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A COST-BENEFIT ANALYSIS OF THE LAV MOBILITY AND OBSOLESCENCE PROGRAM BY USING U.S. ARMY STRYKER SUSPENSIONS

June 2015

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LIST OF ACRONYMS AND ABBREVIATIONS

ANAD	Anniston Army Depot
CI	Confidence Interval
COA	Course of Action
DOD	Department of Defense
DOR	Dropout Rate
EV	Expected Value
EW	Electronic Warfare
FEDLOG	Federal Logistics
FM	Field Manual
GCE	Ground Combat Element
GDLS-C	General Dynamics Land Systems-Canada
HF	High Frequency
IROAN	Inspect/Repair Only as Necessary
LAR	Light Armored Reconnaissance
LAV	Light Armored Vehicle
LAVB	Light Armored Vehicle Battalion
MCLB	Marine Corps Logistics Base
MCWP	Marine Corps Warfighting Publication
NPS	Naval Postgraduate School
NSN	National Stock Number
NWCF	Navy Working Capital Fund
PM-LAV	Program Manager-Light Armored Vehicle
SBCT	Stryker Brigade Combat Team
SIGINT	Signals Intelligence
SME	Subject Matter Expert
TOW	Tube launched Optically tracked Wire Guided
USMC	United States Marine Corps

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First we would like to thank the Marines and Soldiers we have worked with during our respective careers. It is because of them that we continue to serve and it is our wish that this project contributes to the collective knowledge of each service in such a way that it benefits the warfighter down to the lowest level.

Many thanks are also due to PM-LAV, whom this project is meant to directly benefit. Their contributions have been invaluable to our research. Thanks especially to Russell Chestnut, Kheng Be and Major John Draper. As our primary points of contact at PM-LAV, we simply could not have finished this project without you.

Our advisors, Dr. Amilcar Menichini and Dr. Jesse Cunha, have been very helpful at every stage of our project. We greatly appreciate their knowledge, dedication and timeliness throughout the past six months. They kept us pointed in the right direction, which helped us produce sound analysis.

Lastly, we would like to thank our wives, Erica and Connie. Our sanity remains intact solely because of their unyielding love and support.

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I. INTRODUCTION

The business of the Marine Corps is to conduct wartime operations in the interests of the United States. As an organization that is the tip of the spear in sea-to-land warfare, it is imperative that the Marine Corps' equipment and weapon systems be well maintained and up to date. A weapon system that is integral in this process is the Marine Corps Light Armored Vehicle (LAV). According to the staff of the Program Manager Light Armored Vehicles (PM-LAV), at the inception of this weapon system, the intended service life was approximately 20 years (PM-LAV, 2015). They have been in service now for 32 years, with a service life extension to year 2035 (PM-LAV, 2015). To extend the service life, this platform is going to need additional upgrades and improvements to survive the battlefield environments in which the Corps is currently fighting.

The purpose of this project is to analyze the possible cost savings of using U.S. Army Stryker suspensions for the U.S. Marine Corps LAV upgrade program as compared to purchasing new components. The analysis compares the initial cost estimate provided to us by the staff of PM-LAV in 2015, of $6 million per vehicle (cost of purchasing new components for the entire LAV, not just the driveline portion covered in this paper) with alternative courses of action available to the Marine Corps via obtainable resources (Stryker vehicle parts compatible with the LAV) (PM-LAV, 2015). At the onset, it was apparent that there would be cost savings. The primary goal of our research and analysis is to produce a precise figure of cost savings as a result of using Stryker suspension components.

According to PM-LAV, the Marine Corps has done research to find which upgrades would be best for the LAV, taking into account the needs of the warfighter, capabilities necessary on the battlefield and costing options (PM-LAV, 2015). An initial cost estimate found the cost to upgrade the LAV fleet would be approximately $6 million per LAV (PM-LAV, 2015). With 960 vehicles in inventory, the cost would be over $5.75 billion. Due to the fiscal constraints of the Department of Defense (DOD) from sequestration and the monetary toll of the War on Terror, the Marine Corps has a limited budget available to undertake this project. As a result, cost-saving measures are being researched to find ways to decrease the price of this much-needed upgrade.

According to PM-LAV, the most viable cost-saving method is a joint venture between the Army and the Marine Corps (PM-LAV, 2015). During a conversation with the staff from the Stryker Program Manager's office, we were told that the Army Stryker fleet is in the process of being upgraded from a standard, flat-bottomed hull to a V-shape hull (Stryker, 2015). Due to this change, the Strykers' suspensions will also need to be upgraded to maintain their original key performance parameters (Stryker, 2015). This upgrade will remove the original suspensions and install new suspensions. Instead of discarding the original Stryker suspensions, the Marine Corps has found a purpose for them. Both the Stryker and LAV are manufactured by General Dynamics Land Systems-Canada (GDLS-C) and, as a result, have isolated part compatibility (PM-LAV). The Marine Corps will refurbish the compatible parts, which will prevent them from having to be purchased new (PM-LAV, 2015).

An initial concern regarding this program was whether or not the Army would be able to supply Strykers as quickly as the Marine Corps needed them for the upgrade. According to the Sryker Program Management staff, the Army has already commenced their upgrade program and has begun sending parts and vehicles to Marine Corps Depots in Albany, Georgia and Barstow, California (Stryker, 2015). The staff at PM-LAV tells us that the Marine Corps will start upgrading LAVs in 2017 (at approximately 120 per year) (PM-LAV, 2015). By 2017, the Army will have delivered 547 Strykers and will continue to deliver them at 120 or more per year until they have upgraded their entire fleet (Stryker, 2015). At this point, the Marine Corps will have been given 1,222 Strykers for parts refurbishment for the fleet of 960 LAVs. The possible schedule conflict between the services will not be an issue due to sufficient quantities being delivered on time.

In the interest of thoroughness, we wanted to compare the results of similar projects done in the DOD. Based on the research done by the subject matter experts at PM-LAV, a project of this sort has not been identified and we were therefore unable to compare results. There are some similarities in type/model/series refurbishments, but none that matched the parameters of our research. Comparing the costs of those projects against the LAV upgrade program is beyond the scope of our research and therefore not analyzed.

Our research analyzed four possible courses of action (COA): brand new, refurbished, new and refurbished and all refurbished by General Dynamics Land Systems Canada. The information analyzed for each of these COAs were the 17 National Stock Number (NSN) components on the Stryker vehicle driveline that were directly compatible with the LAV and their associated costs. The costs vary significantly for each component depending on the course of action taken. The four options that we used were delineated by PM-LAV in Warren, Michigan.

The first COA (COA 1) is to refurbish all of the 17 NSNs at one of three military depots: Anniston Army Depot, Marine Corps Logistics Base Albany, and Marine Corps Logistics Base Barstow. The implications of this option are that the Army will have a sufficient number of parts to refurbish and cover the LAV fleet, and the cost to refurbish the components can be calculated and assumed to be uniform, on average, for each separate component (the actual procedures for calculating refurbishment costs are explained in detail in Chapter III). We found this COA would cost the Marine Corps approximately $83,323,008.00–$83,716,934.40 with a 95% confidence.

COA 2 is to purchase all of the 17 NSNs brand new and have them installed at one of the three aforementioned military depots. These prices were calculated using piece pricing, for each component, from the Defense Logistics Agency's Federal Logistics (FedLog) website. Since we used the website the government uses to purchase parts, this option is straightforward for calculating the costs for the project. We found this COA would cost the Marine Corps approximately $336,038,937.60.

COA 3 is a combination of refurbishing Stryker parts and buying brand new parts. The reason for this option is, even with the surplus of Stryker vehicles, a combination of needs of the Army for spare Stryker parts and refurbishment dropout rates (the percentage of a certain component that will be unable to be refurbished due to damage) there was not enough of all 17 NSNs to be refurbished and cover the entire LAV fleet. The actual procedures for calculating costs for this option will be explained in detail in chapter three. We found that the only NSNs that did not have a sufficient quantity to provide for the entire fleet were the Control Arm Assembly Left and Right with Sensor and the Control Arm Assembly Left and Right. In order to compensate for this, we calculated brand new piece pricing for those NSNs and used the refurbishment prices we calculated in COA 1 for the rest of the NSNs and combined the costs. We found this COA would cost the Marine Corps approximately $88,234,698.39–$88,748,531.91 with a 95% confidence. It is necessary to note that our calculations do not include the extra funds paid to the contractors using Navy Working Capital Funds (NWCF).

COA 4 is to send all of the Stryker vehicles and LAVs to GDLS-C. General Dynamics would refurbish all of the Stryker parts. The components they are unable to refurbish will be replaced with new parts, and then installed on the LAVs. Since both of these vehicles are made by GDLS, they have the means to undertake the entire project. According to PM-LAV, General Dynamics calculated and put together a list of prices for refurbishment, new components and installation of the Mobility and Obsolescence kits (PM-LAV, 2015). With this information, we calculated this option to cost approximately $167,927,395.20.

In conclusion, we found that COA 3 will save the most money and that COA 4 will be an alternate option. The first COA is not viable because of not having enough of all the components to refurbish for all 960 LAVs. The total approximate cost savings for using COA 3 will be $247,804,239.21–$247,290,405.69 with a 95% confidence and, the total approximate cost savings for using COA 4 will be $168,111,542.40. We also gave several recommendations for future projects to help further narrow the cost range of these two options. Recommendations include calculating correlations between sub-part failures for each of the 17 components that will give a better refurbishment cost estimate. The second recommendation is to do a thorough transportation cost analysis to move the vehicles and parts to the different locations involved in the COAs. The third is to research the NWCF to compare cost information with COAs 3 and 4. These recommendations could have profound effects on the course of action the Marine Corps should take.

II. HISTORY AND LITERATURE REVIEW

A. FAMILY OF LIGHT ARMORED VEHICLES

In the late 1970s, the U.S. Marine Corps established a need for an expeditionary vehicle (Smith, 2006). They desired a vehicle that was smaller than a tank, rapidly deployable, adequately armored and had the capability of mounting a plethora of weaponry; thus came the Mobile Protected Weapons System (Smith, 2006). General Motors-Canada constructed the first eight-wheeled vehicle variant for testing (General Dynamics Land Systems-Canada now builds the LAV) (Smith, 2006). In 1980, the LAV was put through an array of tests at Marine Corps Air Ground Combat Center, Twenty-nine Palms, California (Smith, 2006). The LAV's passed all of the tests and Congress approved the appropriation for the funding of 700 light armored vehicles to General Motors-Canada in September 1982 (Smith, 2006).

Three years after the contract was awarded, the Marine Corps stood up the 2nd LAV Battalion (LAVB) at Camp Lejeune in Jacksonville, North Carolina and a few months later began receiving the first production of Light Armored Vehicles (Smith, 2006). Two additional battalions followed: the 1st LAVB at Camp Pendleton in San Diego, California, and the 3rd LAVB at Twenty-nine Palms, California. Within just four years of standing up the first battalion, the LAV units took part in their first combat engagement in 1989 during Operation Just Cause in Panama. In the years to come, the unit nomenclature would change from LAV Battalion to Light Armored Infantry Battalion and finally, in 1994, to Light Armored Reconnaissance (LAR) battalion (Smith, 2006).

1. LAR Mission and its Importance

This section draws extensively from the Marine Corps Warfighting Publication (MCWP) 3-14, Employment of the Light Armored Reconnaissance Battalion (Headquarters U.S. Marine Corps, 2009). As this reference notes, the mission of the LAR battalion is to support the Ground Combat Element (GCE) by utilizing their superior mobility and firepower to conduct combined arms reconnaissance, security and economy of force operations. The flexibility of LAR to operate as a small tactical unit or part of a much larger unit in a combined arms capacity is essential to supporting the GCE scheme of maneuver.

