Tactical Vehicle Cons & Reps Cost Estimating (CER) Tool

Study Conducted for:

Office of the Deputy Assistant Secretary of the Army for Cost and Economics

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1.0 Introduction

When estimating Operating and Support (O&S), it is reasonable to assume that as reliability increases, consumable and reparable parts (“cons and reps”) cost should decrease (less frequent repairs), while as vehicle price increases, parts cost should increase (more expensive parts). One would expect these variables’ relationship to differ by program, size, capability, etc. Developing a methodology to support cost estimating relationships (CERs) for the Army’s Tactical Vehicle fleet is a significant challenge. Therefore, rather than supplying a single CER to be used for all tactical vehicle parts cost estimating, this study sought an Excel-based tool that would allow cost analysts to build analogies, select data relevant to their specific vehicle, and build tailored CERs. While the foregoing assumptions are certainly logical hypotheses, the topic poses several challenges for cost analysts. This paper will discuss these challenges and detail a three-step process for quantifying the relationship between tactical vehicle reliability and cost of cons and reps.

A lack of consistent data sources and definitions for the data types used to build CERs for estimating parts cost posed a challenge in the data definition phase. These data types are vehicle reliability, vehicle average unit price (AUP), and average annual cons and reps cost with the corresponding miles driven. Quantifying reliability was difficult, as various organizations use different metrics with varying definitions, thus making meaningful comparison difficult. Additionally, obtaining a consistent vehicle AUP posed an issue, as it was initially difficult to find data from the same source and life cycle phase. Lastly, selecting a consistent source for parts cost was a challenge, as sources collect this data in varying ways, leading to certain distinctions and discrepancies.

This study experienced a second challenge in the data collection phase. The Army Materiel Systems Analysis Activity (AMSAA) Sample Data Collection (SDC) metrics were targeted for the reliability portion of the analysis; the study focused on the mean miles between non-mission capable visits (MMB NMC Visits) and MMB NMC Actions metrics. Tactical vehicle production costs and corresponding quantities were pulled from the Wheeled and Tracked Vehicle (WTV) Automated Cost Database (ACDB) and used to calculate vehicle AUP, while the Army Operating and Support Management Information System (OSMIS) was the source of parts costs and miles driven. Upon investigation, it was seen that these three sources contained varying amounts of data for tactical vehicles, making it was necessary to determine for which tactical vehicles the sources could provide the critical amount of information to support CER development.

Additional challenges were met when data analysis was performed. As the data and ensuing relationships were analyzed, it was noted that the data experienced an inherently large amount of variability, even when analyzing within-series relationships. Therefore, as opposed to developing a single CER to be used for all tactical vehicles, an Excel-based visual analysis tool was developed to allow for optimal flexibility in the creation of CERs. In addition to outputting uniquely developed CERs, analysts are able to select analogous systems, add/remove variables of interest, apply various regression equation forms, retrieve appropriate statistics to diagnose and assess the level of fit for the selected CERs, and view the data supporting these regressions.

Due to the ability to easily change any selections—and, therefore, the resulting equations and statistics—analysts may quickly compare and contrast various relationships and perform a variety of in-depth analyses. The result of this study is a robust tool allowing cost analysts to effectively quantify the relationship between a tactical vehicle's reliability and parts cost.

2.0 Background and Previous Work

This study is preceded by two studies also conducted for the Office of the Deputy Assistant Secretary of the Army for Cost and Economics (ODASA-CE) that aided in the development of the current methodology. The objective of these two parent tasks as well as the current task was to develop a methodology to support cons and reps parts cost estimating for a variety of different vehicle subsets. Additionally, the aforementioned studies operated under two hypotheses:

1. Cons and reps cost per mile varies inversely with reliability (i.e., cons and reps cost decreases as vehicle reliability increases)
2. Cons and reps cost per mile varies directly with vehicle price (i.e., cons and reps cost increases as vehicle AUP increases)

Given the basis of these two hypotheses, the studies sought to explore the relationship between cons and reps parts cost and reliability. The theoretical relationship is visually depicted in **Figure 1**.

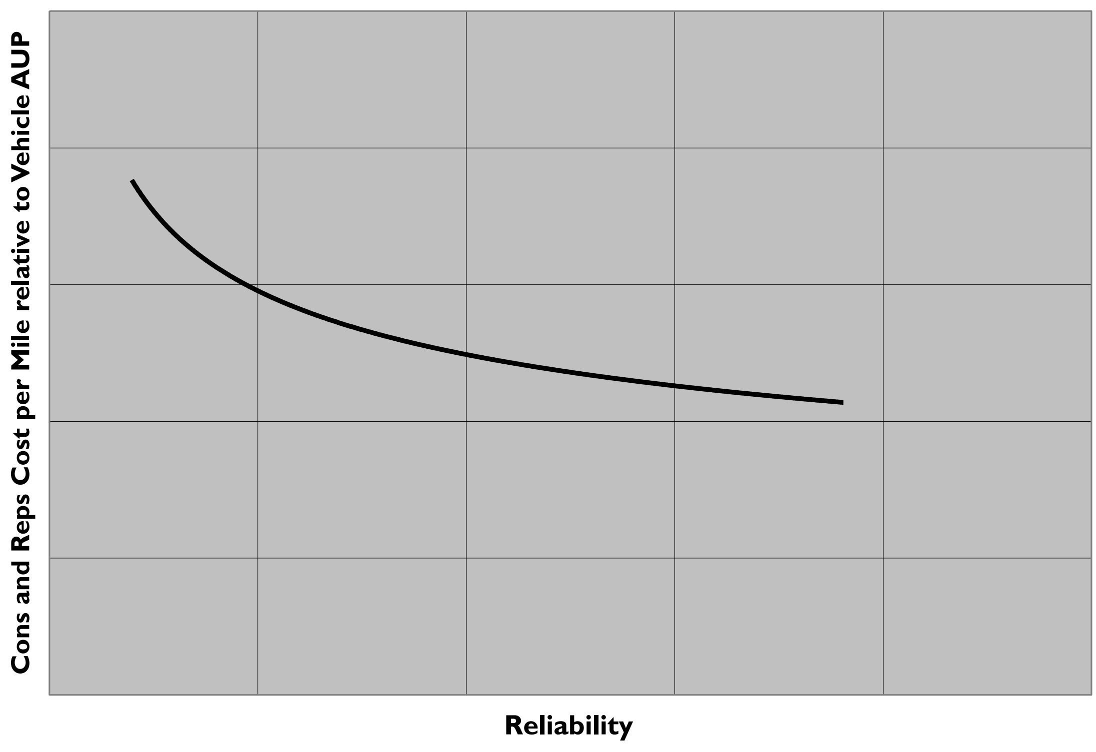

Figure 1: Theoretical Cost Ratio of Cons and Reps per Mile relative to Vehicle AUP vs. Reliability

2.1 January 2008 Study

The first study, completed in January 2008, collected data and constructed relationships while operating under the hypotheses above for the vehicles shown in **Table 1** (1).

