Department of Defense and industry are forming a more cooperative (vice adversarial) relationship in many instances through the Defense Industrial Base Capabilities Study (DIBCS) series. The Department is providing guidance to help industry better support the warfighter.⁴⁴ The DIBCS process is not only influencing the U.S. market but both the United Kingdom and Australia are considering the use of DIBCS's methodologies and processes to conduct their own assessments of their respective industrial bases.

A final trend in the land combat industry is DoD's reliance on sole source contracting and the contractor's reliance on this type of procurement contract as its primary revenue generator. For instance, Textron Marine & Land Systems is the sole provider of the Army's Armored Security Vehicle (ASV) and the ASV is Textron's only major DoD contract. Should Textron close its doors, the Army would be unable to immediately field a replacement combat vehicle, which could seriously degrade its security mission in Iraq. The problem tends to be more acute at the supplier level, where there may only be one supplier for the bolt-on armor plating that attaches to the ASV. This problem can be alleviated, but only with government assistance to the industry.

Turning to strategies and innovations within the industry, another impact of the end of the Cold War and subsequent industry consolidation has been the increased need for focused, long-term strategies and increased attention to innovation. The Cold War kept LCS companies, as well as aviation, shipbuilding, and weapons companies, in business for many years. When it ended, the surviving companies were left with large amounts of excess production capacity, outdated manufacturing processes and a big reduction in product demand since the 1990s downsizing of the military and very limited commercial application for land combat vehicles. In response to these problems, the industry devised four long-term innovative strategies to ensure their future health and ultimate survival.

First, the industry addressed the excess capacity problem by consolidating several LCS companies through mergers during the 1990s, scaling back production lines and facilities, shrinking its work force, and promoting production efficiencies. They implemented modern manufacturing processes such as Six Sigma and Lean Manufacturing to update and improve their production efficiencies. The payoff was not necessarily higher but more sustainable profitability.

A second strategy that LCS companies implemented was focusing on specialty or niche markets. For example, United Defense Limited Partnership continues to build on their specialty of building superior tracked vehicles through the Bradley remanufacturing program and providing much of the platform engineering expertise in FCS Program development. Textron cannot compete on large-scale programs with GDLS or UDLP but they know how to make – at a profit – low volume, lightweight armored vehicles.

Third, LCS companies continue to make focused investments in Independent Research and Development (IRAD) efforts. Their emphasis is obviously on future technologies that will potentially exploit their respective competitive advantages but these companies are also investing in technologies that will improve current systems. Textron increased its annual IRAD spending goal to \$5 million while both UDLP and GDLS are spending millions of dollars on new FCS technologies.

The final trend affecting the LCS industry is the shift of large defense prime contractors (i.e., manufacturers) to the role of system integrators. In the DoD acquisition system, a typical program would have a program management office responsible for awarding and managing a contract, accountable for overseeing configuration control and

the systems' overall integration. As the Army developed the Future Combat Systems, it became clear that this new system was far too complex to be handled in the normal fashion. The Army instead chose a Lead System Integrator (LSI) to manage FCS; the LSI (Boeing Company and SAIC) would "provide the systems engineering and management oversight throughout the development phases of the program, and be responsible for the delivery of the system of systems capable of engaging in net-centric warfare."⁴⁵ The Army expects the LSI to deliver efficiencies, incorporate spiral development processes and ensure smooth integration across all systems at all levels.

