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Developing a Parametric Cost Model for Operating Costs of Army Ground Combat Weapon Systems

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DEVELOPING A PARAMETRIC COST MODEL FOR OPERATING COSTS OF ARMY GROUND COMBAT WEAPON SYSTEMS

by

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ABSTRACT

DEVELOPING A PARAMETRIC COST MODEL FOR OPERATING COSTS OF ARMY GROUND COMBAT WEAPON SYSTEMS

James O. Winbush, Jr.
Old Dominion University, 2000
Director: Dr. Charles B. Keating

The purpose of this research was to develop a parametric cost model for predicting operating costs of Army ground combat weapon systems. The model is intended to be used during the first two phases of the Army's acquisition process. The research necessary to develop the model was guided by two questions: what weapon system characteristics (such as weight, horsepower, fuel consumption, primary mission, NBC protection, fire control and night fighting capability) impact directly on operating ground combat systems; and what is the form of the parametric model for operating costs for ground combat systems? The study extends the bounds of current parametric cost methods by incorporating a risk variable directly into the model. The purpose of the risk variable was to account for uncertainty and reduce the chance of underestimating operating costs. Underestimating operating costs could lead to under funding of weapon systems during the operating and support phase of the acquisition life cycle. The results showed that it is possible to develop parametric cost models using the Army's Operating and Support Management Information System (OSMIS) relational database.

ACKNOWLEDGMENTS

This thesis is the result of nine months of research involving many sources (textbooks, internet materials, Army texts, and academic books). This has been a wonderful and enlightening experience that has furthered my academic skills beyond what I believed achievable. I owe a personal thanks to all the people in my life who have made this work a reality.

I thank my parents, James and Beatrice Winbush, who always instilled in me to do my best in every endeavor and encouraged my every academic goal. I thank my siblings, Johnny, Gwendolyn and Trenia, for always supporting me with encouragement and love. I especially thank my wife, Sharlene, and our son, Alex, for their patience, love, support, and understanding.

I also thank Dr. Charles Keating for pushing me to pursue the thesis option for my degree requirements. He also provided me continuous guidance and maintained my focus, without which this work would have not been completed.

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CHAPTER 1

INTRODUCTION

Parametric modeling techniques, useful in a wide variety of applications, have been an accepted approach to cost estimation by government organizations for many years (Parametric Estimating Handbook, 1999). Although this method's accuracy is limited by the amount and precision of the historical data used to develop the model, it serves as a practical means of providing relevant information for making many management decisions. The Parametric Estimating Handbook (1999) points out that the key element in parametric modeling is credible data. To make it easier to repeat the modeling process, the handbook also recommends using standardized formats, such as work breakdown structures, for collecting and maintaining data.

Parametric cost modeling uses mathematical relationships for cost estimation at the system or sub-system level. This modeling process does require some knowledge of key parameters of the system and the historical data, which represents the cost associated with similar systems (Fatelnig, 1996). In the development of parametric cost models, one usually tries to identify characteristics (cost drivers) that greatly influence the cost of the system. The cost drivers may be parameters such as weight, mass, complexity, or reliability. As Fatelnig (1996) points out, this method is extremely useful for developing rough order of magnitude cost estimates in the early phases of a project.

The yearly operating cost is a key element for developing the total acquisition cost for Army ground combat weapon systems. This study analyzes the use of parametric

The journal model for this work is the *Engineering Management Journal*.

modeling for developing the yearly average operating cost of these weapon systems. In keeping with the holistic point of view of systems science, the cost model reflects the system development process from a concurrent engineering point of view. This study analyzes operating costs using factors such as combat system mission, risk, and activity, which can provide useful information for parametric model development (Meisl, 1993).

BACKGROUND

Developing valid cost estimates for the acquisition of new or upgraded versions of current weapon systems continues to be extremely important to the Department of Defense (DoD). Since the fall of communism in Eastern Europe, the DoD budget continues to decline in purchasing power (see APPENDIX M). The procurement and acquisition of new and upgraded versions of weapon systems has declined proportionally to the reduction in the defense budget. Because operating and support (O&S) costs are the most expensive portion of new weapon systems, there has been increased emphasis on identifying and reducing the O&S costs in recent years (Cost Analysis Improvement Group, 1992). To help control weapon system O&S costs, the Army Acquisition Executive has made each program manager (PM) responsible for the total life cycle costs of his/her system (Department of Defense Directive 5000.1, 1996).

The Army uses DoD cost estimating guidelines to prepare cost estimates for weapon systems. The Cost Analysis Improvement Group (CAIG) and the Defense Acquisition Board (DAB) review these cost estimates to ensure compliance with current policy (Cost Analysis Improvement Group, 1992). The CAIG is an independent cost estimating activity that provides cost estimates for major defense systems, and the DAB is an approval authority for major weapon systems. It is important to note that initial cost estimates are developed during the Concept Exploration phase, which is the first phase in the acquisition life cycle. FIGURE 1 depicts a graphic illustration of the acquisition/development life cycle for a typical Army weapon system. Initial cost estimates are developed prior to a weapon system receiving Milestone I approval, which establishes funding and officially starts an Army acquisition program. Refinements to the initial cost estimate are made in the Program Definition and Risk Reduction (PDRR) and the Engineering and Manufacturing Development (EMD) phases. Developing O&S cost estimates prior to the EMD phase introduces an element of uncertainty that can be related to variance in the final configuration of the weapon system. Under ideal conditions, the final O&S cost estimates are developed during the EMD phase and are forecasted for the planned operational life of the weapon system. Ultimately, the focus of each cost estimate is to provide the most accurate prediction of costs related to operating the weapon system. As design matures, the additional knowledge acquired provides better information for predicting operating costs.

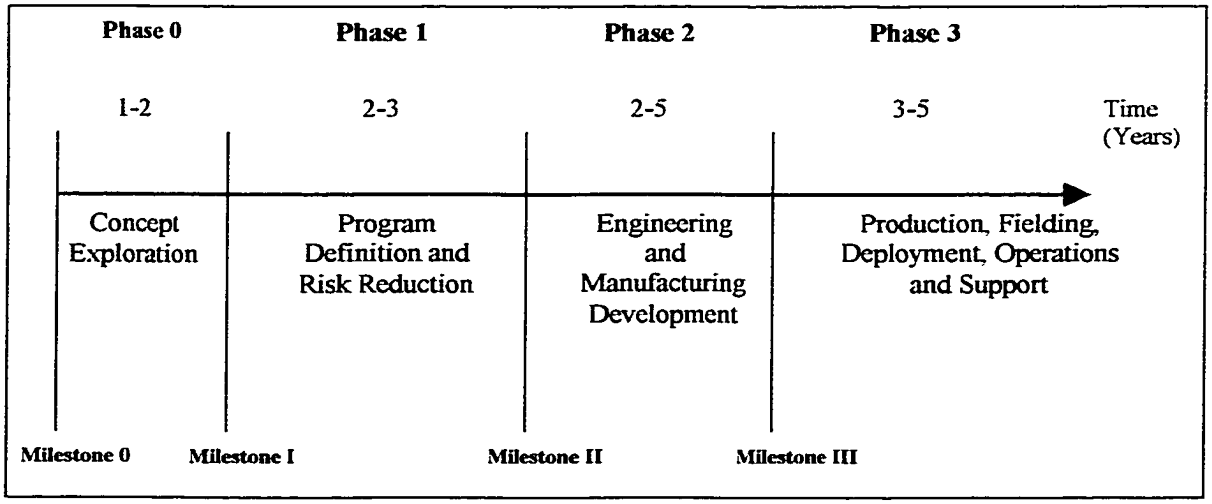

FIGURE 1. Acquisition Life Cycle

The decision to field a new weapon system requires a commitment from the Army to support that system for typically 20-30 years into the future. The decision to develop, procure, and support new weapon systems is based on several factors. One key decision factor is the projected O&S costs of the system over its operational lifetime. The initial design-to-cost efforts and trade-off studies conducted by the system design team establishes the baseline from which O&S costs are derived. Trade-off studies that affect O&S costs are reviewed by the DAB and are part of the major system acquisition review and decision making process within DoD. The feasibility of developing new Army systems is highly dependent on the Army's ability to allocate funds in future budget years necessary to operate and support the system.

O&S costs have a substantial impact on a system over its entire life cycle (FIGURE 2). Typically, O&S costs are 60% to 80% of the total cost of a system over its lifetime (Cost Analysis Improvement Group, 1992). Although not illustrated in FIGURE 2, design and manufacturing decisions made during the Concept Exploration and Engineering and Manufacturing acquisition phases greatly influence O&S costs once the system is placed into operation (Medley, 1996). Life cycle cost estimates figure heavily into the evaluation of different system alternatives. In order to compare alternatives over the entire life cycle, operating costs must be estimated and evaluated, particularly in those areas subject to uncertainty. In the context of this study, operating costs are those costs associated with operating and maintaining an Army ground combat weapon system.

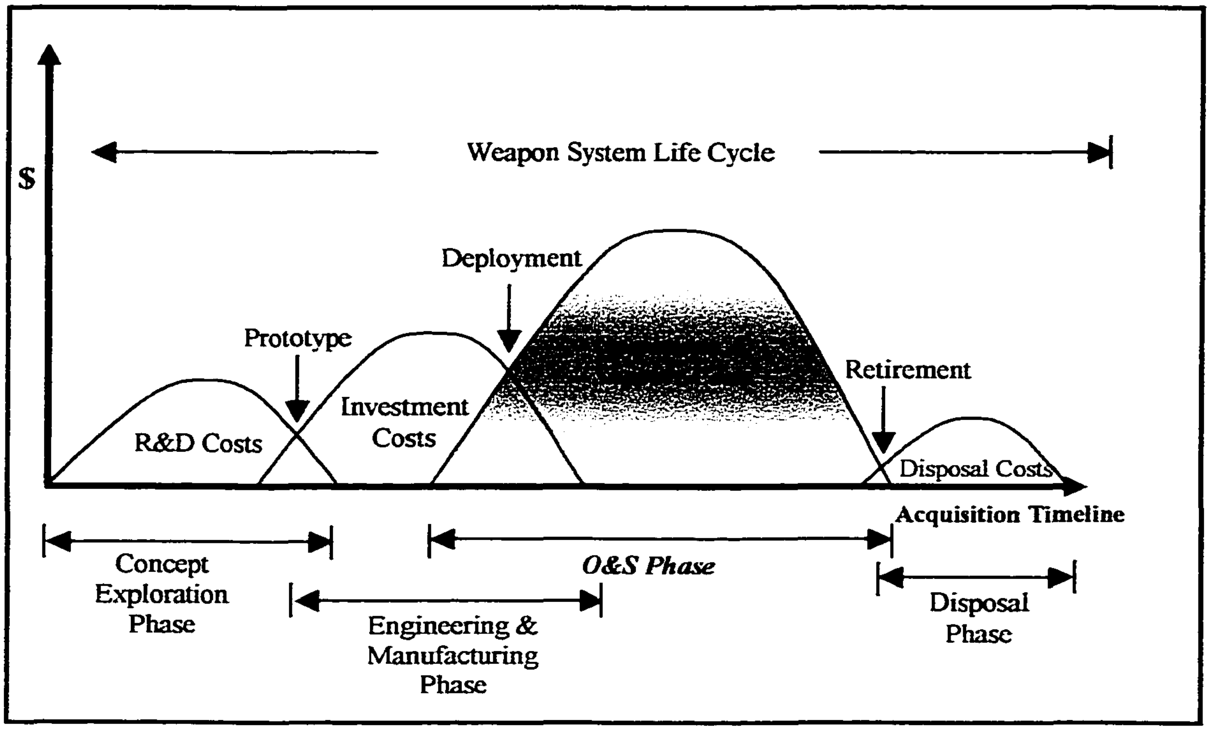

FIGURE 2. Military Life Cycle

Since defense budgets are developed six years prior to execution, it is difficult to estimate operating costs in the Future Years Defense Plan (FYDP), which provides input to the President's Budget. Research and development costs are more visible in the President's Budget because they have their own budget line. Operating costs are less visible because support segments of the budget are organized by functional area and not by individual weapon system. Therefore, it is critical that each element of the operating cost estimate be as accurate as possible when it is allocated to each functional area in the budget. Cost drivers such as physical characteristics (weight, volume, density), policy factors (operational tempo, maintenance concept, crew size), and operational characteristics (power, speed, range, reliability) must be identified early in the acquisition process to facilitate proper budgeting (Cost Analysis Improvement Group, 1992).

Under DoD guidelines, operating cost estimates may be made using any of several cost estimating techniques. Acceptable methods include parametric analysis, analogy, engineering estimation, or a combination of these methods (Cost Analysis Improvement Group, 1992).

PROBLEM STATEMENT

This research study develops a parametric cost model to predict direct operating costs for Army ground combat systems. The model is intended for use during the first two phases (Concept Exploration and Program Definition and Risk Reduction) of the Army's acquisition process.

RESEARCH QUESTIONS

This research is guided by two research questions. The first research question is: What weapon system characteristics (such as weight, horsepower, fuel consumption, primary mission, NBC protection, fire control, and night fighting capability) impact directly on operating Army ground combat systems? The objective of the first research question is to determine what cost drivers are relevant to the parametric cost model's development. The thrust is to focus on factors that impact on "direct" operating costs of ground combat weapon systems. While there are many factors that may influence the operating costs, the research goal is to use a minimum number of factors to generate the model.

The second research question is: What is the form of the parametric model for operating costs of Army ground combat weapon systems? The objective of the second research question is to determine the type of relationship, linear or curvilinear, the predictor variables share with the response variable.

ASSUMPTIONS

This study assumes that the Army's Operating and Support Management Information System (OSMIS) relational database contains representative and sufficient data to adequately model the operating cost process. This assumption is necessary to conduct the study and develop the parametric model. The database is maintained by the Army Cost and Economic Analysis Center and serves as the central source of the Army's Visibility and Management of Operating and Support Cost (VAMOSC) system. DoD regulations require that historical data in the VAMOSC system be used when developing operating and support cost estimates (Cost Analysis Improvement Group, 1992). This requirement implies that there is an underlying assumption that the data is both reliable and sufficient for cost analysis purposes.

Combat roles and missions have a significant impact the operating costs of ground combat systems, and it is assumed that the policy affecting the roles and missions of Army ground combat systems will remain constant. This assumption is necessary because it establishes that the underlying patterns and trends of current weapon systems in the OSMIS database hold true for future systems that the Army develops. Specifically, all current ground combat systems are fully tracked systems. If the database is used to predict costs for a wheeled combat system, the database would not provide relevant data for predicting costs related to the wheel drive train of the combat system. This also establishes that operating costs associated with weapon system characteristics, which are related to its combat role, will hold true for future systems with similar characteristics. For example, costs associated with operating a tank that has a primary mission to defeat enemy armored vehicles (such as the 65 ton, heavily armored M1A1) will continue to be greater than costs associated with operating an infantry fighting vehicle that has a primary mission to defeat enemy infantry vehicles (such as the 33.5 ton, medium armored M2 Bradley).

SCOPE AND LIMITATION

This study focuses on cost estimating relationships using vehicle characteristics, policy factors and performance data of ground combat systems. This analysis and parametric model are limited to Army ground combat systems and uses data from the OSMIS database. The model is not intended to be universally transportable to Army wheel and air systems. In addition, this study is restricted to analysis of direct operating costs and does not address support or indirect costs such as personnel or facilities costs.

The limitations of this study are designed to make the results useful in making cost reductions through the engineering design process for Army ground combat systems. Cost trends show that "for at least the last fifty years, the cost of systems has been driven by performance to ever increasing levels – after inflation has been removed." (Dean and Unal, 1992). As a practical fiscal matter, the Army cannot no longer afford to design and procure weapon systems that are extremely expensive to operate and maintain. The parametric cost model developed in this study is directly applicable to design for cost techniques, which are focused on reducing life cycle costs while maintaining desired system performance (Dean and Unal, 1992). This model may be used as part of the concurrent engineering process to predict future operating for Army ground combat systems. Using an iterative design process, the weapon system engineering team can use the cost predictions to optimized operating costs with performance specifications.

IMPORTANCE OF THE STUDY

The independent review and validation of operating cost estimates is critical for informed decision making for major weapon systems. Valid operating cost estimates are needed to program funds for adequate support in the FYDP. Under-funded weapon systems typically suffer from major readiness problems, which result in a reduction of the Army's total combat capability. This research developed a model that is useful in bridging the information gap caused by the long lead-time between programming funds and actual budget execution.

Another major contribution of this study is in the analysis of uncertainty in cost predictions of military weapon systems. Weapon programs are subject to cost risks, schedule risks, technical risks and other manufacturing/production related risks. An accepted perspective is that cost overruns in programs, which are linked to uncertainty in cost estimates, are related to unresolved areas of risk (Black, 1989). Quantifying operating cost risks provides valuable information for understanding, controlling, or reducing such costs in the concurrent engineering design process.

SUMMARY

The yearly operating cost is a major decision factor for procuring new military weapon systems. As a result of the declining defense budgets, the Army has been forced to better manage the life cycle costs of its ground combat weapon systems. Because up to 80% of the total cost of a weapon system is committed by the end of the design phase (Buede, 2000), it is imperative to reduce the cost of operating ground combat weapon systems in the first two phases of the acquisition process. Likewise, the best possible operating cost information is needed for programming future funding requirements into the FYDP. The Army's ability to maintain its readiness to conduct sustained land combat hinges on its ability to accurately predict and control weapon system operating costs.

Parametric cost modeling has been accepted by government agencies for many years. This technique provides a scientific means of predicting future costs of operating Army ground combat systems. In addition, the modeling process identifies cost factors that are useful in cost reduction efforts commonly associated with many concurrent engineering and optimization processes.

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

The purpose of this chapter is to present existing literature that underpins the theory and application of parametric modeling and cost estimation. The first section provides background information on the theory of parametric analysis and its application to cost estimating. The second section provides information and methods of dealing with uncertainty in cost estimating. The third section presents information on military methodologies and applications for parametric cost estimating.

COST ESTIMATION AND PARAMETRIC ANALYSIS

From a theoretical point of view, every cost estimating function can be viewed as a statistical distribution. This means that one can develop a frequency distribution from the data and determine the associated probabilities of a particular cost for a given data range (Samid, 1996). From a simplistic theoretical viewpoint, cost estimating should focus on narrowing the cost estimating curve around a mean value. With this in mind, the data collection effort must focus on relevant factors that are strong predictors of the cost variable.

Many cost estimating processes use prior knowledge of independent factors to predict the associated cost of performing a task or completing a project. In parametric estimation, the estimated cost is considered as dependent on *m* independent (predictor) variables X_1, X_2, ...X_m (Samid, 1996). The selection of predictor variables formally forms an estimation set, where each X_i is a member of the set. As part of the estimation process, a cost function is developed by forming a subset of the original estimation set. This implies that the estimator must use criteria, mathematical and/or judgmental, to eliminate members of the estimation set. From a practical standpoint, this suggests that the estimator must have knowledge of the underlying process being estimated. To understand the impact of knowledge on the estimating process, we must understand a basic point of Shannon's communication theory. Shannon's theory implies that decoded information is of no better quality than the coded information received from the source (Skyttner, 1996). The purpose of the cost estimate is to communicate information to a user or decision maker. The knowledge of the estimator is a key factor in determining the estimation set elements that are selected to model the cost data. The quality of the final estimation set influences the quality of the cost estimate that is communicated to the user. In this case, knowledge of the process increases the quality of the estimate.

By its very nature, parametric analysis requires that an estimator must select a model. The simplest model of any set of independent variables and its associated cost response function is the linear model

(2.1) $$Y = b_0 + b_1x_1 + b_2x_2 + \ldots + b_kx_k + \varepsilon$$ (Mendenhall, 1968).

The above equation may also be recognized as a general form of a response surface model. This suggests that parametric analysis and modeling may be considered as the application of response surface methodology to cost analysis (Dean, 1995). Thus, the theoretical basis of regression analysis and linear statistical model building form the foundation of parametric cost analysis. In these models, the response variable is a linear function of the unknown parameters (b_0, b_1, ... b_k) and not necessarily a linear function of X (Wackerly, Mendenhall and Scheaffer, 1996). Regression analysis is one of the commonly accepted basic methods of modeling cost and predicting future costs (Hanke and Reitsch, 1998). When building the model, the estimator ideally wishes to select predictors that have the greatest influence on the cost being estimated. From a mathematical perspective, the estimator must select predictors that show some degree of correlation to the cost being estimated. However, by establishing correlation the estimator does not establish causation. Establishing causation may be difficult or even impossible, but establishing correlation allows the estimator to use the model to approximate the true cost.

When estimating cost in projects, products, or systems, the predictor variables are usually design or performance characteristics (such as weight, speed, power, etc.). The parametric model expresses statistical relationships between cost and the predictor variables based on historical information of past designs (Ostwald, 1992). One of the most powerful features of parametric estimating is that it is capable of providing useful budgeting information in early stages of projects, i.e., when formal designs of the new system do not yet exist (Melin, 1994).

DEALING WITH PARAMETRIC UNCERTAINTY

By definition, parametric estimates have elements of uncertainty associated with them. The parametric model is a statistical model that has an associated distribution and probabilities. One of the underlying assumptions of linear statistical models is that the regression line estimates the mean value of the response (Webster, 1998). The model's error term (ε) is assumed to be normally distributed about the regression line. By definition, a normal distribution has a mean and a variance, with the variance representing the model's uncertainty of the estimate.

One method of dealing with uncertainty in cost estimating is to use a "probabilistic" cost estimating approach (Uher, 1996). Monte Carlo simulation offers one method of introducing variables that assign degrees of risk to the modeling process. The basic premise is to use historical data or subjective judgment information to build statistical distributions. The distributions are then used as a part of the model development process. Uher (1996) asserts that probabilistic cost estimating focuses more attention on possible ranges of risk variables, which in turn leads to more robust estimates. This approach may be used at the system (project) level or at the subsystem level to develop risk variables.

When sufficient detail is available, it may be possible to develop more precise system cost estimates by modeling risk at the subsystem level. One method of accommodating a system's risk is to identify cost variability of individual elements in a work breakdown structure (WBS) (Mauro, 1993). This method allocates cost impact to the subsystem level, which helps to facilitate risk management and cost optimization. Mauro (1993) demonstrates that it is possible to combine risk modeling and simulation techniques with parametric modeling. Mauro (1993) suggests selecting a cost (50^{th} percentile, 90^{th} percentile, etc.) based on the variability of the individual WBS cost elements. The summing of the individual elements provides a precise and detailed assessment of the risks for the system. In fact, this method allocates risk directly to appropriate subsystem elements.

In their article "Guidelines for Success for Risk Facilitating," Noor and Rye (2000) also suggest using Monte Carlo simulation as a means of determining the impact of influence factors on cost estimates. Influence factors could be policy type issues or hardware issues that impact on the project or system cost. Likewise, technology and system complexity can be modeled as risk variables that impact the cost of a system. Noor and Rye (2000) suggest that a good method for assessing these types of risks is to assemble a team of experts, directed by a facilitator, to develop the risk models.

Uncertainty is inherent in any cost-estimating endeavor. While the researcher may not be able to eliminate uncertainty from the model, it is important that the uncertainty be recognized and quantitatively accounted for. Because parametric estimating is a statistical process, any acceptable statistical means of accounting for uncertainty will provide valid information related to the cost risks. Resources, such as time or money, and the use of the cost model should drive the level of sophistication of accounting for the uncertainty. Simple methods, such as confidence intervals, can provide valuable information in many applications.

MILATARY PERSPECTIVE

In January 1956, David Novick of the RAND Corporation published the first known comprehensive "weapon system" cost analysis study. It is important to note that this study also uses the term "weapon system" as opposed to weapon. RAND recognized that to adequately estimate the cost of a new weapon, the system must be considered in its entirety. RAND proposed that the cost of a new weapon system includes the cost of related equipment, personnel, maintenance, supply, facilities, operations, provisioning, and other system related costs (Novick, 1956). This thinking represented a fundamental shift in the performance of cost analysis for military weapon systems.

The United States Air Force commissioned the study in an effort to assist organizations manufacturing its products and weapons. The Air Force had discovered that the manufacturing organizations lacked a basic understanding of the methodology RAND employed in performing cost analysis for the research, development, and acquisition of new Air Force equipment. The study attempted to set forth a methodology that accounted for all the factors that affect the cost of a weapon system. It also attempted to provide a means to quantify the economic impact of introducing a specific weapon system into service over a give period. In short, it provided a method to estimate operating and support costs. Novick (1956) pointed out the importance of separating out investment costs from recurring yearly operating and support costs. Although Novicks's study contains no data, he was able to logically argue that cost analysis and estimating is an integral part of the decision making process when comparing different alternatives for a proposed weapon system. Analyzing all the costs of introducing a new weapon system, Novick (1956) showed that the recurring operating and support costs make up the largest portion of the total cost of the weapon system over its life cycle. Specifically, Novick's study broke the total weapon system costs into one-time investment costs (research, new facilities, acquisition, etc.) and recurring yearly costs of operating and maintaining the new weapon system.

RAND's methodology focused on determining the major characteristics that impact the total weapon system's cost. It tried to identify all costs incurred in operating the system in performance of its assigned combat mission in an operational environment.

Novick (1956) identifies maintenance, petroleum products and repair parts as major yearly recurring costs for operating a weapon system. He recommends using existing historical data, from standardized data sources, of existing weapon systems to develop cost estimates for alternatives under consideration for development.

In today's terminology, RAND's methodology is analogous with life cycle costing or total cost management (Medley, 1996). Medley (1996) stated that the entire system cost, from its purpose statement to final disposal, must be considered when estimating its cost. He further suggested that this can only be accomplished by having a clear understanding of the factors affecting the cost of the system.

A recent study demonstrated that it is possible to develop weapon system cost estimates using data from the OSMIS database (Greer and Nussbaum, 1990). The study used system characteristics and performance data to develop parametric models to predict various system costs. Part of the study focused on the development of estimates for operating costs of Army ground combat systems. However, the study did not attempt to evaluate risks at the system or subsystem element levels. The study also developed operating costs, on a per operating mile basis, using characteristics such as hull length and width of the vehicles. While these characteristics did correlate with the operating costs, there was no evidence presented that showed such characteristics are significant causes of operating costs associated with the systems.

SUMMARY

Related literature on parametric modeling shows that it is a relatively straightforward and scientific method for predicting future costs from a known set of data points. Besides being built on sound theoretical mathematical foundations, parametric models are reasonably easy to use and update with new information. The model results are capable of being presented in graphical forms, which provides a simple means of communicating information in a variety of decision-making situations.

Equally important, parametric models lend themselves to a variety of techniques for dealing with uncertainty. The models are capable of incorporating risk variables directly into the cost computations or providing confidence intervals of the response variable based on a specific set of predictors. Parametric models are also flexible enough to use risk variables derived through Monte Carlo simulation techniques.

Lastly, though the results of this literature research showed that while parametric cost modeling is widely accepted by the military, it did not reveal a study that directly incorporates risk variables directly into the development of military weapon system cost models. This study focused on providing results and information useful in filling the gap in this research area. This research developed a unique parametric model that incorporates one risk variable that is derived from statistical distributions of WBS cost data.

CHAPTER 3

RESEARCH METHODOLOGY

The purpose of the research methodology is to provide the reader with the detailed methods and data analysis techniques used to develop the parametric cost model. The first part provides a brief description of the OSMIS database and its data composition. While it is not necessary to fully understand all the details of the OSMIS database, some knowledge is necessary to understand why the assumption was made that the data is relevant and accurate. The second part covers the selection of the vehicles used in the study, and it provides a brief description of the mission of the weapon systems. The next part describes the screening and selection of the actual data elements used to develop the research database. This includes discussion on techniques used to screen and normalize the database. Lastly, the actual methodology used to develop the model is presented.

O&S MANAGEMENT INFORMATION SYSTEM DATABASE

OSMIS is the vital element of the Army's Visibility and Management of Operating and Support Costs program. OSMIS tracks operating and support cost information for several hundred major weapon systems for the United States Army Cost and Economic Analysis Center (USACEAC). These systems include but are not limited to combat vehicles, missile systems, aircrafts, trucks, electronic systems, and combat engineer systems. OSMIS is the Army's designated data source for operating cost information, and it has been used in a past cost analysis research study (Greer and Nussbaum, 1990).

The OSMIS database provides its users a variety of information about operating costs for weapon systems. OSMIS assigns each tracked system a unique weapon identification code (WIC) so that different variants of the same system can be tracked individually. This allows users to create customized information reports useful for researching cost for individual systems or classes of systems. OSMIS also tracks information by WBS, which allows the user to focus in on cost drivers for individual systems and variants.

This database maintains a list of Army units and the OSMIS weapon systems that the units own at the battalion level. Battalions are analogous to medium size organizations (approximately 400 personnel) that may have four to five independent units reporting to a central headquarters. Each unit is based at an installation and is uniquely identified by its unit identification code (UIC). Operating cost information is reported from each unit through its installation and eventually to the OSMIS database. As units use their weapon systems, the activity of the systems is tracked. For example, owning unit personnel check the odometers of ground combat systems on a regular basis, and this information is also fed to OSMIS and processed to generate vehicle mileage across the entire Army fleet of vehicles. OSMIS tracks operating information such as fuel consumption, maintenance information, and repair parts consumption. All reported information is linked to the associated cost of operating a specific weapon system.

THE SAMPLE OF GROUND COMBAT VEHICLES

Selecting a representative sample of Army ground combat vehicles was essential to developing a robust model. In this case, "robust" refers to the model being able to predict operating costs over the entire range of ground combat vehicles. This meant that the model had to be relatively insensitive to variations in the utility of the ground combat systems that were being analyzed. The primary utility, or function, of Army ground combat systems can be subdivided into three categories (see FIGURE 3).

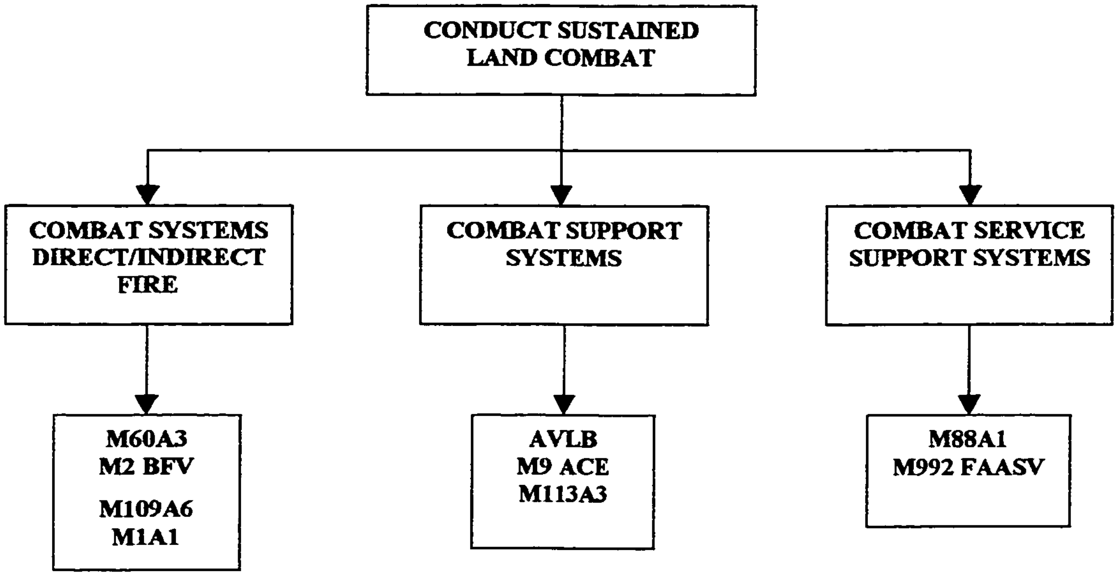

FIGURE 3. Mission and Vehicle Relationships

The first category is primary combat system, which in this study includes direct fire and indirect fire weapon systems. The primary purpose of these weapon systems is to close with and destroy enemy forces through direct fire, indirect fire, and maneuver (U. S. Army Command and General Staff College Battle Book, 1996). For this research study, the M2 Bradley Fighting Vehicle (BFV), the M60A3 tank and the M109A6 howitzer weapon systems were selected as representative vehicles for the primary combat system category of vehicles.

The second category in this study is combat support systems, including common ground combat systems that do not have direct fire or indirect fire missions and Engineer weapon systems. The primary purpose of these weapon systems is to support Infantry, Armor, and Artillery forces to engage, destroy or neutralize enemy forces (U. S. Army Command and General Staff College Battle Book, 1996). In this research study, the Armored Vehicle Launched Bridge (AVLB), the M113A3 armored personnel carrier and the M9 armored combat earthmover (ACE) weapon systems were selected as representative of the combat support system category of vehicles.

The third category in this study is combat service support system, which includes all ground combat systems that have a primary mission to provide logistical functions to combat and combat support weapon systems and their associated crew members. The primary purpose of these weapon systems is to provide maintenance or supply support operations for Infantry, Armor, Artillery, and Engineer weapon systems (U. S. Army Command and General Staff College Battle Book, 1996). In this research study, the M88A1 medium recovery vehicle was selected as a representative vehicle for the combat service support category.

The selected vehicles for this study cover the entire range of Army ground combat systems in the current inventory. Several variants of each system exist; however, system variants are not viewed as different weapon systems in this study. For example, the Army's M6 Linebacker Air Defense System is essentially a M2 BFV with stinger anti-aircraft missiles mounted on it. Additionally, the M1A1 Abrams main battle tank and the M992A1 field artillery ammunition supply vehicle (FAASV) were excluded from the model development process. Data from the M992A1 is used to validate the model. For the purposes of this study, the M1A1 is considered to be a unique ground combat vehicle that features a 1500 horsepower gas turbine engine instead of the traditional diesel engine found in the other systems in this study. Therefore, this vehicle is not considered to fall within the data range identified for model development and evaluation. However, the M1A1 vehicle was used to evaluate the limits of the model and its potential applicability beyond the category of vehicles identified.

DATA SELECTION AND SCREENING

To ensure consistency of the data, only data from the OSMIS database was used in this study. The OSMIS database includes weapons system data from fiscal years 1993 through 1999. Because of missing data problems for 1993, only data from years 1994 through 1999 are included in this study.

The raw data initially selected for the study included the vehicle type, the fiscal year, quarter, WBS information, density of systems reporting, net total cost, average cost per system, activity mileage, and average cost per mile for each system. The data was summarized from all commands reporting in the Army. The data was then screened to ensure that the information on each system was complete and that no duplicate information was recorded. One problem noted with the raw database was that it did not have a standard format. Since the database was arranged by WBS, any WBS element that had no cost reported for the quarter was omitted from the quarter. The database for the study was designed with a standard format using WBS elements 01, 02, 03, 04, 05, 06, 07, 11, 12, 13, 14, and 18. All maintenance and repair parts data reported for WBSs in addition to these were added to WBS 18, which is the other category. OSMIS uses

WBS element 18 to capture data on miscellaneous equipment that does not clearly fall into another WBS category. For purposes of this study, WBS 18 was also used to capture costs for WBS elements, such as vehicle cabs, which do not actually exist on ground combat systems. The fuel cost for each year was recorded as WBS 0 for convenience of developing the cost-estimating database. The raw data was combined to create yearly total operating cost by WBS. The information was also used to compute the average cost per system by WBS and total yearly system cost using the density information. The CER for each WBS is the computed percentage of that WBS element to the total yearly operating cost of the system. The main purpose of computing the simple CERs was for developing risk factors at the WBS level. The study used the derived database (see APPENDIX B) to develop the parametric model.

METHODS

This research study used quantitative methods to develop a parametric cost model for direct operating costs of Army ground combat systems. The weapon systems used in the study were selected from a finite set of Army ground combat systems that are currently used in active or reserve component units. The two main statistical tools used in the study are correlation analysis and least squares regression. Correlation analysis was used to determine the predictor variables that showed a significant relationship with the operating cost of the systems. Variables that did not show a significant relationship to the response variable, cost, or that were highly correlated with other predictor variables were eliminated from further analysis. Regression analysis was then used to develop a linear statistical model that predicted the average yearly operating cost of a system for a given set of parameters. To ensure that the "best" model was selected, all possible regression combinations of the final predictor variables were analyzed. The model that contained the highest coefficient of determination (R^2) was selected and the "best" model. Interestingly, the model with the highest coefficient of determination and highest adjusted R^2 contained all the final predictor variables that resulted from the correlation analysis.

With the method firmly established, ensuring the study used "useful" data was assumed to be one of the key elements in the model's development. It is a well-known fact that the quality of the information obtained from data is no better than the quality of the original data. Therefore, the quality of the database was seen as the critical issue in developing the model. To be useful data, as applied here, the data must be reliable, accurate, relevant, and consistent (Hanke and Reitsch, 1998).

Since the data collected came from the Army's designated source for operating cost information, the OSMIS database, the data was assumed to be both reliable and accurate. Because OSMIS is maintained and operated by the United States Army's Cost and Economic Analysis Center, this is a reasonable assumption to make. The database is audited on a periodic basis to ensure that it is accurate based on available field data. To access the data, users must be a government employee or contractor with a designated need to know the information. Each user must go through a sign up process to obtain a login username and password that verify the identity of the requestor. This procedure is one of the security measures used to maintain the accuracy of the database.

The design of this study and the selection of the ground combat systems ensured that the data is relevant. First, the OSMIS database is updated on a periodic basis to provide the latest operating cost information available on the weapon systems that it tracks. Second, the weapon systems chosen for the study are the major combat and support systems found in Army's heavy mechanized and armor divisions. Assuming that the United States defense strategy remains relatively constant, using the designated weapon systems ensured that data covers all roles, missions and vehicle utility functions of the current ground combat fleet. This information provided enough data to build an empirical distribution that meets cost analysis guidelines for major Army ground combat systems (DoD Regulation 5000.2R).