The biggest enemy to any force in battle is called “the fog of war” (MCWP, p. 1-1). This term refers to the unknown of the battlefield, such as enemy troop movement, terrain and weather, and any other variable that makes up that environment. The more intelligence, the easier it is for the commander to alleviate this problem and “see” the battlefield, and the higher the probability of success; this is where LAR battalions come into play. The LAR battalions bring unique abilities to the table for the GCE commander with their equipment, weaponry, flexibility and communications capabilities. To clear the fog of war, the commander needs to maintain a high degree of situational awareness. To aid with this, the LAR Battalions use a combination of personnel and diverse systems (HF communications, thermal optics, satellite positioning and communication, advanced weaponry, scouts, etc.) to provide intelligence. From this information the commander will make decisions that can affect the outcome of the engagement.

2. LAV Variants

According to PM-LAV, there are 925 LAVs stationed and/or deployed across the globe (PM-LAV, 2015). Seven variants of the LAV accomplish different missions in any clime and place. As seen in Table 1, all of the United States Marine Corps (USMC) LAV variants are listed, along with their mission, weaponry, crew and quantity available in the fleet.

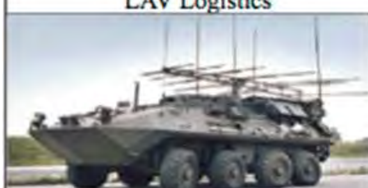
Picture and Nomenclature	Mission	Weaponry	Crew	Number of Variant
 LAV-25 *Standard Variant	Primary fighting plaform of the LAR. Can be used to transport a four man scout team.	25mm cannon, M-240 coax, pintle mounted coax	3	502
 LAV-Anti Tank	Used to defend against heavily armored threats. Each LAR Company has four of this variant to provide support to Platoons.	TOW missile launcher, M-240 machine gun	4	106
 LAV Mortar	Provides indirect fire support to LAR Companies, of which there are two in each.	81mm mortar, M-240 machine gun	5	65
 LAV Recovery	Responsible for recovering damaged vehicles in an LAR Company. Equipped with 9000 lb. boom crane and 30,000 lb. winch.	M-240 machine gun	5	45
 LAV Command and Control	Acts as a communications hub capable of interacting with any other unit, not just LAR units, in the battle space.	M-240 machine gun	2	66
 LAV Logistics	Capable of transporting personnel, equipment and ammunition to the battlefield.	M-240 machine gun	3	127
 LAV Electronic Warfare	Utilized for signals intelligence (SIGINT) and electronic warfare (EW). Specific details are classified.	M-240 machine gun	5	14

Table 1. LAV Variants and Descriptions (after PM-LAV, 2015)

The capabilities of these vehicles include speed, mission flexibility on the battlefield, firepower and utility in offensive and defensive roles. They can move between different formations, into and out of troop lines and can even back up main battle tanks (MCWP 3-14, 2009). They are air-transportable via fixed-wing aircraft as small as a C-130, can be lifted by means of an external lift using a CH-53E helicopter and, in the past have been para-dropped (MCWP 3-14, 2009). The vehicles also have amphibious capabilities, turned fully amphibious in just three minutes, and thus have the ability to traverse rivers and other waterways, increasing their flexibility (MCWP 3-14, 2009).

All the different variants of the LAV have undergone upgrades, as most military weapons systems have, from better weaponry, machine parts and armor to completely new variants of the LAV in order to take on new roles in the advanced war-fighting environment. With the existing and planned upgrades, the Marine Corps expects to extend the LAV's service life to the year 2035.

B. STRYKER FAMILY

Currently, PM-Stryker is upgrading their fleet with a different hull that has caused a need for new suspensions. The plan to upgrade the USMC fleet of LAVs is to take the used suspension components from the Strykers, refurbish them and install them on LAVs. "The SBCT infantry battalion's mission is to close with the enemy by fire and to maneuver to destroy or capture him or to repel his assault by fire, close combat, and counterattack" (Department of the Army, 2003, p. 1-1). Figure 1 displays all of the ten variants of the Army Stryker.

Figure 1. Army Stryker Variants

C. MAINTENANCE PROCESSES

Information in this section covers the maintenance process for military vehicles in the USMC as well as the economic analysis tool to calculate costs of future maintenance. These processes are important because they provide the foundation for one of our recommendations to research NWCF in order to supplement costs for COA 3. This will allow accurate comparison between COA 3 and COA 4.

1. Inspect Repair Only as Necessary Process

In learning about the Marine Corps Inspect Repair Only as Necessary (IROAN) process, a single literary source was used to gather data: An NPS Thesis, Analysis of the costs and benefits of the USMC Light Armored Vehicle Depot (IROAN) Program, written by John Ethan Smith in December of 2006. In the thesis, Smith gives an in depth explanation of how the IROAN process is used and for what purpose.

In short, the IROAN process is a depot level maintenance program. Meaning that this is where higher-level maintenance is performed. The IROAN process is also utilized when certain parameters are met with regard to vehicle age, mileage or operating hours. This process is performed in two locations: Albany, Georgia and Barstow, California.

When it has been determined that an LAV has met the criteria for its cycle in the IROAN program a thorough inspection is done on the vehicle before it is even shipped to the nearest depot. This is to ensure the depot mechanics are aware of the vehicle's deficiencies immediately when it arrives. All of the components of the vehicle are then removed at the depot in order to inspect the hull for corrosion and fractures. When the hull inspection is complete the vehicle is reassembled with repaired components if the originals were nonfunctional and it is then inspected and tested by depot personnel. The average total time for one vehicle to make it completely through this process is 150 days.

2. Economic Analysis Tools

The PM-LAV is required to provide cost estimations to justify vehicle changes and upgrades to milestone decision authorities and budgeting offices. The information and process described in this section came from Cost and Systems Analysis' Joint Assault Bridge (JAB), Armored Vehicle Launched Bridge (AVLB), and Wolverine Economic Analysis. They were tasked to develop a tool for this purpose. In order to achieve the most accurate estimate they take multiple calculable variables into account that pertain to the project. Such variables include benefit to investment ratio, operating and support cost, net present value, economic life and project life, to name a few. These variables adjust for pertinent, or relevant, costs and the benefits of program change to allow the Program Manager to discern if the benefits outweigh the costs.

The economic analysis tool Cost and Systems Analysis came up with not only gives a cost benefit analysis of a program but allows for the program to compare different variable inputs. With this capability PM-LAV is able to pictorially and graphically compare multiple alternatives for the change they want to make for the program. When the calculations are made for the different inputs PM-LAV is able to rank them in order depending on the costs and benefits for each. The Program Manager is then responsible for presenting the different alternatives to milestone authorities in the acquisitions process. Those authorities will use the outcome for each alternative and analyze where the project is going, where it is meant to go and what it is supposed to accomplish. This will also enable the acquisitions decision authorities to ensure the program achieves the end state approved by Congress.

D. SUSPENSION OVERVIEW

As mentioned earlier, the Army is currently upgrading their fleet of Stryker vehicles and needs to find a method of disposal for the parts no longer necessary. In an effort to save money, the Marine Corps has entered a joint venture, with the Army, to take ownership of the parts the Army no longer needs and that will be suitable for the LAV (Be and Petrusevski, 2015). In Figure 2, the parts that are color coded blue can be transplanted onto the LAV without being changed in any way (Be and Petrusevski, 2015).

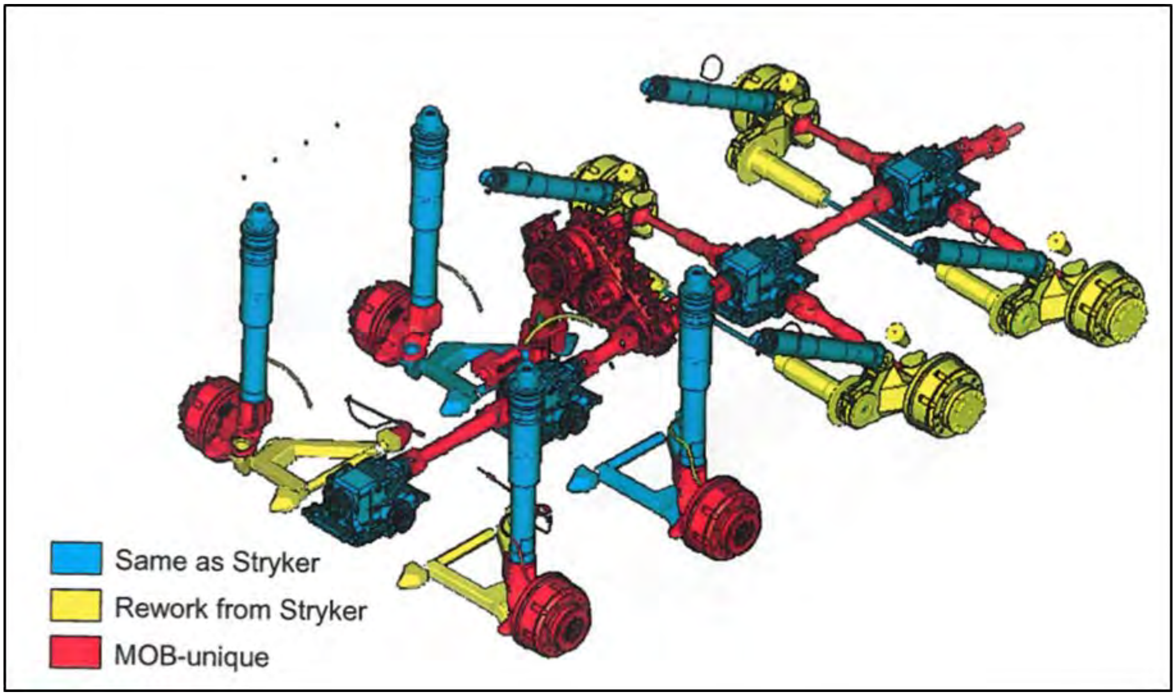


Figure 2. LAV/Stryker Suspension Comparison (from PM-LAV, 2015)

There are 17 separate Stryker NSN, components, identified previously. The remainder of this paper will discuss the cost savings of using those refurbished Stryker NSNs as opposed to buying brand new parts with those same NSN identifiers.

III. METHODOLOGY

Our goal is to determine the total cost savings so that PM-LAV can accurately forecast current and future cost savings through program completion. We will calculate total cost savings by NSN and FY so that PM-LAV will be able justify their budget and the validity of this program. The remainder of this chapter will discuss the four major COAs available to PM-LAV and the techniques we will use to find the greatest cost savings method.

A. COURSES OF ACTION

To determine total cost savings we will use a cost comparison analysis between the four different COA's available to PM-LAV and find the one with the highest cost savings. While there are four separate COAs delineated in this paper the third COA only applies to six out of the 17 total NSN components due to the high dropout rates of those components. Dropout rates will be discussed further in this chapter.

COA 1 is to refurbish Stryker components that are compatible with the LAV, without making changes to them. The refurbishment of these parts will take place at one of three military depots: Anniston Army Depot (ANAD), Marine Corps Logistics Base (MCLB) Albany and MCLB Barstow. For the purposes of our paper PM-LAV identified 17 separate NSN components that meet the COA criteria. We will use the research data gathered to calculate refurbishment cost per NSN. The refurbishment price will include these costs: removal of the component from the Stryker, repair, packaging, shipping and storage (before and after refurbishment). An alternative COA, the fourth COA, uses GDLS-C to perform all of the refurbishment as well as supplying the new components vice using any of the military depots.

COA 2 is to buy new LAV components from GDLS-C. This method provides us with a straightforward means of calculating the cost of each component from GDLS-C to manufacture, package and ship to the maintenance depots. COA two will be used if one of the following requirements is met:

1. The cost of refurbishment for an NSN meets or exceeds the cost of purchasing it new from GDLS-C, or
2. If, after COA 3 analysis, we conclude that it is cheaper to purchase all new components versus a combination of refurbished and new components.

COA 3 is a combination of both of the previous actions. There are six component NSNs the Army will not be able to either provide in the quantity needed or dropout rates will prevent supplying the quantity required; these NSNs will be identified in Chapter IV. For the purposes of our paper we are utilizing piece pricing for new components. Savings to be realized from bulk purchases of new components are beyond the scope of our research.

