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AN ECONOMIC ANALYSIS OF COMMERCIALLY BASED TACTICAL VEHICLES ACQUISITION FOR THE DEPARTMENT OF DEFENSE

by

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December 2001

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As defense budgets decline and traditional defense industry supplies downsize and consolidate, many believe that the Department of Defense (DoD) must continue to increase its business activities in the commercial marketplace. This thesis is an examination of one such venture, as a result of acquisition reform, that explores the viability of using commercially produced vehicles for military use in the Department of Defense as light tactical trucks.

The National Automotive Center (NAC) has initiated a program called Commercially Based Tactical Truck (COMBATT) that identifies dual-need/dual-use automotive technologies within the Defense Department and commercial automotive industry. This innovative approach is to adapt a modified commercial pick-up truck to perform some of the missions now assigned to the High Mobility Multipurpose Wheeled Vehicle (HMMWV).

An economical analysis is presented to determine if the procurement of COMBATTs would be cost effective in augmenting the current light tactical vehicle fleet of HMMWVs. Research includes analyzing production cost and anticipated operation and support costs. Additionally, a cost-effectiveness analysis is performed on the program. COMBATT is shown to reduce the cost of developing and procuring and maintaining a light tactical wheeled vehicle. Recommendations are made for the Army's future buying strategy for its Light Tactical Vehicles. It is concluded that the services should meet their Light Tactical Vehicle needs with an appropriate mix of HMMWVs and COMBATTs.

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AN ECONOMIC ANALYSIS OF COMMERCIALLY BASED TACTICAL VEHICLES ACQUISITION FOR THE DEPARTMENT OF DEFENSE

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ABSTRACT

As defense budgets decline and traditional defense industry supplies downsize and consolidate, many believe that the Department of Defense (DoD) must continue to increase its business activities in the commercial marketplace. This thesis is an examination of one such venture, as a result of acquisition reform, that explores the viability of using commercially produced vehicles for military use in the Department of Defense as light tactical trucks.

The National Automotive Center (NAC) has initiated a program called Commercially Based Tactical Truck (COMBATT) that identifies dual-need/dual-use automotive technologies within the Defense Department and commercial automotive industry. This innovative approach is to adapt a modified commercial pick-up truck to perform some of the missions now assigned to the High Mobility Multipurpose Wheeled Vehicle (HMMWV).

An economical analysis is presented to determine if the procurement of COMBATTs would be cost effective in augmenting the current light tactical vehicle fleet of HMMWVs. Research includes analyzing production cost and anticipated operation and support costs. Additionally, a cost-effectiveness analysis is performed on the program. COMBATT is shown to reduce the cost of developing and procuring and maintaining a light tactical wheeled vehicle. Recommendations are made for the Army's future buying strategy for its Light Tactical Vehicles. It is concluded that the services should meet their Light Tactical Vehicle needs with an appropriate mix of HMMWVs and COMBATTs.

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I. INTRODUCTION

A. OVERVIEW

The National Automotive Center (NAC) which operates under the Army's Tank-Automotive and Armaments Command (TACOM) has initiated a program identifying dual-need/dual-use automotive technologies within the Defense Department and commercial automotive industry. Dual-use technology is defined simply as an application that has both military and commercial uses. The NAC serves as the liaison between the Army and the commercial industry. Their new program called Commercially Based Tactical Truck (COMBATT) was initiated in compliance with the objectives of the acquisition reform. It is designed to leverage capability in the commercial industry by transferring the latest technologies to military tactical vehicles. This innovative approach is to adapt a modified commercial pick-up truck to perform some of the missions now assigned to the High Mobility Multipurpose Wheeled Vehicle (HMMWV). These vehicles are not intended to fully replace, but sufficiently augment the current light tactical vehicle fleet of HMMWVs.

COMBATT is expected to reduce the cost of developing and procuring a new light tactical wheeled vehicle. The Army and Marine Corps are both looking at innovative acquisition and ownership strategies established by the new acquisition procurement initiatives. They are looking to replace some of their aging fleet of light tactical vehicles comprised of HMMWVs and Commercial Utility Cargo Vehicle (CUCVs.) Both services are evaluating the COMBATT program as a potential acquisition strategy to support requirements for Light Tactical Vehicles through fiscal year 2020. Therefore, this thesis examines the viability and cost effectiveness of the COMBATT program.

B. PURPOSE AND BENEFIT OF RESEARCH

The general purpose of this research is to explore the viability of using vehicles produced from commercial production lines for military uses in the Department of Defense. The specific goal of this thesis is to provide an economic analysis to determine if the procurement of commercially based tactical trucks (COMBATT) would be cost effective as a significant part of the current light tactical vehicle fleet. This thesis will explore possible savings and economic benefits of a program that holds great potential for improving procurement processes and integrated technologies that will benefit both the commercial manufacturer and the government.

C. RESEARCH QUESTIONS

1. Primary Research Question

Is acquiring tactical trucks produced from commercial production lines cost effective for the Department of Defense?

2. Secondary Research Questions

a. What are the advantages and disadvantages of using commercial items to satisfy military requirements?

b. What is COMBATT? What are the significant aspects of the COMBATT program?

c. How does COMBATT leverages commercial technology?

d. What are the advantages of COMBATT?

e. What impact will COMBATT have on the current light vehicle fleet?

f. What are the costs and benefits of purchasing COMBATT vehicles?

g. What are the benefits in selling COMBATT vehicles back to the commercial public?

D. SCOPE AND LIMITATIONS

This thesis examines the viability and cost effectiveness of the COMBATT program. This program was initiated in compliance with the objectives of acquisition reform. It is designed to leverage capability in the commercial industry by transferring the latest technologies to military tactical vehicles.

The purpose of this research is to explore the viability of using commercially produced vehicles for military use in the Department of Defense as light tactical trucks. The specific goal is to provide an economical analysis in order to determine if the procurement of commercially based tactical trucks (COMBATT) will be cost effective in augmenting the current light tactical vehicle fleet. Research will include analyzing operation and support costs and the program's cost effectiveness.

This study will provide information required for the acquiring of COMBATT vehicles for the Department of Defense. TACOM, NAC, and the Army's Training and Doctrine Command (TRADOC) plan to use this thesis as an input to deliberations regarding procurement of COMBATT vehicles for the Army and Marine Corps.

E. RESEARCH METHODOLOGY

This thesis is an economic analysis of the COMBATT program's viability for future procurement. The research methodology consists of a literature review, an analysis of cost of current light tactical vehicles and commercial vehicles, interviews with knowledgeable personnel from the Light Tactical Vehicle (LVT) Program Office and the National Automotive Center (NAC), and observations of COMBATT vehicle performances.

Background information is developed from a review of the Federal Acquisition Regulation (FAR), the Defense Federal Acquisition Regulation Supplement (DFARS), DoD Directives, research reports and papers, and defense related periodicals. The research questions were answered by studying and analyzing the program documentation and by conduction personal interviews with experts in the LVT program office and experts in the commercial automotive industry. An analysis of these interviews and researched combined resulted in conclusions and recommendations for the program.

F. ORGANIZATION OF STUDY

Chapter II (Acquisition Reform and the Industrial Base) provides an overview of acquisition reform initiatives and the industrial base. The current policy for acquisitioning commercial items is stated. This chapter shows the efforts designed to integrate military with commercial emerging technologies.

Chapter III (The Evolution of the Light Tactical Vehicle) provides a history of the light tactical vehicle. It dates back to pre-World War II and shows how the original Jeep evolved into the HMMWV we have today. Past commercial vehicle acquisitions are also addressed.

Chapter IV (The COMBATT Program) introduces the National Automotive Center's (NAC) program by outlining its purpose and intent. This chapter contains specific data to be analyzed. It included O&S Cost and address manpower cost and Chapter V (Analysis of COMBATT Program) analyzes the cost-effectiveness of the COMBATT program.

Chapter VI (Conclusions and Recommendations) summarizes the findings of the research and makes recommendations for future procurements of COMBATT vehicles. Chapter VI concludes with a presentation of areas that warrant further research and study.

II. ACQUISITION REFORM AND THE INDUSTRIAL BASE

A. INTRODUCTION

In past years, our acquisition programs were a legacy from a relatively stable era of known threats. The adversary's moves were fairly predictable, and long-range programs could be structured to meet the limited range of hostile activity faced. This is obviously not the case today. Since the end of the cold war, dramatic changes in world geopolitics and national security needs have caused a steady decline in the military budget. Along with this decline in resources the number of threats around the globe have increased. Today, we live in an uncertain and unpredictable world. It is a world where individual terrorists and rogue nations can unleash firepower in many ways as terrifying as that of a global power. They represent a different and difficult challenge to forces organized and equipped around traditional missions. The new threats are willing to employ weapons of mass destruction (chemical, biological and nuclear) and have access to much of the most advanced technology and skills through the worldwide arms market. Finally, they are resistant to deterrence and they often respect no boundaries, whether political, organizational, legal or moral.

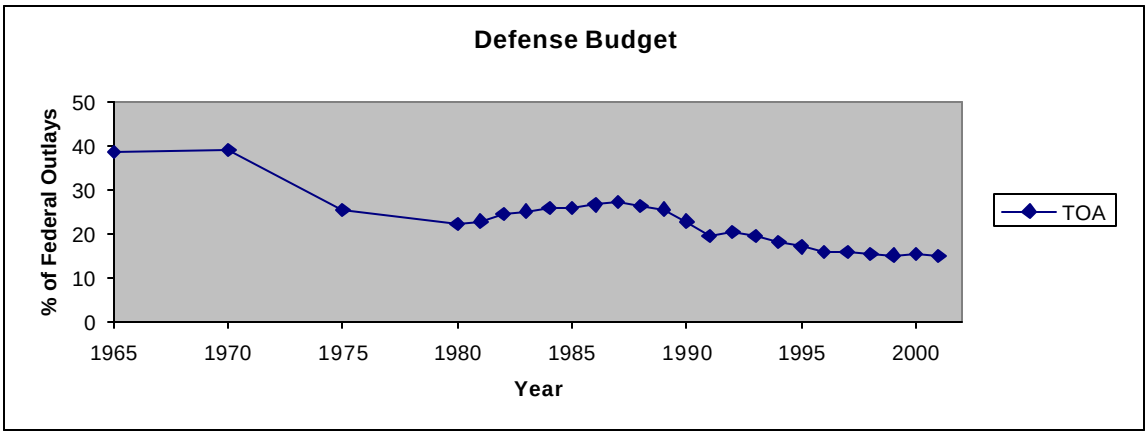

Figure 2.1 – DoD's Share of the Dollar

Since the end of the Vietnam War, DoD's share of the federal budget has declined steadily, as illustrated in Figure 2.1 above (Defense Almanac, FY 2001 Budget.) Over the last decade, defense procurement budgets have been reduced even more dramatically than the overall defense budget. Since 1985, the total DoD budget has declined 38%, with a 23% decline in Research and Development, Test and Evaluation (RDT&E), and a 70% decline in procurement. The procurement budget peaked at $136.6 billion in 1985 down to $55.8 billion in 2001 as illustrated in Figure 2.2 (data reflects 2001 dollars). (Defense Almanac, FY 2001 Budget)

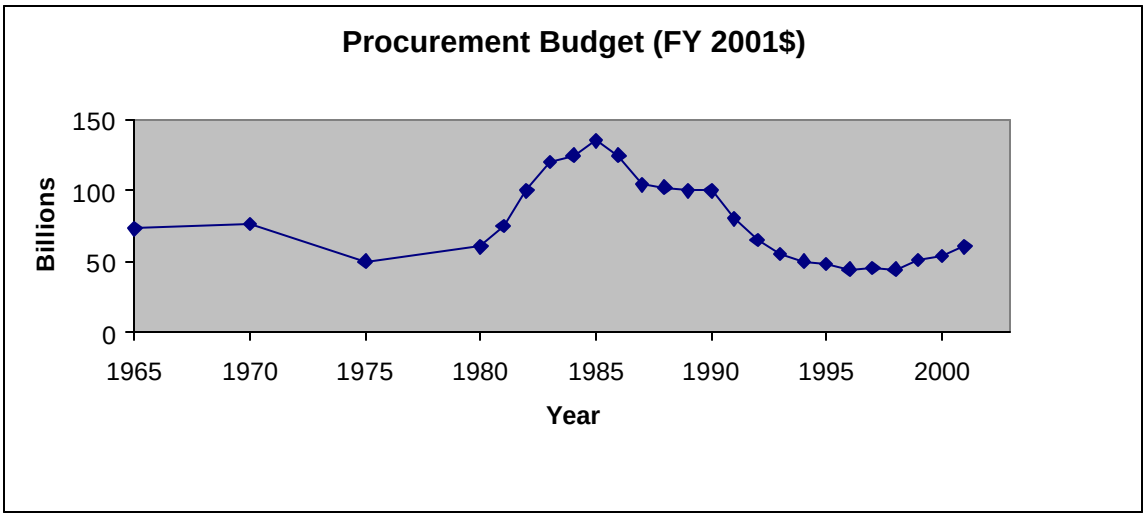

Figure 2.2 – Procurement Funding

Although the 2002 President's budget calls for future increases in the defense budget, there are no significant increases forecast in procurement, research and development. The declining budget placed tremendous pressures on defense spending, forcing DoD to rethink the way it procures weapon systems. Today, with the threat being uncertain and the enemy unknown, procurement, research and development dollars must be balanced against legitimate affordability concerns. These unknowns place tremendous pressure on the defense acquisition system to find ways to be efficient while

still providing high quality equipment and supplies to our armed forces. DoD goals are to achieve a more efficient and effective acquisition and logistics environment that will deliver high performance weapon systems and support to our warfighters in less time and at a lower total ownership cost. In order to meet these goals, the Department of Defense must increasingly rely on an integrated civil-military industrial base vice a defense unique industrial base. Currently, efforts are being made to adopt commercial best business practices as well as emerging technologies throughout the commercial sector in order to consolidated the two industrial bases into one.

The remainder of this chapter will focus on current acquisition reform efforts aimed at integrating the commercial and military sector of the industrial base and the importance of dual use technology strategy being employed by DoD.

B. ACQUISITION REFORM

For years, acquisition reform initiatives have focused on streamlining the acquisition process. Since the passage of the Federal Acquisition Streamlining Act (FASA) of 1994, the preference within the Federal Government has shifted from the acquisition of items developed exclusively for the Government to the acquisition of commercial items. FASA made it easier to buy commercial products and services and was necessary to take full advantages of available and evolving technological innovations. More recently, new initiatives have helped the reform take its full course and enhance the use of commercial items. One of these latest efforts is with the passing of the new 5000 series documents and the other is with doing away with Military Specifications (MILSPECS) and military standards.