Using the same twelve WBS cost elements and fuel costs for each system in this study ensured that the data collected for each system was consistent. Common elements allowed the study's database to be easily manipulated without changing the integrity of the information or interpretation of the elements within the database. This also standardized the CERs and risk factors developed from the data.

SPECIFIC APPROACH

The specific research approach is shown in FIGURE 4 below. This study used the basic cost estimate development approach recommended by the RAND Corporation for the development of military weapon systems (Novick, 1956). Although RAND's study is over 44 years old, its basic principles are still sound and relevant to today's cost estimating efforts. Novick's (1956) study clearly provides a conceptual framework for the basic procedures of weapon system cost analysis and estimating.

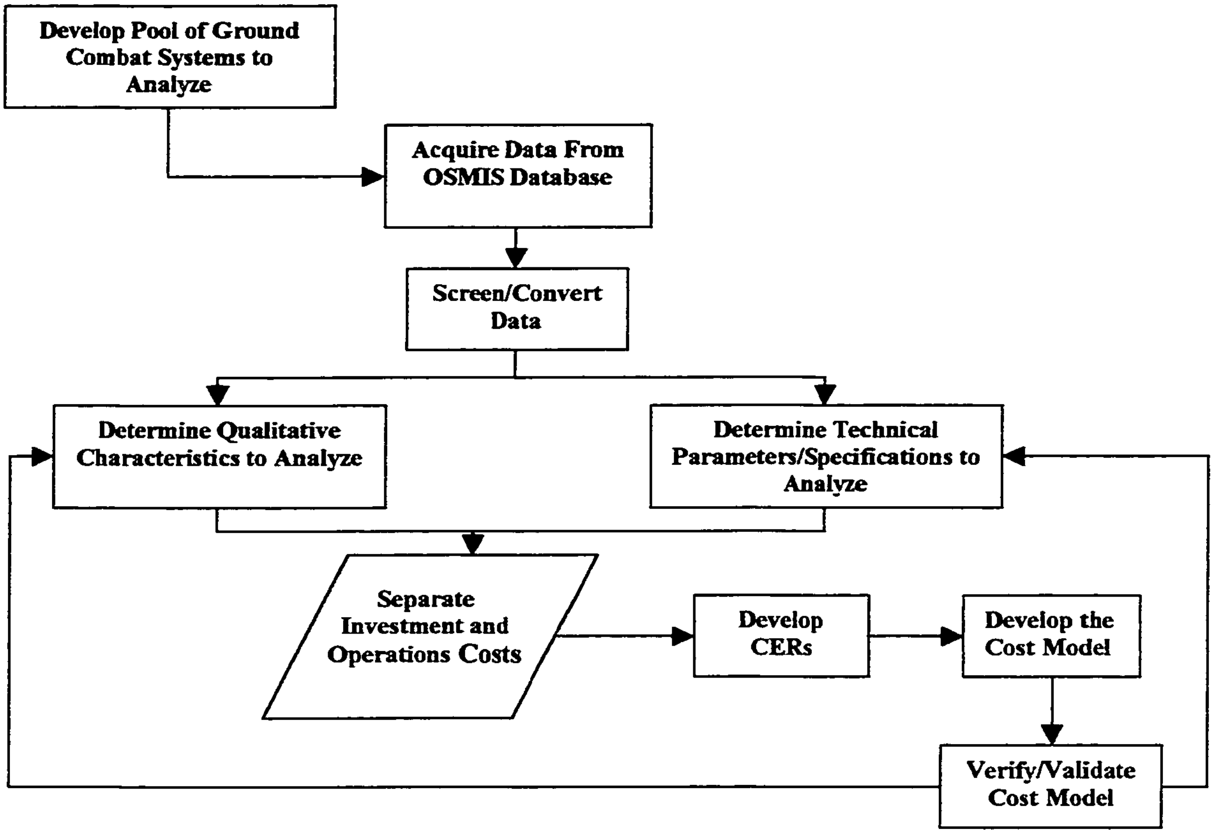

FIGURE 4. Cost Estimating Methodology

The first objective is to identify the major sub-elements of the weapon systems in the OSMIS database. This allows each sub-element to be analyzed individually so that an inference can be drawn about its impact on the total operating costs for the system. To achieve this goal, data collection focuses on maintenance costs, repair parts costs, and petroleum costs for each system. For this study, the twelve standard WBS elements identified above are the sub-elements analyzed for cost impacts. Some elements, such as WBS 11 (NBC Equipment), are treated as qualitative elements and others, such as WBS 02 (Suspension/Steering) are treated as technical elements.

The second objective is to determine the impact of the assigned mission of the weapon system on the total cost. This study deals with the assigned mission by focusing on the utility of the system. For example, the M2 Bradley Fighting Vehicle (BFV) and the M1A1 Abrams tank have similar combat missions, "close with and destroy the enemy by using direct fire and maneuver," (Command and General Staff College Battle Book, 1996). However, the M2 BFV is more suited for supporting mounted and dismounted infantry operations than the M1 tank. Therefore, the two systems have differing utility functions and extremely different associated costs. The vehicle utility is analyzed using a dummy variable (Mission), which has values of 0 (combat service support and combat support vehicles) or 1 (combat indirect fire and direct fire vehicles).

The third objective is to distinguish between the one-time investment costs of the weapon system and the recurring yearly costs of operating the system. In essence, this amounts to determining which are short-term costs and which are long-term costs for the weapon system. However, the decision to build a weapon system is inherently a commitment to fully invest in its future operating and support costs. Therefore, this study focuses on operating resources that can be directly attributed to being consumed by the weapon system.

These three objectives represent the foundation that the study is built on. Completing these tasks allowed the total cost of each element to be aggregated up to develop a total system yearly operating cost. Additionally, this allowed each element to be analyzed to determine potential cost risks associated with that element. Aggregation of the data also allowed the development of a CER for each cost element.

The CERs play an important role in estimating the cost risk associated with the parametric model. As with any known complex system, the "system darkness principle" applies to the weapon systems in this study. The system darkness principle simply states that no system can be completely known (Skyttner, 1996). This general systems theory principle indirectly applies to the parametric model in this study. The model will have a certain degree of uncertainty associated with it and will not perfectly estimate the future cost of operating known or yet to be developed ground combat systems. However, cost models that provide some quantitative means of estimating the cost risks are more effective in communicating the total cost of the system and providing data for making more informed decisions regarding system cost expectations. One method of quantifying risk is using probability distributions to identify elements that have large cost variances (Uher, 1996). This study identifies cost risk factors, which are included in the model, and uses probability distributions to analyze the impact of each WBS sub-element on the total system operating cost.

The model is developed using two statistical tools, (1) correlation analysis, and (2) multiple linear regression. The correlation analysis allows the identified variables to be compared to each other and the response variable (cost). This analysis helps to eliminate variables that are highly dependent on each other and avoid multicollinearity problems in the final model. Multiple linear regression allows the formulation of a mathematical model useful in predicting the operating costs of current and future combat systems within the range of the systems used to develop the model.

Lastly, the study uses several verification and validation testing techniques. The verification process verifies that the model is indeed an unbiased estimator. This is accomplished by analyzing the residuals of each the actual cost to the model's estimate. The residuals of each factor and their probability distributions are also analyzed for normality. The validation process uses one ground combat system, independent of the model, from the OSMIS database to test the predicted average yearly operating costs against the actual average yearly operating cost of the system.

SELECTION OF COST ESTIMATION RELATIONSHIPS

The objective of developing the CERs was to eventually convert the CERs to a cost risk factor (CRF) for use in the final model. In keeping with that objective, a simple cost estimating relationship for each level 3 WBS element was developed. To provide a straightforward means of analyzing the variability of the cost impact of each WBS element, the study used the percentage of each WBS element to the total cost of the system on an annual basis. Computing the cost percentage by year allowed the creation of empirical probability distributions for each of the CERs, which provided variance information useful for including risk in the modeling process.

DATA ANALYSIS

The data needed for addressing the research questions are: (a) the physical characteristics of the vehicles, (b) the performance characteristics of the vehicles, and (c) vehicle utility information for roles and missions of the weapon system. The data for the research questions was downloaded from the OSMIS website to an Excel spreadsheet file in its raw electronic format (Microsoft Excel, 2000). In order to obtain the entire data set for the study, the researcher had to individually query the OSMIS database for each selected weapon system.

Initial Data Screening

After the developed cost estimating database was uniformly formatted for convenience of data analysis, all factors that were not related to yearly recurring costs of operating the weapon system were eliminated from the database. The data items for each system were then reviewed to ensure that the data reported for each system was consistent. Additionally, each data item was reviewed for possible typographical errors and to identify missing data points. Clarification was then made on two elements of the database.

First, it was observed that the WBS elements were not standard for each reporting period in the database. This is because when no Army unit reports a cost related to a WBS element for the reporting period, OSMIS was designed to simply omit the WBS element for the reporting period. To address this issue, the developed cost estimating database (used for analysis) utilized a zero for data elements with no cost activity for any reporting period.

Second, it was observed that there were missing data elements in the OSMIS database for year 1993. To minimize the effects of missing data, only years 1994 through 1999 were used in this study. This limited the selection of ground combat systems for the study and also affected the M109A6 Paladin, one of the systems included in the study. The M109A6's density of systems, activity mileage and fuel consumption information were missing for fiscal years 1994 through 1996. However, all other data elements were available from the OSMIS database. Because Microsoft Excel interprets missing data as zero (Berk and Carey, 1995), the only two logical courses of action were to analyze the data without the years containing partial data or to estimate the values of the missing data elements. Instead of developing the model with the missing data, it was consciously decided that it would be better to estimate the missing values for the database. This issue was handled by limiting the density of systems for years 1994 through 1996 to the minimal number of systems recorded for fiscal year 1997. The minimum number of systems was used to be conservative and not under estimate the yearly operating costs per system. The activity mileage was calculated by taking the average of the activity mileage recorded from 1997 through 1999. The average price for fuel, contained in fuel the reports of the other systems in this study, was used to calculate the Paladin's average yearly cost of fuel for years 1994 through 1996. This procedure allowed the researcher to include the data that was available for the M109A6 for years 1994 through 1996 in the study and eliminated the need to perform regression with the missing data elements.

Before the analysis of data could begin, the created database was transformed to reflect constant year dollars, which allowed yearly comparisons of operating costs. The DoD Parametric Estimating Handbook (1999) outlined the procedure used to normalize the cost-estimating database. Each cost element used to develop the parametric model was multiplied by a yearly discount rate. This study used the U.S. Army's CEAC revised discount rates for year 2000 to normalize the cost data.

Data Item Analysis

This study examined the following vehicle characteristics: vehicle weight, horsepower, fuel consumption, maximum speed, yearly mileage (activity), crew size, and cruising range. It also used dummy variables to examine the following qualitative characteristics: armor protection, adverse weather capabilities (thermal sight), and mission. The cost risk was modeled using a derived variable (CRF) to measure the effects of uncertainty, measured as variance, on the individual WBS elements operating costs. All CERs were examined to determine their impact on total operating costs for each system (see APPENDIX C). From the analysis, the researcher determined that CERs 01, 02, and 03 had the most significant cost impacts (greater than 10% on average) on systems included in this study. Although the 10% rule is somewhat arbitrary, it was necessary to limit the number of variables used in the analysis. One heuristic for limiting the number of predictor variables is to divide the set of data points by ten (Hanke and Reitsch, 1998). Therefore, all CERs that were less than 10% of the total cost were eliminated from the final analysis.

CRF Derivation

The researcher used the empirical distribution functions (EDFs) of CERs 01, 02, and 03 to derive the CRFs for the cost-estimating database. Essentially, the EDFs are the nonparametric form of the approximate cumulative distribution function (CDF) formed from the sample CER data (Conover, 1999). In reality, the EDF is a non-decreasing step function and not a true CDF. The probability that the CER function can take on a distinct value between its minimum and maximum value is k/N, where N is the sample number and k is the number of times an individual value appears in the CER function (see APPENDIX D). The EDF for each CER was then compared to a known lognormal distribution using the Kolmogorov-Smirnov goodness-of-fit test. The Kolmogorov-Smirnov goodness-of-fit test is a nonparametric statistical procedure that tests a given EDF, denoted as S(x), to a known distribution, denoted as F(x) (Conover, 1999). The test compares the absolute value of the largest vertical distance of S(x) to F(x), which allows the calculation of the test statistic for comparison with statistical tables. The test statistic (T) is defined as

(3.1) $T = \sup_x | F(x) - S(x) |$, where T equals the supremum over all x.

As pointed out by Conover (1999), the Kolmogorov-Smirnov test is usually preferred over the Chi-Square test when using small samples. This researcher also prefers the power of the Kolmogorov-Smirnov test because it does not require the assumption that the sample size is large enough to provide a good approximation of the true CDF, which is a requirement when using the Chi-Square test (Wacklerly, Mendenhall and Scheaffer, 1996).

The researcher compared the EDFs to known distributions using the Kolmogorov-Smirnov test for goodness-of-fit (Best Fit, 1998). It was determined that CERs 1, 2, and 3 could be approximated by a lognormal distribution, with mean = μ and variance = σ^2. As a check to the Best Fit distribution comparisons, the Kolmogorov-Smirnov test was conducted using a statistical table and a simulated lognormal distribution using data generated by Monte Carlo simulation (@Risk, 1998). The comparison indicated that the parent distribution could be of lognormal form (see APPENDIX D). Additionally, a comparison of CERs 1, 2, and 3 for each individual ground combat system showed that the CERs can be approximated by a lognormal distribution (APPENDIX D).

To develop the individual CRFs, the variance of CERs 1, 2, and 3 were examined for each system. The variance was then compared to the mean variance of each CER. If the variance of the individual system was greater than the average variance for all the systems, the 80th percentile CER value was used to calculate the CRF instead of the mean value. The CRF was calculated by dividing either the mean CER value or the 80th percentile CER value by the actual CER value for that vehicle and year. Using the 80th percentile is an arbitrary value selected by the researcher, but it follows along the logic proposed by Mauro (1993). Essentially, Mauro pointed out that most decision makers would like to be 80% sure that costs won't exceed a certain value. The 80th percentile value was used here, in the same manner, to derive a factor that represents risk at a WBS sub-element level. The data for the CRF calculations is located in APPENDIX E.

Final Data Screening

The researcher used a correlation matrix to perform final screening of the variables. The initial criterion for screening was determining all independent variables that had an absolute Pearson's Product Moment Correlation of 0.80 or higher. Each variable was successively removed to observe the impact, if any, in the matrix. The final screening used additional criteria, such as the inclusion of at least one risk variable in the model, to determine the removal of variables that the researcher believed to be important to the overall research objective. In order to develop a parsimonious model with relevant variables, independent variables with the smallest correlation to operating cost were also removed from the database. The exception to this rule was in the case of CRF2 and CRF3. The cost percentages of the vehicle suspension/steering sub-systems and power package/drive train sub-systems make up the highest percentage of total cost for each system. Additionally, the researchers military experience has shown that these two sub-systems are physical linked. Therefore, the two CRFs were averaged to develop a combined cost risk variable. Although this risk variable models risk at the system level, the risk can be traced back to the vehicle suspension/steering sub-system and the power package/drive train sub-system. This is important because concurrent engineering efforts to reduce operating costs can now be linked to risk in these sub-systems.

MODEL DEVELOPMENT

The conceptual framework for modeling the operating costs process is shown in FIGURE 5 (adapted from Flood and Carson, 1993).

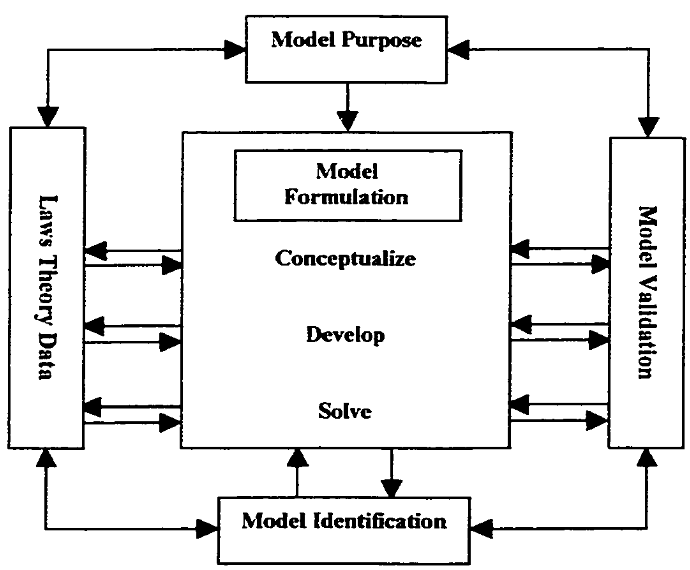

FIGURE 5. Model Process Methodology

In the ideal sense, the purpose of the model is to accurately predict the operating cost of present and future ground combat systems. In the practical sense, the range of characteristics present in the database limits the model. Predictions made of systems with characteristics outside the range of data are likely to be poor estimates of the operating costs. As suggested by Flood and Carson (1998), this framework allows for an iterative approach through a data filtration process. The expected form of the model is

(3.2) $$E(Y) = b_0 + b_1X_1 + b_2X_2 + \ldots + b_nX_n + \epsilon, \text{ where } \epsilon \text{ represents error.}$$

The selected model must be able to fulfill the purpose of the model, to perform cost estimates. The concept of the model should be directly related to the process being modeled. In this case, the linear statistical model development must be considered simultaneously with the assumptions and theory of regression analysis. The validation process tests the sufficiency of the model to its intended purpose. This methodology allows iteration to ensure that the modeling process achieves its intended purpose.

Variable Selection

The researcher formed a correlation matrix of all the factors having possible influence on the parametric cost model. The correlation analysis systematically revealed factors were correlated with each other, which could lead to the development of a model with erroneous net regression coefficients. The first correlation analysis (all correlation analyses are located in APPENDIX F) showed a high correlation between armor protection (Armor) and the fuel consumption ratio (Fuel Consumption). Additionally, Armor was also highly correlated with the Horsepower/WT ratio. Therefore, Armor was eliminated as a regression variable. The second correlation analysis showed a high correlation between night fighting capability (Thermal Sight) and Mission. Therefore, Thermal Sight was eliminated as a regression variable. The third correlation analysis showed a high correlation between Range and CRF3 as well as moderate correlation between Crew and Mission. Because Range had a higher correlation to the response variable (Cost), Crew was eliminated as a regression variable. The fourth correlation analysis showed that Mission had a relatively low (-0.17) negative correlation to Cost, which seems to be inconsistent with the data. Referencing the model data, APPENDIX G, it can be seen that the yearly costs for the AVLB and the M2 BFV are relatively equal but they have different missions. It is possible that the low number of different vehicles in each mission classification or only having two codes for the mission dummy variable (0,1) caused this phenomenon. Therefore, Mission was eliminated as a regression variable. The fifth correlation analysis showed that Range had a high degree of correlation to CRF3. The researcher's military experience led him to combine CRF2 with CRF3 and take the average of the two derived variables. This provided a risk cost factor that measures variability of the total suspension/steering sub-system and the power package/drive train sub-system. The sixth correlation analysis showed that Horsepower/WT had a moderate (-0.62) negative correlation to Fuel Consumption, and Activity had a moderate (-0.58) correlation to the yearly mileage (Activity). In keeping with the general principle of parsimony (Mendenhall and Sincich, 1995), it was desired to develop the cost model from the least amount of predictor variables possible, with little or no loss of predictive capability. Examining the remaining variables revealed that

CRF1 provided the least information (0.11 correlation) relating to the response variable; therefore, CF1 was eliminated as a regression variable. The variables for developing the parametric cost model were Horsepower/WT ratio, Fuel Consumption ratio, Activity, Range, and CRF (the combination of CRF2 and CRF3). The final correlation matrix is shown in TABLE 1 below.

TABLE 1. Parametric Model Final Correlation Matrix

	Horsepower/WT	*Fuel Consumption*	*Activity*	*Range*	*CRF*	*Cost*
Horsepower/WT	1.00					
Fuel Consumption	-0.62	1.00				
Activity	-0.04	-0.35	1.00			
Range	0.34	0.42	-0.58	1.00		
CRF1	-0.11	-0.08	0.09	-0.21		
CRF2/3	-0.37	-0.08	0.02	-0.40	1.00	
Cost	-0.25	0.19	0.64	-0.34	-0.35	1.00

MODEL FORMULATION

TABLE 1 shows that moderate interaction may be expected between the Horsepower/WT ratio and Fuel Consumption and between Activity and Range. The researcher used multiple linear regression to determine the final form of the parametric cost model (Microsoft Excel, 2000). The final data for the model is located in APPENDIX G, and an abbreviated form of final database is listed in TABLE 2 for convenience. The original linear regression model was

(3.3) $$E(Y) = -619.69 + 1529.99\text{ Horsepower/WT} + 601.29\text{ Fuel Consumption} + 29.21\text{ Activity} - 148.27\text{ Range} - 5414.14\text{ CRF.}$$

TABLE 2. Abbreviated Database for Model Development

Observation	Year	Vehicle	Horsepower/WT (Hp/Ton)	Fuel Consumption (Gal/Hr)	Activity	Range	CRF	Cost ($)
1	1994	AVLB	12.93	62.69	62	290	1.22	20,297.59
2	1995	AVLB	12.93	62.96	55	290	1.12	19,317.18
3	1996	AVLB	12.93	62.76	74	290	1.07	18,868.58
4	1997	AVLB	12.93	62.59	66	290	1.16	13,284.05
5	1998	AVLB	12.93	60.72	51	290	1.81	13,544.57
6	1999	AVLB	12.93	62.79	49	290	1.03	16,655.51
7	1994	M109	13.84	31.11	135	186	4.24	4,722.38
8	1995	M109	13.84	31.11	135	186	1.91	9,734.54
9	1996	M109	13.84	31.11	135	186	1.65	15,179.76
10	1997	M109	13.84	31.11	135	186	1.75	14,937.99
11	1998	M109	13.84	30.36	178	186	1.30	32,835.00
12	1999	M109	13.84	31.74	158	186	1.63	26,869.05

The initial examination of the constant ($b_0 = -619.69$) showed that the P-value (0.96) was very high, which could mean that the intercept could statistically occur at the origin (see APPENDIX H). Logically, this result showed that the system under consideration does not become a funded program in the Army's budget. Therefore, no funding is allocated for the system and the cost of the program is indeed zero. Thus, the researcher concluded that it is appropriate to force the intercept to occur at the origin and make $b_0 = 0$.

The second run of the regression analysis was performed with b_0 set to 0. This condition resulted in the final form of the parametric model

$$(3.4) \qquad E(Y) = 1506.54 \text{ Horsepower/WT} + 596.97 \text{ Fuel Consumption} + 29.08 \text{ Activity} - 148.04 \text{ Range} - 5458.86 \text{ CRF}.$$

This final form of the model provided P-values of less than 0.01 for each net regression coefficient, and the researcher accepted this model as sufficient for further analysis (see APPENDIX I).

SUMMARY

This chapter presented the detailed model development process, which initiated with the development of the cost-estimating database. The purpose of the database was to provide relevant information for developing the parametric model. For the model to be accurate, the factors in the database had to provide historical cost driver information (Geaney, 1997).

The details of performing the data analysis were also presented. FIGURE 6 serves as a summary of the data flow for the parametric model development process. As shown, raw data was extracted by querying the online OSMIS database. Initial screening was used to eliminate bad data points from the cost-estimating database used to develop the model. After the initial screening, the database was normalized to ensure that it was in constant year dollars, which allowed yearly comparisons to be made. The derived cost estimating relationships were then used to develop cost risk factors, which modeled the variance of the WBS sub-elements. The finalized cost estimating database was then used to develop the parametric cost model.

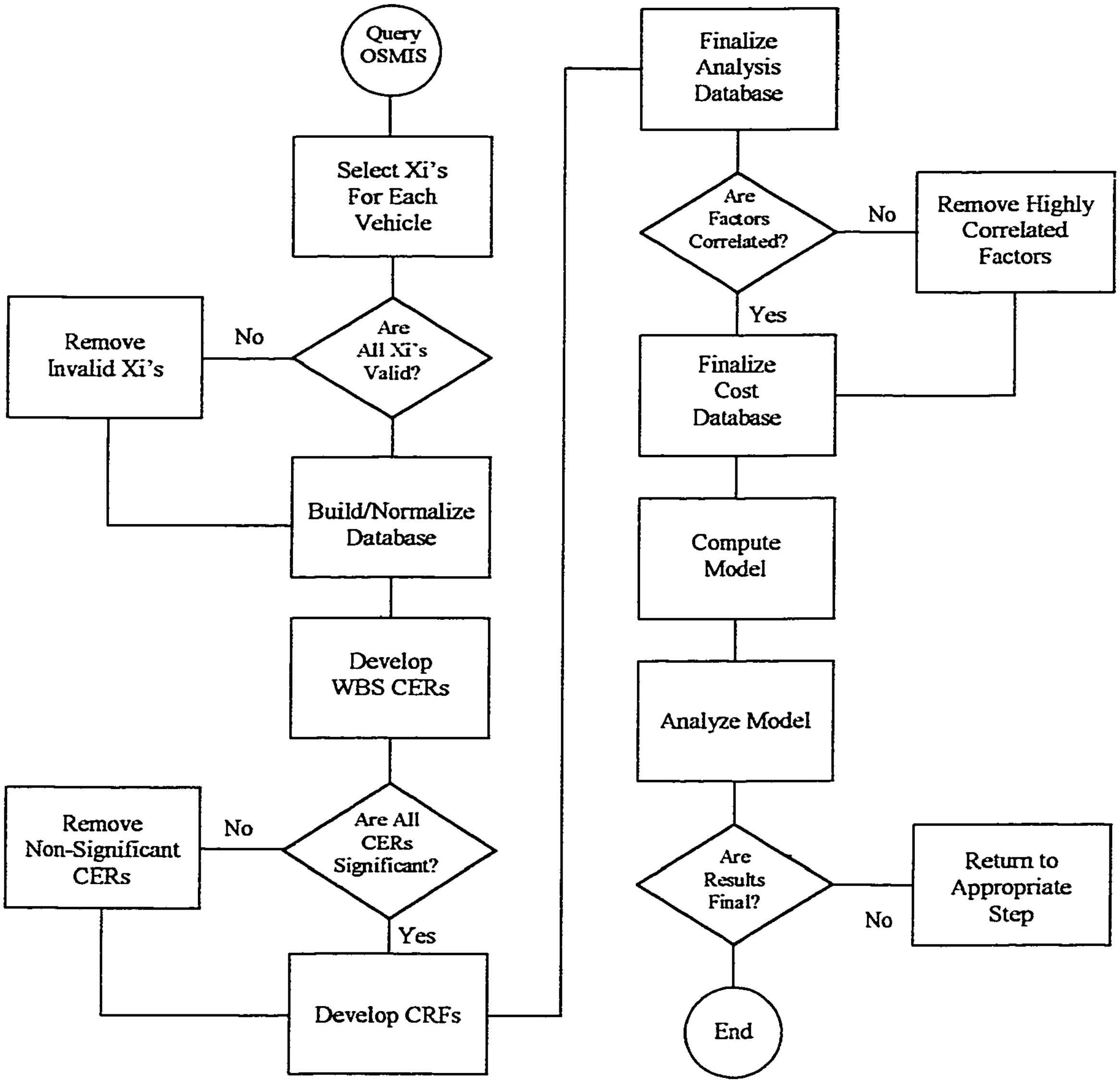

FIGURE 6. Data Flow Diagram.

CHAPTER 4

REARCH RESULTS

This chapter presents the results of this research and is divided into two major sections. First, the verification of the model as a valid prediction tool is presented. This includes analysis of the statistical aspects and a verification of regression assumptions.

The verification process checked the model to ensure that the residuals were independent of each other and normally distributed. Additionally, it checked to ensure that the response values exhibited equal variance and formed a linear relationship with the predictor variables.

Second, the model was validated using an existing Army ground combat system chosen from the OSMIS database. The validation process ensured that the model accurately predicted average yearly operating costs. Validation was limited to one vehicle because of missing data elements for other vehicles within the database. The database lacked additional vehicles with sufficient data, except variants of the same vehicles used to develop the model, which fit within the range of the model's data.

MODEL ANALYSIS/VERIFICATION

The analysis of the model began with examining the regression statistics (see APPENDIX I). The model's multiple correlation statistic (Multiple R) was 0.90. Although this statistic does not directly equate to the Pearson's Product Moment correlation, it is the square root of R^2 (R Square) and does suggest that there is a high degree of correlation between the linear combination of all the predictor variables and the response variable. The coefficient of determination (R^2) was 0.81, which meant that the predictor variables explain approximately 81% of the total sum of squares deviation about their mean. The adjusted R^2 (Adjusted R Square) was 0.76, which is within approximately 6% of the R^2 value. The adjusted R^2 tends to correct the R^2 value based on the number of predictor variables used to develop the model. Both the R^2 and the adjusted R^2 values were high enough to give the researcher confidence in the fit of the regression line to the data, and confidence that the model was useful in making cost predictions.

The standard error estimates the standard deviation of the predicted cost of a ground combat weapon system. Based on the 42 observations in this case, the typical error or deviation about the regression line was approximately $4,000.

The researcher also used analysis of variance to determine if the model's estimated multiple regression coefficients were all statistically equal to zero, or if at least one regression coefficient was statistically not equal to zero (see APPENDIX I). The F-distribution statistic is 30.88, which equates to a probability of random occurrence of approximately zero (Significance F). This result meant that the researcher could be at least 99% certain that at least one multiple regression coefficient was statistically greater than zero. Further analysis of the P-value for each regression coefficient showed that they were all statistically significant to the model and had less than a 0.1% chance of randomly occurring. This led the researcher to conclude that all the regression coefficients were important to predicting the response of the cost variable.

The researcher analyzed the residuals to determine if the model exhibited signs of bias or had variance issues needing resolution. First, the researcher summed the residuals from the original regression equation to ensure that they did add up to zero (see APPENDIX H). This was significant because it verified that the assumption $E(\varepsilon) = 0$ was valid. However, in this study the researcher chose to force the Y-intercept to occur at the origin. This constraint simply implied that an Army ground combat weapon system that has zero values for its predictor variables does not exist and therefore costs zero dollars. This constraint also introduced an upward shift in the location of the Y-intercept and introduced a negative bias in the error (ε). The sum of the residuals was $-78.49, which is an average of $-1.87 for the 42 observations. This evidence strongly suggested that the residuals were randomly distributed about the regression line, which satisfied one of the verification requirements.

The researcher also examined the normality plot of the residuals and the plot of each predictor variable to the residuals. This procedure provided significant verification information because least-square model tests are more optimal if the residuals have a normal distribution (Birkes and Dodge, 1993). The normal plot of the residuals, APPENDIX I, showed that there is a strong linear relationship between the standardized residuals and the cost. This confirmed that the residuals were approximately normally distributed, which satisfied one of the underlying regression assumptions. In addition, the plot of all the residuals to the response variable showed that they visually appear to be randomly distributed. As an additional check for randomness in the residuals, an autocorrelation analysis was performed on all the residual data points (Minitab 13, 2000). The autocorrelation plot showed that there was no significant correlation between the residuals, thus confirming that the residuals exhibited a random pattern (see APPENDIX I). The residuals were also plotted against each predictor variable to determine if problems of unequal variance existed with any of the predictor variables. The Horsepower/WT ratio plot was the only graph that showed any evidence of possible unequal variance. The predictor variables were transformed to their logarithm form in an attempt to eliminate this problem. The resulting plot of Horsepower/WT to residuals, see APPENDIX I, showed little or no improvement in the variance. Therefore, the original form of the predictor variables was maintained for the study.

Lastly, the researcher examined the plots of each predictor variable to determine if the variables exhibited a linear relationship with the response variable (see APPENDIX I). The purpose of this test was to ensure that the model was not incorrectly specified, i.e., no curvilinear trends. All the plots showed that the predictor variables do have a linear relationship with the response variable. As expected, Activity showed the strongest linear relationship with cost. Based on all the evidence, the researcher concluded that the issues of the small error term (ε) and the possible unequal variance were insignificant and that they have little effect on the model's usefulness as a valid operating cost prediction tool for Army ground combat weapon systems.

MODEL VALIDATION

The researcher used data from the M992A1 FAASV to validate the prediction capabilities of the model. The data for the M992 is contained in TABLE 3 below. The M992 is a combat service support vehicle that is built on the same chassis as the M109 howitzer. It is similar in weight, horsepower, fuel, speed, and fuel consumption as the M109; however, due to a slight decrease in weight, it has a slightly greater range than the M109. The M992 uses the same drive train components as the M109; therefore, the researcher used the same CRF as applied to the M109. Because of the M992's logistics function, it did have greater activity mileage than the M109 Paladin. The operational concept of the M992A1 calls for the vehicle to leave the forward firing positions and go to designated ammunition resupply points to get ammunition for the M109. Therefore, it is logical that the M992A1 will have more activity miles than M109.

TABLE 3. M992A1 Data and Yearly Operating Costs

Year	Vehicle	Horsepower/WT	Fuel Consumption	Activity	Range	CRF	Cost
1994	M992A1	14.19	35.00	492	220	4.24	23,551.15
1995	M992A1	14.19	34.51	447	220	1.91	12,867.64
1996	M992A1	14.19	34.54	906	220	1.65	13,362.87
1997	M992A1	14.19	35.00	667	220	1.75	10,623.09
1998	M992A1	14.19	33.73	676	220	1.30	10,155.90
1999	M992A1	14.19	34.59	484	220	1.63	11,277.63
AVG/Yr		14.19	34.56	612	220	2.08	13,639.71

The parametric cost model predicted that the average yearly cost of operating the M992A1 is $15,878.80 (see APPENDIX J). The actual average yearly cost of operating a M992A1 over the six-year period in this study is $13,631.38, which is approximately a 16.5% difference in the average cost. To determine the validity of the cost estimate, the researcher examined the confidence interval and the prediction interval for the estimate (Minitab 13, 2000). The 95% confidence showed that the true yearly average operating cost for the M992A1 could fall between $13,031 and $18,730. The expected value of the estimate ($15,878.80) is well within the 95% confidence interval for the estimate. Strictly interpreted, this means that the true value of the average (mean) yearly operating cost, at the given values of the predictor variables and the entire period in the study, will be between the two limits (Mendenhall and Sincich, 1995).

On the other hand, the 95% prediction interval showed that the true cost in any given year could lie between $7,290 and $18,730. This wider interval corresponds to trying to predict the cost for a specific year, given specific values of the predictors. Since we are no longer dealing with the expected value of the estimate, the prediction interval estimates that the true cost on any given year will be between the two limits. Examining the given data, only one point fell outside the upper 95% prediction interval for the M992. Given all the evidence, the researcher concluded that parametric cost model is a valid tool in predicting operating costs for Army ground combat weapon systems.

OTHER FINDINGS

As an attempt to identify the limitations of the model, the researcher tested the model's prediction capability for the M1A1 Abrams tank. The data for the M1A1 is contained in TABLE 4 below. The M1A1 is a direct fire combat weapon system with a 1500 horsepower gas turbine engine. When compared to other systems used in the model's development, it is clearly outside the model's database range. Specifically, the M1A1 has a higher horsepower to weight ratio and higher fuel consumption than any vehicle included in the database. Because this analysis clearly tries to extrapolate a cost estimate that is outside the model's database range, it is useful in establishing the limitations of the model as a ground combat system operating cost predictor.

TABLE 4. M1A1 Data and Yearly Operating Costs.

Year	Vehicle	Horsepower/WT	Fuel Consumption	Activity	Range	CRF	Cost
1994	M1A1	23.08	304.23	462	275	1.22	74,094.73
1995	M1A1	23.08	304.06	550	275	1.12	68,317.77
1996	M1A1	23.08	304.50	538	275	1.07	66,481.41
1997	M1A1	23.08	304.37	573	275	1.16	55,124.34
1998	M1A1	23.08	295.01	535	275	1.81	56,764.15
1999	M1A1	23.08	284.72	483	275	1.03	59,649.80
AVG/Yr		23.08	299.48	523	275	1.24	63,405.37

Using the average values for each predictor variable, the parametric cost model predicted that the average yearly cost of operating the M1A1 is $181,309.47. The actual average yearly cost of operating a M1A1 over the six-year period in the study was determined to be $63,405.37, which is approximately a 186% difference in the average cost.

This illustrates a practical problem with using regression methods for forecasting future costs. Regression models are limited to the range of data used for the predictor variables. Outside of that range, there is no way of determining if the relationship between the predictor variables and the response variable remains the same (Webster, 1998). In the case of the M1A1, the researcher cannot assume that the linear relationship exhibited by horsepower and fuel consumption coefficients in the model holds true for the M1.

As a follow on the findings in the case of the M1A1, the researcher examined the relationship between the five predictor variables. This process involved using coded values for the data used to develop the model (see APPENDIX K) to determine the interaction among variables (Minitab 13, 2000). An analysis of means (ANOM) was performed and the linear graph of the interactions among the variables was plotted (Phadke, 1989). TABLE 5 shows the average response of the predictor variables for the three levels chosen for each variable. The table points out that the horsepower to weight ratio, fuel consumption ratio, and vehicle range are all significant performance characteristics that affect the operating costs of the weapon systems. While the vehicle activity mileage has the largest impact, it is not a controllable factor by the engineering design team and is not considered in this discussion.