Vehicle Series	Vehicle Variant
HMMWV	M1113
HMMWV	M1114
HMMWV	M1097A2
LMTV	M1078A1
MTV	M1083A1
Stryker	M1126 (ICV)

Table 1: Vehicle Series and Variants from January 2008 Study (1)

Upon analysis of this data set, two undesirable trends were noted and are shown in **Figure 2**:

1. The HMMWV and Stryker series (M1113, M1114, M1097A2, and M1126) showed similar reliabilities yet vastly differing cons and reps costs per mile relative to vehicle AUP (1).
2. The M1114, M1078A1, and M1083A1 showed similar cons and reps costs per mile relative to AUP yet reflected large differences in reliability metrics (1).

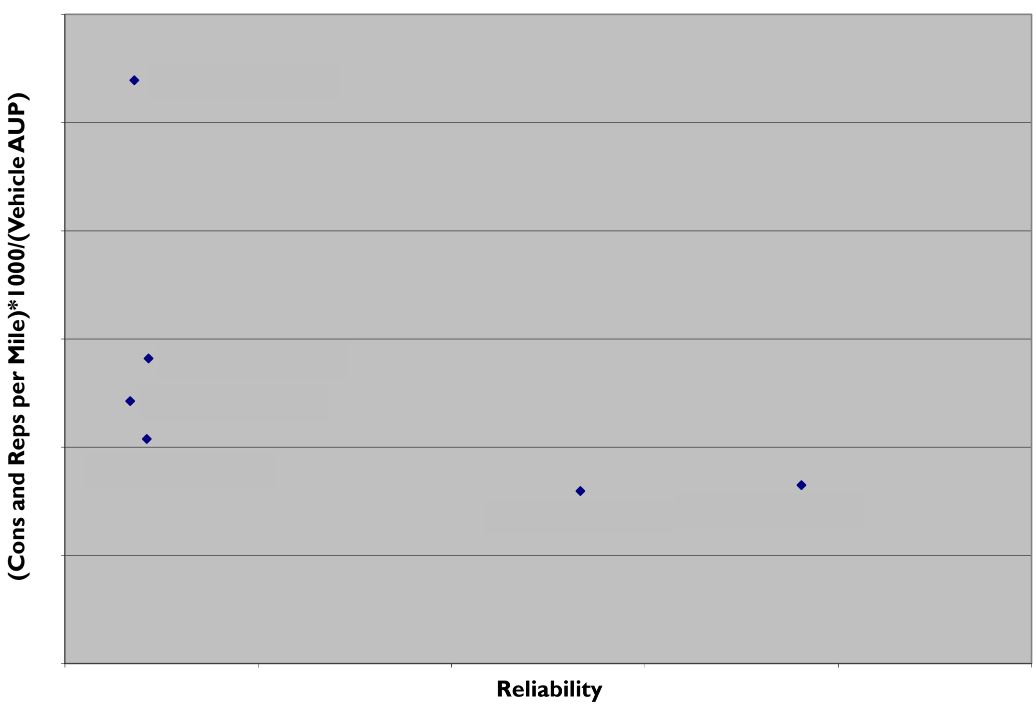

Figure 2: (Cons and Reps per Mile)*1000 / (Vehicle AUP) vs. Reliability from January 2008 Study (1)

Due to the substantial variation in cons and reps per mile experienced by the HMMWV series independently of AUP and reliability, it was determined that the best path forward in this study was to utilize the HMMWV average while completing this analysis. A one variable power model was constructed as a function of reliability, shown in **Figure 3**. Additionally, a two variable power model was constructed as a function of reliability and AUP. In the latter case, the exponent on AUP was found to be nearly one, leading to the conclusion that the cons and reps cost per mile relative to vehicle AUP could confidently be used as the two cases produced nearly the same model (1).

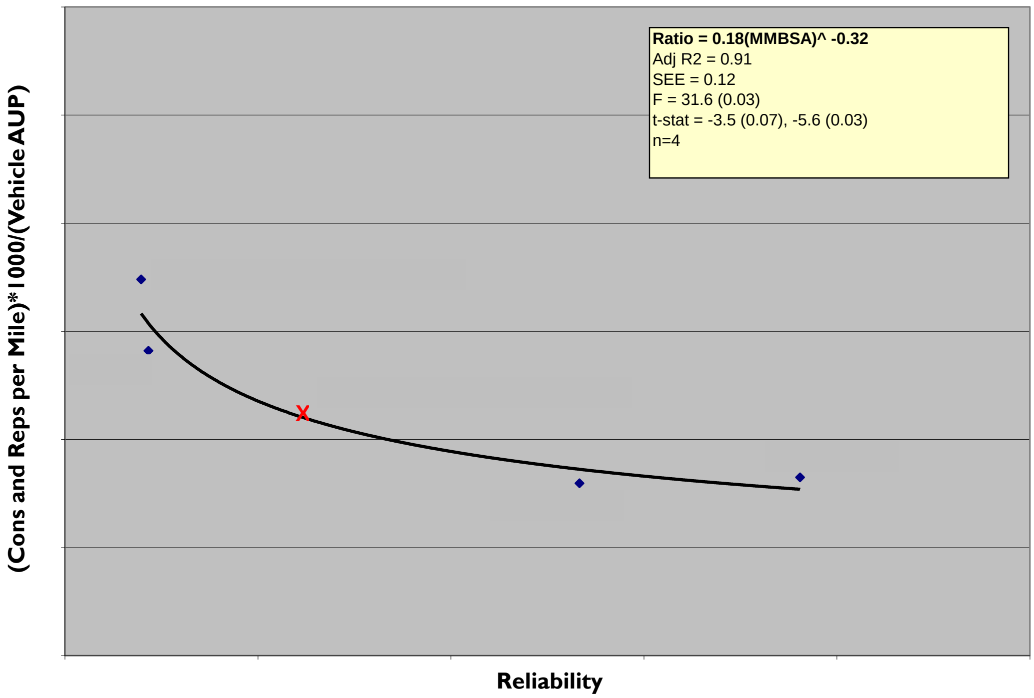

Figure 3: (Cons and Reps per Mile)*1000 / (Vehicle AUP) vs. Reliability, with HMMWV Averaged, from January 2008 Study (1)

