# LAND COMBAT SYSTEMS

*It is not the strongest species that survive, nor the most intelligent,*
*but the ones most responsive to change.*

—Charles Darwin

**ABSTRACT:** The Land Combat Systems (LCS) industry has significantly changed over the last decade. The days when production lines and factories hummed at peak capacity are gone. Orders for land combat systems have been reduced by nearly two-thirds since 1990, and competition for what few procurement dollars remain is stiff. Despite the overall decline in business for land combat systems, firms that have survived have shown a remarkable ability to adapt to this new environment. The industry has moved toward wholly owned subsidiaries, joint ventures, and government to government programs to cut costs, improve profit margins, and better serve customers. These changes represent a new way in which the defense industry works. Meeting customer requirements and improving profitability have become the new corporate benchmarks for measuring success. The LCS industry has also sharpened the focus of its research and development (R&D) to exploit key technology capabilities and performance niches. Those in the industry with the foresight to invest in human capital, to allocate resources to R&D, to take advantage of information technology, to expand their markets beyond traditional boundaries, and to analyze national strategic direction will be the ones that develop competitive advantage. Land combat systems will always be needed as long as there are threats to national security. The challenge for the LCS industry is how well it can provide cost-effective solutions for today's threats while anticipating tomorrow's dangers.

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## PLACES VISITED

**Domestic**:

AM General Corporation, Mishawaka, IN

Defense Advanced Research Projects Agency, Ft. Belvoir, VA

Defense Supply Center Columbus, Readiness and Business Operations Office, Columbus, OH

General Dynamics Land Systems, Sterling Heights, MI

General Motors Defense, London, Ontario, Canada

Lima Army Tank Plant, Lima, OH

Oshkosh Truck Corporation, Oshkosh, WI

Stewart & Stevenson, Tactical Vehicle Systems, Sealy, TX

US Army Tank-automotive and Armaments Command, Warren, MI

US Army Tank-automotive and Armaments Command, Abrams Tank System, Warren, MI

US Marine Corps Advanced Amphibious Assault Vehicle Program Office, Woodbridge, VA

United Defense Limited Partnership, York, PA

United States Army Training and Doctrine Command, Fort Monroe, VA

**International**:

Alvis, London, United Kingdom

British Aerospace, Royal Ordnance, Barrow-in-Furness, United Kingdom

Giat Industries, Versailles, France

Krauss-Maffei Wegmann, Munich, Germany

Steyr-Daimler-Puch Spezialfahrzeug AG, Vienna, Austria

Vickers Defence Systems, Newcastle-upon-Tyne, United Kingdom

**INTRODUCTION**: The purpose of this study is to assess the health of the LCS industry and its ability to support US national security strategy. Industry health and national security are inextricably linked. Industry provides the skills and facilities to research, develop, and manufacture land combat systems while nations require cost-effective capabilities to implement their security policies. Should a country resort to military action, the quality of its equipment is crucial for bringing about successful operations.

The LCS industry plays an important role in national power. The industry trains workers in critical skills, such as assembly, welding, electronics, machining, and logistics. Many of these are advanced skills that take years to perfect. The industry also has a sizeable investment in capital goods. The health of the industry should never be taken for granted. Once the people, skills, and equipment migrate to other industries, gearing up for land combat system production could take months, if not years. A nation may not be able to replace equipment losses, integrate new technology into existing weapons systems, or introduce new systems to meet the latest threats if the industry is left to deteriorate.

For many years, the LCS industry enjoyed the benefits of increased defense spending. Production ran into the thousands of vehicles. Many companies entered the business, making the defense industry their sole focus. Few could have predicted the end of the Cold War, which swept away the Soviet threat and the old bipolar order, leaving a number of turbulent regions in its wake. Nations have a different experience of conflict today as a result. The likelihood of a massive, global conflict has diminished, while the probability of small-scale clashes based on ethnic, religious, or natural resource tensions have increased. Developed nations are adapting to these new challenges by adjusting their training, doctrine, and equipment needs. But as the likelihood of world war has subsided, so have defense budgets.

Fewer dollars for defense has had predictable results on the LCS industry. Some companies folded while others incurred large debts by buying others out. A few got out of the business completely as returns on equity sank. This study examines both the positive and negative trends of the industry and what effects they could have on national security. Additionally, the role of government and the challenges that face the industry today and in the future are examined in detail. Finally, three essays of foremost importance to the industry supplement the study's depth and utility: the US Army's transformation, information technology, and research & development.

The methodology for this study was to integrate course work, individual research, and visits to LCS manufacturers to form conclusions on the industry's ability to meet the current national security strategy. The LCS seminar abided by the Industrial College of the Armed Forces' non-attribution policy, which encouraged frank discussions about the industry. Seminar members were free to form their own opinions based on what they observed. Following each visit, seminar members compared their impressions, noting where industry and national defense policies were consistent and where they fell short. The object of the study was not to criticize or lay blame, but to understand where gaps between resources and policy objectives exist. Of course, no study is complete without recommendations on how to narrow the distance between the two. If the conclusions of this study cause policy makers to examine the resourcing of national security strategy in greater detail, then the LCS seminar will have achieved its purpose.

**THE INDUSTRY DEFINED:** Land combat systems encompass a variety of systems: tanks, infantry fighting vehicles, cannon and missile artillery, tactical trucks, robotics, and research & development. This report includes these systems and expands the definition of the industry. The landscape of today's LCS industry not only includes its products and services, but also its workforce, financial health, manufacturing standards, and surge capacity. The decision to expand the definition of the industry is supported by the seminar's observations of LCS senior executive presentations, which are placing greater emphasis on strategic and financial analysis to chart the industry's future.

Tracked Armored Vehicles. Tracked vehicles are designed to operate in almost any terrain. General Dynamics and United Defense Limited Partnership are the domestic prime contractors and system integrators for tracked vehicles. Vehicles produced by these two companies include the M1-series Abrams tank, the M2/3-series Bradley Fighting Vehicle, the M109-series self-propelled howitzer, the M88-series recovery vehicle, the M9 Armored Combat Earthmover, the M113 family of vehicles, the Multiple Launch Rocket System, and the Marine Corps Amphibious Assault Vehicle. Other systems under development include the Crusader Artillery System (XM2001 and XM2002), the Marine Corps Advanced Amphibious Assault Vehicle, and the Wolverine Heavy Assault Bridge.

Wheeled Armored Vehicles. Like tracked armored vehicles, wheeled armored vehicles are also designed to operate in the harshest terrain. Lacking the heavy armor protection of tracked vehicles, wheeled vehicles are easier to transport, maintain, and logistically support. Wheeled vehicles can be armed with cannons (up through 155-millimeters), machine guns, and missile launchers. General Motors of Canada produces the Light Armored Vehicle III (LAV III) family of vehicles. Textron Marine & Land Systems produces its own family of LAVs and Armored Security Vehicles (ASVs), including the LAV–150, LAV–300, LAV–600, and ASV–150. General Dynamics and Steyr-Daimler-Puch Spezialfahrzeug have established AV Technology Corporation, a joint venture company that offers the PANDUR 6 x 6.

Tactical Wheeled Vehicles. In addition to transporting personnel and equipment, tactical wheeled vehicles can serve as platforms for command, control, and communications as well as medium caliber weapons (up through 30-millimeters). Tactical wheeled vehicles must navigate the same terrain and distances as the combat forces that they support. Although the survivability requirements for tactical wheeled vehicles are less stringent than for armored vehicles, the requirement for off-road tactical mobility, reliability, and ease of maintenance remain fundamental in their design.

