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Analysis of Light Armored Vehicle
Depot Level Maintenance

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December 2005

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ANALYSIS OF LIGHT ARMORED VEHICLE DEPOT LEVEL MAINTENANCE

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Submitted in partial fulfillment of the requirements for the degree of

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An analysis of Light Armored Vehicle (LAV) Depot Level Maintenance is conducted to examine the scheduled maintenance cycle and processes in order to determine potential inefficiencies related to cost or time. Performance is measured by analyzing costs, cycle time, quality, availability, and flexibility. Current operations in Iraq are considered for effects on depot level maintenance, depot capacity, and operational availability. This analysis has implications in determining whether depot level maintenance should be conducted at Barstow, California, or Albany, Georgia, or at both facilities as it is now.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS

Ao	Operational Availability
BD	Battle Damage
DLH	Direct Labor Hours
DLM	Depot Level Maintenance
DLMP	Depot Level Maintenance Process
DMFA	Depot Maintenance Float Allowance
FSD	Fleet Support Division
IROAN	Inspect Repair Only as Necessary
LAV	Light Armored Vehicle
LHR	Labor Hour
LOGCOM	Logistics Command
LTI	Limited Technical Inspection
MC	Maintenance Center
MCA	Maintenance Center Albany
MCB	Maintenance Center Barstow
MCLB	Marine Corps Logistics Base
MDT	Maintenance Down Time
MTBM	Mean Time Between Maintenance
OIF	Operation Iraqi Freedom
PM	Program Manager
RCT	Repair Cycle Time
SECREPS	Secondary Repairables
SLEP	Service Life Extension Program
SOW	Statement of Work
SS	Safety Stock
TOC	Theory of Constraints
TPM	Total Productive Maintenance
TT	Tractor Traylor
VSM	Value Stream Mapping

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I. INTRODUCTION

A. BACKGROUND

Currently, depot level (up to fifth echelon) maintenance for the Light Armored Vehicle (LAV) is performed at Maintenance Centers (MC) located at Marine Corps Logistics Base (MCLB) Albany, Georgia and MCLB Barstow, California. The MC's work for the Commanding General of Marine Corps Logistics Command (LOGCOM) headquartered at MCLB Albany. The mission of the LOGCOM is to provide worldwide, integrated logistics/supply chain and distribution management, depot level maintenance management, and strategic prepositioning capability in support of the operating forces and other supported units to maximize their readiness and sustainability and to support enterprise and program level total life cycle management. The MC's are at the core of the LOGCOM mission.

Each MC provides multi-commodity depot level maintenance capabilities for similar ground combat and ground combat support equipment for units within their geographical regions. Generally speaking, MCLB Albany supports units in the eastern half of the United States, while MCLB Barstow supports units in the western half of the country, including units in Hawaii and Okinawa, Japan. LAV's returning from combat operations, and scheduled for depot level maintenance, are offloaded at Blount Island Command (BIC) in Jacksonville, Florida and sent to either Albany or Barstow, depending upon the available capacity at each maintenance center.

Personnel strength aboard the two logistics bases is composed of 661 Marines in Albany and 198 in Barstow, 1566 civilian employees in Albany and 1005 in Barstow, and 197 contractors in Albany and 95 in Barstow. The total number of support personnel aboard each logistics base do not all work directly in the MC's, but do provide support at some level.

The multi-commodity capability of each MC at both bases provides an infrastructure capable of supporting a wide variety of equipment, weapon systems, and components. Each MC has the ability to rapidly shift work from one equipment line to another to meet changing priorities. Because the processes are basically the same at each maintenance center for each piece of equipment, there are duplicate maintenance functions performed at each base, which gives the Marine Corps flexibility for overflow capacity when operational tempo is high.

There are six different variants of the LAV; the Command and Control (LAV-C2) variant, the Logistics (LAV-Log) variant, the Mortar (LAV-M) variant, the Recovery (LAV-R) variant, the Anti-Tank (LAV-AT), and the 25 millimeter chain gun (LAV-25), which is the primary LAV that makes up the predominant number of LAV's in the Marine Corps' inventory. The hull for each variant is very similar, differing mainly with the weapons systems for the LAV-25, the LAV-M, the LAV-AT and the support components for the LAV-R, the LAV-Log, and the LAV-C2 with its communications equipment.

B. PURPOSE OF ANALYSIS

The purpose of our research is to provide an overall analysis of the depot level maintenance processes for the LAV. It is our intent to provide clarification of the depot maintenance processes for the end users in the operational forces to better understand the importance of the depots role in driving readiness; particularly in the case of the aging LAV fleet. Specifically, we address maintenance costs and Direct Labor Hours (DLH) costs to make a comparison between the depots in Albany and Barstow. Additionally, we address how the depots' have incorporated the Theory of Constraints (TOC) to significantly reduce Repair Cycle Times (RCT) and show how the efficient use of the depots has reduced ownership costs and extended the useful life of the LAV. Factors that are harder to quantify, such as operational tempo's effect on depot capacity, risk associated with single siting maintenance, and the effect that budgetary constraints have on scheduling maintenance will be addressed.

C. SCOPE OF ANALYSIS

There are 398 LAV-25's in the Marine Corps inventory, comprising 54% of the total number of vehicles on hand. Therefore, we will limit the scope of our research to the LAV-25 variant in order to capture the "big picture" of the depot maintenance processes. The LAV-25 maintenance costs and labor costs show trends that are similar to the other five variants. Our research will not be based on the Base Realignment and Closure (BRAC) or any other political factors, which may affect the depots. It must be noted that the entire data gathering, related to costs and cycle times, for both MC's was done through LOGCOM, which commands both MC's and maintains cost and maintenance data for both depots. A site visit was conducted at Maintenance Center Albany (MCA), but not at Maintenance Center Barstow (MCB).

D. METHODOLOGY

The Inspect and Repair Only As Necessary (IROAN) Program is used as the basis for our research. Historically the IROAN Program has accounted for over 90% of the depot maintenance requirements for the LAV. The IROAN Program has the longest history, the most in-depth maintenance practices, and it will be at the center of our analysis. The Service Life Extension Program (SLEP) Program and the battle damaged vehicles from Iraq will be incorporated in our analysis in regards to costs and cycle times at both MC's and how both have affected the IROAN Program short-term.

First, we analyze how incorporating the Theory of Constraints (TOC) has significantly reduced LAV depot maintenance cycle times. We discuss what new practices were incorporated in FY02 and how those practices reduced average maintenance cycle times for all variants of LAV's.

Costs of depot maintenance are analyzed in depth at both MC's from FY01 through FY05. We break down LAV-25 costs at each MC by Direct Labor Hours (DLH) costs and material costs per LAV-25. We then compare DLH and material costs per LAV between the two MC's and analyze the differences in these costs. In addition we analyze the differences in DLH's per LAV between the two MC's and how these differences have produced significant disparity in average DLH costs between Barstow and Albany. We then examine factors which have affected maintenance and labor costs at both MC's, including the introduction of the Theory of Constraints (TOC), Lean Thinking, the Service Life Extension Program (SLEP), current operations in Iraq, budget constraints, and training new personnel. In addition, transportation costs are also analyzed from the operating units to both MC's.

Next, we analyze the Repair Cycle Times (RCT) of the LAV-25 at Maintenance Center Albany (MCA). Each maintenance step for the IROAN and SLEP Programs is detailed, with the corresponding time to conduct the maintenance step, in order to arrive at the RCT. Some LAV-25's scheduled for IROAN maintenance have already had the SLEP upgrades, but others have not. Detailed information regarding the IROAN and SLEP programs is outlined in the Maintenance Processes chapter. The LAV-25's without the SLEP upgrades have them installed in conjunction with scheduled IROAN maintenance and the differences in RCT's between the two processes is analyzed in the Repair Cycle Times chapter. Differences in RCT's between the two MC's are also analyzed to determine where inefficiencies exist. In addition, we will use Operational Availability (Ao) calculations to estimate required Mean Time Between Maintenance (MTBM) for LAV variants based on the current expected vehicle distribution between using units and vehicles in the depot level maintenance (DLM) cycle process.

Lastly, based on our analysis, assumptions are made about the existing inefficiencies and we make recommendations on what we feel can positively affect the depot level maintenance processes at both MC's. Consideration for consolidating depot level maintenance functions and personnel reductions are strategic decisions based on political, financial, operational, and logistical factors beyond the scope of our research. Therefore, we do not make a specific recommendation as to which depot would be the best for consolidating LAV depot maintenance or that consolidation would even result in a net benefit to the Marine Corps.

II. THEORY OF CONSTRAINTS

A. MAINTENANCE CENTERS

The feat for which Maintenance Center Albany (MCA) and Maintenance Center Barstow (MCB) personnel are most proud of over the last few years is the implementation of the Theory of Constraints (TOC) and Lean Thinking into the Depot Level Maintenance Process (DLMP). In analyzing the impact of TOC on costs and RCT's since the system went online formally in late 2002, it's also important to understand the impact on the process and the rationale in moving the LAV's from an assembly line process to a workstation process.

The assembly line process used prior to implementation of the TOC meant that although an LAV was not actually on top of a conveyor belt moving along a restricted line, maintenance personnel still were directed to perform maintenance in a more sequential manner. The obvious concern in this type of system is the impact of bottlenecks and unforeseen issues arising with an individual vehicle. Ultimately, this process held RCT's high at an average of over 180 days. For example, when a vehicle hull needed welding, the assembly line process could not react well in keeping RCT's under control.

1. Contract Consulting

MCA and MCB contracted with Vector Strategies (VS) in assisting with implementation of TOC. The most important consideration that VS had to give MCA and MCB was the fact that as a government agency and not a for-profit private firm, MCA and MCB required a TOC and Lean Thinking system tailored to its unique needs. Each of the facets of TOC as they have been developed more fully since 1984 when Eli Goldratt wrote "The Goal" were considered in the MCA/MCB process. However, not all of them were prudent for the government agency. But looking back even further, why TOC?

2. Concept

The leadership at MCA/MCB knew that it had to gain and maintain the upper hand on information flowing into and out of the DLM program, and to learn how to best utilize the available information to improve processes and RCT. A central concept of TOC is a basic understanding of cause and effect. Understanding how and why things happen around you, from the maintenance personnel and supervisors to the highest levels of the hierarchy, is an essential element in any attempt at improvement. This Thinking Process has given MCA/MCB a foundation in that it provides them the ability to recognize paradigm shifts as times change, without changing the assumptions and rules within the organization.

TOC typically consists of three parts:

1. A set of problem solving tools-called the Thinking Processes (TP)-to logically and systematically answer the questions, "What to change? What to change to? How to effect the change?"
2. A set of daily management tools from the TP's that can be used to improve vital skills such as communication, effecting change, team building, and empowerment.
3. Solutions created by applying the TP to areas like production, distribution, marketing, project management, direction setting, etc.

3. Goals

Goals of the maintenance center (MC) included meeting requirements for cost, schedule, and quality, increasing throughput, decreasing costs, decreasing WIP, and reducing RCT's. Vector Strategies and MCA/MCB examined each of the above possibilities in determining the potential for improvement within the processes of maintenance centers. The first thing they did was to establish the overarching strategy by which everyone could focus on a process and improve it. This 5 step process consists of:

1. Identify the constraint
2. Exploit the constraint
3. Subordinate everything to the constraint
4. Elevate the constraint
5. Return to Step 1. Do not let inertia set in!

The two scheduling methodologies that they focused on were the Critical Chain and the Simplified Drum-Buffer-Rope. In the Critical Chain the PM plans for the known and buffers for the unknown, especially with regards to major end items (a core competency of the MC'S). The S-DBR is used for component management and uses buffers to schedule components to be completed in time for installation with the Critical Chain.

At this point two of the most important concepts to understand are the scheduling and the sub-assembly processes of the LAV. The MC'S is unique in adopting this newer scheduling concept in which the most important date to the supervisor is the date promised, or the end-date. The RCT for the LAV-25 is currently on a 120 day schedule. In order to maintain the flow, workload, budget, etc. within the MC, a vehicle may not have work started on it for some time after induction into the maintenance cycle; sometimes as long as three weeks. None-the-less, vehicles rarely exceed the RCT of 120 days. This is due in part to the fact that components stripped from an LAV hull, whether it be the turret, engine, or transmission, rarely are remanufactured or repaired and then reinstalled back on the same hull from which they were pulled. Therefore the throughput of the sub-assembly processes instantly became candidates for the constraints addressed by TOC.