COA 4 is to send all the vehicles, parts and kits to GDLS-C to be refurbished and rebuilt and then shipped back to their perspective units. This option means the Marine Corps only has to send the LAVs to a single place to be worked on and can possibly simplify shipping. One issue is that we do not know what price GDLS-C quoted covers (i.e. if it is purely refurbishment cost or do they also include profit margin and overhead as well). This matter is covered later in the paper.

B. DATA SOURCES AND CALCULATIONS

Subject matter experts (SMEs) from MCLB Albany and Barstow provided the data we will use to analyze costs regarding the LAV. The data used to analyze costs related to the Stryker is provided by SMEs at ANAD. Also, data relative to the structure of the program and partnership between the Army and the Marine Corps comes from the Program Management offices of PM-LAV and PM-Stryker, both located in Warren, Michigan.

Using Stryker materials for the upgrade instead of purchasing new components will obviously reveal cost savings. Our calculations will include labor hour rates (will be dependent upon location), piece pricing for brand new components per the Defense Logistics Agency’s Federal Logistics (FEDLOG) pricing and component refurbishment pricing (the costs for inventory, packaging and shipping).

The Marine Corps has a fleet of 960 LAVs needing to be upgraded (PM-LAV, 2015). The Army is expected to deliver 1,222 Stryker’s to harvest components for the refurbishment process (Stryker, 2015). These numbers provide the Marine Corps with an overage of inventory to compensate for component dropout rates. For the purposes of our paper we have isolated 17 NSNs for the LAV 3.5 driveline system. Those NSNs are:

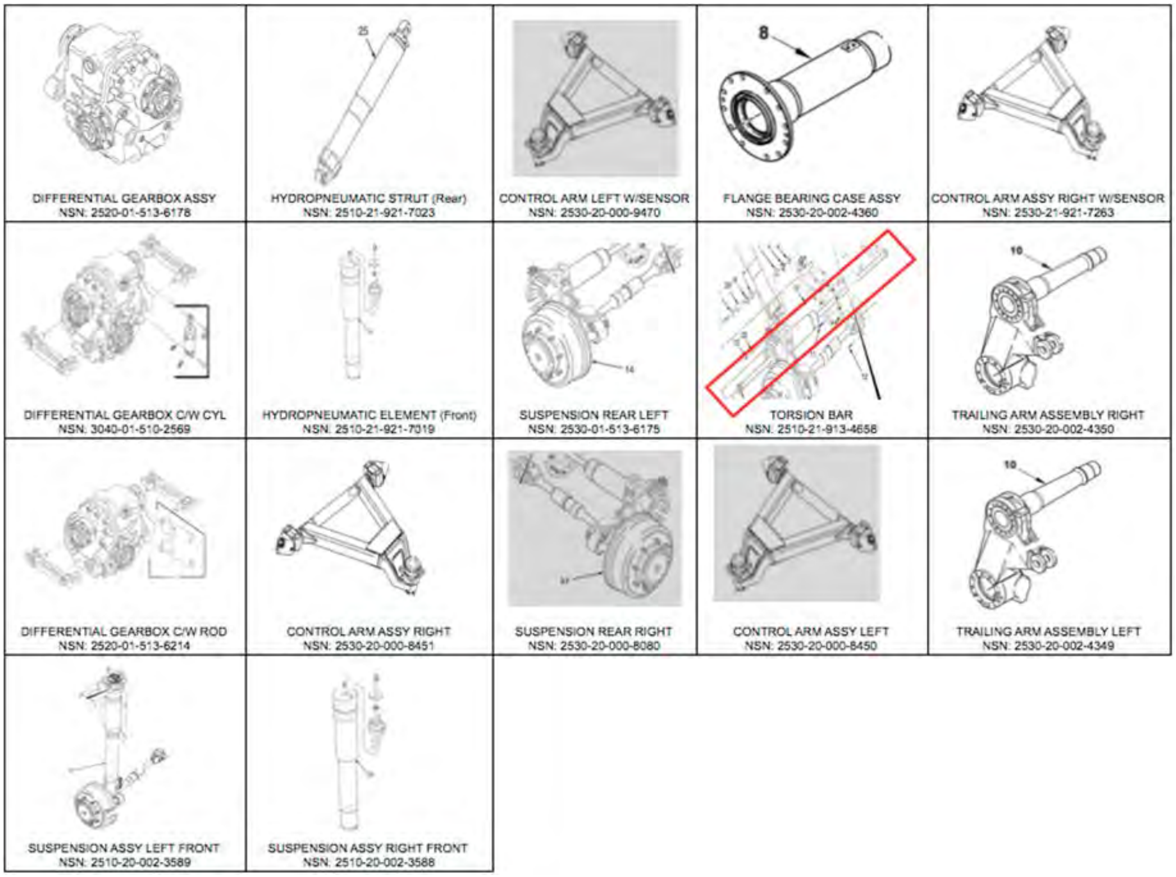


Table 2. Component NSNs (after PM-LAV, 2015)

In addition to the data for the NSNs, we were also provided labor rates provided to us by PM-LAV and Stryker (rates based on extrapolations, company policy forbid us from getting exact figures): $110 per hour at ANAD and $89.10/hour at Albany and $110.59 per hour at Barstow (PM-LAV and Stryker, 2015). Tooling lists and costs were also supplied but those figures were determined to be a sunk cost; with the exception of tools given to USMC which are cost savings and will be added at the end. We used the information in Figures 3 (the price for each NSN brand new) and 4 (labor hours to refurbish each NSN) to aid in our calculations.

BRAND NEW PARTS COST			
DESCRIPTION	QTY PER USMC VEH	FEDLOG PRICE	TOTAL PER VEH
DRIVE LINE			
DIFFERENTIAL GEARBOX ASSY	4	$12,565.00	$50,260.00
DIFFERENTIAL GEARBOX C/W CYL	3	$22,020.00	$66,060.00
DIFFERENTIAL GEARBOX C/W ROD	1	$13,524.00	$13,524.00
FRONT SUSPENSION			
SUSPENSION ASSY LEFT FRONT	2	$20,004.00	$40,008.00
SUSPENSION ASSY RIGHT FRONT	2	$17,944.00	$35,888.00
HYDROPNEUMATIC STRUT (Rear)	4	$6,327.00	$25,308.00
HYDROPNEUMATIC ELEMENT (Front)	4	$8,450.00	$33,800.00
CONTROL ARM ASSY RIGHT	1	$2,120.00	$2,120.00
CONTROL ARM ASSY RIGHT W/SENSOR	1	$2,976.00	$2,976.00
CONTROL ARM ASSY LEFT	1	$2,286.00	$2,286.00
CONTROL ARM LEFT W/SENSOR	1	$2,905.00	$2,905.00
REAR SUSPENSION			
SUSPENSION REAR LEFT	2	$12,332.00	$24,664.00
SUSPENSION REAR RIGHT	2	$11,147.00	$22,294.00
TRAILING ARM ASSEMBLY RIGHT	2	$1,055.00	$2,110.00
TRAILING ARM ASSEMBLY LEFT	2	$1,461.00	$2,922.00
FLANGE BEARING CASE ASSY	4	$926.00	$3,704.00
TORSION BAR	2	$728.00	$1,456.00
Total			$332,285.00

Figure 3. Cost to Buy NSNs New (after Stryker, 2015)

A&R REPAIR & OVERHAUL TIMES SCHEDULE				
	REPAIR TIMES/PHASE OF THE R&O PROCESS			
R&O CANDIDATE	DISSASSEMBLE, CLEAN, INSPECT & ORDER PARTS HRS	ASSEMBLY HRS	TEST & PACKAGING HRS	TOTAL HRS
DIFFERENTIAL GEARBOX C/W CYL	4	6.5	2	12.5
DIFFERENTIAL GEARBOX ASSY	4	6.5	2	12.5
DIFFERENTIAL GEARBOX C/W ROD	6	7.5	2	15.5
SUSPENSION ASSY LEFT FRONT	4	8	2	14
SUSPENSION ASSY RIGHT FRONT	4	8	2	14
SUSPENSION REAR LEFT	4	8	2	14
SUSPENSION REAR RIGHT	4	8	2	14
CONTROL ARM ASSEMBLY W/S (R)	1	2	0.5	3.5
CONTROL ARM ASSEMBLY W/S (L)	1	2	0.5	3.5
CONTROL ARM ASSEMBLY (R)	1	1.5	0.5	3
CONTROL ARM ASSEMBLY (L)	1	1.5	0.5	3
TRAILING ARM ASSEMBLY RIGHT	1	2	1	4
TRAILING ARM ASSEMBLY LEFT	1	2	1	4
FLANGE BEARING CASE ASSY	1	1	1	3
TORSION BAR	0.5	1	0.5	2
HYDROPNEUMATIC STRUT (Rear)	Done by GDLS-C			
HYDROPNEUMATIC ELEMENT (Front)	Done by GDLS-C			

Figure 4. Refurbishment Times by NSN (after Stryker, 2015)

With regard to the refurbished components, there will be some that are declared unusable due to severe wear and tear and will therefore contribute to that component's dropout rate (DOR), which will be expressed as a percentage. For example, if a DOR is 10%, for every 100 pieces of that component, ten of them will not be usable. The DOR for each component will vary and some will not have a DOR associated due to the percentage being so small it is insignificant. The percentages given in Figure 5 are estimations given to us by ANAD (Stryker, 2015) but according to their company policies they were unable to tell us exactly how they arrived at those figures.

DROP OUT RATES BY NSN	
Description	**DOR**
DIFFERENTIAL GEARBOX ASSY	NA
DIFFERENTIAL GEARBOX C/W CYL	1%
DIFFERENTIAL GEARBOX C/W ROD	1%
SUSPENSION ASSY LEFT FRONT	3%
SUSPENSION ASSY RIGHT FRONT	3%
HYDROPNEUMATIC STRUT (Rear)	NA
HYDROPNEUMATIC ELEMENT (Front)	NA
CONTROL ARM ASSY RIGHT	50%
CONTROL ARM ASSY RIGHT W/SENSOR	25%
CONTROL ARM ASSY LEFT	50%
CONTROL ARM LEFT W/SENSOR	25%
SUSPENSION REAR LEFT	3%
SUSPENSION REAR RIGHT	3%
TRAILING ARM ASSEMBLY RIGHT	1%
TRAILING ARM ASSEMBLY LEFT	1%
FLANGE BEARING CASE ASSY	NA
TORSION BAR	NA

Figure 5. DOR by NSN (after Stryker, 2015)

These rates will come into play when deciding between which COA to use. There are several NSN's that have a high dropout rate that will force those component costs to be calculated using the third COA. This is due to there not being enough available components to refurbish to cover the entire LAV fleet.

To calculate a cost for a brand new component the process is to simply cross check the FEDLOG for the price to purchase the component from the factory. This price will be taken and multiplied by the number needed for each LAV and then multiplied once again by the total number needed for the fleet. For example, if we needed to purchase brand new flange bearing case assemblies for 450 LAVs we know from the data given in Figure 3 there are 4 required per LAV. The FEDLOG price is $926.00 so the formula would be:

- $926.00 x 4 per LAV x 450 LAVs = $1,666,800.00

This portion of the calculations is straightforward since we are using a piece pricing method for bulk buying of new parts.

The method we will use to calculate the range of costs for refurbishing components is more involved. The first piece of information needed is to find all the pieces that can be changed out when one of the main components is being refurbished. The next part is to find the cost for each of those smaller individual parts, or sub-parts. The third part of this data is to use the history of these parts being refurbished in order to establish a percentage of the time each of these sub-parts is changed when refurbishing the larger component. It should be obvious that the longer the period of time this process is observed the more accurate these percentages will be. For our purposes we used 100% or less (meaning will always be changed, normally this is because the part is destroyed when the component is disassembled, i.e., an oil seal), 50% or less, 25% or less and 5% or less. These percentages represent the amount of time the parts were changed, this is important to note because we will also need to use the percentage of the time each part was not replaced to find the variance later.