Tactical wheeled vehicles fall into three main categories: light, medium, and heavy. Vehicles typical of these categories include the following:

The High-Mobility Multipurpose Wheeled Vehicle (HMMWV), the Commercial Utility Cargo Vehicle, and other trucks having less than 2 ½ tons cargo capacity are light wheeled vehicles.

The Army’s Family of Medium Tactical Vehicles (FMTV) and the Marine Corps’ Medium Tactical Vehicle Replacement (MTVR) with capacities between 2 ½ and 7 tons are examples of medium wheeled vehicles.

The Heavy Equipment Transporter (HET), the Heavy Expanded Mobility Tactical Truck (HEMTT), the Palletized Load System (PLS), and the Marine Corps’ Logistics Vehicle System (LVS), along with other trucks having capacities of more than 7 tons are categorized as heavy tactical vehicles.

**CURRENT CONDITION**: This section of the industry study examines the global market and trends in the US and European land combat systems industries.

## Global Market

Tracked Armored Vehicles: The market for tracked vehicles is highly competitive. With nations participating in more humanitarian and peacekeeping missions in the aftermath of the Cold War, demand for tanks has dampened.[1] Tracked vehicle manufacturers in the United States and in Europe compete against one another for fewer orders. Potential customers for tanks include Turkey and Greece. Potential buyers for self-propelled howitzers are Kuwait for the Paladin and Poland for British Aerospace's (BAE) AS90. The AS90 and Germany's PzH2000 self-propelled howitzers are the biggest competitors in the European market. But even with these potential clients, orders for tracked vehicles won't add up to more than a modest number.

Despite lower demand, one favorable trend for tracked vehicle manufacturers is that countries are extending the service life of their systems. The M1 Abrams tank, for instance, will remain in the world's arsenal at least through 2030—nearly fifty years. European defense contractors are following suit as every manufacturer of main battle tanks—Vickers, Giat, Krauss-Maffei—offer significant enhancements to their products. With the cost effectiveness of greater service life, the armored vehicle industry will continue to upgrade rather than develop new products. The LCS industry can expect continued competition, longer service life for vehicles, and manufacturers combining resources to gain technology and cost advantages.[2]

Wheeled Armored Vehicles: This sector is also a buyer's market as there are more suppliers chasing fewer orders. The US Army's selection of the LAV III, co-produced by General Motors Defense and General Dynamics Land Systems (GM/GDLS LLC), represents a welcome spike in demand for wheeled armored vehicles. The US Army intends to purchase 2,131 LAV IIIs for its Interim Brigades, a contract worth nearly $4 billion.[3] This purchase, however, doesn't lead the seminar to conclude that Europe will follow in America's footsteps for the LAV III. Nearly every European country embraces an armored wheeled vehicle design, and overseas manufacturers, such as Steyr and Alvis, are already filling European requirements for equivalent types of vehicles. While the international market as a whole won't benefit from the US Army's choice of the LAV III, other nations will certainly take note of how the US Army integrates the LAV III into its Interim Brigade design. The sizeable US contract for LAV III's, a global interest in lighter, more economical vehicle designs, enhanced survivability and firepower, and aftermarket support will keep the wheeled armored vehicle sector healthy through 2020 and beyond.

Tactical Wheeled Vehicles: The competition among manufacturers for tactical wheeled vehicles has produced significant improvements in performance and durability. The LCS industry has incorporated the latest technology in trucks—anti-lock brakes, electronically controlled transmissions, electronic technical manual interface and diagnostics, and superior diesel engine technology—to provide outstanding mobility, handling, and power. Domestic tactical wheeled vehicle manufacturers have specialized in a particular segment of the market, carving out niches that they dominate. AM General's HMMWV, for example, enjoys worldwide name recognition for light wheeled vehicles. Stewart & Stevenson is noted for its expertise in medium-sized wheeled

vehicles. Oshkosh Truck Corporation is the heavy weight champion for vehicles over 10 tons, recently winning a $75 million contract to supply the United Kingdom's Ministry of Defense with heavy equipment transporters (HETs). The tactical wheeled vehicle industry has remained viable through a combination of product improvements, global marketing, aftermarket support, and expansion into commercial sectors. The wheeled vehicle sector still shows sensitivity to overall procurement spending, as illustrated by Stewart & Stevenson's Tactical Vehicle Division's (TVSD) operating losses in 1997 and 1998. However, military vehicles eventually wear out and have to be replaced or refurbished. Stewart & Stevenson's TVSD turned the corner in 1999 by winning a $1.4 billion follow-on contract for wheeled vehicles from the US Army and by reorganizing its management and businesses processes, netting a $30 million operating profit in the same year.[4]

**U. S. Industry Trends**

The end of the Cold War ushered in a reduction in US military forces and a smaller defense budget. During the period 1989 to 1995, the US armed forces were reduced by 250,000 active-duty military personnel and layoffs in defense industries over roughly the same period amounted to nearly 2 million. Moreover, the overall defense budget dropped by 8 percent and procurement by 25 percent.[5] Less money for defense left many in the US LCS industry with idle production lines. Many larger companies purchased smaller ones to gain supply and manufacturing efficiencies, but assumed a large amount of debt in doing so. When the dust from the mergers settled, the US had only two manufacturers capable of producing tracked armored vehicles. From the seminar's observations, the US LCS industry's consolidation didn't completely achieve the level of efficiency expected. Although plant ownership may have changed hands, some facilities resembled empty, cavernous hangers. This idle capacity represents considerable cost in overhead and lost growth opportunities.

To place the last ten years of US LCS industry trends in perspective, Jacques S. Gansler, a former Deputy Assistant Secretary of Defense, wrote that the end of the Cold War with the former Soviet Union represented a permanent downturn rather than a cyclical decline in the defense budget. "This critical transition period," he added, "required a restructuring of the defense acquisitions process to achieve a balance between economic concerns and national security, while maintaining the force size and equipment modernization necessary for deterring future conflicts."[6] Gansler's assessment of a permanent downturn proved correct. In general the US defense industry saw its profitability decline, its market capitalization fall 33 percent, and its bond ratings topple from high margins of protection to questionable repayment. Returns on equity were also among the lowest in the manufacturing sector, making the defense industry unattractive to investors.[7] Disillusioned, many companies simply left the defense industry altogether. The extent of the exodus was acutely felt by the industry—of the 50 major defense firms existing in 1989, only five remain today.[8]

Some in the LCS industry have taken Jacques Gansler's exhortations to heart by realigning their established manufacturing processes to produce products valued in civilian markets while maintaining their defense capabilities. For Oshkosh Truck Corporation the realignment was not too difficult as commercial and military truck technology and production are relatively straightforward to integrate. This diversity

provides a hedge against fluctuations in defense spending. Ironically, it was Oshkosh's defense business that cushioned the truck manufacturer's income loss during second Quarter Fiscal 2001.[9]

The decade-long recession for the LCS industry will continue in many respects for tracked vehicle manufacturers. United Defense Limited Partnership (UDLP), the prime contractor for the Crusader artillery system, may see the funds for its flagship program diverted. Many consider the Crusader as part of the US Army's "legacy force." The Army's shift of emphasis—and resources—to armored wheeled vehicles casts the future of this artillery system in doubt, even though the Army's "legacy force" will remain in service for many years and still has a requirement for Crusader's capabilities. Crusader's cancellation would adversely affect UDLP. GDLS's Advanced Amphibious Assault Vehicle (AAAV) for the US Marine Corps holds better promise for bearing fruit. The three-year, $300 million development contract that started in 1996 could result in a $4 billion contract when GDLP is given the go-ahead for full-scale production.[10] GDLS may have a difficult time finding potential buyers for the AAAV outside of the US market, however. With a price tag of nearly $4 million per vehicle, the AAAV may be too expensive to float in other navies.