A few shortfalls were identified with this study, and these shortfalls were the basis of improvement for the follow-on study completed in March 2012. These shortfalls mainly revolved around a lack of consistent data sources. Specifically, the vehicle AUP data utilized for this study was collected from a variety of different sources. Additionally, the reliability metrics utilized were inconsistent. The dataset consisted of mean miles between operational mission failure (MMBOMF), mean miles between system abort (MMBSA), and mean miles between hardware mission failure (MMBHMF) metrics, and these varying data types were captured during different stages in the lifecycle of the vehicle (e.g., they may have been calculated during Developmental Test (DT), Operational Test (OT), Limited User Test (LUT), or another event). In addition to a lack of consistent data, it was noted that consolidating the HMMWV data may have masked the inherent variability across vehicles with varying missions (2).

2.2 March 2012 Study

In March 2012, the follow-on study was completed, focusing on the tactical wheeled vehicle class of vehicles and aiming to account for the shortcomings of the previous study by maintaining consistency in data sources. Additionally, the study focused on the tactical wheeled vehicle class of vehicles. While the January 2008 study utilized OSMIS as the cons and reps parts cost resource, this study assessed two sources for this data type: OSMIS and AMSAA SDC data (2). Therefore, the consistent data sources and main premises of this follow-on study were as follows:

1. Vehicle AUPs were all calculated via data housed within the WTV ACDB (2).
2. Reliability metrics were all provided by the AMSAA SDC (2).

3. Cons and reps costs and respective miles driven were all provided by the AMSAA SDC (2).
4. A parallel comparative analysis was conducted using cons and reps costs and miles driven extracted from the Army OSMIS (2).

As stated previously, all of the studies operated under the same two hypotheses, as graphically depicted in **Figure 1**. A list of vehicles for which adequate data were available from the various data sources was compiled, consisting of 11 vehicle variants for which CERs were generated. This list is shown in **Table 2** (2).

Vehicle Series	Vehicle Variant
FMTV	M1078A1
FMTV	M1083A1
MFTV	M1088A1
HEMTT	M977
HET	M1070
HMMWV	M997
HMMWV	M998
HMMWV	M1025
HMMWV	M1026
HMMWV	M1038
HMMWV	M1114

Table 2: Vehicle Series and Variants from March 2012 Study (2)

Through the comparative analysis of cons and reps costs from AMSAA SDC and OSMIS, significant differences were found in the two data sources, as depicted in **Figure 4** and **Figure 5**. The main reason for these discrepancies was that cons and reps costs from OSMIS were based on demands whereas cons and reps costs from AMSAA SDC were based on actual replacement of parts (2).

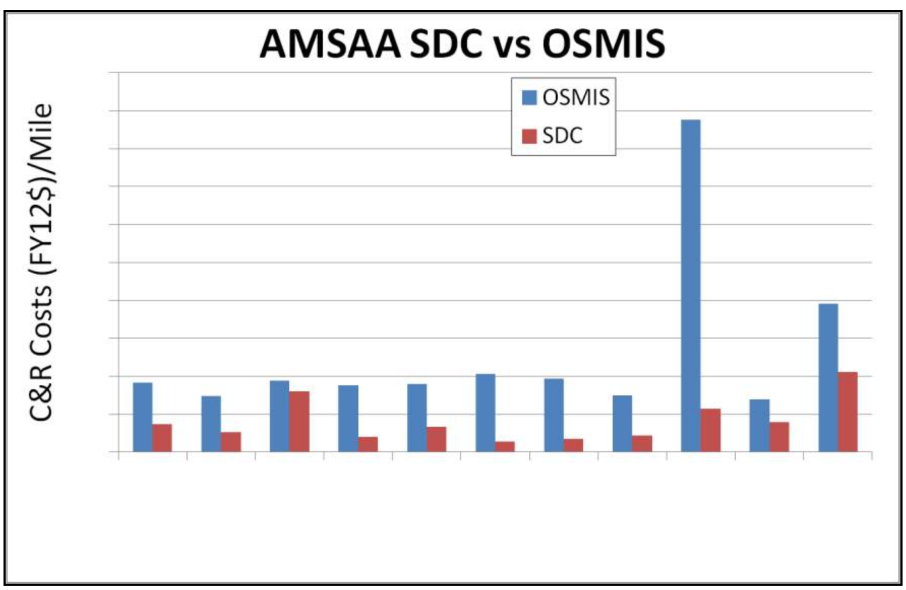

Figure 4: AMSAA SDC vs. OSMIS: Comparative Analysis Conducted Under March 2012 Study (2)

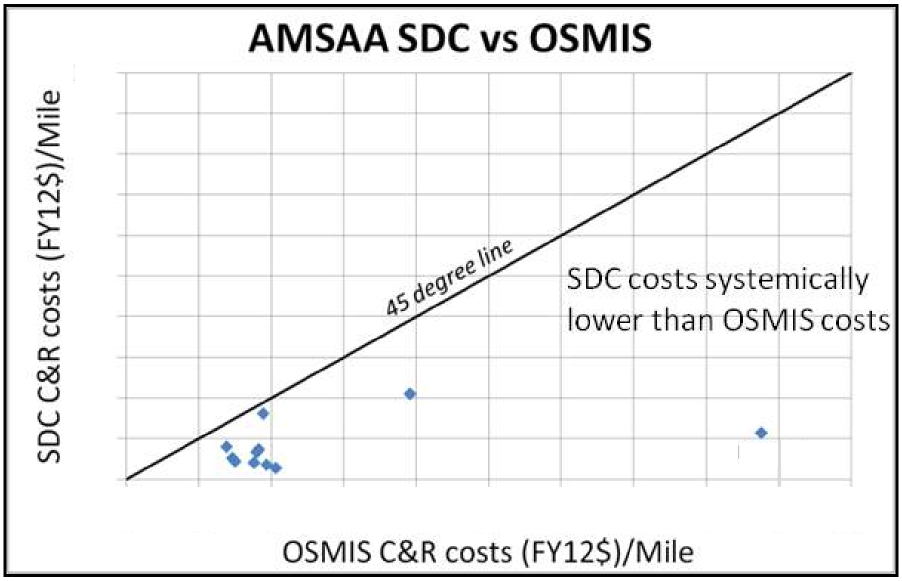

Figure 5: AMSAA SDC vs. OSMIS: Comparative Analysis Conducted Under March 2012 Study (2)