B. LEAN PROCESS

Lean Thinking was a key element in the transformation. The tenets of thinking Lean are many, and where the possibility for adherence to the concepts was practical, the tenets were put into place. 5-S/Visual, TPM, VSM, flow, Kaizen, Kanban (pull), were the primary focus for thinking lean, and are all addressed here.

The process of creating workplace cleanliness and organization for the sake of creating greater efficiency and visual and psychological satisfaction was implemented. To the 5-S's of Sort, Straighten, Scrub, Standardize, and Sustain, MCA added the 6th S of Safety to lay the foundation. The MC'S proudly displays both before and after photographs of the work-bays in advertising its successes.

1. Total Productive Maintenance

Total Productive Maintenance (TPM) is the systematic process for optimizing overall equipment effectiveness by minimizing the unavailability of required machinery. The relationship between maintenance personnel, supervisors, and internal distributors, and the delineation of tasks, was a key element for the MC'S in improving efficiency.

The maintenance of tools and equipment, attempts at reducing costs, and taking advice from the maintenance personnel and operators so that the PM could work with the contractors and acquisitions specialists in improving the reliability and capabilities of the LAV were key factors. One small but life-saving example of this included the production of a modification that reinforced the "bullet proof" peep holes so that in the event of an external blast, the small windows would not disconnect from the hull and injure crew members, as they had in the past.

2. Value Stream Mapping

Value Stream Mapping(VSM) helped the MC'S reduce the non-value added activities, or waste, that was plaguing the RCT's. Some of these efforts tied directly to the 6-S's in that the seeming organization created by having inventories an arms length away from the maintenance personnel were often merely creating inefficiencies. Additionally, many inefficiencies were inevitable based on the original design of the LAV's. The variability in length and width of an LAV hull can be more than one inch because they were manufactured with a craftsman concept over two decades ago. Consequently attempts at standardizing many remanufacturing processes at the depot level created many problems for the assembly line maintenance processes. Much of this waste was reduced by moving to the team concept in which a group of workers now spends approximately 21 days on a vehicle together in the reassembly process. They quickly learn the intricacies of the skeleton hull dropped into their work-station, and work accordingly.

3. Process Flow

Flow processes of similar operations were consolidated in order to eliminate waste, and this was important in transforming the assembly line process into the work-station concept. Flow issues tie directly to the VSM issues addressed above. The end result being a strong adherence to the promised RCT, the improvement in quality since everything fits together better than it did after an assembly line LAV was completed, and the reduction of floorspace requirements due to the improved communication with the distribution warehouses.

The real empowerment of the maintenance personnel came with Kaizen, and they actually use this distinctly Japanese term at the MC'S. The workers were trained to identify and eliminate wasteful activities in an effort to continually improve the system. Along with witnessing many of the above lean concepts in action during our tour of MCA, we did observe the ritualistic team meeting with the supervisor prior to commencement on the days work. This was an opportunity for communication to move both vertically and horizontally, for team members to share tips among one another and bring up issues to the supervisor, and for the supervisor to delineate shifts in taskings and hold workers accountable for progress. The implementation of Kaizen at the MC'S has improved quality, very much through information sharing, reduced costs by maintaining minimizing variability and staying on budget, and held the MC'S to its advertised RCT's.

The natural system shift that went along foundationally with the above tenets was the shift to more of a pull system using Kanban. The disassembly and reassembly processes were linked closely with the sub-assembly processes. This has allowed the 6-S's to maintain the cleanliness, shine, and safety in the work-bays by keeping inventories on hand minimal. The pull system also works hand in hand with Kaizen as communication flow increased drastically, and with the flow processes and VSM as schedules are mapped out and adjusted incrementally to accommodate the progress on a particular LAV. For example, when a hull is ready for specific steps in the reassembly process, this is communicated to the LAV component warehouse in which the parts are gathered into a container and then delivered via forklift directly to the requesting workstation.

We also must remember that this type of system makes sense for the MC because of the fact that parts pulled off of an LAV hull during disassembly are not likely to be the ones reinstalled on the hull during reassembly. This flexibility is beneficial to keeping RCT's down as they pertain to the LAV proper, but does little for the sub-assembly processes since they work predominantly on a first come first basis in which components requiring extensive rework are subject to the constraints imposed by the Marine Corps supply system. Ultimately, although this pull, or Kanban, system has reduced inventory in the workbays and has arguably helped to maintain output schedules, it is difficult to attribute a dollar amount or even a percentage when trying to estimate the improvement.

4. Setup Reduction and Six Sigma

Other lean concepts that found some practical application in the LAV maintenance process are Setup Reduction and Six Sigma. The reduction in changeover time from the last good piece of the previous run to the first good piece of the next run is normally found to be more applicable to a production line. However, many of the components of the LAV rely on internally manufactured sub-components. These machine tools are computer controlled and operate as water jet cutters, lathes, punch presses, and grinders, among others. By optimizing the batch sizes produced at this level, the MC has realized reduced inventories, greater organization capabilities through the 6-S's, and reduced costs. It is within these sub-assembly processes, like the hydraulics and suspension section or the hull repair section that the Setup Reduction practices have proven beneficial.

The quality issues faced at the MC'S were improved through many of the tenets discussed above, to include tenets from Six Sigma. The structured approach to identifying and eliminating quality problems that this method helped with are often considered applicable to only a manufacturing environment and not the remanufacturing environment at the MC'S. However, just like the Setup Reduction concepts were applied at the sub-assembly process level, Six Sigma concepts have been used to increase quality and employee involvement through team participation, which has reduced the cost of maintaining quality standards and increased capacity.

Parallel to the implementation of the TOC, one of the keys to maintaining oversight of the program lay in maintenance centers' (MC) adoption of the PM concept. Knowing that mid-level management concepts could reap much greater rewards through an empowered supervisor, the PM system was adopted. The floor supervisors report directly to the LAV PM. This individual not only has a sole focus on the LAV maintenance program, and reports directly to the MC Commander regularly on progress and cost issues, but also works closely with contractors in incorporating modifications to the LAV as requirements and deficiencies have developed due to the extremely high operational tempo imposed on the vehicles during OIF. For example, once a requirement to reinforce the crew’s small sight windows was identified in order to prevent them from coming off during a blast, the PM worked closely with contractors to design a simple cage to strengthen and reinforce the shatter-proof windows. This particular modification has already proven itself worthy of taking the impact of a nearby blast without putting the crew in danger.

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III. THE MAINTENANCE PROCESSES

A. INSPECT AND REPAIR ONLY AS NECESSARY PROGRAM

The Inspect Repair Only as Necessary (IROAN) Program is a life cycle management program that provides depot level maintenance for ground combat equipment at scheduled intervals throughout the life cycle. The purpose of the IROAN Program is to conduct a complete inspection and testing of a piece of ground combat equipment within guidelines established by a Statement of Work (SOW) and to make any necessary repairs found during the inspection. The IROAN maintenance technique determines the extent of work to be done, any repair parts required, and thus, minimizes disassembly parts replacement. The SOW specifies the work required and specifically the inspections to be performed, which parts will be replaced, which parts will be rebuilt, and which parts will be repaired. LAV repairs, as dictated by the SOW, may range from repairing entire sections of the hull, to secondary repairables like the engine and transmission, to consumable class IX repair parts.

1. Schedule

Scheduling LAV IROAN maintenance is based on multiple factors. There are three primary determinates that currently determine the Mean Time Between IROAN Maintenance ($MTBM_{iroan}$). The first determinate is 2,000 hours of operation, the second is 25,000 miles, and the third is 6 years since the last scheduled depot maintenance. Only one of these three determinates are required for an LAV to be scheduled for depot level maintenance and given the high operational tempo of the operating forces it is highly unlikely that an LAV will go 6 years between scheduled maintenance. Additional factors that effect annual scheduling include capacity of the two depots, operational commitments that affect LAV usage, and funding constraints.

The Program Manager (PM), located in Warren, Michigan, is responsible for determining annual LAV depot level maintenance requirements, requesting funds for those maintenance requirements, and scheduling the workload within once the annual budget has been determined. The PM has to balance the annual maintenance requirements within budgetary constraints that are often out of his/her control. Once the final number of LAV's is determined for the next Fiscal Year (FY), the forecasted annual workload is reflected on the Master Work Schedule (MWS) that shows the number of each variant that are scheduled for maintenance at each depot. The MWS also reflects required delivery dates that enable each depot to control workflows and prevent queues or gaps from developing in the maintenance centers.

LAV's are sent to the Fleet Support Division (FSD) once they arrive at either depot. If the maintenance center is not ready to induct the LAV into the maintenance cycle, it sits in a queue at the FSD. The following maintenance functions compose the different phases of the IROAN for all LAV variants:

- Phase I – Limited Technical Inspection (LTI)
    1. MC conducts joint LTI with contractor and compares it to LTI conducted by the using unit prior to shipment.
- Phase II – IROAN
    1. Disassembly, clean, and blast hull.
    2. Inspect and repair hull.
    3. Inspect and repair/replace necessary parts.
    4. Prime hull, reassemble, and paint.
    5. Install communications equipment, optics, and small arms.
- Phase III – Inspection, Testing, and Acceptance
    1. Inspection by the MC.
    2. Testing conducted by the contractor to include road and chassis test.
    3. Correction of deficiencies.
    4. Final testing and acceptance.
- Phase IV – Packaging, Handling, Storage, and Transportation
    1. Vehicle is preserved, packaged, and prepared for transportation back to a using unit by the FSD.

Immediately following completion of the maintenance cycle the LAV's are returned to the FSD where they remain in the queue awaiting transportation back to an operating unit.

The Marine Corps' policy is to ensure unit readiness is maintained at the highest level possible while the LAV's are undergoing depot level maintenance. LAV's are not scheduled to return to the same using unit that they originated from, but ideally a using unit conducts a one-for-one exchange with the depot when an LAV is sent to the depot for IROAN. In order to ensure availability, the depots each maintain a Depot Maintenance Float Allowance (DMFA) pool that provide a quantity of LAV variants that have undergone IROAN maintenance and are ready for issue. High operational tempo and combat damage to vehicles has made the DMFA pool difficult to maintain and operating units may be Table of Equipment (T/E) deficient until the depots can provide a replacement vehicle.

B. SERVICE LIFE EXTENSION PROGRAM

The LAV Service Life Extension Program (SLEP) will ensure that the LAV's combat capabilities will be preserved through 2015, although a replacement platform is not scheduled for fielding until 2025. Most of the 730 plus LAV's in operation today have been in service since the early 1980's and are nearing the end of their serviceable life. The LAV's are becoming maintenance intensive, corroding, lack sufficient armor, the weapons systems are outdated, and they don't have adequate communications equipment to meet the current fast-paced demands of the modern battlefield. The goal of the SLEP is to improve survivability, sustainability, maintainability, and lethality through the following upgrades:

- Corrosion Control Upgrades
- Control Panel and Electronic Upgrades:
    1. Modify the Power Distribution Assembly (PDA)
    2. Modify the Control Display Assembly (CDA)
    3. Modify the Gun Control Unit (GCU)
- Tire/Wheel Replacement:
    - Split wheel design to facilitate maintainability
    - A more reliable and robust tire
- Improved Thermal Sight System w/ Laser Rangefinder

- Hull modifications:
    - Install standoffs
    - Install brackets
    - Install bosses

The SLEP modifications and upgrades are conducted in conjunction with the IROAN program when the LAV's go to the depots for scheduled maintenance and add very little maintenance time to the entire process. According to the MC, SLEP upgrades and modifications add no more than 14-15 hours of additional work to the RCT. The remainder of the upgrades are done during reassembly process with no addition man-hours because the MC's are installing the SLEP components provided instead of the old baseline components. Currently, incorporating the SLEP upgrades is not adding additional time to the IROAN RCT's and is expected to reduce the RCT's and maintenance costs as the SLEP'd vehicles rotate back to the depots in their scheduled IROAN maintenance cycle.

The SLEP Program was initiated in late FY03 and is scheduled to be completed in FY06. The SLEP upgrades should slow the rapidly growing supportability costs and improve the effectiveness of the Light Armored Reconnaissance (LAR) Battalions that use the LAV. Improved operational availability and maintainability are expected as a result of the SLEP Program.