**European Industry Trends**

Despite increasing economic, political, and defense collaboration in Europe, the LCS industry overseas is organized around nation states. Although European LCS industries agree that greater unification is necessary, they disagree at the pace of integration. There are still significant obstacles to overcome before Europe realizes a continental shift in its defense industry. European governments shelter their employment base and such barriers are particularly problematic for corporate mergers and acquisitions. Making these barriers even more troublesome are two recently proposed amendments to a new merger code passed by the European Parliament. One proposal allows companies to employ aggressive tactics to resist takeovers, such as issuing stock to dilute shareholder value without shareholder approval. The second proposal would require European Union corporate directors to maintain "a view of safe-guarding jobs," which would constrain mergers from eliminating redundant positions.[11] Government regulatory obstacles and a culture that promotes social welfare over efficiency will prevent any type of meaningful consolidation of the European LCS industry.

Other obstacles to successful consolidation are military conservatism and an ethos of self-reliance and independence. These obstacles conspire against the harmonization of requirements and the method in which to solve problems. Simple agreements get lost in matters of national pride and lead to a breakdown in cooperation and trust. Moreover, few industrialized nations want to give up their independence in areas that affect national security. Europe has significantly more manufacturing capacity than needed, so keeping artificial barriers in place to prevent consolidation results in hefty opportunity costs for its LCS industry.

Despite the overall fragmentation of the European LCS industry, there are entrepreneurial ventures where companies cooperate to share risk, financing, and technology to meet specific performance needs. Stork PWV, a subsidiary of the $3 billion Dutch conglomerate of the same name, has recently joined ARTEC, a joint venture between Alvis Vehicles Ltd., Rheinmetall Landsysteme GmbH, and Krauss-

Maffei Wegmann GmbH. ARTEC is a collaborative program between the UK, Germany, and Holland for the development and initial production of the Multi-Role Armored Vehicle (MRAV), an armored 8x8 wheeled vehicle that combines modern armor technology with high mobility and capacity. The addition of Netherlands to the program increases the value of the MRAV development contract by $71 million and the production contract by at least $570 million. Although Stork will perform the majority of additional work, Alvis will benefit from the increased scope of the program and from providing the components for Dutch vehicles in the production phase.[12]

The US Army is not the only organization affected by transformation. The U.K. Ministry of Defense (MOD) is also undergoing a significant reevaluation of its ability to project military power. The kidnapping of 11 British soldiers by armed rebels in Sierra Leone August 25, 2000, underscored the operational need to consolidate the Army's eight models of light to medium weight armored vehicles into a single system in the 15 metric ton range.[13] The Future Rapid Effect System (FRES) is MOD's answer to developing a medium weight capability using existing Armored Fighting Vehicle (AFV) funds to field an air transportable system between 2006 and 2008. The system is to have utility beyond early effects, meaning it will be expected to perform in multiple roles. The MOD plans to field between 1,700 and 2,200 vehicles, making FRES the future AFV program for the U.K. Army. With an expected cost of $4.25 billion, FRES will be MOD's second most expensive land combat system, surpassed only by the Challenger main battle tank program. The biggest difference between this transformation and that of its US counterpart is that FRES will exploit existing technologies rather than skip the next generation of armored fighting vehicles.

## **CHALLENGES**:

Of the many challenges facing the US LCS industry, three issues prominently stand out. The first issue is a decline in the industrial base should one or more prime contractors leave the industry. The second issue is sustaining the US LCS industry's professional and technical workforce. The third issue is incorporating world-class standards in manufacturing and logistics support. All three issues affect national security.

### The Industrial Base

Following the Cold War, Americans were eager for a “peace dividend.” The result was a one-third reduction of US military personnel and a corresponding decrease in the demand for land combat systems. For example, the US Army’s truck requirements in 2007 will be 163,000 vehicles less than it was in 1987, a 41 percent reduction. This decrease in demand has captured the attention of domestic manufacturers. A senior vice president for a major military truck manufacturer stated that the most pressing issue facing the industry was whether the government would keep buying trucks

In addition to less demand for total systems, doctrinal changes within the US Army call for forces that are lighter, more deployable, and easier to sustain. This doctrinal shift has major implications for the LCS industry. Tanks, self-propelled artillery, and other heavy systems have already been scaled back significantly. Continuation of some tracked vehicle programs, such as the Army's Wolverine Heavy

Assault Bridge, is in doubt. Reduced demand and new strategic direction threaten some in the LCS industry, as they find their products no longer competitive or wanted. Allowing these firms to go out of business reduces the nation's defense industrial base and capacity to surge if an emergency arises. The nation's concern over replenishing its arsenal of cruise missiles during the Yugoslavian bombing campaign serves as a harbinger for land combat systems should production lines be allowed to deteriorate further.

**Workforce**

Despite a decade of fewer orders, downsizing, consolidations, and layoffs, the industry suffers from a shortage of science and technology professionals. As the LCS industry shifts its focus from manufacturing to systems integration, electrical, mechanical, and software engineers are in greater demand. Exacerbating this shortage is an aging workforce, one-third of which will be eligible to retire in five years. Recent developments in higher education are also eroding the long-term prospects for producing the number of engineers needed by the industry. While the total number of bachelor's degrees rose about 15 percent between 1987 and 1996, the number of bachelor's degrees in math, computer science, and engineering fell 20 percent.[14]

Competition for technical talent is fierce throughout industry. Experienced engineers are lured away from the LCS industry with offers of higher salaries and better benefits. According to one top US Army official, the industry's brain drain and relatively small recruiting budgets "present a serious situation, with far-reaching consequences." The shortage of engineering talent could threaten the industry's ability to meet the ever-increasing technology requirements that advanced land combat systems demand.

Since the US depends heavily on the technical superiority of its land combat systems, the Federal government should take part ownership in the health of the LCS workforce. A good place to start would be to increase funding for undergraduate and graduate public institutions where most science and engineering education take place. State funding has not kept pace with enrollment at these institutions, causing state universities to cut spending per student. Demand for technical education far exceeds supply, but with fewer dollars to spend on students, enrollment in science and engineering courses are the first to be rationed due to expensive equipment and competition for qualified teachers. Moreover, higher technical education is a joint product with research. Although many students complete the practical aspects of their education by working in faculty laboratories, Federal support for university research in science and engineering has risen only 2 percent annually, far behind the needs of a technology driven economy.

**Manufacturing and Logistics Standards**

The LCS industry is in transition regarding world-class standards in manufacturing and logistics. The LCS companies the seminar visited were in various stages of adopting best business practices in resource planning, supply chain management, lean manufacturing, and quality assurance. Efforts observed included:

- International Organization for Standardization (ISO) certification of manufacturing processes and operations[15]
- Workforce retention initiatives
- Total quality management designed to reach six-sigma quality[16]
- Reduced production cycle time
- Lean manufacturing with reduced inventory
- Better supply management through fewer suppliers to manage
- Use of long-term contracts with suppliers to leverage quality, service, and price
- Introduction of resource planning, electronic interchange management, and web-based communications with customers and suppliers to boost efficiency

The LCS industry has taken several steps to demonstrate to potential customers that it is moving to match world-class standards in manufacturing, operations, and logistics. Full implementation of these initiatives, however, appears to be restricted to those with significant defense contracts. A disturbing trend in the industry is that some firms have placed their quality management plans on hold until additional resources become available. The development of two distinct camps—those firms that can include quality assurance measures in their bids and those that cannot—may affect future contract awards. Under such conditions government efforts to keep competition alive between industry rivals may become moot. The real issue concerning competition could boil down to the rivals themselves, where quality management differences determine who wins the contract.