The reliability metric utilized in this study was mean miles between non-mission-capable visits (MMB NMC Visits) as it was determined that this reliability metric related to peacetime data and would, therefore, provide less variability than that which was to be expected for wartime data. Additionally, the MMB NMC Visits metric was found to most closely match the reliability metrics reported in requirements documents and Cost Analysis Requirements Descriptions (CARDs). When both the AMSAA SDC and OSMIS cons and reps costs were plotted per miles driven normalized to AUP against this MMB NMC Visits reliability metric, the OSMIS cons and reps cost data produced no significant trends whereas the AMSAA SDC cons and reps cost data trends were significant. These results are shown in **Figure 6** and **Figure 7** (2).

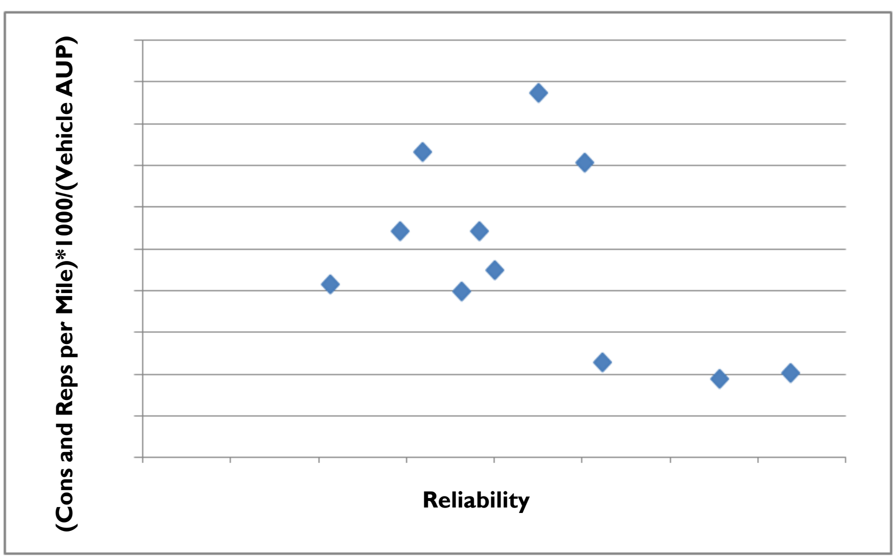

Figure 6: (OSMIS Cons and Reps per Mile)*1000 / (Vehicle AUP) vs. Reliability from March 2012 Study (2)

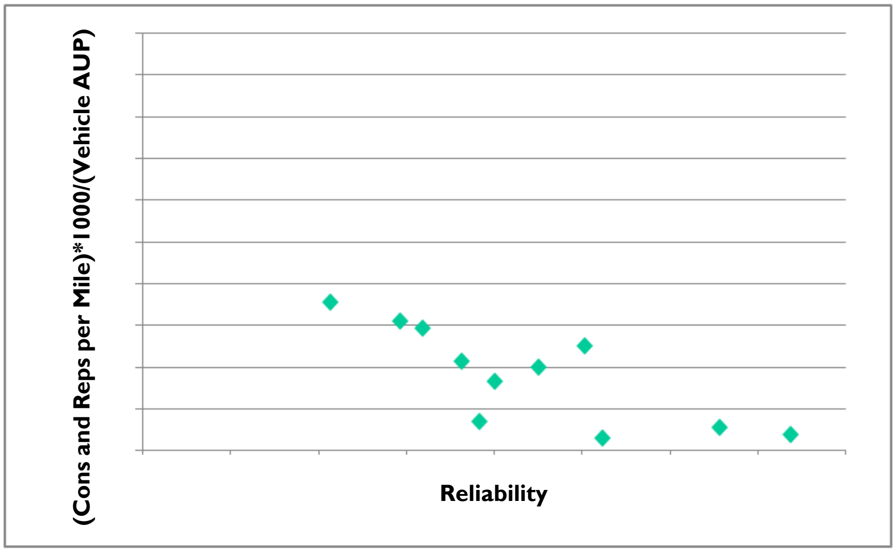

Figure 7: (AMSAA SDC Cons and Reps per Mile)*1000 / (Vehicle AUP) vs. Reliability from March 2012 Study (2)

Based on these findings and the fact that OSMIS data is based on demands whereas AMSAA SDC data is based on actual part replacement and usage, it was determined that the remainder of the study would be conducted using AMSAA SDC as the source of cons and reps parts cost and associated miles driven (2).

One variable linear, power, and logarithmic models were analyzed. It was determined that the y-intercept of the linear relationship, shown in **Figure 8**, was a concern because vehicle reliability will never reach zero (i.e., as vehicle reliability approaches zero, cons and reps costs will increase drastically). Therefore, it was recommended that the range of reliability inputs be restricted to 400 – 1,400 miles (2).