C. MAINTENANCE CENTER CAPACITY AND INFRASTRUCTURE

The maintenance centers base their capacities on the Department of Defense (DoD) Directive 4151.18 definition that states that capacity is "an indicator, expressed in Direct Labor Hours (DLH), required by a shop or depot to support funded workload requirements and provide essential core capabilities." Both maintenance centers calculate DLH by production shop categories that include the same type of weapons systems. The LAV is classified as a ground combat vehicle as are Amphibious Assault Vehicles and the M1A1 Abrams Tank. Both maintenance centers have enormous capacity that is not currently being fully utilized. MCA stated that they have the capacity to conduct all the depot level maintenance for the entire fleet of LAV's. It is likely that both MC’s could each handle the entire LAV fleet because of their ability to shift capacity from one production line to another as maintenance requirements change. The multi-commodity capability gives the MC’s tremendous flexibility and both can respond rapidly to a surge in maintenance demand.

1. Infrastructure

The infrastructure of both MC’s is composed of the facilities, diagnostic equipment, tools, and technology that are required to conduct depot maintenance of the LAV and its weapons systems. Both MC’s have nearly the same processes, but two differing processes must be noted. MCA uses a static four axle chassis dynamometer that tests the components of the drive train, while MCB uses a mobile, towed chassis dynamometer. MCA uses a live-fire facility to test the 25 millimeter chain gun on the LAV-25, while MCB uses a dry-cycle fire test that cycles inert ammunition through the gun to test for specific load capacity and cycling rates.

D. INVENTORY AND SECONDARY REPAIR PARTS

Class IX repair part inventory policies are established at both MC’s by Material Control Centers (MCC) that are responsible for overall centralized planning and management of repair parts. MCC responsibilities include material requirement determination, procurement, requisitioning, receipt, and inventory accountability of Class IX consumable repair parts. Production and material planners determine replacement factor rates for each component in order to arrive at a washout rate that management can use for forecasting. The SOW details the work requirements to be performed and management can then use the LAV maintenance schedule to determine daily usage rates, reorder points, and the amount of safety stock to be maintained.

Secondary Repairables (SECREPS) are components designated as repairable, when it is determined that it is more economical and timely to repair them than purchase replacements. SecReps are broken down into two categories: Field Level Repairables (FLR) and Depot Level Repairables (DLR). FLR’s are repairables that can be repaired at supporting Combat Service Support organizations that possess third and fourth echelon maintenance capability. DLR’s are SecReps requiring depot level repair beyond the maintenance capability of the Combat Service Support organizations.

The SecRep Program at each MC exists to provide a source of serviceable repairables to support the operating forces. Each MC possesses maintenance capabilities to repair LAV SecReps as well as an inventory of SecReps as safety stock to support operational units within their geographical region. Both MC DLR assets are managed by a centralized inventory manager that is located at MCLB, Albany. Initial inventory levels of SecReps were determined by LOGCOM during the provisioning process and allowance changes can be made semiannually based on actual usage data consisting of forecasted demand, repair rates, washout rates, and administrative and production lead times.

IV. COST ANALYSIS

A. OVERVIEW

The financial impact of the War on Terror on budgeting at the depots has been significant. Increases over the budgeting rates pre 911 have put the Service Life Extension Program (SLEP) and Inspect and Repair Only As Necessary (IROAN) processes for the LAV's on the fast-track. However, with the drastic increase in the tempo of operations overseas, especially as companies of LAV's patrol the Iraqi borders daily, the financial influx may be stressed to maintain the vehicles as they require depot level maintenance (DLM) much more often now than they did before Operation Iraqi Freedom (OIF).

Four major differences from today were in effect in FY01 and at least part of FY02 that very much impacted the ability of the maintenance centers to perform IROAN. This was prior to the implementation of the Theory of Constraints on an extremely stringent and insufficient budget and prior to the incorporation of the SLEP program. Additionally this period operated using the assembly-line process and not the team/craftsman concept discussed in the TOC chapter. Each of these factors impacted the DLM process in different ways. Whether the impacts have been positive or negative over time and to-date are examined here.

The fiscal constraints prior to 911 were arguably more than a little constrictive. With a total of 732 LAV's on-hand, the IROAN total for FY01 was limited to 37 for both depots combined. With a maximum time allowed between IROAN's of six years, at that rate only 222 LAV's would receive the necessary DLM, or less than one-third. FY02 was not significantly better though with only 59 LAV's IROAN'd, at a rate of nearly one-half of the required rate. It must be remembered at this point that these numbers are prior to the severely increased operational tempo created by OIF, and this will be addressed later.

When interpreting the figures and tables throughout this section, it is essential to understand what costs they reflect, and what costs they do not. In compiling data, we focused on IROAN's and IROAN/SLEP combinations, but never SLEP cost data alone.

This was because our focus is on IROAN's. Once the vehicle is SLEP'd and becomes and is then identified by the A1 addition to its nomenclature, its IROAN's include the components added or upgraded during the SLEP. Additionally, we consider the SLEP by itself to have an insignificant impact in terms of additional cost and time. Therefore the charts show LAV's that were IROAN'd, whether they were previously SLEP'd or not, and show combination IROAN/SLEP's.

In the tables listed below, the columns reflect six aspects of cost over time that we deemed essential for our analysis. Five of the column headings pertain to the average cost of the particular heading per each vehicle serviced. LAV's IROAN&SLEP reflects total vehicles serviced as explained in the previous paragraph. LHR's refers to the average number of total Labor Hours per vehicle. Labor Dollars reflects the average cost per vehicle as allocated in the cost allocation per task charts displayed in Appendices A and B. Average LHR Cost reflects the average cost per labor hour per vehicle and is determined by dividing Labor Dollars by LHR's. Materials reflect the average cost per vehicle of material resources used in performing the IROAN or IROAN/SLEP combination. The last column, Each, reflects average total cost of each vehicle and sums the cost of Labor Dollars and Materials to get the total.

B. TRENDS FOR ALL VARIANTS

Before examining LAV-25's specifically, it is worthwhile to briefly list the overall changes in cost for all of the variants combined with regards to labor hours, average LHR cost, material cost, and total cost each. These measures will prove to be the most prudent in analyzing costs. These numbers are a compilation of the data provided by LOGCOM in Albany. The original cost data was input into an Excel spreadsheet in order to model costs over time and across geographical regions in contrasting MCA with MCB. When necessary the averages were weighted in compiling over time and in comparing the two MC's. The data reflects the combined cost of performing an IROAN and SLEP as the two separate processes became combined in late FY03. The cost of performing a SLEP exclusively will not be analyzed, but will be considered for its affects on total costs. Figure 1 pertains to all LAV variants and reflects the average total cost of each LAV receiving an IROAN or IROAN/SLEP, and the graph is broken down further to show the impact of both labor and materials on the average total cost.

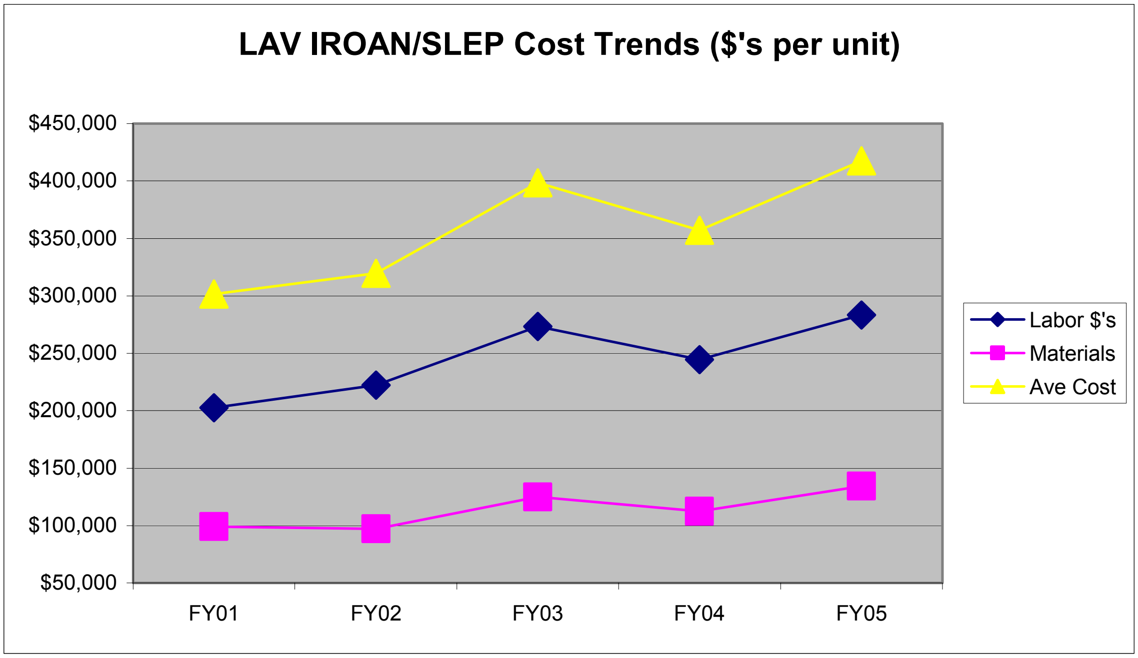

Figure 1. LAV IRON/SLEP Cost Trends

An often ignored factor that reduces the ability of the MC's to perform DLM is the perception of unit commanders. Even though the LAV program maintains the Depot Maintenance Float Allowance (DMFA) in which a one for one swap of LAV's is conducted upon the arrival at the MC of the vehicle to be inducted, any significant change in the expected number of vehicles to be shipped away from the unit can very easily be met with resistance by the using unit. Whether it is the established training schedule, a crewman's affinity for a particular vehicle, or the dozens of man-hours of preparation required to get an LAV ready for shipment to a depot, there is often a struggle to get units to follow new schedules when higher authority has increased induction rates. However, this has not affected the total number of LAV's IROAN'd even considering potential commander inhibitions.

Table 1 delineates the average costs per vehicle over time for all variants per the column headings addressed in the Cost Analysis Overview. The weighted average LHR cost since FY01 has increased modestly from $75 to $85, or 13%. Material costs have risen more dramatically though from $99K to $134K per vehicle, or 35%. Finally, the total cost per vehicle has increased from $301K to $417K, or 38%. The LAV-25 alone reflects these overall trends in cost, and focusing on this single variant will in no way detract from an analysis of all variants. At this juncture, it must be remembered that analysis pertains to the LAV-25's unless specifically stated.

	LAV's IROAN&SLEP	LHR's	Labor Dollars	Average LHR Cost	Materials	Each
FY01	**37**	**2,687**	**202,534**	**75**	**99,110**	**301,644**
FY02	**59**	**2,979**	**222,379**	**75**	**97,192**	**319,571**
FY03	**119**	**3,534**	**273,358**	**77**	**124,942**	**398,300**
FY04	**60**	**3,030**	**244,553**	**80**	**112,525**	**357,079**
FY05	**152**	**3,309**	**283,223**	**85**	**134,249**	**417,472**

Table 1. Average Costs Per Vehicle FY01 – 05 (All Variants)

C. THE LAV-25

As seen below in the Table 2, the LAV-25's are reflective of all variants combined, at least from FY02-05. The disparity in the FY01 data is reflective of a single piece of data for MCB, which shows that zero LAV-25's were IROAN'd that year. Therefore, the LAV-25 cost analysis will pertain to the years of FY02-05. This time period captures both old and new processes, and old and new budget issues pertaining to the IROAN and SLEP programs. From FY02 through FY05, the weighted average LHR cost increased 17%. Material costs increased 39% during the same period. Finally, the total cost of each vehicle IROAN'd and SLEP'd grew 29%.

	LAV-25's IROAN&SLEP	LHR's	Labor Dollars	Average LHR Cost	Materials	Each
FY01	**3**	**3,523**	**283,937**	**81**	**109,209**	**393,146**
FY02	**33**	**3,135**	**235,714**	**75**	**94,749**	**330,464**
FY03	**79**	**3,766**	**291,687**	**78**	**136,004**	**427,691**
FY04	**27**	**3,202**	**258,320**	**80**	**114,102**	**372,422**
FY05	**73**	**3,340**	**296,110**	**88**	**131,551**	**427,660**

Table 2. 2 Average LHR and Labor Cost FY 01 – 05 (LAV – 25)

1. Labor Hours and Personnel

The effects of budget increases are not always all positive. The ability to IROAN additional LAV's in a single year must be weighed against many factors. One factor is in the physical capacity to perform the additional work vis-à-vis labor requirements. An increased budget does not alone provide the capability to increase output.