**OUTLOOK**:

**Near Term**. The LCS industry is capable of supporting the US national security requirements in the near term. Several domestic firms produce wheeled vehicles and two companies have the capability to manufacture tracked vehicles. In addition to US companies, the international market includes several European prime contractors that are prepared to seek a local presence through US firms if a domestic shortfall ever occurs. Intense competition for a limited number of contracts gives the customer excellent leverage for the best deal possible.[17] The short-term period from 2002 through 2005 finds steady contract work for tracked armored vehicle upgrades and sizeable contract awards for wheeled armored vehicles and tactical wheeled vehicles.

**Tracked Armored Vehicles**. The tank continues to be the main component of most land combat forces. The short-term outlook includes potential sales to Greece and Turkey, although recent economic problems and natural disasters have postponed Turkey's decision. GDLS is also currently upgrading and retrofitting M1 and M1A2 tanks to the M1A2 System Enhanced Program (SEP) version. In addition, GDLS is overhauling the M1A1 tank under its Abrams Integrated Management Program. This program will bring the tanks back to a like-new condition, but with 1980s technology. Several Middle East countries, including Saudi Arabia and Kuwait, have expressed an interest in upgrading their tanks to the M1A2 SEP as well. Refurbishment and upgrades

to the Bradley Fighting Vehicle and to the M88-Hercules Recovery Vehicle offer additional near term work for domestic manufacturers.[18]

**Wheeled Armored Vehicles**. The recent award of the US Army's Interim Armored Vehicle (IAV) contract to GM/GDLS LLC represents a major domestic opportunity for work in this market. The US Army plans to buy a total of 2,131 IAVs in support of the initial and interim Brigade Combat Teams. Canada and Saudi Arabia also have current contracts for wheeled armored vehicles and potential markets exist in Thailand, Taiwan, South Korea, New Zealand, and Australia. Several European countries have on-going or planned buys, too. Austria is buying Steyr's PANDUR 6X6 while the United Kingdom, Germany, and the Netherlands are co-producing the Multi-Role Armored Vehicles (MRAV).

**Tactical Wheeled Vehicles**. The market for tactical wheeled vehicles looks strong and is anticipated to grow in the near future. Recent and on-going production contracts by the US Army for the FMTV and HMMWV and by the Marine Corps for the MTVR mean additional business for domestic companies. Furthermore, current and pending foreign military sales of the FMTV and the HMMWV contribute to a strong market demand. Refurbishment programs for currently fielded systems such as the HEMTT and the HMMWV along with the award of a follow on FMTV contract ensure that production lines remain active.

**Long Term**. The forecast through 2020 and beyond continues to show a stable market with steady work for tactical wheeled vehicle manufacturers. The market for combat tracked and wheeled vehicles will depend on decisions made by countries as to which vehicle offers the best combination of capability and affordability. Governments will continue to fund service life enhancements because these programs are more economical than acquiring an entirely new system. Moreover, the US Army plans to begin fielding the Future Combat System (FCS). The impact of FCS on the industry is difficult to judge, as future land combat systems may not resemble today's equipment. Likewise, plans by the United Kingdom to develop and procure up to 2,200 of the Future Rapid Effect Systems (FRES) will provide European companies with production work through 2008 and recapitalization in the out years.

**Tracked Armored Vehicles**. In the long-term, expect completion of tank contracts with Taiwan, Greece, and Turkey. The remainder of the market for tracked vehicles will consist of new production contracts for the Marine Corps' Advanced Amphibious Assault Vehicle (AAAV), possibly the US Army's Crusader, and additional upgrades to the Abrams tank. Domestic tracked armored vehicle manufactures could suffer a setback if the Crusader and Abrams retrofit programs, which undergo annual reviews, are terminated. South Korea, Taiwan, and Singapore have expressed an interest in the AAAV, but at nearly $4 million a copy, they may go elsewhere for something less expensive.

**Wheeled Armored Vehicles**. Anticipate greater interest and contract work through 2020 for wheeled armored vehicles based on new programs such as the Multi-

Role Armored Vehicle for the UK, Germany, and the Netherlands, the LAV III for the US and Canada, the Future Rapid Effect System for the UK, and the US Marine Corps' MAGTF Expeditionary Family of Fighting Vehicles (MEFFV). In addition, successful completion of at least a dozen prototype wheeled armored vehicle systems for specific performance requirements, like French Giat's Caesar, a wheeled 155mm howitzer, may spark interest from governments looking for cost-effective solutions to security problems.

**Tactical Wheeled Vehicles**. The tactical wheeled vehicle market has the potential to grow as new technologies make vehicles safer, more reliable, and more economical. There is already a strong interest in hybrid-electric drive trains and fuel cell technology, which would offer significant savings in fuel to the military. While fuel cell technology has been demonstrated in proof of principle applications, it has not advanced to the point of providing sufficient energy for real missions. Once technology overcomes safety and thermal signature concerns, fuel cells have the potential to create a new generation of fuel-efficient vehicles. Tests conducted by the Defense Advanced Research Project Agency's Advanced Energy Technologies Program and the US Marine Corps show that remote communication sites using fuel cells to power their transmitters each save $800 a day in fuel costs.[19]

## GOVERNMENT: GOALS AND ROLE

The government's goals and role in land combat system procurement—to acquire the best possible equipment and services at a reasonable price—has not changed. However, the method in which the government achieves its goals has changed dramatically. Smaller budgets and fewer procurement dollars have placed a new emphasis on keeping acquisition costs to a minimum. The government plays three roles: customer, steward of funds, and provider of goods and services.

The DoD 5000 series of regulations define the government's role as a customer. The most recent revision of this regulation focuses on acquisition reform initiatives enacted over the last few years. The most important of these reforms is the renewed focus on cost. There are significant requirements relating to cost reduction during all phases of the acquisition process. The regulation goes as far as suggesting that the purchase of an existing foreign system is preferred over the development of a new domestic one.[20]

Another change in the government's role as a customer is more involvement with the contractor. In recent years the government has become more active with the contractor in the development of land combat systems. This has manifested itself through Integrated Product and Process Development (IPPD) using Integrated Product Teams (IPTs). The active participation of government in all phases of product development has replaced the antagonistic styles of the past. Contractors are looking for feedback from the government so they can provide exactly what the customer wants. A more cooperative approach throughout all phases of the acquisition process has led to improvements in system performance and customer satisfaction. The government's greater involvement has encouraged some in the LCS industry to relocate their operations closer to their customers to foster partnerships. Feedback from both the LCS industry and government has been positive, with both praising the ability to resolve problems quickly as the biggest benefit of the change.

A third major change in government's role as a customer is the inclusion of interoperability as a Key Performance Parameter (KPP) in the Federal Acquisition Regulation (FAR). KPP requires the Program Manager to prove that his system is interoperable with other systems before he can begin production. The government's role in interoperability is of major importance in that the services must be able to communicate across platforms if they truly are to operate jointly.