TABLE 5. Predictor Factors Response Table

	HP/WT (HP/ton)	Fuel (Gal/hr)	Activity (Miles/yr)	Range (Miles)	CRF
1	10,557.26	14,901.98	20,549.76	11,527.88	10,198.98
0	19,903.21	17,929.67	14,802.19	13,379.33	14,853.84
-1	14,712.81	10,007.97	10,140.00	19,619.46	16,390.96
Delta	9,345.95	7,921.71	10,409.77	8,091.59	6,191.98

This provided more evidence that all the final factors derived from the correlation analysis are important for inclusion in the cost model. Additionally, this suggested that the model is useful for identifying WBS elements that are likely to be operating cost drivers during the design process. By focusing on these high cost areas, the weapon system engineering team may be able to reduce operating costs by designing more robust and reliable systems.

As a final observation in this area, this analysis also showed that there are existing interactions between the predictor variables. FIGURE 7 is a graph of each predictor factor responses at their coded levels. The crossed lines indicate that all the factors interact with each other to some degree (Phadke, 1989), which supports the results of the correlation analysis.

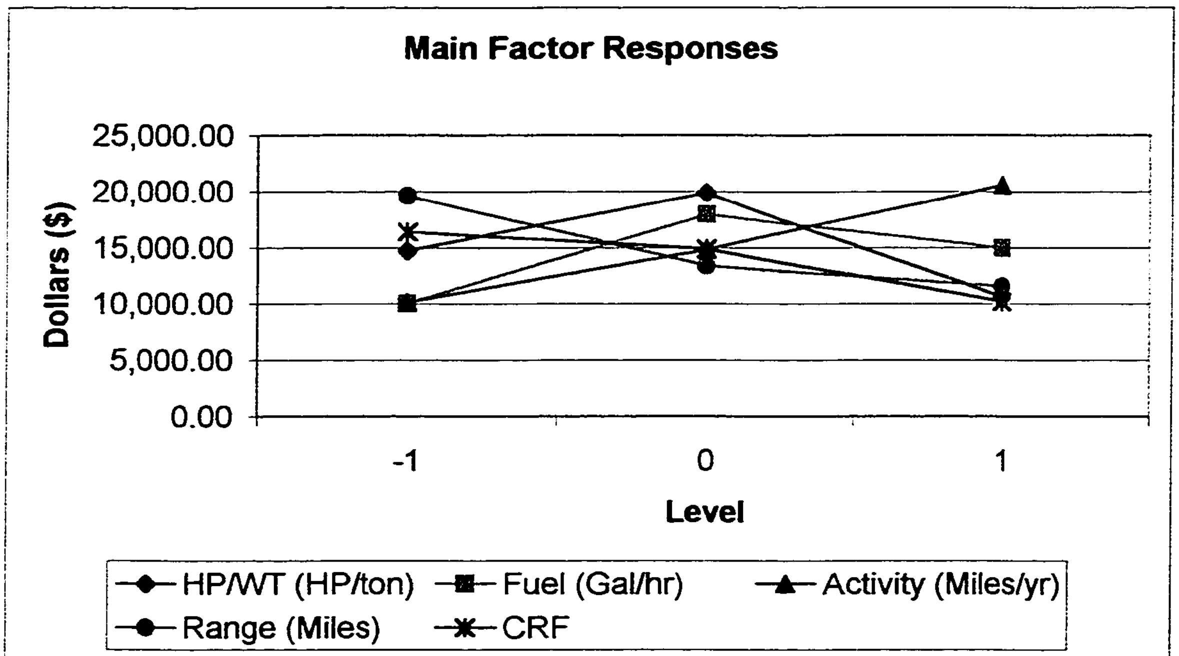

FIGURE 7. Predictor Variable Interactions

The graph also showed, except for activity mileage, that there are some nonlinear relationships between the predictor variables and the response variable. The curvature of the lines at level zero indicated that there is a second order term associated with the true operating costs. However, this analysis did not determine if the second order terms are significant to the model.

Another interesting finding was the relationship exhibited by yearly operating cost of all the weapon systems over the study period. It can be seen that the yearly operating cost per system shows a second-degree polynomial trend (see APPENDIX L). Additionally, the overall yearly operating cost exhibited a deceasing second-degree polynomial trend (see APPENDIX L). This trend indicated that there seems be a decrease in operating costs for Army ground combat systems over the period of this study. This observed phenomenon could be the result of better readiness of the fleet in general, or it could be related to decreases in the Army's operating and maintenance budget. The October 9, 2000 issue of *Army Times Magazine* reported that General Eric Shinseki, Army Chief of Staff, told Congress (September 27, 2000) that the Army needs approximately $10 billion more a year to complete its post Cold War transformation and reverse the effects years of under-funding (Crawley, 2000). General Shinseki's comments, as well as those by other service chiefs, suggested that it is possible that the OSMIS database reflects years of under-funding, which could mean that "true" yearly operating costs are higher than reported in OSMIS. Although it is noted that the under-funding may affect the developed parametric cost model, the cause of the decreasing cost trend is beyond the scope of this study. An implied assumption of using the OSMIS database was that it reflects the "true" costs associated with operating and maintaining the Army's ground combat systems. However, if budget constraints have affected the level of spending for the historical data, the developed model may not predict the "true" cost of operating the weapon systems in the database.

SUMMARY

The parametric model developed from this research met the verification criteria for a linear regression model. Specifically, it has been demonstrated that the error terms (residuals) of the model are random and normally distributed. The variance of the response variable appeared to be constant, and the linear model formed a good fit to the data points ($R^2 = 0.81$).

Likewise, the validation process demonstrated that the parametric model was capable of accurately predicting the yearly operating costs for Army ground combat weapon systems. The true value of operating the M992 FAASV was well within the confidence limits of the model's prediction. Additionally, it has been demonstrated that the model's predictive capability was limited to the range of data for the ground combat systems used in the model's development. Therefore, it was not capable of accurately predicting costs associated with the M1A1 Abrams tank.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This section summarizes the results of this research study. It also provides conclusions about the value of using this modeling process for the development of Army ground combat systems. In addition, it provides recommendations on areas that need further research in this field of study.

This research has shown that it is possible to use the OSMIS database to develop a parametric cost model to predict average yearly operating costs. The research also demonstrated that a minimum set of key factors can be used to derive the model, and the parametric model does have a linear form.

This research also confirmed that Monte Carlo simulation can be combined with parametric methods to directly incorporate risk into the cost model. Including risk as a predictor variable ensured that the risk was considered throughout the model development process. This research showed that cost variances at the WBS sub-element levels can be modeled as risk factors for cost predictions. This technique ensured that risk was not just considered at the total system level at the very end of the modeling process. Using this approach, combined with concurrent engineering and cost optimization, would allow the engineering team to directly address costs at the sub-element level during the system design phase of Army acquisition programs.

SUMMARY

This research demonstrates that it is possible to use parametric modeling to develop operating cost estimates for Army ground combat weapon systems using data from the OSMIS database. Using only a few key cost driving characteristics, parametric models can provide reasonable operating cost estimates for ground combat weapon systems. The models are relatively simple to develop, use, and update with current OSMIS information.

As shown by this research, the power of the model is not in the point estimate provided by the values of the predictor variables. Rather, the power of the model is in the derived confidence and predictor interval limits developed for each point estimate. It is critical to remember that the true cost is expected to lie within these two intervals, which further reflects the uncertainty of the modeling process. Human judgment, expert opinion, and statistical distributions are important tools that can help in determining reasonable operating costs to budget in the future years defense plan. To that end, the researcher demonstrated the value of quantitatively modeling cost risks associated with the parametric model. This study showed that the cost risk factor developed for the parametric model is correlated with the operating costs, and it provides useful cost prediction information.

Although parametric modeling is a powerful tool for developing cost estimates of Army ground combat systems, care must be given when extrapolating outside the range of the predictor variables. Even though it may be required for an analyst to extrapolate, the analyst must keep in mind that every model is false by its very nature (Henrion and Morgan, 1998). By "false," the researcher means that the model is an approximation of reality, and it has a limiting finite level of detail. Moving outside of the predictor variables range increases the uncertainty of the model's estimate and suggests that other factors should be examined to improve the estimate. One possible solution to dealing with extrapolation cases, such as the M1A1, is to use Monte Carlo simulation to estimate values for inclusion in the model database. The revised model may give better predictions than extrapolating using the range of data in the original database.

CONCLUSIONS

Army ground combat weapon system requirements and specifications are not only useful in predicting operating costs, but may be potential cost drivers relevant to making acquisition program decisions. Army program managers must fully understand their system requirements and the impact of the requirements on the operating costs (Castellana, 1989). As pointed out by Castellana (1989), little information may be known about the details of a ground combat weapon in its first two acquisition phases. Still, Castellana (1989) maintains that parametric models are useful tools for life cycle cost estimating in the first two acquisition phases. Using parametric modeling methods may help program managers to develop better operating cost estimates, and may also lead to weapons systems with lower yearly operating costs.

Being able to accurately model operating costs is a vital element for improving concurrent engineering efforts and design for cost methods for system development (Dean and Unal, 1992). This study's parametric modeling methodology, in conjunction with design of experiments techniques, is useful in optimizing ground combat system requirements with operating cost. Optimizing requirements, such as fuel consumption and mean-time-between-failures, can lead to reduced operating costs and more reliable weapon systems.

RECOMMENDATIONS

While this study shows the usefulness of parametric modeling for predicting operating costs, it does not exhaust the research needed in this area. In particular, this study does not include information such as availability, mean-time-between-failures, or mean-time-to-repair. While such information alone may not make this study classified information, it does make the study more sensitive when it is combined with the specific weapon system information included in this study. Therefore, the researcher made a conscious decision to exclude it from this study. However, an important area for future research is to examine the influence each reliability and maintainability characteristic has on operating costs of Army ground combat systems. These characteristics are important to determining the overall life cycle costs of any system (Ostwald, 1992). Additionally, more research needs to be conducted to show how the complexity of the system affects operating costs. Modeling the complexity of the ground combat systems may also lead to better estimates of systems, such as the M1A1, that exceed the range of some or all of the other predictor variables. Lastly, the nonlinear relationship between the predictor variables needs further research. The inclusion of second order terms may reduce the parametric model's error and make it more robust for predicting operating costs outside its range of data points.

As this was a study to analyze the direct operating cost of ground combat weapon systems, it did not deal with any indirect costs or support costs for the systems. As pointed out by Novick (1956), a complete cost estimate of a weapon system should include these costs. The costs associated with manning, arming, transporting, and housing the weapon system may influence the selection of less costly alternative systems. Additionally, all direct and indirect operating and support costs must be estimated and included in the budgeting process to ensure that future defense plans contain sufficient funds to operate and support Army ground combat systems. Insufficient funding in any operating or support area can potentially affect the combat readiness of the Army and limit its ability to conduct sustained land combat.

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APPENDIX A

Glossary of Terms

Analogy Estimation. In this technique, a currently fielded system (reference system) similar in design and/or operation to the proposed system is identified. The cost of the proposed system is then calculated by adjusting the cost of the reference system to account for differences between it and the new system. One drawback to analogy estimating at the subsystem level is the extensive amount of detailed technical and engineering data required. The analogy approach places heavy weight on the opinions of "experts."

Concept Exploration. This is the first phase in the Army acquisition process. The Army conducts formal studies to develop feasible material solutions to meet required mission needs. The studies may also use limited experimentation to determine the feasibility of proposed concepts. This phase serves as a tool to fully develop system level requirements and specifications.

Disposal Costs. Captures costs associated with deactivating or disposing of a military system at the end of its useful life. These costs typically represent only a small fraction of a system's life-cycle cost and are usually excluded from most system cost estimates.

Engineering and Manufacturing Development. This is the third phase of the Army acquisition process. It is used to develop detailed drawings of the system, final system/component specifications, and the manufacturing process. The program/product manager will also ensure the system undergoes rigorous developmental and operational testing. The program/product must demonstrate that the system can be mass-produced and that it meets the stakeholders' requirements.

Engineering Estimation. This approach produces detailed "bottoms-up" estimates. An engineering estimate is constructed by consolidating estimates for individual work segments into a total project projection. The objective is to determine as accurately as possible all of the actions that would occur in the "real world."

Ground Combat System. Full tracked combat vehicles (such as tanks, infantry fighting vehicles, and personnel carriers) designed as a direct fire, indirect fire or supporting systems for Army ground combat operations.

Investment Costs. Consists of costs incurred during the Production and Deployment phase (from low rate production through completion of deployment). Encompasses costs associated with producing, procuring, and deploying the primary hardware and directly associated hardware and activities, such as system-specific support equipment, training, data, initial spares, and military construction.

Milestone 0. This is a major Army decision point for acquisition of a new weapon system. It provides the authority to begin formal paper studies and experiments to develop Army materiel solutions for combat requirements. The authorization is usually in the form of a mission needs statement or operational requirements document.

Milestone I. This formal authorization to start a new Army acquisition program and is usually based on an approved operational requirements document. It provides formal funding for programs in the FYDP and establishes a program office and program or product manager.

Milestone II. Provides formal authority to enter into the Engineering and Manufacturing Development phase. This decision point usually establishes a limited number of systems to be produced during low rate initial production.

Milestone III. Provides formal authorization to mass-produce and field the new system to Army units.

Operating Costs. Includes only the yearly costs of directing operating a fielded weapon system. These costs include maintenance, consumable and repairable materials, and fuel.

Operating and Support Costs. Includes all yearly costs of operating, maintaining, and supporting a fielded system. It encompasses costs for personnel; consumable and repairable materials; fuel; organizational, intermediate and depot maintenance; and facilities.

Parametric Estimation. Parametric estimation employs cost-estimating relationships (CERs) to develop projections of weapons costs using various statistical techniques. A CER is simply an equation that relates one or more characteristics of a system to some element of its cost.

Production, Fielding, Deployment and Operations Support. This is the final phase of the Army acquisition process, and it includes plans for system retirement and disposal. The weapon systems are manufactured at the production facility and readied for shipment to Army units. During this phase, the system and all support packages (logistics, training, computer resources, etc.) are delivered to actual Army units. Fielding is not considered complete until the units have been trained on all aspects of the system. After all systems have been fielded, the program/product manager transitions to operations support of the system and production ceases.

Program Definition and Risk Reduction. This is the second phase of the Army acquisition process. The Army uses this phase to develop some detail specifications and a limited number of system prototypes, which are tested and refined to meet stakeholder requirements. This phase results in a proposed system for full-scale development.

Research and Development Costs. Consists of costs incurred from program initiation at Concept Demonstration and Approval (Milestone I) through the Engineering and Manufacturing Development phase. It includes costs of feasibility studies; modeling; trade-off analyses; engineering design; development, fabrication, assembly, and test of prototype hardware and software; system tests and evaluation; system- specific support equipment; and documentation.

APPENDIX B

Vehicle Data

This Appendix contains the formatted data used in the study. The data is broken down by maintenance operating costs and fuel costs for each vehicle used in the study. To provide clarification, the WBS elements are listed below.

TABLE B1. WBS Definitions

WBS	WBS Description	WBS Level
01	HULL/FRAME	3
02	SUSPENSION/STEER	3
03	PWR PKG/DRIVE TR	3
04	AUXILIARY AUTO	3
05	TURRET ASSEMBLY	3
06	FIRE CONTROL	3
07	ARMAMENT	3
12	SPECIAL EQUIPMENT	3
10	AUTO/REMOTE PILOT	3
11	NBC EQUIPMENT	3
13	NAVIGATION	3
14	COMMUNICATIONS	3
15	VEH APPS SOFTWARE	3
16	VEH SYSTEM SOFTWARE	3
18	OTHER	3

TABLE B2. AVLB WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
AVLB	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,027,429.61	2,122.79	0.10
AVLB	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,176,660.51	2,431.12	0.12
AVLB	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	6,116,188.46	12,636.75	0.62
AVLB	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	521,096.14	1,076.64	0.05
AVLB	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
AVLB	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	131.03	0.27	0.00
AVLB	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	7.46	0.02	0.00
AVLB	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	7,873.64	16.27	0.00
AVLB	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	40,045.05	82.74	0.00
AVLB	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
AVLB	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	8,883.90	18.36	0.00
AVLB	1994	TOTAL ARMY SUMMARY	18	OTHER	738,530.42	1,525.89	0.08
AVLB	1994	TOTAL ARMY SUMMARY	0	FUEL	187,185.61	386.75	0.02
					9,824,031.84	20,297.59	
AVLB	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,115,589.60	2,166.19	0.11
AVLB	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,504,274.18	2,920.92	0.15
AVLB	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	5,583,940.62	10,842.60	0.56
AVLB	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	571,164.33	1,109.06	0.06
AVLB	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
AVLB	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	453.37	0.88	0.00
AVLB	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	451.97	0.88	0.00
AVLB	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	1,179.87	2.29	0.00
AVLB	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	46,916.80	91.10	0.00
AVLB	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
AVLB	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	8,984.96	17.45	0.00
AVLB	1995	TOTAL ARMY SUMMARY	18	OTHER	959,285.39	1,862.69	0.10
AVLB	1995	TOTAL ARMY SUMMARY	0	FUEL	156,107.43	303.12	0.02
					9,948,348.52	19,317.18	
AVLB	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	926,569.06	1,712.70	0.09
AVLB	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,607,116.85	2,970.64	0.16
AVLB	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	5,860,709.58	10,833.10	0.57
AVLB	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	543,831.98	1,005.23	0.05
AVLB	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
AVLB	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	0.00	0.00	0.00
AVLB	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	0.00	0.00	0.00
AVLB	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	3,022.27	5.59	0.00
AVLB	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	56,449.18	104.34	0.01
AVLB	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
AVLB	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	6,209.74	11.48	0.00
AVLB	1996	TOTAL ARMY SUMMARY	18	OTHER	978,421.84	1,808.54	0.10
AVLB	1996	TOTAL ARMY SUMMARY	0	FUEL	225,569.84	416.95	0.02
					10,207,900.34	18,868.58	
AVLB	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	968,769.66	1,771.06	0.13
AVLB	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,228,185.83	2,245.31	0.17

TABLE B2. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
AVLB	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,320,089.50	6,069.63	0.46
AVLB	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	442,260.92	808.52	0.06
AVLB	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
AVLB	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	65.26	0.12	0.00
AVLB	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	2.28	0.00	0.00
AVLB	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	10,294.72	18.82	0.00
AVLB	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	35,126.56	64.22	0.00
AVLB	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	9.80	0.02	0.00
AVLB	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	96,944.35	177.23	0.01
AVLB	1997	TOTAL ARMY SUMMARY	18	OTHER	955,851.80	1,747.44	0.13
AVLB	1997	TOTAL ARMY SUMMARY	0	FUEL	208,773.56	381.67	0.03
					7,266,374.24	13,284.05	
AVLB	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,080,952.50	1,983.40	0.15
AVLB	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	544,939.22	999.89	0.07
AVLB	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,991,280.60	7,323.45	0.54
AVLB	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	305,118.63	559.85	0.04
AVLB	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
AVLB	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	1,148.46	2.11	0.00
AVLB	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	0.00	0.00	0.00
AVLB	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	6,753.93	12.39	0.00
AVLB	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	9,050.44	16.61	0.00
AVLB	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
AVLB	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	130,467.14	239.39	0.02
AVLB	1998	TOTAL ARMY SUMMARY	18	OTHER	1,155,827.89	2,120.79	0.16
AVLB	1998	TOTAL ARMY SUMMARY	0	FUEL	156,251.89	286.70	0.02
					7,381,790.68	13,544.57	
AVLB	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,125,981.79	1,948.07	0.12
AVLB	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,720,977.12	2,977.47	0.18
AVLB	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	5,310,162.51	9,187.13	0.55
AVLB	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	323,816.44	560.24	0.03
AVLB	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
AVLB	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	205.50	0.36	0.00
AVLB	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	2.98	0.01	0.00
AVLB	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	4,416.30	7.64	0.00
AVLB	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	30,682.73	53.08	0.00
AVLB	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	0.53	0.00	0.00
AVLB	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	102,738.63	177.75	0.01
AVLB	1999	TOTAL ARMY SUMMARY	18	OTHER	845,504.52	1,462.81	0.09
AVLB	1999	TOTAL ARMY SUMMARY	0	FUEL	162,393.78	280.96	0.02
					9,626,882.82	16,655.51	

TABLE B3. M109A6 WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M109A6	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	103,184.83	407.85	0.09
M109A6	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	35,606.07	140.74	0.03
M109A6	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	279,662.24	1,105.38	0.23
M109A6	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	45,090.52	178.22	0.04
M109A6	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	10,217.36	40.38	0.01
M109A6	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	169,567.93	670.23	0.14
M109A6	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	74,717.37	295.33	0.06
M109A6	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	4,905.93	19.39	0.00
M109A6	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M109A6	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	116,809.56	461.70	0.10
M109A6	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	76,394.40	301.95	0.06
M109A6	1994	TOTAL ARMY SUMMARY	18	OTHER	109,764.51	433.85	0.09
M109A6	1994	TOTAL ARMY SUMMARY	0	FUEL	168,842.65	667.36	0.14
					1,194,763.37	4,722.38	
M109A6	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	251,987.06	996.00	0.10
M109A6	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	140,513.37	555.39	0.06
M109A6	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	428,783.93	1,694.80	0.17
M109A6	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	99,777.47	394.38	0.04
M109A6	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	40,123.97	158.59	0.02
M109A6	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	255,495.52	1,009.86	0.10
M109A6	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	234,346.11	926.27	0.10
M109A6	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	20,934.76	82.75	0.01
M109A6	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M109A6	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	392,570.64	1,551.66	0.16
M109A6	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	235,367.53	930.31	0.10
M109A6	1995	TOTAL ARMY SUMMARY	18	OTHER	194,096.59	767.18	0.08
M109A6	1995	TOTAL ARMY SUMMARY	0	FUEL	168,842.65	667.36	0.07
					2,462,839.60	9,734.54	
M109A6	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	390,266.18	1,542.55	0.10
M109A6	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	248,831.95	983.53	0.06
M109A6	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	786,971.03	3,110.56	0.20
M109A6	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	219,169.55	866.28	0.06
M109A6	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	84,168.76	332.68	0.02
M109A6	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	465,469.94	1,839.80	0.12
M109A6	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	328,844.68	1,299.78	0.09
M109A6	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	10,891.99	43.05	0.00
M109A6	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M109A6	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	593,734.33	2,346.78	0.15
M109A6	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	258,390.36	1,021.31	0.07
M109A6	1996	TOTAL ARMY SUMMARY	18	OTHER	284,896.78	1,126.07	0.07
M109A6	1996	TOTAL ARMY SUMMARY	0	FUEL	168,842.65	667.36	0.04
					3,840,478.20	15,179.76	
M109A6	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	674,745.83	2,241.68	0.15
M109A6	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	292,496.80	971.75	0.07

TABLE B3. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M109A6	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	865,120.19	2,874.15	0.19
M109A6	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	347,472.13	1,154.39	0.08
M109A6	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	208,136.68	691.48	0.05
M109A6	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	432,321.30	1,436.28	0.10
M109A6	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	592,255.73	1,967.63	0.13
M109A6	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	239,359.11	795.21	0.05
M109A6	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	5,744.78	19.09	0.00
M109A6	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	197,246.53	655.30	0.04
M109A6	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	196,177.10	651.75	0.04
M109A6	1997	TOTAL ARMY SUMMARY	18	OTHER	344,745.39	1,145.33	0.08
M109A6	1997	TOTAL ARMY SUMMARY	0	FUEL	100,512.00	333.93	0.02
					4,496,333.57	14,937.99	
M109A6	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,353,016.88	3,213.82	0.10
M109A6	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	842,396.05	2,000.94	0.06
M109A6	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,539,552.48	8,407.49	0.26
M109A6	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	807,606.43	1,918.31	0.06
M109A6	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	253,469.66	602.07	0.02
M109A6	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	1,584,048.47	3,762.59	0.11
M109A6	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	1,603,845.98	3,809.61	0.12
M109A6	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	485,185.94	1,152.46	0.04
M109A6	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	26,661.07	63.33	0.00
M109A6	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	1,294,993.43	3,075.99	0.09
M109A6	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	1,058,003.40	2,513.07	0.08
M109A6	1998	TOTAL ARMY SUMMARY	18	OTHER	796,556.36	1,892.06	0.06
M109A6	1998	TOTAL ARMY SUMMARY	0	FUEL	178,198.17	423.27	0.01
					13,823,534.32	32,835.00	
M109A6	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,398,007.62	2,406.21	0.09
M109A6	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,183,058.02	2,036.24	0.08
M109A6	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,340,761.31	5,750.02	0.21
M109A6	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	837,063.52	1,440.73	0.05
M109A6	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	223,982.17	385.51	0.01
M109A6	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	1,133,773.79	1,951.42	0.07
M109A6	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	1,581,311.50	2,721.71	0.10
M109A6	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	620,180.88	1,067.44	0.04
M109A6	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	15,921.66	27.40	0.00
M109A6	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	2,903,680.15	4,997.73	0.19
M109A6	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	721,527.21	1,241.87	0.05
M109A6	1999	TOTAL ARMY SUMMARY	18	OTHER	1,423,830.50	2,450.65	0.09
M109A6	1999	TOTAL ARMY SUMMARY	0	FUEL	227,817.78	392.11	0.01
					15,610,916.11	26,869.05	

TABLE B4. M113A3 WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M113A3	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	6,621,955.04	711.43	0.20
M113A3	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	2,014,163.30	216.39	0.06
M113A3	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	16,493,706.24	1,771.99	0.50
M113A3	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,510,970.43	162.33	0.05
M113A3	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	117.52	0.01	0.00
M113A3	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	85,325.07	9.17	0.00
M113A3	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	468,023.92	50.28	0.01
M113A3	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M113A3	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M113A3	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M113A3	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	935,801.19	100.54	0.03
M113A3	1994	TOTAL ARMY SUMMARY	18	OTHER	3,642,364.08	391.32	0.11
M113A3	1994	TOTAL ARMY SUMMARY	0	FUEL	985,326.02	105.86	0.03
					32,757,752.81	3,519.31	
M113A3	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	5,658,199.76	602.58	0.23
M113A3	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	2,020,384.92	215.16	0.08
M113A3	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	11,545,333.41	1,229.53	0.46
M113A3	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,330,824.82	141.73	0.05
M113A3	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M113A3	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	266,815.43	28.41	0.01
M113A3	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	417,620.92	44.48	0.02
M113A3	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M113A3	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M113A3	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M113A3	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	782,537.20	83.34	0.03
M113A3	1995	TOTAL ARMY SUMMARY	18	OTHER	1,924,544.60	204.96	0.08
M113A3	1995	TOTAL ARMY SUMMARY	0	FUEL	1,107,685.35	117.96	0.04
					25,053,946.41	2,668.15	
M113A3	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	4,314,567.56	483.53	0.19
M113A3	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,844,893.25	206.76	0.08
M113A3	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	10,851,851.44	1,216.17	0.49
M113A3	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,332,258.69	149.31	0.06
M113A3	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M113A3	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	214,657.04	24.06	0.01
M113A3	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	379,960.06	42.58	0.02
M113A3	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M113A3	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M113A3	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M113A3	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	474,151.07	53.14	0.02
M113A3	1996	TOTAL ARMY SUMMARY	18	OTHER	1,863,521.26	208.84	0.08
M113A3	1996	TOTAL ARMY SUMMARY	0	FUEL	1,020,305.81	114.35	0.05
					22,296,166.18	2,498.73	
M113A3	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	3,724,146.47	421.62	0.21
M113A3	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	2,210,956.08	250.31	0.12

TABLE B4. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M113A3	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	6,743,664.26	763.46	0.38
M113A3	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,027,380.79	116.31	0.06
M113A3	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M113A3	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	35,743.41	4.05	0.00
M113A3	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	373,748.73	42.31	0.02
M113A3	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M113A3	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	7,104.78	0.80	0.00
M113A3	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	1,919.39	0.22	0.00
M113A3	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	1,278,878.60	144.78	0.07
M113A3	1997	TOTAL ARMY SUMMARY	18	OTHER	1,292,393.61	146.31	0.07
M113A3	1997	TOTAL ARMY SUMMARY	0	FUEL	1,136,385.23	128.65	0.06
					17,832,321.34	2,018.83	
M113A3	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	2,953,551.85	369.84	0.18
M113A3	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,866,900.12	233.77	0.12
M113A3	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	6,587,297.65	824.86	0.41
M113A3	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	534,583.56	66.94	0.03
M113A3	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M113A3	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	113,778.59	14.25	0.01
M113A3	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	369,185.90	46.23	0.02
M113A3	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	65,637.81	8.22	0.00
M113A3	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	138,187.57	17.30	0.01
M113A3	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	1,405.67	0.18	0.00
M113A3	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	1,469,704.01	184.04	0.09
M113A3	1998	TOTAL ARMY SUMMARY	18	OTHER	1,116,912.72	139.86	0.07
M113A3	1998	TOTAL ARMY SUMMARY	0	FUEL	965,111.81	120.85	0.06
					16,182,257.25	2,026.33	
M113A3	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,560,958.50	463.47	0.15
M113A3	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,575,832.90	467.88	0.15
M113A3	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	4,143,163.27	1,230.16	0.40
M113A3	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	479,130.20	142.26	0.05
M113A3	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M113A3	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	0.00	0.00	0.00
M113A3	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	256,890.65	76.27	0.02
M113A3	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	20,432.17	6.07	0.00
M113A3	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	8,022.69	2.38	0.00
M113A3	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M113A3	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	879,076.20	261.01	0.08
M113A3	1999	TOTAL ARMY SUMMARY	18	OTHER	1,022,811.62	303.69	0.10
M113A3	1999	TOTAL ARMY SUMMARY	0	FUEL	445,711.96	132.34	0.04
					10,392,030.16	3,085.52	

TABLE B5. M2 BFV WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M2A2	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,970,473.09	1,151.65	0.05
M2A2	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	2,336,606.90	1,365.64	0.06
M2A2	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	9,455,964.90	5,526.57	0.24
M2A2	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	2,491,197.31	1,455.99	0.06
M2A2	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	2,259,952.62	1,320.84	0.06
M2A2	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	5,148,720.19	3,009.19	0.13
M2A2	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	8,741,471.79	5,108.98	0.22
M2A2	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	40,884.63	23.90	0.00
M2A2	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	7.26	0.00	0.00
M2A2	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	6.06	0.00	0.00
M2A2	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	809,982.00	473.40	0.02
M2A2	1994	TOTAL ARMY SUMMARY	18	OTHER	5,627,106.39	3,288.78	0.14
M2A2	1994	TOTAL ARMY SUMMARY	0	FUEL	627,154.49	366.54	0.02
					39,509,527.64	23,091.48	
M2A2	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,662,835.54	1,082.58	0.07
M2A2	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,466,532.55	954.77	0.06
M2A2	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	6,291,033.64	4,095.73	0.26
M2A2	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,865,732.61	1,214.67	0.08
M2A2	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	1,636,663.53	1,065.54	0.07
M2A2	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	2,679,864.12	1,744.70	0.11
M2A2	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	3,594,926.05	2,340.45	0.15
M2A2	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	54,373.35	35.40	0.00
M2A2	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	1.63	0.00	0.00
M2A2	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	36.32	0.02	0.00
M2A2	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	522,060.10	339.88	0.02
M2A2	1995	TOTAL ARMY SUMMARY	18	OTHER	3,536,584.68	2,302.46	0.15
M2A2	1995	TOTAL ARMY SUMMARY	0	FUEL	475,696.66	309.70	0.02
					23,786,340.79	15,485.90	
M2A2	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,298,519.39	1,096.72	0.08
M2A2	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,697,513.25	1,433.71	0.10
M2A2	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,543,365.03	2,992.71	0.21
M2A2	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,153,337.78	974.10	0.07
M2A2	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	963,190.47	813.51	0.06
M2A2	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	2,693,044.01	2,274.53	0.16
M2A2	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	2,709,558.47	2,288.48	0.16
M2A2	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	27,841.73	23.51	0.00
M2A2	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M2A2	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M2A2	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	471,600.91	398.31	0.03
M2A2	1996	TOTAL ARMY SUMMARY	18	OTHER	1,976,941.51	1,669.71	0.12
M2A2	1996	TOTAL ARMY SUMMARY	0	FUEL	321,337.54	271.40	0.02
					16,856,250.10	14,236.70	
M2A2	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,098,276.61	781.69	0.07
M2A2	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	931,439.17	662.95	0.06

TABLE B5. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M2A2	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,417,872.17	2,432.65	0.21
M2A2	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,074,662.79	764.88	0.07
M2A2	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	751,640.35	534.98	0.05
M2A2	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	2,641,166.03	1,879.83	0.16
M2A2	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	2,133,139.43	1,518.25	0.13
M2A2	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	11,461.48	8.16	0.00
M2A2	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	12,587.03	8.96	0.00
M2A2	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	44.69	0.03	0.00
M2A2	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	535,615.81	381.22	0.03
M2A2	1997	TOTAL ARMY SUMMARY	18	OTHER	3,279,057.50	2,333.85	0.20
M2A2	1997	TOTAL ARMY SUMMARY	0	FUEL	395,107.90	281.22	0.02
					16,282,070.96	11,588.66	
M2A2	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	809,183.82	596.74	0.06
M2A2	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,423,537.64	1,049.81	0.10
M2A2	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,599,043.57	2,654.16	0.26
M2A2	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	998,349.87	736.25	0.07
M2A2	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	790,998.94	583.33	0.06
M2A2	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	2,329,212.74	1,717.71	0.17
M2A2	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	1,622,195.24	1,196.31	0.12
M2A2	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	3,501.22	2.58	0.00
M2A2	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	17,280.15	12.74	0.00
M2A2	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M2A2	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	257,425.49	189.84	0.02
M2A2	1998	TOTAL ARMY SUMMARY	18	OTHER	1,905,442.43	1,405.19	0.14
M2A2	1998	TOTAL ARMY SUMMARY	0	FUEL	294,516.39	217.19	0.02
					14,050,687.50	10,361.86	
M2A2	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	644,356.97	584.72	0.06
M2A2	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	496,525.73	450.57	0.05
M2A2	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	2,333,370.86	2,117.40	0.23
M2A2	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	789,563.56	716.48	0.08
M2A2	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	359,732.19	326.44	0.04
M2A2	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	1,648,448.23	1,495.87	0.16
M2A2	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	1,678,806.34	1,523.42	0.16
M2A2	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	2,790.48	2.53	0.00
M2A2	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	36,277.42	32.92	0.00
M2A2	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	14.99	0.01	0.00
M2A2	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	195,551.16	177.45	0.02
M2A2	1999	TOTAL ARMY SUMMARY	18	OTHER	1,735,656.34	1,575.01	0.17
M2A2	1999	TOTAL ARMY SUMMARY	0	FUEL	257,670.37	233.82	0.03
					10,178,764.63	9,236.63	

TABLE B5. M60A3 WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M60A3	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	466,057.00	174.95	0.06
M60A3	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,076,719.38	404.17	0.14
M60A3	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	2,726,260.27	1,023.37	0.35
M60A3	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	291,697.27	109.50	0.04
M60A3	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	122,850.79	46.12	0.02
M60A3	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	879,360.21	330.09	0.11
M60A3	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	537,596.09	201.80	0.07
M60A3	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	27,454.38	10.31	0.00
M60A3	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	262.68	0.10	0.00
M60A3	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M60A3	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	307,246.97	115.33	0.04
M60A3	1994	TOTAL ARMY SUMMARY	18	OTHER	702,695.82	263.77	0.09
M60A3	1994	TOTAL ARMY SUMMARY	0	FUEL	611,003.08	229.36	0.08
					7,749,203.94	2,908.86	
M60A3	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	364,796.75	132.89	0.07
M60A3	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	275,788.41	100.47	0.05
M60A3	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	2,084,252.30	759.29	0.40
M60A3	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	160,736.97	58.56	0.03
M60A3	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	87,030.11	31.70	0.02
M60A3	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	754,959.61	275.03	0.15
M60A3	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	309,917.05	112.90	0.06
M60A3	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	41,486.77	15.11	0.01
M60A3	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	123.28	0.04	0.00
M60A3	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M60A3	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	266,763.23	97.18	0.05
M60A3	1995	TOTAL ARMY SUMMARY	18	OTHER	486,055.47	177.07	0.09
M60A3	1995	TOTAL ARMY SUMMARY	0	FUEL	334,647.04	121.91	0.06
					5,166,557.00	1,882.17	
M60A3	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	181,872.73	78.66	0.06
M60A3	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	88,686.00	38.36	0.03
M60A3	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	1,298,874.20	561.80	0.40
M60A3	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	102,360.64	44.27	0.03
M60A3	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	26,875.50	11.62	0.01
M60A3	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	454,710.78	196.67	0.14
M60A3	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	139,615.15	60.39	0.04
M60A3	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	17,216.15	7.45	0.01
M60A3	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M60A3	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M60A3	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	106,252.17	45.96	0.03
M60A3	1996	TOTAL ARMY SUMMARY	18	OTHER	329,948.81	142.71	0.10
M60A3	1996	TOTAL ARMY SUMMARY	0	FUEL	492,835.43	213.16	0.15
					3,239,247.56	1,401.06	
M60A3	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	244,684.66	144.96	0.05
M60A3	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	395,243.54	234.15	0.08

