NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

Was It Really Worth the Pain?
Refurbishment of Mercedes-Benz Trucks
by Botswana Defence Force

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December 2005

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** December 2005	**3. REPORT TYPE AND DATES COVERED** MBA Project	
4. TITLE AND SUBTITLE: Was it Really Worth Pain? Refurbishment of Mercedes-Benz Trucks by Botswana Defence Force			**5. FUNDING NUMBERS**
6. AUTHOR(S) Samuel A. Rangobana and Hussain K. Alkebaisi			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this report are those of the author(s) and do not reflect the official policy or position of the Department of Defence or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			**12b. DISTRIBUTION CODE**

13. ABSTRACT

The following project studies the refurbishment of the Mercedes-Benz trucks by the Botswana Defence Force. The study covers the application of project management techniques, evaluation as well as the quality of the refurbished trucks contribution to the mission achievement capabilities of the BDF. A visit to the project site as well as a survey of users, project managers, and a project sponsor were carried out to gather data on project management. Logistics statistics, for refurbished trucks returned to user units, are also gathered from the asset management software database, Mincom Ellipse, in use by the Botswana Defence Force Mechanical Engineers Regiment for fleet management. The finding of the project is that the planning for the refurbishment project was mediocre. The availability of the refurbished trucks is 83 percent at the end of three years and has a life cycle cost of BWP499,200 compared to that of a new truck which is BWP449,397. The spare parts for the trucks are difficult to source. The conclusion of the study was that the project was not worth the pain. Had initial planning been ardently carried out; then new fewer trucks should have been procured instead of refurbishing the aged trucks.

14. SUBJECT TERMS: Project Management, Public Projects, vehicles' refurbishment, Botswana Defence Force, Organizational Culture, Life Cycle Cost.			**15. NUMBER OF PAGES** 129
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UL

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WAS IT REALLY WORTH THE PAIN? "REFURBISHMENT OF MERCEDES BENZ TRUCKS BY THE BOTSWANA DEFENCE FORCE"

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MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
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LIST OF ACRONYMS AND ABBREVIATIONS

ADF	AUSTRALIAN DEFENCE FORCE
AOA	ANALYSIS OF ALTERNATIVES
BDF	BOTSWANA DEFENCE FORCE
BDP	BOTSWANA DEMOCRATIC PART
CAS	CORPS OF ARMAMENT DEPOT
CTO	CENTRAL TRANSPORT ORGANIZATION
DCP	DEFENCE CAPABILITY PLAN
DMO	DEFENCE MATERIAL ORGANIZATION
DOD	DEPARTMENT OF DEFENCE
FW	FIELD WORKSHOPS
GPO	GENERAL PURCHASE ORDER
GW	GARRISON WORKSHOPS
MBSA	MERCEDES-BENZ SOUTH AFRICA
MER	MECHANICAL ENGINEERS REGIMENT
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OEM	ORIGINAL EQUIPMENT MANUFACTURER
PPADB	PUBLIC PROCUREMENT AND ASSET DISPOSAL BOARD
RCM	RELIABILITY CENTERED MAINTENANCE
SLEP	SERVICE LIFE EXTENSION PROGRAM
SOP	STANDARD-OPERATING PROCEDURE

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ACKNOWLEDGMENTS

We are most greatly grateful to the government of Kingdom of Bahrain and government of Botswana and we would like to record our appreciation to Bahrain Defence Force and Botswana Defence Force for providing us the opportunity to achieve an advanced degree in the United States of America.

Next, we would like to thank the Naval Postgraduate School staff and faculty for the high quality of education and facilities provided during our study. We would also like to thank Professor Geraldo Ferrer and Professor Keebom Kang for their help and support throughout our study.

Finally, we would like to acknowledge our leaders, friends and spouses for the support they have shown us throughout our long periods at the study table putting the whole project together.

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I. INTRODUCTION

A. BACKGROUND

1. General

Organizations engage in projects to achieve something that they cannot otherwise achieve in their normal day-to-day work setup. For most organizations, starting a project entails forming a specialized group of experts to achieve the task at hand. Traditional organization setups are normally devised to deal with long-term routine functional duties such as finance, administration, routine repairs, and materials management. Projects require expertise in planning and production control techniques that can produce predictable products acceptable to the customer or end user. Nontraditional organizations like defence departments are, therefore, often overwhelmed when they are faced with such daunting tasks as planning and running a production-related project. An accepted description of project objective is from Simpson (1987), who states, "for a project to be completed within time, within budget cost, and to meet planned performance or end user-project goals."