CONCLUSION

The LCS industry appears, for now, to be investment worthy. Recapitalization and remanufacturing work will keep UDLP going at least through the 2008 timeframe. GDLS benefits from Stryker production and future EFV production. Both of these firms, as mentioned, are major players in FCS research and development and, presumably, ultimate production. AM General will continue to build HMMWVs and Armor Holdings will continue to put armor on them. Textron Land and Marine Systems cracked the code on how to be a profitable low volume producer with the ASV. Finally, supplemental appropriations will likely be passed for at least the next two years to support operations in Iraq and Afghanistan. These appropriations benefit the LCS industry. In all, there looks to be enough work to generate sufficient profits with which to pay modest dividends. There may even be stock appreciation in the short term but only to about 2009 – 2010. After that, declining DoD budgets and the confluence of possible Social Security reforms, rising entitlement payouts and the onus of deficits will conspire to induce change in the U.S. LCS industry as companies seek efficiency and compete for scarce resources. This change may involve further mergers and consolidations, decisions by companies not to compete at all given the financial risks, or, in the extreme case, Government subsidization of critical strategic LCS capabilities. The first "trial balloon" may well be how the Government decides to deal with Allison Transmissions: either pay for the 85,000 annual man-hour requirement regardless of production levels or take substantial risk and let the market solve the problem.

The short and mid term outlook in Europe is perhaps a bit better than in the U.S. There appears to be a concentrated effort at the highest levels of EU governance to rationalize and make more efficient (and profitable) European defense companies. This effort manifests itself by the formation and fledgling operation of the European Defense Association (EDA). The idea is to have a central body consolidate the acquisition functions of 25 Ministries of Defense (MODs). This extends to requirements generation and validation, determining funding levels and directing specific production to specific companies within the EU. Although clearly a step toward Globalization, the EDA nevertheless is at odds with a growing nationalism within EU nations. This friction is exacerbated by the increasingly intense competition for emerging eastern European and Asian markets. The Spanish government, for example, decided it wanted not only to have tanks in its military, it wanted its own industry to produce them. They got what they wanted but at the cost of inefficiency and excess production capability.

Notwithstanding the existence, mission and potential impacts of the EDA, European LCS manufacturers have also figured out how to be profitable low volume producers. They leverage their respective competitive advantages and buttress their sales

through exports. In fact, the majority of European firms visited during this study split their work approximately 50 – 50 domestic/export. What enhances the European LCS industry outlook is the current popularity of wheeled combat vehicles. Steyr-Daimler-Puch makes the agile Pandur vehicle, KMW excels at armored light and medium wheeled vehicles (Dingo and Mungo) and Oto-Melara makes the Centauro, a lethal 120mm main gun mounted on an 8-wheeled vehicle. Current production and formidable order backlogs will fuel European LCS manufacturers to respectable levels of profitability through 2010.

The long term health of both the U.S. and European LCS industries depends on a wide array of political and economic factors. Chief among these are affordability, the emergence of a new business model and EU growing pains.

FCS is clearly the Army's, if not DoD's, flagship program for Transformation. But with a price tag of anywhere between \$100B and \$150B, it's a very expensive program. Moreover, it's a risky program in that it depends on unproven complementary technologies. Given its cost and technical risk, FCS must still compete in the coming years for dwindling DoD resources with other high priority programs such as Joint Strike Fighter, the F-22 and missile defense. Given this funding and technical uncertainty, it behooves senior Army and DoD leaders to lock in critical design and performance parameters as soon as practicable. This would send a strong message to the U.S. LCS industry that DoD is committed to getting FCS into production. This in turn should mitigate sufficient risk for companies to continue to invest their own IRAD resources as well as to keep bidding on future FCS contracts. Finally, the Army – and to some extent the Marine Corps with EFV – must continue to be able to justify the need for FCS (or EFV) despite the fact that it's in the same cost category now as aircraft.

The study group encountered many opinions regarding the FCS Lead System Integrator concept. On one hand, some believe the Government is paying a 25% to 30% additional premium for it while on the other hand, some believe a traditional project management-prime contractor relationship would almost certainly have failed given the scope and complexity of FCS. When pressed, however, it became clear that contractors prefer having a piece of the pie rather than no pie at all. To be sure, the LSI comes with proprietary and legal issues, but when it comes to making money businesses are finding innovative ways to share information and facilitate technical cooperation. This proliferation of best practices can only strengthen the overall industry. It's also worth noting that those firms that can succeed at C4ISR integration can perhaps be more profitable than traditional automotive manufacturing firms because the Government desires to transfer risk in this area and is willing to pay for it.