TABLE B5. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M60A3	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	2,720,601.61	1,611.73	0.55
M60A3	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	84,107.97	49.83	0.02
M60A3	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	18,951.26	11.23	0.00
M60A3	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	178,981.68	106.03	0.04
M60A3	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	529,825.53	313.88	0.11
M60A3	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	17,583.03	10.42	0.00
M60A3	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	45,419.08	26.91	0.01
M60A3	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	63.34	0.04	0.00
M60A3	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	191,005.76	113.16	0.04
M60A3	1997	TOTAL ARMY SUMMARY	18	OTHER	290,589.58	172.15	0.06
M60A3	1997	TOTAL ARMY SUMMARY	0	FUEL	194,766.18	115.38	0.04
					4,911,823.22	2,909.85	
M60A3	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	114,732.03	2,249.65	0.08
M60A3	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	157,793.16	3,093.98	0.10
M60A3	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	817,458.43	16,028.60	0.54
M60A3	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	50,683.70	993.80	0.03
M60A3	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	4,523.61	88.70	0.00
M60A3	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	139,881.91	2,742.78	0.09
M60A3	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	39,861.69	781.60	0.03
M60A3	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	1,082.49	21.23	0.00
M60A3	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.51	0.01	0.00
M60A3	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	54.11	1.06	0.00
M60A3	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	59,982.56	1,176.13	0.04
M60A3	1998	TOTAL ARMY SUMMARY	18	OTHER	49,855.02	977.55	0.03
M60A3	1998	TOTAL ARMY SUMMARY	0	FUEL	69,843.19	1,369.47	0.05
					1,505,752.41	29,524.56	
M60A3	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	154,505.20	898.29	0.05
M60A3	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	927,114.63	5,390.20	0.27
M60A3	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	1,442,385.49	8,385.96	0.42
M60A3	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	57,948.56	336.91	0.02
M60A3	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	14,966.85	87.02	0.00
M60A3	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	393,278.61	2,286.50	0.11
M60A3	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	37,969.89	220.76	0.01
M60A3	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	2,445.04	14.22	0.00
M60A3	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	3,584.70	20.84	0.00
M60A3	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	667.46	3.88	0.00
M60A3	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	222,140.54	1,291.51	0.06
M60A3	1999	TOTAL ARMY SUMMARY	18	OTHER	84,464.99	491.08	0.02
M60A3	1999	TOTAL ARMY SUMMARY	0	FUEL	91,297.76	530.80	0.03
					3,432,769.73	19,957.96	

TABLE B6. M88A1 WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M88A1	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	4,447,369.86	2,651.98	0.11
M88A1	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	3,846,894.93	2,293.91	0.10
M88A1	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	26,568,922.32	15,843.13	0.66
M88A1	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	953,941.62	568.84	0.02
M88A1	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M88A1	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	604,111.12	360.23	0.02
M88A1	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	92,025.21	54.87	0.00
M88A1	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	10.09	0.01	0.00
M88A1	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	9,199.38	5.49	0.00
M88A1	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M88A1	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	357,966.29	213.46	0.01
M88A1	1994	TOTAL ARMY SUMMARY	18	OTHER	2,293,240.04	1,367.47	0.06
M88A1	1994	TOTAL ARMY SUMMARY	0	FUEL	784,844.56	468.01	0.02
					39,958,525.42	23,827.39	
M88A1	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	4,304,054.48	2,505.27	0.13
M88A1	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	4,252,970.41	2,475.54	0.13
M88A1	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	20,399,654.52	11,874.07	0.60
M88A1	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	843,393.92	490.92	0.02
M88A1	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	3.33	0.00	0.00
M88A1	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	1,049,588.99	610.94	0.03
M88A1	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	108,198.23	62.98	0.00
M88A1	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M88A1	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	28,661.70	16.68	0.00
M88A1	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M88A1	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	250,520.42	145.82	0.01
M88A1	1995	TOTAL ARMY SUMMARY	18	OTHER	1,803,393.78	1,049.71	0.05
M88A1	1995	TOTAL ARMY SUMMARY	0	FUEL	915,337.44	532.79	0.03
					33,955,777.23	19,764.71	
M88A1	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	2,915,141.21	1,637.72	0.10
M88A1	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	3,605,093.29	2,025.33	0.12
M88A1	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	19,157,800.92	10,762.81	0.64
M88A1	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	719,061.95	403.97	0.02
M88A1	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	8.00	0.00	0.00
M88A1	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	965,728.09	542.54	0.03
M88A1	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	121,194.23	68.09	0.00
M88A1	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M88A1	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	34,287.53	19.26	0.00
M88A1	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M88A1	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	166,546.89	93.57	0.01
M88A1	1996	TOTAL ARMY SUMMARY	18	OTHER	1,523,295.00	855.78	0.05
M88A1	1996	TOTAL ARMY SUMMARY	0	FUEL	860,992.44	483.70	0.03
					30,069,149.56	16,892.78	
M88A1	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	3,890,601.91	2,111.02	0.14
M88A1	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	3,580,129.84	1,942.56	0.13

TABLE B6. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M88A1	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	15,045,580.86	8,163.64	0.55
M88A1	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	738,822.87	400.88	0.03
M88A1	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	41.74	0.02	0.00
M88A1	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	963,701.48	522.90	0.04
M88A1	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	132,719.04	72.01	0.00
M88A1	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M88A1	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	52,553.21	28.52	0.00
M88A1	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	691.78	0.38	0.00
M88A1	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	607,027.70	329.37	0.02
M88A1	1997	TOTAL ARMY SUMMARY	18	OTHER	1,286,066.01	697.81	0.05
M88A1	1997	TOTAL ARMY SUMMARY	0	FUEL	931,741.78	505.56	0.03
					27,229,678.21	14,774.65	
M88A1	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	4,424,940.31	2,428.62	0.14
M88A1	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	3,831,651.88	2,102.99	0.12
M88A1	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	18,468,943.52	10,136.63	0.60
M88A1	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	727,201.51	399.12	0.02
M88A1	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	35.09	0.02	0.00
M88A1	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	507,867.04	278.74	0.02
M88A1	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	89,554.05	49.15	0.00
M88A1	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M88A1	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	73,864.28	40.54	0.00
M88A1	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	457.87	0.25	0.00
M88A1	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	596,311.01	327.28	0.02
M88A1	1998	TOTAL ARMY SUMMARY	18	OTHER	1,521,817.64	835.25	0.05
M88A1	1998	TOTAL ARMY SUMMARY	0	FUEL	749,761.42	411.50	0.02
					30,992,405.64	17,010.10	
M88A1	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	3,812,123.97	2,029.88	0.13
M88A1	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	5,261,424.81	2,801.61	0.18
M88A1	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	15,697,763.62	8,358.77	0.54
M88A1	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	749,660.75	399.18	0.03
M88A1	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	41.49	0.02	0.00
M88A1	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	549,136.27	292.40	0.02
M88A1	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	131,796.38	70.18	0.00
M88A1	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	0.00	0.00	0.00
M88A1	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	26,929.72	14.34	0.00
M88A1	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M88A1	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	576,427.76	306.94	0.02
M88A1	1999	TOTAL ARMY SUMMARY	18	OTHER	1,409,619.52	750.60	0.05
M88A1	1999	TOTAL ARMY SUMMARY	0	FUEL	732,615.45	390.10	0.03
					28,947,539.73	15,414.03	

TABLE B7. M9 ACE WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M9ACE	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	2,004,441.35	5,219.90	0.22
M9ACE	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,275,338.37	3,321.19	0.14
M9ACE	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	4,586,095.56	11,942.96	0.50
M9ACE	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	134,332.07	349.82	0.01
M9ACE	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M9ACE	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	126.37	0.33	0.00
M9ACE	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	2,305.43	6.00	0.00
M9ACE	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	7,854.57	20.45	0.00
M9ACE	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	38.36	0.10	0.00
M9ACE	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M9ACE	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	68,818.99	179.22	0.01
M9ACE	1994	TOTAL ARMY SUMMARY	18	OTHER	867,593.91	2,259.36	0.09
M9ACE	1994	TOTAL ARMY SUMMARY	0	FUEL	189,859.04	494.42	0.02
					9,136,804.02	23,793.76	
M9ACE	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	2,201,076.01	5,502.69	0.24
M9ACE	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	2,386,258.95	5,965.65	0.26
M9ACE	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,685,681.92	9,214.20	0.39
M9ACE	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	133,432.29	333.58	0.01
M9ACE	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M9ACE	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	1,737.65	4.34	0.00
M9ACE	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	4,324.50	10.81	0.00
M9ACE	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	6,916.20	17.29	0.00
M9ACE	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M9ACE	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M9ACE	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	55,374.45	138.44	0.01
M9ACE	1995	TOTAL ARMY SUMMARY	18	OTHER	694,472.69	1,736.18	0.07
M9ACE	1995	TOTAL ARMY SUMMARY	0	FUEL	180,207.89	450.52	0.02
					9,349,482.55	23,373.71	
M9ACE	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	2,261,972.26	5,334.84	0.19
M9ACE	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	3,504,109.54	8,264.41	0.30
M9ACE	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	4,940,224.21	11,651.47	0.42
M9ACE	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	191,290.63	451.16	0.02
M9ACE	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M9ACE	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	0.00	0.00	0.00
M9ACE	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	1,646.89	3.88	0.00
M9ACE	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	10,809.21	25.49	0.00
M9ACE	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M9ACE	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M9ACE	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	58,499.76	137.97	0.00
M9ACE	1996	TOTAL ARMY SUMMARY	18	OTHER	595,860.36	1,405.33	0.05
M9ACE	1996	TOTAL ARMY SUMMARY	0	FUEL	210,444.38	496.33	0.02
					11,774,857.25	27,770.89	
M9ACE	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,715,495.86	4,008.17	0.24
M9ACE	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	2,074,089.91	4,846.00	0.29

TABLE B7. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M9ACE	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	2,495,174.32	5,829.85	0.34
M9ACE	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	122,691.71	286.66	0.02
M9ACE	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M9ACE	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	0.00	0.00	0.00
M9ACE	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	2,164.72	5.06	0.00
M9ACE	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	4,339.22	10.14	0.00
M9ACE	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	28.21	0.07	0.00
M9ACE	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	292.44	0.68	0.00
M9ACE	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	182,615.24	426.67	0.03
M9ACE	1997	TOTAL ARMY SUMMARY	18	OTHER	481,185.63	1,124.27	0.07
M9ACE	1997	TOTAL ARMY SUMMARY	0	FUEL	181,648.37	424.41	0.03
					7,259,725.64	16,961.98	
M9ACE	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,902,143.17	4,117.19	0.24
M9ACE	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	1,470,862.11	3,183.68	0.19
M9ACE	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	3,440,074.88	7,446.05	0.44
M9ACE	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	158,948.54	344.04	0.02
M9ACE	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M9ACE	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	3.81	0.01	0.00
M9ACE	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	2,170.61	4.70	0.00
M9ACE	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	3,410.51	7.38	0.00
M9ACE	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	22,490.03	48.68	0.00
M9ACE	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	8,739.72	18.92	0.00
M9ACE	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	221,225.29	478.84	0.03
M9ACE	1998	TOTAL ARMY SUMMARY	18	OTHER	399,676.04	865.10	0.05
M9ACE	1998	TOTAL ARMY SUMMARY	0	FUEL	174,729.29	378.20	0.02
					7,804,473.99	16,892.80	
M9ACE	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	2,161,381.03	4,878.96	0.22
M9ACE	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	2,296,399.69	5,183.75	0.23
M9ACE	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	4,241,631.11	9,574.79	0.43
M9ACE	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	277,815.48	627.12	0.03
M9ACE	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M9ACE	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	0.51	0.00	0.00
M9ACE	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	1,345.13	3.04	0.00
M9ACE	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	4,010.40	9.05	0.00
M9ACE	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	31,202.45	70.43	0.00
M9ACE	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	10,752.39	24.27	0.00
M9ACE	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	244,938.03	552.91	0.02
M9ACE	1999	TOTAL ARMY SUMMARY	18	OTHER	470,748.67	1,062.64	0.05
M9ACE	1999	TOTAL ARMY SUMMARY	0	FUEL	166,002.78	374.72	0.02
					9,906,227.67	22,361.69	

TABLE B8. M992A1 WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M992A1	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	1,171,024.11	2,226.28	0.09
M992A1	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	939,950.76	1,786.98	0.08
M992A1	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	6,389,804.51	12,147.92	0.52
M992A1	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,624,252.54	3,087.93	0.13
M992A1	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	2.03	0.00	0.00
M992A1	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	88.90	0.17	0.00
M992A1	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	46,199.68	87.83	0.00
M992A1	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	218,216.45	414.86	0.02
M992A1	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	107.94	0.21	0.00
M992A1	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M992A1	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	259,944.53	494.19	0.02
M992A1	1994	TOTAL ARMY SUMMARY	18	OTHER	1,544,171.06	2,935.69	0.12
M992A1	1994	TOTAL ARMY SUMMARY	0	FUEL	194,140.95	369.09	0.02
					12,387,903.47	23,551.15	
M992A1	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	934,556.54	2,044.98	0.16
M992A1	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	373,387.15	817.04	0.06
M992A1	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	2,191,838.13	4,796.14	0.37
M992A1	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,096,603.55	2,399.57	0.19
M992A1	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M992A1	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	60.57	0.13	0.00
M992A1	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	38,475.96	84.19	0.01
M992A1	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	59,876.37	131.02	0.01
M992A1	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M992A1	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M992A1	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	168,705.55	369.16	0.03
M992A1	1995	TOTAL ARMY SUMMARY	18	OTHER	884,509.80	1,935.47	0.15
M992A1	1995	TOTAL ARMY SUMMARY	0	FUEL	132,496.75	289.93	0.02
					5,880,510.36	12,867.64	
M992A1	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	619,696.16	1,791.03	0.13
M992A1	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	429,781.04	1,242.14	0.09
M992A1	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	1,832,325.17	5,295.74	0.40
M992A1	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	799,570.96	2,310.90	0.17
M992A1	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M992A1	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	0.00	0.00	0.00
M992A1	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	39,784.90	114.99	0.01
M992A1	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	59,736.44	172.65	0.01
M992A1	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M992A1	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M992A1	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	74,480.53	215.26	0.02
M992A1	1996	TOTAL ARMY SUMMARY	18	OTHER	558,506.51	1,614.18	0.12
M992A1	1996	TOTAL ARMY SUMMARY	0	FUEL	209,670.22	605.98	0.05
					4,623,551.94	13,362.87	
M992A1	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	941,934.31	1,846.93	0.17
M992A1	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	459,413.50	900.81	0.08

TABLE B8. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M992A1	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	1,638,400.10	3,212.55	0.30
M992A1	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	723,426.95	1,418.48	0.13
M992A1	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M992A1	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	8,400.52	16.47	0.00
M992A1	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	60,118.27	117.88	0.01
M992A1	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	64,991.70	127.43	0.01
M992A1	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	41,220.54	80.82	0.01
M992A1	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	348.57	0.68	0.00
M992A1	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	227,514.95	446.11	0.04
M992A1	1997	TOTAL ARMY SUMMARY	18	OTHER	1,015,561.02	1,991.30	0.19
M992A1	1997	TOTAL ARMY SUMMARY	0	FUEL	236,445.85	463.62	0.04
					5,417,776.27	10,623.09	
M992A1	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	719,990.44	1,306.70	0.13
M992A1	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	294,804.83	535.04	0.05
M992A1	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	1,579,979.46	2,867.48	0.28
M992A1	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	695,916.33	1,263.01	0.12
M992A1	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M992A1	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	4,715.16	8.56	0.00
M992A1	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	62,553.12	113.53	0.01
M992A1	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	218,548.24	396.64	0.04
M992A1	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	124,250.38	225.50	0.02
M992A1	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	297.46	0.54	0.00
M992A1	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	447,065.44	811.37	0.08
M992A1	1998	TOTAL ARMY SUMMARY	18	OTHER	1,201,800.08	2,181.13	0.21
M992A1	1998	TOTAL ARMY SUMMARY	0	FUEL	245,980.77	446.43	0.04
					5,595,901.72	10,155.90	
M992A1	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	785,816.95	1,155.61	0.10
M992A1	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	662,970.50	974.96	0.09
M992A1	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	2,497,018.34	3,672.09	0.33
M992A1	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	1,035,867.55	1,523.33	0.14
M992A1	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	0.00	0.00	0.00
M992A1	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	8,140.10	11.97	0.00
M992A1	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	73,870.99	108.63	0.01
M992A1	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	227,955.84	335.23	0.03
M992A1	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	71,737.74	105.50	0.01
M992A1	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	0.00	0.00	0.00
M992A1	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	490,024.78	720.62	0.06
M992A1	1999	TOTAL ARMY SUMMARY	18	OTHER	1,592,787.81	2,342.34	0.21
M992A1	1999	TOTAL ARMY SUMMARY	0	FUEL	222,600.54	327.35	0.03
					7,668,791.13	11,277.63	

TABLE B9. M1A1 WBS DATA

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M1A1	1994	TOTAL ARMY SUMMARY	1	HULL/FRAME	16,594,075.81	6,054.02	0.08
M1A1	1994	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	11,855,191.29	4,325.13	0.06
M1A1	1994	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	102,351,570.19	37,340.96	0.50
M1A1	1994	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	8,430,129.39	3,075.57	0.04
M1A1	1994	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	7,674,561.09	2,799.91	0.04
M1A1	1994	TOTAL ARMY SUMMARY	6	FIRE CONTROL	28,044,483.40	10,231.48	0.14
M1A1	1994	TOTAL ARMY SUMMARY	7	ARMAMENT	8,704,169.12	3,175.55	0.04
M1A1	1994	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	587,939.80	214.50	0.00
M1A1	1994	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	2,622.41	0.96	0.00
M1A1	1994	TOTAL ARMY SUMMARY	13	NAVIGATION	630,670.56	230.09	0.00
M1A1	1994	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	4,627,010.63	1,688.07	0.02
M1A1	1994	TOTAL ARMY SUMMARY	18	OTHER	6,708,487.71	2,447.46	0.03
M1A1	1994	TOTAL ARMY SUMMARY	0	FUEL	6,882,730.28	2,511.03	0.03
					203,093,641.67	74,094.73	
M1A1	1995	TOTAL ARMY SUMMARY	1	HULL/FRAME	18,702,207.40	6,201.00	0.09
M1A1	1995	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	15,865,396.95	5,260.41	0.08
M1A1	1995	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	104,885,036.61	34,776.21	0.51
M1A1	1995	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	8,042,657.03	2,666.66	0.04
M1A1	1995	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	7,223,048.33	2,394.91	0.04
M1A1	1995	TOTAL ARMY SUMMARY	6	FIRE CONTROL	21,891,121.48	7,258.33	0.11
M1A1	1995	TOTAL ARMY SUMMARY	7	ARMAMENT	9,699,942.18	3,216.16	0.05
M1A1	1995	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	389,233.08	129.06	0.00
M1A1	1995	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	2.66	0.00	0.00
M1A1	1995	TOTAL ARMY SUMMARY	13	NAVIGATION	26,014.74	8.63	0.00
M1A1	1995	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	1,974,465.44	654.66	0.01
M1A1	1995	TOTAL ARMY SUMMARY	18	OTHER	9,446,450.89	3,132.11	0.05
M1A1	1995	TOTAL ARMY SUMMARY	0	FUEL	7,897,810.61	2,618.64	0.04
					206,043,387.39	68,316.77	
M1A1	1996	TOTAL ARMY SUMMARY	1	HULL/FRAME	16,809,791.65	5,568.00	0.08
M1A1	1996	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	15,181,163.56	5,028.54	0.08
M1A1	1996	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	104,830,503.60	34,723.59	0.52
M1A1	1996	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	6,726,684.62	2,228.12	0.03
M1A1	1996	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	6,700,882.11	2,219.57	0.03
M1A1	1996	TOTAL ARMY SUMMARY	6	FIRE CONTROL	23,104,372.67	7,652.99	0.12
M1A1	1996	TOTAL ARMY SUMMARY	7	ARMAMENT	9,654,241.53	3,197.83	0.05
M1A1	1996	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	243,334.42	80.60	0.00
M1A1	1996	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	0.00	0.00	0.00
M1A1	1996	TOTAL ARMY SUMMARY	13	NAVIGATION	206,352.65	68.35	0.00
M1A1	1996	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	1,554,954.07	515.06	0.01
M1A1	1996	TOTAL ARMY SUMMARY	18	OTHER	7,717,151.93	2,556.19	0.04
M1A1	1996	TOTAL ARMY SUMMARY	0	FUEL	7,977,946.20	2,642.58	0.04
					200,707,379.01	66,481.41	
M1A1	1997	TOTAL ARMY SUMMARY	1	HULL/FRAME	17,395,613.28	5,205.15	0.09
M1A1	1997	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	14,072,895.58	4,210.92	0.08

TABLE B9. CONTINUED

MDS	FY	MACOM	WBS	WBS Name	Net Total	COST/SYS	CER
M1A1	1997	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	94,079,378.33	28,150.62	0.51
M1A1	1997	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	7,590,870.37	2,271.36	0.04
M1A1	1997	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	5,116,599.73	1,531.00	0.03
M1A1	1997	TOTAL ARMY SUMMARY	6	FIRE CONTROL	19,257,042.26	5,762.13	0.10
M1A1	1997	TOTAL ARMY SUMMARY	7	ARMAMENT	7,939,413.18	2,375.65	0.04
M1A1	1997	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	235,011.13	70.32	0.00
M1A1	1997	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	9,698.91	2.90	0.00
M1A1	1997	TOTAL ARMY SUMMARY	13	NAVIGATION	2,714.44	0.81	0.00
M1A1	1997	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	2,177,914.56	651.68	0.01
M1A1	1997	TOTAL ARMY SUMMARY	18	OTHER	6,703,003.10	2,005.69	0.04
M1A1	1997	TOTAL ARMY SUMMARY	0	FUEL	9,645,375.82	2,886.11	0.05
					184,225,530.69	55,124.34	
M1A1	1998	TOTAL ARMY SUMMARY	1	HULL/FRAME	16,916,689.42	5,098.46	0.09
M1A1	1998	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	11,797,089.83	3,555.48	0.06
M1A1	1998	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	98,773,585.85	29,769.01	0.52
M1A1	1998	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	7,550,489.77	2,275.61	0.04
M1A1	1998	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	5,278,538.59	1,590.88	0.03
M1A1	1998	TOTAL ARMY SUMMARY	6	FIRE CONTROL	22,051,293.74	6,645.96	0.12
M1A1	1998	TOTAL ARMY SUMMARY	7	ARMAMENT	6,731,268.06	2,028.71	0.04
M1A1	1998	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	109,321.57	32.95	0.00
M1A1	1998	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	75,411.75	22.73	0.00
M1A1	1998	TOTAL ARMY SUMMARY	13	NAVIGATION	8,129.75	2.45	0.00
M1A1	1998	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	2,714,823.31	818.21	0.01
M1A1	1998	TOTAL ARMY SUMMARY	18	OTHER	7,790,324.40	2,347.90	0.04
M1A1	1998	TOTAL ARMY SUMMARY	0	FUEL	8,546,494.49	2,575.80	0.05
					188,343,460.51	56,764.15	
M1A1	1999	TOTAL ARMY SUMMARY	1	HULL/FRAME	17,353,126.16	5,244.22	0.09
M1A1	1999	TOTAL ARMY SUMMARY	2	SUSPENSION/STEER	15,729,566.29	4,753.57	0.08
M1A1	1999	TOTAL ARMY SUMMARY	3	PWR PKG/DRIVE TR	97,220,111.58	29,380.51	0.49
M1A1	1999	TOTAL ARMY SUMMARY	4	AUXILIARY AUTO	12,988,065.87	3,925.07	0.07
M1A1	1999	TOTAL ARMY SUMMARY	5	TURRET ASSEMBLY	4,434,377.54	1,340.10	0.02
M1A1	1999	TOTAL ARMY SUMMARY	6	FIRE CONTROL	21,339,624.98	6,448.96	0.11
M1A1	1999	TOTAL ARMY SUMMARY	7	ARMAMENT	9,113,894.46	2,754.27	0.05
M1A1	1999	TOTAL ARMY SUMMARY	11	NBC EQUIPMENT	100,319.93	30.32	0.00
M1A1	1999	TOTAL ARMY SUMMARY	12	SPECIAL EQUIPMENT	114,289.51	34.54	0.00
M1A1	1999	TOTAL ARMY SUMMARY	13	NAVIGATION	6,386.36	1.93	0.00
M1A1	1999	TOTAL ARMY SUMMARY	14	COMMUNICATIONS	3,422,872.06	1,034.41	0.02
M1A1	1999	TOTAL ARMY SUMMARY	18	OTHER	7,646,551.31	2,310.83	0.04
M1A1	1999	TOTAL ARMY SUMMARY	0	FUEL	7,911,999.75	2,391.05	0.04
					197,381,185.81	59,649.80	

TABLE B10. ABLV FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1994	1	JP8	1.63	25,725.00	0.78	41,931.75	487		
1994	2	JP8	1.63	35,248.00	0.78	57,454.24	471		
1994	3	JP8	1.63	35,047.00	0.78	57,126.61	478		
1994	4	JP8	1.63	23,292.00	0.78	37,965.96	502		
				119,312.00		194,478.56	485	0.9625	187,185.61
1995	1	JP8	1.49	31,641.00	0.71	47,145.09	506		
1995	2	JP8	1.49	43,543.00	0.71	64,879.07	526		
1995	3	JP8	1.49	29,191.00	0.71	43,494.59	526		
1995	4	JP8	1.49	8,731.00	0.71	13,009.19	502		
				113,106.00		168,527.94	515	0.9263	156,107.43
1996	1	JP8	1.59	35,225.00	0.76	56,007.75	562		
1996	2	JP8	1.59	51,263.00	0.76	81,508.17	564		
1996	3	JP8	1.59	40,717.00	0.76	64,740.03	519		
1996	4	JP8	1.59	31,911.00	0.76	50,738.49	519		
				159,116.00		252,994.44	541	0.8916	225,569.84
1997	1	JP8	1.69	46,880.00	0.81	79,227.20	549		
1997	2	JP8	1.69	30,970.00	0.81	52,339.30	573		
1997	3	JP8	1.69	33,726.00	0.81	56,996.94	540		
1997	4	JP8	1.69	32,387.00	0.81	54,734.03	527		
				143,963.00		243,297.47	547	0.8581	208,773.56
1998	1	JP8	1.68	30,513.00	0.83	51,261.84	571		
1998	2	JP8	1.68	26,635.00	0.83	44,746.80	539		
1998	3	JP8	1.68	26,263.00	0.83	44,121.84	539		
1998	4	JP8	1.68	29,202.00	0.83	49,059.36	534		
				112,613.00		189,189.84	546	0.8259	156,251.89
1999	1	JP8	1.80	33,444.00	0.86	60,199.20	570		
1999	2	JP8	1.80	21,997.00	0.86	39,594.60	541		
1999	3	JP8	1.80	31,170.00	0.86	56,106.00	641		
1999	4	JP8	1.80	26,886.00	0.86	48,394.80	560		
				113,497.00		204,294.60	578	0.7949	162,393.78

TABLE B11. M109A6 ABLV FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1997	1	JP8	0.72	28,339	0.81		253		
1997	2	JP8	0.72	48,123	0.81	34,648.56	306		
1997	3	JP8	0.72	35,286	0.81	25,405.92	307		
1997	4	JP8	0.72	50,937	0.81	36,674.64	339		
				162,685		96,729.12	301	0.8581	83,003.26
1998	1	JP8	0.72	57,460	0.83	41,371.20	346		
1998	2	JP8	0.72	67,811	0.83	48,823.92	359		
1998	3	JP8	0.72	79,700	0.83	57,384.00	424		
1998	4	JP8	0.72	94,699	0.83	68,183.28	554		
				299,670		215,762.40	421	0.8259	178,198.17
1999	1	JP8	0.78	112,489	0.86	87,741.42	578		
1999	2	JP8	0.78	76,313	0.86	59,524.14	524		
1999	3	JP8	0.78	90,177	0.86	70,338.06	599		
1999	4	JP8	0.78	88,456	0.86	68,995.68	623		
				367,435		286,599.30	581	0.7949	227,817.78

TABLE B12. M113A3 FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1994	1	JP8	0.45	525,618	0.78	236,528.10	9,302		
1994	2	JP8	0.45	548,455	0.78	246,804.75	9,247		
1994	3	JP8	0.45	568,561	0.78	255,852.45	9,291		
1994	4	JP8	0.45	632,289	0.78	284,530.05	9,394		
				2,274,923		1,023,715.35	9,309	0.9625	985,326.02
1995	1	JP8	0.41	696,194	0.71	285,439.54	9,461		
1995	2	JP8	0.41	623,015	0.71	255,436.15	9,450		
1995	3	JP8	0.41	749,985	0.71	307,493.85	9,296		
1995	4	JP8	0.41	847,433	0.71	347,447.53	9,355		
				2,916,627		1,195,817.07	9,391	0.9263	1,107,685.35
1996	1	JP8	0.44	711,982	0.76	313,272.08	9,304		
1996	2	JP8	0.44	543,875	0.76	239,305.00	9,160		
1996	3	JP8	0.44	576,176	0.76	253,517.44	8,722		
1996	4	JP8	0.44	768,771	0.76	338,259.24	8,506		
				2,600,804		1,144,353.76	8,923	0.8916	1,020,305.81
1997	1	JP8	0.47	716,091	0.81	336,562.77	8,908		
1997	2	JP8	0.47	590,036	0.81	277,316.92	9,156		
1997	3	JP8	0.47	789,249	0.81	370,947.03	8,704		
1997	4	JP8	0.47	722,292	0.81	339,477.24	8,564		
				2,817,668		1,324,303.96	8,833	0.8581	1,136,385.23
1998	1	JP8	0.47	666,942	0.83	313,462.74	7,920		
1998	2	JP8	0.47	547,297	0.83	257,229.59	8,061		
1998	3	JP8	0.47	600,810	0.83	282,380.70	8,158		
1998	4	JP8	0.47	671,244	0.83	315,484.68	7,803		
				2,486,293		1,168,557.71	7,986	0.8259	965,111.81
1999	1	JP8	0.50	248,541	0.86	124,270.50	3,349		
1999	2	JP8	0.50	210,084	0.86	105,042.00	3,319		
1999	3	JP8	0.50	324,261	0.86	162,130.50	3,402		
1999	4	JP8	0.50	338,543	0.86	169,271.50	3,402		
				1,121,429		560,714.50	3,368	0.7949	445,711.96

TABLE B13. M2 BFV FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1994	1	JP8	0.92	179,941	0.78	165,545.72	1,646		
1994	2	JP8	0.92	204,829	0.78	188,442.68	1,779		
1994	3	JP8	0.92	138,720	0.78	127,622.40	1,630		
1994	4	JP8	0.92	184,759	0.78	169,978.28	1,790		
				708,249		651,589.08	1,711	0.9625	627,154.49
1995	1	JP8	0.84	145,066	0.71	121,855.44	1,750		
1995	2	JP8	0.84	67,797	0.71	56,949.48	1,539		
1995	3	JP8	0.84	84,377	0.71	70,876.68	1,495		
1995	4	JP8	0.84	314,123	0.71	263,863.32	1,361		
				611,363		513,544.92	1,536	0.9263	475,696.66
1996	1	JP8	0.89	68,333	0.76	60,816.37	1,328		
1996	2	JP8	0.89	121,523	0.76	108,155.47	1,301		
1996	3	JP8	0.89	114,072	0.76	101,524.08	1,056		
1996	4	JP8	0.89	101,022	0.76	89,909.58	1,052		
				404,950		360,405.50	1,184	0.8916	321,337.54
1997	1	JP8	0.95	84,897	0.81	80,652.15	1,475		
1997	2	JP8	0.95	141,614	0.81	134,533.30	1,532		
1997	3	JP8	0.95	113,708	0.81	108,022.60	1,282		
1997	4	JP8	0.95	144,460	0.81	137,237.00	1,332		
				484,679		460,445.05	1,405	0.8581	395,107.90
1998	1	JP8	0.95	76,366	0.83	72,547.70	1,355		
1998	2	JP8	0.95	86,641	0.83	82,308.95	1,370		
1998	3	JP8	0.95	48,266	0.83	45,852.70	1,370		
1998	4	JP8	0.95	164,096	0.83	155,891.20	1,328		
				375,369		356,600.55	1,356	0.8259	294,516.39
1999	1	JP8	1.01	108,486	0.86	109,570.86	1,095		
1999	2	JP8	1.01	53,913	0.86	54,452.13	1,048		
1999	3	JP8	1.01	72,653	0.86	73,379.53	1,125		
1999	4	JP8	1.01	85,893	0.86	86,751.93	1,139		
				320,945		324,154.45	1,102	0.7949	257,670.37

TABLE B14. M60A3 FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1994	1	JP8	1.63	90,128	0.78	146,908.64	2,723		
1994	2	JP8	1.63	40,106	0.78	65,372.78	2,586		
1994	3	JP8	1.63	166,391	0.78	271,217.33	2,648		
1994	4	JP8	1.63	92,828	0.78	151,309.64	2,698		
				389,453		634,808.39	2,664	0.9625	611,003.08
1995	1	JP8	1.49	64,545	0.71	96,172.05	2,468		
1995	2	JP8	1.49	72,277	0.71	107,692.73	2,956		
1995	3	JP8	1.49	75,546	0.71	112,563.54	2,789		
1995	4	JP8	1.49	30,097	0.71	44,844.53	2,766		
				242,465		361,272.85	2,745	0.9263	334,647.04
1996	1	JP8	1.59	268,690	0.76	427,217.10	2,457		
1996	2	JP8	1.59	22,980	0.76	36,538.20	2,412		
1996	3	JP8	1.59	18,851	0.76	29,973.09	2,222		
1996	4	JP8	1.59	37,123	0.76	59,025.57	2,156		
				347,644		552,753.96	2,312	0.8916	492,835.43
1997	1	JP8	1.69	73,323	0.81	123,915.87	2,037		
1997	2	JP8	1.69	8,933	0.81	15,096.77	2,018		
1997	3	JP8	1.69	10,149	0.81	17,151.81	1,570		
1997	4	JP8	1.69	41,899	0.81	70,809.31	1,127		
				134,304		226,973.76	1,688	0.8581	194,766.18
1998	1	JP8	1.68	17,542	0.83	29,470.56	49		
1998	2	JP8	1.68	4,926	0.83	8,275.68	45		
1998	3	JP8	1.68	7,493	0.83	12,588.24	45		
1998	4	JP8	1.68	20,376	0.83	34,231.68	66		
				50,337		84,566.16	51	0.8259	69,843.19
1999	1	JP8	1.80	14,335	0.86	25,803.00	89		
1999	2	JP8	1.80	18,817	0.86	33,870.60	187		
1999	3	JP8	1.80	14,523	0.86	26,141.40	90		
1999	4	JP8	1.80	16,133	0.86	29,039.40	322		
				63,808		114,854.40	172	0.7949	91,297.76

TABLE B15. M88A1 FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1994	1	JP8	1.56	120,366	0.78	187,770.96	1,667		
1994	2	JP8	1.56	125,126	0.78	195,196.56	1,676		
1994	3	JP8	1.56	168,110	0.78	262,251.60	1,665		
1994	4	JP8	1.56	109,105	0.78	170,203.80	1,701		
				522,707		815,422.92	1,677	0.9625	784,844.56
1995	1	JP8	1.42	176,507	0.71	250,639.94	1,721		
1995	2	JP8	1.42	134,624	0.71	191,166.08	1,751		
1995	3	JP8	1.42	179,311	0.71	254,621.62	1,736		
1995	4	JP8	1.42	205,449	0.71	291,737.58	1,662		
				695,891		988,165.22	1,718	0.9263	915,337.44
1996	1	JP8	1.52	193,948	0.76	294,800.96	1,782		
1996	2	JP8	1.52	161,215	0.76	245,046.80	1,801		
1996	3	JP8	1.52	130,771	0.76	198,771.92	1,771		
1996	4	JP8	1.52	149,376	0.76	227,051.52	1,767		
				635,310		965,671.20	1,780	0.8916	860,992.44
1997	1	JP8	1.62	170,970	0.81	276,971.40	1,882		
1997	2	JP8	1.62	144,372	0.81	233,882.64	1,921		
1997	3	JP8	1.62	177,902	0.81	288,201.24	1,811		
1997	4	JP8	1.62	177,015	0.81	286,764.30	1,758		
				670,259		1,085,819.58	1,843	0.8581	931,741.78
1998	1	JP8	1.61	160,216	0.83	257,947.76	1,829		
1998	2	JP8	1.61	128,665	0.83	207,150.65	1,813		
1998	3	JP8	1.61	125,411	0.83	201,911.71	1,814		
1998	4	JP8	1.61	149,566	0.83	240,801.26	1,831		
				563,858		907,811.38	1,822	0.8259	749,761.42
1999	1	JP8	1.72	155,429	0.86	267,337.88	1,883		
1999	2	JP8	1.72	105,541	0.86	181,530.52	1,826		
1999	3	JP8	1.72	156,030	0.86	268,371.60	1,987		
1999	4	JP8	1.72	118,840	0.86	204,404.80	1,818		
				535,840		921,644.80	1,879	0.7949	732,615.45