After we have established the price and the percentage of the times replaced for each sub-part we multiply those numbers together to get an Expected Value (EV) for that individual sub-part. That means the answer is an average of the cost that sub-part incurs over time. Next we find the variance, which is done by subtracting the parts changed percentage from 1 to get the percentage of the time the parts are not changed (i.e. 1–25% of time part changed = 75% of time part not changed). Now that we have the number of each sub-part needed per component, price of that part and percentages for times that part is and is not changed we will multiply all four of those numbers together to find the variance in the price, over time (i.e., 2 sub-parts x $29.74 sub-part cost x 25% of time part is changed x 75% of time part is not changed = $5.58 variance in the cost of this sub-part over time). This process is done for each sub-part for each of the 17 NSNs.

Now we have the EV and variance for all of the sub-parts for each NSN. The next step is to calculate the EV, variance and standard deviation for each NSN from the previous calculations. To get the Expected Value and variance is simple. We added all the EVs and variances from the sub-parts for each individual NSN. From there we calculated the standard deviation by taking the square root of the total variance for the NSN (so we added up all the sub-part variance numbers and then took the square root). From here we had to make some assumptions in order to stay within the scope of our research. The first assumption is that the need to replace a sub-part is independent from the other sub-parts (not a very strong assumption but to be able to correlate each sub-parts failure rates and all affected parts for each NSN is a recommendation for a thesis topic by itself) and the second assumption is that the failure rate is normally distributed (again not a strong assumption but this feeds into the aforementioned recommendation).

With these assumptions made we were able to use confidence intervals to calculate an EV range for each of the 17 NSNs. We did this by using the EV as our mean, the standard deviation for the NSN and then calculated a 95% confidence interval to show the range of possible Expected Values for each NSN to be refurbished. After we calculated the confidence intervals for all 17 NSNs separately we needed to get a cost range for the whole project. To do this we simply added all the Expected Values together then all the variances together and took the square root to get the standard deviation for the whole driveline. Then we followed the same format as described previously for the individual NSNs. We used EV as our mean, the standard deviation and calculated a 95% confidence interval to find the total estimated range of possible costs for the driveline refurbishment with 95% confidence. After calculating the refurbishment price range for each component we then have to add the cost for labor hours. Using the hours for refurbishment completion in Figure 4 and the three possible labor rates, at Anniston, Albany or Barstow, we will arrive at the total possible cost range for each component. We averaged the three labor rates together so that we would only have one price range to work with. Since the rates are so far apart and the Marine Corps will be sending vehicles to all three locations using all three rates would create a much larger price range. We can justify the averaging of the rates because of the large discrepancy between them and doing this will provide the more accurate and realistic price range.

In our research, we are making several more assumptions to perform the necessary analysis. These assumptions will allow us to perform the analysis in a timely manner without searching for information that was not critical to the research accuracy.

First, we assumed that there are only 17 NSNs to evaluate. While there are more NSNs associated with the Stryker, we are only analyzing the ones compatible with the LAV suspension systems without any change. The next assumption is that when a part is refurbished, it is as good as new. According to the SMEs at PM-LAV, this is not only an assumption but also a fact. When a component is refurbished, it is as good as one newly manufactured. Due to the amount of Stryker components available as well as the taking the DOR into consideration, we are assuming that 11 of the 17 NSNs will not need to be purchased new. The cost for the remaining six NSNs will only be calculated using the third and fourth COA's since they will need to refurbish the parts available and purchase the rest new.

We further assumed to use piece pricing for all components purchased new from GDLS-C. This is an assumption based on there being a potential cost savings associated with buying in bulk. Should reduced pricing be available, it will simply add to the cost savings. Our final major assumption deals with the utilization of GDLS-C as location for refurbishing components. It is assumed that GDLS-C has the necessary tooling needed for refurbishing Stryker components for installation onto LAVs. This is a significant assumption as it justifies reducing all costs for tool purchase to zero.

IV. ANALYSIS

For the purposes of this project, "refurbished" simply means that the part has been rebuilt and/or retooled (not a new part) to what is known as Condition Code Bravo. When a part is bought brand new it is Condition Code Alpha and the fact the part is brand new is the only thing that distinguishes Code Alpha from Code Bravo. During our analysis we identified sub-parts that would be replaced to bring the component up to Condition Code Bravo. Then we calculated an approximate rate that each sub-part failed and needed to be replaced during refurbishment; 100%, 50%, 25% or 5% (see Table 3).

There are 50 sub-parts for the Differential Gearbox Assembly that can or will be changed during the refurbishment process. First, we calculated the Expected Value of the price for each sub-part. Then we added all 50 answers together to get the total EV of the refurbishment over time. Next we calculated the variance of the price for each sub-part and then added those together for a total variance, assuming a Bernoulli distribution. The formulas we used were:

- Quantity per Assembly x (Price x % of the time part replaced) = EV
- Quantity per Assembly x Price x % of time part replaced x % of time part not replaced = Variance

Then we took the square root of total variance to get the standard deviation. Finally, we used a 95% confidence interval to find the cost range for each component using the total Expected Value and its standard deviation.

Ser	Part Number	Description	EV	Variance	Std Dev
1	10501062	Spacer	$4.05	$3.03	$1.74
2	10501064	Spacer	$2.55	$1.91	$1.38
3	10501065	Compensation Disc	$44.30	$0.00	$0.00
4	10501066	Shaft Seal	$4.65	$3.49	$1.87
5	10501067	Shift Yoke	$45.75	$34.31	$5.86
6	10501068	Shoe	$29.10	$21.82	$4.67
7	10501069	Gearshift Collar	$47.89	$35.92	$5.99
8	10501071	Sealing Expanding Cap	$6.10	$4.57	$2.14
9	10501072	Lever	$19.92	$14.94	$3.86
10	10501075	Supporting Ring	$10.51	$7.88	$2.81
11	10501613	Pin	$3.52	$1.76	$1.33
12	10501745	Circlip	$3.68	$0.00	$0.00
13	10501748	Seal Oil	$34.17	$0.00	$0.00
14	10501749	Seal Oil	$34.17	$0.00	$0.00
15	10501765	Sealing Ring	$1.28	$0.00	$0.00
16	10501786	Bearing Cone	$16.44	$8.22	$2.87
17	10501787	Bearing Cone	$16.71	$8.36	$2.89
18	10501788	Bearing Cup	$9.28	$4.64	$2.15
19	10501789	Bearing Cup	$8.11	$4.06	$2.01
20	10501790	Bearing Cup	$5.89	$2.94	$1.72
21	10501791	Bearing Cone	$10.07	$5.03	$2.24
22	10501795	Plug Hex Head	$2.03	$1.02	$1.01
23	10501796	Sealing Ring	$0.74	$0.00	$0.00
24	10501802	Bearing Ball	$25.58	$12.79	$3.58
25	10501804	Bearing Ball	$72.02	$36.01	$6.00
26	10501805	Cap Push-In Sealing	$2.04	$0.00	$0.00
27	10501806	Supporting Ring	$0.37	$0.27	$0.52
28	10501817	Key Parallel	$0.19	$0.10	$0.31
29	10503049	Washer	$0.02	$0.02	$0.12
30	10617803	Threaded Rivet	$0.80	$0.00	$0.00
31	10617937	Bearing Housing	$9.95	$9.45	$3.07
32	10617938	Plug Screw	$0.18	$0.09	$0.30
33	10617949	Bearing Housing	$15.95	$15.15	$3.89
34	10617976	Cover	$97.50	$73.13	$8.55
35	10617977	Self-Locking Diff	$69.25	$65.79	$8.11
36	10617979	Taper Roller Bearing Cup	$18.79	$9.40	$3.07
37	10617986	Taper Roller Bearing Cup	$18.79	$9.40	$3.07
38	10617987	Cone, Taper Roller Bearing	$17.31	$8.65	$2.94
39	10618013	Shim Ring Set	$26.66	$13.33	$3.65
40	10618014	Shim Ring Set	$11.22	$5.61	$2.37
41	10618016	Shim Ring Set	$17.61	$8.81	$2.97
42	10618024	Oil Sight Glass	$13.77	$10.33	$3.21
43	10618025	Shim Ring Set	$6.47	$3.24	$1.80
44	10618039	Washer	$40.30	$30.23	$5.50
45	10624805	Washer, Wave Type	$2.45	$0.00	$0.00
46	10624806	Washer, Wave Type	$13.02	$0.00	$0.00
47	10624812	Nut Hex Thin	$2.00	$1.00	$1.00
48	10624893	Bolt Hexagon Head	$0.92	$0.46	$0.68
49	10624894	Bolt Hex Head	$0.46	$0.23	$0.48
50	10624897	Screw Hex Head	$5.46	$2.73	$1.65
			$849.94	$480.08	$21.91

Table 3. Differential Gearbox Assembly (after PM-LAV, 2015)

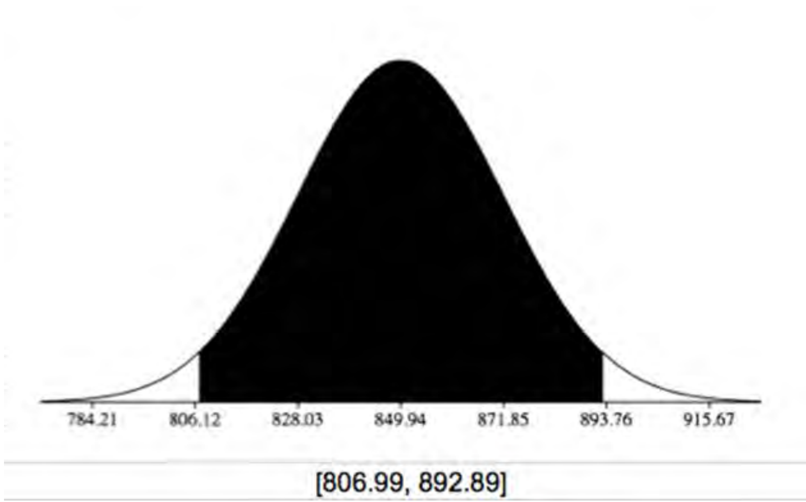


Figure 6. Differential Gearbox Assembly 95% Confidence Interval

The price range for the Differential Gearbox Assembly was calculated to be $806.99–$892.89 as depicted in Figure 7. The labor rates for Anniston, Albany and Barstow are, respectively, $110, $89.10 and $110.59 with a mean of $103.23. Per Figure 5, in Chapter III, the labor hours to refurbish this component totaled 12.5 hours. Using the formula:

- Mean hourly rate x total labor hours = Labor dollars
- (Labor dollars + $806.99) to (Labor dollars + $892.89) = $2,097.37–$2,183.27

This new price range, with 95% confidence, represents the approximate cost of refurbishment per component. One of these components is required per vehicle and the USMC has 960 LAVs in their fleet. We determined the fleet cost by finding the product of the number of LAVs and the price range:

- (Number of LAVs x $2,097.37) to (Number of LAVs x $2,183.27) = $2,013,470.40–$2,095,934.40

This data is presented in Table 4 as well as the data for the remaining components. We were unable to gather the data required to assign a price range for five components: Suspension assembly right and left front, trailing arm assembly right and left and the flange bearing case assembly. The prices noted for them are a single price calculated from an average of the recent history of those parts being refurbished, the actual number of refurbishments is unknown. Another piece that does not have a range is the torsion bar because it is a single, solid piece that only requires labor hours to disassemble, clean and inspect and then reassemble. The hydropneumatic strut and hydropneumatic element are always refurbished by GDLS-C and cost a standard price to refurbish each time. The fleet pricing is then calculated using 960 LAVs (number of LAVs in the Marine Corps fleet). This was our process for COA 1.

Using the information in Table 5, we calculated the costs to buy the parts brand new from the Defense Logistics Agency’s FedLog prices. These prices do not include labor hours to assemble and install. We used the same labor hours for refurbishment and multiplied it by the total LAVs in the Marine Corps fleet and then added that to the cost of purchasing all new parts:

- (Labor Hour Dollars/LAV x Total LAVs) + New Parts Cost = Total Cost
- ($17,755.56 x 960) + $318,993,600 = $336,038,937.60

This number represents the total cost of purchasing and installing brand new parts for the LAV 3.5 Driveline system for COA 2.