As delineated in Table 2, labor hours saw a significant jump in FY03 before settling back down in FY04-05. The depots saw an average increase of over 600 LHR's required per vehicle completed, which was about a 20% increase. But the potential rationale for this includes the newly introduced TOC process, the shift to the teams and the craftsman concept, and the large number of less experienced workers. Distinguishing specifically between the effects of these three factors is a challenge, so they are analyzed together here. With any newly introduced program, the learning curve may be rapid, but the initial impact is usually very noticeable on bottom lines as is the case here. The significant training required in the transition to TOC would have easily extended LHR's as personnel learned their new system of empowerment and teamwork, on top of the additional training required to become an efficient and effective worker in the new process. Figure 2 demonstrates the effects of average labor and material costs on average total costs of the LAV-25 exclusively over time.

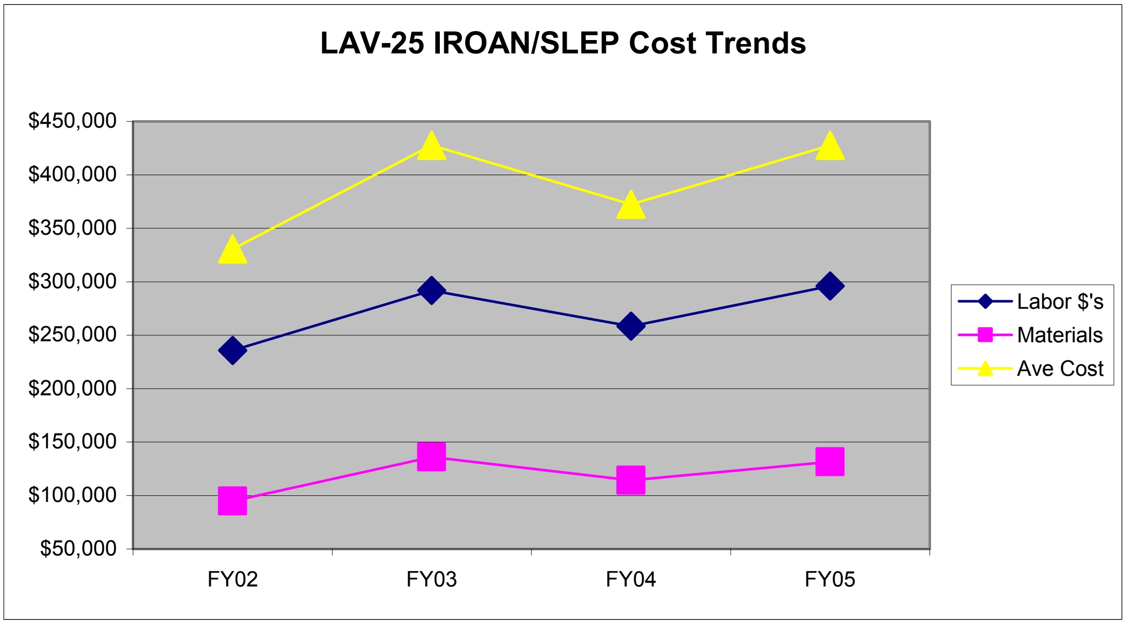

Figure 2. LAV-25 IROAN/SLEP Cost Trends

Although we are not 100% certain of how the MC's filled the gaps with new personnel, we believe that most if not all of the labor gaps were filled by current employees. If necessary, the second means would have been the hiring of new workers, only because contracting out the work done in the IROAN process would not have been prudent fiscally or otherwise. Either way, the addition of less experienced workers into the new LAV IROAN process would surely have an impact, and help to explain in part the nearly 15% increase in LHR's between FY02-03.

The impact on LHR's of more than doubling the number of LAV's IROAN'd in FY03 might be expected to be profound. The MC's have a few methods to decide between when a need for additional labor arises. First, they can hire new people and train them, but if the demand for this labor wanes then the MC has a new problem, the oversupply of labor. Second, using contractors to complete work is a favorable option because once the terms of the contract are complete, those workers leave the MC without significant problems. Third and most favorably, other sections who have excess labor, or which are lower on the priority list, shift those people to the new section; often from the AAV (Amtrak) or M1A1 Abrams sections. These workers are then trained and incorporated into the new section.

As for the effects of additional employees, we expected that they would have also slowed down the DLM process. However, considering that most if not all of the new employees in the LAV section came from other departments within the maintenance centers, we must consider that any new hires were expected to learn the new TOC system as well. But since the new and old employees would have all been learning the new processes together, we suspect that the negative effects of new employees may have had less of an impact on LHR's than they might have if the process was not transforming during the same time period. Therefore, it is our finding that although a spike in LHR's was to be expected, at least half of the increase should be attributed to the very new process.

Once the shocking effects of FY03 concluded, not only would we expect that LHR's would diminish as efficiencies were realized, but also the total number of LAV-25's IROAN'd was cut in half, which likewise helps to account for the reduced LHR's.

2. Average LHR Cost

At this point, we might expect that the average LHR cost might jump significantly as well, considering the many effects on labor during this time period, or that the accumulated effect might be extreme. But although they did increase from $75 to $88, or over 17%, we consider this to be moderate. The rationale for this can be attributed to cost accounting and the spread of overhead across activities. As the number of LAV-25's receiving DLM doubled in FY03, the distribution of overhead costs affected the overall perception of total costs. This explanation serves us well for FY03, but with the significant reduction in LAV-25's at the depots in FY04 we can no longer extrapolate the reasons for the distribution of overhead costs as the dominant factor. There are obviously more factors involved, but these will be analyzed in comparing the two MC's later. In FY04 as the number of LAV's serviced was cut in half, we would expect overhead costs to be recalculated and reassigned. However, as we have discussed already the rise in average LHR costs were only moderate, even during this time period. For now, we remain impressed that the combined total of a 17% increase in the average cost per labor hour is all the depots experienced. Figure 3 denotes the increase in average labor hour cost per LAV-25 over time.

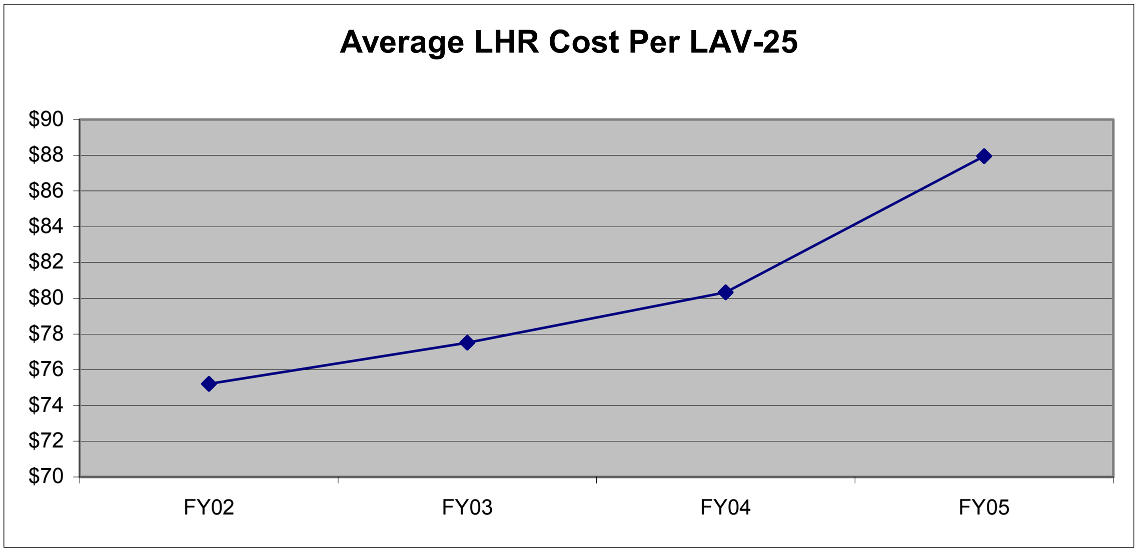

Figure 3. Average LHR Cost Per LAV-25

3. Introduction of SLEP and Material Costs

The SLEP began a phase-in process in late FY03. More recently in FY05 we began to see some of the SLEP'd vehicles return to the depot for IROAN. This is proof of how rapidly many of the LAV's are meeting the set requirements for returning to the depot: 6 years, 20K hours, or 25K miles. The introduction of SLEP to the IROAN process currently adds only 1.5 days to the total RCT.

There is a marked difference between material costs in FY01-02, prior to the incorporation of the SLEP's with the IROAN's. But since SLEP's were introduced in late FY03, we find difficulty in assigning blame to SLEP for the massive increase in material costs in FY03 of $40,000 between MCA and MCB, for a combined increase of 42%. And then, even more perplexing is the drop in material costs in FY04 by 16%. With the introduction of SLEP, we suspected that material costs would rise and stay higher, not fluctuate as they have over the last three years.

But more profoundly the impact on material costs was due to the increased op-tempo during FY03 causing extreme stress to many sub-systems of the LAV above and beyond normal wear-and-tear, as well as damage to these same systems from operating in a severe environment; this is not counting Battle-damaged vehicles. Additionally, the increase in price of repair parts as suppliers rushed to increase production along with their prices also serves to explain the increase in material costs. Looking out an additional year, material costs have increased by an average of $30,000, for a combined increase of over 27%, but where they will settle in FY06 is anyone's guess.

4. Reduced Repair Cycle Times

Another factor must be analyzed though so that it is not assumed that the number of labor workers also doubled just because the number of LAV's IROAN'd doubled. This requires an examination of the reduction of RCT's over the last 5 years. In FY01 the average LAV RCT was 231 days, and this was just in the MC and did not count time in FSD and all transition times. Between the budget increases in FY02 due to the War on Terror, the expected learning curve, and improvements in the old assembly-line process at the MC's, the RCT dropped to 137 days in FY02. Ultimately, by FY03 at the time that the number of LAV's going through the IROAN process doubled, there was most likely excess labor within the LAV section itself, which helped to absorb the increased requirement, and minimize the number of new workers required in the section. Additionally, even as the section struggled to adopt the TOC and incorporate the SLEP along with the IROAN process, the RCT for FY03 still dropped significantly to 116 days average, also helping to dismiss the question of whether a larger adjustment to meet the new higher demand would be necessary. Currently the average RCT that MCA is capable of is 96 days, while it continues to advertise 120 as it maintains its schedules per the TOC, but we will elaborate on this distinction in the Repair Cycle Time Analysis chapter.

5. Total Costs

The effect on total costs per vehicle IROAN'd may seem relatively easy to predict at this juncture, since we've examined both the increase in Material Costs and the Average Cost per Labor Hour. Over the last four years the weighted average cost per LAV-25 has increased 29%, from $330K to $427K. Both labor costs and material costs account for this increase, but even though material costs have increased 40% over the last four years, material costs only account for 30% of the total cost of an IROAN. Therefore the other 70% of total costs is attributable to labor costs and how and what overhead costs are attached to each task. As we might expect, FY03 saw the most severe increase in total costs of nearly $100K per vehicle completed, for over a 29% increase. While total costs settled back down in FY04, FY05 brought the total costs back to the FY03 rates. This is also an apparent blow to the TOC and Lean Thinking processes adopted, but as we'll see later there is a profound difference in the financial success of the different MC's.

D. MCA VERSUS MCB

To this point we have been looking at DLM issues collectively. However, a distinction must be made when analyzing cost data between the two MC's. Significant differences exist in the allocation of costs per task, average cost per labor hour, and in material costs.

1. Allocation of Costs by Task

The cost per task in the DLM process for the LAV at MCA and MCB is listed in Appendix A. As each specific task is performed, costs are assigned to the project based on the total hours it takes to complete the task. The first thing one realizes when comparing the costs assigned to the various tasks at the two MC's is the severe disparity between them. Although the various tasks required in performing an IROAN/SLEP are the same, the allocation of costs, and the description, even within the same task may vary somewhat, although the basic premises are the same.

A few examples of the differences will suffice. At MCA the cost of an hour working on the Power Train is $66.25, while at MCB the cost is $82.06, or 24% higher. The Power Train cost allocation difference is subtle compared to Welding, which at MCA is $62.44 and at MCB is $113.09, or 82% higher. Even a task that requires a basic skill level like Painting shows great disparity: $62.44 and $113.09 at MCA and MCB respectively, for a difference of 82% as well. Our data is not reflective of either specific costs related to individual labor wages or overhead costs. However, the combination of both is reflected in the massive disparity in the cost allocation structures between the two maintenance centers. Now that we have created a general expectation of what we might find when comparing specific metrics, let's see if our analysis will support our current expectations.