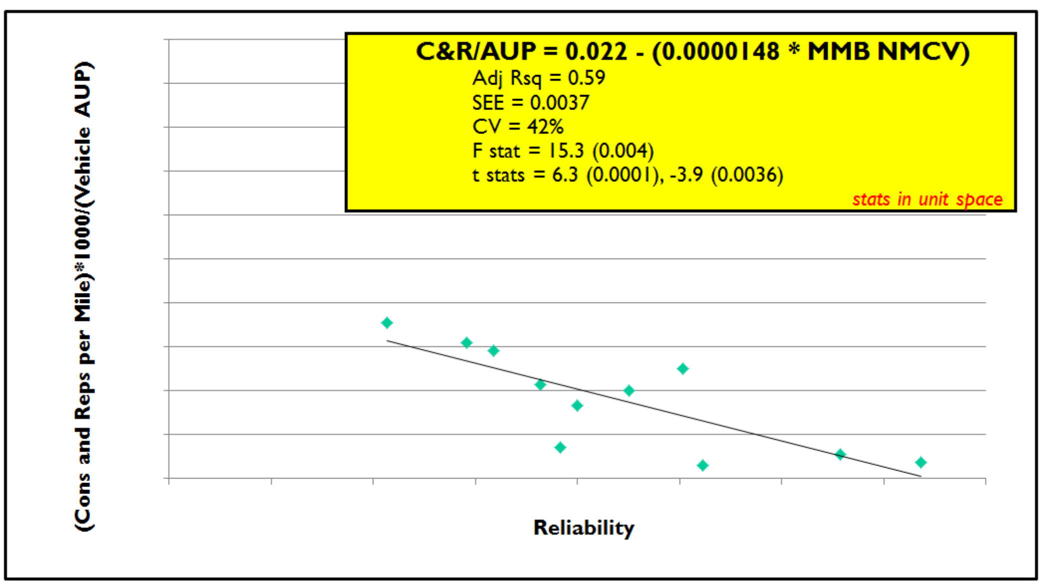

Figure 8: (Cons and Reps per Mile)*1000/(Vehicle AUP) One Variable Linear Model from March 2012 Study (2)

The power model, shown in **Figure 9**, eased the concerns of the linear model due to the asymptotic trend as reliability approached zero, a trend that makes logical sense and is likely more consistent with actual data behavior. Again it was recommended that the range of reliability inputs be restricted to 400 – 1,400 miles (2).

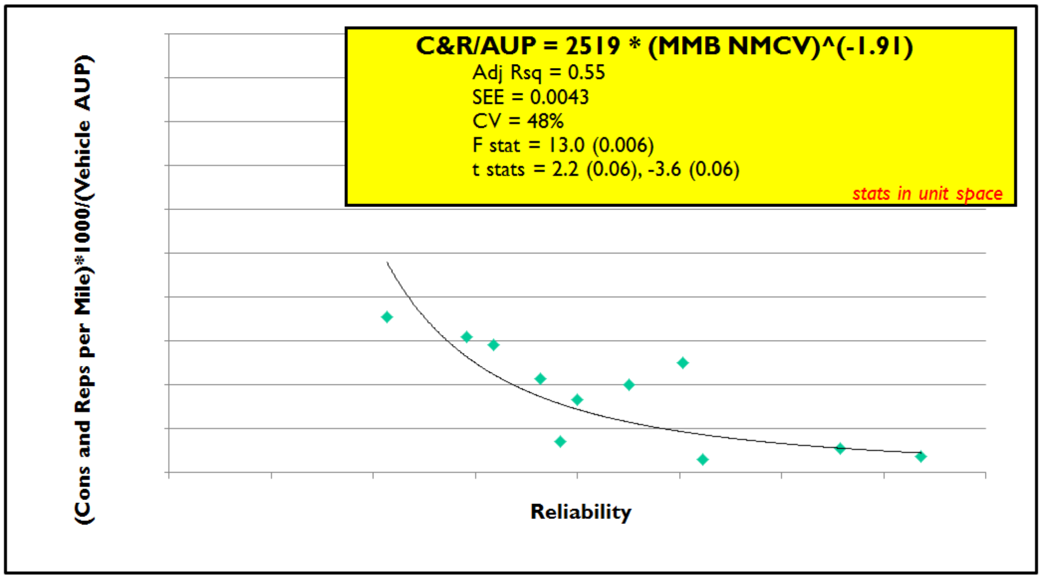

Figure 9: (Cons and Reps per Mile)*1000/(Vehicle AUP) One Variable Power Model from March 2012 Study (2)

The logarithmic one variable model, shown in **Figure 10**, produced the best statistical results; however, although the y-intercept concern was slightly addressed via this relationship, it was once again recommended that the range of reliability inputs be restricted to 400 – 1,400 miles (2).

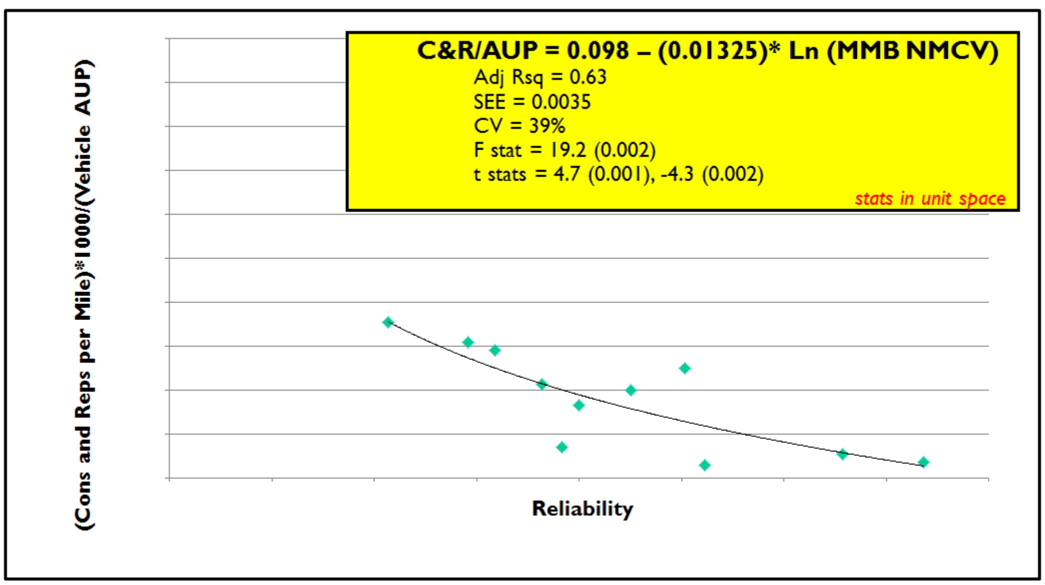

Figure 10: (Cons and Reps per Mile)*1000/(Vehicle AUP) One Variable Logarithmic Model from March 2012 Study (2)

These two studies created the framework under which the current study would be completed. This current study aims to develop relationships more relevant to Army cost analysts; specifically, the study was to be completed using OSMIS as the primary source of cons and reps parts cost and miles driven as it is the Army's primary source of O&S phase costs. Finally, this study would operate under the same hypotheses as depicted in **Figure 1** and would maintain consistent data sources (2).