In Table 6, the dropout rates listed for each NSN are what we used to calculate the number of components projected to be available. The numbers in this table are based on the Army delivering 1222 Strykers to the Marine Corps and then adjusting for how many components are needed per vehicle. Some components have such a low DOR it was insignificant but others were very high. The red numbers on Table 6 represent the number of that component the Marine Corps will need to buy new in order to have the requisite parts for all 960 LAVs. Due to the high dropout rates for the four types of control arm assemblies there are an insufficient number to refurbish and accommodate the fleet, therefore new components must be bought to supplement the remainder needed. Table 7 calculates the price for the brand new parts using labor hours, new part cost and number of parts needed.

Since there are not enough components to refurbish for the entire fleet, Table 8 includes the new part cost calculations with the refurbished parts cost. We adjusted the refurbish cost of the control arms to reflect the amount available to be refurbished and then calculated the total refurbishment cost. Then we took the cost we calculated for the new parts in Table 7 and added that to both sides of the range to arrive at our new total cost for COA 3.

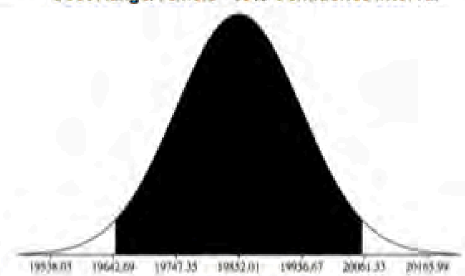
For COA 4, we used figures given to us by General Dynamics Land Systems-Canada (Table 9) to calculate the cost of this option. It should be noted that Canada/US contract laws stipulate that Canadian companies are not obligated to disclose all separate costs within the total quoted cost. This means that we do not know if the prices GDLS-C sent us include transportation costs, overhead and labor rates and so on. The only way to compare this COA and COA 3 for cost effectiveness is to research the NWFC to see how much PM-LAV receives from them to pay overhead rates for the civilian workers at the military depots and add that cost to the total for COA 3. Without this comparison it is not possible to know which of the options is the best.

Part	EV	Variance	Std Dev	Qty	Adj EV	Adj Var	Std Dev	Labor Hours	Labor/Part	Labor/Veh
DIFFERENTIAL GEARBOX C/W CYL	$3,189	$1,793		3	$9,567	$5,378		12.5	$1,290	$3,871
DIFFERENTIAL GEARBOX ASSY	$850	$480		4	$3,400	$1,920		12.5	$1,290	$5,162
DIFFERENTIAL GEARBOX C/W ROD	$3,197	$1,798		1	$3,197	$1,798		15.5	$1,600	$1,600
SUSPENSION REAR RIGHT	$420	$205		2	$840	$410		14	$1,445	$2,890
SUSPENSION REAR LEFT	$420	$205		2	$840	$410		14	$1,445	$2,890
CONTROL ARM ASSY RIGHT W/SENSOR	$676	$358		1	$676	$358		3.5	$361	$361
CONTROL ARM LEFT W/SENSOR	$676	$358		1	$676	$358		3.5	$361	$361
CONTROL ARM ASSY RIGHT	$329	$160		1	$329	$160		3	$310	$310
CONTROL ARM ASSY LEFT	$329	$160		1	$329	$160		3	$310	$310
Totals	$10,085	$5,518	$74.29		**$19,852**	**$10,954**	**$104.66**		**$8,413**	**$17,756**

Cost Range/NSN - 95% Confidence Interval

[9939.232, 10230.508]

Cost Range/Vehicle - 95% Confidence Interval



[19646.84, 20057.18]

Part	Cost Range/NSN			Qty/Vehicle	Cost Range/Vehicle			Fleet Cost		
DIFFERENTIAL GEARBOX C/W CYL										
DIFFERENTIAL GEARBOX ASSY										
DIFFERENTIAL GEARBOX C/W ROD										
SUSPENSION REAR RIGHT										
SUSPENSION REAR LEFT	$18,352	to	$18,644		$37,402	to	$37,813	$35,906,304	to	$36,300,230
CONTROL ARM ASSY RIGHT W/SENSOR										
CONTROL ARM LEFT W/SENSOR										
CONTROL ARM ASSY RIGHT										
CONTROL ARM ASSY LEFT										
SUSPENSION ASSY RIGHT FRONT		$3,500		2		$7,001			$6,720,826	
SUSPENSION ASSY LEFT FRONT		$3,500		2		$7,001			$6,720,826	
TRAILING ARM ASSEMBLY RIGHT		$1,104		2		$2,209			$2,120,410	
TRAILING ARM ASSEMBLY LEFT		$1,104		2		$2,209			$2,120,410	
FLANGE BEARING CASE ASSY		$1,357		4		$5,429			$5,211,533	
TORSION BAR		$206		2		$413			$396,403	
HYDROPNEUMATIC STRUT		$2,851		4		$11,404			$10,947,533	
HYDROPNEUMATIC ELEMENT		$3,432		4		$13,728			$13,178,765	
Totals					$86,795	to	$87,205	**$83,323,008**	**to**	**$83,716,934**
Total Vehicles in Fleet	960									

*All costs include the labor hour rate of $103.23 and Fleet Costs are based on Total Vehicles in Fleet

**All numbers in the graph are rounded to nearest dollar, costs in paper are actual cost estimates.

Table 4. Refurbishment Cost (COA 1)

PARTS NEEDED PM LAV				
DESCRIPTION	QTY PER USMC VEH	FEDLOG PRICE	TOTAL PER VEH	FLEET COST
DRIVE LINE				
DIFFERENTIAL GEARBOX ASSY	4	$12,565.00	$50,260.00	$48,249,600.00
DIFFERENTIAL GEARBOX C/W CYL	3	$22,020.00	$66,060.00	$63,417,600.00
DIFFERENTIAL GEARBOX C/W ROD	1	$13,524.00	$13,524.00	$12,983,040.00
FRONT SUSPENSION				
SUSPENSION ASSY LEFT FRONT	2	$20,004.00	$40,008.00	$38,407,680.00
SUSPENSION ASSY RIGHT FRONT	2	$17,944.00	$35,888.00	$34,452,480.00
HYDROPNEUMATIC STRUT (Rear)	4	$6,327.00	$25,308.00	$24,295,680.00
HYDROPNEUMATIC ELEMENT (Front)	4	$8,450.00	$33,800.00	$32,448,000.00
CONTROL ARM ASSY RIGHT	1	$2,120.00	$2,120.00	$2,035,200.00
CONTROL ARM ASSY RIGHT W/SENSOR	1	$2,976.00	$2,976.00	$2,856,960.00
CONTROL ARM ASSY LEFT	1	$2,286.00	$2,286.00	$2,194,560.00
CONTROL ARM LEFT W/SENSOR	1	$2,905.00	$2,905.00	$2,788,800.00
REAR SUSPENSION				
SUSPENSION REAR LEFT	2	$12,332.00	$24,664.00	$23,677,440.00
SUSPENSION REAR RIGHT	2	$11,147.00	$22,294.00	$21,402,240.00
TRAILING ARM ASSEMBLY RIGHT	2	$1,055.00	$2,110.00	$2,025,600.00
TRAILING ARM ASSEMBLY LEFT	2	$1,461.00	$2,922.00	$2,805,120.00
FLANGE BEARING CASE ASSY	4	$926.00	$3,704.00	$3,555,840.00
TORSION BAR	2	$728.00	$1,456.00	$1,397,760.00
Subtotals			$332,285.00	
Total				$318,993,600.00

Table 5. New Parts Purchase Cost (COA 2) (after PM-LAV, 2015)

Part Name	# in Stryker Fleet (1222)	# per vehicle	DOR	# Adjusted after DOR	# Needed by USMC (960)	Buy New or Excess
Differential Gearbox C/W CYL	3666	3	1%	3629.34	2880	749.34
Differential Gearbox Assy	4888	4	0%	4888	3840	1048
Differential Gearbox C/W Rod	1222	1	1%	1209.78	960	249.78
Suspension Rear Right	2444	2	3%	2370.68	1920	450.68
Suspension Rear Left	2444	2	3%	2370.68	1920	450.68
Suspension Assy Right Front	2444	2	3%	2370.68	1920	450.68
Suspension Assy Left Front	2444	2	3%	2370.68	1920	450.68
Control Arm Assembly R w/sensor	1222	1	25%	916.5	960	-43.5
Control Arm Assembly L w/sensor	1222	1	25%	916.5	960	-43.5
Control Arm Assembly R	1222	1	50%	611	960	-349
Control Arm Assembly L	1222	1	50%	611	960	-349
Trailing Arm Assembly Right	2444	2	1%	2419.56	1920	499.56
Trailing Arm Assembly Left	2444	2	1%	2419.56	1920	499.56
Flange Bearing Case Assy	4888	4	0%	4888	3840	1048
Torsion Bar	2444	2	0%	2444	1920	524
Hydrop Strut	4888	4	0%	4888	3840	1048
Hydrop Element	4888	4	0%	4888	3840	1048

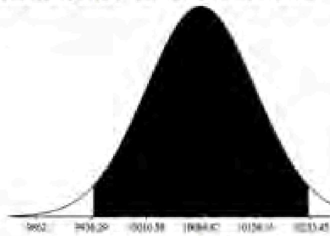
Table 6. Dropout Rates (after Stryker, 2015)

Part Name	# to Purchase	Purchase Price	Labor Hours	Total
Control Arm Assembly R w/sensor	44	$2,976.00	3.5	$453,096.00
Control Arm Assembly L w/sensor	44	$2,905.00	3.5	$442,286.25
Control Arm Assembly R	349	$2,120.00	3.0	$2,219,640.00
Control Arm Assembly L	349	$2,286.00	3.0	$2,393,442.00
Total				**$5,508,464.25**

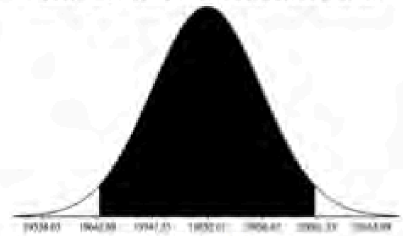
Table 7. COA 3 New Part Cost (after Stryker, 2015)

Part	EV	Variance	Std Dev	Qty	Adj EV	Adj Var	Std Dev	Labor Hours	Labor/Part	Labor/Veh
DIFFERENTIAL GEARBOX C/W CYL	$3,189	$1,793		3	$9,567	$5,378		12.5	$1,290	$3,871
DIFFERENTIAL GEARBOX ASSY	$850	$480		4	$3,400	$1,920		12.5	$1,290	$5,162
DIFFERENTIAL GEARBOX C/W ROD	$3,197	$1,798		1	$3,197	$1,798		15.5	$1,600	$1,600
SUSPENSION REAR RIGHT	$420	$205		2	$840	$410		14	$1,445	$2,890
SUSPENSION REAR LEFT	$420	$205		2	$840	$410		14	$1,445	$2,890
CONTROL ARM ASSY RIGHT W/SENSOR	$676	$358		1	$676	$358		3.5	$361	$361
CONTROL ARM LEFT W/SENSOR	$676	$358		1	$676	$358		3.5	$361	$361
CONTROL ARM ASSY RIGHT	$329	$160		1	$329	$160		3	$310	$310
CONTROL ARM ASSY LEFT	$329	$160		1	$329	$160		3	$310	$310
Totals	$10,085	$5,518	$74.29		**$19,852**	**$10,954**	**$104.66**		**$8,413**	**$17,756**