Government's role as a good steward of public trust is outlined in the Federal Acquisition Regulation (FAR). The FAR is designed to ensure taxpayer dollars are spent judiciously. Acquisition regulations ensure performance standards in terms of cost, quality, and timeliness are met. The regulation also lays out standards of conduct for Government business. Simply stated, Government business shall be conducted in a manner above reproach with complete impartiality and with no preferential treatment.

Transactions relating to the expenditure of public funds require the highest degree of public trust and an impeccable standard of conduct. The general rule is to strictly avoid any conflict of interest or even the appearance of a conflict of interest in Government-contractor relationships. While the FAR places many restrictions on the actions of Government employees, their official conduct must be such that they would have no reluctance to make a full public disclosure of their actions. Some find the FAR too restrictive and even inefficient. But without a standard to follow, the public's trust and confidence in its government would severely erode. The FAR is Government's method of codifying standards of conduct for both business and individuals and is necessary for making acquisition decisions that deliver the best value, product, and service to the customer without losing sight of the public's interest.

The third role of the government is to provide supplies and services. Government plays an important role in providing unique supply and service capabilities to the LCS industry through its depots. Without any guarantee of a return on its investment, the LCS industry is reluctant to invest in durable capital goods, such as plant equipment and facilities. Government is in a much better position to underwrite these costs and has done so through government-owned, contractor-operated facilities, such as the Lima Army Tank Plant. Once a major tank production facility during World War II, the Lima Tank Plant was mothballed from 1959 to 1976. When the US Army needed the LCS industry to produce the M1 tank, the plant provided industry an incentive to bid on the contract because there was no extra cost incurred for building a manufacturing facility.

Government also provides a unique manufacturing capability through its government-owned, government-operated depots. Watervliet Arsenal, for instance, is America's sole manufacturing facility for large caliber cannon. Cost would prohibit the LCS industry to duplicate Watervliet's complete lifecycle management of gun tubes. It's no surprise that GM/GDLS LLC contracted with the arsenal to provide the cannon for its LAV III. Moreover, Watervliet completed a ten-year $350 million renovation program that has made the arsenal one of the most sophisticated heavy manufacturing and machining centers in the world. Collocated with Benet Labs, a fully staffed research and engineering facility, Watervliet can perform industrial research and testing. Watervliet is also ISO 9002 certified, which assures customers that its management team, manufacturing processes, and products meet international standards. The Government plays an important role in the LCS industry by providing these unique services. These

services allow the LCS industry to avoid spending the large capital investment it would otherwise take to match these capabilities.

## ESSAYS ON MAJOR TOPICS

### Objective Force

US Army in the 21st Century must be strategically responsive and dominant across the entire spectrum of operations as well as agile, versatile, lethal, survivable, and sustainable. Specifically, Army plans are to deploy a combat brigade anywhere in the world within 96 hours, a division within 120 hours, and five divisions within 30 days.[21]

In order to achieve these goals, the Army has prepared a three-level strategy. The first level consists of legacy forces that retain the current level of combat overmatch. The second level is an interim force aimed at providing a bridge between the legacy and a future objective force. The interim force's core competencies are operational and tactical mobility, enhanced situational awareness, and combined arms integration down to the company level. The US Army will organize the interim force into brigade combat teams with a full suite of interim armored vehicles (IAV) on common platforms. The objective force is the Army's ultimate transformation goal. The centerpiece of the objective force will be the future combat system, a digitized system of systems with overwhelming combat capability and multi-mission functionality.

The changes the US Army is undergoing will pump new life into prime contractors who win major contracts.[22] Upgrading the legacy force through 2020 will provide a measure of stability for the only two remaining domestic tracked vehicle manufacturers. Legacy force upgrades are long overdue, especially for such venerable systems as the M1 Abrams tank. The workhorse of Operation DESERT SHIELD/STORM in the early 1990s, the tank's turbine engine is 1970s technology. Industry has not manufactured a new turbine engine since 1992, leaving the US Army to live off of rebuilds for almost a decade.

The System Enhancement Program (SEP) for the Abrams tank is a welcome improvement, both for tankers and General Dynamics Land Systems, the program's prime contractor. Among the more significant improvements this program offers are a newly redesigned turbine engine and second-generation forward looking infrared for enhanced vision at night and through obscurants. These improvements will keep the Abrams tank one step ahead of its competitors.

The development of the US Army's interim force has provided the LCS industry a windfall of new business. The Army's requirements for an interim armored vehicle were straightforward: C-130 transportable, reduced logistics footprint, survivability, 20-ton weight class, the ability to operate for 72 hours without external support, and a low maintenance cost. These requirements led to a platform performance demonstration at Fort Knox, Kentucky, followed by the Army's release of a request for proposal. Having received proposals from several LCS firms in the spring of 2000, the Army made its recommendation to Dr. Jacques Gansler, and he approved the Army's selection of the LAV III on November 16, 2000.

The selection of the LAV III represents a major milestone for both the US Army and GM/GDLS LLC, the vehicle's manufacturer. The US Army's choice of the LAV III

is a significant step toward building the objective force. The LAV III enables the US Army to move rapidly forward in equipping, training, and developing the doctrine for the interim brigade. By allowing today's young officers and noncommissioned officers to command, organize, and fight these combined arms teams, they grow in the capability to lead the organizations of the future.

For the LCS industry, the estimated worth of the LAV III contract is $4 billion. LTG Paul J. Kern, Military Deputy Assistant Secretary of the Army for Acquisition, Logistics, and Technology, foresees the Army keeping the vehicle in its inventory for 30 or more years. According to Kern, the LAV III is the first new vehicle that the Army has acquired since the Bradley Fighting Vehicle. To manufacture the vehicle and meet the Army's aggressive delivery schedule, General Motors and General Dynamics Land Systems formed a limited liability corporation. This corporation is a strategic alliance that enables both companies to bring the best in engineering, design, production, and logistics to the table.

The $4 billion LAV III contract will be evenly divided between the two firms. General Motors owns the LAV III's technical data package and will assemble the lower hull structure. General Dynamics Land Systems will manufacture the vehicle's turret in Lima, Ohio. Anniston Army Depot will marry the hull and turret and complete the vehicle's final assembly. Several other domestic LCS firms are involved in manufacturing the LAV III. Caterpillar will provide the engines. Transmissions will come from Allison. CACI International of Arlington, Virginia, will supply the Nuclear, Biological, and Chemical reconnaissance system while Watervliet Arsenal will make the vehicle's cannon. LTG Kern adds that the acquisition of the LAV III will expand the nation's LCS industrial base. "General Motors, which has not been involved in our defense industry for many years, has now become a player, bringing its experience to our industrial base," Kern briefed a press conference upon unveiling the winner of the IAV contract. The partnership between GM and General Dynamics highlights the flexibility of the LCS industry and the model to be followed in meeting national security needs.

The creation of the US Army's objective force has already had positive effects on the LCS industry's R&D programs. DARPA and the US Army awarded contracts valued at nearly $7 million to eight contractor teams for development of the Unmanned Ground Combat Vehicle (UGCV) program.[23] The UGCV program is only one of several DARPA and US Army initiatives aimed at developing enabling technologies for the future combat system. The UGCV program is exploring new robotic vehicle designs unconstrained and unburdened by onboard human crew. These designs are expected to leverage new technologies and develop solutions and technologies that don't yet exist. The final results are expected to support rapid delivery of mobile ground assets to enhance the effectiveness of soldiers in a network centric battlefield.