As of the writing of this report, both the French and Dutch people rejected the proposed EU constitution. The ratification process will continue but it would appear that, for now, it will not succeed. In spite of these political hiccups, EU leadership is determined to position itself – and its LCS industry – as formidable economic competitors to the United States. They'll be helped by Globalization and the EDA. Certainly Europe must deal with rising popular discontent with the EU, decreasing productivity and demographic trends that portend long term reliance on immigrants as a source of labor but the consensus opinion among firms visited is that the EU will “muddle through” their problems. In fact, they must or be bypassed completely by Globalization.

The study group wishes to thank our speakers and our domestic and international hosts. We sincerely appreciated your time, your hospitality and most of all your willingness to share your ideas with us. We benefited greatly from our interactions; we hope our paths will cross again soon. The paper closes with some bullets that might describe the LCS industry in 2010.

- FCS will be on the verge of Low Rate Production but will still be shrouded in technical and funding uncertainty.
- EFV will be entering Full Rate Production but total quantities remain undetermined.
- BAE/UD, touting C4ISR integration expertise, may exert pressure to replace the Boeing/SAIC LSI. GDLS-Europe makes inroads to eastern European, other, markets.
- Competition will be sufficient to sustain innovation and efficiency gains (Exception: Allison Transmissions).
- Congressional oversight of FCS increases.
- Federal fiscal crisis and political acrimony come to a head in the 2010 mid-term elections. A period of political “belt tightening” ensues.
- The EU constitution, after revision, is close to ratification; the EDA is busy synchronizing direction and operations of the European LCS industry.
- Proliferation of light and medium armored wheeled vehicles leads to a resurgence of tracked vehicles.
- The ruthless march to Globalization begins to trump nationalism. Smaller European firms begin to merge into the portfolios of larger ones (Giat, Finmeccanica, BAE).
- China . . . ???

The logo for the International Council of Aerospace Defense Contractors (ICAF) is visible as a large, light-colored watermark in the background. It features a circular emblem with a globe and the text 'INDUSTRIA ET DEFENSIO INSEPARABILES' around the perimeter. Below the emblem, the acronym 'ICAF' is written in large, bold, sans-serif letters.

APPENDIX A
Domestic Land Combat Systems (LCS) Industry Matrix

The table below depicts key vendors in the U.S. LCS market, but these companies face additional competition from within the U.S. Government. Government Owned-Contractor Operated (GOCO) and Government Owned-Government Operated (GOGO or service depots) increase competition within the LCS marketplace – specifically, the after-sales market.

<u>Key Domestic LCS Manufacturers</u>	<u>LCS Manufacturer's Expertise</u>	<u>Current LCS Systems</u>	<u>Future LCS Systems</u>	<u>Current Programs</u>	<u>Remarks</u>
United Defense	Tracked Vehicles Gun Systems	M-2 Bradley M113 FOV	Subcontractor for FCS	Bradley Reset FMS Sustainment	Pending merger with BAE (UK)
General Dynamics	Tracked Systems Wheeled Systems	M-1 Abrams Stryker	Subcontractor for FCS and EFV (USMC)	Abrams Tank Resets Stryker Prod and Reset	
Boeing/SAIC	Lead Systems Integrator (LSI)	FCS	FCS	FCS LSI Contractor	
Textron	Niche Vehicles and Systems	ASV	ASV Upgrades	ASV Production	Seeks niche competitive advantage within LCS

Depots operate with varying degrees of efficiency, offering both advantages and disadvantages. They are responsive to immediate demands, but suffer shortcomings in both efficiency and reliability. For example, comparing heavy duty transmission remanufacturing between Allison (the original manufacturer) and Anniston Army Depot (GOGO) highlights potential shortfalls in reliability as Allison's remanufactured transmissions last, on average, 21,000 miles compared to Anniston's 7,000 – far short of the required 19,000 miles. While government depots fill unique requirements and some voids, the quality of their production sometimes fails to meet the stringent requirements of LCS systems.