1. New DOD 5000 Series Documents

Another significant acquisition reform effort, from the perspective of this thesis, occurred in 2000 with the release of the new DoD 5000 Series. The revision of these documents offers some solutions and flexible approaches to accelerate the acquisition

process. The application of relatively mature technology has allowed DoD to quickly bring innovative systems through the development cycle. This is designed to bring weapon systems into the field in fewer years (5-7) than the typical 10-12 years. The main factor this faster acquisition process is high priority placed on the use of mature commercial technology. It is reflected in the new DoD 5000 series which states:

> In response to user requirements, priority consideration shall always be given to the most cost-effective solution over the system's life cycle. In general, decision-makers, users, and program managers shall first consider the procurement of commercially available products, services, and technologies, or the development of dual-use technologies, to satisfy user requirements, and shall work together to modify requirements, whenever feasible, to facilitate such procurements. (www.web2.deskbook.osd.mil Sub-Paragraph 4.2.3)

Simply put, if DoD intends to field state-of-the-art systems in a cost-effective manner, then it must incorporate commercial items into these systems. In the past, our acquisition process and practices had three main challenges that caused it to be inefficient. First, the acquisition cycle took too long. On average, a program took ten to twelve years from identifying requirements to fielding. Second, our weapon systems cost too much. This is partly a result of the length of cycle time. In the past, it has not been unusual for weapon system requirements to be set so high that the initial estimate of the resources necessary to develop a weapon falls short of the mark. By the time these resources are obtain and equipment is fielded, we have normally paid twice or more than the amount estimated initially. Significant cost increases in weapon system programs can be traced to not having achieved this match between requirements and resources at program start (GAO Report, March 2001.) Third, the process is incompatible with modern technology cycles. By the time equipment reaches the warfighters in the fleet, some equipment will be obsolete. The newly revised 5000 series incorporates a mentality of evolutionary acquisition as a preferred acquisition strategy. It imposes time-based requirements and, for the first time, includes Total Ownership Cost (TOC) as a military requirement that drives industry design, procurement, and support. DoD TOC "is

comprised of costs to research, develop, acquire, own, operate, and dispose of weapon and support systems and other equipment and real property, the costs to recruit, train, retain, separate and otherwise support military and civilian personnel, and all other cost of business operations of the DoD" (DAB, 2001.)

In order to help clarify the goals of acquisition reform and the new 5000 rewrite, the former Under Secretary of Defense (Acquisition, Technology, & Logistics) released a statement in January 2001 saying, "To effectively provide our warfighters with the technological advantage to win future conflicts, we must uniformly look first to the commercial marketplace before developing new systems; upgrading legacy systems; or procuring spare parts and support services" (Gansler, 2001.) In order for us to take advantage of this opportunity, we have to vigorously study areas where commercial products and practices would be more economical and in the best interests of the Government.

The main focus of the new DoD 5000 is delivering advanced technology to warfighters, reducing total ownership costs improving affordability, and deploying interoperability and supportability systems, and more importantly, reducing cycle time. In short, it is designed to improve performance with higher quality at a lower cost in less time.

2. Requirements and Performance-Based Acquisition

Mission need is the preeminent concern in developing requirements documents. The Government has substantial latitude to describe its needs in terms that take advantage of the best industry practices available such as distribution and support options and methods for assuring reliability. The essential item/service characteristics defined during requirements identification should not change in other stages, such as market research and acquisition. Nevertheless, all members of the acquisition team must be open to evolving the requirements description and acquisition strategy as market research reveals a greater understanding of how commercial items may be used to satisfy mission needs.

In order to maximize competition, innovation, and interoperability, and to enable greater flexibility in capitalizing on commercial technologies to reduce costs, performance-based strategies for the acquisition of products and services shall be considered and used whenever practical. For products, this includes all new procurements and major modifications and upgrades, as well as the reprocurement of systems, subsystems, and spares that are procured beyond the initial production contract award. Government requirements are now stated in terms of measurable standards such as functions to be performed, performance required, or essential physical characteristics. This was a reversal of the long-standing policy which relied upon the use of military specifications (MILSPECS) and standards. This promotes the use of commercial items to fulfill the end-user's needs. Stating requirements in a performance-based manner rather than specifying exactly how the item should be manufactured, increases the possibility that previously unforeseen solutions available in the commercial marketplace will emerge to fulfill the mission requirements.

C. COMMERCIAL ITEM ACQUISITION

One of the main thrusts of the recent acquisition reform initiatives was to improve access to the commercial marketplace by making it easier for DoD to purchase commercial items. To the maximum extent possible, commercial acquisitions should be conducted using Federal Acquisition Regulation (FAR) Part 12. The use of FAR Part 12 is designed to provide the Department of Defense with greater access to commercial markets with increased competition, better prices, new market entrants, and access to leading edge technology. However, market research and analysis shall be conducted to determine the availability, suitability, operational supportability, interoperability, and ease of integration of existing commercial technologies and products and of non-developmental items prior to the commencement of a development effort (Commercial Item Handbook, 2001.)

1. Commercial Item Definition

The commercial item definition is broad and includes any item that is of a type customarily used for nongovernmental purposes that has been sold, leased, or licensed or offered for sale, lease, or license to the general public. (FAR, Part 12) Also included in the commercial item definition is any item that evolved from a commercial item as described above, through technical/performance advances, even if it is not yet available in the commercial market place, as long as it will be available in time to satisfy the Government's requirements.

A commercial item does not have to be "off-the-shelf" to be classified as commercial. Commercial-off-the-shelf (COTS) items are a subset of commercial items. The commercial items definition is much broader than products that are presently available off-the-shelf. Items that require modifications of a type customarily available in the commercial marketplace or minor Government unique-modifications still are considered commercial items. Commercial-off-the-shelf (COTS), non-development items (NDI), and Government-off-the-shelf (GOTS) items are related to commercial items, but the terms are not synonymous. Further, the fact that an item or service to be procured does not easily fit into the NDI or GOTS categories does not mean it is not a commercial item. (Commercial Item Handbook, 2001)

Additionally, the FAR definition of commercial item also includes services. A service is considered a commercial item when it is provided in support of an item that meets the commercial item definition, or when it is of a type offered and sold competitively in substantial quantities in the commercial market based on established market prices for specific tasks performed under standard commercial terms and conditions. Warehousing, garbage collection, transportation of household goods, and software design are examples of services that are commercial.

2. Commercial Item Determination

Because of their reliance on flexibility and the exercise of sound business judgment by Government acquisition personnel, commercial item policies and procedures rely heavily on the education, training, and professional expertise of acquisition personnel. A by-product of the reliance on business judgment is wide variation in interpretations and application of policies and procedures. The decision whether the Government's requirements for a specific acquisition can be met by a commercial item is based on market research and analysis of the marketplace.

Through in-depth market research, the agency must determine to what extent commercial items or modified commercial items will meet its requirement. When items available in the commercial market cannot meet the Department's need, DoD must determine whether market items can be or have been modified so that FAR Part 12 can be used. Two types of modifications are available: (1) modifications of a type available in the commercial marketplace; and (2) minor modifications of a type not customarily available in the commercial marketplace made to Federal Government requirements. (Commercial Item Handbook, 2001) For modifications of a type available in the commercial marketplace, the size or extent of modifications is unimportant as long as the item retains a predominance of nongovernmental functions or physical characteristics.

Acquisition professionals must begin each acquisition presuming the item/service to be procured (even if only at a sub-system level) is available commercially. Only after careful review of the commercial items definition and significant evidence that the item is not commercial, should they consider the item Government-unique. Once an agency determines that commercial items can meet its requirement, the agency can conduct an acquisition in accordance with FAR Part 12.

3. Common Misperceptions about Commercial Item Acquisitions

Some members of the acquisition community have expressed concern that FAR Part 12 contracts afford the Government less assurance that the acquisition will result in

receipt of a high-quality product. A well-planned and constructed commercial acquisition could provide greater protection from poor quality than a Government-unique contract provides. When a commercial market exists for a product, the Government should be able to choose from a range of items or services that provides the best value to the Government.

Additionally, a product does not have to be developed at private expense to be commercial. Even if the Government paid for development of a product, or a product had a military origin, a commercial market can subsequently develop for that product. The issue of who paid for development is not part of the commercial item determination.

Along these same lines, the presence of unique Government requirements does not, in and of itself, mean an item is a Government-unique item. (CommItemHandbook, 2001)

4. Risks with Commercial Items

Although Federal Acquisition Streamlining Act (FASA) of 1994 eliminated regulatory barriers to buying commercial items, the risk of departing form MILSPECS must be considered. Commercial products must be able to perform in a military environment that may be more stressful on the component or system than in a commercial environment. If the risk is low and substitution possible, then commercial units will generally be less expensive. Program offices can be successful by deliberately pre-planning for frequent upgrades of commercial items, technology insertion, and retirement of obsolete items.

There are no commercial panaceas when dealing with commercial items. While there are significant benefits, these benefits can be attained only by understanding and addressing the significant new challenges that are driven by the fundamental differences between building items and buying them. It must also be emphasized that the risks associated with traditional system development do not go away simply because the system makes use of commercial items. Lastly, no matter how much a system is

supported by commercial items the overall system still must be engineered, developed, integrated, tested, delivered, sustained and managed (Commercial Item-Lessons Learned, 2000).

D. DEFENSE INDUSTRY AND ITS INDUSTRIAL BASE

Along with tightening budgets, a shrinking defense industrial base has forced the Department of Defense to make significant changes in the way it acquires weapon systems. One objective of acquisition reform initiative is to integrate commercial and military industrial bases to minimize costs and improve efficiency.

Defense acquisition encompasses a variety of activities. On one end on the spectrum, DoD procures relatively small quantities of major weapon systems consisting of complex and expensive subsystems. At the other end lies procurement of commercial products characterized by large quantities of standard items with a relatively low unit cost. Defense manufacturing processes are often quite different from the processes common in commercial manufacturing. Traditionally, defense markets are small in scale and exhibit both monopsony (one customer) and monopoly (one provider) characteristics. Defense industry processes are often low-volume and labor intensive where designers emphasize performance of the products. In sharp contrast, a primary concern for a commercial firm is to design the product for producibility on a highly automated, high-volume production line. The commercial sector realizes reduced prices through economies of scale by mass production. Commercial manufacturers also contend with market and competitive forces that affect price. Another advantage in the commercial marketplace is that the market rewards the innovative manufacturer who makes quality products efficiently. The result of these processes lead to lower, stable prices, fast delivery of products, and satisfied consumers.

Defense products are designed and built primarily in defense-specific plants or in isolated divisions of larger corporations. Many commercial companies often segregate themselves from their defense counterparts to avoid the requirements unique to Government contracting. Commercial companies simply cannot afford to change their

practices to comply with Government requirements. Changing practices would often mean sacrificing their competitive position in the commercial marketplace.

The defense industrial base consists of the prime contractors and multiple tiers of subcontractors that can develop and build defense weapon systems. Recently, many vendor defense contractors have merged, and others have focused their efforts away from the defense industry due, in part, to the declining business base. Defense contractors have experienced the same downsizing pressures that the Government and military have endured throughout the past several years. The smaller and restructured industrial base has resulted in less competition, higher pricing, and a slowdown in innovation. As the budget declines, affordability of future systems is becoming more and more important. The budget cannot continue to support the defense-unique industrial base. In turn, with smaller procurements, DoD business alone is not sufficient to keep many defense-unique suppliers in business. Therefore, many acquisition professionals believe that DoD must rely on the commercial industry to provide a significant portion of DoD's supplies and services (Skibbie, 2001.)

1. Civil-Military Integration

In one of his last speeches delivered before leaving the office of Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), Dr. Jacques Gansler stated:

> While the many mergers and acquisitions have been both necessary and desirable, there is a growing concern that we may end up with only sole source producers in critical defense sectors, thus eliminating the innovation, cost, and responsiveness benefits of competition. A solution likely lies in a broadening of the defense industrial base to include commercial firms. (USD(AT&L) www.acq.osd.mil)

The Office of Technology Assessment (OTA) defines civil-military integration as the process of merging the Defense Technology and Industrial Base and the large Commercial Technology and Industrial Base into a unified National Technology and Industrial Base. (www.wws.princeton.edu) Civil-Military Integration can occur through conversion of existing defense plants to commercial products, diversification of defense companies into commercial product lines, or dual-use technology where a single production line can produce both civilian and military components. Such actions will bring in commercial firms and reward all firms for high performance and lower cost and save DoD billions of dollars each year.

Additionally, the benefits of integrating commercial and military production bases includes a wider base (both commercial and military combined) that, in concept, will better serve surge requirements. To achieve this, DoD must reduce or eliminate, where practical, those unique terms and conditions including unique Cost Accounting Systems (CAS) and revert to Generally Accepted Accounting Procedures (GAAP). This will not only improve the department of defense's ability to get goods and services faster, better and cheaper, but will also help our domestic industrial markets. Secretary of Defense Donald Rumsfeld recently stated, "Until we break this habit [CAS], we automatically exclude a large porting of the commercial industry to whom the CAS are anathema" (Skibbie, 2001.)

2. Dual-Use Technology

Dual-use strategy is an attempt by DoD to integrate the military technology and industrial base with that of the commercial sector by using more commercially available components in its systems or using commercial production lines to manufacture unique military components. DoD initiated the Dual-Use Science & Technology (DUS&T) program in 1997 to increase the use of dual-use technologies in defense systems. The program has two primary purposes. The first is to jointly develop dual use technologies with industry. The second is to embed the concepts being developed under this and

earlier dual use programs in DoD and make the development of dual use technologies with industry a standard way of doing business throughout the DoD.

Dual-use technology is defined as an application that has both military and commercial uses. Dual-use technology is a key component in DoD's investment strategy for maintaining the performance superiority and affordability of U.S. military forces in this new technological and economic environment. It is a two-way program to help defense firms enter the commercial market and firms enter the defense market. It is either 1) technology developed by the Government (DoD, defense contractors, etc.) which is shared with commercial industry or 2) technology developed by the commercial sector which is then utilized by the Government. In past years, dual-use has been normally viewed as a Government-to-commercial industry relationship. However, with the changes in the defense industry and advancing technologies in the marketplace, the reverse has been occurring. Elements of the dual-use technology strategy serve to:

- ***Ensure*** that key elements of the domestic commercial technology base that are critical for national security remain at the leading edge;

- ***Support*** the transitioning of defense-sponsored technology and the integration of military production with the commercial base; and

- ***Facilitate*** insertion of commercial technologies into military systems.

Moreover, some of the largest acquisition programs such as tanks, submarines, and nuclear warheads do not have parallel demand in the commercial market. Therefore, acquisition and program management of these types of systems would not become overly dedicated to the DUS&T program. There are, however, other types of systems such as trucks and communications that do have parallel demand in the commercial sector.

Additionally, there are many components of unique military systems that could be dual-use in nature.

There are numerous examples of projects which are implementing DoD's dual use technology policy. For example, the Air Force's Military Products from Commercial Lines pilot program is demonstrating the commercial manufacture of military electronics modules. Rather than being produced on a dedicated military line, the tactical fighter's (Air Force's F-22) and advanced helicopter's (Army's Comanche) electronics boards will be processed on a commercial automotive manufacturing line. Incorporation of commercially produced military avionics on military aircraft will dramatically reduce the cost of electronic suites by taking advantage of economies of scale and automated manufacturing processes. This has resulted in 30 percent to 50 percent savings and a product that actually exceeds the requirement for operating in a high-temperature environment. (Openshaw, 1998) By increasing the use of dual use technologies in defense systems, DoD can take advantages of the same competitive pressures and market driven efficiencies that lead to accelerated development and cost savings in the commercial sector.

3. Maintaining Competition

Maintaining competition is important because it clearly influences costs. When a contract award or a funding of a single program will result in only one contractor remaining in any critical area (prime or sub), the DoD (as the sole buyer of weapons systems) must consider ways to maintain the potential for future competition. In many programs, this means carefully considering industrial base concerns as a key ingredient in shaping the acquisition strategies.

Competition is critical for providing innovation, product quality, and affordability. All DoD Components shall acquire systems, subsystems, equipment, supplies and services in accordance with the statutory requirements for competition. Competition provides major incentives to industry and Government organizations to reduce cost and increase quality. The Department must take all necessary actions to

promote a competitive environment, including 1) examination of alternative systems to meet stated mission needs, 2) structuring Science and Technology investments and acquisition strategies to ensure the availability of competitive suppliers throughout a program's life and for future programs, 3) ensuring that prime contractors foster effective competition for major and critical products and technologies, and 4) ensuring qualified international sources are permitted to compete. (DoD 5000 Deskbook, 2001) Acquisition, technology, and logistics decisions shall be made with full consideration of their impacts on a competitive industrial base, including not only the prime contractor level but also the subcontractor level.