TABLE B16. M9 ACE FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1994	1	JP8	1.05	66,359	0.78	69,676.95	400		
1994	2	JP8	1.05	39,942	0.78	41,939.10	384		
1994	3	JP8	1.05	42,290	0.78	44,404.50	366		
1994	4	JP8	1.05	39,272	0.78	41,235.60	386		
				187,863		197,256.15	384	0.9625	189,859.04
1995	1	JP8	0.96	54,366	0.71	52,191.36	385		
1995	2	JP8	0.96	64,855	0.71	62,260.80	411		
1995	3	JP8	0.96	64,864	0.71	62,269.44	411		
1995	4	JP8	0.96	18,567	0.71	17,824.32	394		
				202,652		194,545.92	400	0.9263	180,207.89
1996	1	JP8	1.02	79,868	0.76	81,465.36	415		
1996	2	JP8	1.02	50,773	0.76	51,788.46	423		
1996	3	JP8	1.02	48,328	0.76	49,294.56	428		
1996	4	JP8	1.02	52,433	0.76	53,481.66	428		
				231,402		236,030.04	424	0.8916	210,444.38
1997	1	JP8	1.09	51,837	0.81	56,502.33	412		
1997	2	JP8	1.09	40,722	0.81	44,386.98	413		
1997	3	JP8	1.09	59,716	0.81	65,090.44	449		
1997	4	JP8	1.09	41,933	0.81	45,706.97	437		
				194,208		211,686.72	428	0.8581	181,648.37
1998	1	JP8	1.08	63,717	0.83	68,814.36	476		
1998	2	JP8	1.08	36,987	0.83	39,945.96	462		
1998	3	JP8	1.08	50,408	0.83	54,440.64	462		
1998	4	JP8	1.08	44,779	0.83	48,361.32	448		
				195,891		211,562.28	462	0.8259	174,729.29
1999	1	JP8	1.16	50,910	0.86	59,055.60	430		
1999	2	JP8	1.16	36,663	0.86	42,529.08	429		
1999	3	JP8	1.16	37,414	0.86	43,400.24	455		
1999	4	JP8	1.16	55,043	0.86	63,849.88	458		

TABLE B17. M992A1 FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED TOTAL COST
1994	1	JP8	0.78	73,434	0.78	57,278.52	499		
1994	2	JP8	0.78	58,409	0.78	45,559.02	523		
1994	3	JP8	0.78	57,938	0.78	45,191.64	511		
1994	4	JP8	0.78	68,815	0.78	53,675.70	569		
				258,596		201,704.88	526	0.9625	194,140.95
1995	1	JP8	0.70	64,283	0.71	44,998.10	507		
1995	2	JP8	0.70	55,709	0.71	38,996.30	507		
1995	3	JP8	0.70	77,448	0.71	54,213.60	483		
1995	4	JP8	0.70	6,901	0.71	4,830.70	330		
				204,341		143,038.70	457	0.9263	132,496.75
1996	1	JP8	0.75	85,266	0.76	63,949.50	401		
1996	2	JP8	0.75	63,232	0.76	47,424.00	369		
1996	3	JP8	0.75	77,606	0.76	58,204.50	324		
1996	4	JP8	0.75	87,445	0.76	65,583.75	290		
				313,549		235,161.75	346	0.8916	209,670.22
1997	1	JP8	0.81	82,964	0.81	67,200.84	495		
1997	2	JP8	0.81	73,029	0.81	59,153.49	509		
1997	3	JP8	0.81	109,029	0.81	88,313.49	521		
1997	4	JP8	0.81	75,158	0.81	60,877.98	515		
				340,180		275,545.80	510	0.8581	236,445.85
1998	1	JP8	0.80	95,711	0.83	76,568.80	446		
1998	2	JP8	0.80	63,833	0.83	51,066.40	574		
1998	3	JP8	0.80	110,713	0.83	88,570.40	574		
1998	4	JP8	0.80	102,035	0.83	81,628.00	609		
				372,292		297,833.60	551	0.8259	245,980.77
1999	1	JP8	0.85	79,804	0.86	67,833.40	599		
1999	2	JP8	0.85	69,183	0.86	58,805.55	686		
1999	3	JP8	0.85	86,029	0.86	73,124.65	738		
1999	4	JP8	0.85	94,438	0.86	80,272.30	699		
				329,454		280,035.90	681	0.7949	222,600.54

TABLE B18. M1A1 FUEL DATA

FY	QTR	FUELTYPE	FUELCOST PER MILE	ACTIVITY MILES	FUEL PRICE (Then Years $)	TOTAL POL COST (Then Years $)	DENSITY	DISCOUNT RATE	ADJUSTED FUEL COST
1994	1	JP8	5.65	285,908	0.78	1,615,380.20	2,623		
1994	2	JP8	5.65	281,424	0.78	1,590,045.60	2,635		
1994	3	JP8	5.65	302,329	0.78	1,708,158.85	2,744		
1994	4	JP8	5.65	395,983	0.78	2,237,303.95	2,962		
				1,265,644		7,150,888.60	2,741	0.9625	6,882,730.28
1995	1	JP8	5.14	445,564	0.71	2,290,198.96	3,103		
1995	2	JP8	5.14	369,078	0.71	1,897,060.92	3,056		
1995	3	JP8	5.14	470,575	0.71	2,418,755.50	3,054		
1995	4	JP8	5.14	373,575	0.71	1,920,175.50	2,849		
				1,658,792		8,526,190.88	3,016	0.9263	7,897,810.61
1996	1	JP8	5.51	482,580	0.76	2,659,015.80	3,003		
1996	2	JP8	5.51	435,554	0.76	2,399,902.54	3,108		
1996	3	JP8	5.51	329,970	0.76	1,818,134.70	2,982		
1996	4	JP8	5.51	375,834	0.76	2,070,845.34	2,982		
				1,623,938		8,947,898.38	3,019	0.8916	7,977,946.20
1997	1	JP8	5.87	487,737	0.81	2,863,016.19	3,339		
1997	2	JP8	5.87	384,162	0.81	2,255,030.94	3,389		
1997	3	JP8	5.87	522,389	0.81	3,066,423.43	3,376		
1997	4	JP8	5.87	520,599	0.81	3,055,916.13	3,263		
				1,914,887		11,240,386.69	3,342	0.8581	9,645,375.82
1998	1	JP8	5.83	473,431	0.83	2,760,102.73	3,260		
1998	2	JP8	5.83	360,077	0.83	2,099,248.91	3,307		
1998	3	JP8	5.83	400,796	0.83	2,336,640.68	3,309		
1998	4	JP8	5.83	540,670	0.83	3,152,106.10	3,397		
				1,774,974		10,348,098.42	3,318	0.8259	8,546,494.49
1999	1	JP8	6.23	390,079	0.86	2,430,192.17	3,283		
1999	2	JP8	6.23	346,390	0.86	2,158,009.70	3,332		
1999	3	JP8	6.23	467,535	0.86	2,912,743.05	3,540		
1999	4	JP8	6.23	393,661	0.86	2,452,508.03	3,080		
				1,597,665		9,953,452.95	3,309	0.7949	7,911,999.75

APPENDIX C

Cost Estimating Percentages

This appendix provides a complete listing of all the cost estimating percentages calculated for the study. The cost estimating percentages are tabulated by weapon system and WBS element. They are used in developing the cost risk factors used in the parametric model.

TABLE C1. WBS COST PERCENTAGES

AVLB

Year	CER01	CER02	CER03	CER04	CER05	CER06	CER07	CER11	CER12	CER13	CER14	CER0
1994	0.10	0.12	0.62	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
1995	0.11	0.15	0.56	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
1996	0.09	0.16	0.57	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02
1997	0.13	0.17	0.46	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03
1998	0.15	0.07	0.54	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
1999	0.12	0.18	0.55	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
AVG(X)	0.12	0.14	0.55	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
VAR(X)	4.7E-04	1.7E-03	2.7E-03	1.4E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.7E-05	0.0E+00	6.7E-05	1.7E-05

M109A6

Year	CER01	CER02	CER03	CER04	CER05	CER06	CER07	CER11	CER12	CER13	CER14	CER0
1994	0.09	0.03	0.23	0.04	0.01	0.14	0.06	0.00	0.10	0.11	0.06	0.14
1995	0.10	0.06	0.17	0.04	0.02	0.10	0.10	0.01	0.00	0.16	0.10	0.07
1996	0.10	0.06	0.20	0.06	0.02	0.12	0.09	0.00	0.00	0.15	0.07	0.04
1997	0.15	0.07	0.19	0.08	0.05	0.10	0.13	0.05	0.00	0.04	0.04	0.02
1998	0.10	0.06	0.26	0.06	0.02	0.11	0.12	0.04	0.00	0.09	0.08	0.01
1999	0.09	0.08	0.21	0.05	0.01	0.07	0.10	0.04	0.00	0.19	0.05	0.01
AVG(X)	0.11	0.06	0.21	0.06	0.02	0.11	0.10	0.02	0.02	0.12	0.07	0.05
VAR(X)	5.1E-04	2.8E-04	1.0E-03	2.3E-04	2.2E-04	5.5E-04	6.0E-04	5.1E-04	1.7E-03	2.9E-03	4.7E-04	2.5E-03

M113A3

Year	CER01	CER02	CER03	CER04	CER05	CER06	CER07	CER11	CER12	CER13	CER14	CER0
1994	0.20	0.06	0.50	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.03
1995	0.23	0.08	0.46	0.05	0.00	0.01	0.02	0.00	0.00	0.00	0.03	0.04
1996	0.19	0.08	0.49	0.06	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.05
1997	0.21	0.12	0.38	0.06	0.00	0.00	0.02	0.00	0.00	0.00	0.07	0.06
1998	0.18	0.12	0.41	0.03	0.00	0.01	0.02	0.00	0.01	0.00	0.09	0.06
1999	0.15	0.15	0.40	0.05	0.00	0.00	0.02	0.00	0.00	0.00	0.08	0.04
AVG(X)	0.19	0.10	0.44	0.05	0.00	0.01	0.02	0.00	0.00	0.00	0.05	0.05
VAR(X)	7.5E-04	1.1E-03	2.5E-03	1.2E-04	0.0E+00	3.0E-05	1.7E-05	0.0E+00	1.7E-05	0.0E+00	9.1E-04	1.5E-04

M2 BFV

Year	CER01	CER02	CER03	CER04	CER05	CER06	CER07	CER11	CER12	CER13	CER14	CER0
1994	0.05	0.06	0.24	0.06	0.06	0.13	0.22	0.00	0.00	0.00	0.02	0.02
1995	0.07	0.06	0.26	0.08	0.07	0.11	0.15	0.00	0.00	0.00	0.02	0.02
1996	0.08	0.10	0.21	0.07	0.06	0.16	0.16	0.00	0.00	0.00	0.03	0.02
1997	0.07	0.06	0.21	0.07	0.05	0.16	0.13	0.00	0.00	0.00	0.03	0.02
1998	0.06	0.10	0.26	0.07	0.06	0.17	0.12	0.00	0.00	0.00	0.02	0.02
1999	0.06	0.05	0.23	0.08	0.04	0.16	0.16	0.00	0.00	0.00	0.02	0.03
AVG(X)	0.07	0.07	0.24	0.07	0.06	0.15	0.16	0.00	0.00	0.00	0.02	0.02
VAR(X)	1.1E-04	5.0E-04	5.1E-04	5.7E-05	1.1E-04	5.4E-04	1.2E-03	0.0E+00	0.0E+00	0.0E+00	2.7E-05	1.7E-05

TABLE C1. CONTINUED

M60A3

Year	CER01	CER02	CER03	CER04	CER05	CER06	CER07	CER11	CER12	CER13	CER14	CER0
1994	0.06	0.14	0.35	0.04	0.02	0.11	0.07	0.00	0.00	0.00	0.04	0.08
1995	0.07	0.05	0.40	0.03	0.02	0.15	0.06	0.01	0.00	0.00	0.05	0.06
1996	0.06	0.03	0.40	0.03	0.01	0.14	0.04	0.01	0.00	0.00	0.03	0.15
1997	0.05	0.08	0.55	0.02	0.00	0.04	0.11	0.00	0.01	0.00	0.04	0.04
1998	0.08	0.10	0.54	0.03	0.00	0.09	0.03	0.00	0.00	0.00	0.04	0.05
1999	0.05	0.27	0.42	0.02	0.00	0.11	0.01	0.00	0.00	0.00	0.06	0.03
AVG(X)	0.06	0.11	0.44	0.03	0.01	0.11	0.05	0.00	0.00	0.00	0.04	0.07
VAR(X)	1.4E-04	7.5E-03	6.7E-03	5.7E-05	9.7E-05	1.5E-03	1.2E-03	2.7E-05	1.7E-05	0.0E+00	1.1E-04	1.9E-03

M88A1

Year	CER01	CER02	CER03	CER04	CER05	CER06	CER07	CER11	CER12	CER13	CER14	CER0
1994	0.11	0.10	0.66	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.02
1995	0.13	0.13	0.60	0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.03
1996	0.10	0.12	0.64	0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.03
1997	0.14	0.13	0.55	0.03	0.00	0.04	0.00	0.00	0.00	0.00	0.02	0.03
1998	0.14	0.12	0.60	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.02
1999	0.13	0.18	0.54	0.03	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.03
AVG(X)	0.13	0.13	0.60	0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.02	0.03
VAR(X)	2.7E-04	7.2E-04	2.3E-03	2.7E-05	0.0E+00	6.7E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-05	2.7E-05

M9 ACE

Year	CER01	CER02	CER03	CER04	CER05	CER06	CER07	CER11	CER12	CER13	CER14	CER0
1994	0.22	0.14	0.50	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
1995	0.24	0.24	0.39	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
1996	0.19	0.30	0.42	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
1997	0.24	0.29	0.34	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03
1998	0.24	0.19	0.44	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02
1999	0.22	0.23	0.43	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
AVG(X)	0.23	0.23	0.42	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
VAR(X)	3.9E-04	3.7E-03	2.8E-03	5.7E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-04	1.7E-05

APPENDIX D

Kolmogorov-Smirnov Tests and CER Graphs

TABLE D1. CER1 EMPERICAL DISTRIBUTION

CER1 (%)	P(x)	S(x) CDF	F(x) CDF	K-S Stat	K-S Critical
5	0.0714	0.071	0.071	0.000	0.210
5	0.0714	0.071	0.071	0.000	
5	0.0714	0.071	0.071	0.000	
6	0.0952	0.167	0.101	0.066	
6	0.0952	0.167	0.101	0.066	
6	0.0952	0.167	0.101	0.066	
6	0.0952	0.167	0.101	0.066	
7	0.0714	0.238	0.161	0.077	
7	0.0714	0.238	0.161	0.077	
7	0.0714	0.238	0.161	0.077	
8	0.0476	0.286	0.248	0.038	
8	0.0476	0.286	0.248	0.038	
9	0.0714	0.357	0.329	0.028	
9	0.0714	0.357	0.329	0.028	
9	0.0714	0.357	0.329	0.028	
10	0.1190	0.476	0.409	0.067	
10	0.1190	0.476	0.409	0.067	
10	0.1190	0.476	0.409	0.067	
10	0.1190	0.476	0.409	0.067	
10	0.1190	0.476	0.409	0.067	
11	0.0476	0.524	0.481	0.043	
11	0.0476	0.524	0.481	0.043	
12	0.0238	0.548	0.558	0.010	
13	0.0714	0.619	0.618	0.001	
13	0.0714	0.619	0.618	0.001	
13	0.0714	0.619	0.618	0.001	
14	0.0476	0.667	0.680	0.013	
14	0.0476	0.667	0.680	0.013	
15	0.0714	0.738	0.729	0.009	
15	0.0714	0.738	0.729	0.009	
15	0.0714	0.738	0.729	0.009	
18	0.0238	0.762	0.833	0.071	
19	0.0476	0.810	0.860	0.050	
19	0.0476	0.810	0.860	0.050	
20	0.0238	0.833	0.881	0.048	
21	0.0238	0.857	0.914	0.057	
22	0.0476	0.905	0.932	0.027	
22	0.0476	0.905	0.932	0.027	
23	0.0238	0.929	0.940	0.011	
24	0.0714	1.000	0.949	0.051	
24	0.0714	1.000	0.949	0.051	
24	0.0714	1.000	0.949	0.051	

0.077 < 0.210, Conclude S(x) could be distributed lognormal

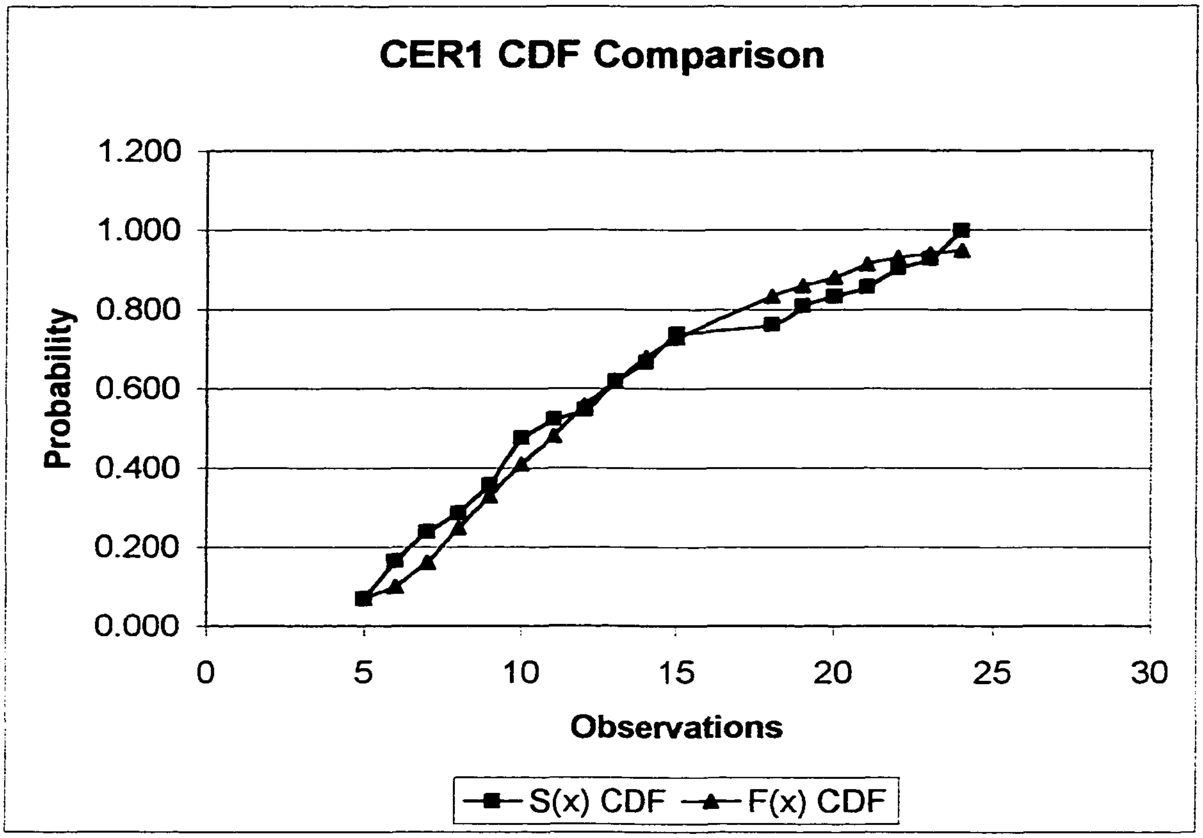


FIGURE D1. CER1 CDF COMPARISON

TABLE D2. CER2 EMPERICAL DISTRIBUTION

CER2 (%)	P(x)	S(x) CDF	F(x) CDF	K-S Stat	K-S Critical
3	0.05	0.05	0.018	0.030	0.210
3	0.05	0.05	0.018	0.030	
5	0.05	0.10	0.102	0.007	
5	0.05	0.10	0.102	0.007	
6	0.17	0.26	0.167	0.095	
6	0.17	0.26	0.167	0.095	
6	0.17	0.26	0.167	0.095	
6	0.17	0.26	0.167	0.095	
6	0.17	0.26	0.167	0.095	
6	0.17	0.26	0.167	0.095	
6	0.17	0.26	0.167	0.095	
7	0.05	0.31	0.247	0.063	
7	0.05	0.31	0.247	0.063	
8	0.10	0.40	0.330	0.075	
8	0.10	0.40	0.330	0.075	
8	0.10	0.40	0.330	0.075	
8	0.10	0.40	0.330	0.075	
10	0.10	0.50	0.477	0.023	
10	0.10	0.50	0.477	0.023	
10	0.10	0.50	0.477	0.023	
10	0.10	0.50	0.477	0.023	
12	0.12	0.62	0.607	0.012	
12	0.12	0.62	0.607	0.012	
12	0.12	0.62	0.607	0.012	
12	0.12	0.62	0.607	0.012	
12	0.12	0.62	0.607	0.012	
13	0.05	0.67	0.662	0.005	
13	0.05	0.67	0.662	0.005	
14	0.05	0.71	0.707	0.007	
14	0.05	0.71	0.707	0.007	
15	0.05	0.76	0.750	0.012	
15	0.05	0.76	0.750	0.012	
16	0.02	0.79	0.779	0.007	
17	0.02	0.81	0.814	0.004	
18	0.05	0.86	0.842	0.015	
18	0.05	0.86	0.842	0.015	
19	0.02	0.88	0.860	0.021	
23	0.02	0.90	0.930	0.025	
24	0.02	0.93	0.937	0.008	
27	0.02	0.95	0.960	0.008	
29	0.02	0.98	0.972	0.004	
30	0.02	1.00	0.975	0.025	

0.095 < 0.210, Conclude S(x) could be distributed lognormal

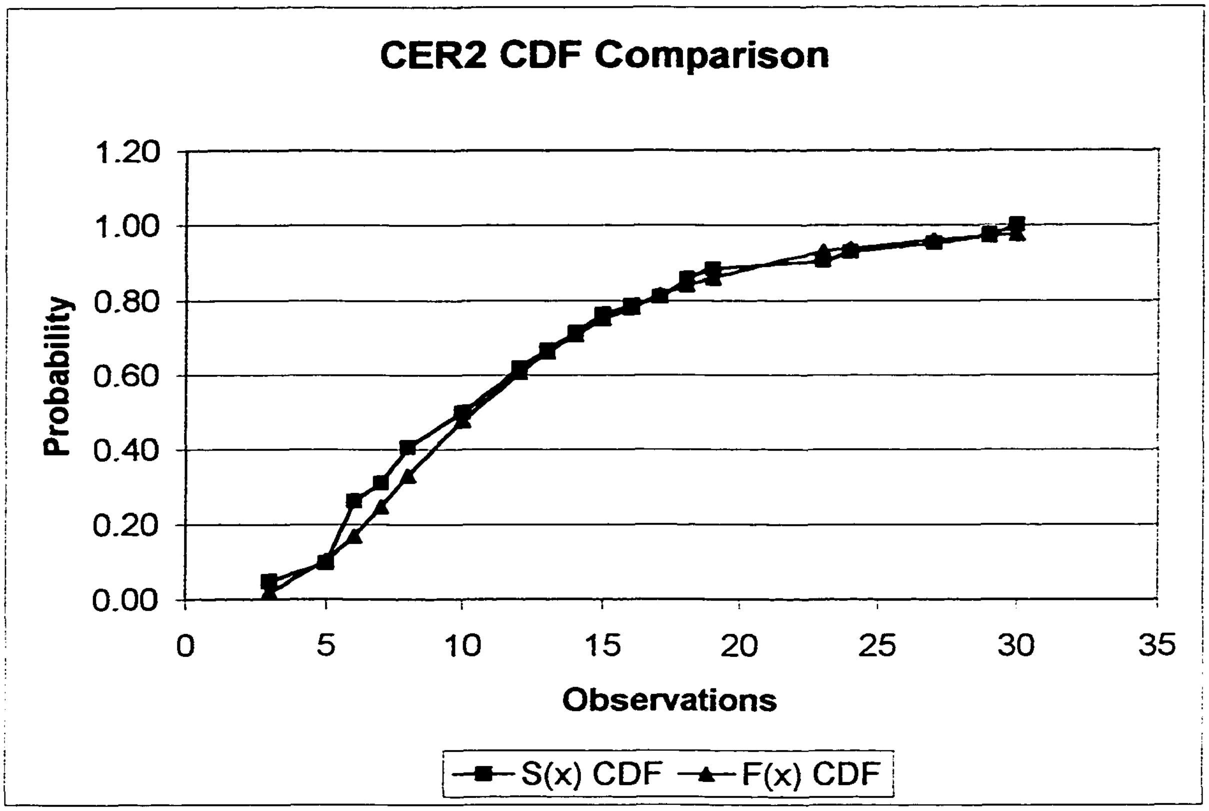


FIGURE D2. CER2 CDF COMPARISON

TABLE D3. CER3 EMPERICAL DISTRIBUTION

CER3 (%)	P(x)	S(x) CDF	F(x) CDF	K-S Stat	K-S Critical
17	0.02	0.02	0.027	0.003	0.210
19	0.02	0.05	0.039	0.009	
20	0.02	0.07	0.048	0.023	
21	0.07	0.14	0.070	0.073	
21	0.07	0.14	0.070	0.073	
21	0.07	0.14	0.070	0.073	
23	0.05	0.19	0.096	0.094	
23	0.05	0.19	0.096	0.094	
24	0.02	0.21	0.117	0.097	
26	0.07	0.29	0.161	0.125	
26	0.07	0.29	0.161	0.125	
26	0.07	0.29	0.161	0.125	
34	0.02	0.31	0.382	0.072	
35	0.02	0.33	0.402	0.069	
38	0.02	0.36	0.488	0.131	
39	0.02	0.38	0.511	0.130	
40	0.07	0.45	0.534	0.082	
40	0.07	0.45	0.534	0.082	
40	0.07	0.45	0.534	0.082	
41	0.02	0.48	0.571	0.095	
42	0.05	0.52	0.592	0.068	
42	0.05	0.52	0.592	0.068	
43	0.02	0.55	0.614	0.066	
44	0.02	0.57	0.638	0.067	
46	0.05	0.62	0.678	0.059	
46	0.05	0.62	0.678	0.059	
49	0.02	0.64	0.737	0.094	
50	0.05	0.69	0.752	0.062	
50	0.05	0.69	0.752	0.062	
54	0.07	0.76	0.812	0.050	
54	0.07	0.76	0.812	0.050	
54	0.07	0.76	0.812	0.050	
55	0.07	0.83	0.819	0.014	
55	0.07	0.83	0.819	0.014	
55	0.07	0.83	0.819	0.014	
56	0.02	0.86	0.820	0.037	
57	0.02	0.88	0.846	0.035	
60	0.05	0.93	0.874	0.055	
60	0.05	0.93	0.874	0.055	
62	0.02	0.95	0.896	0.056	
64	0.02	0.98	0.906	0.070	
66	0.02	1.00	0.921	0.079	