APPENDIX B

Performance-Based Logistics Study Findings

INTRODUCTION

The Land Combat Systems (LCS) industry study group evaluated the use and implementation of Performance-Based Logistics (PBL) for land combat systems. Many major LCS systems are using all or part of the techniques and procedures inherent in PBL, with a variety of performance support agreements between the government and logistics support contractors.

PBL means different things to different people, but principally it is defined as writing a contract or agreement with a logistics provider for a certain level of performance, for an item at a system or subsystem level. This level of performance can be achieved by a contractor (in this case, it may be called contractor logistics support (CLS)), the government, or a combination of both.

There are five “preferred” PBL metrics – operational availability, operational reliability, cost per unit usage, logistics footprint, and logistics response time.⁴⁶ Any combat system must have a high level of reliability and be “up” or available almost all of the time. Additionally, if it “goes down,” the logistics support network system must respond quickly and efficiently to get it “up” as soon as possible. In this respect, PBL is no different than traditional logistics support arrangements. In any case, a good metric must encourage dynamic improvement over time.

The implementation of PBL by the government, in recent years, is a departure from historic logistics support arrangements wherein an organic depot performed wholesale maintenance, and retail-level maintenance was accomplished with military personnel. Unit and first echelon logistics support (often call 10/20 level maintenance) is primarily located in a using unit or within supply, maintenance, transportation, and logistics companies. Many of these support companies/units are part of the U.S. Army Reserve (USAR), and are activated in times of increased operational tempo as in the case of the Iraq War. Implementing PBL across a number of LCS systems will require operators, logisticians, and planners to reconsider the delivery of logistics to support these systems, and the delivery of logistics support as a whole.

PBL RESEARCH

The LCS industry team researched PBL and interviewed a number of companies and organizations that provided PBL support for the Army/Marine customer. Most companies defined PBL, in part, as good supply chain management – the delivery of spares to the retail customer, where and when needed, and as soon as possible. Clearly, this can be a problem when the customer is an Army unit half a world away in battle or maneuvering to a new location. Nevertheless, several companies surprised the study group with their ingenuity and proactive assistance in providing parts, managing inventories, supplying field support representatives, and retrograding to their (wholesale level repair) facility for CONUS-based maintenance actions.

PBL contractors work for profit. In the case of contracting for logistics, how do you establish a system that provides adequate incentives for the contractor to perform this work -- sometimes under battlefield conditions? Moreover, is it better to write a contract

for product support at the system or subsystem level? The LCS study team concludes that adequate financial incentives must be in place to motivate the contractor. Additionally, any PBL product support agreements (PSA) must consider the spare parts management and parts availability as a primary and essential component of a successful PBL program. One must also consider delivery times for parts, both in garrison and during wartime. Further, the maintenance times (or time-to-repair) once parts are available, is also crucial.

Sustainability by a contractor or government PBL provider, particularly at the system level, must be concerned with what happens to the system in ten years in addition to what happens when the production line shuts down. To be complete, the PBL PSA agreement must also concern itself with training and deployment within a garrison context, and have adequate mechanisms for wartime or Military Operations Other Than War (MOOTW) contingencies. The PBL customer must always ask, “How does the contractor (or government provider) make their money?”

MEASURING PBL

The level of PBL support within the system is an important concern. Should a PBL provider replace at the component module level, versus replace/repair at the part level. Component module replacement (i.e. Line Replacement Units – LRUs) will increase, availability but it is also more expensive and leaves a larger ‘logistics footprint.’ In addition, there is a cost associated with sending back *repairables* for depot rework. The trade space between PBL metrics (availability/reliability vs. logistics footprint) requires complex logistics analysis given that a system can either spend more on labor and less on parts, or more on cost effectiveness. Therefore, any PBL agreement must have a complex pricing structure.

Another consideration is whether the PBL provider cares about the transportation costs, and who will manage the organic authorized stockage level (ASL)? In the latter case the acquisition logistician must undertake a rationalization of the supply system and must ask, “Can we measure PBL in wartime since they don’t have control of parts of the supply chain?” In other words, “Does PBL makes sense for war?”