Currently, there is only one sole supplier of High Mobility Multipurpose Wheeled Vehicle (HMMWVs) for DoD. It is the AM General Corporation located in South Bend, Indiana. AM general has been the sole HMMWV producer since its initial contract with DoD in 1985. Based on lack of competition the HMMWV has received in the past, with projected future quantities less than what the Army procured historically, there is a risk of not receiving competition of future requirements, especially with other contractors competing against the incumbent vehicles manufacturer. A sole source contract with the incumbent HMMWV manufacturer may increase the risk of gaining a reasonable vehicle price.

If DoD does not have a competitive defense industry, it looses out on both major weapon system objectives of affordability and high performance. Even though the HMMWVs are meeting all aspects of performance as stated in the ORD, their procurement costs have been escalating. Thus, it is both the government's responsibility and in the government's best interest to encourage a competitive, healthy, and technologically advanced defense industrial base. (www.acq.osd.mil)

4. Affordability

Performance at an ***affordable*** cost is especially important today. Cost is a requirement that must be considered at every stage of our acquisition process while still continuing to meet essential weapon system performance. With the reduced budget, it is

no longer economically viable to have a completely separate military and commercial base. By integrating the two industrial bases, DoD can exploit the market-driven efficiencies of the commercial sector.

E. THE NATIONAL AUTOMOTIVE CENTER

The DUS&T program jointly funds research projects with industry for the development of dual-use technologies. One such venture, which will be the focus of this thesis, is with a current dual-use program sponsored by the National Automotive Center (NAC). The National Automotive Center (NAC), founded in 1992, is the Tank-Automotive and Armaments (TACOM) focal point for the development of dual-needs/dual-use automotive technologies and their application to military ground vehicles. The NAC accelerates the use of these technologies by fostering relationships and forming cost shared programs that link Government, industry and academia. Its primary focus is to benefit current and future military ground vehicle systems through performance improvements, service life extensions, and reduction in ground vehicle life cycle costs.

The NAC is the Army's principal conduit for development of dual-use vehicle technologies. By supporting cost-shared partnerships for the development of new vehicle technologies, the Army is able to integrate its requirements into the design, lower the cost of development, and tie its requirements to the commercial marketplace, thus lowering the cost of acquisition, maintenance and parts replacement. For fiscal year 2001, the NAC had eight Dual Use Science and Technology proposals accepted with a total budget of $56 million.

The establishment of the NAC in southeast Michigan places it among 96 major automotive research and development centers including Chrysler, Ford, General Motors, Honda, Hyundai, Mazda, Nissan, Saturn, Toyota and Volkswagen. In addition to these organizations, over 85% of the nation's automotive supplier technical centers are located in Michigan. With over 60% of U.S. automotive engineers living and working in Michigan, the NAC resides in the heart of a concentrated source of automotive expertise unmatched anywhere in the country.

As a result of collaboration and partnering with industry, last year the National Automotive Center (NAC) unveiled its first Commercially Based Tactical Truck (COMBATT) demonstration vehicle. This innovative approach to dual-use technology will adapt a commercial pick-up truck to perform some missions now assigned to the High Mobility Multipurpose Wheeled Vehicle (HMMWV). This basis of this program will be explained in detail in later chapters.

F. SUMMARY

We are in an era of unprecedented change in the make-up and nature of the national and defense industrial bases. Dramatic changes in the world threat combined with the declining defense budget have forced acquisition professionals to rethink the way DoD procures its weapon systems. During the past few years, the Department of Defense has embarked on an ambitious and challenging acquisition reform effort.

Acquisition reform initiatives have focused on making it easier for DoD to procure commercial assets. Tapping the commercial market is an important step towards integrating the commercial and military sectors of the industrial base. New acquisition policies have been geared to achieving that objective. We must expand the use of commercial items in the Department of Defense systems so we can leverage the massive technology investments of the private sector reaping the benefits of reduced cycle times, faster insertion of new technologies, lower life cycle costs, greater reliability and availability, and support from a robust industrial base. To accomplish this, we must capitalize on the technical advances in the commercial market place by carefully reviewing our specifications to determine where they can be altered to enable the Department of Defense to leverage the commercial sector.

The bottom line is that our traditional processes and strategies for acquiring, developing, fielding and supporting weapons and business systems must now be adapted to the modern world. The next chapter discusses how the industrial base was first called upon in acquiring the first light tactical vehicles: Military Jeeps.

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III. THE EVOLUTION OF THE MILITARY LIGHT TACTICAL VEHICLE

A. THE ORIGINAL JEEP

The history of the light tactical vehicle spans over 60 years. The original truck, General Purpose (GP) or Jeep was born of necessity and hand-built in just seven weeks. As early as World War I, the U.S. Army looked for a fast, lightweight reconnaissance vehicle. The Army wanted a universal vehicle to replace the aging motorcycles with sidecar from WWI. In the early 1940s, the need to rapidly develop this vehicle became more urgent as the Axis powers scored victories in Europe and Northern Africa. The Army put out a call to automobile manufacturers asking for a prototype for such a vehicle. This vehicle had to meet certain military specifications: such as a payload capacity of 600 pounds, wheelbase under 75 inches, fold-down windshield, gross vehicle weight less than 1200 pounds, and four-wheel drive. Of 135 companies invited to compete in the contest, only three companies entered, American Bantam Car Company, Willys-Overland Motors, and Ford Motor Company. (www.storm.ca/~seanm/miljeeps/history.html)

American Bantam Car Company was the first to submit a design within the required time (49 days) and was awarded the initial contract of 70 jeeps. The prototype vehicle, called the 'Bantam', was delivered to the Army in September 1940. Willys-Overland produced their model called 'Quad' and delivered it to the Army on November 13, 1940. Although heavier and more powerful, it was otherwise virtually identical to the 'Bantam'. Ford produced their model called 'Pygmy', and delivered it to the Army in December 1940. It also resembled the 'Bantam'. Many suspected that Willys-Overland and Ford were both given access to Bantam's blueprints by the U.S. Army. American Bantam protested, but nothing came out of it. Nevertheless, there were some concerns about American Bantam's limited production capability after the first 70 vehicles were produced given the emerging need for a very large number of these vehicles. As a result, a political decision was made in March 1941 that all three companies would receive an initial order for 1,500 vehicles each, provided that they met the original specification.

In July 1941, the military decided that standardization was needed amongst the three designs. It was impractical to operate and maintain three different designs.

During initial testing, all three vehicles performed well but it was decided that Willys-Overland's design represented the best overall value for the money at $739, compared with $1166 for a 'Bantam'. Willys-Overland's vehicle, called 'Willys' by servicemen, were adopted as the standard Army vehicle and secured the contract to provide the next 16,000 vehicles. Although American Bantam Car Company was the first to design and build jeeps for the Army, their role in Jeep history ended after their initial delivery of vehicles. By the end of October 1941, the Army was keen to find a second source of supply for two reasons: 1) Willys-Overland could no longer keep up with the growing demand for jeeps, and 2) there was the need to safeguard the supply of jeeps against the Willys plant being bombed or sabotaged. Therefore, in early November, Ford was awarded an additional contract to build 15,000 jeeps to the Willys design specification. Willys-Overland and Ford would land many follow-on contracts for jeeps. In fact, during World War II, Willys and Ford filled orders for more than 700,000 of these vehicles.

The Willys' jeeps were the heroes of World War II. They served in every theater of war, in every conceivable role and with every allied army. Jeeps changed the way Americans looked at the automobile and added a new word to our vocabulary. After the war, there was a considerable demand for the jeep. Servicemen were so impressed that many wanted jeeps of their own after returning home. Minor alterations to the transmission, transfer case, axle ratios and steering made it available and more desirable for the domestic market. (http://ourworld.compuserve.com/)

With the outbreak of the Korean conflict, Willys-Overland designed an improved version of the WWII Jeep, the M38 utility truck and its later version the M38A1. In all, over 150,000 vehicles were produced, including 5,000 M170 front line ambulances in which the basic body and chassis of the M38A1s were extended to accommodate litter patients.

The military jeep known as the M151, came as a result of Ford Motor Company being awarded the contract for development of replacements for the aging military

vehicle fleet of WWII and Korea. It began in 1951 under a program known as the Military Utility Tactical Truck Project (MUTT). It became known as a most reliable vehicle suitable for multipurpose roles and applications. The MUTT became standardized for American and allied countries in 1960 and was the replacement vehicle for the M38A1. The M151 is a large departure from previous jeeps, both in looks and design. This Vietnam-era Jeep featured a split windshield and a horizontally-slotted stamped steel front grille. Although larger in size, the M151 was the same weight as a World War II jeep. Along with Ford, Kaiser Company (former Willys-Overland) and AM General also manufactured M151s during the 1960s. (www.texasmuseum.org) Figure 3.1 below displays a brief history of the first light tactical vehicles.

1940 - American Bantam Car Company awarded contract for the first four-wheel drive, ¼ ton utility truck. American Bantam produced only the initial 70 units. The "Bantam" is the undisputed first "jeep."
1941 - Subsequent jeep contracts were given to Willys-Overland and Ford. The Willys' "Quad" marked the beginning of Willys' dominance of the series. Ford built the "Pygmy" which was the third of the vehicles involved in the fierce, three-way competition that marked the opening chapter of the Jeep legend. During World War II, Willys-Overland and Ford filled more than 700,000 orders for the Army.
1950 - Willys-Overland built improved Jeeps, the M38 and M38A1, that were used in the Korean War. A total of 61,423 M38s and 101,488 M38A1s were produced in all.
1960 - Ford begins producing the M151 "Military Unit Tactical Truck" (MUTT) to replace the M38A1s. Kaiser Jeep (former Willys-Overland) and AM General also produced M151s. Of the 120,000 total produced during the Vietnam era, AM General produced 95,000 of them.
1981 - HMMWV contract awarded to AM General in 1981 with production starting in 1983. Since then, more than 150,000 HMMWVs have been delivered to the U.S. Armed Forces and over 30 friendly overseas nations. The HMMWV is recognized throughout the world as the most durable and most serious 4X4 wheeled vehicle with credible combat experience in Panama and the Persian-Gulf War.

Figure 3.1 – Brief History of the Light Tactical Vehicle

B. MODERNIZING THE FLEET

The end of an era came to a close in 1981. "The combat experience of the 1970's, together with the changing methods of conducting land warfare around the world, called for a comprehensive wheeled combat system that would be air transportable, versatile, reliable, maintainable and survivable. This is what the U.S. Armed Forces wanted in the design of the new M998 Series, 1-1/4 ton, 4x4 multipurpose vehicle. In 1981, three major U.S. companies set about developing such a vehicle to meet these requirements. The result: On March 22, 1983, AM General was awarded a contract for the production of the Highly Mobile Multi-Purpose Wheeled Vehicle (HMMWV), dubbed the Hummer." (McGrady, 1999)

The armed forces ended their orders for jeeps and a new vehicle was ushered in, the HMMWV. The HMMWV, which isn't referred to as a jeep, original design shows how far automotive design has progressed since the original 'Bantam'. Known officially as the M998 series and nicknamed 'Hummer', this vehicle satisfied the need for superior mobility in a tactical field environment. It is versatile, mobile, and fast, and replaced most M151s and an assortment of other vehicles to include all M274s (1/4-ton Mules), all M561s (1-1/2-ton Gama Goats), and some M880s (1-1/4-ton pick-up trucks). It has symbolized the modern Army just as the Jeep symbolized the Army during WWII.

The initial contract awarded to AM General Division of LTV Aerospace and Defense (now AM General Corporation) was executed over five years, producing 55,000 vehicles for a sum of $1.2 billion (www.amgeneralcorp.com.) AM General is the world leader in the design, engineering and production of military and special purpose vehicles, with more than 60 years of experience. Since production of HMMWVs began in 1983, the company has delivered more than 150,000 of the versatile, 4-wheel drive vehicles to the U.S. Armed Forces and over 30 friendly overseas nations.

The HMMWV is the cornerstone of the contemporary light tactical fleet. It has been in continuous use since initial production in 1983. It meets the basic needs for troop transport, cargo hauling, ambulance services, and serving as a prime mover for towed equipment. Originally designed as a weapons platform for vehicle mounted machine

guns, anti-tank and anti-aircraft missiles, it is more than what is needed for many garrison missions. There is some consensus that the HMMWV is overbuilt for many mundane daily chores, such as hauling troops and general cargo.

The Army is the lead service for HMMWV development and procurement. The HMMWV serves in many roles and is used throughout the Army, Air Force, Navy and Marines at more than 350 locations worldwide. The HMMWV has been living with the 'commonality ' concept over the past years. The HMMWVs have common power train, subsystems, and chassis in order to have a logistical advantage of common parts, maintenance tasks, and special tools. This concept ensures that the HMMWV is sustainable on the battlefield. Additionally, commonality of parts reduces the amount of spare parts the force must stock to ensure the readiness of the vehicles.

The Army purchased a large number of HMMWVs early in the acquisition cycle during the early 1980s. These earlier vehicles (Block 1s) are now approaching 20 years of age. Many are as old as their drivers. As the Department of Defense conducts upgrades and Extended Service Programs (ESPs), the HMMWV fleet becomes even older. The Economic Useful Life (EUL) of the HMMWV is 15 years. However, most vehicles are pushed to 20 years or more. The Economic Useful Life (EUL) serves as the timeframe for replacing or upgrading the current fleet to prevent obsolescence defined as reaching the end of useful life, and no longer mission capable. The 15-year EUL of the HMMWV used throughout this thesis is based on Tank Automotive and Armaments Command (TACOM) Fleet Planning Office (FPO) analysis of HMMWV (M998) fleet data.

With many of our HMMWVs approaching their end of service life, the cost to maintain these vehicles has increased accordingly. Historically, an aging fleet is likely to produce increased O&S costs. In the Army and Marine Corps today, operating forces have aging vehicles with increasingly expensive Operation and Support (O&S) costs. This practice is directly contrary to Army goals and policies. Vehicles aging affect operational readiness as obsolescence reduces the number of available mission capable systems. By FY03, over 50% of the HMMWVs in the fleet will exceed their 15-year Economic Useful Life (EUL) (McGrady, 1999)

1. Acquisition Strategy

In 1998, Congress directed that the Army conduct an analysis to provide analytical insights and underpinnings that support the Army's strategy for acquiring and supporting the light tactical vehicle (LTV) fleet through FY 2020. This strategy focuses on maintaining current HMMWV production; modernizing the fleet; and recapitalizing the Army's initial investment in the aging fleet through an Extended Service Program (ESP) (McGrady, 1999.)

The current HMMWV procurement strategy is to maintain production with seven-year, iterative modernization upgrades (PM-LTV, 2001.) Today's light fleet modernization centers on continued production of the HMMWVA2. Along with the A2s, current production activities focus on the Heavy HMMWV for customers needing to place a variety of systems onto the HMMWV chassis. The other piece of production is the Up-Armored HMMWV. This variant, the M1114, is for units requiring upgraded mine and ballistic protection. Currently, a shortage exists in these two variants in the Army today. Therefore, this part of the strategy is for attaining the proper balance of these two HMMWV variants Army wide.

The second part of the strategy is the modernization piece. The modernization component calls for competition for a new contract every seven years (five year multi-year plus two additional option years) with the vehicles integrating all available technology improvements to meet the new HMMWV ORD. The upgrade from the A2 model will be a block improvement program to produce a more capable HMMWV without performing a major redesign of the vehicle. There are things that will be added such as, an anti-lock breaking system, and sound-proofing the interior of the vehicle. The user requirement for the HMMWV has necessitated the request for improved capabilities of the HMMWV. As of the writing of this thesis, a TRADOC approved HMMWV ORD, is on its way up for Department of the Army approval. The current version of the ORD sets the stage for what the next generation HMMWV will be. In the next seven-year upgrade, which will start approximately six years from now, the Army will focus on those key performance parameters that they will need to meet Force XXI

objectives. As the Army After Next (AAN) requirements and technology evolve, the need for a new system emerges. It is intended that this process be continued and updated in approximately seven-year cycles and the ORD requirements updated to keep pace with military needs.