0.131 < 0.210, Conclude S(x) could be distributed lognormal

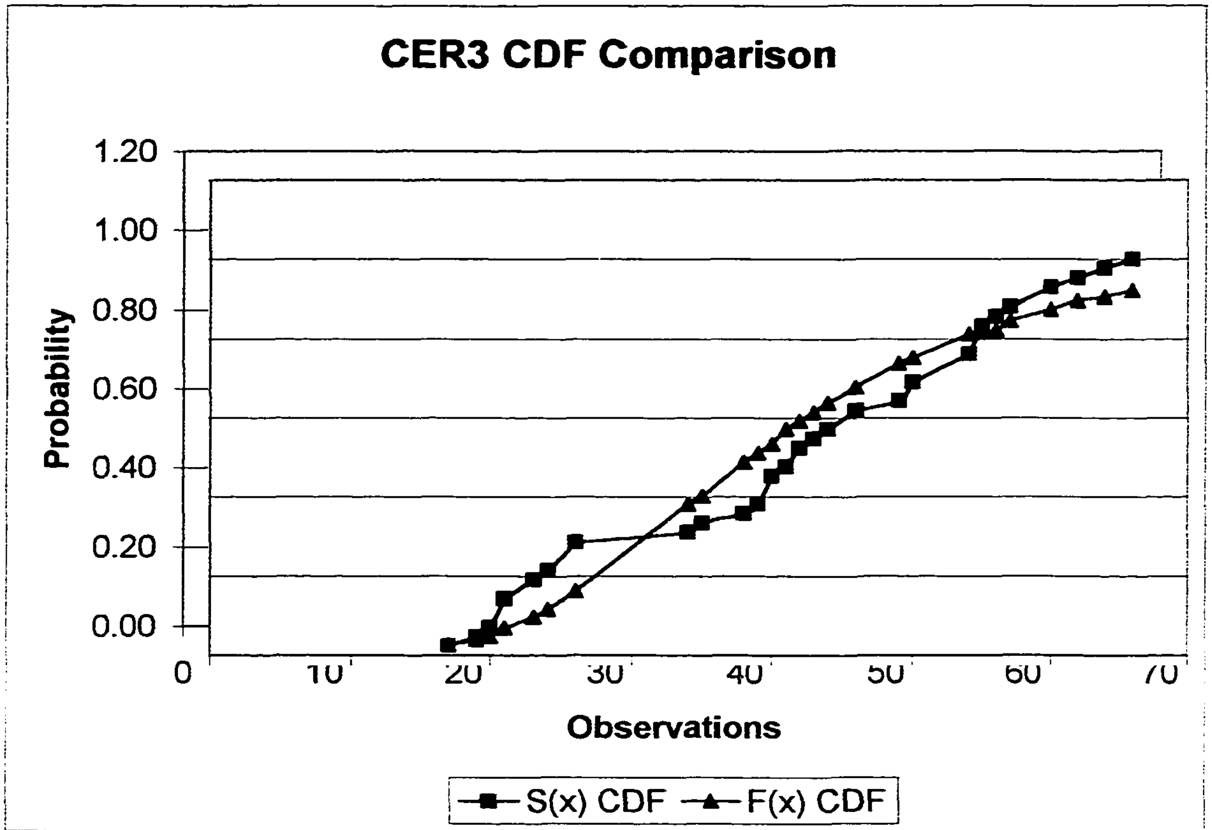


FIGURE D3. CER3 CDF COMPARISON

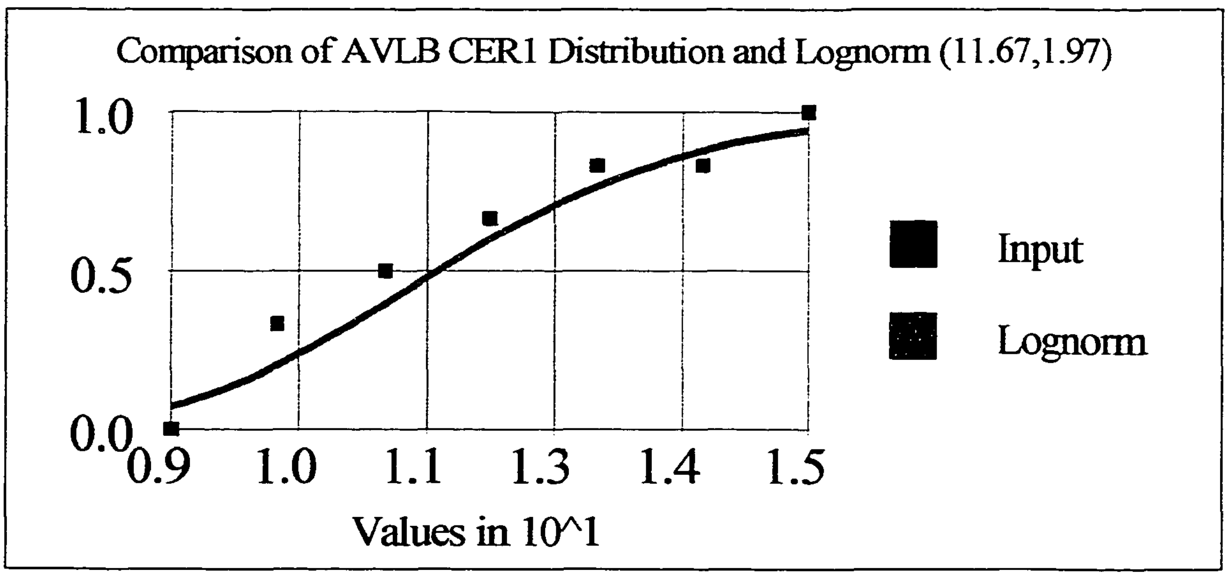


FIGURE D4. AVLB CER1 CDF

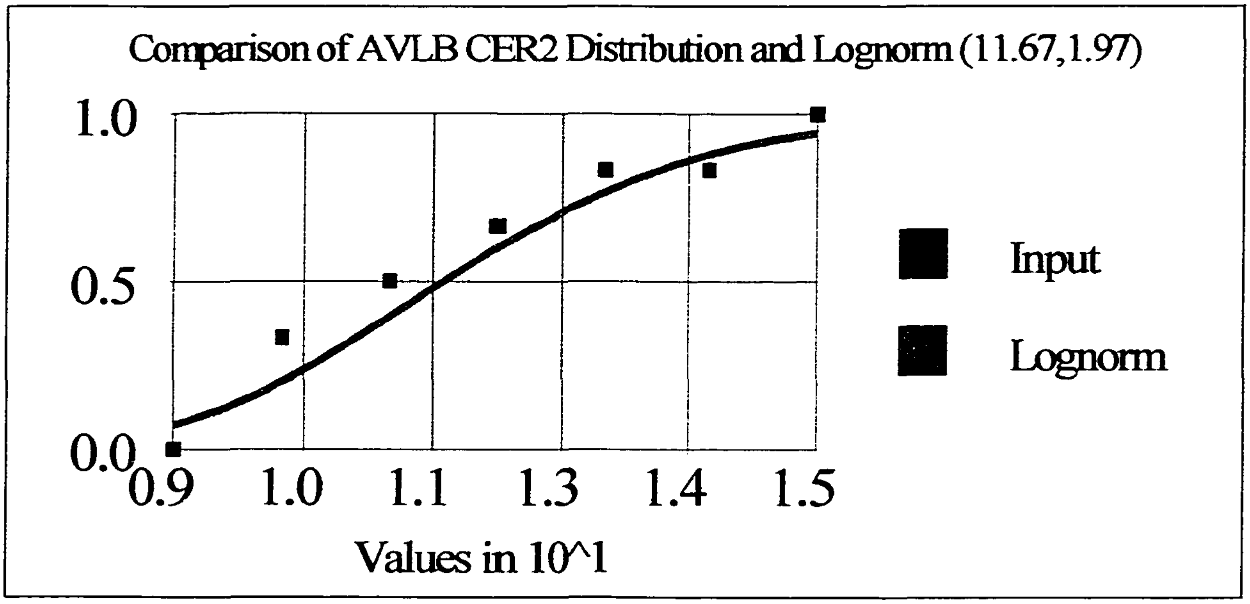


FIGURE D5. AVLB CER2 CDF

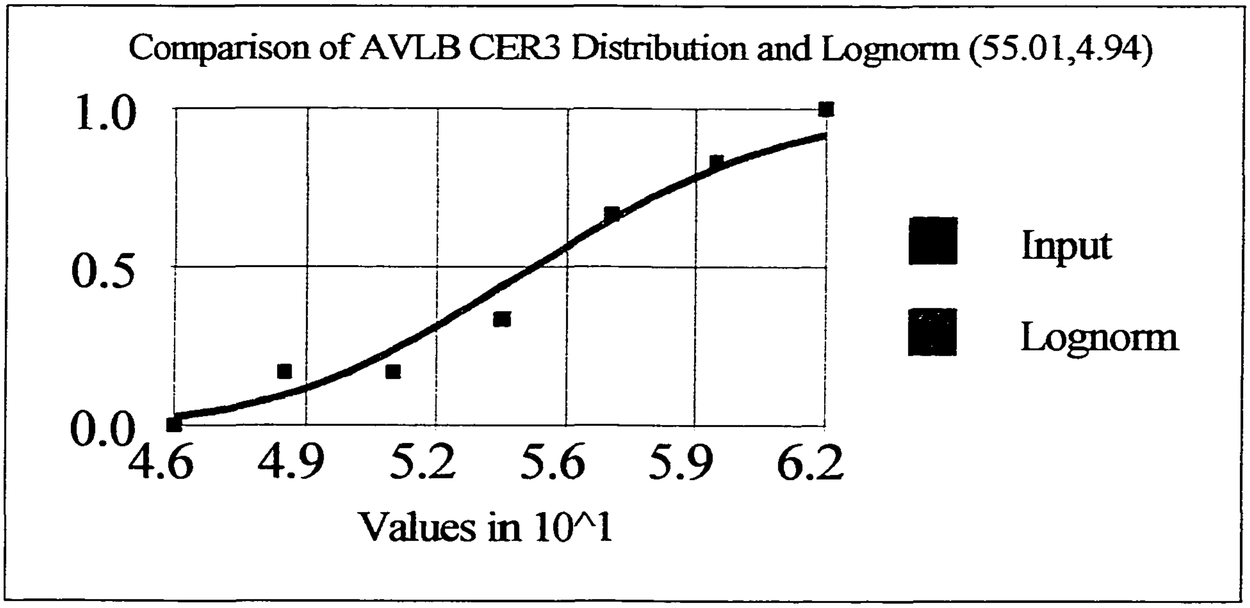


FIGURE D6. AVLB CER3 CDF

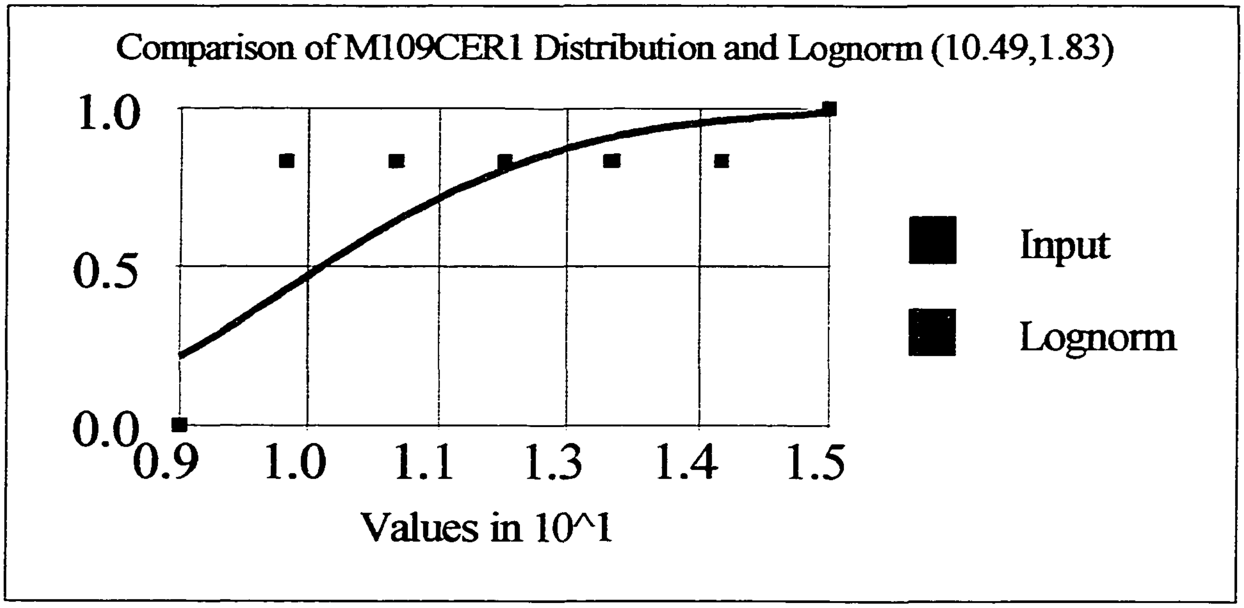


FIGURE D7. M109 CER1 CDF

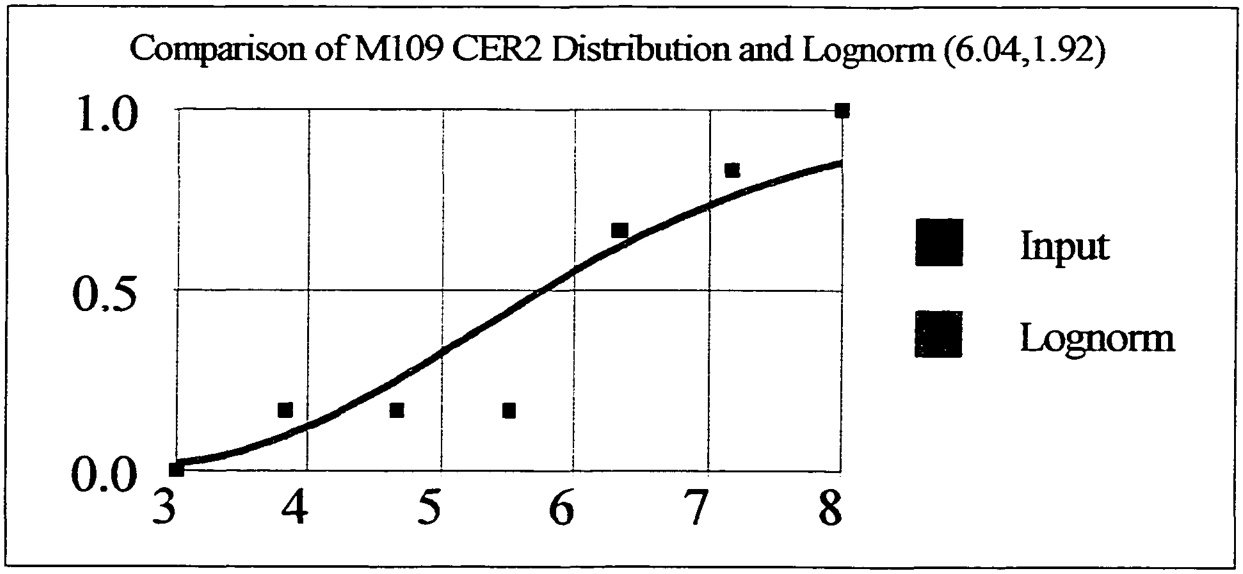


FIGURE D8. M109 CER2 CDF

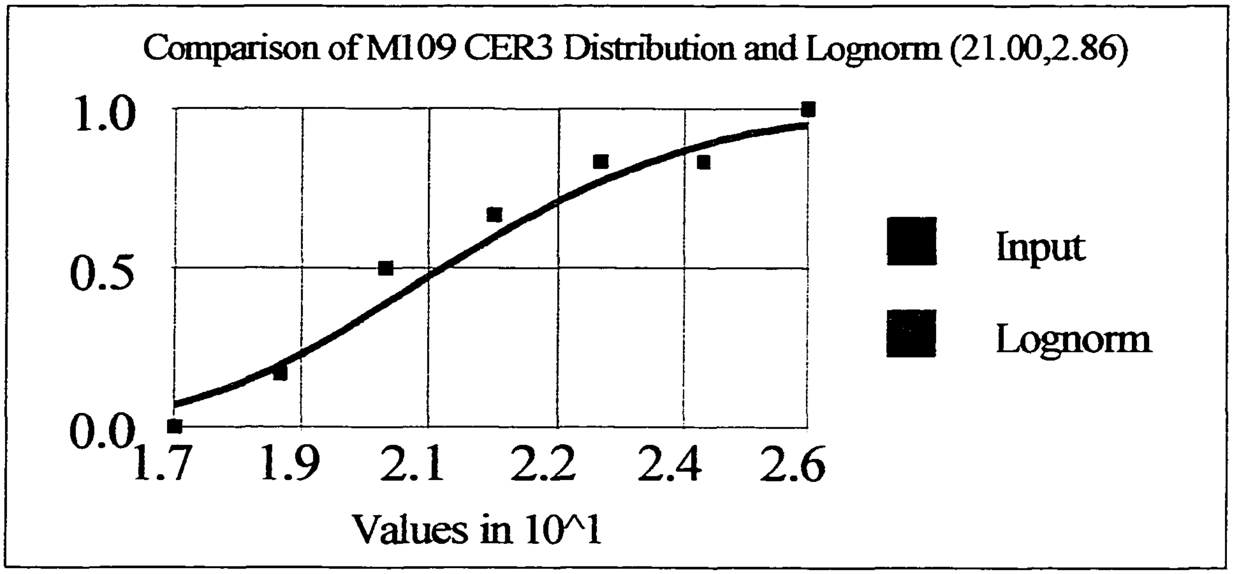


FIGURE D9. M109 CER3 CDF

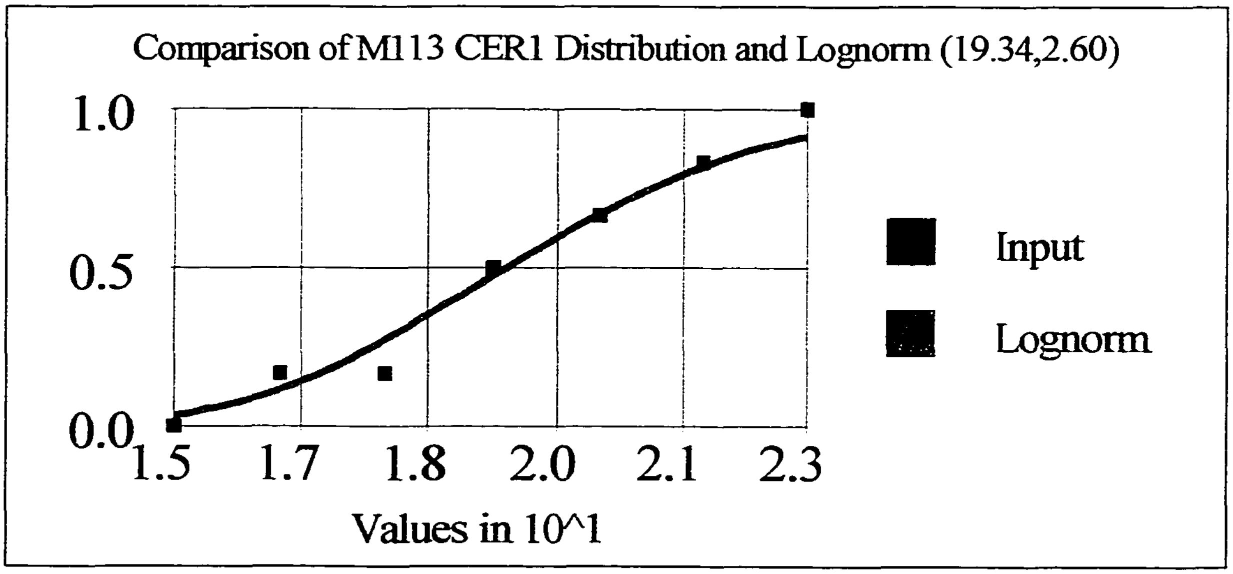


FIGURE D10. M113 CER1 CDF

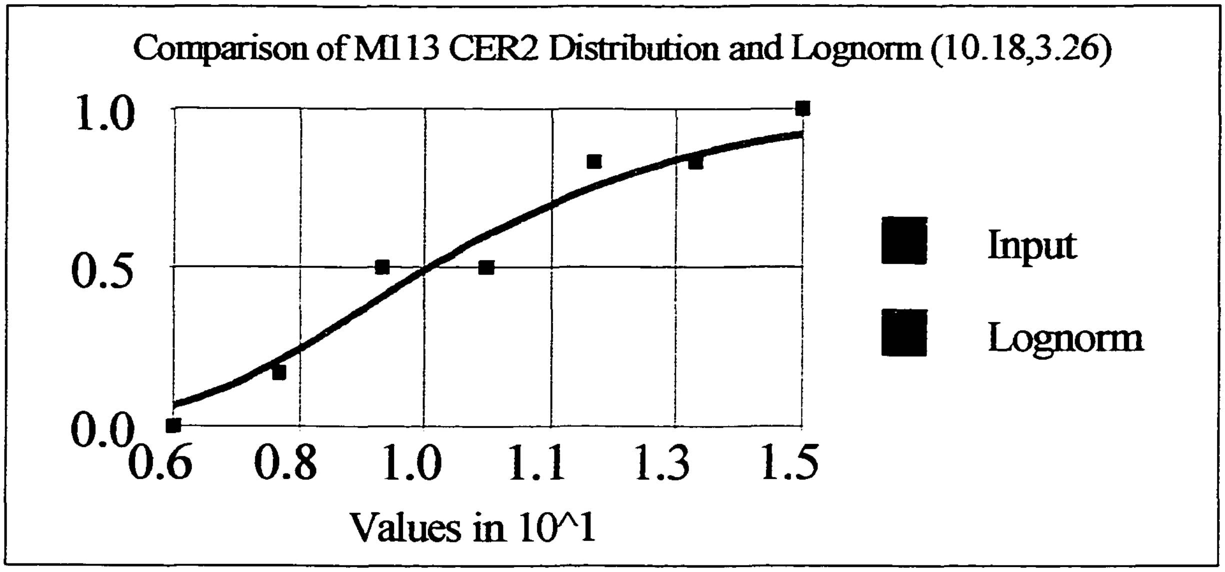


FIGURE D11. M113 CER2 CDF

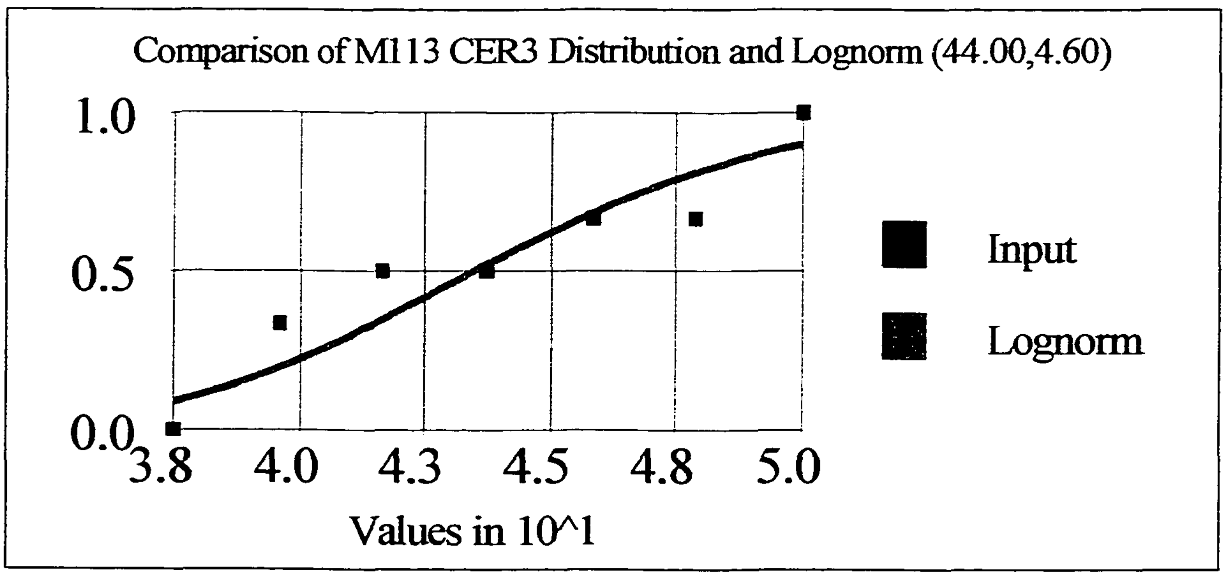


FIGURE D12. M113 CER3 CDF

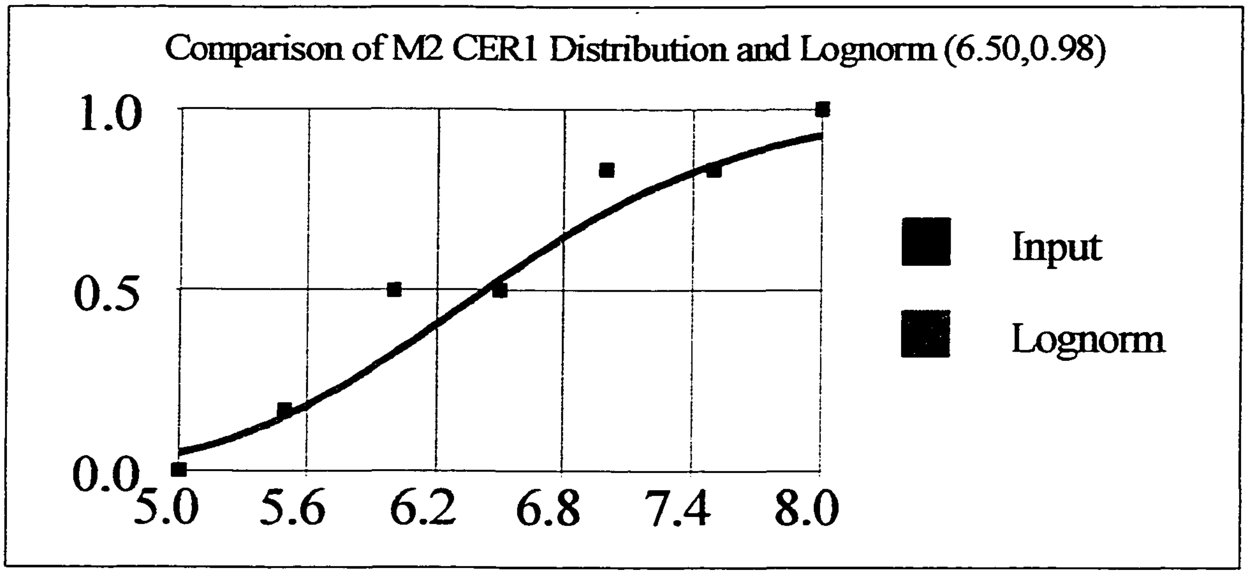


FIGURE D13. M2 BFV CER1 CDF

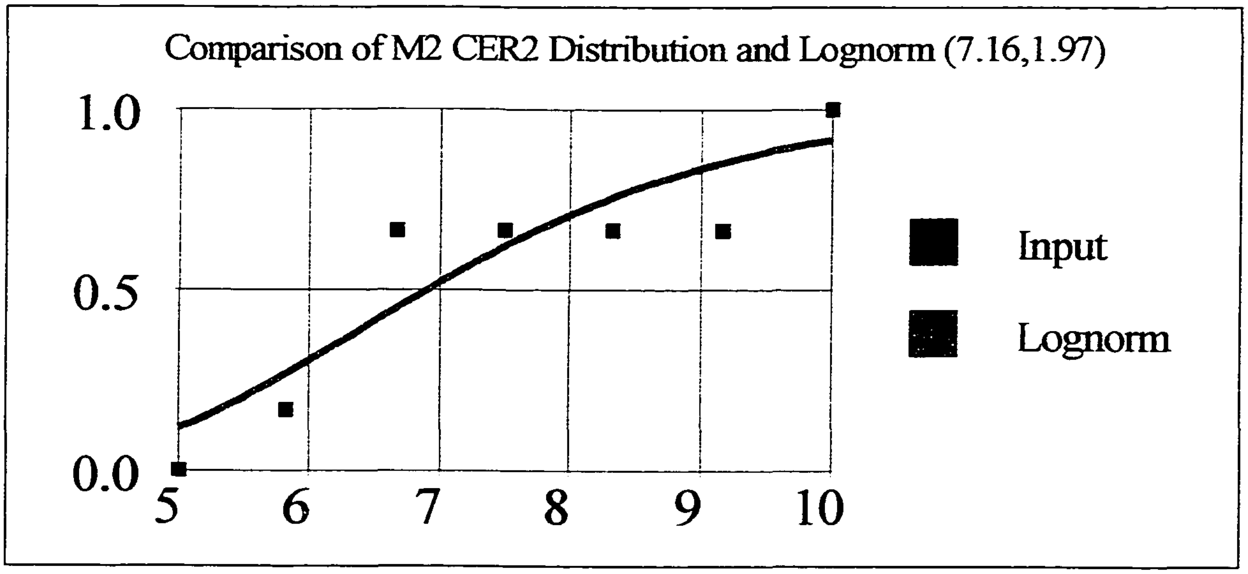


FIGURE D14. M2 BFV CER2 CDF

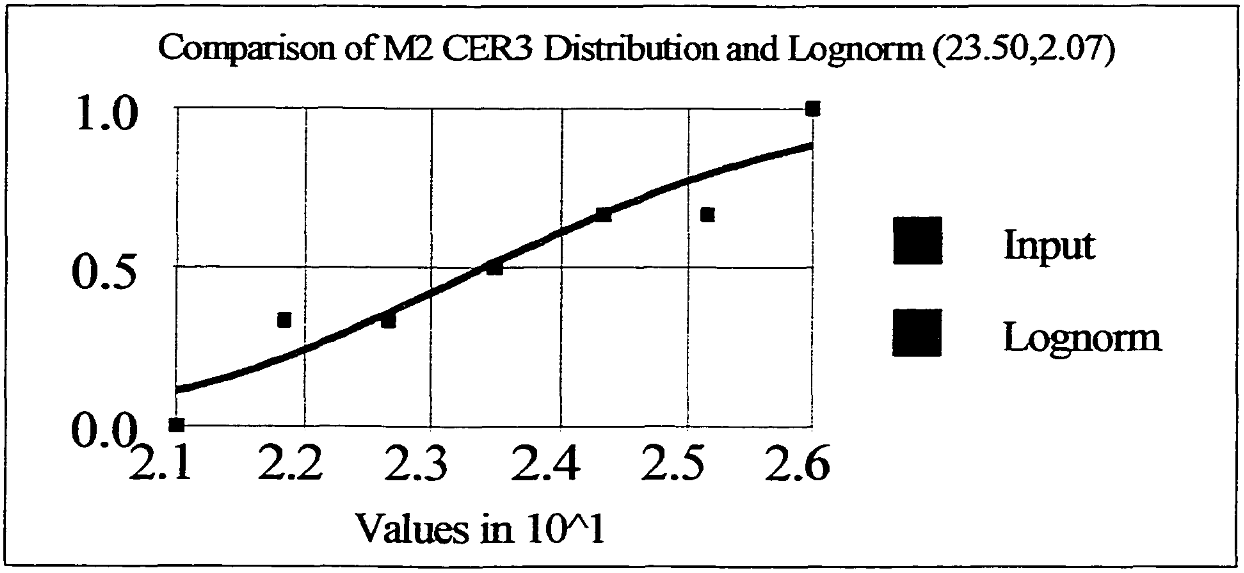


FIGURE D15. M2 BFV CER3 CDF

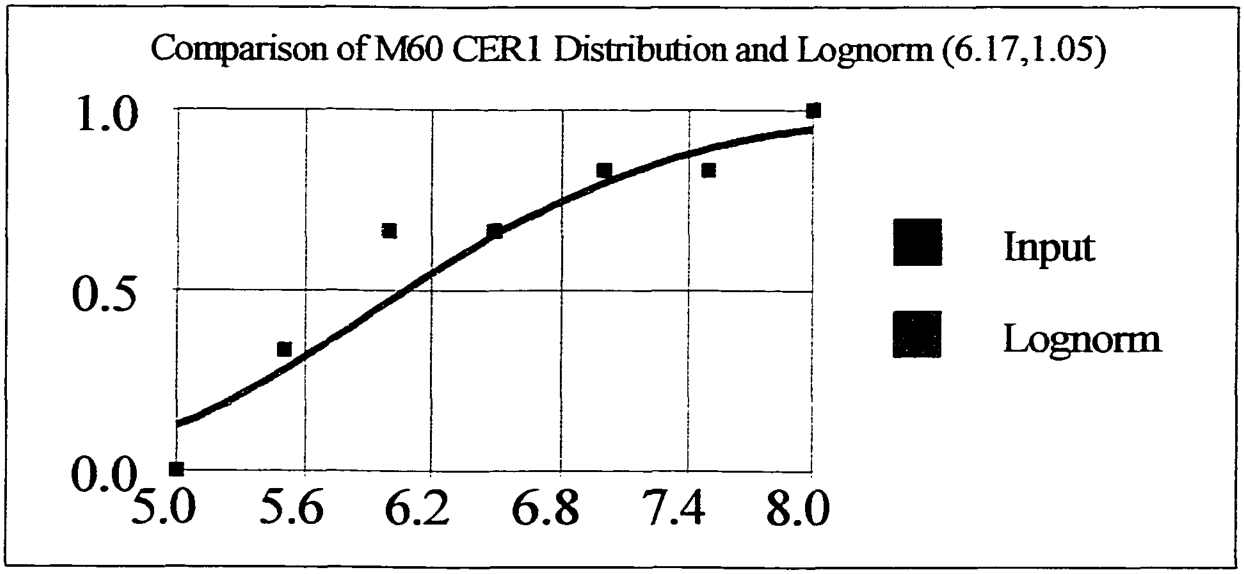


FIGURE D16. M60 CER1 CDF

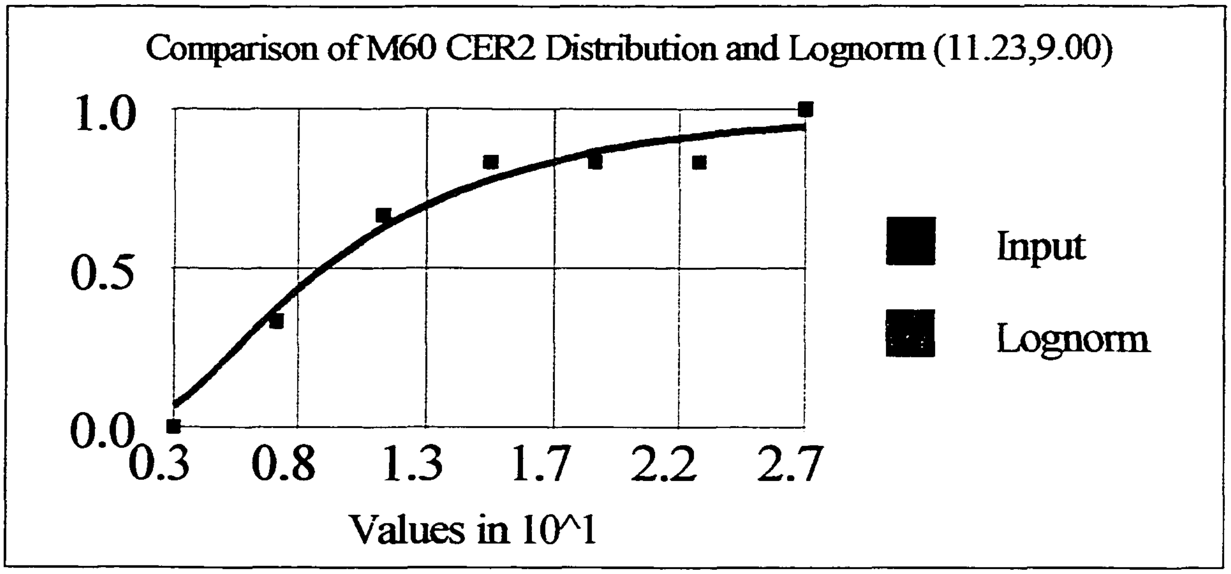


FIGURE D17. M60 CER2 CDF

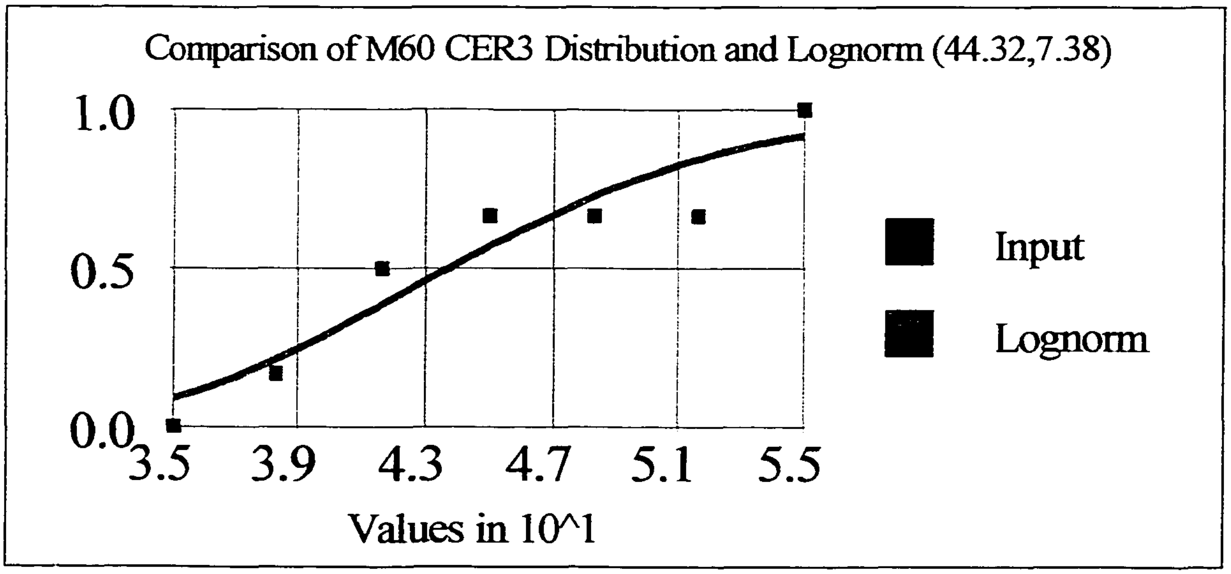


FIGURE D18. M60 CER3 CDF

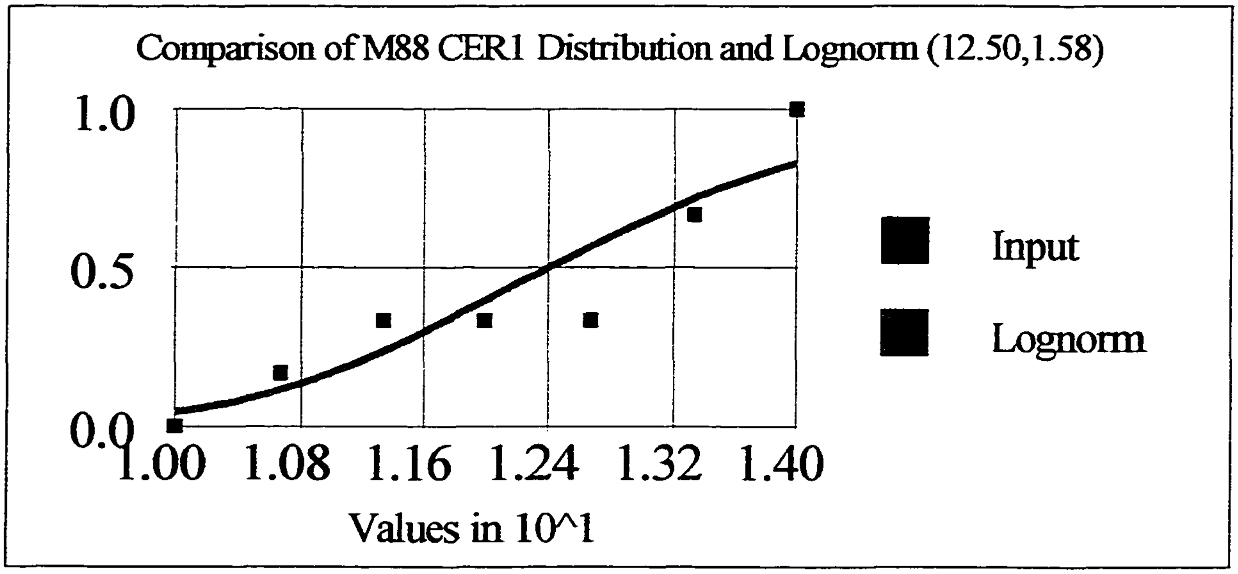


FIGURE D19. M88 CER1 CDF

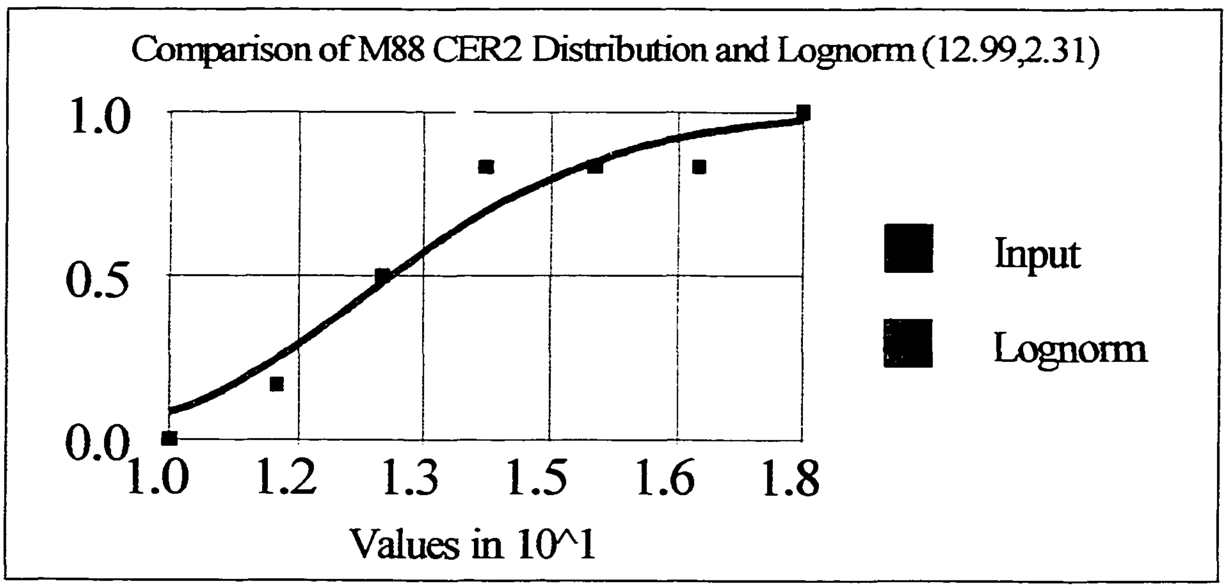


FIGURE D20. M88 CER2 CDF

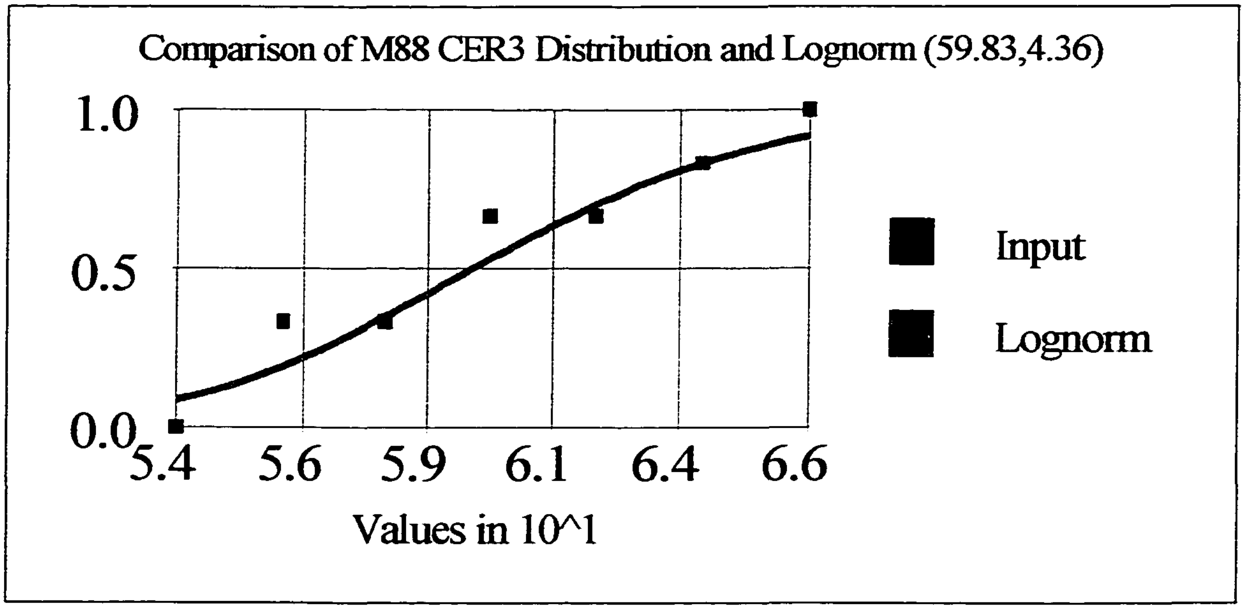


FIGURE D21. M88 CER3 CDF

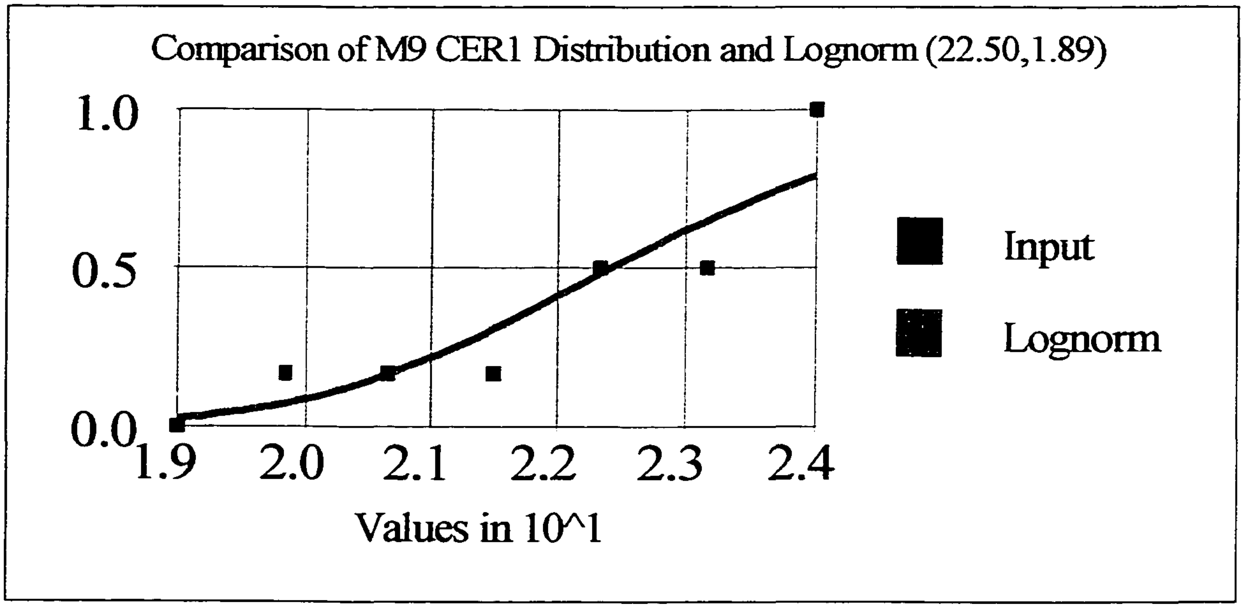


FIGURE D22. M9 ACE CER3 CDF

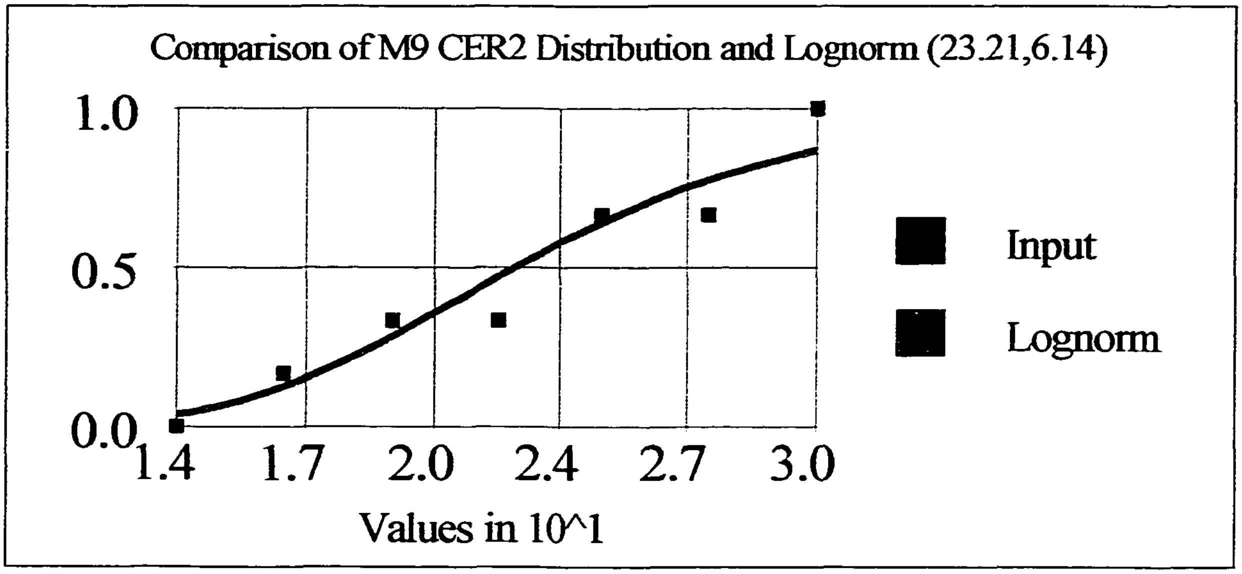


FIGURE D23. M9 ACE CER2 CDF

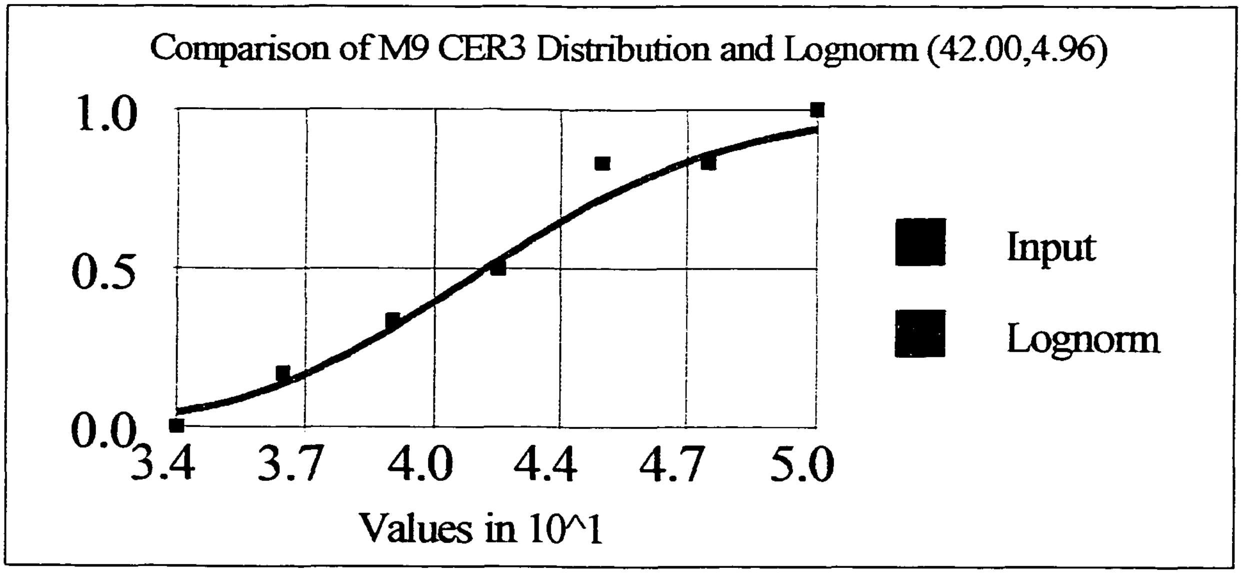


FIGURE D24. M9 ACE CER2 CDF

APPENDIX E

Cost Estimating Percentages Distribution Data

The following distribution data was used to calculate the cost risk variables CRF1, CRF2, and CRF3. The data shows the basic statistics for the empirical distributions for CER1, CER2, and CER3. It also shows Kolmogorov-Smirnov comparison test results and the values of the 10^{th} through the 95^{th} percentiles.