Since under wartime conditions, maneuver units will switch ASLs between units to maintain parts availability, PBL performance levels will necessarily fluctuate. Therefore, one must ask, “Can we establish a contract to allow us to change the performance level, such as going from 90% availability, down to 85% -- what would be the savings?” In addition, what about surge capacity? -- If we go from peace to war, how can the contractor get more mechanics, quickly? These considerations must be evaluated for a PBL arrangement to be successful. A product manager cannot develop a PSA contract for a given support level, and automatically assume that the right level and type of logistics support will be there. Lastly, one must inquire, “What will happen if the contractor decides to leave the battlefield?” There are notable examples of this happening in the Iraq War and therefore the government must have an alternate plan.

CONCLUSIONS AND RECOMMENDATIONS

The LCS study team recommends the following considerations for the industry when planning performance-based logistics as the preferred logistics solution for the land

combat warrior. A public/private partnership between organic government depots and contractor logistics providers is healthy because the competition helps control costs and two providers encourage some redundancy and reduces risk. There were numerous examples in the LCS study of government and contractors developing prime/subcontractor arrangements with excellent examples of both working well together for the benefit of the Army/Marine land combat warrior.

Because there are few simple PBL metrics and *one size does not fit all*, PBL planners should look for a warranty for newly produced items and then expand on that warranty as the genesis for follow-on PBL support – amending the PSA as the logistics team learns more about failure rates, critical parts usage, user induced failures, and deficiencies in the organic logistics base. Component service-wide contracts (i.e., transmissions, tires, engines, etc.) should be given serious consideration recognizing the dynamics between modularity and readiness, and that reliability-centered maintenance can reduce maintenance-induced failures and increase operational availability for end items.

PBL *should not* necessarily be the preferred logistics solution but it should be mandatory to consider PBL-type support when evaluation the logistics feasibility for products -- this should be done use the Logistics Supportability Analysis (LSA) process and *not* in the Business Cost Analysis (BCA), although both products are necessary for informed decision-making. Lastly, several government (organic) depots have demonstrated sophisticated PBL support for many military systems. The organic industrial base should be given serious consideration when making PBL decisions on LCS acquisition programs. Even if they are not awarded the PBL contract, they can support the PM (as a consultant) in planning for full-scale logistics support.



BIBLIOGRAPHY

- Baumal, William J., Alan S. Blinder, **Economics Principles and Policy**, 9th ed. Mason, OH: South-Western, 2003.
- Boeing Corporation, Boeing Future Combat System Website, April 2005, [On-line] Available at: <http://www.boeing.com/defense-space/ic/fcs/bia/flash.html>
- Capaccio, Tony, "Army Projects New Boeings Combat System to Cost \$133 Billion, Up 45%," March 2005, [On-line] Available at: <http://www.bloomberg.com>,
- Department of Defense, "Annual Industrial Capabilities Report to Congress," February 2005.
- Department of Defense, "Index of Top 100 Parent Companies - Fiscal Year 2004," [On-line] Available at: <http://www.dior.whs.mil/peidhome/procstat/p01/fy2004/P01FY04-top100-table1.pdf>.
- DiMascio, Jen, "Army Officials: Service Adding more Armor to Vehicles as Fast as Possible," **Inside the Army**, 20 December 2004.
- Donnelly, John M., "GOP Splits over Liberalization of Military Technology Rules," **Congressional Quarterly – Defense**, 23 October 2004.
- Evanhoff, Ted, "Future of Indianapolis' GM Allison transmission Division is Questioned," **Indianapolis Star**, 17 August 2003.
- Executive Overview, "European Defence Manufacturing Consolidates, Revives," **Jane's World Defence Industry**, 12 Aug 2004.
- Flamm, Kenneth, "Post Cold War Policy and the U.S. Industrial Base," Volume 35, Number 1, Spring 2005, [On-line] Available at: <http://www.nae.edu/NAE/bridgecom.nsf/weblinks/MKEZ-6AGPFS?OpenDocument>.
- Farrell Jr., Lawrence P., "Global Industry Key to Defense Preparedness," **National Defense**, July 2004.
- Finalist General Motors Defense, <http://www.gm-defense.com>.
- Flood, Scott and Paul, Richard, "An Assessment of the Lead Systems Integrator Concept as Applied to the Future Combat System Program," **ICAF Paper**, Washington, DC, March 2005.
- Globalsecurity.org Website [On-line.] Available at: <http://www.globalsecurity.org/military/systems/ground/fcs-back.htm>.
- Hanel, Dieter, "The AFV Industry in the USA," **Military Technology**, 23 October 1999.
- Kaplan, Fred, "A Future the Army Can't Afford," 6 April 2004, [On-line] Available at: <http://slate.msn.com/id/2115867/>.
- Kapstein, Ethan B., "America's Arms-Trade Monopoly: Lagging Sales will Starve Lesser Suppliers," **Foreign Affairs**, May/June 1994.
- Kennelly, Dennis and Ben Stone, "Industry Suggests Improvements for Exports," **National Defense**, May 2003.
- Kuger, Richard L. and Binnendijk, Hans, "Shaping Future Defense Budgets," Washington, D.C., **National Defense University**, 2004.
- Neuger, James G., "U.S. Wins EU Allies in Bid to Keep Chinese Arms Ban," 5 April, 2005, [On-line] Available at: http://www.bloomberg.com/apps/news?pid=10000087&sid=a2hXTb90yKFE&refer=top_world_news
- Plummer, Anne, "TACOM Develops Plan to Sustain Availability of Tank Transmissions," **Inside the Army**, 12 April 2004.
- United Defense Industries, <http://www.hoovers.com/unite-defense-industires>.
- Witt, Clyde E., "Economic Strategies: Inventory Management," **Material Handling Management**, May 2003.