The third component of HMMWV modernization strategy focuses on the recapitalization. This phase focuses on all the aged HMMWVs between 12-13 years old. The objective of the recapitalization program is to extend the life of the over-age HMMWVs by 21 years while enhancing performance and minimizing O&S cost. An Extended Service Program (ESP) for the HMMWVs is scheduled to commence in FY05, when the average age of the vehicles will be 17 or 18 years old. However, as of the writing of this thesis, no production dollars have been approved for the HMMWV recapitalization.

2. Next Generation HMMWV

In October of 2001, Training and Doctrine Command (TRADOC) reassessed the Army's operational requirements for HMMWVs and approved the HMMWV Operational Requirements Documents (ORD). The intent of the ORD update is to incorporate light tactical fleet changes occurring since the last HMMWV ORD was published in 1998. It is currently being reviewed at HQDA Deputy Chief of Staff for Operations and Plans (DCSOPS) for approval. This ORD identifies capabilities not found in the current HMMWV and which are required to meet the needs of the future battlefield. Some of these requirements are stated in the passage below:

> As the Army transition to the Interim Force and the Interim Brigade Combat Teams (IBCT), a critical need exists for a highly mobile, multi-capable light tactical wheeled vehicle capable of transporting greater payloads than the originally fielded HMMWVs, while attaining the performance (mobility and transportability) levels of the originally fielded HMMWVs. This vehicle is required for Interim and current forces and will be present as the Army transitions to the Objective Force. This multi-capable vehicle will be employed throughout the entire battlefield; although it's primary anticipated use is by selected units at division level

> and below which have an operational requirement to routinely and customarily operate in off-road and cross-country environments, and by units that routinely conduct route reconnaissance and classification. It will function as a deployable, mobile platform for numerous systems that contribute directly to the warfight (HMMWV ORD.)

The updated ORD is intended to articulate thresholds that focus on reflecting realistic requirements for today's fleet and objectives that reflect the requirements necessary to meet projected Force XXI requirements. Program risks associated with this strategy being applied to the existing HMMWV are that KPPs may not allow sufficient flexibility to meet cost objectives. There is risk that without careful consideration, interrelated requirements will result in actual physical impossibilities.

C. COMMERCIALLY-BASED TACTICAL VEHICLE PROGRAMS

In dire need to replace dilapidated jeeps in the early 1980s, the U.S. Army bought commercial pick-up trucks along with HMMWVs. Introduced in 1983, the Commercial Utility Cargo Vehicle (CUCV) met the military need for a commercially based tactical support vehicle. The CUCV is a commercial non-development item based on the full-size Chevrolet pick-up and Blazer. It is a 5/4-ton, 4X4 vehicle with cargo, shelter, and ambulance variants.

Originally, the CUCV was designed to replace the M880 gas-engine commercial vehicles that were fielded in 1976. It also was intended to augment the HMMWV in replacing the high density of M151s throughout the services. The HMMWV Joint Mission Element Need Statement (JMENS) of 1980 appears to have been the MNS for the CUCV which called for the Army to procure commercial vehicles as "substitutes for those wheeled vehicles in the ¼ thru 1-1/4 ton category whose mission or role will permit, and ruggedization is not required, and whose replacement by a HMMWV is not cost effective." (Welker, 1980) After being procured and fully fielded, it became apparent that some of these CUCVs didn't perform sufficiently in some of the units they went to. Many went to combat and combat support units where a more robust and mobile vehicle was required for tactical movements. Nonetheless, the CUCV was new, the jeeps

were old, and some planners mistakenly sent them to front-line units that needed a 4X4 vehicle.

During Operation Desert Shield/ Storm of the Persian-Gulf War in 1990, some of these vehicles were sent to the front line combat support units in the deserts of Southwest Asia and the results were disastrous. The CUCVs exhibited insufficient cross-country mobility and were unable to keep up with the tactical movement of other military trucks. These trucks were essentially commercial pick-up trucks with camouflage paint. They were not robust enough for significant off-road operations. In turn, the CUCV suffered a bad reputation for two reasons: 1) the performance gap between the CUCV and the HMMWV was significant, and 2) it was fielded to units that should not have had it. The CUCVs have since been relegated to primarily on-road service in non-maneuver elements because of its limited mobility and unsuitability for military operations in severe or hostile environments. Even though it was later realized that it was a fielding error which caused CUCVs not perform to their capability, this bad reputation has been carried over into the current acquisition strategy that consciously omits buying any commercial vehicles for the light tactical fleet.

MACOM	**DENSITY**
U.S. Army Special Operations Command	18
U.S. Army Reserve	4,993
U.S. Army Europe	467
Forces Command	154
Army National Guard	11,270
U.S. Army Pacific	65
U.S. Army Europe	25
Training and Doctrine Command	571
U.S. Army South	1
U.S. Army Material Command	544
Total	**18,108**

Figure 3.2 – Major Army Commands Density List of CUCVs

(From OPMIS Relational Database, 2000)

Less than 50% of the original Army fleet remains in service. Today, about 88% of the CUCV fleet is in the Army National Guard or reserve component or storage, and less than 1% of the Army's overseas fleet of light tactical vehicles is comprised of the CUCV. (TACOM Fleetbook, 1998) Figure 3.2 above shows the density of CUCVs at major Army commands:

The CUCV is at the end of its economic useful life. Many CUCVs are not being replaced after being retired. This is creating a readiness problem for some units due to not having any 4X4 capability. The current breakout of the light tactical vehicle fleet of HMMWVs and CUCVs are shown in Figure 3.3. The HMMWVs make up about 84% of the fleet today and CUCVs make up about 16% of the fleet as depicted in Figure 3.3 below:

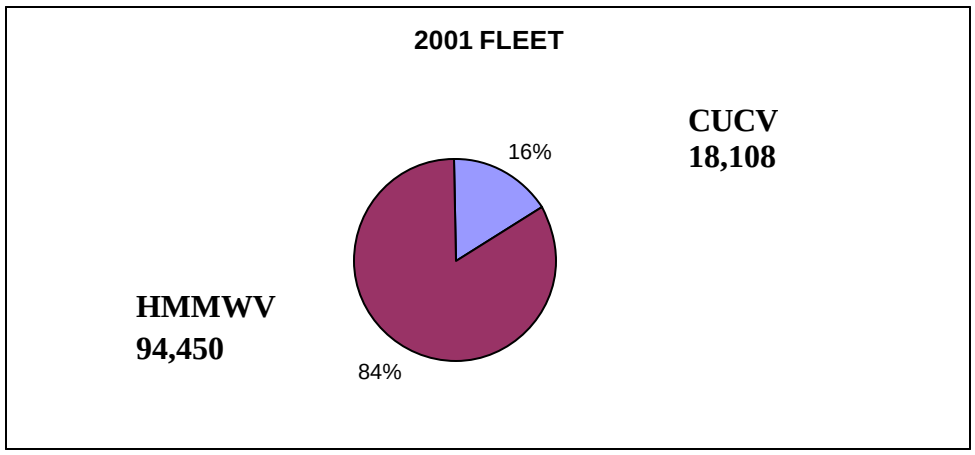

Figure 3.3 – 2001 Light Tactical Fleet

From 1983 to 1986, General Motors Corporation delivered over 70,000 CUCVs to armed forces in the US and overseas. There are still over 18,000 of these vehicles, now 15-17 years old, in the light vehicle inventory. These vehicles are now outdated, don't have sufficient mobility or capacity for many military needs. They, as well as the thousands of over-age HMMWVs, will soon have to be replaced by newer vehicles. In 1990, the DCSOPS directed that all units below Corps level be "pure-fleeted" with the

HMMWV due to the limited mobility of the Commercial Utility Cargo Vehicle (CUCV). Then, in 1996, the DCSOPS directed that the entire fleet be "pure-fleeted" with the HMMWV which has become the mainstay of the Army's light tactical vehicle fleet (McGrady, 1999a.) It was directed that the entire light vehicle fleet be "pure-fleeted." Based on this pure-fleet strategy, the CUCV requirements will be eliminated and all light vehicle requirements will become HMMWV requirements. CUCVs are expected to be eliminated from the fleet by 2003. (TACOM Fleetbook, 1998)

D. A RAPID ACQUISITION SUCCESS MODEL

Acquiring commercial vehicles is nothing new. The military has acquired commercial light vehicles with contracts that included commercial logistics support. The Army Rangers currently use the British made Land Rover Defender Model 110 as its Ranger Special Operations Vehicle (RSOV). The RSOV was originally fielded in 1992 as a replacement for the M151 series jeeps. These vehicles provide each of the three battalions in the U.S. Army's 75th Ranger Regiment with a versatile, multi-configuration tactical transportation platform capable of moving Rangers and their equipment in a variety of operational environments.

The Marine Corps has successfully procured a commercial vehicle to replace its last remaining M-151s Fast Attack Vehicle (FAV) that are deployed with its Marine Expeditionary Unit (MEU) forces. The Marine Corps needs capability for fast attack vehicular maneuver when operating in the littorals. Therefore, in May of 1999, a search commenced for an interim vehicle. The Interim Fast Attack Vehicle (IFAV) is a short term (1999-2003) commercially procured item that addressed the need for a diesel powered, helicopter internally-transportable solution. The IFAV overcomes the deficiencies of safety, lack of speed, difficulty in maintenance and use of gasoline as a fuel that existed in the old M-151 vehicle.

The Statement of Need (SON) letter was signed in May 1999 for an interim replacement. The market research focused on rapid acquisition to meet the requirement, making maximum use of best commercial practices outlined in the Federal Acquisition

Regulations (FAR) Part 2 and 12. In June 1999, the announcement went out to commercial vendors for an open firm-fixed price contract for sixty-two IFAVs. They were obtained through a competitive bid process that required a commercial-off-the-shelf vehicle that could be ready for use quickly. Two weeks later, the contract was awarded to Advanced Vehicle Systems of Washington, D.C., a contractor for Daimler-Chrysler, for a commercially modified version of the Mercedes long bed version of the MB290 GT. The Mercedes MB290 GT is world-class, high quality four-wheel drive off-road vehicle. The Marines' version, called the 'Gelundeswagon' is a cross between a World War II vintage jeep and a mini-pickup truck.

The entire contracting process took less than 60 days from receipt of the IFAV requirement to award. In December 1999, AVS had modified and delivered to the MEUs, all 62 vehicles built at the production facility in Graz, Austria. The entire procurement and fielding effort took less than seven months from requirement generation to throughput of delivery. These vehicles were hurried to deploying combat units as a replacement for the M151 jeeps, which had been notoriously hard to maintain and prone to roll over. In this age of acquisition reform, this was a success story for the acquisition community. It raised the bar to a new level and provided the benchmark for non-wartime procurement. The IFAV was procured more quickly than any previous combat vehicle in the Marine Corps. Using commercial business practices, the acquisition program for the IFAV was condensed from the typical ten or more years down to the span of six months. The Marine Corps has procured and fully fielded a quality commercial based tactical vehicle at a price 33% lower than originally envisioned, with full contractor logistics support (www.acq-ref.navy.mil.)

Currently, the Marine Corps is looking for a permanent replacement for the IFAVs in which the final solution will be called Internally Transportable Vehicle (ITV). Using more normal acquisition methods, these vehicles are not expected for more than three years.

E. SUMMARY

For a period of over 60 years and three major wars in all, the Jeep established a record of reliability and proven performance under a wide range of operational areas worldwide. It will go into military transportation hall of fame as a vehicle which served its country well. The HMMWV ushered in a new era much like the original jeep experience back in the early 1940s. It has no peer in sight for the foreseeable future. Vehicles with commercial heritage such as the CUCVs have shown that they can also complement the light tactical fleet by taking on some of the on-road missions and diverting the more strenuous ones for the HMMWV. Nevertheless, some HMMWVs and most CUCVs are approaching 20 years of service and are in need of retirement or replacement. The Marine Corps' IFAV program has provided valuable lessons for follow-on programs and has set new standards for rapid, streamlined commercial procurement of tactical vehicles.

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IV. THE COMBATT PROGRAM

A. INTRODUCTION

The National Automotive Center (NAC), which operates under the Army's Tank-Automotive and Armaments Command (TACOM), serves as a liaison between the Army and the commercial auto industry. One of NAC's missions is to help the Army modernize its vehicles by adopting state-of-the art commercial technology from the civilian sector. Last year, the National Automotive Center (NAC) unveiled its first Commercially Based Tactical Truck (COMBATT) demonstration vehicle. COMBATT is a two-year-old program managed by Veridian-ERIM International of Ann Arbor, Michigan. The program tests the viability of ruggedizing up commercial pickup trucks for military uses such as carrying general cargo and troops. Its objective is to modify a pickup truck to perform some of the missions now assigned to the HMMWV. The program is expected to reduce the cost of developing and procuring a new light tactical vehicle by leveraging the commercial base and transferring the latest technologies to military tactical vehicles. The majority of the savings would result from a drastic reduction in the cost of ownership or life cycle costs. Further savings could be realized from the use of Contractor Logistics Support (CLS) by adopting the Original Equipment Manufacturer's (OEM) existing parts distribution network and logistics, reducing inventories during peacetime. Additionally, the opportunity exists for commercial resale of used platforms to recycle some of the procurement dollars spent on these systems back into new procurement. These areas of potential cost savings will be presented in this chapter and analyzed in the following chapter.

B. THE COMBATT PROGRAM

In 1998, Congress directed the Army to conduct an Analysis of Alternatives (AoA) to determine if there was a cost effective alternative to the current HMMWV. At the time of the AoA, COMBATT was in its infancy and not mature enough to provide a

detailed system description of a commercially based tactical truck. The first phase of COMBATT was essentially a technology demonstration. It demonstrated the ability to merge commercial automotive technologies and future military light vehicle needs. Technology from this program such as anti-lock braking systems (ABS) and reduced interior noise was brought into the modernization plans for the HMMWV. Thus, the commercial truck in the study (AoA) was based on a generically defined commercial vehicle. The alternatives in the AoA were considered to be a replacement effort for the HMMWV. The commercial truck alternative could not meet many of the requirements based on the HMMWV ORD at that time. The results of the AoA was the Army's current LTV strategy which called for continued HMMWV acquisition, upgrade, and support through FY2020 (McGrady, 1999.)

In 1999, commercial auto manufacturers, working in alliance with the Army's National Automotive Center (NAC) in Detroit, attested that they could deliver high-performance, light trucks for military use. Ford and Daimler-Chrysler each have provided prototypes for the COMBATT vehicle. General Motors is currently building its prototype. COMBATT prototype vehicles have been successfully tested over 1000 miles of rugged terrain at the Nevada Automotive Test Center (NATC). Evaluations of these vehicles indicate that Modified Commercial-Off-The-Shelf (M-COTS) vehicles are capable of handling most of the non-combat duties of the HMMWV. The big three in automotive manufacturing (Ford, GM, Daimler Chrysler) have a continued interest in pursuing a competitive production contract with the Army.

COMBATT would have an average lifespan of 10 years (COMBATT ORD, Appendix A.) The vehicles will be produced on the same line as their civilian counterparts, the Ford F-350 and Dodge Ram 2500. Each will receive military upgrades including air-adjustable suspension, electronically controlled shock absorbers, tire-inflation systems and heavy-duty axle differentials. They will be capable of providing tactical standard mobility required for infrequent off-road operations over selected terrain with the preponderance of operations on primary and secondary roads.