TABLE E1. DISTRIBUTION STATISTICS

	CER1		CER2		CER3	
	Input Distribution	Lognorm	Input Distribution	Lognorm	Input Distribution	Lognorm
Parameter 1		12.777		12.183		41.648
Parameter 2		6.516		7.445		16.954
Parameter 3						
Formula						
Minimum	5		3		17	
Maximum	24		30		66	
Mean	12.738	12.777	12.119	12.183	41.381	41.648
Mode	6.583	9.033	7.050	7.568	53.750	33.091
Median	11.000	11.382	10.000	10.395	42.000	38.575
Standard Deviation	6.037	6.516	6.869	7.445	14.476	16.954
Variance	36.442	42.461	47.181	55.432	209.559	287.438
Skewness	0.766	1.663	1.410	2.062	-0.221	1.289
Kurtosis	1.965	8.287	3.245	11.400	1.720	6.091
Histogram						
Minimum	5	5	3	3	17	17
Maximum	24	24	30	30	66	66
P1	12	8.766	4	5.585	9	5.042
P2	10	10.747	13	8.982	3	9.307
P3	6	8.253	4	8.183	8	9.311
P4	3	5.298	7	6.128	7	7.000
P5	4	3.155	5	4.239	10	4.541
P6	7	1.823	4	2.839	5	2.719
#Classes	6		0	1.880	6	
Interval Width	3.167		2.000	1.244	8.167	
Results						
Kolmogorov-Smirnov						
Test Value		0.095		11.257		0.156
Confidence		>0.15 *		>0.25		>0.15 *
Kolmogorov-Smirnov						
Adjusted Value		0.627		0.666		1.032
Critical Value @ .15		1.138		1.138		1.138
Critical Value @ .1		1.224		1.933		1.224
Critical Value @ .05		1.358		2.492		1.358
Critical Value @ .025		1.480		3.070		1.480
Critical Value @ .01		1.628		3.857		1.628
Targets						
#1 Value	6.000	6.146	5.200	5.050	21.000	23.354
#1 Percentile%	10%	10%	10%	10%	10%	10%
#2 Value	7.000	7.594	6.000	6.470	23.400	27.744
#2 Percentile%	20%	20%	20%	20%	20%	20%
#3 Value	8.600	8.845	7.000	7.736	30.800	31.414
#3 Percentile%	30%	30%	30%	30%	30%	30%
#4 Value	10.000	10.077	8.000	9.012	39.800	34.932

TABLE E1. CONTINUED

	CER1		CER2		CER3	
	Input Distribution	Lognorm	Input Distribution	Lognorm	Input Distribution	Lognorm
#4 Percentile%	40%	40%	40%	40%	40%	40%
#5 Value	11.000	11.382	10.000	10.395	42.000	38.575
#5 Percentile%	50%	50%	50%	50%	50%	50%
#6 Value	13.000	12.857	12.000	11.990	46.000	42.598
#6 Percentile%	60%	60%	60%	60%	60%	60%
#7 Value	15.000	14.646	14.000	13.968	51.600	47.367
#7 Percentile%	70%	70%	70%	70%	70%	70%
#8 Value	19.000	17.060	16.600	16.701	55.000	53.632
#8 Percentile%	80%	80%	80%	80%	80%	80%
#9 Value	22.000	21.078	22.200	21.397	59.400	63.714
#9 Percentile%	90%	90%	90%	90%	90%	90%
#10 Value	23.900	25.101	26.700	26.257	61.800	73.455
#10 Percentile%	95%	95%	95%	95%	95%	95%

Vehicle	**Var (CER1)**	**Var (CER2)**	**Var (CER3)**
AVLB	1.97	4.71	4.94
M109	1.97	4.71	4.94
M113	2.60	3.26	4.60
M2BFV	0.98	1.97	2.07
M60A3	1.05	9.00	7.38
M88A1	1.58	2.31	4.36
M9ACE	1.89	6.14	4.96
TOTAL	77.39		
MEAN	3.69		
STDEV	2.15		

APPENDIX F

Correlation Analysis

The correlation analysis is located in the following pages. The analysis was performed in sequence to allow that analyst to eliminate one variable at a time. The purpose of the correlation analysis was to eliminate variables that could cause multicollinearity problems and screen out potentially poor predictor variables.

TABLE F1. CORRELATION ANALYSIS 1

Correlation 1	*HP/WT*	*Fuel*	*Activity*	*Range*	*Armor*	*Thrmal Sight*	*Crew*	*CRF1*	*CRF2*	*CRF3*	*Mission*	*Cost*
HP/WT	1.00											
Fuel	-0.62	1.00										
Activity	-0.05	-0.36	1.00									
Range	0.34	0.42	-0.60	1.00								
Armor	-0.79	0.84	-0.26	0.23	1.00							
Thrml Sight	-0.16	0.44	-0.17	0.37	0.42	1.00						
Crew	-0.40	0.18	0.12	-0.11	0.55	0.48	1.00					
CRF1	-0.11	-0.08	0.04	-0.21	0.04	-0.05	0.17	1.00				
CRF2	-0.21	0.14	-0.22	0.03	0.18	0.17	0.13	0.01	1.00			
CRF3	-0.36	-0.39	0.43	-0.81	0.03	-0.22	0.50	0.22	-0.07	1.00		
Mission	-0.33	0.17	0.05	-0.06	0.36	0.86	0.55	0.07	0.18	0.19	1.00	
Cost	-0.25	0.19	0.62	-0.34	0.05	-0.18	-0.12	0.11	-0.40	0.02	-0.17	1.00

ELIMINATE ARMOR

TABLE F2. CORRELATION ANALYSIS 2

Correlation 2	*HP/WT*	*Fuel*	*Activity*	*Range*	*Thrml Sight*	*Crew*	*CRF1*	*CRF2*	*CRF3*	*Mission*	*Cost*
HP/WT	1.00										
Fuel	-0.62	1.00									
Activity	-0.05	-0.36	1.00								
Range	0.34	0.42	-0.60	1.00							
Thrml Sight	-0.16	0.44	-0.17	0.37	1.00						
Crew	-0.40	0.18	0.12	-0.11	0.48	1.00					
CRF1	-0.11	-0.08	0.04	-0.21	-0.05	0.17	1.00				
CRF2	-0.21	0.14	-0.22	0.03	0.17	0.13	0.01	1.00			
CRF3	-0.36	-0.39	0.43	-0.81	-0.22	0.50	0.22	-0.07	1.00		
Mission	-0.33	0.17	0.05	-0.06	0.86	0.55	0.07	0.18	0.19	1.00	
Cost	-0.25	0.19	0.62	-0.34	-0.18	-0.12	0.11	-0.40	0.02	-0.17	1.00

ELIMINATE THERMAL SIGHT

TABLE F3. CORRELATION ANALYSIS 3

Correlation 3	*HP/WT*	*Fuel*	*Activity*	*Range*	*Crew*	*CRF1*	*CRF2*	*CRF3*	*Mission*	*Cost*
HP/WT	1.00									
Fuel	-0.62	1.00								
Activity	-0.05	-0.36	1.00							
Range	0.34	0.42	-0.60	1.00						
Crew	-0.40	0.18	0.12	-0.11	1.00					
CRF1	-0.11	-0.08	0.04	-0.21	0.17	1.00				
CRF2	-0.21	0.14	-0.22	0.03	0.13	0.01	1.00			
CRF3	-0.36	-0.39	0.43	-0.81	0.50	0.22	-0.07	1.00		
Mission	-0.33	0.17	0.05	-0.06	0.55	0.07	0.18	0.19	1.00	
Cost	-0.25	0.19	0.62	-0.34	-0.12	0.11	-0.40	0.02	-0.17	1.00

ELIMINATE CREW

TABLE F4. CORRELATION ANALYSIS 4

Correlation 4	*HP/WT*	*Fuel Consumption*	*Activity*	*Range*	*CRF1*	*CRF2*	*CRF3*	*Mission*	*Cost*
Horsepower/WT	1.00								
Fuel Consumption	-0.62	1.00							
Activity	-0.05	-0.36	1.00						
Range	0.34	0.42	-0.60	1.00					
CRF1	-0.11	-0.08	0.04	-0.21	1.00				
CRF2	-0.21	0.14	-0.22	0.03	0.01	1.00			
CRF3	-0.36	-0.39	0.43	-0.81	0.22	-0.07	1.00		
Mission	-0.33	0.17	0.05	-0.06	0.07	0.18	0.19	1.00	
Cost	-0.25	0.19	0.62	-0.34	0.11	-0.40	0.02	-0.17	1.00

ELMINATE MISSION

TABLE F5. CORRELATION ANALYSIS 5

Correlation 5	*HP/WT*	*Fuel Consumption*	*Activity*	*Range*	*CRF1*	*CRF2*	*CRF3*	*Cost*
Horsepower/WT	1.00							
Fuel Consumption	-0.62	1.00						
Activity	-0.05	-0.36	1.00					
Range	0.34	0.42	-0.60	1.00				
CRF1	-0.11	-0.08	0.04	-0.21	1.00			
CRF2	-0.21	0.14	-0.22	0.03	0.01	1.00		
CRF3	-0.36	-0.39	0.43	-0.81	0.22	-0.07	1.00	
Cost	-0.25	0.19	0.62	-0.34	0.11	-0.40	0.02	1.00

COMBINE CRF2 AND CRF3

TABLE F6. CORRELATION ANALYSIS 6

Correlation 6	*HP/WT*	*Fuel Consumption*	*Activity*	*Range*	*CRF1*	*CRF2/3*	*Cost*
Horsepower/WT	1.00						
Fuel Consumption	-0.62	1.00					
Activity	-0.05	-0.36	1.00				
Range	0.34	0.42	-0.60	1.00			
CRF1	-0.11	-0.08	0.04	-0.21	1.00		
CRF2/3	-0.37	-0.08	0.03	-0.40	0.13	1.00	
Cost	-0.25	0.19	0.62	-0.34	0.11	-0.35	1.00

ELIMINATE CRF1

APPENDIX G

Model Data

TABLE G1. ORIGINAL MODEL DATA

Obs	Year	Horsepower/WT	Fuel Consumption	Activity	Range	Armor	Thermal Sight	Crew	CRF1	CRF2	CRF3	Mission	Cost
1	1994	12.93	62.69	246	290	1	0	2	1.17	1.48	0.95	0	20,297.59
2	1995	12.93	62.96	220	290	1	0	2	1.06	1.18	1.05	0	19,317.18
3	1996	12.93	62.76	294	290	1	0	2	1.30	1.11	1.04	0	18,868.58
4	1997	12.93	62.59	263	290	1	0	2	0.90	1.04	1.28	0	13,284.05
5	1998	12.93	60.72	206	290	1	0	2	0.78	2.54	1.09	0	13,544.57
6	1999	12.93	62.79	196	290	1	0	2	0.97	0.99	1.07	0	16,655.51
7	1994	13.84	31.11	540	186	1	0	4	1.30	5.92	2.57	1	4,722.38
8	1995	13.84	31.11	540	186	1	0	4	1.17	0.34	3.47	1	9,734.54
9	1996	13.84	31.11	540	186	1	0	4	1.17	0.34	2.95	1	15,179.76
10	1997	13.84	31.11	540	186	1	0	4	0.78	0.39	3.11	1	14,937.99
11	1998	13.84	30.36	712	186	1	0	4	1.17	0.34	2.27	1	32,835.00
12	1999	13.84	31.74	632	186	1	0	4	1.30	0.45	2.81	1	26,869.05
13	1994	20.22	23.65	244	300	1	0	2	0.97	2.10	0.96	0	3,519.31
14	1995	20.22	23.68	311	300	1	0	2	0.84	1.58	1.04	0	2,668.15
15	1996	20.22	23.74	291	300	1	0	2	1.02	1.58	0.98	0	2,498.73
16	1997	20.22	23.79	319	300	1	0	2	0.92	1.05	1.26	0	2,018.83
17	1998	20.22	23.22	311	300	1	0	2	1.08	1.05	1.17	0	2,026.33
18	1999	20.22	23.84	333	300	1	0	2	1.29	0.84	1.19	0	3,085.52
19	1994	17.91	48.36	414	300	1	1	3	1.30	1.19	0.98	1	23,091.48
20	1995	17.91	48.51	398	300	1	1	3	0.93	1.19	1.11	1	15,485.90
21	1996	17.91	48.01	342	300	1	1	3	0.81	0.72	0.89	1	14,236.70
22	1997	17.91	48.09	345	300	1	1	3	0.93	1.19	0.89	1	11,588.66
23	1998	17.91	46.93	277	300	1	1	3	1.08	0.72	1.11	1	10,361.86
24	1999	17.91	48.15	291	300	1	1	3	1.08	1.43	0.98	1	9,236.63
25	1994	12.50	62.69	146	290	0	1	4	1.03	1.13	1.51	1	2,908.86
26	1995	12.50	62.96	88	290	0	1	4	0.88	3.17	1.32	1	1,882.17
27	1996	12.50	62.76	150	290	0	1	4	1.03	5.29	1.32	1	1,401.06
28	1997	12.50	62.59	80	290	0	1	4	1.23	1.98	0.96	1	2,909.85
29	1998	12.50	60.72	987	290	0	1	4	0.77	1.59	0.98	1	29,524.56
30	1999	12.50	62.79	371	290	0	1	4	1.23	0.59	1.26	1	19,957.96
31	1994	17.50	52.00	312	300	0	0	3	1.14	1.30	0.91	0	23,827.39
32	1995	17.50	52.00	405	300	0	0	3	0.96	1.00	1.00	0	19,764.71
33	1996	17.50	52.00	357	300	0	0	3	1.25	1.08	0.93	0	16,892.78
34	1997	17.50	52.00	364	300	0	0	3	0.89	1.00	1.09	0	14,774.65
35	1998	17.50	50.43	309	300	0	0	3	0.89	1.08	1.00	0	17,010.10
36	1999	17.50	52.00	285	300	0	0	3	0.96	0.72	1.11	0	15,414.03
37	1994	16.39	40.38	489	230	0	0	1	1.02	2.00	0.92	0	23,793.76
38	1995	16.39	40.56	507	230	0	0	1	0.94	1.16	1.18	0	23,373.71
39	1996	16.39	40.26	546	230	0	0	1	1.18	0.93	1.10	0	27,770.89
40	1997	16.39	40.37	454	230	0	0	1	0.94	0.96	1.35	0	16,961.98
41	1998	16.39	39.04	424	230	0	0	1	0.94	1.47	1.05	0	16,892.80
42	1999	16.39	40.47	406	230	0	0	1	1.02	1.21	1.07	0	22,361.69

TABLE G2. FINAL MODEL DATA

Year Vehicle	Horsepower/WT (HP/ton)	Fuel Consumption (Gal/hr)	Activity (Miles/yr)	Range (Miles)	CRF	Cost (Per/sys)
1994 AVLB	12.93	62.69	246	290	1.22	20,297.59
1995 AVLB	12.93	62.96	220	290	1.12	19,317.18
1996 AVLB	12.93	62.76	294	290	1.07	18,868.58
1997 AVLB	12.93	62.59	263	290	1.16	13,284.05
1998 AVLB	12.93	60.72	206	290	1.81	13,544.57
1999 AVLB	12.93	62.79	196	290	1.03	16,655.51
1994 M109A6	13.84	31.11	540	186	4.24	4,722.38
1995 M109A6	13.84	31.11	540	186	1.91	9,734.54
1996 M109A6	13.84	31.11	540	186	1.65	15,179.76
1997 M109A6	13.84	31.11	540	186	1.75	14,937.99
1998 M109A6	13.84	30.36	712	186	1.30	32,835.00
1999 M109A6	13.84	31.74	632	186	1.63	26,869.05
1994 M113A3	20.22	23.65	244	300	1.53	3,519.31
1995 M113A3	20.22	23.68	311	300	1.31	2,668.15
1996 M113A3	20.22	23.74	291	300	1.28	2,498.73
1997 M113A3	20.22	23.79	319	300	1.15	2,018.83
1998 M113A3	20.22	23.22	311	300	1.11	2,026.33
1999 M113A3	20.22	23.84	333	300	1.02	3,085.52
1994 M2 BFV	17.91	48.36	414	300	1.09	23,091.48
1995 M2 BFV	17.91	48.51	398	300	1.15	15,485.90
1996 M2 BFV	17.91	48.01	342	300	0.80	14,236.70
1997 M2 BFV	17.91	48.09	345	300	1.04	11,588.66
1998 M2 BFV	17.91	46.93	277	300	0.91	10,361.86
1999 M2 BFV	17.91	48.15	291	300	1.21	9,236.63
1994 M60A3	12.50	62.69	146	290	1.32	2,908.86
1995 M60A3	12.50	62.96	88	290	2.25	1,882.17
1996 M60A3	12.50	62.76	150	290	3.30	1,401.06
1997 M60A3	12.50	62.59	80	290	1.47	2,909.85
1998 M60A3	12.50	60.72	987	290	1.28	29,524.56
1999 M60A3	12.50	62.79	371	290	0.92	19,957.96
1994 M88A1	17.50	52.00	312	300	1.10	23,827.39
1995 M88A1	17.50	52.00	405	300	1.00	19,764.71
1996 M88A1	17.50	52.00	357	300	1.01	16,892.78
1997 M88A1	17.50	52.00	364	300	1.04	14,774.65
1998 M88A1	17.50	50.43	309	300	1.04	17,010.10
1999 M88A1	17.50	52.00	285	300	0.91	15,414.03
1994 M9 ACE	16.39	40.38	489	230	1.46	23,793.76
1995 M9 ACE	16.39	40.56	507	230	1.17	23,373.71
1996 M9 ACE	16.39	40.26	546	230	1.01	27,770.89
1997 M9 ACE	16.39	40.37	454	230	1.16	16,961.98
1998 M9 ACE	16.39	39.04	424	230	1.26	16,892.80
1999 M9 ACE	16.39	40.47	406	230	1.14	22,361.69

APPENDIX H

Original Model

TABLE H1. ORIGINAL MODEL

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.90
R Square	0.81
Adjusted R Square	0.78
Standard Error	4,054.76
Observations	42.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5.00	2.47E+09	4.94E+08	30.05	0.000
Residual	36.00	5.92E+08	1.64E+07		
Total	41.00	3.06E+09			

	Coefficients	*Std Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-619.69	11,393.51	-0.05	0.96	-23,726.77	22,487.40
Horsepower/WT	1,529.99	607.71	2.52	0.02	297.49	2,762.49
Fuel Consumption	601.29	118.38	5.08	0.00	361.19	841.39
Activity	29.21	4.90	5.96	0.00	19.28	39.15
Range	-148.27	34.22	-4.33	0.00	-217.68	-78.87
CRF	-5,414.14	1,244.33	-4.35	0.00	-7,937.77	-2,890.52

RESIDUAL OUTPUT

Observation	*Predicted Cost*	*Residuals*	*Std Residuals*
1.00	14,463.95	5,833.64	1.54
2.00	14,377.45	4,939.73	1.30
3.00	16,686.71	2,181.87	0.57
4.00	15,186.52	-1,902.47	-0.50
5.00	8,876.29	4,668.28	1.23
6.00	14,079.49	2,576.02	0.68
7.00	4,496.33	226.05	0.06
8.00	17,144.29	-7,409.75	-1.95
9.00	18,555.23	-3,375.47	-0.89
10.00	17,981.92	-3,043.93	-0.80
11.00	24,954.05	7,880.95	2.07
12.00	21,697.15	5,171.90	1.36
13.00	-1,079.66	4,598.97	1.21
14.00	2,064.79	603.36	0.16
15.00	1,715.42	783.31	0.21
16.00	3,209.60	-1,190.77	-0.31
17.00	2,890.12	-863.79	-0.23
18.00	4,385.19	-1,299.67	-0.34
19.00	17,588.90	5,502.58	1.45

PROBABILITY

Percentile	*Cost*
1.19	1,401.06
3.57	1,882.17
5.95	2,018.83
8.33	2,026.33
10.71	2,498.73
13.10	2,668.15
15.48	2,908.86
17.86	2,909.85
20.24	3,085.52
22.62	3,519.31
25.00	4,722.38
27.38	9,236.63
29.76	9,734.54
32.14	10,361.86
34.52	11,588.66
36.90	13,284.05
39.29	13,544.57
41.67	14,236.70
44.05	14,774.65

TABLE H1. CONTINUED

RESIDUAL OUTPUT

Observation	*Predicted Cost*	*Residuals*	*Std Residuals*
20.00	16,868.63	-1,382.73	-0.36
21.00	16,803.88	-2,567.18	-0.68
22.00	15,641.89	-4,053.23	-1.07
23.00	13,670.76	-3,308.90	-0.87
24.00	13,234.89	-3,998.26	-1.05
25.00	10,327.07	-7,418.21	-1.95
26.00	3,786.19	-1,904.02	-0.50
27.00	-243.26	1,644.32	0.43
28.00	7,503.89	-4,594.04	-1.21
29.00	33,911.92	-4,387.36	-1.15
30.00	19,108.72	849.24	0.22
31.00	16,074.14	7,753.25	2.04
32.00	19,367.57	397.14	0.10
33.00	17,904.56	-1,011.78	-0.27
34.00	17,913.41	-3,138.76	-0.83
35.00	15,408.20	1,601.90	0.42
36.00	16,317.05	-903.02	-0.24
37.00	21,031.76	2,762.00	0.73
38.00	23,194.65	179.06	0.05
39.00	25,015.52	2,755.37	0.73
40.00	21,607.24	-4,645.26	-1.22
41.00	19,397.03	-2,504.23	-0.66
42.00	20,367.79	1,993.90	0.52
Residuals Sum		0.00	0.00

PROBABILITY

Percentile	*Cost*
46.43	14,937.99
48.81	15,179.76
51.19	15,414.03
53.57	15,485.90
55.95	16,655.51
58.33	16,892.78
60.71	16,892.80
63.10	16,961.98
65.48	17,010.10
67.86	18,868.58
70.24	19,317.18
72.62	19,764.71
75.00	19,957.96
77.38	20,297.59
79.76	22,361.69
82.14	23,091.48
84.52	23,373.71
86.90	23,793.76
89.29	23,827.39
91.67	26,869.05
94.05	27,770.89
96.43	29,524.56
98.81	32,835.00

APPENDIX I

Final Model and Related Graphs

TABLE I1. FINAL MODEL

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.90
R Square	0.81
Adjusted R Square	0.76
Standard Error	3,999.76
Observations	42.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5.00	2.470E+09	4.941E+08	30.88	0.000
Residual	37.00	5.919E+08	1.600E+07		
Total	42.00	3.062E+09			

	Coefficients	*Std Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.00	#N/A	#N/A	#N/A	#N/A	#N/A
Horsepower/WT	1,506.54	422.45	3.57	0.001	650.57	2,362.50
Fuel Consumption	596.97	86.56	6.90	0.000	421.58	772.36
Activity	29.08	4.18	6.95	0.000	20.60	37.55
Range	-148.04	33.50	-4.42	0.000	-215.91	-80.17
CRF	-5,458.86	921.38	-5.92	0.000	-7,325.75	-3,591.97

RESIDUAL OUTPUT

Observation	*Predicted Cost*	*Residuals*	*Std Residuals*
1.00	14,489.21	5,808.38	1.55
2.00	14,409.42	4,907.76	1.31
3.00	16,711.64	2,156.94	0.57
4.00	15,212.24	-1,928.19	-0.51
5.00	8,888.59	4,655.98	1.24
6.00	14,119.27	2,536.24	0.68
7.00	4,438.18	284.20	0.08
8.00	17,190.60	-7,456.06	-1.99
9.00	18,613.19	-3,433.43	-0.91
10.00	18,035.14	-3,097.15	-0.82
11.00	25,007.61	7,827.39	2.09
12.00	21,740.72	5,128.33	1.37
13.00	-1,068.07	4,587.38	1.22
14.00	2,077.33	590.82	0.16
15.00	1,731.67	767.06	0.20
16.00	3,227.39	-1,208.56	-0.32
17.00	2,913.46	-887.13	-0.24
18.00	4,407.01	-1,321.49	-0.35
19.00	17,545.03	5,546.45	1.48

PROBABILITY

Percentile	*Cost*
1.19	1,401.06
3.57	1,882.17
5.95	2,018.83
8.33	2,026.33
10.71	2,498.73
13.10	2,668.15
15.48	2,908.86
17.86	2,909.85
20.24	3,085.52
22.62	3,519.31
25.00	4,722.38
27.38	9,236.63
29.76	9,734.54
32.14	10,361.86
34.52	11,588.66
36.90	13,284.05
39.29	13,544.57
41.67	14,236.70
44.05	14,774.65

TABLE I1. CONTINUED

RESIDUAL OUTPUT

Observation	*Predicted Cost*	*Residuals*	*Std Residuals*
20.00	16,823.40	-1,337.50	-0.36
21.00	16,783.70	-2,547.00	-0.68
22.00	15,610.32	-4,021.66	-1.07
23.00	13,659.21	-3,297.35	-0.88
24.00	13,202.97	-3,966.34	-1.06
25.00	10,371.14	-7,462.28	-1.99
26.00	3,795.45	-1,913.28	-0.51
27.00	-288.72	1,689.78	0.45
28.00	7,550.53	-4,640.68	-1.24
29.00	33,853.95	-4,329.39	-1.15
30.00	19,140.15	817.81	0.22
31.00	16,037.07	7,790.32	2.08
32.00	19,322.71	442.00	0.12
33.00	17,865.67	-972.89	-0.26
34.00	17,872.05	-3,097.40	-0.83
35.00	15,381.01	1,629.09	0.43
36.00	16,291.93	-877.90	-0.23
37.00	21,015.18	2,778.58	0.74
38.00	23,187.76	185.95	0.05
39.00	25,011.80	2,759.09	0.73
40.00	21,608.84	-4,646.86	-1.24
41.00	19,403.92	-2,511.12	-0.67
42.00	20,376.04	1,985.65	0.53
Residuals Sum		-78.49	-0.02

PROBABILITY

Percentile	*Cost*
46.43	14,937.99
48.81	15,179.76
51.19	15,414.03
53.57	15,485.90
55.95	16,655.51
58.33	16,892.78
60.71	16,892.80
63.10	16,961.98
65.48	17,010.10
67.86	18,868.58
70.24	19,317.18
72.62	19,764.71
75.00	19,957.96
77.38	20,297.59
79.76	22,361.69
82.14	23,091.48
84.52	23,373.71
86.90	23,793.76
89.29	23,827.39
91.67	26,869.05
94.05	27,770.89
96.43	29,524.56
98.81	32,835.00

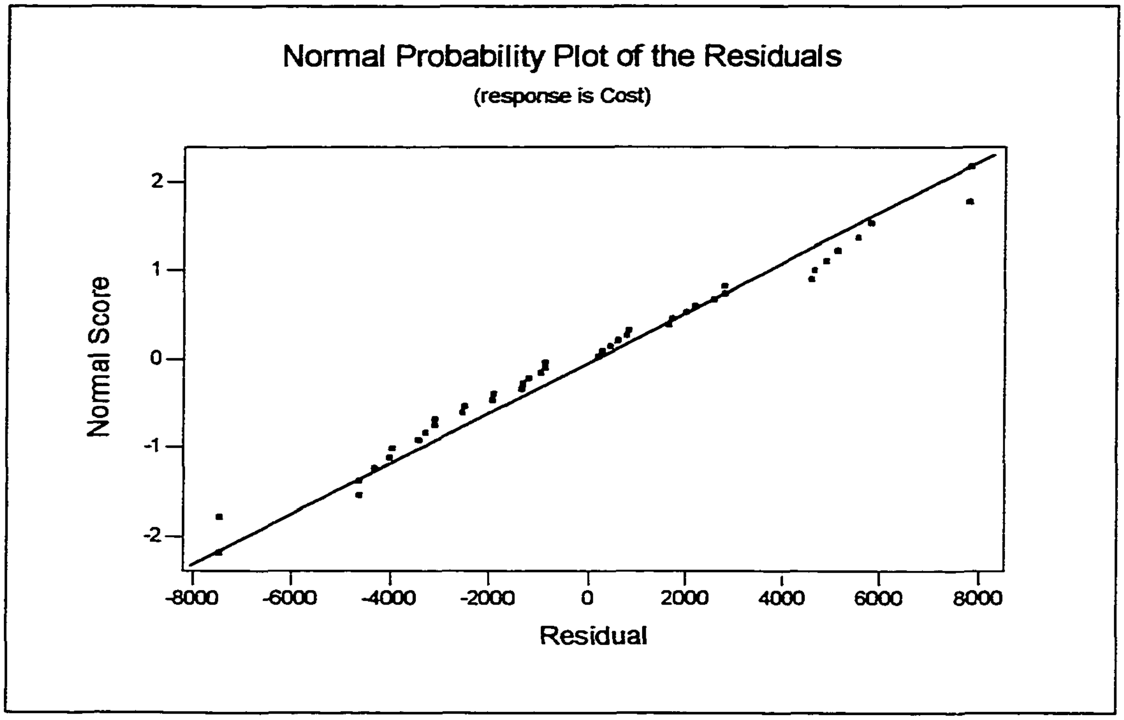
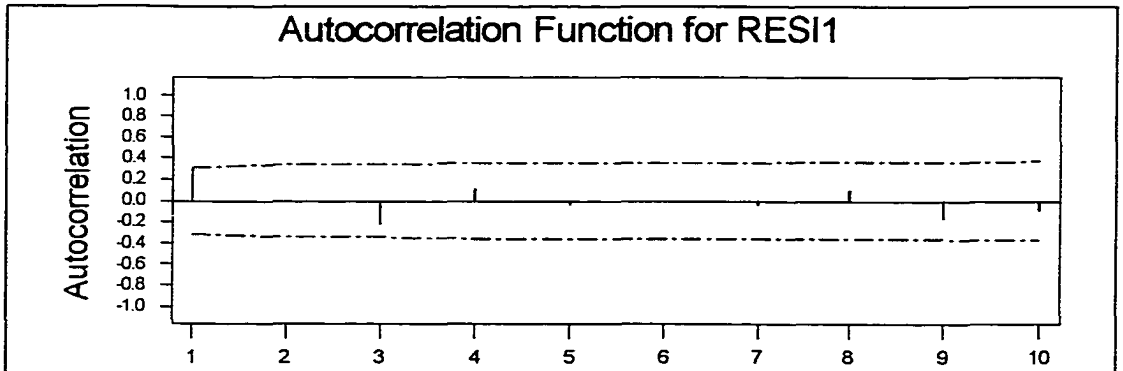


FIGURE I1. NORMALITY PLOT



Lag	Corr	T	LBQ	Lag	Corr	T	LBQ
1	0.32	2.07	4.62	8	0.11	0.61	8.50
2	-0.01	-0.04	4.62	9	-0.17	-0.94	10.11
3	-0.22	-1.32	6.99	10	-0.09	-0.50	10.60
4	0.11	0.64	7.61				
5	-0.05	-0.27	7.72				
6	-0.01	-0.06	7.73				
7	-0.05	-0.26	7.85				

FIGURE I2. AUTOCORRELATIONS

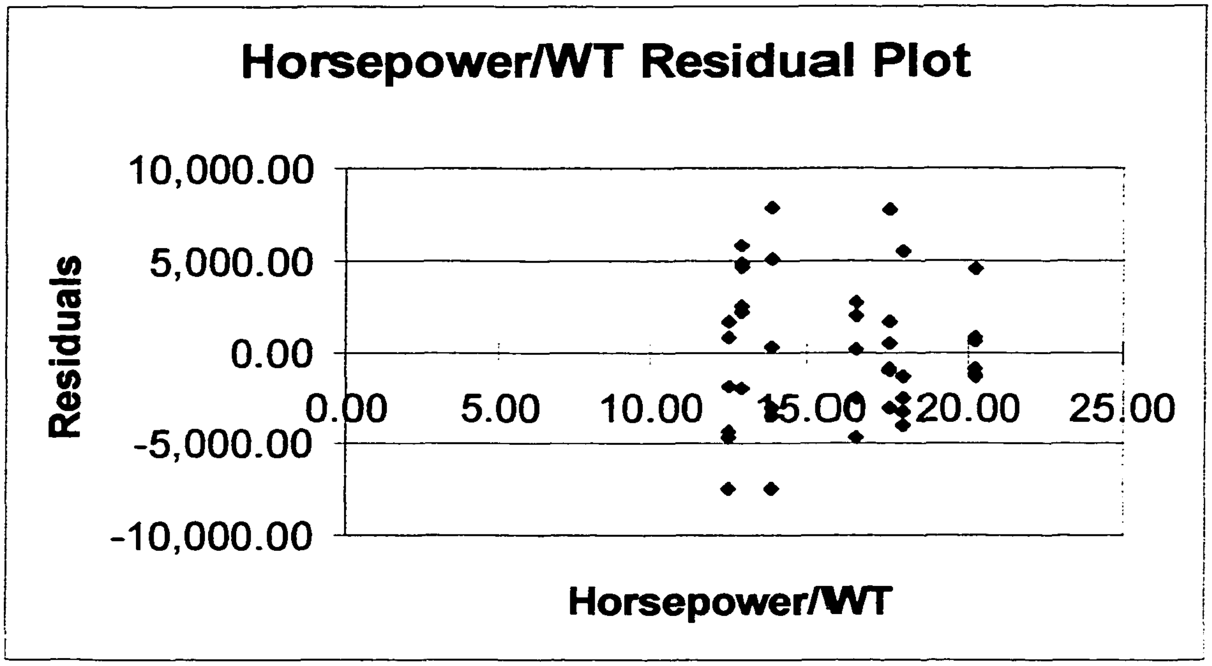
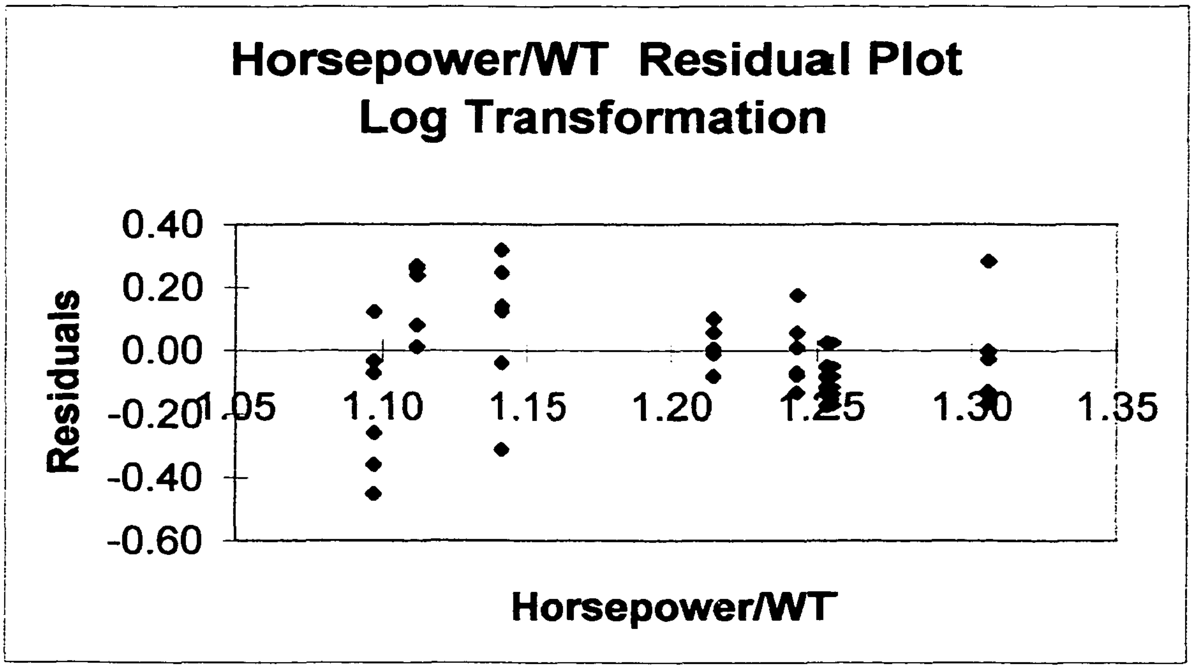