The UGCV contractor teams will conduct an eight-month design effort. The program will then select three or four teams to develop more detailed designs and conduct risk reduction experiments. In the summer of 2002, one or two teams will be chosen to build proof-of-concept prototype systems and conduct laboratory and field tests. The contractor selected to build the final design will certainly be a consortium of research labs, suppliers and manufacturers who have combined their skills to meet the requirements of the UGCV program. The creation of the Army's objective force will bring a fresh infusion of talent and capital to the LCS industry.

## Information Technology

Information technology is having a tremendous impact on how the LCS industry conducts business. The bottom line is that companies that use information technology can gain a competitive advantage over those that don't.

Information technology presents a host of challenges to the LCS industry, including globalization, market transformation, and organizational makeovers. But along with challenges come opportunities. The power of the microprocessor has improved 25,000 times since its invention 30 years ago, and computing power is doubling every 18 months. In today's LCS organization it is now possible to put the power of a large mainframe computer on every manager's desk. With the improvements in information technology, employees can access vast storehouses of data on the Internet, exchange information around the world, and conduct business transactions electronically.

Information technology has promoted a number of changes in the LCS industry. The most common form of IT-enabled organizational change is automation. In its simplest form, automation helps individual employees perform their tasks more efficiently and effectively. In more complex applications, the LCS industry is using information technology to design and manufacture its products. The larger corporations in the industry already have the capability to fully design and test vehicle models without actually building a prototype. Others have automated manufacturing processes, such as painting, eliminating much of the human labor involved with preparing and priming vehicles. The end result is a more efficient process with lower costs.

A more powerful type of organizational change in the LCS industry is business reengineering. Business reengineering is more far-reaching than automation as the reengineering process involves rethinking how the work should be done. Using information technology, organizations can streamline their business processes to improve speed, service, and quality. Business reengineering reorganizes workflow, cuts waste, and eliminates repetitive tasks. Reengineering a business process is more likely to require new ideas on how to best organize the work. The LCS industry has reengineered many of its logistics services by placing them on the Internet. Customers can now request parts and track the status of their orders on line. With this knowledge, logisticians can accurately predict when the parts will arrive, the time needed for the repair, and when the owning unit can expect its vehicle returned fully mission capable.

Information technology can ultimately affect the design of an entire organization by transforming how the organization carries out its business or even the nature of business itself. This is the most radical organizational change, as it often requires a shift in strategic focus. The prevailing practice for delivering inventory in the LCS industry is for a distributor to deliver products to the manufacturer's warehouse. Information technology, however, has enabled some LCS manufacturers to eliminate inventory entirely by shifting this responsibility to the distributor. Linked to the LCS manufacturer's production schedule through IT, the distributor assumes responsibility for getting the right quantities of supplies to the customer on time.

In the LCS industry, the Defense Logistics Agency (DLA) provides a good example of how information technology can transform business practices and the organization itself. As DLA has shifted its strategic focus from inventory storage to

knowledge based services, the agency has shed a large amount of its overhead. DLA has closed 75 percent of its depots and warehouses and has downsized its workforce from 62,000 employees to 28,600. Despite the downsizing, LTG Henry T. Glisson, DLA's director, estimates that the agency's response time to supply requests has been reduced by 50 percent. He credits new business practices, information technology, and a knowledge-based work force as reasons why DLA has been able to improve its performance while simultaneously restructuring into a leaner organization.[24]

The pervasiveness and power of information technology and the widespread use of the Internet have made security and control of information a concern for the LCS industry. Corporations have the dual challenge of keeping information accessible to the public yet secure from intruders. Without proper safeguards, information systems are highly vulnerable to destruction, abuse, error, and loss. The price of losing sensitive or proprietary information can run into the millions of dollars.

Most businesses in the industry have taken some type of security precaution, such as antivirus software and firewalls. But according to one leading Internet security company, 97 percent of all websites tested are vulnerable to intrusion.[25] According to other high-tech experts, more than 50 new viruses are created each day. Even the Internet sites of software security giants are not safe from intrusion as one corporation learned after its website suffered a denial of service attack. One analyst gloomily predicted that corporate networks have just begun to see the tip of the iceberg when it comes to cyber-crimes and computer attacks.

This isn't good news for those in the LCS industry that are moving more of their business and company information to the Internet. Organizations that rely on the Internet, such as DLA, could suffer lost sales and productivity as a result of a malicious attack. Customer and shareholder confidence could be badly shaken by theft of sensitive data. Because of the potential for lost business and consumer confidence, information security is not just the chief of information officer's (CIO) problem. Senior executives must also be involved in protecting their information and networks from intrusion.

All LCS industry CIO's interviewed for this study had implemented methods of verifying network and account users, with passwords the most common form of protection. Every company that offered on-line sales used secure servers and encryption to protect the integrity of business transactions. These measures are a good start to keep transactions and networks secure, but a determined hacker often has sophisticated tools at his disposal to bypass such safeguards. The industry standard of forty-bit encryption can be cracked with tools as unsophisticated as a Pentium I computer.[26]

An even more insidious threat to Internet sites and networks is found in the codes software engineers use to write their applications. The likelihood of software applications containing holes, tiny bugs, and weaknesses is very real. Software makers usually provide patches for these problems, but not until there has already been trouble with the program. A recent visit to Microsoft's Windows Update Internet site showed thirteen security patches available for Office 2000, a popular productivity desktop application in the LCS industry.[27]

No network or Internet site is ever completely secure from those determined to break in. But while most land combat system companies have taken some precautions to protect their information assets, few have developed comprehensive security policies or the culture to stringently adhere to those policies if they have been written. The argument

that not every company has the resources to devote to information security is dangerously misleading. If the company's information and networks are of strategic value, then that firm should consider security as critical to its core competency as the building of a weapon system.

**Research and Development**

As the US begins the 21st Century, it is critical that the LCS industrial base remains capable and ready to respond to the security needs of the nation. R&D supports the ability of the US to respond to today's threats as well as prepare for tomorrow's challenges. Joint Vision 2020 stresses the value of conducting research and development. It states the need for the military of the future "to be faster, more lethal, and more precise than today" with investment in development today the key to achieving this military capability in the future. The National Security Science and Technology Strategy also identifies the need to maintain military unique industrial capabilities that do not have a commercial counterpart.

The Army's transformation into a highly deployable, more responsive, agile force, that can react across the full spectrum of operations, is the main driver for many of its new R&D programs. Current and new R&D programs are focused on technologies and systems that can support both the Interim and Objective Forces. R&D funding also supports enhancements and upgrades for systems under the Legacy Force. While a portion of the US Army's R&D funding supports the Legacy Force, the Future Combat System (FCS) is the US Army's top research project and the main program for the Objective Force. It represents a sizable investment of the science and technology budget of the US Army and is jointly funded by DARPA. The FCS is intended to combine the survivability and lethality of heavy combat vehicles with the mobility and deployability of light combat vehicles. The focus of the research effort is on enabling technologies that will provide the separate functions of robotic direct fire, indirect fire, and sensor platforms controlled by a separate command and control platform.