3.0 Current Study Methodology

3.1 Data Definition

Consistency in data sources is key when completing any analysis. This consistency verifies the ability to accurately compare across data points in a data set and determine significant relationships without added variability introduced by differences in data sources. Therefore, it was important to maintain consistent data sources and definitions for vehicle AUP, reliability, and cons and reps parts cost and associated miles driven when completing this study so as to verify that the relationships being analyzed were significant due to variable interaction and not variations in the data sources.

Determining which data sources to use for the variables of interest in this study proved difficult at times due to the different metrics and associated definitions for these various metrics. Moreover, different people and organizations have conflicting opinions regarding which metrics are the best to use. These facts posed particular problems when collecting reliability and cons and reps parts cost and associated miles driven metrics for this study.

Regarding reliability, there are various definitions often used by analysts: MMBOMF, MMBSA, MMBHMF, MMB NMC Visits, and MMB NMC Actions to name a few. A reliability metric that would reflect complete operational failure of the system was desired for this study; in other words, a metric reflecting the average miles between which a vehicle broke down, was no longer able to complete its mission, and needed to be repaired was of interest to this study. Additionally, this metric needed to come from the same source for all systems. Although any of the metrics listed above may have served as an adequate metric for the purposes of this study, it was difficult to find one consistent data source for all vehicles in the data set from which to obtain these metrics. Therefore, MMB NMC Visits and MMB NMC Actions from AMSAA SDC were chosen. Definitions relating to these metrics are provided in **Table 3**. Lastly, it was desirable to have peacetime reliability metrics as these are preferable to cost analysts and reflect less variability than wartime metrics. AMSAA was able to oblige and provide peacetime MMB NMC Visits and MMB NMC Actions metrics.

Terms	Definition
Total Visits	Total maintenance visits (how many times the vehicle went into the shop for maintenance)
Total Actions	Total maintenance actions (how many different maintenance tasks were performed on the vehicle during the maintenance visit)
Total NMC Visits	Same as total maintenance visits except only counting the visits that were Non-Mission Capable (vehicle goes into maintenance for an engine replacement vs. replacing a seat cushion)
Total NMC Actions	Same as total maintenance actions except only counting actions that were Non-Mission Capable (action was to replace an engine vs. a seat cushion)

Table 3: AMSAA Definitions

During the preceding studies, the two sources of cons and reps parts cost and associated miles driven (AMSAA and OSMIS) were both scrutinized and questioned. As shown in **Figure 6**, plotting cons and reps costs per mile from OSMIS relative to vehicle AUP against reliability did not produce significant relationships. Additionally, **Figure 7** shows that plotting cons and reps costs per mile from AMSAA relative to vehicle AUP against reliability did produce significant relationships. Notable discrepancies between the AMSAA and OSMIS cons and reps data were observed and are displayed in **Figure 4** and **Figure 5**. Through communications with AMSAA and the OSMIS support contractor CALIBRE, it was found that these differences and discrepancies are largely due to the fact that OSMIS data is based on demands whereas AMSAA data is based on actual replacements.

Although these findings led to the use of AMSAA SDC data as the source of parts cost and miles driven in the March 2012 study, the Army uses OSMIS as its primary source of O&S phase costs. Therefore, because the Army is more familiar and comfortable with using OSMIS data, OSMIS was selected as the source of parts cost and miles driven for the current tactical vehicle study. Once again, peacetime data was preferable. The OSMIS system contains both peacetime (Without Conops) and wartime data (Only Conops); therefore, the preferable peacetime data was able to be extracted from the system.

Lastly, it was necessary to determine a source for vehicle AUP. The WTV ACDB contains various contracts and Cost and Software Data Reports (CSDRs) for wheeled and tracked vehicle systems. This data contains both pricing and quantity information, thereby providing the necessary information to calculate vehicle AUP for this study. Additionally, the WTV ACDB is the Army's primary source of contractor acquisition data. Therefore, WTV ACDB was chosen as the source for vehicle AUP.

3.2 Data Collection

The first step in the data collection phase was to get a "lay of the land"; that is, a list of vehicles for initial data collection needed to be compiled. In order to do so, a list was assembled of all tactical vehicles for which contracts and CSDR reports—specifically, Cost Data Summary Reports (CDSRs)—were available in the WTV ACDB. The WTV ACDB contains a System Type filter that was leveraged in order to determine the tactical wheeled vehicles housed within the database. Using this filter, the "Tactical Wheeled Vehicles" System Type and others with "wheeled" in the name were selected. These were the vehicles for which the necessary information was available to calculate vehicle AUP, and since this data type was needed for the analysis, it was logical to constrain data collection to these vehicles. This initial step resulted in a set of 364 tactical wheeled vehicles variants.

The list compiled in the above step was then sent to AMSAA, following which AMSAA SDC data was provided for vehicles in the list for which SDC metrics were captured. AMSAA provided 384 records spanning 116 different vehicles during a timeframe from 1990-2013. As requested, this was all peacetime data. These 116 vehicles were then compared to the initially generated list of 364 vehicles, thereby decreasing the number of vehicles in our data set.

The next step in data collection was to extract cons and reps data and respective miles driven from the Army OSMIS. This extraction was done for vehicles residing in OSMIS that corresponded with data available through the WTV ACDB and AMSAA SDC. Class IX Summary cons and reps costs, inventory (density), and mileage (activity) were pulled for the selected systems from 2003 to 2012. The data was averaged across these ten years in an effort to level out fluctuations in the data. To assess the effect of varying surcharge applications, this data was pulled both in Base Year 2012 dollars and Then Year dollars, which were escalated to Base Year 2012 via the Army OMA indices. As desired, all of the data extracted were peacetime data.