END NOTES

- ¹ ICAF Acquisition Power Point Brief, ODUSD (Industrial Policy), “Ground Combat Vehicles Industrial Base Review,” January 2004, ICAF Issue, pp. 25-27.
- ² John M. Donnelly, “GOP Splits over Liberalization of Military Technology Rules,” **Congressional Quarterly-Defense**, 23 October 2004, p. 25.
- ³ Kenneth Flamm, “Post Cold War Policy and the U.S. Industrial Base”, Volume 35, Number 1 – Spring 2005, p.2/3, [On-line] Available at:
<http://www.nae.edu/NAE/bridgecom.nsf/weblinks/MKEZ-6AGPFS?OpenDocument>
- ⁴ Executive Overview, “European Defence Manufacturing Consolidates, Revives”, **Jane’s World Defence Industry**, 12 Aug 2004, p. 1-3.
- ⁵ Iveco DVD Company In-Brief as Presented to 2005 ICAF LCS Industry Study Class, 18 May 2005.
- ⁶ Observed by 2005 ICAF LCS Industry Study Class During IVECO DVD Plant Tour, 18 May 2005.
- ⁷ Oto Melara Company In-Brief as Presented to 2005 ICAF LCS Industry Study Class, 17 May 2005.
- ⁸ Paolo Valpolini, “Blazing a Trail,” **Jane’s Defence Weekly**, 30 January 2002, pp. 1-3.
- ⁹ KMW In-Brief as Presented to 2005 ICAF LCS Industry Study Class, 13 May 2005.
- ¹⁰ James G. Neuger, “U.S. Wins EU Allies in Bid to Keep Chinese Arms Ban”, 5 April 2005, [On-line] Available at:
http://www.bloomberg.com/apps/news?pid=10000087&sid=a2hXTb90yKFE&refer=top_world_news
- ¹¹ Ethan B. Kapstein, “America’s Arms-Trade Monopoly: Lagging Sales will Starve Lesser Suppliers,” **Foreign Affairs**, May/June 1994, p. 13.
- ¹² Jen DiMascio, “Army Officials: Service Adding more Armor to Vehicles as Fast as Possible,” **Inside the Army**, 20 December 2004.
- ¹³ Fred Kaplan, “A Future the Army Can’t Afford,” 6 April 2004, [On-line] Available at:
<http://slate.msn.com/id/2115867/>.
- ¹⁴ General Dynamics [On-line] Available at: <http://www.generaldynamics.com/>
- ¹⁵ General Dynamics Land Systems Briefing, Anniston, Alabama, 3 March 2005.
- ¹⁶ **Ibid.**
- ¹⁷ General Dynamics Annual Report 2004, [On-line] Available at: <http://www.generaldynamics.com/>
- ¹⁸ **Ibid.**
- ¹⁹ **Ibid.**
- ²⁰ General Dynamics Annual Report 2004, General Dynamics, Form 10-K for period ending 31 December 2004, filed 18 February 2005, [On-line] Available at: <http://www.generaldynamics.com/>.
- ²¹ Data Monitor, “United Defense Industries, Inc., Company Profile,” July 2004, [On-line] Available at: <http://www.datamonitor.com>.
- ²² United Defense Industries, Inc., UDI, Form 10-K for period ending 31 December 2004, filed 9 March 2005, [On-line] Available at:
<http://phx.corporate-ir.net/phoenix.zhtml?c=130499&p=irol-seccat>
- ²³ **Ibid.**
- ²⁴ **Ibid.**
- ²⁵ United Defense Industries, Inc., “Home Page, Technology and Innovation Section,” [On-line] Available at: <http://www.uniteddefense.com/cap/techinno.htm>
- ²⁶ United Defense Industries, Inc., UDI, Form 10-K, for period ending 31 Dec 2004, filed 9 March 2005, [On-line] Available at: <http://phx.corporate-ir.net/phoenix.zhtml?c=130499&p=irol-seccat>
- ²⁷ **Ibid.**
- ²⁸ **Ibid.**
- ²⁹ Richard L. Kuger and Hans Binnendijk, “Shaping Future Defense Budgets,” p. 7.
- ³⁰ **Ibid, p. 9.**
- ³¹ **Ibid, p. 1.**
- ³² Finalist General Motors Defense, [On-line] Available at: <http://www.gm-defense.com>.
- ³³ Tony Capaccio, “Army Projects New Boeing’s Combat System to Cost \$133 Billion, Up 45%,” March 2005, [On-line] Available at: <http://www.bloomberg.com>.
- ³⁴ United Defense Industries, [On-line] Available at: <http://www.hoovers.com/unite-defense-industries>
- ³⁵ Globalsecurity.org Website [On-line] Available at:
<http://www.globalsecurity.org/military/systems/ground/fcs-back.htm>
- ³⁶ Interview Source #1, 14 April 2005.

-
- ³⁷ Interview Source #2, 14 April 2005.
- ³⁸ Jen DiMascio, "Army Restructuring Future Combat System Contract," **Inside Defense**, 5 April 2005.
- ³⁹ Paul L. Francis, Testimony Before the Subcommittee on Tactical Air and Land Forces, Committee on Armed Services, House of Representatives: Future Combat Systems Challenges and Prospects for Success. **Government Accountability Office Report**, GAO-05-428T, March 16, 2005.
- ⁴⁰ **Ibid.**
- ⁴¹ Jen DiMascio, "JTRS and Manned Ground Vehicles Critical to Success of FCS," **Inside the Army**, 21 March 2005.
- ⁴² Boeing Corporation, Boeing Future Combat System Website. [On-line.] Available at: <http://www.boeing.com/defense-space/ic/fcs/bia/flash.html>.
- ⁴³ Department of Defense, "Index of Top 100 Parent Companies - Fiscal Year 2004," [On-line] Available at: <http://www.dior.whs.mil/peidhome/procstat/p01/fy2004/P01FY04-top100-table1.pdf>
- ⁴⁴ Department of Defense, "Annual Industrial Capabilities Report to Congress," February 2005, p. 2.
- ⁴⁵ Scott Flood and Richard Paul, "An Assessment of the Lead Systems Integrator Concept as Applied to the Future Combat Program," March 2005, p. 6.
- ⁴⁶ Department of Defense Publication, "Performance Based Logistics: A Program Manager's Product Support Guide," 1 November 2004, p. 12.