COMBATT's maximum gross vehicle weight is 4,100 pounds. They are outfitted with 37-inch tires with a run-flat system. The truck's ride height, tire pressure,

and firmness automatically adjust to the driving conditions. COMBATT is equipped with diesel engines and are 30-40 percent more fuel-efficient than current HMMWVs. It meets military requirements of traversing 30-inch deep water and operating in -50 to 120 degree temperatures. It also has an upgraded electrical system providing 12, 24, and 110-V power. The interior includes global positioning system (GPS) hardware, computer monitors, infrared night vision displays, and collision-warning devices.

A prototype vehicle of COMBATT is projected to meet approximately 91.4% of the HMMWVA2 Operational Requirement Document (ORD) requirements (See Appendix B.) Nevertheless, knowing that COMBATT is not likely to not meet all the expectation for the updated ORD, there is the up front assumption that these vehicles will not fully replace, but could augment, the current fleet of HMMWVs. COMBATT can supplement the military light vehicle fleet by replacing HMMWVs and CUCVs in selected units and assignments where the full capability of the HMMWV is not required. This will make supplanted HMMWVs available for distribution to units that have a greater need for that platform. COMBATT can be used as a command, control, and communications platform, shelter carrier, medical evacuation platform, and to transport ammunition, light cargo, and personnel. The HMMWV's primary missions would include, fording, traveling at high speeds on rough ground, armored operations, carrying weaponry, and mobility in terrain where a commercial truck would never be able to go.

In order to avoid the many problems encountered by the fielding and deployment of the CUCVs, these vehicles would deploy to units that operate in rear areas of the battlefield, and in installations and training support roles. Examples of these include units at echelons Corps and above, some combat services support units, and training commands which spend most of their time on hard surfaced roads and don't require the extreme cross-country mobility of the HMMWV.

C. LIFE-CYCLE COST OF VEHICLES

The decision to field a new system requires a commitment to multi-year support. Decisions to develop, procure, and support new systems are based on many factors, one

of which is the projected cost of the systems over their operational lifetime or Life Cycle Cost (LCC). Life-cycle cost is the total cost, whether direct or indirect, recurring or nonrecurring, to the Government for a program over its life span (Deskbook, 2000.) Components are research and development, procurement, operations and support and disposal. Figure 4.1 illustrates a typical program's life-cycle and shows how its various phases related to the phases of a system's life-cycle cost.

Operating and support costs constitute a major portion of the system life-cycle costs, approximately 64% (OSD CAIG, 1992.) Hence, Operating and Support (O&S) costs are considered critical in the evaluation of acquisition alternatives (USD(AT&L), 1999.)

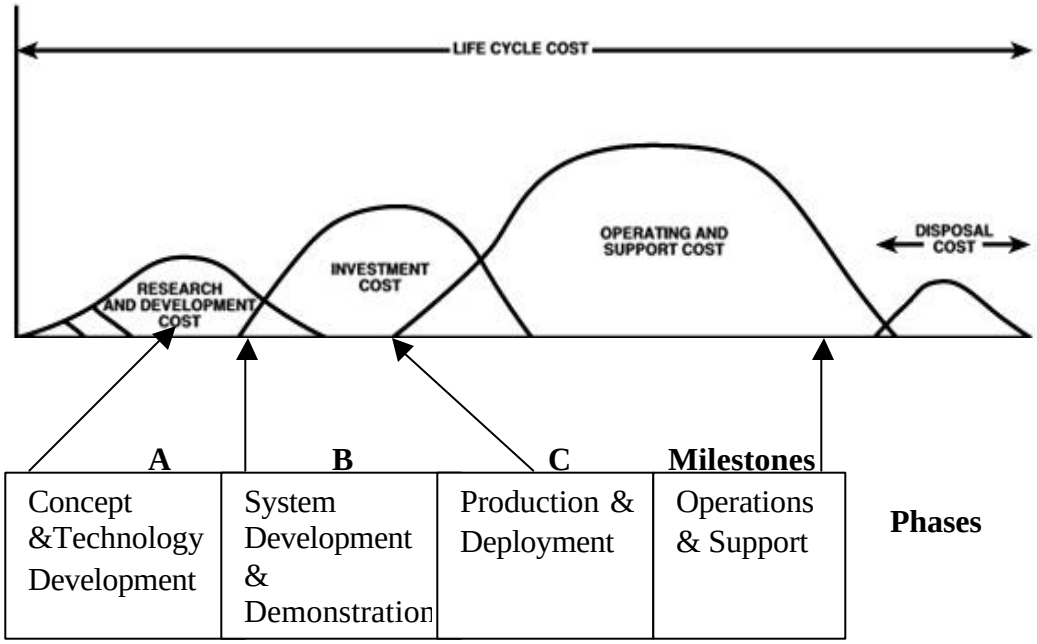

Figure 4.1 – Life-Cycle Cost Diagram

(From Cost Analysis Improvement Group, 1992)

1. Operating and Support Cost (O&S)

Operating and Support (O&S) includes all cost resulting from operations, maintenance, and support of a weapon system after it is accepted into the DoD inventory. It encompasses cost for personnel, consumable and repairable materials, organizational, intermediate and depot maintenance, facilities, and sustaining the equipment (Deskbook, 2000.) Many military leaders and defense analysts believe that increases in the O&S costs of aging equipment have created a budgetary crisis. We cannot replace much of our equipment in the near future. Consequently, operations and maintenance costs will continue to escalate. Unless we reverse the trend, we can face what is called a 'death spiral'. This is a situation where increased O&S cost requires removing more and more dollars from equipment modernization, further delaying modernization, which in turn causes aging equipment to be over-used, further increasing O&S (CBO Report, 2001.)

The effects of aging are likely to become increasingly important because, even with planned purchases of new equipment, many Light Tactical Vehicles (LTVs) will increase significantly in average age during the coming decade. Therefore, determining the best time to replace or remanufacture LTVs based on affordability and mission effectiveness is essential to fleet management. Buying new LTVs to replace assets before they have reached the end of their useful life would be an ill-advised use of scarce procurement funds. On the other hand, keeping assets beyond their useful life leads to unacceptable O&S costs, and is generally accompanied by a decrease in wartime operational effectiveness. Economic Useful Life (EUL) is used to provide a sound basis for fleet-wide life-cycle management policies, which can minimize peacetime operating costs while maintaining the required wartime capability. In the broadest sense, the EUL provides the Army's with a tool to gauge the condition of the existing fleet and to help plan for future retirements, upgrades, and acquisitions (CEAC, 2001.)

2. Maintenance Manpower

The selection, design, development, maintenance, and support concepts for a defense system influence how its O&S costs are analyzed and evaluated. In order to compare system alternatives fully, it is also necessary to identify maintenance and manpower requirements. For example, the number of crew members needed to operate a weapon system may be identical regardless of the alternative selected. However, the reliability of alternative systems may result in very different maintenance manning and materiel costs. Analysis in Chapter Five identifies the maintenance manpower requirements associated with COMBATT and the HMMWV.

3. Contractor Logistics Support

Due to the increasing use of commercial items within DoD, there has been a growing demand for commercial logistics and maintenance support. Contractor Logistics Support (CLS) is a method of obtaining support for a product or service for a specified period of time. It may be implemented to provide total support for a product or system, or specific functions such as maintenance, supply and distribution, training, information technology, and software/hardware support. CLS is an effective means to support ground equipment, ground weapon systems, munitions and information systems under the appropriate conditions. Operating and support costs may be lowered by utilizing Contractor Logistics Support (CLS.)

D. COST EFFECTIVENESS OF COMBATT

Cost analysis alone is not sufficient for a complete assessment of light tactical vehicle alternatives. The effectiveness of each alternative in fulfilling its mission requirements must also be examined. A ratio can be developed to measure cost-effectiveness in terms of cost per unit of outcome of effectiveness. This ratio involves computing the ratio of the input to the output for two alternatives.

The key factors in finding the optimum solution is the ability of a system to meet its Key Performance Parameters (KPP) while keeping within cost constraints. KPPs are those system capabilities or characteristics considered essential for successful mission accomplishment. For tactical wheeled vehicles, these critical areas are payload, performance, maintainability, and interoperability.

In addition to KPPs, a System Effectiveness Ratio (SER) is used to assess how well a vehicle meets the requirements of a particular mission. It is derived using a variety of Key Performance Parameter calculations. For each mission area, a vehicle is evaluated on payload, mobility, transportability, and reliability and maintainability. Each category, for example, is assigned a 100-point value, with a 400-point total being the maximum. Points are assigned based on a vehicle's design parameter against the required value as depicted in Figure 4.2.

Example:	Payload	
Design	12,000	
Required	15,000	
Category		Points:
(12,000/15,000)*100=80		

Figure 4.2 – Determining Category Points
(After McGrady, 1999)

The category points are summed and divided by 400 to obtain a system effectiveness ratio for a mission area for a vehicle.

Example:	Category Points	
	Payload	80
	Mobility	96
	Transportability	76
	Reliability and Maintainability	68
	Total	**320**
	(System Effectiveness Ratio	320/400= .80)

Figure 4.3 - Determining SER
(After McGrady, 1999)

The derivation of the effectiveness ratio essentially is a measure of how well COMBATT satisfies the 1998 HMMWV Operational Requirements Document (ORD) specifications.

E. RESALE OF COMBATTS

Another concept seriously considered by those tasked with modernizing and sustaining the LTV fleet is the sale of older equipment to finance new procurements. Commercially based vehicles such as COMBATT, could be sold back to the commercial auto industry, or to the public after the military no longer has any use for them. This will represent additional savings that could be used to finance the purchase of new vehicles.

There is an agency to assist with this venture. The Defense Reutilization and Marketing Service (DRMS) is a worldwide organization with headquarters in Battle Creek, Michigan. Established in 1972, DRMS is part of a much larger organization, the Defense Logistics Agency. DRMS inventories, evaluates and revalues reusable military resources by reusing property or selling it at best prices that saves millions of dollars.

DRMS oversees a number of Defense Reutilization and Marketing Offices (DRMOs). Most often, they are located in or near a military installation. DRMS also transfers goods to fill needs in other Government agencies and donates goods to community groups, educational institutions, or other recognized nonprofit organizations. Goods remaining after these needs have been met are sold to the public in order to generate operating revenues.

Resale of defense materiel has traditionally been limited to excess inventory. However, in light of the shrinking Defense budget and in keeping with the best business practices, the Army now sees a potentially large, untapped resource in commercially-based vehicles where aging vehicles may be inadequate and unserviceable for the Army but still valuable in the commercial sector or foreign militaries. In accordance with the Federal Property Management Regulations (FPMR), to reduce an agency's need for additional funding for the acquisition of replacement property, "if an agency has personal property that needs to be replaced, it can exchange or sell that property and apply the exchange allowance or sales proceeds to the acquisition of similar replacement property." (Title 41 U.S.C. Part 101-46.) An example of this would be funds generated from used Army watercraft sales would go back into new watercraft procurement (not tanks or trucks.) This process does not violate Congressional intent for the funding. However, if inventory is reported as excess and is to be sold by the DRMS or any other agency, "any sales proceeds are forwarded to the miscellaneous receipts accounts at the United States Treasury and are not available to the agency disposing of the property." (Title 41 U.S.C. Part 101-46) Light tactical vehicle sales to the public have taken place recently with the sale of many CUCVs and Small Unit Support Vehicles (SUSVs) from National Guard units as well as vehicles from TACOM. The proceeds from these sales went towards the purchase of new LTV procurement.

Currently, DoD has a rebuild contract with AM General to upgrade and refurbish HMMWVs for further use. HMMWVs that are not suitable for the rebuild program are little more than residual and do not meet all the U.S. Department of Transportation (DOT) motor vehicle safety standards. They are usually sold for recovery of parts and scrap (www.drms.dla.mil.) This restriction limits their commercial resale value. The civilian version of HMMWV, called "Hummer", manufactured by AM General, is DOT

certified and can be used on U.S. highways. Vehicles with a commercial heritage, such as COMBATT, could easily be made available to the public or commercial sector and used on public roads.

F. SUMMARY

The COMBATT program has shown many real benefits that could be found in lower costs to taxpayers, as well as a capable military LTV. The goal is to save the Government money by tapping the auto industry for mass-production vehicles. The majority of the savings would result from a drastic reduction in the operating and support costs.

Operating and Support (O&S) costs are considered critical in the evaluation of acquisition alternatives. Thus far, COMBATT has shown that it has the potential to lower life cycle cost. With today's budget constraints, this is considered important since O&S cost constitutes a major portion of a systems' life-cycle cost. It is also important that these cost are analyzed early in the acquisition process, preferably design phase, in order to prevent long-term commitment to high-maintenance systems.

In addition to considering O&S cost, one must analyze the cost-effectiveness of a program or system. An analysis of this nature will ensure that we are getting the best equipment available for our limited procurement dollars. It is the job of the Program Manager to provide the user with maximum operational capability while remaining within budget constraints.

In the past, commercial based vehicles have been sold to the public, such as the CUCV. DRMS is charged with finding new lives and new non-tax revenues for military goods that are no longer needed in active services. Resale opportunities exist for vehicles such as COMBATTs where the commercial resale of used platforms can be carried out by DRMS to recycle some of the procurement dollars spent on these systems back into new procurement.

V. ANALYSIS OF THE COMBATT PROGRAM

A. INTRODUCTION

Thus far, the COMBATT program has demonstrated that it is indeed possible for DoD to buy commercial vehicles manufactured on a commercial production line. This chapter analyzes the COMBATT program by comparing O&S costs, manning requirements, and cost-effectiveness ratios. Currently, there are 102,784 light tactical vehicles on-hand in the Army, the first of which were fielded in 1985. The Army needs approximately 19,000 additional vehicles to meet mission requirements of 121,692 vehicles (McGrady, 1999.) These requirements are not expected to change substantially between FY 2003 and FY 2010.

There are two alternatives to be considered to meet the Army's need for LTVs in the Army After Next (AAN) objective force. They are stated below:

> **a)** Procure improved versions of the current HMMWVA2 Model. Modernized HMMWVs are to meet Army XXI requirements found in the updated ORD.
>
> **b)** Procure a mix of HMMWVs and commercial vehicles to meet light tactical vehicle requirements. As the existing HMMWV/CUCV fleet reaches the end of its economic useful life, vehicles are replaced by either HMMWVs or by commercial vehicles manufactured by a domestic automobile company (in selected units).

Alternative A would result in a LTV force of vehicles that consist of *all* improved versions of the HMMWV. The primary mission of the improved HMMWV is to provide a light tactical wheeled vehicle for command and control, troop transport, light cargo transport, shelter carrier, ambulance, towed weapons prime mover, and weapons platform

throughout all areas of the battlefield. It will function as a deployable, mobile platform for numerous systems that contribute directly to warfighting (HMMWV ORD.)

The proposed vehicle will be employed in all Army units requiring light tactical vehicle needs regardless of if they need the full capability of that vehicle or not. This alternative will fully represent the 'pure-fleet' concept and the associated training logistics advantages.

Alternative B would result in a LTV force of vehicles that will consist of a high-low mix of HMMWVs and COMBATT vehicles. COMBATTs can supplement the light vehicle fleet by replacing HMMWVs and CUCVs in selected units and assignments where the full characteristics of the HMMWVs are not required. This will free up current and newer HMMWVs for distribution/redistribution to units that have a greater need for that platform, such as Infantry, Armor, Field Artillery, Air Defense Artillery, Military Police, Signal, Military Intelligence, Medical, Ordnance, Engineer, Chemical, and other selected Combat Service Support (CSS) units.

For the COMBATT, vehicle this would include all units in echelons ***Corps and above*** as well as units in installation and training support environments that spend a preponderance of their time on hard surfaced roads. It will operate in the rear areas of the battlefield. By replacing over-age CUCVs and selected HMMWVs, COMBATTs would provide an updated platform that reduces the average age as well as fill the Army's requirement for light tactical vehicles. It is envisioned that a commercial vehicle with the COMBATT stated essential characteristics would perform the non-combat, logistics and administrative missions in these units.