Lack of planning is often the cause of failure in many projects. Despite the well-accepted school of thought, many projects are still begun without proper planning. More often than not, the project goals are assumed, leading to haphazardness in the initial stages of the project. This leads to astronomical costs when initial blunders are corrected. This foregoing scenario is captured well by Dvir et al. "In fact, although planning does not guarantee project success, lack of planning will probably guarantee failure." At an evaluation stage, there is a need to regard all the factors leading to the identification and success of the project. The traditional approach is to consider the costs of the project under consideration as well as the time that it takes to complete the project. While this is an acceptable and reasonable policy, it tends to cloud the main objective of the project. Many project managers feel that the delivery of an end product is an indication that a project has been successful. This cannot be further from the truth. Dvir et al. advise: "there are many cases where projects are executed as planned, on time, on budget, and achieve the performance goals but turn out to be complete failures because they failed to

produce actual benefits to the customer." The delivery alone cannot be taken as a measure for the project success. The following project analysis, therefore, focuses on benefits to the customer as well as the quality of the products of the project. The project delves into the evaluation of the refurbishment project life cycle by seeking the opinion of the project-planning, execution, and results executives, project managers as well as the customers through postal questionnaires, and a visit to the project site.

2. The Mercedes-Benz Trucks Refurbishment Project Overview

a. The Project

The Mercedes-Benz Trucks Refurbishment Project was set up in 1996 to refurbish one hundred of ten-to fifteen-year old trucks of series LP911 and LA1113 in the Botswana Defence Force (BDF) fleet. The project consisted of two phases. Phase one was to refurbish fifty trucks. Phase two was to refurbish the other fifty trucks. The first phase of the project ended in June 1998; the second phase ended in July 2002.

b. The Reason of the Project

The BDF has Mercedes Benz trucks that have served reasonably well over an average of twelve years. The aging trucks were becoming unreliable and had low operational availability. The budget for new trucks was low, and fewer trucks could be procured with the ever dwindling amount that the vehicle replacement budget was awarded over the years. With the scarce resources of the Botswana government, the BDF recommended the refurbishment project as more economically viable than the procurement of new trucks to sustain the same number of trucks that they had held at the time.

c. The Motives for the Refurbishment Decision

The BDF advanced several reasons at the time for the decision to refurbish the Mercedes Benz trucks. One of the major reasons was that the BDF had just completed a refurbishment project on their medium-sized operational vehicle, the Land Rover 110 model. The Land Rover refurbishment project was outsourced in 1996 to a British company, All-Makes, to refurbish fifty Land Rovers, which had been in operation for nine years. The expected life after refurbishment was about ten to twelve years. The

project was entirely funded by the Botswana government. It should be noted that the actual years that the Land Rovers served after refurbishment was never determined. There was no post-project evaluation.

Another reason was that, the Mercedes-Benz LP911 and LA1113 trucks were the oldest in the BDF fleet, their post-refurbishment reliability was assumed to mimic the pre-refurbishment availability. The Mercedes-Benz trucks were bought in the mid 1980s.

The Mechanical Engineers Regiment appealed to the government of the Federal Republic of Germany for sponsorship of the project as the trucks were a German product. The Germans were well placed to give advice as well as to provide parts. Retired models of the truck were quite plentiful in Germany and a lot of spare parts were held as "dead stock" by truck owners in Germany. The German Army came to the rescue of the BDF by providing supervision staff, funding part of the project and helping to source spare parts from German firms.

The project lacked a suitably equipped place to carry out the refurbishment. A service bay for the Mechanical Engineers heavy duty vehicles was therefore vacated. The German army also donated machine tools, engine reconditioning equipment, and sandblasting equipment. Individual tradesmen were also given on-the-job training. This aid and support from the Federal Republic of Germany was a major reason why the BDF finally decided to carry out the refurbishment of the trucks.

B. PROJECT OBJECTIVES

The objectives of this project were, first to analyze and evaluate the refurbishment project of Mercedes-Benz trucks in the Botswana Defence Force according to the project management principles, as practiced widely in the operations management, to determine the extent to which those practices were applied. A second objective was to state lessons learned from the project and to recommend the best practices that can be applied in public projects. The discussion includes two main parts: qualitative analysis and quantitative analysis. The qualitative analysis evaluates the project according to the project management techniques used to achieve project delivery and end user satisfaction.

The quantitative analysis involves the calculation of the project cost effectiveness, the logistical metrics that are applied to the project, including reliability, operational availability, and the total expected life-cycle cost of the trucks after the completion of the project. Descriptive analysis will also be discussed in regard to the common and critical failures of the trucks.

C. RESEARCH QUESTIONS

1. Primary Question

Was the Mercedes-Benz Trucks Refurbishment Project Worth the Pain?

2. Subsidiary Questions

The project set out to answer the following questions:

- Were there any clear objectives that the Mercedes-Benz refurbishment set out to achieve?
- Was the planning of the project done thoroughly so the project would run according to schedule and stay within budget?
- Were there any control measures in place during the delivery of the project in regard to the budget, personnel issues, and the issue of internal repairs or the outsourcing of components that could not be repaired internally? Were the time constraints and financial management monitored?
- Were the objectives of the project met? Has user satisfaction been ensured?
- What are the lessons learned from the project? Do the lessons have any bearing on any future projects of a similar nature?