2. Labor Hours

The implementation of the Theory of Constraints spread through both MCA and MCB during roughly the same time periods. Along with the TOC, the shift from the assembly-line process to the team/craftsman concept, as well as the implementation of the SLEP's, were all in similar time periods.

To reiterate, since MCB performed no IROAN's on LAV-25's in FY01, we will look at the last four years primarily as we contrast the two depots. For MCA, the moderate increase in LHR's from FY02-05 was met with a spike in FY03, which was to be expected as we have elaborated on above with so many changes and factors above. The 160 additional LHR's over the four years represent only a 5% increase, which we consider insignificant considering the additional time required for SLEP, the occasional modifications, and the high fluctuations in manpower requirements. MCB saw a 205 hour increase over the same period, which represents about a 6% increase. This increase is equally insignificant considering that all of the same factors that applied to MCA also applied to MCB, and had similar effects on spikes in LHR's in FY03 for example. But what is more disconcerting to us is in the comparison of total LHR's required. Even in FY02 with all of the old processes and budgetary issues, MCA required only 92% of the

LHR's required in MCB. By the end of FY05, MCA was 9% more efficient than MCB, at least with regards to total LHR's per vehicle.

This would not be an insignificant disparity if the cost allocation per task listed similar costs between the two MC's. However, based on our previous analysis we know that this 9% disparity in LHR's highly exacerbates total labor dollars per vehicle to the point of extremes. In FY02 labor dollars in MCA were about $226K, and discounting the spike in FY03, drifted down to $219K by the end of FY05, for a 3% reduction. Unfortunately we did not find the same effects at MCB as labor dollars increased from $243K to $343K, a 41% increase. Figure 4 demonstrates the profound disparity in Labor Dollars per the two maintenance centers over time.

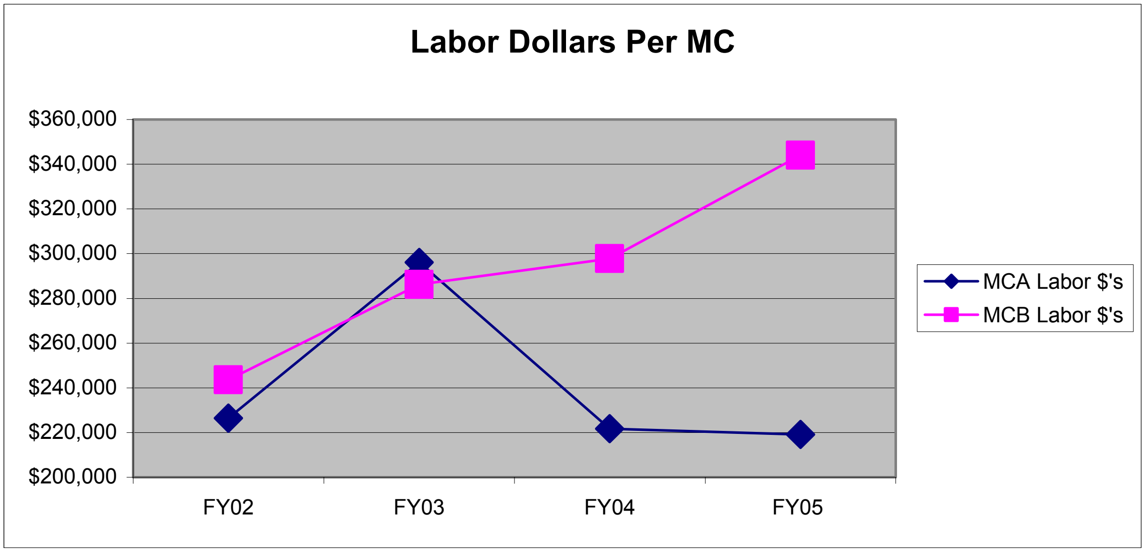

Figure 4. Labor Dollar per MC

Accounting for these disparities is difficult, but along with the disparity in LHR's, the huge disparity in cost allocation, i.e. overhead and labor rates, developed over the last four years as well. The doubling of LAV's to IROAN in FY03 means that the allocation of overhead costs would have been reduced in order to help balance the budget. However, the next year in FY04 the number of vehicles serviced was cut in half, but the cost allocation structure remained low only at MCA, but not at MCB. We partially attribute this to the success of implementing the TOC and Lean Thinking at MCA discussed in the TOC chapter. FY03 was the year in which both MC's were severely challenged by the increase in op-tempo and by the transition to the TOC, but it appears at this point that MCA is outperforming MCB. Tables 3 and 4 delineate average total costs as well as total costs for the LAV-25 for MCA and MCB respectively.

ALBANY							
FY	Labor/HR	Labor Dollars	Av c Lhr	Material Cost	Cost EA	# of LAV's	Total Cost
FY01	3,523	283,937	80.60	109,209	393,146	3	1179438
FY02	2,996	226,403	75.57	100,622	327,025	15	4905375
FY03	3,886	296,008	76.17	144,248	440,256	44	19371264
FY04	3,084	221,673	71.88	113,940	335,613	14	4698582
FY05	3,156	219,196	69	147,656	366,852	28	5,487,859

Table 3. MCA Costs FY 01 - 05

BARSTOW							
FY	Labor/HR	Labor Dollars	Ave c Lhr	Material Cost	Cost EA	# of LAV's	Total Cost
FY01	2,692	176,269	65.48	112,865	289,134	0	0
FY02	3,250	243,474	74.92	89,855	333,329	18	5999922
FY03	3,615	286,255	79.19	125,641	411,896	35	14416360
FY04	3,330	297,786	89.43	114,277	412,063	13	5356819
FY05	3,455	343,967	$99.56	121,529	465,496	45	10,942,272

Table 4. MCB Costs FY 01 – 05

3. Average LHR Cost

It is important to note the successes of the changes at MCA during FY02 as they translate into the average cost per labor hour. Obviously overhead costs are attached to each task so that the Working Capital Fund might balance at the end of the fiscal year. But a trend has been realized at MCA that can be explained in a few ways. The trend is that average cost per labor hours steadily reduced and is currently $69 per hour, 9% less than in FY02. Even considering the strains and adjustments during FY03, the cost held steady from the previous year. In FY04 when the annual number of LAV's IROAN'd is cut approximately in half, as it is in Barstow, we expected average LHR cost to increase. But regardless of the cost allocation of overhead on the reduced number of vehicles, this statistic at MCA reduces by 6% from $76 to $72. The MC attributes this to the TOC and Lean Thinking, and we find it difficult to disagree. Much of FY03 was spent in refining the teamwork practices, craftsman techniques, and other lean practices implemented with the TOC. By FY04 these operations were running even more smoothly, efficiently, and effectively. Even more amazingly, as the number of LAV's IROAN'd in FY05 increased by 15%, the average LHR cost continued to decline dramatically by over 12%. This statistic alone does much to justify the gains made by TOC and demonstrates not only the efficiencies, but also the agility of MCA.

It is understandable that average LHR cost would increase during FY03 at both MC's. They were both transitioning to the TOC, both increasing their workload and training new personnel to work on the LAV's due to the increased budget, and both incorporating SLEP into the IROAN process. But moving on to FY04 and 05 the trend is very surprising at MCB. There, the progress took a different direction altogether. While the RCT's of both MC's have continued to decline dramatically over the last five years, the dominating cost factor of labor has only decreased at MCA, while it has increased dramatically at MCB. Not only has the average cost per labor hour increased over 33% in the last five years, but nearly 26% of that has occurred since adopting the TOC and sits at the end of FY05 at $99 per hour. Figure 5 demonstrates the disparity in average labor hour cost over time between the two MC's.

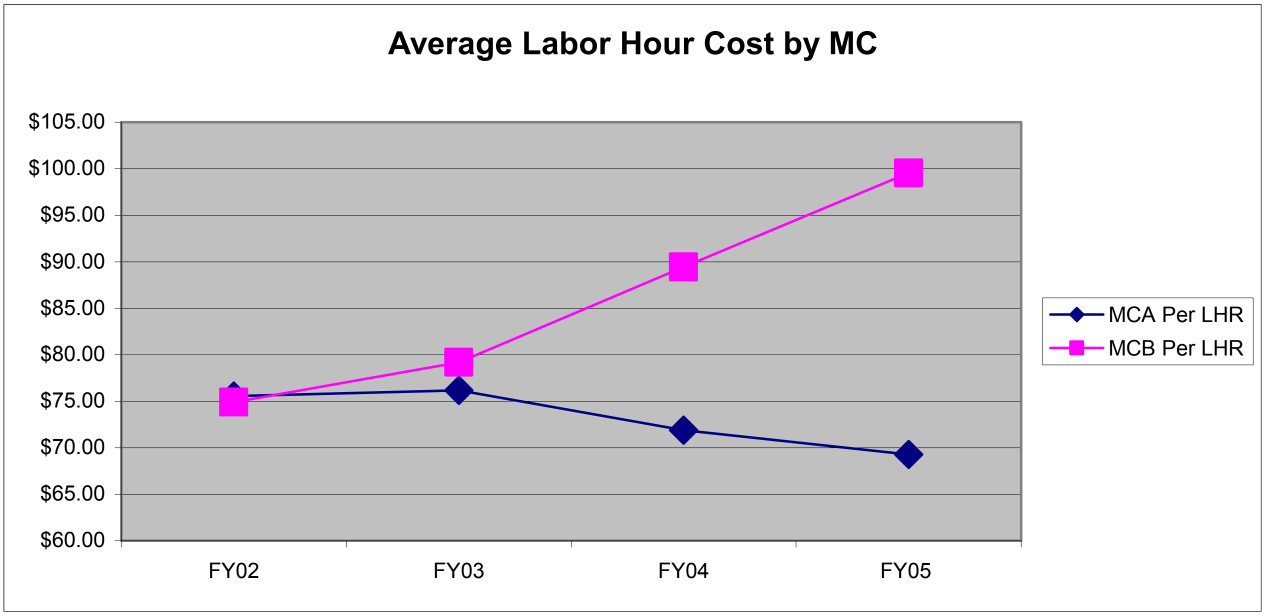

Figure 5. Average Labor Hour Cost by MC

4. Material Costs

When it comes to analyzing material costs, the tables are turned a bit on MCA. There, costs rose $47K since FY02, or 47%. As expected, costs shot up in FY03 for several reasons already discussed above, and we initially attributed approximately 10% of the increase to the SLEP. But miraculously they dropped back down to $113K each during FY04. Our theory is that because the vehicles IROAN'd at MCA were predominantly from units on the east coast which had not yet deployed for OIF, and because of the efficiencies gained during FY03, the material costs during FY04 make sense. We do not have information on how many vehicles may have come off of MPS ships during FY04 that actively participated in OIF, but we believe the number to be either zero or very low.

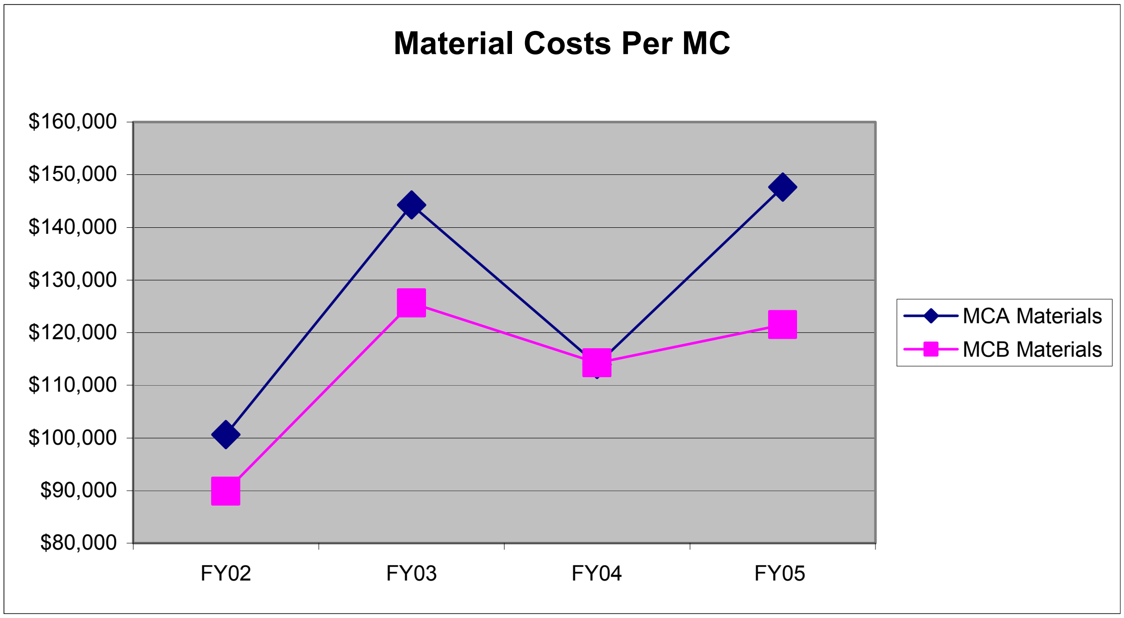

Figure 6. Material Costs per MC

Figure 6 graphs both the similarity in trends as well as the significant disparity in material costs per vehicle between the two MC's. As for MCB and material costs, the effects of time have been less profound. Although they increased over $31K over four years, this is only a 34% increase and much better in relation to MCA. Additionally their FY03 spike was less severe than MCA's as well, and after FY05 MCB's material costs are $26K less per vehicle, or 18% less. This is most likely explained by significant cost factors such as transportation costs from suppliers because we do not suspect that MCB would be significantly more cost efficient at inventory than MCA. However, this aspect of cost is left for further analysis in a separate project.