Estimating the number of systems needed for this alternative will be based on a high-low mix. Based on the current distribution of the basic HMMWV model and all CUCVs, it is estimated that up to 50,000 of COMBATT vehicles could serve effectively as the low end of the high-low mix of LTVs. This is only an estimate and should not serve as the definitive source for documenting the distribution or basis of issue.

B. LIFE CYCLE COST ANALYSIS

To determine if a program is cost-effective, one should analyze life cycle cost of competing alternative, in accordance with OMB Circular A-94. Whichever alternative is determined to have the lowest cost per unit of effectiveness expressed in present value terms for a given amount of benefits is considered most economical (Circular A-94.)

1. Operating and Support Cost (O&S)

The comparative Operations and Support (O&S) cost analysis was conducted to determine the estimated resource requirements of the COMBATT alternative for the LTV fleet. It is based on validated LCC estimates received from TACOM Cost Analysis Directorate. The cost for the alternatives includes continuing to maintain old, inherited systems until they are replaced by new alternative systems, as well as the cost to maintain the new alternative systems. Therefore, these estimates should be used to provide a comparison of the alternatives, and not as a budgetary estimate of a particular alternative system's cost.

These estimates represent the cost of maintaining a force structure of 50,000 vehicles for the period FY 1998 to FY 2020. It is based on data extrapolated from cost estimates to maintain a fleet of 121,692 vehicles. The following table, Figure 5.1, provides a comparison of average O&S costs for the improved HMMWV and COMBATT. It shows associated cost to acquire 19,000 vehicles and to continue to own and operate the current fleet through FY2020 (McGrady, 1999.) All cost are presented in FY 1999 constant dollars.

ELEMENT	Improved HMMWV	COMBATT
$M		
OM FUNDED ELEMENTS		
REPL REPARABLES (SPARES)	$ 132	$ 84
REPL CONSUMABLES (REPAIR PARTS)	$ 1,181	$ 1,000
PETRO, OIL AND LUBE (POL)	$ 165	$ 226
TRANSPORTATION	$ 85	$ 144
TRAINING	$ 302	$ 309
TOTAL O&S COST	**$ 1,865**	**$ 1,763**

Figure 5.1 – HMMWV and COMBATT Operation and Support Costs

(After McGrady, 1999)

These cost presented above represents the cost of owning and maintaining the Army's LTV fleet of 50,000 vehicles for the period FY1998-FY2020. The estimates are based on the Army's standard costing methodology. For this analysis the fleet consist of 50,000 COMBATTs or HMMWVs. The total O&S cost estimates are approximately $1.9 billion for the improved HMMWV and $1.8 billion for the COMBATT vehicle. The difference is a cost avoidance of $102 million. COMBATT has a much lower repair parts requirement since the systems will be new when fielded and the subsystems that have had a high failure rate on the inherited HMMWVs will have been replaced by new, improved subsystems which are projected to have a lower failure rate. Additionally, the O&S cost for the commercial variant is less since replacement parts are readily available on the commercial marked and, therefore, can be purchased at a lower cost (McGrady, 1999.) The training and logistical costs associated with the mixed fleet concept was not estimated. Because of the similarities in the functioning of the systems, operator training costs are considered negligible. Most logistical support will be provided in a CLS arrangement, limiting logistics personnel training and also limiting COMBATT unique spare parts handling and storage.

The Life Cycle Cost (LCC) estimate used 5 cost elements which included repairables, consumables, petroleum, oil, and lubricants (POL), transportation and training. The estimates are based on average repair-parts costs as documented in the Operating and Support Management Information System (OSMIS) relational database and assumed a 15-year useful life for the current HMMWV. OSMIS is the core of the Army Visibility and Management of Operating and Support Costs (VAMOSC) program. OSMIS tracks operating and support information for over four hundred major Army weapon/materiel systems for the US Army Cost and Economic Analysis Center (USACEAC).

2. Maintenance Manpower Analysis

The objective of the Maintenance Manpower Analysis is to estimate the maintenance manpower requirements of the COMBATT program in comparison to the HMMWV maintenance requirement. This manpower analysis was completed to provide an estimate of the number of organizational and DS/GS level maintenance personnel required to maintain the total fleet for each alternative. For the Army, maintenance in support of all versions of the HMMWV is performed at three levels: organizational, direct support (DS), and general support (GS). The primary maintainer at the organizational level is the Light Wheel Vehicle Mechanic, MOS 63B. The primary maintainer at the DS/GS level is the Wheel Vehicle Repairer, MOS 63W. The analysis will estimate the amount of manpower that is required for the each level.

Additionally, the Army National Guard (ARNG) has two organizations designed to support the geographical dispersion of their equipment. The Organizational Maintenance Shop (OMS) provides DS and backup organizational maintenance support. The OMS supports units/armories on an area basis. The number of OMS depends upon the number of vehicles in an area and the capabilities of the units in that area. The second organization is the Combined Support Maintenance Shop (CSMS) which provides DS and backup GS maintenance support. One or two of these exist in each state.

Although an ARNG division may have units in several states, maintenance support is organized by state (McGrady, 1999.)

The number of maintenance personnel required in a unit, such as a division, brigade, or MACOM, is a direct function of the number of support systems, their maintenance ratios (MR), usage, and the Military Occupational Specialty (MOS) availability factor for that unit. The requirements for each variant are then summed for all variants in the unit, resulting in an organizational level maintenance manpower requirement and a DS/GS maintenance manpower requirement for the unit as computed using the formula displayed in Figure 5.2 (McGrady, 1999.) For each alternative, the number of maintainers required to support the fleet is computed by summing the requirements computed for each of the units. The final results are values for each alternatives representing the maintenance manpower requirements at organizational and DS/GS levels.

For each group of vehicles in a unit:

$$\text{Maintenance Manpower (at Organizational or DS/GS)} = \frac{\text{Number of Vehicles X MR X Usage Rate}}{\text{Annual Ground Maintenance Availability Factor}}$$

Figure 5.2 – Maintenance Manpower Determination
(From McGrady, 1999)

Figure 5.3 provides a summary of the maintenance manpower necessary to support each of the vehicle alternatives. For a fleet of 50,000 light vehicles, maintenance manpower requirement estimates range from 1405 maintainers for the improved HMMWV to a low of 514 maintainers for COMBATT (McGrady, 1999.)

Alternative	Maintainers Required		
	Organic Mechanic (63B)	DS/GS Repairer (63W)	Fleet Total
Improved HMMWV	1063	342	1405
COMBATT	440	74	514

Figure 5.3 – Maintenance Requirements
(After McGrady, 1999)

As depicted above, the improved HMMWV requires almost three times the number of maintainers than are necessary to support COMBATT. Crew personnel are assumed constant between the two alternatives. However, the number of maintenance personnel required among them varied significantly. An additional 891 maintainer are required for the improved HMMWV. The estimated cost for these additional maintainers equates to approximately $16 million dollars as computed in Figure 5.4 below:

Number of Maintainers X Average Salary = Total Manpower Cost

891 X $18,268 = $16,276,788

Figure 5.4 - Computing Cost For Additional Maintainers

Again, this will represent a cost avoidance because COMBATT will require fewer maintainers, thus making those assets available for other duties. The average cost per year for each maintainer is $18,268. This cost represents the military pay and allowances for maintenance (non-supervisory) personnel. It does not include retirement pay or any special allowances or bonuses. Nonetheless, it represents a lower bound of the cost difference.

3. Contractor Logistics Support

COMBATT support concepts employ a unique logistics process by using commercially available parts, with extensive peacetime use of the automotive dealer maintenance network. This could result in savings in operational and support costs. The maintenance concept for COMBATT features will be operator maintenance equivalent to normal 'owners maintenance' on the commercial variant of the vehicle platform. These procedures will be outlined in the 10/20 level manuals. All Direct Support (DS) and General Support (GS) maintenance actions will be performed by contractor logistics support maintenance agreement in accordance with the prime manufacturer's warranty.

Both military and contract personnel will support COMBATT logistically by the most cost-effective means available during peacetime with acceptable risk when in transition to wartime. The major automotive companies are backed by a global authorized dealer and service network. Under CLS, an agreement would be made with the auto manufacturers that will provide deployed personnel to provide on-site support during contingencies and training exercises as required. Nevertheless, ordering parts during deployed exercises would be seamless and transparent.

Last year, many of the large players in auto industries have banded together to create an e-marketplace specific to their industry. It is called COVISANT. This is a new business-to-business combined internet procuring agreement among the automotive suppliers and manufacturers. COVISANT acts as an intermediary that stocks, sells, and distributes auto parts. It serves as one-stop-shopping for automakers. Reduced prices are offered because of the significant volume of orders it receives from all automakers and dealers. With COVISANT, the military could get reduced prices for commercial vehicle repair parts that may be requisitioned through COVISANT. Next day delivery would be available through Federal Express.

Thinking beyond the active Army, the local National Guard Armories and Reserve Centers would be able to get peacetime maintenance support at the local GM, Ford, or Dodge dealer rather than from its organic maintenance unit which could be

located miles away in another town or state, or only functional during weekend and annual drill.

C. COST EFFECTIVENESS ANALYSIS

A program is cost-effective if, on the basis of Life Cycle Cost analysis of competing alternatives, it is determined to have the lowest costs expressed in present value terms for a given amount of benefits (Circular A-94.) In analyzing the alternatives one must determine the cost effectiveness ratio (CE Ratio.) The CE Ratio reveals the average cost per unit of effectiveness. The cost effective analysis uses the vehicle unit cost and its associated system effectiveness ratio (SER) to calculate a cost effectiveness ratio as shown in Figure 5.5. The unit cost is the recurring hardware unit cost. The system effective ratio (SER) provides a quantitative basis for comparison of each vehicle's ability to meet requirements (McGrady, 1999.) These requirements are Key Performance Parameters (KPPs) set forth in the Operational Requirements Document (ORD.)

To compute the cost-effectiveness ratio, one takes the ratio of the cost of each alternative and divides by the effectiveness of that alternative. The most cost-effective project has the lowest average cost per unit of effectiveness (smallest CE Ratio.) This analysis is based on the assumption that the SERs for both alternatives apply to the most recently signed ORD for HMMWVs. As previously shown in Chapter 4, the SER for the improved HMMWV and COMBATT were computed to be .96 and .82 respectively (McGrady, 1999.)

One additional factor that must be considered in comparing the cost of alternatives is the economic useful life. At a EUL of 10 years for COMBATT and 15 years for HMMWVs, it is clear that HMMWVs will require one and a half COMBATT replacements for every HMMWV over the course of its EUL. As depicted in Figure 5.5 below, COMBATT appears to be the most-costly alternative. The Improved HMMWV is the least expensive, and the most effective option. The COMBATT is more expensive

Vehicle Type	Unit Cost	System Effectiveness Ratio (SER)	Cost Effectiveness Ratio (CER) (Unit Cost/SER)
Improved HMMWV (15yr EUL)	$73,194	.96	$76,244
COMBATT (10yr EUL)	$72,218 ($48,145*1.5)	.82	$88,070

Figure 5.5 - Cost Effective Analysis of Alternatives

as the Army needs 1.5 COMBATTs for every HMMWV displaced. The lower SER is expected, but as discussed in this thesis, the measures of effectiveness overstate requirements for the day-to-day peacetime expected use of the COMBATT.

As depicted in Figure 5.6 below, there is only a cost savings of $976 per vehicle by procuring COMBATT as opposed to the improved HMMWV. This may not seem like much, but when the savings are added to the potential resale (residual) value of vehicles to public, the offset is significantly higher at $9,926. A property's residual value is an estimate of the price that the property could be sold for at the end of the period of the purchase or lease. The assets will have value because they can fill requirements of future organizations or because they can be sold. Residual value is a benefit that is speculative at best. It does not represent savings but does represent a potential value (OMB Circular A-94.) This estimate was derived from the estimated residual value of similar, comparably aged property that is currently selling for in commercial markets.

Therefore, it will require the proceeds from resale to the public that makes COMBATT somewhat less expensive. Additionally, in sustaining the fleet until FY2020, the cost avoidance would be approximately $118 million dollars. This figure represents the increased costs in O&S for sustaining a fleet of 50,000 improved HMMWVs as depicted in Figure 5.6 below:

For each vehicle:

Improved HMMWV	$	73,194
COMBATT	$	72,218 ($48,145 X 1.5)
Difference	$	976
Average residual value at 10 yrs.	$	8,950 (represents potential value)
Total Additional Value for COMBATT:	$	**9,926** (per vehicle)

For LTV fleet:

O&S Savings	$102,000,000
Manpower Savings	$ 16,276,788
Cost Savings/Avoidance:	$**118,276,788** (for sustaining 50,000 vehicles thru FY2020)

Figure 5.6 - Cost Comparison

As for compliance to the HMMWV ORD, of the 138 overall requirements, there are 93 areas that are 'applicable requirements' for COMBATT. These 93 areas are the non-combat mission areas for the HMMWV. With some simple modifications, the COMBATT vehicle can satisfy 85 out of 93 overall applicable requirements outlined in the HMMWV ORD. The percent of applicable requirements met or will meet is 91.4% (See Appendix B.) The 8 mission areas which COMBATT couldn't meet are as follows:

- Ride Quality - Vertical acceleration 45 mph at 4" and halfround to 6mph at 12".
- Transportability - Air transportable at GCW by C-130 and larger aircraft. A minimum of 3 HMMWVs at GVW shall be transportable by C-130 aircraft using ramp. Can load only 2 COMBATTs in a C-130.

- Transportability -All versions using Light variant as base platform shall not exceed 180 inches w/o org-removable kits. COMBATT will not meet. Length = 244" USMC Requirement.
- Transportability - Heavy variant @CW shall not exceed 190.5 inches w/o org-removable kits. COMBATT will not meet. Length = 244" USMC Requirement.
- Transportability - Command and control configuration (incl. light utility version @CW w/w, 4 combat soldiers, 2 CNR, camo net) by single UH-60L.
- High-Altitude Electromagnetic Pulse (HEMP).
- Embedded diagnostics, COMBATT uses commercial.
- Batteries must meet current US, NATO military standard requirements for both configuration & performance. COMBATT uses commercial low maintenance batteries.

The remaining 45 areas are not applicable to COMBATT as they refer to specific requirements for which COMBATT is not a serious candidate. These mission areas would be accomplished with special variants of HMMWVs such as the Heavy, Up-Armored, and Shelter variants.

D. ANALYSIS OF FUTURE FUNDING OF LIGHT TACTICAL VEHICLES

The budget for the entire tactical wheeled vehicle (TWV) fleet averages $1 billion annually over the period 1998-2012 (Fleetbook, 1998.) Concurrently, TWV funding for HMMWVs will be increasing over the next few years as depicted in Figure 5.7

Along with increases in the budget for LTV, the procurement costs for LTVs are increasing as well. The improved HMMWVs come with a higher price tag, about $73,000 for the basic model. Current HMMWVA2s are costing DoD about $57,000 for the basic model produced at 24 per day. In comparison, in 1985, DoD was paying $28,000 for a basic HMMWV produced at 96 per day.

A production type COMBATT vehicle should cost less than a new HMMWV. With modifications included, COMBATT would cost approximately $48,000 each, about $10,000 cheaper (20%) than the price for of a basic HMMWVA2 model today and $25,000 cheaper (35%) than the improved HMMWV (See Appendix C.)