The AMSAA SDC and Army OSMIS composite peacetime data set included 93 different vehicle variants. In order to reduce sample size to a manageable number of systems, what was referred to as a "Pareto-Plus" analysis was completed such that the new data set included vehicles comprised of the top 95% of total inventory and the top 95% of total miles driven. After completing this analysis to reduce sample size, 52 vehicles remained in the sample set. It was for these 52 vehicles that vehicle AUP was now sought.

As stated previously, WTV ACDB was leverage in order to obtain the information necessary to calculate vehicle AUPs. Vehicles residing in WTV ACDB that corresponded with the list of 52 vehicles were exported and analyzed, yielding 561 total records spanning 48 different WTV vehicle types. Where possible, to calculate weighted average vehicle AUP, the total price was normalized to Base Year 2012 dollars via Army's OPA inflation indices and divided by the total quantity.

After completing vehicle AUP calculations with the data extracted from the WTV ACDB, all necessary data metrics had been collected for the 52 vehicles. In a later update to this study, the ASV and MRAP M-ATV were added to the data set. The 54 vehicles in this study, spanning 12 vehicle series, are shown in **Table 4**.

Vehicle Series	Vehicle Variant		Vehicle Series	Vehicle Variant
HMMWV	M998		M939	M923A2
HMMWV	M1025		M939	M923
HMMWV	M1097A2		M939	M931A2
HMMWV	M1114		M939	M931
HMMWV	M997-2274		M939	M925
HMMWV	M1113		M939	M925A2
HMMWV	M1038		M939	M929A2
HMMWV	M1037		M939	M929
HMMWV	M1026		M915	M915A3-4847
HMMWV	M966		M915	M915A1
HMMWV	M1025A2		M915	M915A2
HMMWV	M1152		M915	M915
FMTV	M1078A1-6343		M915	M920
FMTV	M1083A1-3890		HEMTT	M978-7672
FMTV	M1088A1-3893		HEMTT	M984A1
FMTV	M1078A1P2-8577		HEMTT	M977-6426
FMTV	M1083A1P2-8610		HEMTT	M985-7673
FMTV	M1088A1P2 -7759		HEMTT	M1120A2
FMTV	M1078A1-3888		HEMTT	M1120A2R1
FMTV	M1083A1-3884		HEMTT	M978A2-8215
FMTV	M1089A1-3892		HEMTT	M977-0260
FMTV	M1078A1P2		HEMTT	M984A2
M35	M35A2-1617		PLS	M1075
M35	M35A2C-0873		PLS	M1074
HET	M1070		M809	M818-8984

Vehicle Series	Vehicle Variant		Vehicle Series	Vehicle Variant
M916	M916		M809	M813A1-8913
ASV	M1117		MRAP	M1240 (M-ATV)

Table 4: Vehicle Series and Variants for Tactical Vehicle Cons and Reps CER Tool

Analysis and generation of CERs could now be completed for these 54 vehicles.

3.3 Analysis

The objective of the current task was to develop a methodology to support cons and reps parts cost estimating for tactical wheeled vehicles; that is, to develop a CER to be applied in order to estimate cons and reps parts cost for tactical wheeled vehicles. Preliminary analysis showed that due to the nature of the data, the desired estimating methodology and results drastically differed depending on the subset of tactical wheeled vehicles of interest. These differences were attributable to the inherent variations in the cons and reps data as well as large variations in data depending on the vehicle of interest (size, weight, mission, etc.). Not only was it difficult to determine a single CER to be used for estimating parts cost for tactical wheeled vehicles, it did not appear to make sense to force the use of a single CER in all occasions. Therefore, multiple relationships were under investigation.

In order to increase efficiency in analyzing these various relationships, an Excel-based visual analysis tool (VAT) was created and used for analysis, following which it was determined that this VAT was the key to this type of estimation. The VAT was expanded to allow the user to select one, two, and three variable regressions with reliability; reliability and AUP; and reliability, AUP, and miles driven as the respective independent variables. The following are automatically generated for effective visual analysis: graphs of these one, two, and three variables against the y-axis metric ((Cons and Reps per Mile)*1000/(Vehicle AUP); Cons and Reps per Mile; or Cons and Reps in the one, two, and three variable cases, respectively).

The user may select one of two reliability metrics discussed previously: MMB NMC Visits or MMB NMC Actions. Additionally, relationships may be analyzed for cons and reps, together or separately, for various MACOM groupings: Total, Total (excluding Other), Active, Reserve, National Guard, TRADOC, or Other, where the Other grouping encompasses the Undistributed and U.S. Army Materiel Command MACOMs reported in OSMIS. The user may decide which OSMIS data pull method to utilize: costs pulled in Base Year 2012 or costs pulled in Then Year dollars and escalated to Base Year 2012. Moreover, the user may choose to use the average of the cons and reps cost data or the data from the individual years. With a few clicks of the mouse, the user is able to select and deselect various vehicle series and variants, allowing them to build analogies most relevant to their program of interest. The user may opt to average one or more vehicle series for input to their analysis, and the user also has the option to input a value of standardized residuals for which to flag data points as potential outliers. These potential outliers may be removed, given adequate information to do so, by clicking the respective checkboxes. The user may then select to obtain linear, power, logarithmic, or exponential regression statistics and resulting equations as well as apply axes constraints to the analysis. The tool contains a Visual User Guide and list of acronym definitions in order to assist the user in making selections and using the tool.

Upon making the desired selections, the user may navigate to the “Stats” page in order to obtain the necessary statistics to assess the level of fit of the selected data set as well as the resulting CER (all statistics as well as the CER are both provided in fit and unit space). The “Residual Analysis” page allows the user to perform a residual analysis by observing y-axis metric predicted versus actual trends as well as a standardized residual plot. The “Data” tab contains the x and y-axes data feeding the various relationships, statistics, and equations. This data has been provided for ease of retrieval in order to extract and perform additional analysis, if desired.

All of these selections are made via a few clicks of a button, and all graphs, statistics, CERs, residual analyses, and underlying data are generated automatically for the analyst's retrieval in seconds. This Excel-based VAT, shown in **Figure 11**, enables the analyst to spend less time gathering and formatting data and more time analyzing the data. The user is able to assess multiple relationships in minutes, thereby allowing for more efficient and comprehensive analyses.