5. Total Costs

The location in which the IROAN is performed had a dramatic impact total cost per LAV. Since FY02, the total cost per LAV-25 has risen from $327K to $367K, or 12%. And just as one might expect, FY03 costs spiked at over $440K before dropping back down significantly. However, considering all of the changes over the last four years, these numbers seem quite impressive.

The situation at MCB is much less impressive though. The FY02 total each rested at $333K, but rose to $465K for FY05, a nearly 40% increase. While total cost each was very compatible in FY02 between the two MC's, time has not been friendly to MCB. By the end of FY05, not only can MCA perform IROAN/SLEP's at a lower rate than MCB, but this lower rate is massive at a $98K difference. MCA can perform the same tasks for 21% less cost. Hypothetically, if MCA had serviced the LAV-25's that went to MCB in FY05, approximately $4.5M would have been saved using current rates. Figure 7 displays the average total cost per vehicle by maintenance center and clearly distinguishes MCA as the cost saver over time.

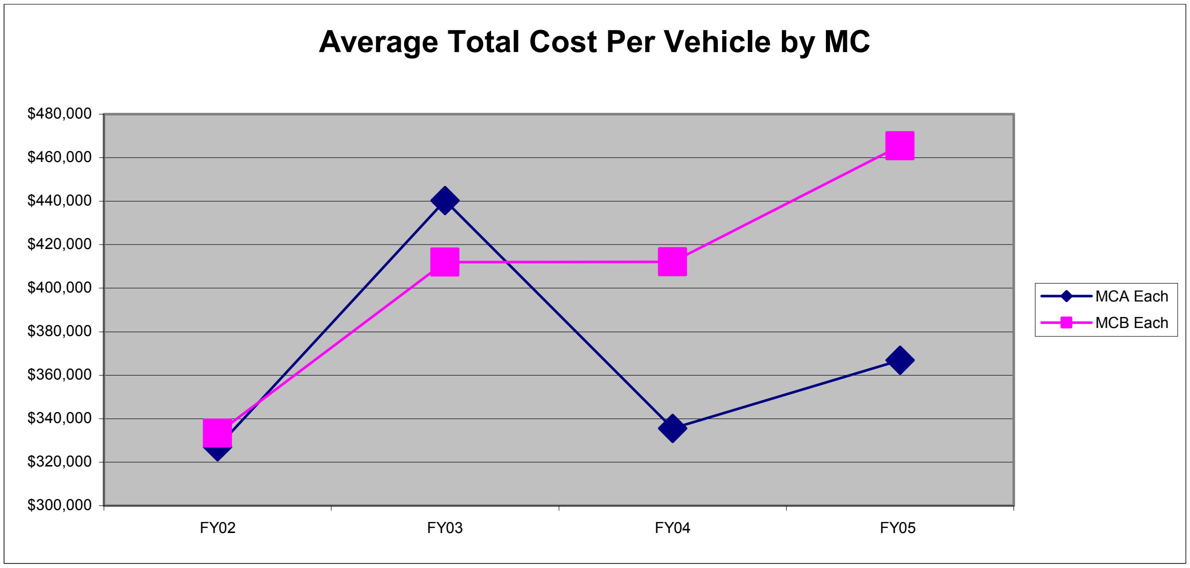

Figure 7. Average Total Cost per Vehicle by MC

Based on our analysis of labor costs and material costs, it is basic to see that the labor costs have a much greater impact on total cost. Above we demonstrated how material costs at MCB have remained significantly lower, $26K lower, than those at MCA. But in the end the total cost is reflective of the massive impact of labor costs where we have seen a huge disparity in which MCB pays labor costs at a rate over 57% higher than those at MCA.

E. TRANSPORTATION OF LAV'S

Transportation costs have changed dramatically over the last five years. Although the cost of maritime shipping has held steady, the costs of shipping by Tractor Traylor (TT) have nearly doubled. To make matters worse, the variability of cost when shipping by TT can be as high as 57%. However, since movement by TT is significantly less expensive than by ship (only because of the lesser distance), this variability has not had an extreme impact on budgeting and will therefore be disregarded in our analysis. We will instead focus on average cost of the potential carriers.

The one way averages listed in Table 5 show the cost to move an LAV from and to the listed origins. The cost of shipment from Camp Pendleton to Barstow for example is rather insignificant in relation to the cost of the entire IROAN process, as is the cost in movement from Camp Lejeune to Albany. Both of these movements have geography on their side. However, the cost of movement across country and across oceans must be considered when budgeting for IROAN, since these costs are significant. In an extreme case, a vehicle moving from Okinawa to Barstow and then on to Albany due to either under-capacity at Barstow, over-capacity at Albany, or several other reasons, could cost nearly $28,000 round trip. Although this cost is not factored into the total cost of an IROAN, it cannot be overlooked that it is approximately 7% of the total current IROAN cost. More likely though, the total transportation cost is only 1-2% of the total cost. But the main point is that transportation costs must be factored into the planning stages by the PM's when considering maximum budget allowances and throughput, especially when LAV's require IROAN/SLEP from overseas units.

From	To	Averages	Var in Price Range
Camp Pendleton	Albany	$3,199.37	+- 8%
Camp Pendleton	Barstow	$640.54	+-21%
Camp Lejeune	Albany	$1,010.81	+-10.5%
Camp Lejeune	Barstow	$4,511.07	+-11.5%
Albany	Barstow	$3,905.70	+-11.5%
Pt Hueneme	Barstow	$685.56	+-29%
Okinawa	Pt Hueneme	$9,098.65	+-2%
Hawaii	Pt Hueneme	$5,370.09	+-3%

Table 5. Transportation Costs (Current)

F. BATTLE DAMAGED LAV’S

Although our intent here is not to incorporate battle-damaged LAV’s into our previous analysis, it is at least important to address the financial impact that they have on the system, and even more important to address the potential influence that they may have on cycle-times and the MC’s ability to maintain schedules and the DMFA, which will all be addressed in the cycle-time chapter.

The total number of LAV’s that have been categorized as battle-damaged since the operations in the War on Terror began is 27. Average cost of repairing an LAV has averaged $347K for a total of $9.4M. However, this does not affect budgets in the MC’s since these repairs are paid for by supplementals from the Program Manager in Michigan. Detecting trends with regards to these vehicles would be purely speculation, and therefore we will refrain from doing so. However, considering the variation in cost associated in repairing these vehicles, we assume that even if a vehicle is due for an IROAN or SLEP, or close to its IROAN limits, it will receive service primarily on the damage for which it came into DLM. This is because of restrictions on the use of funds for repairing BD vehicles. But if the BD vehicle is due for the IROAN or SLEP then it will be incorporated into the process, and costs for these processes will be billed accordingly.

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V. REPAIR CYCLE TIMES ANALYSIS

A. INTRODUCTION

A tremendous emphasis has been placed on the reduction of Repair Cycle Times (RCT) at both MC's in order to return LAV's to the operating units as quickly as possible and to reduce costs. The introduction of the Theory of Constraints and Lean Thinking have transformed the manner in which the MC's conduct maintenance and have improved operational availability in the operating units as well as improving capacities at the MC's. For the purposes of this analysis we consider repair cycle times and maintenance cycle times as the same.

1. Using Unit to Ready for Issue

From the operating unit's perspective the RCT's begin when they prepare an LAV for shipment to a depot and end when they receive a replacement LAV. The operating units don't see how the MC's work to reduce RCT's, they only notice that their LAV's are sent to the depots and are gone for months. The operating units are using the correct interpretation of RCT's. The entire time an LAV is away from the operating unit should be considered the RCT because every step from preparing the LAV for shipment at the unit, to shipment, to awaiting maintenance at the FSD, to induction at either MC, back to the FSD awaiting shipment, to return shipment, and finally returned to an operating unit is all part of the RCT. It does not do a lot of good to only reduce RCT's at one point in the chain and ignore the cycle times everywhere else.

Our analysis uncovered that, although there is an emphasis on maintenance processes and RCT's at the MC's, there is no accounting for time anywhere else along the chain of events that encompass depot level maintenance of LAV's. This is due partially to misconceptions about what an RCT actually is and a chain of custody during the entire process that changes hands several times, with each custodian concerned only about their own responsibilities and not the big picture maintenance cycle time.

B. MAINTENANCE STEPS

For the purpose of our analysis we asked MCA to give us the Work Order Routing lists for two recently completed IROAN LAV-25's; one a baseline (without

SLEP upgrades) to SLEP and the second an A1 (SLEP upgrades completed previous IROAN cycle). We then built two tables to compare the difference in processes between the two LAV-25's. Appendix D provides the compiled results from the baseline to SLEP LAV-25 and illustrates the 38 maintenance steps and 409 total maintenance hours to complete the IROAN and SLEP upgrades for this particular LAV-25. Appendix E provides the compiled results from the A1 LAV-25 that was completed the same month as our baseline LAV-25 and illustrates 36 maintenance steps and 380 total maintenance hours to complete an IROAN that has already had the SLEP upgrades completed. The maintenance hours are only the hours necessary to complete the task, not the man-hours.

1. SLEP Maintenance Additions

Both Appendix D & E indicate that there is very little difference between the two maintenance processes, since both use the IROAN as the standard process. The only differences are the SLEP upgrades, which are the additions of steps 16 and 17 in Appendix E, adding 25 hours to the process and an additional 3 hours in administration in step 38. The remainders of the maintenance steps are the same between the two LAV's. The LAV Program Lead in MCA stated that there is normally an additional 10 hours during the hull repair to install SLEP bosses, standoffs, and brackets. An additional 4-5 hours are required for electrical modifications, and the remainder of the SLEP upgrades are done during the reassembly process with no additional hours because the mechanics would have been installing the old baseline components as opposed to the provided SLEP components.

2. Hull Maintenance Factors

The hull repair in step 11 of both Appendix D & E indicates that 100 hours was spent on this critical maintenance step for both LAV's. The ability of the armor to withstand an Improvised Explosive Devise (IED) is critical to the survivability of the LAV and crew so it is not surprising that approximately 25% of the entire maintenance hours are spent on repairing the hull. It is also the step where the most variability exists. If the hull has little damage and requires fewer repairs it will greatly reduce the RCT on that particular LAV. The MC also spends 45 hours in various inspections, indicating that quality is a priority.

C. RCT REDUCTION SINCE FY 01

The MC's have invested considerable capital and time in an attempt to reduce RCT's. The introduction of the TOC occurred during the latter part of FY01 and as shown later in figure – 8, the average RCT at the MC in Albany dropped significantly in FY02 from 231 days to 137 days, which is a reduction of 40% in a matter of months. It is obvious that the MC was not very efficient prior to the introduction of the TOC and even a steep learning curve did not affect a rapid improvement in RCT's. No new maintenance processes were added, or deleted, in FY01 or FY02. The MC was still doing the same IROAN and the reduction in RCT's can be fully attributed to the introduction of the TOC.