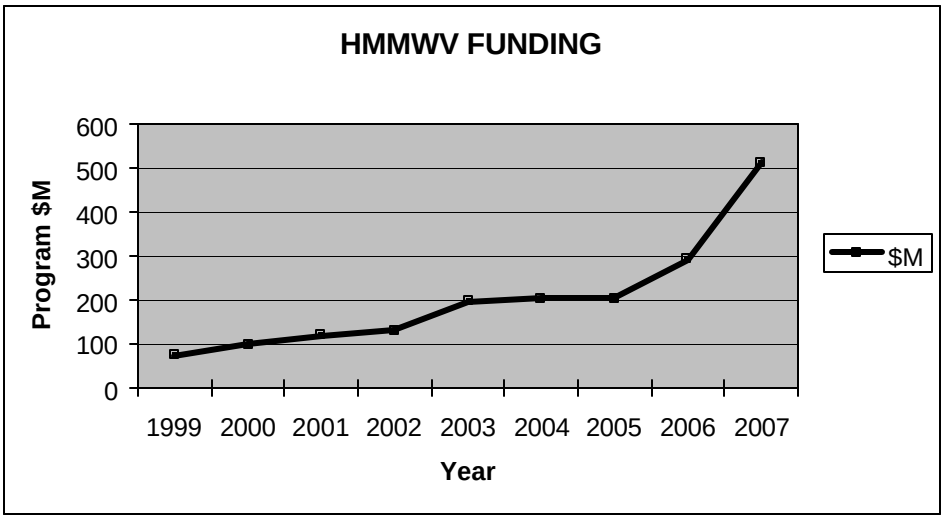

Figure 5.7 – HMMWV Funding

Figure 5.8 below shows projected threshold and objective costs for each HMMWV variant projected in the updated ORD. Base vehicle costs are built on current contract costs that are predicated on a rate of production of twenty-four (24) vehicles per day. The costs were validated using two different calculation methods to ensure a comprehensive and thorough evaluation. The PM LTV developed the cost estimate, which represented a "bottom up" industrial engineering approach that was based on independent and parametric estimates for all modifications. The Directorate for Cost and Systems Analysis, U.S. Army Tank-automotive and Armaments Command (TACOM), performed a formal validation of these detailed costs. To provide further validation, a comparison of an analogous method was applied. This method examined the growth of unit costs for the HMMWV fleet through its evolution and applied that historical rate of increase to the current contract prices. Once the cost increase factors were applied, the derived costs were compared to the "bottom up" estimate established by the formal validation and found to be in line with the ORD threshold cost numbers (HMMWV ORD.) Block I identifies the four Key Performance Parameters (KPP) for this modernization strategy. It does not include all ORD threshold requirements for the improved HMMWV. Figure 5.8 depicts these costs for Block 1 module below. All costs stated below are in then-year, Base Year (BY) '02 dollars (HMMWV ORD.)

VARIANT	Threshold Cost	Objective Cost
Light Utility 2 Man	$ 80,514	$ 73,194
Light Utility 4 Man	$ 81,192	$ 73,811
Light Weapons Carrier	$ 96,052	$ 87,319
Light Weapon Carrier W/W	$ 98,182	$ 89,257
Heavy Shelter Carrier	$ 86,432	$ 78,575
Heavy Up-Armored	$ 172,112	$ 156,465
Light Howitzer Towing	$ 89,860	$ 81,691
Ambulance (USMC Soft Top 2-Litter)	$ 84,465	$ 76,786
Ambulance (4-Litter and Army 2- Litter)	$ 136,400	$ 124,000

Figure 5.8 – HMMWV Block Mod 1

(From HMMWV ORD)

With increasing prices, replacements are not being procured in sufficient quantities to replace over-age HMMWVs, complete replacement of CUCVs, and to cover attrition. The replacement interval for the CUCV and HMMWV exceeds the most optimistic estimates of the effective service life of the equipment, with 20 year-old CUCVs in the inventory by 2005, and 26 year-old HMMWVs by 2013 (Fleetbook, 1998.) HMMWV ESP & future LTV procurements currently programmed will not fill the total Army requirement for Light Tactical Vehicles of 121,692 vehicles until about 2016. The arithmetic is pretty straightforward. At current light tactical vehicle funding levels and increasing unit costs of the HMMWV, there won't be many functioning light vehicles in the near future. Additionally, in FY03, the production commences for a HEMTT-II and FHTV programs that will compete for limited TWV funding.

Other events have occurred that have weakened the buying opportunity for new LTVs. As stated previously, the Program Objective Memorandum (POM) only supports the effort required to modernize the existing HMMWV and does not include enough funding to cover RDT&E and attrition. The RDT&E funding levels are sufficient only to

fund a single contractor effort. Having only one contractor for the development phase locks the program into a sole-source award for production. As previously mentioned, lack of competition for production will potentially increase cost.

E. RESALE ANALYSIS

For the COMBATT program, the opportunity exists for the vendor and the public to buy vehicles originally sold to the military. At the end of a specified year of the contract, the Original Equipment Manufacturer (OEM) would be given the first opportunity to buy back all the vehicles initially sold to the Government. The vehicles would be sold at their residual values. Once sold to the public, cash from the vehicles would then be turned into new vehicle manufacturing from the OEM. A third party may also procure the vehicles giving the government freedom to procure new platforms through competition between the OEMs.

Additionally, the vehicles could be sold in a public auction hosted by DRMS. The proceeds that the military would receive from this arrangement would be turned back into the procurement of similar products. The resale of COMBATT vehicles to the public or back to the commercial industry offers opportunities for recouping dollars spent on these vehicles.

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VI. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSIONS

During the last few years, the Department of Defense has embarked on an ambitious and challenging acquisition reform effort. Notable changes brought about by acquisition reform have allowed COMBATT to become a reality. The COMBATT program was initiated in compliance with the objectives of acquisition reform. It emphasizes the viability of commercial vehicles for certain military missions. Many other examples of this program are apparent as in the rapid acquisition of commercial vehicles for the Marine Corps and Army Rangers. With new changes ongoing in acquisition reform, we are now moving from concept to deployment with the best and most affordable technology available for our warfighters.

If DoD is to have access to the latest technologies developed in commercial marketplace, we must continue to build on the reformation of using the commercial industry for manufacturing our weapon systems. This transfer of technology and implementation of commercial best practices will result in more examples of dual use technology development and utilization. A unified industrial base provides surge capacity and potential manufacturing capabilities that the nation may rely upon in the future. The use of civil-military integration will enhance competition and result in a more efficient and innovative base and provide less dependency on sole-source providers.

Integration makes sense for the COMBATT program. It will continue to allow us to change our way of doing business in order to free up funds for badly needed modernization programs. That said, the Army and Marine Corps cannot accept front line units equipped with a commercial derivative for mission reasons. However, there are many missions the COMBATTs can perform. Many units could meet their operational needs with COMBATT alone. COMBATT would be used to provide command, control and communications, medical evacuation, and transport of ammunition, light cargo and personnel for Corps and echelon above Corps units that operate in improved areas and which do not require a HMMWV level of mobility. Typical units that COMBATT would

fully benefit include combat service support, training, base security, and many units throughout the Air Force and Navy.

Due to budget limitations, the Army is still short of the total HMMWV requirement of 121,692 vehicles. With the current budget constraints and the increasing prices of HMMWVs, there isn't enough money to 'pure fleet' our light tactical vehicles. With current budget estimates, the replacement interval for the CUCV and HMMWV given the current funding profile exceeds the most optimistic estimates with 20 year-old CUCVs in the inventory by 2005, and 26 year-old HMMWVs by 2013. At this rate, some HMMWVs may be in the field up to 36 years before they are replaced or recapitalized. In order to meet this requirement in the near future, it is likely that some form of commercial vehicle may need to be procured.

It appears that the commercial automotive producer is technically capable of manufacturing robust commercial vehicles that meet many of the requirements of the HMMWV at lower O&S costs. This analysis has shown that COMBATT can lower life cycle costs and significantly lower manpower requirements and costs. It can attain over 91% of all HMMWV applicable requirements which, in a non-combat environment, would be fully mission capable. The COMBATT program thus far has demonstrated it is a marginally more cost effective solution to filling the light tactical vehicle requirement deficiencies for the Army. With COMBATT, the Government acquires vehicles with new technology, better safety features, and acceptable mobility. Then, once the Government has used them, they can sale them back to manufacturers at their residual values and buy newer vehicles.

B. RECOMMENDATIONS

Based on the rationale that we buy only the capability that is needed, if we pure fleet with one type of truck, the HMMWV, we are paying for additional capability that is not needed. Every unit in the Army does not need a HMMWV. Some units only need basic transportation, plus the capability that COMBATT would provide. To meet the

needs of today's force at today's budget, the Army's buying strategy should include purchases of a mix of new commercial trucks and HMMWVs for the light vehicle fleet.

The Army's Training and Doctrine Command (TRADOC) should revalidate the actual need for HMMWV level performance at all Army commands and the other services should provide their input. Additionally, this solution will also be particularly accommodating for services that don't require the extreme capabilities of the HMMWV, such as the Air Force or Navy.

As we saw in Chapter 3, the preponderance of all CUCVs are in the National Guard and reserve forces, a total of 90%. With Homeland Defense now being the Department of Defense highest priority, the active and reserve forces would benefit directly from COMBATT as the operating environment within the U.S. will be conducive for a commercial platform that is better fit for primarily on-road driving conditions.

The COMBATT solution offers a cost effective alternative to fulfill current shortfalls in the light truck fleet that exist in the Army today.

C. AREAS FOR FURTHER RESEARCH

This thesis identified areas below that merit additional research:

- Identify what specific units in the Army and Marine Corps should have the HMMWVs/COMBATTs.
- Identify what specific units in the Air Force and Navy should have the HMMWV/COMBATTs.
- Analyze the benefits of leasing COMBATT vehicles.
- Identify additional future programs where DoD may benefit from commercial military integration.

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APPENDIX: A

LIST OF ABBREVIATIONS AND ACRONYMS

AAN	Army After Next
ARNG	Army National Guard
CAS	Cost Accounting Systems
CLS	Contractor Logistics Support
COMBATT	Commercially Based Tactical Truck
COTS	Commercial-off-the-shelf
CSMS	Combined Support Maintenance Shop
CUCV	Commercial Utility Cargo Vehicle
DEA	Drug Enforcement Agency
DCSOP	Deputy Chief of Staff for Operations and Plans
DFARS	Defense Federal Acquisition Regulation Supplement
DOD	Department of Defense
DOT	Department of Transportation
DRMS	Defense Reutilization and Marketing Service
DS	Direct Support
DUS&T	Dual-Use Science & Technology
ESP	Extended Service Program
EUL	Economic Useful Life
FAR	Federal Acquisition Regulation
FASA	Federal Acquisition Streamlining Act
FAV	Fast Attack Vehicle

FBI	Federal Bureau of Investigation
FPO	Fleet Planning Office
FPMR	Federal Property Management Regulations
GAAP	Generally Accepted Accounting Procedures
GAO	General Accounting Office
GOTS	Government-off-the-shelf
GP	General Purpose
GPS	Global Positioning System
HMMWV	High-Mobility Multipurpose Wheeled Vehicle
IBCT	Interim Brigade Combat Teams
IFAV	Interim Fast Attack Vehicle
INS	Immigration and Naturalization Service
ITV	Internally Transportable Vehicle
JMNS	Joint Mission Needs Statement
KPP	Key Performance Parameter
LCC	Life Cycle Cost
LTV	Light Tactical Vehicle
M-COTS	Modified Commercial Off The Shelf
MEU	Marine Expeditionary Unit
MILSPECS	Military Specifications
MOE	Measure of Effectiveness
MOS	Military Occupational Specialty
MUTT	Military Utility Tactical Truck Project

NAC	National Automotive Center
NATC	Nevada Automotive Test Center
NDI	Non-development item
OEM	Original Equipment Manufacture
ORD	Operational Requirements Document
O&S	Operation and Support
OPA	Other Procurement, Army
OPMIS	Operating and Support Costs Management Information
OMS	Organizational Maintenance Shop
OTA	Office of Technology Assessment
PM	Program Manager
POL	Petroleum, Oil, & Lubricants
POM	Program Objective Memorandum
RDT&E	Research Development Test & Evaluation
RSOV	Ranger Special Operations Vehicle
SER	System Effectiveness Ratio
SON	Statement of Need
TACOM	Tank- Automotive and Armaments Command
TOC	Total Ownership Cost
TRADOC	Training and Doctrine Command
TWV	Tactical Wheeled Vehicle
USACEAC	U.S. Army Cost Economic Analysis Center
USD(AT&L)	Under Secretary of Defense (Acquisition, Technology, and Logistics)

USMC	United States Marine Corps
VAMOSC	Visibility and Management of Operation and Support Cost

APPENDIX: B

COMPLIANCE MATRIX COMBATT TO HMMWV ORD (21 Jan 00)