Cost Range/NSN - 95% Confidence Interval



Cost Range/Vehicle - 95% Confidence Interval

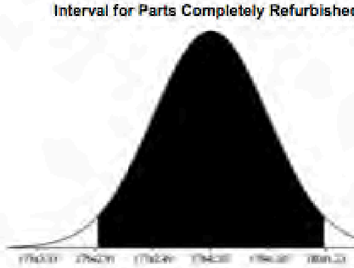


Part	Cost Range/NSN	Qty/Vehicle	Cost Range/Vehicle	Fleet Cost
DIFFERENTIAL GEARBOX C/W CYL				
DIFFERENTIAL GEARBOX ASSY				
DIFFERENTIAL GEARBOX C/W ROD				
SUSPENSION REAR RIGHT				
SUSPENSION REAR LEFT	$18,352 to $18,644		$37,402 to $37,813	$35,309,530 to $35,823,364
CONTROL ARM ASSY RIGHT W/SENSOR				
CONTROL ARM LEFT W/SENSOR				
CONTROL ARM ASSY RIGHT				
CONTROL ARM ASSY LEFT				
SUSPENSION ASSY RIGHT FRONT	$3,500	2	$7,001	$6,720,826
SUSPENSION ASSY LEFT FRONT	$3,500	2	$7,001	$6,720,826
TRAILING ARM ASSEMBLY RIGHT	$1,104	2	$2,209	$2,120,410
TRAILING ARM ASSEMBLY LEFT	$1,104	2	$2,209	$2,120,410
FLANGE BEARING CASE ASSY	$1,357	4	$5,429	$5,211,533
TORSION BAR	$206	2	$413	$396,403
HYDROPNEUMATIC STRUT	$2,851	4	$11,404	$10,947,533
HYDROPNEUMATIC ELEMENT	$3,432	4	$13,728	$13,178,765
Control Arm New Parts Cost	**$5,508,464**		$86,795 to $87,205	$82,726,234 to $83,240,068
Totals				$88,234,698 to $88,748,532
Total Vehicles in Fleet	960			

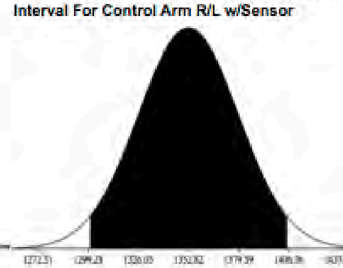
*All costs include the labor hour rate of $103.23 and Fleet Costs are based on Total Vehicles in Fleet

**All four Conrol Arm Assembly fleet refurbish costs are based off of having 916, 916, 611 and 611 parts respectively. Totals include buying rest of Control Arms brand new. All numbers are rounded to nearest dollar.

Interval for Parts Completely Refurbished



Interval For Control Arm R/L w/Sensor



Interval for Control Arm R/L

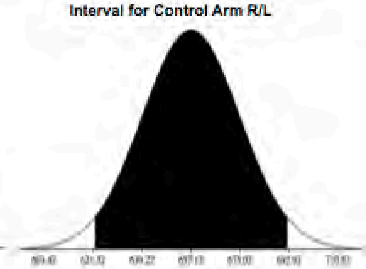


Table 8. Refurbished and New Part Cost (COA 3)

GDLS-C FLEET COST INFORMATION			
Part	**Cost/NSN**	**Qty/Vehicle**	**Cost/Vehicle**
DIFFERENTIAL GEARBOX C/W CYL		3	$27,354.13
DIFFERENTIAL GEARBOX ASSY	$1,952.54	4	$7,810.16
DIFFERENTIAL GEARBOX C/W ROD		1	$9,118.04
SUSPENSION REAR RIGHT		2	$22,939.21
SUSPENSION REAR LEFT		2	$22,939.21
CONTROL ARM ASSY RIGHT W/SENSOR		2	$1,707.98
CONTROL ARM LEFT W/SENSOR		2	$1,707.98
CONTROL ARM ASSY RIGHT		1	$1,541.07
CONTROL ARM ASSY LEFT		1	$1,541.07
SUSPENSION ASSY RIGHT FRONT		1	$22,765.61
SUSPENSION ASSY LEFT FRONT		1	$22,765.61
TRAILING ARM ASSEMBLY RIGHT	$691.46	2	$1,382.92
TRAILING ARM ASSEMBLY LEFT	$691.46	2	$1,382.92
FLANGE BEARING CASE ASSY	$1,047.48	4	$4,189.92
TORSION BAR		2	$646.96
HYDROPNEUMATIC STRUT		4	$11,403.69
HYDROPNEUMATIC ELEMENT		4	$13,727.89
Subtotal			$174,924.37
Total			$167,927,395.20

*Cost for Diff Grbox Assy, Trailing Arm Assy L/R and the Flange Brng Case Assy info came from Anniston Army Depot. GDLS-C did not give the info for these NSNs.

**Total was calculated based on the 960 total LAVs the Marine Corps will purchase.

***GDLS-C is not required to release the information regarding what each price consists of so we were able to break down the pricing.

Table 9. General Dynamics Land Systems-Canada Cost Information (after PM-LAV, 2015)

V. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSIONS

The priority of the United States Marine Corps is to maintain its edge in combat. To do this the need for flexibility and maneuverability on the battlefield is paramount. The Light Armored Vehicle gives a field commander the freedom of maneuverability needed to lift the fog of war and help ensure victory. To maintain such a needed element of a commander's arsenal this joint venture between the Army and the Marine Corps must be a success. However, with the fiscal climate faced by our country and the obvious need to cut funding and stay within budget this program defines success not only as coming to fruition but doing so with significant cost savings.

As stated in the beginning of this paper, our research is only a small portion of this program but will still be able to realize large savings. This is important to understand so that more research can be done to further the cause of cost savings for the LAV to complete the mission on time and present the Marine on the battlefield with the best equipment possible. It is our hope this work will be the foundation for future research into this topic.

A brief recap of the courses of action we evaluated:

- COA 1—Refurbishment of all 17 NSN components that can be transferred, without being changed, to the LAV.
- COA 2—Buy all 17 NSN components brand new.
- COA 3—Combination of buying new and refurbishing parts.
- COA 4—General Dynamics Land Systems-Canada handles the refurbishments of the entire Mobility and Obsolescence kits.

Each of these COAs has been explained in detail, as have the methods used to calculate their costs. Upon completion of our research and calculations we have concluded that there are two options to be seriously considered. The first primary option is COA 3, to refurbish all of the parts at the depots in Anniston, Albany and Barstow and buying necessary new parts. Do to the high DORs for the four types of control arm assemblies there will not be sufficient numbers of those components to be refurbished. Therefore, COA 1, while offering the most cost savings, it is not a possibility. We found that COA 3 will cost approximately $88,234,698.39–$88,748,531.91, with 95% confidence. After subtracting this cost from the total cost to purchase the driveline NSNs, $336,038,937.60 (total cost for COA 2), the range of cost savings for this option is estimated to be $247,804,239.21–$247,290,405.69. However, these savings do not account for the overhead rates paid for the civilian work by the NWCF.

The second primary option is COA 4, using GDLS-C to refurbish the components. We found this COA will cost approximately $167,927,395.20 total. After subtracting this cost from the total cost to purchase the driveline NSNs brand new the range of cost savings for this course of action is estimated to be between $168,111,542.40. This COA saves approximately 50.03% of brand new cost according to our research.

Further cost savings have already been realized regardless of the option being chosen because of the specialty tools the Army has already given the Marine Corps. These tools would have cost the Marine Corps $753,176.01 if they would have had to be purchased. Earlier in the paper we stated that tooling costs were sunk and therefore irrelevant. This is the case because regardless of the COA the Marine Corps choses to take specialty tools would have to be purchased to maintain the vehicles. These tools were given to the Marine Corps instead of being bought, representing money that would not have to be spent for this one instance, making this cost savings relevant. This number can be added to the total cost savings estimate range to arrive at a total of $248,557,415.22–$248,043,581.70 savings for COA 3 and $168,864,718.41 savings for COA 4.

B. RECOMMENDATIONS

Based on our conclusions, we have several recommendations to further increase the precision and accuracy of the cost estimate for the entire project. The first recommendation is to perform this same research for all aspects of the LAV that can be refurbished using Stryker vehicle parts. This work provides a foundation for further research that will give more accurate estimates and truly allow Marine Corps leadership to understand the potential for cost savings that can be realized with this project.

Another recommendation is a thesis based purely on transportation cost for the COAs our research recommended. The reasons for this recommendation are that between the two recommended COAs (refurbishing all the Drivelines at GDLS-C or refurbishing them at ANAD, Albany and Barstow) is due to the plethora of transportation options, cost associated and possible taxes that need to be factored in to establish an accurate transportation cost estimate. Having to send all LAVs and Stryker parts to be refurbished and reassembled to Canada may have significant cost differences than shipping the same parts and vehicles to the military depots in the United States. A large enough difference could change the COA the Marine Corps should use. If this assumption is accurate it could have a significant impact on the bottom line savings for the Marine Corps.

The third recommendation is to research the Navy Working Capital Funds to figure out how much those funds contribute to pay the overhead for the civilian workers at the depots. The reason for this research project is to be able to accurately compare COAs 3 and 4 and arrive at a conclusion as to which option is the most monetarily viable for the Marine Corps.

The final recommendation is to do a correlation study for each NSN in this project as well as any other NSN that is not on the driveline system but that will be refurbished from the Sryker for the LAV, to find out the dependence within sub-parts for failure tendencies and percentages. The reason for this recommendation is that this research is outside the immediate scope of our own (as it will be for anyone else that does this same work for a different section of the LAV) and should be conducted independently on each of the NSNs in order to find out correlation between part failures. This will establish a more accurate and smaller price range for each NSN refurbishment and the project as a whole. This portion of the research will build off of ours and give a more precise cost estimation to Marine Corps leadership.

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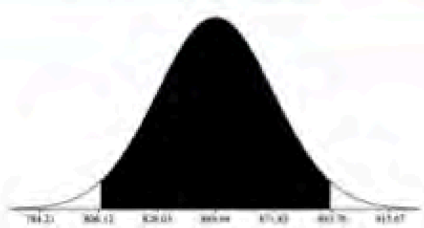
APPENDIX. DIFFERENTIAL PARTS USAGE CHARTS