The Marine Corps is investing a significant part of its science and technology budget into areas that will develop new vehicle technologies to support its Marine Air/Ground Task Force (MAGTF) Expeditionary Family of Fighting Vehicles (MEFFV). The MEFFV will conduct operations against an array of systems including small arms, heavy and light armored vehicles, mounted and dismounted infantry, and mines. The MEFFV concept consists of two classes of vehicles. One MEFFV class will be designed around a 10 ton gross vehicle weight (GVW) limit to allow full utilization of the heavy lift helicopter's (the CH-53E or its follow-on) range for transport to deep operational objectives as part of the vertical maneuver element. The other class will be designed around a 30 ton GVW enabling two of these MEFFVs to be transported on a landing craft as part of the surface maneuver element. The Marine Corps expects to field this system in the 2015-2020 timeframe. [28]

The Marine Corps is also developing the Advanced Amphibious Assault Vehicle (AAAV). The AAAV is part of the Marine Corps amphibious triad of new programs that support its "Operational Maneuver from the Sea" warfighting doctrine. The AAAV will provide improved capability for surface assault forces including the ability to launch

assaults from over the horizon. The increased mobility over water and on land allows the AAAV to transition quickly at the beach to support inland attacks.

The long term health and viability of the LCS industry depends not only on an infusion of R&D funding but also on procurement funding for new systems. While all signs point to an increase in R&D funding for the LCS industry, the potential still exists for changes that could spell decline for the LCS industry. The cancellation of any current R&D programs or a significant decrease in the R&D budget in the out-years could have adverse effects on the industry. If this occurs, the LCS industry may not be in a position to respond to tomorrow's threats with the success of the past.

## Conclusion

The seminar has come to several conclusions regarding the LCS industry. Tough times hit the industry during the last ten years and many firms became casualties of lower procurement spending. Despite these difficult times, those that survived showed remarkable resiliency in adapting to smaller defense budgets. The old business model relied on manufacturing, government support, and quantity. The new business model discards many of these traditional practices, now placing a premium on being a prime contractor, managing risk, pooling resources, and offering affordable technical solutions. This shift in business focus is more than just the latest management fad; it is a significant change in the way the industry strategically thinks and is expected to last well into the future.

From its research and industry travel, this seminar concludes that even where state ownership prevails, the LCS industry will most likely be privatized within ten years. This assessment has several implications for both government and the industry itself. To remain profitable, LCS firms will have to continue their efforts to broaden their markets and services. This means greater efforts to exploit information technology in order to control worldwide operations and maximize efficiency. It also means that governments will have to review their trade policies and streamline some of the bureaucracies that prevent their defense industries from competing in a global market on a level playing field. That will be a delicate balancing act. Public opinion and security considerations dramatically affect what land combat systems get sold to a world that is rapidly changing and often unstable.

Despite the move toward privatization in the LCS sector, governments will continue to play an active role in the industry through policy formulation, principle buyer of goods and services, and requirements developer. For example, despite a 50 percent decline in direct federal R&D support for the US defense industry between 1987 and 1999, the US Government still provides nearly three-quarters of the industry's R&D funding. The success of the US Army's transformation depends largely on Federal money for the technical solutions needed by its future combat systems. And despite the best efforts of French Giat to privatize, its future business strategy counts on one-half of its book orders coming from the French government. The implication for the LCS industry is that it will have to maintain a close relationship with government and continually assess the strategic direction in which the political leadership is heading. Failing to lobby political support and neglecting strategic direction could cost the industry opportunity.[29]

Access to skilled labor is also a primary concern to the LCS industry. An aging workforce, intense competition from other industrial sectors, and fewer US students graduating with engineering degrees could spell trouble for the LCS industry before too long. The previous US administration's National Security Science and Technology Strategy was a step in the right direction in that it officially recognized the link between science and technology and military preparedness. But without appropriate Congressional funding, gaps exist between the strategy's objectives and resources. The recommendation of this study is to resource US investments in science and technology to maintain the strength and capabilities of the domestic LCS industry.[30] The LCS industry need not wait for the government to act; there is much it can do for itself. The defense industry can award scholarships and internships, programs that were unfortunately abandoned when the industry downsized. Profitability has improved, so there is no reason for these programs to lie dormant.

Finally, the seminar comes away from this study with a guarded optimism about the overall health of the LCS industry and its ability to support US national security strategy. All of the firms visited had a good perspective of the industry's strengths and weaknesses, having survived one way or another the leanness of the post-Cold War years. And there is a silver lining in the clouds: the LCS industry is more competitive, offers quality technical solutions, and has either whipped its management team into shape or has replaced them. The change in the industry has been nothing less than revolutionary, and this revolution has enabled the industry to stay at the cutting edge of new technology so that our Armed Forces remain trained, equipped, and ready.

## Notes

[1] The frequency of other than war military operations has greatly intensified. The situation in Europe is a case in point. From 1945 to 1989, USAREUR participated in only 29 peacekeeping or humanitarian missions; however, from 1991 (marking the end of the Gulf War) to the present, USAREUR has participated in over 100 such missions. This change represents more than a threefold increase in the number of military deployments for peacekeeping and humanitarian missions. Carl A Castro and Amy B. Alder, "OPTEMPO: Effects on Soldier and Unit Readiness," *Parameters*, Autumn 1999: 86.

[2] For collaborative programs see http://defence-data.com/current/pagerip2.htm.

[3] "Army Discusses Interim Armored Vehicle Program," *DefenseLINK News*, http://www.defenselink.mil/news/Nov2000/t11172000_t117army.html (1 May 2001).

[4] Stewart & Stevenson Annual Income Statement, http:///www.ssss.com/investor/99report.pdf (18 May 2001).

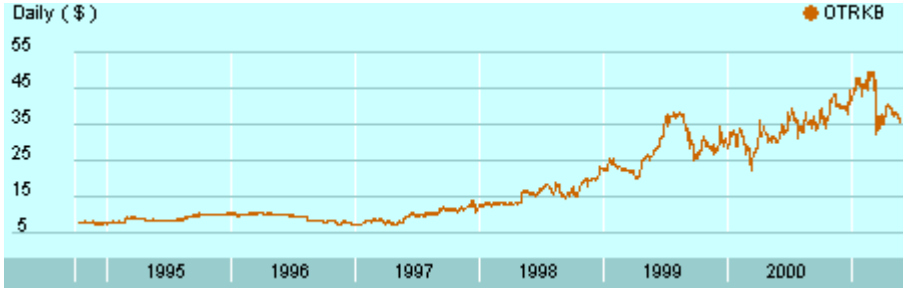
[5] Jacques S. Gansler, "Defense Conversion: Transforming the Arsenal of Democracy," as quoted by *The Century Foundation*, http://www.tcf.org/Publications/Foreign_PolicyDefense_Conversion/forward.html (13 May 2001).

[6] Ibid.

[7] The financial industry uses four criteria to assess a company's health: growth, profitability, cash flow, and valuation. Growth is the increase in revenue over a period of time. Profitability, or return on equity, is the percentage a company earns on the money shareholders have invested in it. Cash flow is the amount of cash a company generates after capital spending. Valuation tells the relationship between what people are willing to pay for a stock and its underlying business value. See http://www.morningstar.com/classroom/article/0,3163,2929-1,00.html for an in-depth discussion of these criteria.