FIGURE I3. HORSEPOWER RESIDUAL



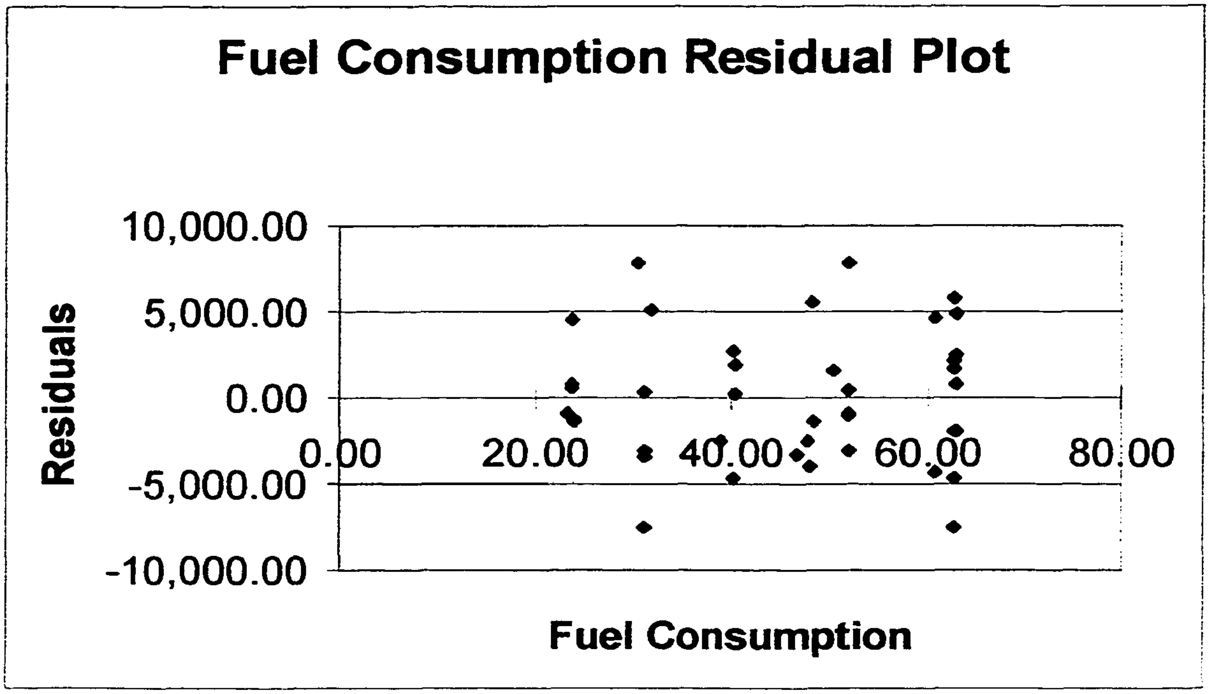


FIGURE I4. FUEL CONSUMPTION RESIDUAL

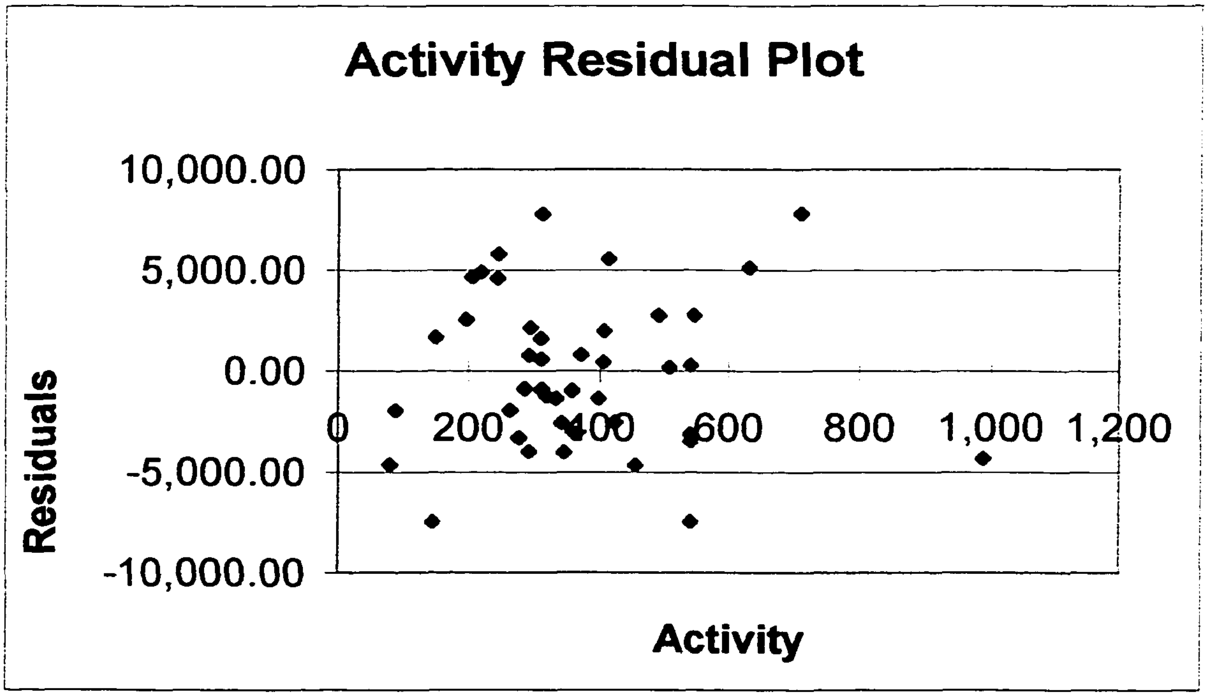


FIGURE I5. ACTIVITY RESIDUAL

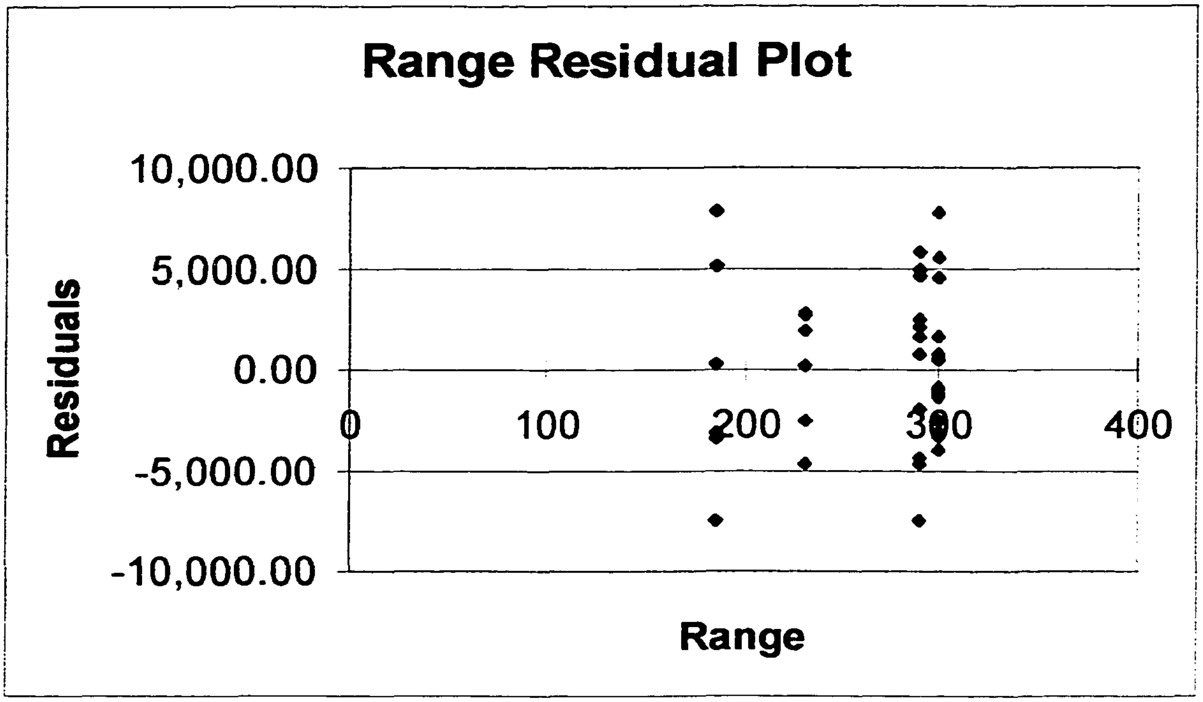


FIGURE I6. RANGE RESIDUAL

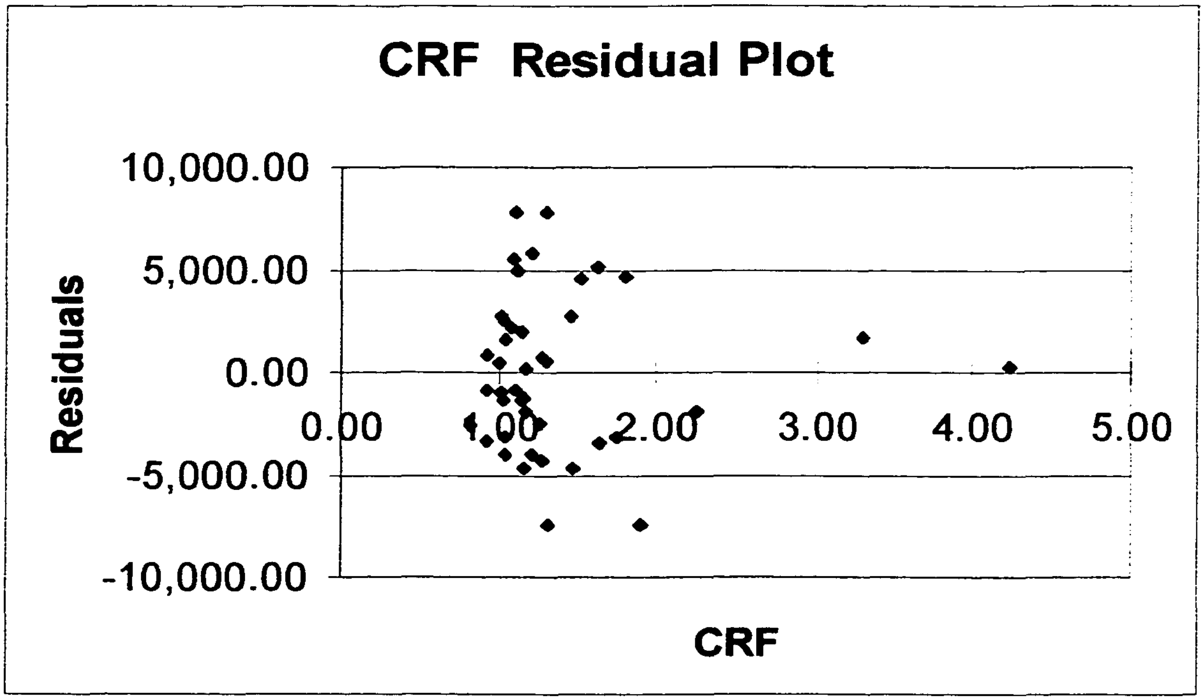


FIGURE I7. CRF RESIDUAL

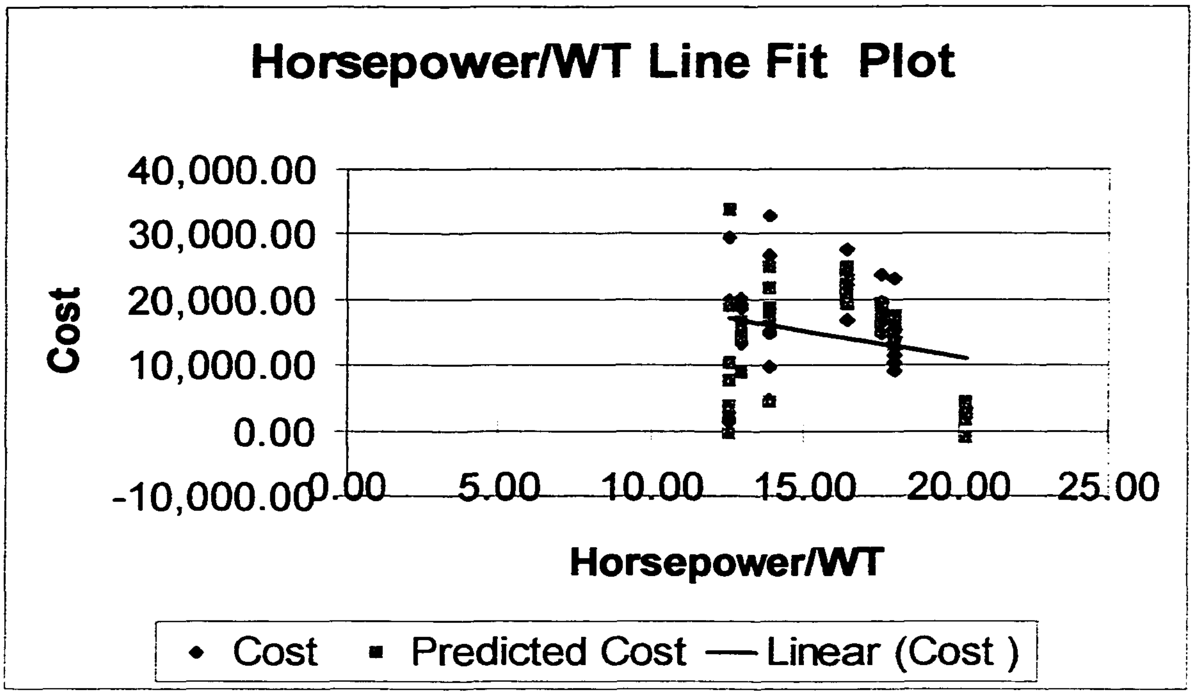


FIGURE I8. HORSEPOWER LINE FIT

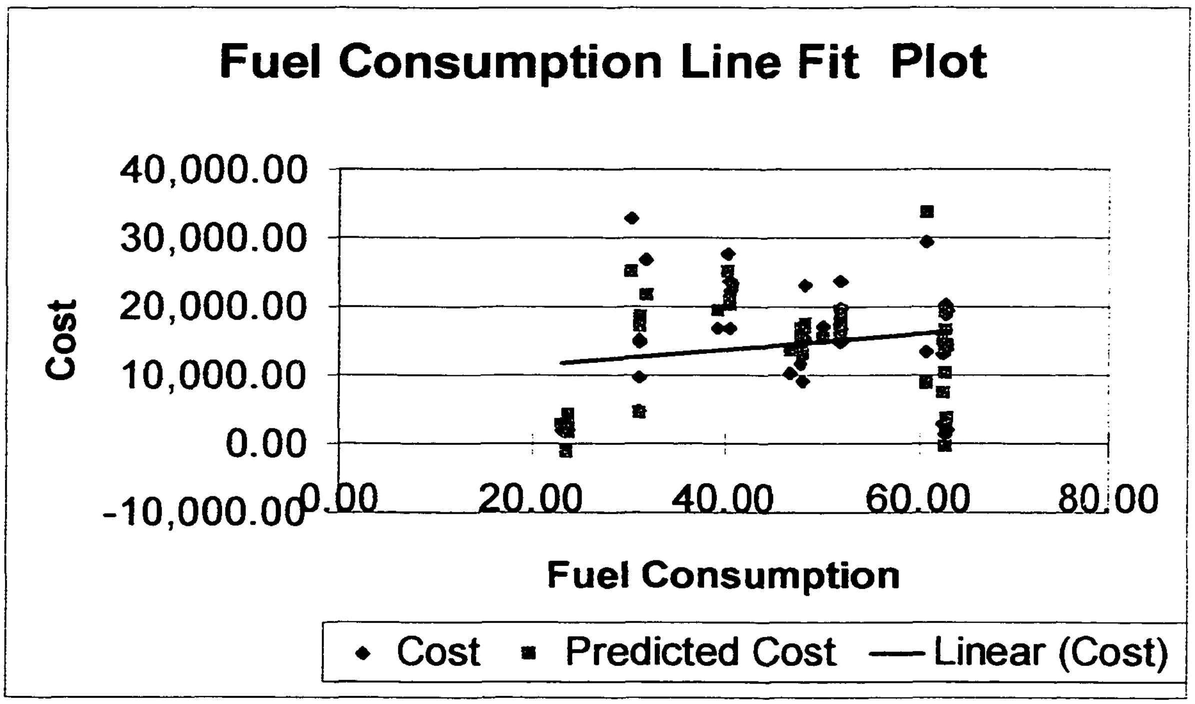


FIGURE I9. FUEL CONSUMPTION LINE FIT

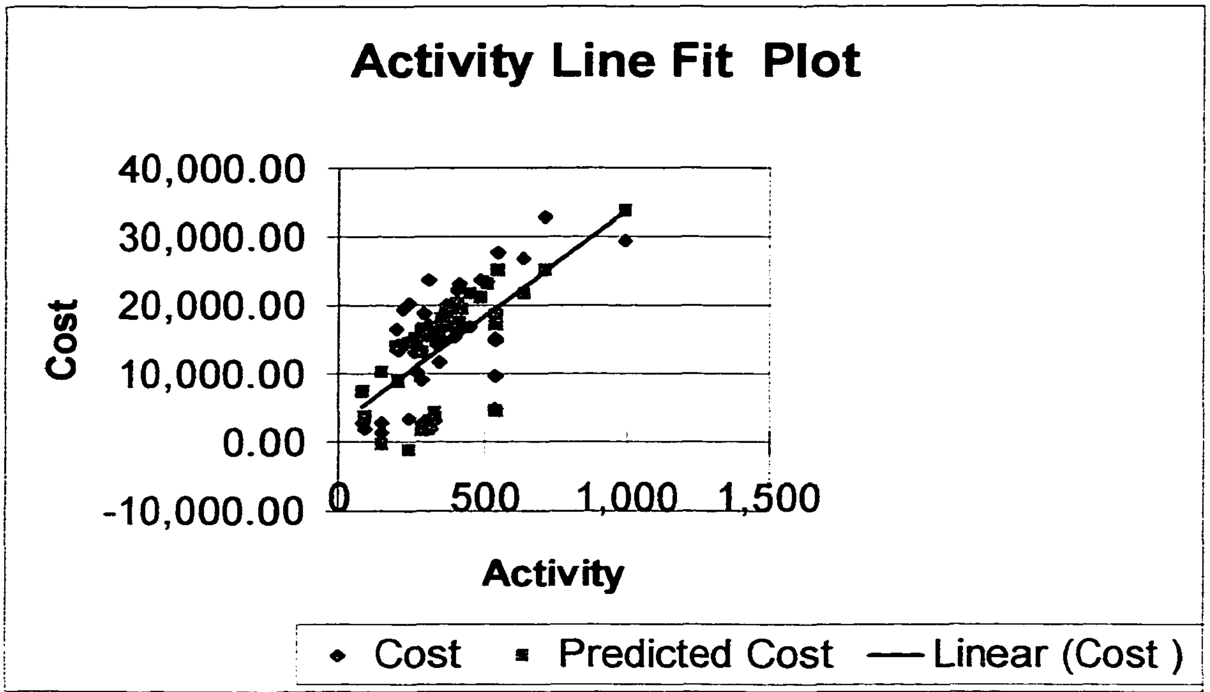


FIGURE I10. ACTIVITY LINE FIT

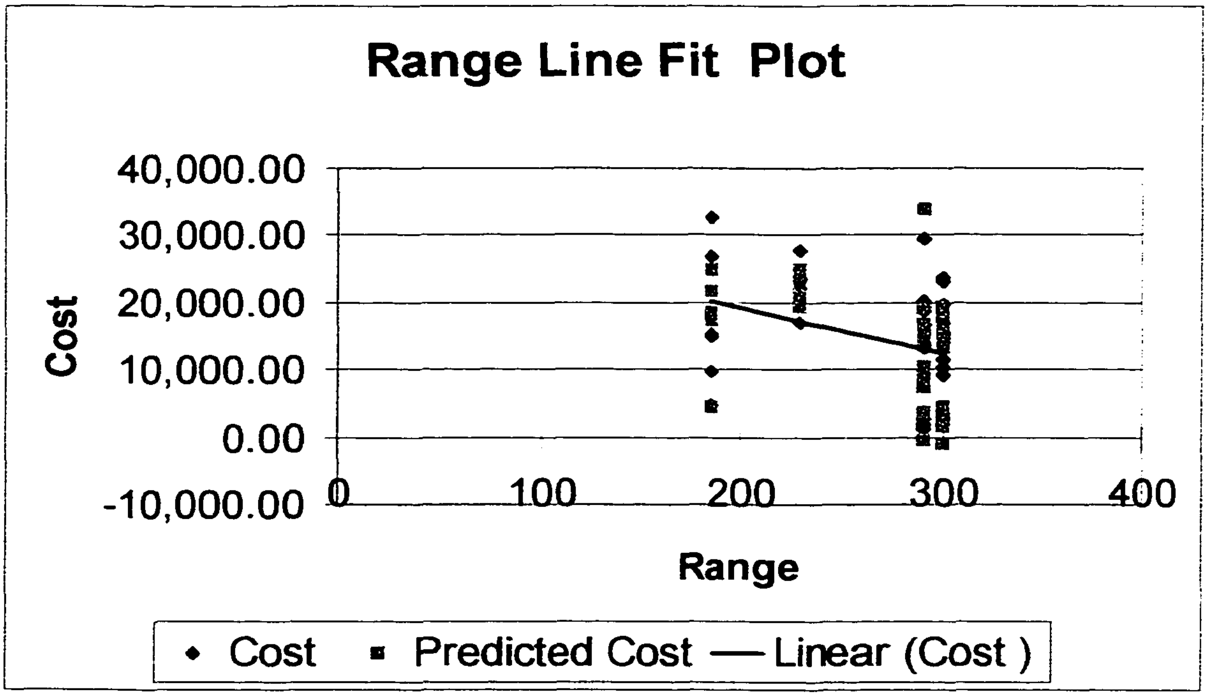


FIGURE I11. RANGE LINE FIT

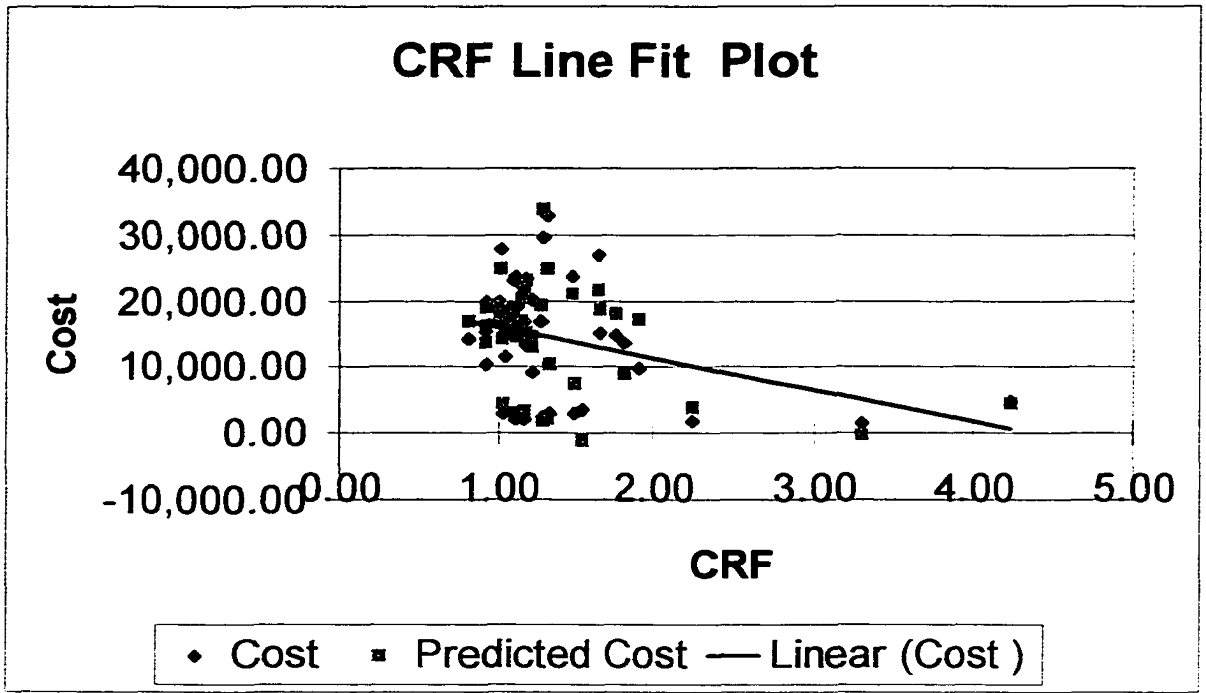


FIGURE I12. CRF LINE FIT

APPENDIX J

Model Prediction

TABLE J1. M992A1 MODEL PREDICTION

Year	Vehicle	Horsepower/WT	Fuel Consumption	Activity	Range	CRF	Cost
1994	M992A1	14.19	35.00	492	220	4.24	23,551.15
1995	M992A1	14.19	34.51	447	220	1.91	12,867.64
1996	M992A1	14.19	34.54	906	220	1.65	13,362.87
1997	M992A1	14.19	35.00	667	220	1.75	10,623.09
1998	M992A1	14.19	33.73	676	220	1.30	10,155.90
1999	M992A1	14.19	34.59	484	220	1.63	11,277.63
		14.19	34.56	612	220	2.08	13,639.71
M992A1 Predicted Average Yearly Cost							**15,878.80**
M992A1 Actual Average Yearly Cost							13,639.71

APPENDIX K

Coded Data

TABLE K1. CODED DATA

CODED
DATA

Year	Vehicle	Horsepower/WT (HP/ton)	Fuel Consumption (Gal/hr)	Activity (Miles/yr)	Range (Miles)	CRF	Cost (Per/sys)
1994	AVLB	-1	1	-1	0	0	20,297.59
1995	AVLB	-1	1	-1	0	0	19,317.18
1996	AVLB	-1	1	-1	0	-1	18,868.58
1997	AVLB	-1	1	-1	0	0	13,284.05
1998	AVLB	-1	1	-1	0	1	13,544.57
1999	AVLB	-1	1	-1	0	-1	16,655.51
1994	M109A6	-1	-1	1	-1	1	4,722.38
1995	M109A6	-1	-1	1	-1	1	9,734.54
1996	M109A6	-1	-1	1	-1	1	15,179.76
1997	M109A6	-1	-1	1	-1	1	14,937.99
1998	M109A6	-1	-1	1	-1	0	32,835.00
1999	M109A6	-1	-1	1	-1	1	26,869.05
1994	M113A3	1	-1	-1	1	1	3,519.31
1995	M113A3	1	-1	0	1	0	2,668.15
1996	M113A3	1	-1	-1	1	0	2,498.73
1997	M113A3	1	-1	0	1	0	2,018.83
1998	M113A3	1	-1	0	1	0	2,026.33
1999	M113A3	1	-1	0	1	-1	3,085.52
1994	M2 BFV	1	0	0	1	-1	23,091.48
1995	M2 BFV	1	0	0	1	0	15,485.90
1996	M2 BFV	1	0	0	1	-1	14,236.70
1997	M2 BFV	1	0	0	1	-1	11,588.66
1998	M2 BFV	1	0	-1	1	-1	10,361.86
1999	M2 BFV	1	0	-1	1	0	9,236.63
1994	M60A3	-1	1	-1	0	0	2,908.86
1995	M60A3	-1	1	-1	0	1	1,882.17
1996	M60A3	-1	1	-1	0	1	1,401.06
1997	M60A3	-1	1	-1	0	0	2,909.85
1998	M60A3	-1	1	1	0	0	29,524.56
1999	M60A3	-1	1	0	0	-1	19,957.96
1994	M88A1	0	1	0	1	0	23,827.39
1995	M88A1	0	1	0	1	-1	19,764.71
1996	M88A1	0	1	0	1	-1	16,892.78
1997	M88A1	0	1	0	1	-1	14,774.65
1998	M88A1	0	1	0	1	-1	17,010.10
1999	M88A1	0	1	-1	1	-1	15,414.03
1994	M9 ACE	0	0	0	-1	0	23,793.76
1995	M9 ACE	0	0	1	-1	0	23,373.71
1996	M9 ACE	0	0	1	-1	-1	27,770.89
1997	M9 ACE	0	0	0	-1	0	16,961.98
1998	M9 ACE	0	0	0	-1	0	16,892.80
1999	M9 ACE	0	0	0	-1	0	22,361.69

APPENDIX L

Cost Trends

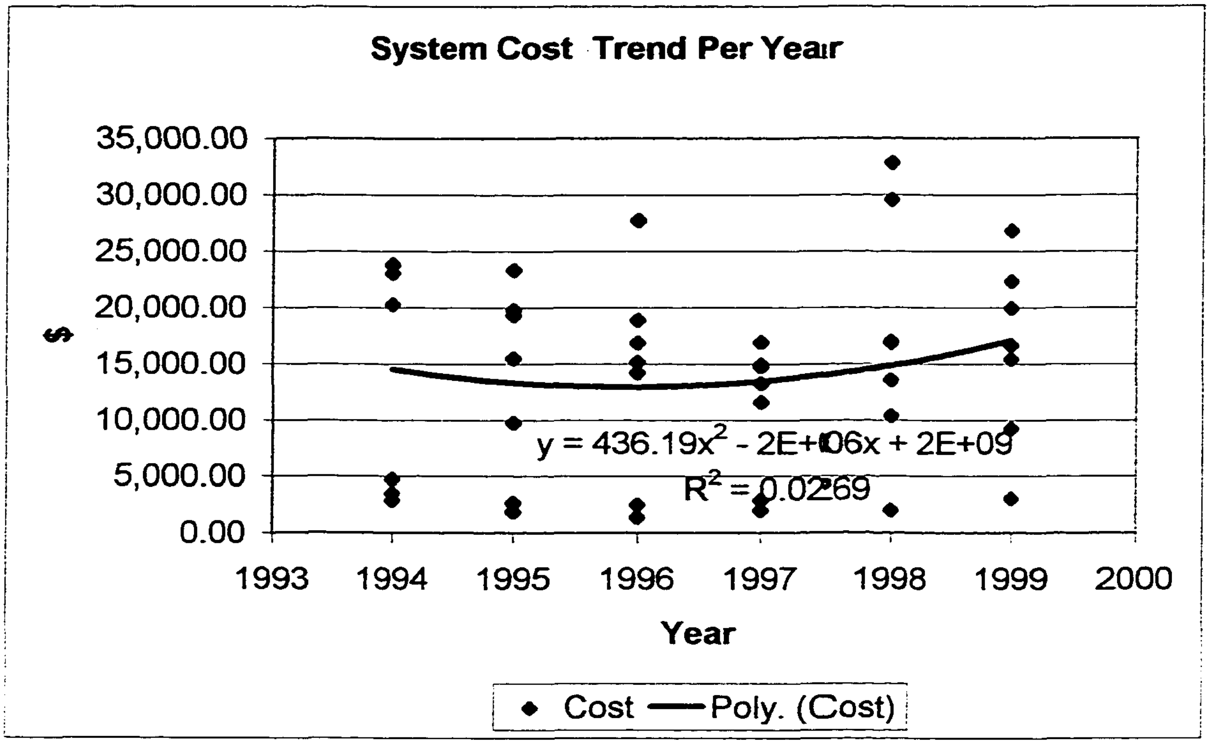


FIGURE K1. VEHICLE YEARLY OPERATING COST TREND

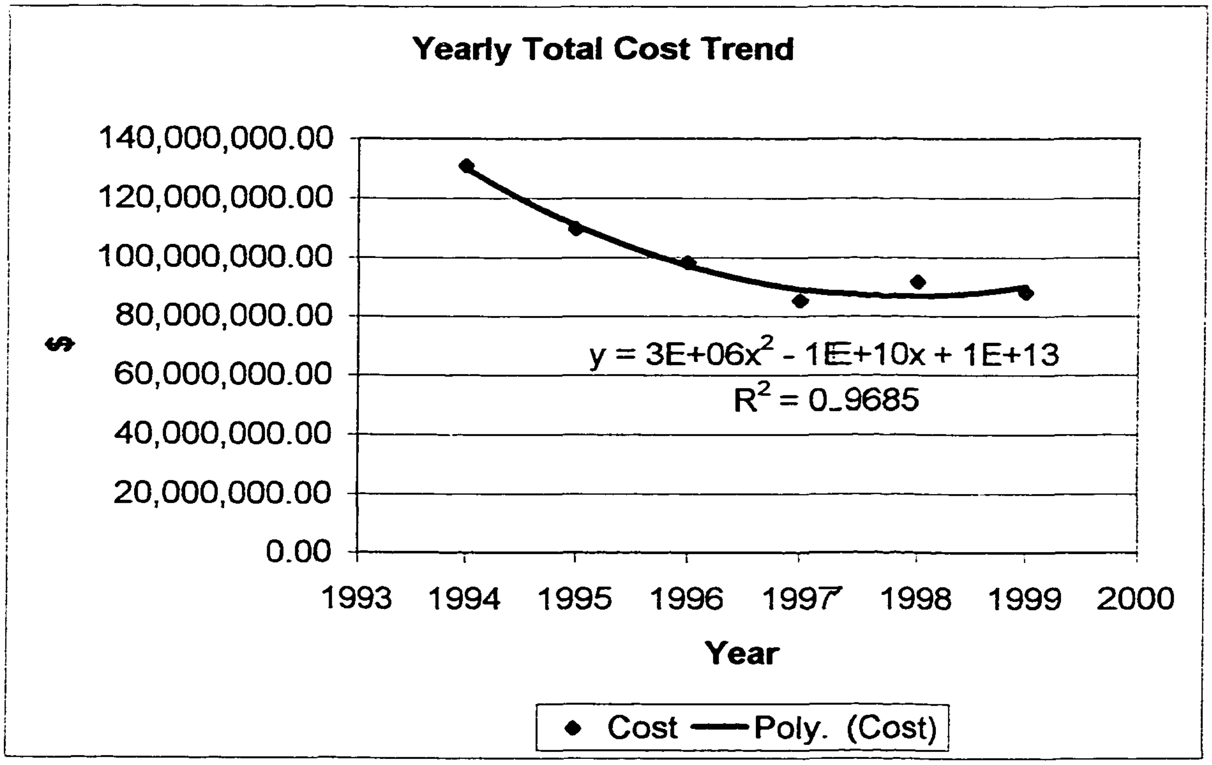


FIGURE K1. TOTAL YEARLY OPERATING COST TREND

APPENDIX M

DoD Budgets

TABLE M1. DoD Budget Percentages

DEFENSE OUTLAY AS PERCENTAGE OF FEDERAL BUDGET		
FISCAL YEAR	**FEDERAL OUTLAYS**	**NET PUBLIC SPENDING**
2000	14.8	9.1
1999	15.3	9.4
1998	15.5	9.5
1997	16.1	9.9
1996	16.2	10.0
1995	17.2	10.7
1994	18.4	11.5
1993	19.8	12.4
1992	20.7	13.1
1991	19.8	12.6
1990	23.1	14.8
1989	25.8	16.5
1988	26.5	17.0
1987	27.3	17.6
1986	26.8	17.9
1985	25.9	17.6
1984	25.9	17.5
1983	25.4	17.3
1982	24.7	16.9
1981	23.0	15.8
1980	22.5	15.3
1975	25.5	16.5
1970	39.4	25.4
1965	38.8	25.2

CURRICULUM VITA
for
JAMES OLIVER WINBUSH, JR.

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EMPLOYMENT:
United States Army, August 1987 to present

SCIENTIFIC AND PROFESSIONAL SOCIETIES MEMBERSHIP:
Military Operations Research Society

HONORS AND AWARDS:
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