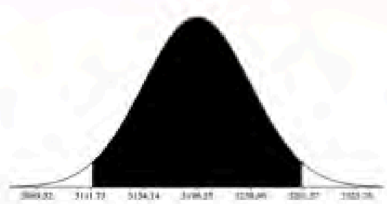
Gen 3.5 - Differential Replacement Parts			Differential Gearbox Assembly										
Ser	***Part Number***	***Description***	***Qty per Assembly***	***100%***	***50%***	***25%***	***5%***	Price	% Changed	% Not Changed	Mean	Variance	Std Dev
1	10501062	Spacer	1			X		$16.18	0.25	0.75	$4.05	$3.03	$1.74
2	10501064	Spacer	1			X		$10.19	0.25	0.75	$2.55	$1.91	$1.38
3	10501065	Compensation Disc	1	X				$44.30	1	0	$44.30	$0.00	$0.00
4	10501066	Shaft Seal	1			X		$18.61	0.25	0.75	$4.65	$3.49	$1.87
5	10501067	Shift Yoke	1			X		$183.01	0.25	0.75	$45.75	$34.31	$5.86
6	10501068	Shoe	2			X		$58.19	0.25	0.75	$29.10	$21.82	$4.67
7	10501069	Gearshift Collar	1			X		$191.57	0.25	0.75	$47.89	$35.92	$5.99
8	10501071	Sealing Expanding Cap	1			X		$24.38	0.25	0.75	$6.10	$4.57	$2.14
9	10501072	Lever	1			X		$79.66	0.25	0.75	$19.92	$14.94	$3.86
10	10501075	Supporting Ring	2			X		$21.02	0.25	0.75	$10.51	$7.88	$2.81
11	10501613	Pin	2		X			$3.52	0.5	0.5	$3.52	$1.76	$1.33
12	10501745	Circlip	4	X				$0.92	1	0	$3.68	$0.00	$0.00
13	10501748	Seal Oil	3	X				$11.39	1	0	$34.17	$0.00	$0.00
14	10501749	Seal Oil	3	X				$11.39	1	0	$34.17	$0.00	$0.00
15	10501765	Sealing Ring	2	X				$0.64	1	0	$1.28	$0.00	$0.00
16	10501786	Bearing Cone	1		X			$32.87	0.5	0.5	$16.44	$8.22	$2.87
17	10501787	Bearing Cone	1		X			$33.42	0.5	0.5	$16.71	$8.36	$2.89
18	10501788	Bearing Cup	1		X			$18.56	0.5	0.5	$9.28	$4.64	$2.15
19	10501789	Bearing Cup	1		X			$16.22	0.5	0.5	$8.11	$4.06	$2.01
20	10501790	Bearing Cup	1		X			$11.77	0.5	0.5	$5.89	$2.94	$1.72
21	10501791	Bearing Cone	1		X			$20.13	0.5	0.5	$10.07	$5.03	$2.24
22	10501795	Plug Hex Head	1		X			$4.06	0.5	0.5	$2.03	$1.02	$1.01
23	10501796	Sealing Ring	1	X				$0.74	1	0	$0.74	$0.00	$0.00
24	10501802	Bearing Ball	1		X			$51.16	0.5	0.5	$25.58	$12.79	$3.58
25	10501804	Bearing Ball	2		X			$72.02	0.5	0.5	$72.02	$36.01	$6.00
26	10501805	Cap Push-In Sealing	1	X				$2.04	1	0	$2.04	$0.00	$0.00
27	10501806	Supporting Ring	1			X		$1.46	0.25	0.75	$0.37	$0.27	$0.52
28	10501817	Key Parallel	1		X			$0.38	0.5	0.5	$0.19	$0.10	$0.31
29	10503049	Washer	1			X		$0.08	0.25	0.75	$0.02	$0.02	$0.12
30	10617803	Threaded Rivet	2	X				$0.40	1	0	$0.80	$0.00	$0.00
31	10617937	Bearing Housing	1				X	$199.00	0.05	0.95	$9.95	$9.45	$3.07
32	10617938	Plug Screw	1		X			$0.35	0.5	0.5	$0.18	$0.09	$0.30
33	10617949	Bearing Housing	1				X	$319.00	0.05	0.95	$15.95	$15.15	$3.89
34	10617976	Cover	2			X		$195.00	0.25	0.75	$97.50	$73.13	$8.55
35	10617977	Self-Locking Diff	1				X	$1,385.09	0.05	0.95	$69.25	$65.79	$8.11
36	10617979	Taper Roller Bearing Cup	1		X			$37.58	0.5	0.5	$18.79	$9.40	$3.07
37	10617986	Taper Roller Bearing Cup	1		X			$37.58	0.5	0.5	$18.79	$9.40	$3.07
38	10617987	Cone, Taper Roller Bearing	1		X			$34.61	0.5	0.5	$17.31	$8.65	$2.94
39	10618013	Shim Ring Set	2		X			$26.66	0.5	0.5	$26.66	$13.33	$3.65
40	10618014	Shim Ring Set	2		X			$11.22	0.5	0.5	$11.22	$5.61	$2.37
41	10618016	Shim Ring Set	1		X			$35.22	0.5	0.5	$17.61	$8.81	$2.97
42	10618024	Oil Sight Glass	1			X		$55.07	0.25	0.75	$13.77	$10.33	$3.21
43	10618025	Shim Ring Set	1		X			$12.94	0.5	0.5	$6.47	$3.24	$1.80
44	10618039	Washer	2			X		$80.60	0.25	0.75	$40.30	$30.23	$5.50
45	10624805	Washer, Wave Type	35	X				$0.07	1	0	$2.45	$0.00	$0.00
46	10624806	Washer, Wave Type	14	X				$0.93	1	0	$13.02	$0.00	$0.00
47	10624812	Nut Hex Thin	1		X			$3.99	0.5	0.5	$2.00	$1.00	$1.00
48	10624893	Bolt Hexagon Head	4		X			$0.46	0.5	0.5	$0.92	$0.46	$0.68
49	10624894	Bolt Hex Head	2		X			$0.46	0.5	0.5	$0.46	$0.23	$0.48
50	10624897	Screw Hex Head	12		X			$0.91	0.5	0.5	$5.46	$2.73	$1.65
											$849.94	$480.08	$21.91



[806.99, 892.89]

Figure 7. Data Set for Differential Gearbox Assembly (after PM-LAV, 2015)

Gen 3.5 - Differential Replacement Parts	Differential Gearbox Assembly C/W Rod												
Ser	***Part Number***	***Description***	***Qty per Assembly***	***100%***	***50%***	***25%***	***5%***	Price	% Changed	% Not Changed	EV	Variance	Std Dev
51	10624902	Screw Hex Head	8		X			$2.71	0.5	0.5	$10.84	$5.42	$2.33
52	10624903	Screw Hex Head	26		X			$0.78	0.5	0.5	$10.14	$5.07	$2.25
53	10624917	Pin Spring Type Straight	2	X				$1.40	1	0	$2.80	$0.00	$0.00
54	10624918	Pin Spring Type SL TD	2			X		$9.18	0.25	0.75	$4.59	$3.44	$1.86
55	10624947	Plug Hex Head Magnet	1		X			$22.09	0.5	0.5	$11.05	$5.52	$2.35
56	10625744	Seal Oil	2	X				$11.39	1	0	$22.78	$0.00	$0.00
57	10639202	Stub Shaft	2		X			$460.00	0.5	0.5	$460.00	$230.00	$15.17
58	10649961	Friction Pack Repair Kit	1		X			$484.00	0.5	0.5	$242.00	$121.00	$11.00
59	10649964	Gear Repair Kit	1			X		$1,295.00	0.25	0.75	$323.75	$242.81	$15.58
60	10650878	Nut	4		X			$0.52	0.5	0.5	$1.04	$0.52	$0.72
61	10650986	Cover	1				X	$115.00	0.05	0.95	$5.75	$5.46	$2.34
62	10650987	Helical Gear Assy.	1				X	$648.00	0.05	0.95	$32.40	$30.78	$5.55
63	10650990	Helical Gear	1				X	$311.00	0.05	0.95	$15.55	$14.77	$3.84
64	10650991	Transmission Shaft	1				X	$419.00	0.05	0.95	$20.95	$19.90	$4.46
65	10650994	Pinion Shaft	1		X			$609.75	0.5	0.5	$304.88	$152.44	$12.35
66	10650995	Ring Gear	1		X			$143.00	0.5	0.5	$71.50	$35.75	$5.98
67	10650998	Gearbox Housing	1				X	$853.00	0.05	0.95	$42.65	$40.52	$6.37
68	10651004	Bushing	4		X			$9.32	0.5	0.5	$18.64	$9.32	$3.05
69	10651008	Output Shaft	1				X	$50.83	0.05	0.95	$2.54	$2.41	$1.55
70	10651012	Spacer Ring	1			X		$13.18	0.25	0.75	$3.30	$2.47	$1.57
71	10651013	Bearing Flange	2			X		$235.00	0.25	0.75	$117.50	$88.13	$9.39
72	10651022	Bearing Cone	1		X			$30.99	0.5	0.5	$15.50	$7.75	$2.78
73	10651024	Bearing Ball Deep Groove	1		X			$2.77	0.5	0.5	$1.39	$0.69	$0.83
74	10651025	Shim Ring Set	1		X			$3.81	0.5	0.5	$1.91	$0.95	$0.98
75	10651033	Cone, Taper Roller Bearing	1		X			$32.87	0.5	0.5	$16.44	$8.22	$2.87
76	10651034	Shaft Seal	2	X				$34.07	1	0	$68.14	$0.00	$0.00
77	10651035	Screw	1			X		$17.14	0.25	0.75	$4.29	$3.21	$1.79
78	10651036	Pan	1			X		$169.00	0.25	0.75	$42.25	$31.69	$5.63
79	10651042	Nut Hex Torque Type	2		X			$0.28	0.5	0.5	$0.28	$0.14	$0.37
80	10651043	Washer Conical Spring	2	X				$7.98	1	0	$15.96	$0.00	$0.00
81	10651044	Bushing	2		X			$3.81	0.5	0.5	$3.81	$1.91	$1.38
82	10651045	Washer Assy.	1			X		$32.96	0.25	0.75	$8.24	$6.18	$2.49
83	10651048	Bracket Assy.	2			X		$259.00	0.25	0.75	$129.50	$97.13	$9.86
84	10651056	Bearing Bushing Assy.	1			X		$299.00	0.25	0.75	$74.75	$56.06	$7.49
85	10617878-156	O-Ring	4	X				$0.89	1	0	$3.56	$0.00	$0.00
86	10618136-1	Identification Plate	1	X				$13.55	1	0	$13.55	$0.00	$0.00
87	10651063-011P	Drive Flange Assy.	2		X			$468.00	0.5	0.5	$468.00	$234.00	$15.30
88	10651064-011P	Drive Flange Assy.	1		X			$404.00	0.5	0.5	$202.00	$101.00	$10.05
89	10651065-011P	Drive Flange Assy.	1		X			$404.00	0.5	0.5	$202.00	$101.00	$10.05
90	10651066-001P	Cover	1				X	$373.00	0.05	0.95	$18.65	$17.72	$4.21
91	10657325-001P	Mounting Lug	1			X		$83.77	0.25	0.75	$20.94	$15.71	$3.96
92	10624801	Washer wave type	4	X				$1.23	1	0	$4.92	$0.00	$0.00
93	10501070	Cylinder Assy.	1			X		$417.43	0.25	0.75	$104.36	$78.27	$8.85
94	10501842	Retaining Ring	1	X				$0.86	1	0	$0.86	$0.00	$0.00
95	10501616	Split Pin	1	X				$0.22	1	0	$0.22	$0.00	$0.00
96	10511997	Parts Kit	1	X				$22.55	1	0	$22.55	$0.00	$0.00
97	10624892	Pin Clevis	1			X		$79.74	0.25	0.75	$19.94	$14.95	$3.87
98	10624916	Washer Plain	1			X		$1.05	0.25	0.75	$0.26	$0.20	$0.44
99	10618006	Rod Assy.	1			X		$30.68	0.25	0.75	$7.67	$5.75	$2.40
											$3,196.55	$1,798.26	$42.41



[3113.41, 3279.69]

Figure 8. Data Set for Differential Gearbox Assembly C/W Rod (after PM-LAV, 2015)