HMMWV ORD Requirements (21 Jan 00)	Demonstration Phase	Comments for Demonstration Phase:
(1) System Design Goals		
(a) Human Engineering	Met by Mfg Design	
(b) Maintainability	Met by Mfg Design	
(c) Commonality	Met	Commonality within family of platforms and with commercial variants
(d) (KPP) Performance	Met at NATC Testing	
(e) Fuel Economy	Met by Local Testing	
(2) Payload		
(a) (KPP) Light	Met at NATC Testing	
(b) (KPP) Heavy	Will Meet-Not Demo'ed	Demonstrated at 4100 pound payload
(3) Reliability and Maintainability (RAM)		
(a) Reference versions vs. representative mms (obtained from OMS/MP): Table in ORD		
(b) (KPP) Vehicle Reliability (90% probability of completing each mission's respective 96 hour OMS/MP)	Met by Mfg Design	
(c) Winch Reliability	Met by Mfg Design	
(d) (KPP) Maintainability		
(1) Maintenance Ratios	Met by Mfg Design	
(2) Mean Time To Repair 2hrs	Met by Mfg Design	
(3) Maximum Time To Repair 4hrs	Met by Mfg Design	
(4) Removal and replacement of single major sub-component 14hrs	Met by Mfg Design	
(4) Mobility		
(a) Forward Speed 75mph	Met at NATC Testing	
(b) Acceleration 0-30mph in 7 sec	Met at NATC Testing	
(c) Mobility Rating	Met - NRMM Model	Met 42 of 48 ORD NRMM requirements (other 6 very close)
(d) Gradability		
(1) Longitudinal slopes 4 mph @ 60%	Met at NATC Testing	
(2) Side slopes 40 %	Met at NATC Testing	
(3) Speed on grade 5mph @ 5%	Met at NATC Testing	
(4) Vertical Step 18" objective / 24" desired	Will Meet-Not Demo'ed	
(e) Fording 30" objective / 48" desired	Will Meet-Not Demo'ed	
(f) Ride Quality		
(1) Ride Limiting Speed 25mph @ 1" rms to 10mph @ 2.5"	Met at NATC Testing	
(2) Vertical acceleration 45 mph @ 4" halfround to 5 mph @ 12"	Will Not Meet	Tested at 3" and 6"; will be difficult to meet
(g) Range 300 miles	Met by Local Testing	
(5) Transportability		
(a) At GCW with a representative towed load weighing 4,600 lb, GVW, CW:		
(1) Meet highway legal limits	Met	
(2) Have military standard lifting and tie-down provisions for loading at GVW	Met	Tie downs met, lifting points will be met in production
(3) Be rail transportable	Will Meet-Not Demo'ed	
(4) Be marine transportable	Will Meet-Not Demo'ed	
(5) Air transportable at GCW by C-130 and larger aircraft. A minimum of 3 HMMWVs at GVW shall be transportable by C-130 aircraft using ramp.	Will Not Meet	Can load 2 vehicles in C130
(6) USMC overall length limit n/p		
(a) All versions using Light variant as base platform shall not exceed 180 inches w/o org-removable kits.	Will Not Meet	Length = 244" USMC Requirement
(b) Heavy variant @ CW shall not exceed 190.5 inches w/o org-removable kits.	Will Not Meet	Length = 244" USMC Requirement
(c) 4-liter ambulance shall not exceed 203 inches.	N/A	
(b) At GVW individually externally transportable (sling-load) by CH-47D and in tandem with its trailer/howitzer 4,000 ft. ASL, 95 deg. F., 30 naut. miles.	Will Meet-Not Demo'ed	Lift Points not designed, will do in production
(c) Be transportable by UH-60L 4,000 ft. ASL, 95 deg. F., 30 naut. miles in following configurations:		
(1) Command and control configuration (incl. light utility version @ CW w/o, 4 combat soldiers, 2 CNR, camo net) by single UH-60L.	Will Not Meet	Production vehicles in year 2003-2004 may meet weight objective
(2) Light Utility version with either 2-liter ambulance kit @ GVW w/o crew, patients by single UH-60L.	N/A	
(3) Heavy Shelter version @ GVW by 2 UH-60L to incl. 4-L ambulance.	N/A	
(4) Heavy/Light Howitzer Towing versions plus howitzer by 2 UH-60L.	N/A	
(5) Light weps carrier by 2 UH-60L.	N/A	
(6) (Objective) Heavy Up-Armored version (CW w/w, 4 combat soldiers, 2 CNR, camo nets, all other components of up-armored config.) by 2 UH-60L.	N/A	
(d) Light utility, USMC ambulance, light weps carrier, heavy shelter carrier externally transportable by MV-22 @ 3,000 ASL cruise, ashore/island from SL, 91.5 Deg. F., 100 NM radius.	N/A	
(e) Externally transportable by CH-53 (threshold)(assume high hot), internally transportable (objective) by USMC CH-53E @ 150 knots cruise.	N/A	
(f) Withstand wind during external transport	Will Meet-Not Demo'ed	
(g) Be capable of Low Velocity Aerial Delivery	Will Meet-Not Demo'ed	
(6) Shelter Carrier	N/A	
(7) Towing		
(a) Capacity 4500 lbs with 450 lbs tongue	Will Meet-Not Demo'ed	
(b) Brakes controllable	Will Meet-Not Demo'ed	
(c) Second Pintle	Met	
(d) Self Towing	Will Meet-Not Demo'ed	
(e) Recovery/Towing	Will Meet-Not Demo'ed	
(f) Tow Eyes	Met	
(8) Fuel JP8	Will Meet-Not Demo'ed	
(9) Automatic transmission	Met	
(10) Tires/Wheels	Met	
(11) Cargo Tie-Down Provisions	Met	
(12) Seating		
(a) Primary Crew Seats 2-3	Met	
(b) Secondary Seating 2	Met	Not fold flat
(c) Troop Seats Kit	Met	
(13) Individual Weapons Stowage	Will Meet-Not Demo'ed	
(14) Crew Safety		
(a) Crew Restraint system with body armor & MOPP IV	Will Meet-Not Demo'ed	
(b) Vehicle Control Enhancement	Met	
(c) Survivable Space	Met by Mfg Design	
(15) Front-End Protection brush guards etc.	Met	
(16) Vehicle Security Keys & locks	Met	
(17) Camouflage	Met	Non CARC paint
(18) Climatic Conditions starting <5min @ 35F to <10min @ -25F	Will Meet-Not Demo'ed	
(19) Cab Operating Environment	Met	
(20) Cargo Compartment Heater	Will Meet-Not Demo'ed	
(21) Arctic and MOPP IV Clothing	Will Meet-Not Demo'ed	

HMMWV ORD Requirements (21 Jan 00)	Demonstration Phase	Comments for Demonstration Phase:
(22) Nuclear, Biological, and Chemical (NBC)	Will Meet-Not Demo'ed	With CARC paint
(23) High-Altitude Electromagnetic Pulse (HEMP)	Will Not Meet	Could meet with some modifications
(24) Electromagnetic Interference (EMI)	Will Meet-Not Demo'ed	
(25) Electrical Components		
(a) NATO electrical slave receptacle	Met	
(b) Secure lighting and blackout drive	Met	
(c) Embedded diagnostics	Will Not Meet	Uses commercial embedded diagnostics
(d) Basic electrical sockets for 12 & 24 VDC	Met	
(e) An electrical power source outlet (junction box) in the cargo compartment	Will Meet-Not Demo'ed	
(f) Vehicle electric power source of at least 300 amperes DC delivered output at high idle speed (MTE 1250 RPM, threshold), low adjusted idle speed (MTE 600 RPM, objective). (15% NAC is kit)	Met	
(g) An idle RPM control	Met	Demo'ed on Ford only
(h) Batteries must meet current US, NATO military act. mpa. for both configuration & performance.	Will Not Meet	Commercial low maint. batteries under hood
(i) System or onboard device which permits starting the vehicle when vehicle batteries lack power to start engine, exclusive of slave starting.	Will Meet-Not Demo'ed	
(j) Temperature-compensated voltage regulation, using temperature sensing in battery compartment.	Met by Mfg Design	
(26) Radios	Will Meet-Not Demo'ed	
(27) Ancillary/Electronic Equipment	Will Meet-Not Demo'ed	
(28) Extended Electrical Capability/Capacity (Objective)	Met	Demo'ed on Dodge only
(29) Noise Suppression	Met by Mfg Design	
(30) Fuel Jerrcan Connection	N/A	
(31) Night Vision Device Compatibility	Will Meet-Not Demo'ed	
(32) Mounting Points	Will Meet-Not Demo'ed	
(33) Flashing Warning Beacon Kit	Will Meet-Not Demo'ed	
(34) Configuration/System Accommodation:		
(a) Contact maintenance truck configurations	Will Meet-Not Demo'ed	
(b) Light howitzer prime mover configuration	Will Meet-Not Demo'ed	
(c) Large Area Screening System configuration	N/A	
(d) TOW missile system configuration.	N/A	
(35) Crew Compartment Protection Kit:		
(a) Underbody Protection Kit (UPK)	N/A	
(b) Ballistic Protection Kit (BPK)		
(1)) Small Arms Protection	N/A	
(2)) Area Weapon Protection	N/A	
(c) Mounting	N/A	
(d) Crew Compartment Protection Kit Maintenance Impact		
(1)) Minimum interference with maintenance of the vehicle	N/A	Can be up armored
(2)) No maintenance beyond standard PMCS	N/A	
(e) Crew Compartment Protection Kit Storage	N/A	
(36) Ambulance Kits		
(a) 4-Litter Shelter Kit	N/A	
(b) Two 2-Litter kits, capable of mount/dismount at unit, UH-60 transportable, LVAD	N/A	
(1)) Demountable 2-litter kit w/ capabilities similar to M998	N/A	
(2)) For USAIC, demountable 2-litter kit w/ capabilities similar to M1035	N/A	
(37) Cargo Bed Cover	Will Meet-Not Demo'ed	Commercial covers available
(38) Tarp and Bows Kit	Met	
(39) Winch Kit		
(a) A winch kit (electric desired)		
(1)) Capable of operations from both front and rear	Met	
(2)) Removed and installed on another vehicle in 45 min. (threshold), 45 min. (objective) or less	Met	5 minutes to mount front or back
(3)) Withstand and overcome loads equal to two times weight of heaviest HMMWV GVW	Met	
(4)) Reach and/or 75 feet from HMMWV and return	Met	
(5)) Automatic brake	Met	
(6)) Free spooling capability	Met	
(b) Mounting points/power supply provisions, inside-/outside-vehicle operations	Met	
(c) Separate TOE item, also available as AAL item.	Met	
(d) Provided with all Heavy Up-Armored and Light Weapons Carrier versions	N/A	
(40) Snow Plow Kit		
(a) Snowplow kit w/ capabilities at least as good as current light vehicle snowplow kit as AAL item	Will Meet-Not Demo'ed	
(b) Mounting points/power supply provisions	Will Meet-Not Demo'ed	
(41) Heavy Up-Armored Version		
(a) Self-Defense Weapons	N/A	
(1)) Primary	N/A	
(2)) Secondary	N/A	
(b) Ammunition Stowage	N/A	
(c) Gunner Restraint System	N/A	
(d) Built-in Protection	N/A	
(e) Gun Shield	N/A	
(f) Vehicle Gun Mobility (Objective)	N/A	
(g) Maintenance	N/A	
(h) Minimum payload of 1,600 pounds	N/A	
(42) Light Weapons Carrier version		
(a) Self-Defense Weapons		
(1)) Primary	N/A	
(2)) Secondary	N/A	
(b) Ammunition Stowage	N/A	
(c) Gunner Restraint System	N/A	
(d) Crew Compartment Protection Kit Mounting Provisions	N/A	
(e) Gun Shield (Desired)	N/A	
(f) Mobility	N/A	
(43) Heavy Howitzer Towing Version (P3I program)		
(a) Payload	N/A	
(b) Towing Capacity	N/A	
(c) Mobility	N/A	
(d) Transportability	N/A	

COMPLIANCE MATRIX COMBATT TO HMMWV ORD (21 Jan 00)

Overall Requirements:		138
Overall Applicable Requirements:		93
Number "Met"		53
Number "Will Meet - Not Demo'ed"		32
Number "NA"		24
Number "Will Not Meet"		8
Percent of Applicable Requirements "Met" or "Will Meet"		91.4%

APPENDIX: C

COMBATT & EMCV VEHICLE COST COMPARISIONS

COMBATT/EMCV
Vehicle Descriptions

Commercially Based Tactical Truck
(COMBATT-military vehicle)
&
Enhanced Mobility Commercial Vehicle
(EMCV-civilian vehicle)
Program

Vehicle Cost Comparisons

Prepared by

MTL SERVICES INTERNATIONAL, INC.

Cost Estimates for Body Upgrades

Cost Estimates for Dodge & Ford COMBATT Vehicles
Estimated Budget for Production
Cargo/Troop Carrier COMBATT Vehicles

		Budget (Nov 2000 Economics)		
Base Vehicle: $31,250	Dodge or Ford (4wd, Crew quad cab, ABS, PS, PB, trailer pkg, auto trans, air Cond., air bags, diesel, speed control)	COMBATT Demo Vehicle	Base COMBATT Vehicle	Base EMCV
Upgrades:				
Body	Antenna mounts	$75	$75	$75
	Brush guards	$125	$0	$0
	Bumpers – approach angle, tie downs.	$300	$300	$300
	Fenders rework	$500	$500	$500
	Fender flares	$125	$125	$125
	Paint (CARC replacement)	$750	$750	$0
	Rifle holder	$50	$50	$50
	Seats – mesh design or heavy duty material	$200	$200	$0
	Tie downs (pickup box)	$100	$100	$100
	Trailer pintle – front	$90	$0	$0
	Trailer pintle – rear	$90	$90	$90
	Winch mounts front & rear	$125	$125	$0
	Section Subtotals	$2530	$2315	$1240

Cost Estimates for Chassis Upgrades

Cost Estimates for Dodge & Ford COMBATT Vehicles Estimated Budget for Production Cargo/Troop Carrier COMBATT Vehicles		Budget (Nov 2000 Economics)		
Base Vehicle:	Dodge or Ford (4wd, Crew quad cab, ABS, PS, PB, trailer pkg, auto trans, air Cond., air bags, diesel, speed control)	COMBATT Demo Vehicle	Base COMBATT Vehicle	Base EMCV
Upgrades:				
Chassis	Adjustable air springs	$300	$300	$300
	Air Compressor System	$1,100	$550	$550
	Air Dryer	$800	$800	$800
	Brakes – Mods for 40% grade, parking	$200	$200	$200
	CTIS($ coordinated w/ axles and air springs)	$2,300	$0	$0
	Dampers – Semi Active	$1,000	$1,000	$1,000
	Frame tie downs	$150	$150	$150
	Goodyear 37x12.5 R17 tires	$1,000	$1,000	$1,000
	Lift rings	$400	$400	$0
	Skid plates	$300	$300	$300
	Wheels with run flat, 2 piece	$2,400	$2,400	$0
	Section Subtotals	$9,950	$7,100	$4,300

Cost Estimates for Electronics Upgrades

Cost Estimates for Dodge & Ford COMBATT Vehicles Estimated Budget for Production Cargo/Troop Carrier COMBATT Vehicles		Budget (Nov 2000 Economics)		
Base Vehicle:	Dodge or Ford (4wd, Crew quad cab, ABS, PS, PB, trailer pkg, auto trans, air Cond., air bags, diesel, speed control)	COMBATT Demo Vehicle	Base COMBATT Vehicle	Base EMCV
Upgrades:				
Electronics	200 Amp alternator 12/24 Volt (mil grade)	$1,800	$1,800	$0
	Air Spring controller	$600	$600	$600
	Batteries (2 additional for 24 Volt)	$180	$180	$0
	Black-out lights	$300	$300	$0
	Engine idle control	$175	$0	$0
	Integrated flat panel display & Computers	$2,500	$0	$0
	Inverter for 120 VAC	$400	$400	$0
	NATO connectors – cab, box	$125	$125	$0
	NATO connectors – front & rear jump start	$350	$350	$0
	Radio mounts (console)	$175	$175	$175
	Trailer tow wiring	$150	$150	$0
	Wiring harness overlays	$200	$200	$0
	Section Subtotals	$6,955	$4,280	$775

Cost Estimates for Powertrain & Other

Cost Estimates for Dodge & Ford COMBATT Vehicles Estimated Budget for Production Cargo/Troop Carrier COMBATT Vehicles		Budget (Nov 2000 Economics)		
Base Vehicle:	Dodge or Ford (4wd, Crew quad cab, ABS, PS, PB, trailer pkg, auto trans, air Cond., air bags, diesel, speed control)	COMBATT Demo Vehicle	Base COMBATT Vehicle	Base EMCV
Upgrades:				
Powertrain	Axle mods for CTIS	$500	$0	$0
	Axles/Differentials	$500	$500	$500
	Fuel filler neck for NATO nozzle	$50	$50	$0
	Mods for –25 F starting (-20 F is standard)	$50	$50	$0
	Venting for stream fording (multiple)	$100	$100	$0
	Section Subtotals	$1,200	$700	$500
Other	Military owners guide	$75	$75	$0
	Up-fitter assembly price	$3,000	$2,500	$2,000
	Section Subtotals	$3,075	$2,575	$2,000

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Cost Estimates - Overall COMBATT

Cost Estimates for Dodge & Ford COMBATT Vehicles
Estimated Budget for Production
Cargo/Troop Carrier COMBATT Vehicles

		Budget (Nov 2000 Economics)		
Base Vehicle:	Dodge or Ford (4wd, Crew quad cab, ABS, PS, PB, trailer pkg, auto trans, air Cond., air bags, diesel, speed control)	COMBATT Demo Vehicle	Base COMBATT Vehicle	Base EMCV
Upgrades:				
Body		$2,530	$2,315	$1,240
Chassis		$9,950	$7,100	$4,300
Electronics		$6,955	$4,280	$775
Powertrain		$1,200	$700	$500
Other		$3,075	$2,500	$2,000
	Upgrade Subtotals	$23,710	$16,895	$8,815
	Base Vehicle Cost	$31,250	$31,250	$31,250
	Estimated Vehicle Costs	$54,960	$48,145	$40,065

VEHICLE DESCRIPTIONS

- COMBATT Demonstration Vehicle: This vehicle is equippe with all technologies, military options, and electronic devices developed in this program.

- Base COMBATT Vehicle: This vehicle is equipped with the basic technologies developed to upgrade the body, chassis, electronics, powertrain, and suspension and includes most military options as required by the HMMWV Operational Requirements Document (ORD) .

- Base EMCV: This vehicle is equipped the same as the Base COMBATT vehicle minus some of the military-specific options.

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