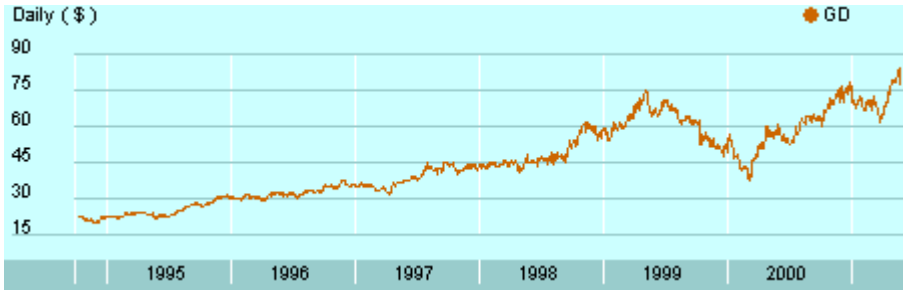
[8] Stock performances for three US LCS manufacturers: Oshkosh Truck (OTRKB), General Dynamics (GD), and Stewart & Stevenson (SSSS). The affect of lower procurement spending on stock value is apparent through most of the last decade.

Oshkosh Truck



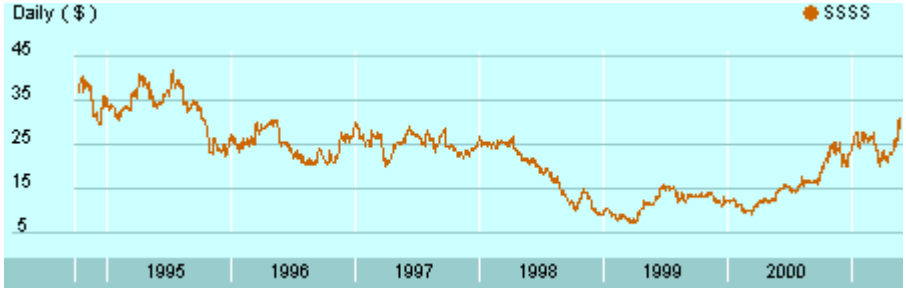

Source: Morningstar

General Dynamics



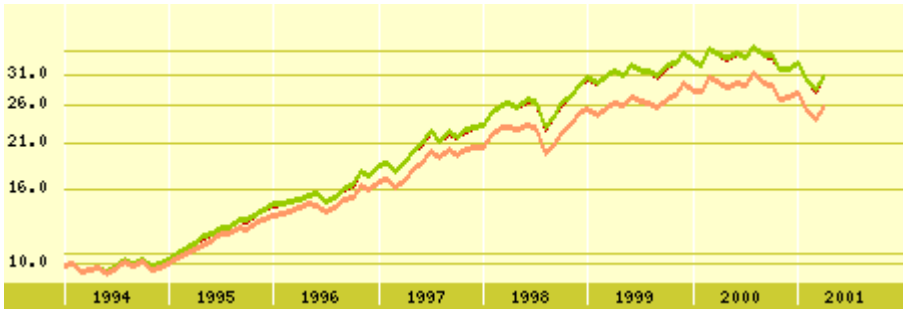
Source: Morningstar

Stewart & Stevenson



Source: Morningstar

S&P 500 and S&P 500 Index Fund



Source: Morningstar

[9] "Oshkosh Truck Reports Income from Continuing Operations down 5% in Second Quarter; Tightens Annual EPS Estimate at $2,80 Per Share for Fiscal 2001," *OTC News Release*, http://www.oshkoshtruck.com (15 May 2001).

[10] See http://www.gdls.com for additional information on the unique capabilities of the AAAV.

[11] Robert C. Poznan, "Continental Shift: The Securitization of Europe," *Foreign Affairs*, 80.3 (2001): 12.

[12] "Netherlands Joins UK and Germany in Multi-Role Armoured Vehicle (Mrav) Programme," http:www.alvis.plc.uk/news/05_02_01.htm (11 May 2001).

[13] Douglas Farah, "Hostages Rescued in Sierra Leone; 1 British Paratrooper Killed, 12 Hurt in 'Fierce' Fighting," *The Washington Post*, Sep. 11, 2000: A16.

[14] Linda R. Cohen and Robert G. Noll, "Is US Science Policy at Risk: Trends in Federal Support for R&D," *Brookings Review*, Winter 2001: 10.

[15] See http://www.iso.ch/iso/en/ISOOnline.openerpage for additional information on the International Organization for Standardization.

[16] To achieve Six Sigma quality, a process must produce no more than 4 defects per million opportunities.

[17] For example, in competition with Germany, France, and the Ukraine for replacing the Greek Army's main battle tank, General Dynamics sweetened its deal with the Hellenic Republic by offering co-production of its M1A1 Abrams tank. According to a study by Foresight International, a US company specializing in economic analysis of military and government procurements, the offer would result in 2,350 new jobs and $523 million of economic benefits to Greece if accepted.

[18] The U.S. Army Tank-automotive and Armaments Command (TACOM) awarded GDLP a multiyear contract to deliver 307 M1A2 Abrams upgrade tanks with the System Enhancement Package (SEP), awarding a $240 million increment of the $741 million contract March 30, 2001. Contract funding will be awarded in three yearly increments with a period of performance from August 2001 through December 2004.

United Defense LP (UDLP) was awarded a $228 million fixed-price contract by TACOM for 109 Bradley A3 vehicles and other system variants. UDLP also received a $75.4 million contract for 44 M88A2 HERCULES recovery vehicles for the US military. The contract calls for 29 US Army and 15 US Marine Corps vehicles, plus spares. Combined with a long-lead item award issued in December 2000, the total value of the contract is $99.3 million.

[19] http://www.arpa.mil/darpatech2000/speeches/dsospeeches/dsoadvancedenergy (nowak).doc (28 May 2001).

[20] For a detail listing of federal acquisition reforms visit http://www.acq.osd.mil/ ar/ar.htm (7 May 2001).

[21] "The Army Vision," Feb. 2000: http://www.army.mil/armyvision/chain.htm (6 May 2001).

[22] The Army has reprogrammed 96 percent of its science and technology spending through FY 07 in order to develop the Objective Force platforms and equipment. The Army plans to begin production of the Future Combat System in FY 08 and field the first system by FY 10. The Army has entered into a $900 million joint venture with DARPA,

the largest DARPA collaborative program ever, to accelerate the development of key technologies. To meet the Engineering and Manufacturing Development milestone of FY 06, the US Army will select the best technologies and concepts to enter the detailed design and demonstration phase in FY 03. See http://www.army.mil/usa/Cover%20 Sheet.htm for additional information on the US Army's Transformation.

[23] "Contractor for PerceptOR Program Announced," *Defense Advanced Research Projects Agency News Release*, Mar. 29, 2001: http://www.darpa.mil/body/NewsItems/ DARPA.doc (17 May 2001).

[24] Joshua A. Kutner, "Glisson: DLA to Retain Clout Despite Downsizing." *National Defense*, Mar 2001. An electronic copy of this article can be found at http://nationaldefense.ndia.org/article.cfm?Id=443.

[25] "Securing a Global IT Infrastructure." Mod. Arvind K. Krishna. Washington, D.C., FOSE 2001, Mar 22, 2001.

[26] "Government Should Allow US Software Firms to Compete in Global Market," http://www.house.gov/adamsmith/oped6.html (26 May 2001).

[27] http://office.microsoft.com/ProductUpdates/staticCatalog2000.aspx (7 May 2001).

[28] See http://www.onr.navy.mil/02/baa/baameffvpip.htm for a detailed review of MEFFV concepts and requirements.

[29] For an account of how Vermont Senator James M. Jeffords' departure from the Republican Party has affected the defense industry, see Kristina S. Stefanova's "Power shift in Senate hits General Dynamics," *Washington Business Times*," 28 May 2001, D12.

[30] The full version of the National Security Science and Technology Strategy can be viewed on line at http://www.ostp.gov/html/nssts/html/letter.html (10 May 2001).

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