1. RCT at MCA

The MC in Albany has noticed an improvement every year since the introduction of the TOC, indicating the RCT's are gradually going down as the MC becomes more adept at implementing the TOC. The average RCT's were reduced 21 days from FY02 to FY03, a 15% reduction, and in FY04 there was a further reduction of 9 days, or 7%, and another reduction in FY05 of 19% to 96 days of actual RCT. Even the introduction of the SLEP during the last quarter of FY01 did not slow the reduction of the RCT's down very much, indicating that the MC is very efficient and flexible in handling new tasks and that the TOC is working well. The MC in Albany has estimated that improved efficiencies have given them the additional funds and capacity to process 6 additional LAV-25's through the MC.

2. Capacity

In FY03 there was a surge in capacity at the MC in Albany due to Operation Iraqi Freedom. There were 55 LAV-25's repaired at the MC in FY03, including battle damaged vehicles, as opposed to 15 in FY02 showing a 266% surge in capacity from FY02 to FY03. The surge in FY03 of LAV-25's repaired at the MC was typical for all the variants, indicating that the MC was able to efficiently handle the capacity and still reduce average RCT's by 9% from FY03 to FY04. The manner in which the MC handled the surge of LAV's inducted for maintenance in FY03 also gives us an idea about overall capacity. The LAV Project Lead in Albany stated that the MC could handle all of the LAV depot maintenance, without additional facilities, and still maintain low

RCT's. There was a inflow of funds to support the maintenance costs in FY03 to present and it is difficult to assess what the impact of those additional funds is concerning RCT's. If those funds are reduced it is very probable that the MC's would become less efficient and the RCT's would begin to go up. There is a direct correlation between funds and efficiencies at the MC's, but we do not measure it in this analysis.

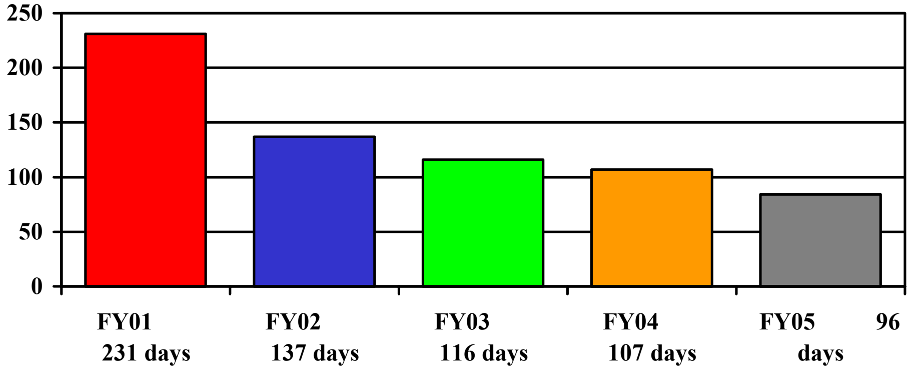

Figure 8. MC Albany Average Repair Cycle Times FY01 - FY05

D. COMPARING RCT'S AT ALBANY AND BARSTOW

Both MC's at Albany and Barstow advertise current RCT's of 120 days for the LAV-25. Actual average RCT's in Albany are 96 days, but Barstow uses the full 120 to complete depot maintenance. Part of this may be due to Albany doing a better job of implementing the TOC and Lean Thinking, but Barstow processes more LAV's through depot maintenance than does Albany, the exception being FY03. Other factors that may effect RCT differences between the two MC's are a larger work force in Albany to draw from and Albany is co-located with it's parent command LOGCOM, giving it more visibility.

1. Battle Damaged LAV's

Battle damaged LAV-25's are averaging 119 day RCT's at the MC in Albany, only 23 days more than a scheduled IROAN vehicle. Both MC's are repairing battle damaged LAV's with approximately the same RCT's, but we were unable to obtain data from Barstow to compare the two MC's directly.

E. CALCULATING OPERATIONAL AVAILABILITY AND MTBM

Calculating operational availability (Ao) for the LAV-25 can lead to much confusion. Therefore, it is imperative that the numbers, which our Ao represents be well defined. Considering the extremely high operational tempo that the LAV's are currently maintaining in support of OIF, it is to be expected that Ao might suffer. However, these low Ao's are not truly representative of the situation with these vehicles. An examination of the LM2 Readiness database as displayed in the Marine Corps Equipment Readiness Information Tool (MERIT) will help us to explore these issues.

1. LAV Distribution

Historically, the readiness database would have provided information on only six primary major units: I, II, and III MEF, Reserves, Base Units, and MPS's. More recently, a seventh major unit was added in order to provide for greater equipment accountability in the form of a "Deployed RUC" that became part of the Marine Corps concept in which deploying units would "fall" onto some of the same equipment used by the units being replaced. This unit is the VII MEF. The major problem with building this account in the SASSY system is that although the Marine Corps established an "Authorized SASSY" quantity for the VII MEF account, it did not reduce the Authorized SASSY accounts of the major units from which these LAV's were redistributed from. This is likely due to the expectation that doing so would create confusion in the future when this equipment returns to the primary using units stateside. In the meantime, defining and advertising specific Ao's must be met with skepticism and a basic understanding of the above.

2. Defining Operational Availability Parameters

We will now define the parameters we used in calculating Ao's per the 18 November 2005 MERIT Report, our estimates of Maintenance Down-time (MDT), and the current Safety Stock (SS). Remember that there is an expectation of a one-for-one swap from the DFMA when using units send LAV's to DLM. Additionally, we consider the Safety Stock to include the vehicles in the DFMA as well as those in other delay time statuses. Ultimately, SS will be the difference between all existing LAV-25's and the current Authorized quantity listed in MERIT, less the VII MEF account.

In estimating MDT, we had to consider several time factors, which included transportation time from the using unit to the depot, the time spent in FSD both before and after receiving service in the maintenance center, and finally the RCT within the MC itself. Because the variation in transit times is rather extreme, ranging from 2 days to potentially a few months for an LAV returning from Iraq via an MPS, we decided to use an extreme but known transit time from Kaneohe, HI and Okinawa, Japan of 50 days for the transit time.

Transit	FSD	MC	Total	MDT		MTBM	MDT	Ao	Safety Stock
50	30	120	200	6.58		24	6.58	0.78	86.03

Table 6. 6 Process Times and Operational Availability

As for time spent in the FSD receiving preparation for service in the MC, we had to consider many factors. For one thing, our attempts at retrieving data pertaining to time spent in the FSD were ultimately fruitless. However, considering the comments made by employees at MCA whom we consider experts, we estimated delay times in FSD to be at a minimum somewhere between two and six weeks. Based on this we took the average and used 30 days for our calculation. Once the LAV has had its required items reinstalled at the FSD after receiving DLM, it is again Ready for Issue (RFI), and it is at this point that our time stops. Lastly, regardless of the potential RCT of 96 days for the LAV-25 at MCA, we were compelled to use the advertised RCT of 120 days. These three major factors add up to a total of 200 days of MDT, or 6.58 months.

3. MTBM and Operational Availability Determination

The other major variable in calculating Ao is Mean Time Between Maintenance (MTBM). Although we know the three primary milestones that qualify an LAV for DLM, i.e. 6yrs., 2K operating hours, or 25K miles, we do not have data delineating which of these factors dominates. Therefore, we determined to estimate current MTBM based on other known factors by working our formulas backwards.

Since we know that 398 LAV-25's exist in the Marine Corps, and that 314 are authorized assignment to either operating units or MPS's, we subtracted the difference between these totals to determine the planned Safety Stock of 84 vehicles. Next, we were able to Solve for the expected Ao that would require approximately 84 vehicles. This expected Ao was determined to be .79. And now with the expected Ao known, we could

Solve for the current MTBM since we already calculated the MDT. Therefore, using the current SS and the estimated MDT, we estimate the MTBM to be 24 months.

This 24 months is a best-case scenario, but as we have alluded to in the previous chapters, the current rate at which LAV-25's are IROAN'd is not sufficient to meet the requirements of the current operating tempo. Additionally, what we truly suspect, but cannot prove to be the case at this time, is that the current MDT is much greater than 6.58 months, and maybe as high as 9 months. Holding the SS constant, we must adjust the MTBM out to 37 months (a more favorable estimate), which also holds the Ao constant at .79.

In reality we would like for this to be the case, but as of yet we have not considered deficiencies within operating units themselves. Although 314 is the current SASSY Authorized quantity, the actual possessed quantity is only 280. Translation being that although the expected Marine Corps wide Ao for LAV-25's is .79, the actual Ao is only .71. More profoundly, this lowers the current MTBM requirement even further to 16 months, with a required SS increase to 118 LAV-25's to round out the calculations accordingly. Whether current capacity is capable of IROAN/SLEP at this rate is equally as important as the exceptionally high cost of maintaining LAV's at this rate, but capacity is addressed elsewhere. For now the concern is that the system is strained somewhere, which is creating difficulties in keeping Possessed quantities equal to Authorized quantities.

The short answers for increasing Ao and reducing our T/E deficiencies are many, and some more practical than others. For example, we know that a majority of the LAV's require less than 8 days to travel from the using unit to the depot. Plugging this value into our formula not only reduces MDT by 20%, but increases Ao by .03 and reduces the required SS to 68 from 84. More realistically, a concerted effort to push vehicles through the FSD and to sustain the potential RCT of 96 would reduce MDT by 15%, increase Ao by .025, and reduce the number of LAV-25's out of the hands of using units by 13 vehicle's.

VI. CONCLUSIONS AND RECOMMENDATIONS

Our analysis has demonstrated the merits of the Theory of Constraints and Lean Thinking, at least when they are properly applied, when personnel are well trained, and when overhead and labor costs are not crippling factors in total cost structure of the maintenance center. The total costs spent on IROAN/SLEP at the respective MC's gives us the profound picture of the present and future of finances at MCA and MCB. We have demonstrated how the weighted average of the total costs spent on these programs at the two depots is $8.3M. However, we have also contrasted the two maintenance centers and shown that the total costs for the LAV-25 at MCA in FY05 are only $5.5M, while total cost at MCB neared $11M, and MCB only serviced four more vehicles than did MCA.

A. CONCLUSIONS

1. General

Our analysis has displayed the variations in the effects of major changes at the two Marine Corps MC's even as they implemented the various programs simultaneously. We have seen the implementation of the Theory of Constraints and Lean Thinking, and have delved into the potential savings that these programs helped to create as we analyzed the maintenance center at Albany. However, we have also seen that a program in itself is obviously not enough to effect positive change and efficiencies over time, as we have analyzed the maintenance center at Barstow.

We have also concluded that although the cost of materials has risen over time, this has been of little impact in the total cost of an IROAN/SLEP, and therefore we are not highly concerned with material costs. However, the disparity in material costs between the two depots is significant.

Most profoundly we have determined labor costs to be over 70% of the cost of performing IROAN/SLEP's, and we have delineated the effects of stable average LHR costs and overhead costs on the total cost of a vehicle at MCA, and we have likewise delineated the effects of a cost allocation system that severely increases total labor costs and total costs at MCB. Unfortunately from our perspective, not nearly as much attention has been paid to properly implementing TOC and Lean Thinking concepts at MCB as was done at MCA. In the end, the realities of DoD budget constraints will come to affect how and where the Marine Corps focuses its DLM processes.

2. In Line with BRAC

Although we were somewhat aware of the BRAC Commission's plans to realign certain organizations in Barstow, and to shift certain maintenance efforts to depots other than Barstow, we intentionally did not study the Commission's findings until our analysis was complete in order to remain more objective. We have now found that our findings are in line with the Commission's observations of MCB and its recommendations as well.

We will not consider all of the SECDEF's recommendations, but those that are pertinent in relation to MCA require addressing. It was recommended that a consolidation of depot maintenance of conventional weapons, engines/transmissions, material handling, powertrain components, starter/alternators/generators, TMDE, and wire be conducted at Albany. Especially with regards to the sub-process of performing DLM on the engines and transmissions of the LAV at MCA, the cost savings should be significant since these have been and will remain core competencies at MCA, and the efficiencies gained in these processes have been displayed in terms of cost and cycle-times. The Commission expected to reduce the cost of DLM operation across DoD through consolidation and elimination of 30 percent of duplicate overhead structures required to operate multiple DLM activities. They planned to increase the use of existing capacity while maintaining capability to support future force structure. The Commission rejected Barstow's claims that cycle-times and quality of work would be affected.

B. RECOMMENDATIONS

1. Conduct Further Analysis of Cost Allocation Disparity between MCA and MCB

Our research demonstrates how the cost allocation system contrasts wildly between the two depots. Depending on the specific task, the same task can be between 24% and 82% more expensive at MCB than at MCA. We have also delineated the effects of these labor costs on total costs, since labor is 70% of the driver in total costs. The nearly $100K in excess costs at MCB has had a tremendous impact on bottom lines, and amazingly over eight LAV-25's could have been IROAN/SLEP'd at MCA with the $4.5M in additional funds spent at MCB.