Gen 3.5 - Differential Replacement Parts		Differential Gearbox Assembly C/W Cylinder											
Ser	Part Number	Description	Qty per Assembly	100%	50%	25%	5%	Price	% Changed	% Not Changed	EV	Variance	Std Dev
51	10624902	Screw Hex Head	8		X			$2.71	0.5	0.5	$10.84	$5.42	$2.33
52	10624903	Screw Hex Head	26		X			$0.78	0.5	0.5	$10.14	$5.07	$2.25
53	10624917	Pin Spring Type Straight	2	X				$1.40	1	0	$2.80	$0.00	$0.00
54	10624918	Pin Spring Type SL TD	2			X		$9.18	0.25	0.75	$4.59	$3.44	$1.86
55	10624947	Plug Hex Head Magnet	1		X			$22.09	0.5	0.5	$11.05	$5.52	$2.35
56	10625744	Seal Oil	2	X				$11.39	1	0	$22.78	$0.00	$0.00
57	10639202	Stub Shaft	2		X			$460.00	0.5	0.5	$460.00	$230.00	$15.17
58	10649961	Friction Pack Repair Kit	1		X			$484.00	0.5	0.5	$242.00	$121.00	$11.00
59	10649964	Gear Repair Kit	1			X		$1,295.00	0.25	0.75	$323.75	$242.81	$15.58
60	10650878	Nut	4		X			$0.52	0.5	0.5	$1.04	$0.52	$0.72
61	10650986	Cover	1				X	$115.00	0.05	0.95	$5.75	$5.46	$2.34
62	10650987	Helical Gear Assy.	1				X	$648.00	0.05	0.95	$32.40	$30.78	$5.55
63	10650990	Helical Gear	1				X	$311.00	0.05	0.95	$15.55	$14.77	$3.84
64	10650991	Transmission Shaft	1				X	$419.00	0.05	0.95	$20.95	$19.90	$4.46
65	10650994	Pinion Shaft	1		X			$609.75	0.5	0.5	$304.88	$152.44	$12.35
66	10650995	Ring Gear	1		X			$143.00	0.5	0.5	$71.50	$35.75	$5.98
67	10650998	Gearbox Housing	1				X	$853.00	0.05	0.95	$42.65	$40.52	$6.37
68	10651004	Bushing	4		X			$9.32	0.5	0.5	$18.64	$9.32	$3.05
69	10651008	Output Shaft	1				X	$50.83	0.05	0.95	$2.54	$2.41	$1.55
70	10651012	Spacer Ring	1			X		$13.18	0.25	0.75	$3.30	$2.47	$1.57
71	10651013	Bearing Flange	2			X		$235.00	0.25	0.75	$117.50	$88.13	$9.39
72	10651022	Bearing Cone	1		X			$30.99	0.5	0.5	$15.50	$7.75	$2.78
73	10651024	Bearing Ball Deep Groove	1		X			$2.77	0.5	0.5	$1.39	$0.69	$0.83
74	10651025	Shim Ring Set	1		X			$3.81	0.5	0.5	$1.91	$0.95	$0.98
75	10651033	Cone, Taper Roller Bearing	1		X			$32.87	0.5	0.5	$16.44	$8.22	$2.87
76	10651034	Shaft Seal	2	X				$34.07	1	0	$68.14	$0.00	$0.00
77	10651035	Screw	1			X		$17.14	0.25	0.75	$4.29	$3.21	$1.79
78	10651036	Pan	1			X		$169.00	0.25	0.75	$42.25	$31.69	$5.63
79	10651042	Nut Hex Torque Type	2		X			$0.28	0.5	0.5	$0.28	$0.14	$0.37
80	10651043	Washer Conical Spring	2	X				$7.98	1	0	$15.96	$0.00	$0.00
81	10651044	Bushing	2		X			$3.81	0.5	0.5	$3.81	$1.91	$1.38
82	10651045	Washer Assy.	1			X		$32.96	0.25	0.75	$8.24	$6.18	$2.49
83	10651048	Bracket Assy.	2			X		$259.00	0.25	0.75	$129.50	$97.13	$9.86
84	10651056	Bearing Bushing Assy.	1			X		$299.00	0.25	0.75	$74.75	$56.06	$7.49
85	10617878-156	O-Ring	4	X				$0.89	1	0	$3.56	$0.00	$0.00
86	10618136-1	Identification Plate	1	X				$13.55	1	0	$13.55	$0.00	$0.00
87	10651063-011P	Drive Flange Assy.	2		X			$468.00	0.5	0.5	$468.00	$234.00	$15.30
88	10651064-011P	Drive Flange Assy.	1		X			$404.00	0.5	0.5	$202.00	$101.00	$10.05
89	10651065-011P	Drive Flange Assy.	1		X			$404.00	0.5	0.5	$202.00	$101.00	$10.05
90	10651066-001P	Cover	1				X	$373.00	0.05	0.95	$18.65	$17.72	$4.21
91	10657325-001P	Mounting Lug	1			X		$83.77	0.25	0.75	$20.94	$15.71	$3.96
92	10624801	Washer wave type	4	X				$1.23	1	0	$4.92	$0.00	$0.00
93	10501070	Cylinder Assy.	1			X		$417.43	0.25	0.75	$104.36	$78.27	$8.85
94	10501842	Retaining Ring	1	X				$0.86	1	0	$0.86	$0.00	$0.00
95	10501616	Split Pin	1	X				$0.22	1	0	$0.22	$0.00	$0.00
96	10511997	Parts Kit	1	X				$22.55	1	0	$22.55	$0.00	$0.00
97	10624892	Pin Clevis	1			X		$79.74	0.25	0.75	$19.94	$14.95	$3.87
98	10624916	Washer Plain	1			X		$1.05	0.25	0.75	$0.26	$0.20	$0.44
											$3,188.88	$1,792.51	$42.34

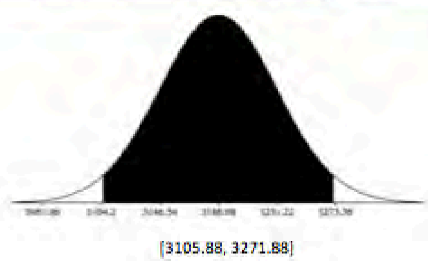
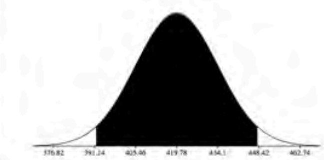


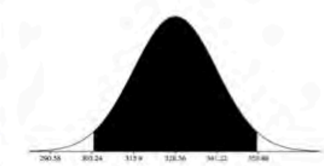
Figure 9. Data Set for Differential Gearbox Assembly C/W Cylinder (after PM-LAV, 2015)

Gen 3.5 - REAR SUSPENSION Replacement Parts		Rear Suspension Left and Right											
PERTAINS TO REAR SUSPENSION ONLY													
Ser	Part Number	Description	Qty per Assembly	100%	50%	25%	5%	Price	% Changed	% Not Changed	EV	Variance	Std Dev
104	10501254	Spacer	1		X			$79.28	0.5	0.5	$39.64	$19.82	$4.45
105	10501255	Spacer	1		X			$47.01	0.5	0.5	$23.51	$11.75	$3.43
106	10501256	Thrust Ring	2		X			$14.45	0.5	0.5	$14.45	$7.23	$2.69
107	10501856	Oil Seal	1	X				$7.01	1	0	$7.01	$0.00	$0.00
108	10501958	Nut	1		X			$25.98	0.5	0.5	$12.99	$6.50	$2.55
110	10618262	Shaft Seal	2	X				$5.73	1	0	$11.46	$0.00	$0.00
111	10624805	Washer	2		X			$0.07	0.5	0.5	$0.07	$0.04	$0.19
112	10624834	Ring, Sealing	2	X				$0.28	1	0	$0.56	$0.00	$0.00
113	10624839	Drain Plug Hex Head	2		X			$4.66	0.5	0.5	$4.66	$2.33	$1.53
114	10624942	Screw Hex	2		X			$0.78	0.5	0.5	$0.78	$0.39	$0.62
117	10626063	Bracket	1			X		$17.82	0.25	0.75	$4.46	$3.34	$1.83
118	10650825	Trailing Arm Assy Left	1				X	$1,461.00	0.05	0.95	$73.05	$69.40	$8.33
119	10650826	Trailing Arm Assy Right	1				X	$1,055.00	0.05	0.95	$52.75	$50.11	$7.08
135	10618257	Flange Bearing Case Assy	1								$0.00	$0.00	$0.00
136	10618259	Flanged Bearing Case	1				X	$722.00	0.05	0.95	$36.10	$34.30	$5.86
137	10501259	Bushing	1	X				$57.37	1	0	$57.37	$0.00	$0.00
140	10618261	Bushing	1	X				$80.93	1	0	$80.93	$0.00	$0.00
											$419.78	$205.19	$14.32



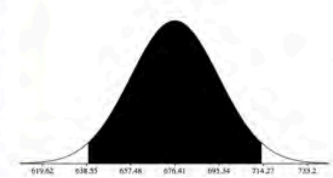
[391.71, 447.85]

Gen 3.5 CONTROL ARM Replacement Parts		Control Arm Assembly Left and Right											
Ser	Part Number	Description	Qty per Assembly	100%	50%	25%	5%	Price	% Changed	% Not Changed	EV	Variance	Std Dev
142	10501943	Oil Seal	4	X				$4.29	1	0	$17.16	$0.00	$0.00
143	10617803	Rivet	2	X				$0.40	1	0	$0.80	$0.00	$0.00
144	10617979-121	O-ring	2	X				$0.28	1	0	$0.56	$0.00	$0.00
145	10617979-135	O-ring	2	X				$0.28	1	0	$0.56	$0.00	$0.00
146	10618136-1	Identification Plate	1	X				$13.55	1	0	$13.55	$0.00	$0.00
147	10625840	Retaining Ring	2	X				$22.27	1	0	$44.54	$0.00	$0.00
148	10501942	Spherical Bearing	2		X			$16.76	0.5	0.5	$16.76	$8.38	$2.89
149	10627896	Thrust Piece Assembly	2		X			$63.26	0.5	0.5	$63.26	$31.63	$5.62
150	10501123	Bearing Block	2			X		$200.57	0.25	0.75	$100.29	$75.21	$8.67
151	10501121	Protector Cone	2			X		$74.02	0.25	0.75	$37.01	$27.76	$5.27
152	10501122	Thrust Piece	2		X			$14.23	0.5	0.5	$14.23	$7.12	$2.67
153	10625841	Ball	2		X			$4.28	0.5	0.5	$4.28	$2.14	$1.46
154	10501806	Suppoting Ring	2			X		$1.46	0.25	0.75	$0.73	$0.55	$0.74
155	10625842	Screw Hex Socket	4		X			$2.87	0.5	0.5	$5.74	$2.87	$1.69
156	10627897	Screw Hex Head	2		X			$5.10	0.5	0.5	$5.10	$2.55	$1.60
157	10627898	Nut Hex Thin	2		X			$3.99	0.5	0.5	$3.99	$2.00	$1.41
											$328.56	$160.20	$12.66



[303.74, 353.38]

Gen 3.5 CONTROL ARM Replacement Parts		Control Arm Assembly w/Sensor Left and Right											
Ser	Part Number	Description	Qty per Assembly	100%	50%	25%	5%	Price	% Changed	% Not Changed	EV	Variance	Std Dev
159	10501943	Oil Seal	4	X				$4.29	1	0	$17.16	$0.00	$0.00
160	10617803	Rivet	2	X				$0.40	1	0	$0.80	$0.00	$0.00
161	10617979-121	O-ring	1	X				$0.28	1	0	$0.28	$0.00	$0.00
162	10617979-133	O-ring	1	X				$0.28	1	0	$0.28	$0.00	$0.00
163	10617979-135	O-ring	2	X				$0.28	1	0	$0.56	$0.00	$0.00
164	10618136-1	Identification Plate	1	X				$13.55	1	0	$13.55	$0.00	$0.00
165	10625840	Retaining Ring	2	X				$22.27	1	0	$44.54	$0.00	$0.00
166	B1867BC030100	Pan Head Screw	4	X				$1.33	1	0	$5.32	$0.00	$0.00
167	10501942	Spherical Bearing	2		X			$16.76	0.5	0.5	$16.76	$8.38	$2.89
168	10627896	Thrust Piece Assembly	2		X			$63.26	0.5	0.5	$63.26	$31.63	$5.62
169	10501123	Bearing Block	2			X		$200.57	0.25	0.75	$100.29	$75.21	$8.67
170	10501121	Protector Cone	2			X		$74.02	0.25	0.75	$37.01	$27.76	$5.27
171	10501122	Thrust Piece	2		X			$14.23	0.5	0.5	$14.23	$7.12	$2.67
172	10625841	Ball	2		X			$4.28	0.5	0.5	$4.28	$2.14	$1.46
173	10501806	Suppoting Ring	2			X		$1.46	0.25	0.75	$0.73	$0.55	$0.74
174	10625842	Screw Hex Socket	4		X			$2.87	0.5	0.5	$5.74	$2.87	$1.69
175	10627897	Screw Hex Head	2		X			$5.10	0.5	0.5	$5.10	$2.55	$1.60
176	10627898	Nut Hex Thin	2		X			$3.99	0.5	0.5	$3.99	$2.00	$1.41
177	10657297-16035	Set Screw Hexsoc	1		X			$0.98	0.5	0.5	$0.49	$0.25	$0.49
179	10639655	Thrust Bearing	1		X			$48.51	0.5	0.5	$24.26	$12.13	$3.48
180	10639658	Cover Cone	1			X		$229.00	0.25	0.75	$57.25	$42.94	$6.55
181	10639660	Thrust Piece Assembly	1			X		$162.00	0.25	0.75	$40.50	$30.38	$5.51
183	10651567	Support Segment	2			X		$20.08	0.25	0.75	$10.04	$7.53	$2.74
184	B1836B120200KNH	Set Screw Hex Head	2		X			$210.00	0.5	0.5	$210.00	$105.00	$10.25
											$676.41	$358.41	$18.93



[639.30, 713.52]

Figure 10. Data Set for Rear Suspension Left and Right, Control Arm Assembly Left and Right, and Control Arm Assembly with Sensor Left and Right (after PM-LAV, 2015)

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