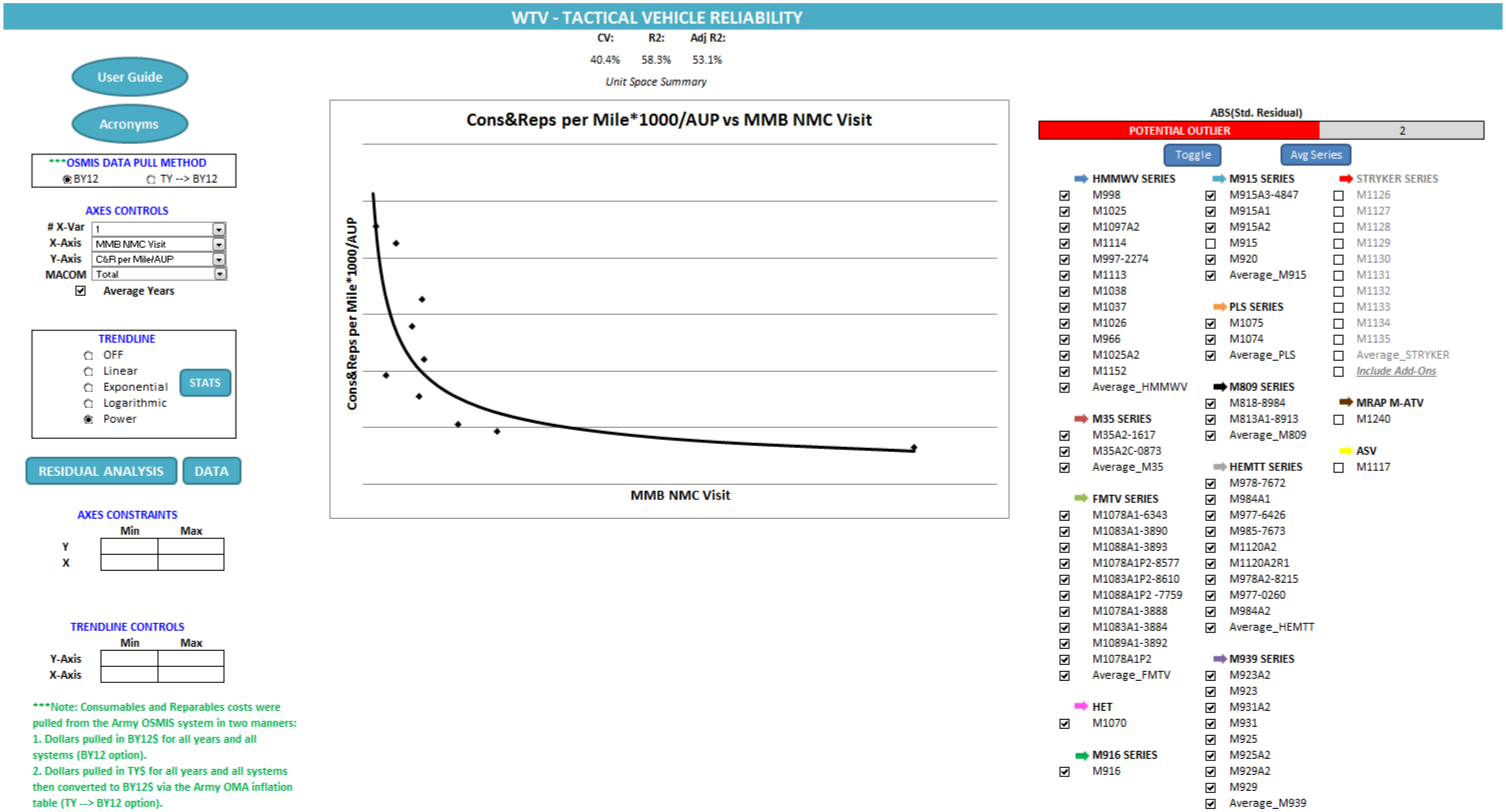

Figure 11: Tactical Vehicle Cons and Reps Cost Estimating Tool

4.0 Study Results

The specific CER an analyst should use depends on the purpose of the analysis and the system at hand. There are various characteristics of a system that should be considered when building analogies: size, weight, engine type, mission, etc. These characteristics may be vastly different from platform to platform. Therefore, it does not make sense and is not recommended to provide a single CER to be used in all instances of tactical wheeled vehicles cons and reps parts cost estimation.

It is recommended that MACOMs be summed (i.e., "Total" is the selected MACOM) because no significant relationships were determined to warrant the use of the individual MACOM groupings. Additionally, it is recommended that cons and reps parts cost be averaged across the years when the user is exploring CERs via this tool. Looking at the years individually leads to suffering statistics, large annual variances, and skewed results (e.g., one vehicle may have 8 years of data whereas another may have 2 years of data, skewing the results toward the data point with 8 years of data). Lastly, it is recommended that the two variable power model be utilized when assessing the dataset as a whole for the following reasons: the power relationship makes the most sense when considering asymptotic trends; R^2 significantly improves when compared to the one variable power model; and this relationship provides estimations for cons and reps parts cost *per mile*, which is typically the preferred output for Army cost estimating. However, the specific CER utilized may be determined by the individual analyst in order to best suit the estimation needs.

The Tactical Vehicle Cons and Reps CER Tool is a robust tool that enables analysts to effectively explore and analyze various relationships and generate the best CER for their analyses. Providing this tool allows analysts to be just that: analysts.

5.0 Conclusion

The Tactical Vehicle Cons and Reps CER Visual Analysis Tool allows for quick comparison and contrast of various relationships, lending an ability to complete more in-depth analyses in order to determine the relationship that makes most sense for the estimation at hand. Analysts are able to have control and insight into the relationships they are building and obtain all information necessary to make the best CER selection. The result of this study is a robust tool that allows cost analysts to effectively analyze and quantify the relationship between a tactical vehicle's reliability and parts cost.

The maintenance of consistent data sources and definitions coupled with the automatically generated graphs, statistics, equations, residual analysis, and data allow the creation of meaningful CERs for subsets of tactical wheeled vehicles. The VAT facilitates this process by providing visibility in all listed areas for every selected vehicle subset.

6.0 References

1. **Technomics, Inc.** *Consumables & Reparables Cost Estimating.* January 2008.
2. **Technomics, Inc.** *Consumables & Reparables Cost Estimating.* March 2012.