We recommend that further studies be conducted to determine the extent of overhead costs attached to specific tasks at both MCA and MCB, as well as of the costs and impact of direct labor both currently and long term on the maintenance centers. We consider the fact that these cost allocations are not standardized between the only two logistics depots in the Marine Corps to be an extreme oversight. Putting costs in parallel will allow higher level civilian and military managers, as well as future BRAC Commissions, to better compare progress and efficiencies at both depots.

2. Conduct Further Analysis of Disparity in Material Costs between MCA and MCB

Our research has demonstrated some significant disparities in material costs between the two maintenance centers. Although material costs have risen moderately at MCB, they have risen more severely at MCA. In fact, they have risen nearly 50% there. We explored the possibility that the introduction of the SLEP program may have severely impacted material costs, but have determined that only a small portion of this increase is attributable to SLEP. Therefore, much of this increase is unaccounted for.

We recommend that further studies be conducted to determine the source of such high costs for materials at MCA in relation to MCB. We are not convinced that transportation costs account for more than some of the increase. We suspect that more likely the per unit cost of materials may have risen in response to the implementation of Lean Thinking concepts in which the MC's have attempted to reduce inventories. However, we are not certain of this and would like to see more detailed analysis of material cost increases over time and the disparities between the two MC's.

3. MC's Should Better Track Individual Vehicle Statistics Pertaining to Total Cycle-Time

Within the cycle-time chapter we demonstrated the process through which we estimated certain aspects of the total cycle-time. While the maintenance centers seem to "live and die" by their advertised RCT's, the FSD appear to not even track the length of time vehicles spend in their care. Total Turn-around-time (TAT) may not be as important to an LAR Battalion since LAV's have a DMFA program, but since we've shown the negative affects of high transit and FSD processing times, as well as of high operational tempo on MTBM, total cycle-time matters even more now than it ever has. The 24 month MTBM has shown us that the current rate of IROAN's is more than insufficient in meeting the requirements of the current operating tempo.

It is therefore imperative that the FSD's begin to track and publish the time spent in their care so that the effects of this potentially high time period can be further analyzed and managed in order to reduce total cycle-times.

APPENDIX A. LABOR COST ALLOCATION AT MAINTENANCE CENTER ALBANY

$66.25	603	QA/QC CONFIG DATA
$48.47	611	ENGINEERING DEPT
$48.47	616	INDUSTRIAL ENGINEERING
$41.72	621	MATERIAL MANAGEMENT
$41.72	622	SFC TMDE/ELECTRONICS
$41.72	623	SFC HEAVY MOBILE
$41.72	624	SFC MPTS
$41.72	625	INVENTORY MANAGEMENT
$41.72	626	MATERIAL HANDLING (MHE)
$66.25	640	PROGRAM MANAGEMENT
$66.25	711	ENGINES
$66.25	712	POWER TRAIN
$66.25	713	HMMWV
$66.25	714	5-TON
$66.25	715	M88
$66.25	716	LVS
$66.25	717	ENG/CONSTRUCTION
$66.25	721	ELECTRICAL COMPONENTS
$66.25	722	ELECTRICAL COMPONENTS
$66.25	723	AAV
$66.25	724	LAV
$66.25	725	M1A1
$66.25	726	HYDRAULICS/MISC
$66.25	727	MECHANICAL COMPONENTS
$66.25	728	OPTIS COMPONENTS
$66.25	729	SMALL ARMS
$62.44	740	MPST
$62.44	741	MACHINE
$62.44	742	SHEET METAL
$62.44	743	WELDING
$62.44	744	BODY SHOP HEAVY
$62.44	745	CLEAN/BLAST
$62.44	746	PRESERVATION
$62.44	747	BODY SHOP HEAVY
$62.44	749	PAINT
$77.43	730	ELECTRONIC
$77.43	731	ATEP SUPPORT
$77.43	732	ELECTRONIC CALB
$77.43	733	MECHANICAL CALB
$77.43	734	COMM/ELEC EQUIP
$77.43	735	GENERATOR ELECT

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APPENDIX B. LABOR COST ALLOCATION AT MAINTENANCE CENTER BARSTOW

$62.67	616	PROCESS ENGRNG
$58.19	602	PROJECT MANAGER
$58.19	607	MASTER SCHEDULING
$58.19	620	QUALITY ANALYSIS
$58.19	622	M.C.C.
$58.19	623	MATERIAL MANAGEMENT
$58.19	624	INVENTORY MANAGEMENT
$104.61	681	ELEC CAL/RADIAC
$104.61	684	PHYSCIAL DIMENSION/CAL
$104.61	685	LASER/ELECTRO OPTICS
$104.61	686	TMDE
$104.61	687	NIGHT SIGHTS
$104.61	688	WEAPON SYSTEMS
$82.06	710	HEAVY MOBILE EQUIPMENT B.C.
$82.06	711	MOTOR ROOM
$82.06	713	HMMWV/LAV/SEE/Radiator
$82.06	714	TRKS/LVS/CRANES/FORKLIFTS
$82.06	719	PAXMAN/TIRE
$82.06	721	TRANSMISSION/POWERTRAIN
$82.06	723	AAV HULLS
$82.06	725	M1A1/M88/DOZER/M9ACE/AVLB
$82.06	726	HYDRAULICS/FIRE SUSPENSION
$82.06	727	AAV COMPONENTS
$82.06	728	ELECTRO-OPTICS
$82.06	729	TURRET/ARTILLERY
$104.61	730	COMM/ELECT B. C.
$104.61	731	ELECT/AC/GEN/BATTERY
$104.61	732	GROUND COM
$104.61	733	MTDS
$104.61	734	HAWK/ATE
$104.61	735	RADAR
$104.61	737	LAUNCHER
$113.09	740	SUPPORT B. C.
$113.09	741	MACHINE SUPPORT
$113.09	742	SHEET METAL AND BODY SHOP
$113.09	743	WELDING & NDT
$113.09	744	UNDERCOAT/LUBE
$113.09	745	MATERIAL HANDLING (MHE)
$113.09	746	STEAM/BLAST
$113.09	748	CLEAN/PAINT/LATE/CANVAS
$113.09	749	PAINT, FINAL
	781	TAD

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APPENDIX C. MERIT – LAV DISTRIBUTION BY MAJOR SUBORDINATE COMMAND

MEF	AUTH	POSS	EXCESS	DEF	D/L
I MEF Camp Pendleton, CA	52	8	0	44	6
I MEF Camp Pendleton, CA	46	34	0	12	7
I MEF Camp Pendleton, CA	4	4	0	0	0
II MEF Camp Lejeune, NC	56	35	0	21	6
II MEF Camp Lejeune, NC	4	4	0	0	0
III MEF Okinawa, JP	8	8	0	0	1
III MEF Okinawa, JP	6	6	0	0	0
IV Reserves	60	60	0	0	16
Prepositioned (MPS/NALMEB)	7	7	0	0	0
Prepositioned (MPS/NALMEB)	7	7	0	0	0
Prepositioned (MPS/NALMEB)	7	7	0	0	0
Prepositioned (MPS/NALMEB)	7	7	0	0	0
Prepositioned (MPS/NALMEB)	7	7	0	0	0
Prepositioned (MPS/NALMEB)	7	7	0	0	0
VII MEF	2	2	0	0	0
VII MEF	0	13	13	0	6
VII MEF	41	15	0	26	1
VII MEF	0	13	13	0	0
Bases Posts and Stations	21	21	0	0	3
Bases Posts and Stations	15	15	0	0	2
GRAND TOTAL	357	280	26	103	48
Less VII MEF Authorized	314	280	26	103	48

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APPENDIX D. BASELINE IROAN TO SLEP MAINTENANCE

Step	Maintenance Process	Hours
1.	Conduct a joint Limited Technical Inspection (LTI) with MC and FSD.	3
2.	Remove the main gun.	1
3.	Drain all petroleum, oils and lubricants.	5
4.	Disassemble LAV to include turret, engine, transmission, and components.	22
5.	Remove vision blocks and periscope retainers.	1
6.	Remove communications gear.	1
7.	Inspection of components.	1
8.	Hull steam clean.	4
9.	Hull blast (inside and out down to metal)	20
10.	Hull NDT crack inspection. (concentrate on strut caps and shock towers, exhaust outlet, vision blocks, tow pintle, hatches, doors, grill, and tow eye).	5
11.	Hull Repair. If no defects are found go to step 12 then continue from 17.	100
12.	Machinist repairs (damaged bolts, bosses).	1
13.	Preliminary radiographic inspection.	1
14.	Hull NDT inspection (from previous welding).	18
15.	Correct hull defects.	1
16.	Support weld shop.	1
17.	SLEP upgrade application.	24
18.	Hull spot blast and blow down.	10
19.	Hull prime and paint.	12
20.	Install electrical cable set #1.	1
21.	Level 1 assembly (brake lines, air system, differential vent lines, winch, hydraulic components and lines, and NBC system).	20
22.	Install electrical cable set #2.	1
23.	Level 2 assembly (SLEP upgrade kits)	27
24.	Level 3 assembly (install suspension, steering bearings, linkages, and gears).	21
25.	Level 4 assembly (install heater, fuel tank and lines, seats, fire suppression system, floor plates, and test brake pressure and fuel pump).	29
26.	Terminate engine cables and test.	1
27.	Level 5 assembly (install pack, fan tower and grills, turret, hatch seals, wheel assembly and align).	20
28.	Level 6 yellow tag (test propeller drive units, road test, and water test).	8
29.	Install main gun.	2
30.	Final clean (steam).	3
31.	Final paint (prep, base coat, apply camo paint, touch up).	17
32.	Install communications equipment and test including turret stabilization.	10
33.	Optics installation and test.	10
34.	Final small arms installation and inspection.	2
35.	Final turret inspection.	1
36.	Level 7 green tag quality assurance inspection.	11
37.	Final acceptance inspection.	2
38.	Administration.	4
	Total	409

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APPENDIX E. A1 IROAN MAINTENANCE PROCESSES (SLEP UPGRADES INPLACE)

Step	Maintenance Process	Hours
1.	Conduct a joint Limited Technical Inspection (LTI) with MC and FSD.	3
2.	Remove the main gun.	1
3.	Drain all petroleum, oils and lubricants.	5
4.	Disassemble LAV to include turret, engine, transmission, and components.	22
5.	Remove vision blocks and periscope retainers.	1
6.	Remove communications gear.	1
7.	Inspection of components.	1
8.	Hull steam clean.	4
9.	Hull blast (inside and out down to metal)	20
10.	Hull NDT crack inspection. (concentrate on strut caps and shock towers, exhaust outlet, vision blocks, tow pintle, hatches, doors, grill, and tow eye).	5
11.	Hull Repair. If no defects are found go to step 12 then continue from 17.	100
12.	Machinist repairs (damaged bolts, bosses).	1
13.	Preliminary radiographic inspection.	1
14.	Hull NDT inspection (from previous welding).	18
15.	Correct hull defects.	1
16.	Hull spot blast and blow down.	10
17.	Hull prime and paint.	12
18.	Install electrical cable set #1.	1
19.	Level 1 assembly (brake lines, air system, differential vent lines, winch, hydraulic components and lines, and NBC system).	20
20.	Install electrical cable set #2.	1
21.	Level 2 assembly (install transfer and differential)	27
22.	Level 3 assembly (install suspension, steering bearings, linkages, and gears).	21
23.	Level 4 assembly (install heater, fuel tank and lines, seats, fire suppression system, floor plates, and test brake pressure and fuel pump).	29
24.	Terminate engine cables and test.	1
25.	Level 5 assembly (install pack, fan tower and grills, turret, hatch seals, wheel assembly and align).	20
26.	Level 6 yellow tag (test propeller drive units, road test, and water test).	8
27.	Install main gun.	2
28.	Final clean (steam).	3
29.	Final paint (prep, base coat, apply camo paint, touch up).	17
30.	Install communications equipment and test including turret stabilization.	10
31.	Optics installation and test.	10
32.	Final small arms installation and inspection.	2
33.	Final turret inspection.	1
34.	Level 7 green tag quality assurance inspection.	11
35.	Final acceptance inspection.	2
36.	Administration.	1
	Total	380

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