D. METHODOLOGY

In this project, the authors will:

- Conduct a literature review of books, magazines articles, professional journals, internet data, and other library resources to address topics in the art of project-management concepts and principles, general refurbishment practices and procedures applied, and, finally, lessons learned from refurbishment case studies in the public and the private sector.

- Introduce an overview of the BDF fleet management procedures and organizational culture.
- Conduct a quantitative and quantitative analysis as well as a statistical analysis of the project data.
- Carry out an in-depth discussion of the findings of the project data analysis.
- Conclude the discussion and summarize the lessons learned from the project and present recommendations for future BDF projects.

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II. LITERATURE REVIEW

A. INTRODUCTION

The following chapter provides an overview of the literature pertaining to project management techniques, including sources from both the public and private sector firms. Good project identification, appraisal, implementation, and evaluation are generally accepted as major steps in project management. According to an article by Hayes (2005) on the Six Sigma web site, "for any management initiative to yield the advertised results; many factors must be considered, aligned, measured and acted upon." There is no better way to do this than to employ the tried and tested techniques of project management. The literature review also covers some applicability of refurbishment in major transport vehicles.

B. CONCEPTS OF PROJECT MANAGEMENT

1. Introduction

> "Would you tell me, please, which way I ought to go from here?"
>
> "That depends a good deal on where you want to get to," said the Cat.
>
> "I don't much care where" said Alice.
>
> "Then it doesn't matter which way you go," said the Cat.
>
> "So long as I get SOMEWHERE," Alice added as an explanation.
>
> "Oh, you're sure to do that," said the Cat, "if you only walk long enough."
>
> Alice's adventures in wonderland, Lewis Carroll (1865)

Managing a venture that involves a great deal of resources has always required a concrete method of aligning the resources to the attainment of the goals that the venture sets out to achieve. As noted by the cat, from Carroll (1865) in the quotation above, man has always recognized this. The concept of project management is, therefore, not really a new management tool, but rather a basic human reaction, adding order and accountability to interrelated tasks that demand a lot of effort and cash outlay, that has existed since time immemorial.

The very nature of an endeavor that involves a number of steps that are both complex and expensive to undertake calls for clarity of thought before the endeavor can commence. This points to planning, using a tool that has been structured over time, dubbed "project management." A project has a beginning and an end and often brings together people from several functional groups. Wysocki et al. (1995) describe project management as "a sequence of unique, complex and connected activities having one goal or purpose and that must be completed by a specific time, within budget, and according to specification." Project management entails planning and implementation as well as the evaluation phases. The Wikipedia website lists five phases in any project development:

(1) Project initiation (Kickoff)

(2) Project planning

(3) Project production or execution

(4) Project monitoring or controlling

(5) Project completion and evaluation

Many public and government-sponsored projects now include all stages, which are adopted as policy in order to enhance accountability and structure feedback from projects. Depending on the nature of the project, it can go through steps two, three and four multiple times. The steps can also be varied slightly, but the general concept is to have steps 2, 3 and 4 always present in one way or the other in any format.

The concept of project management has been refined and proven so successful that, since 1960, many governments have formally made project management part of their policy and an underlying management and control tool for any capital venture. In introducing project management as part of policy to guide future projects, the Australian government's Review of Major IT Projects Guide (2004) states that, "Failure to recognize the need for specific skills results in ineffective project management and has been a contributing factor in the failure of a number of projects. To improve

government's performance, we need mechanisms to harness and build on the limited experience available. One such mechanism will be the wider adoption of formal project management methodologies."

According to the Six Sigma website, a project should generally meet the following guidelines:

- They should have clearly defined deliverables.
- They must be approved by management.
- They are not so large that they are neither unmanageable nor so small that they are unimportant or uninteresting.
- They relate directly to the organization's mission.

The manual further states that, in order to be objective and to fulfill all the expectations of the project, the project initial management plan guides the manager toward the data and the indicators that must be used. Conditions or risks that may arise during the project are also considered objectively when project management techniques are applied. This is because the proven techniques of project management provide clear guidance for how to steer the project in the right direction, without ambiguity.

According to Gido and Clements (1999), it is important "to plan the work, and then work the plan." The authors encourage planning in project management as they contend that without it there will be chaos: the project would be at a high risk of failure in the absence of planning. They go on to state that planning is determined by what needs to be done, who needs to do it, how long the project would take, and how much it will cost for the project to be completed.

2. Stages of Project Management

a. Project Initiation

Project initiation is a process of defining planned-project deliverables and anticipating the actions needed to complete a project. Pinto and Morris (2004) state that the process of initiation involves: "the identification of activities, tasks and a project schedule, with both milestones and deadlines to complete the project." The authors go on

to state that a project exists within larger systems, and hence, they recommend that there is a need to relate project control and deliverables to the organization's project strategy. The project initiation stage defines what work is to be done, what is to be delivered, how long it will take, by whom, how much it will cost, and why it is worth doing. According to the WISDM website (2005), "many project sponsors and managers are tempted to jump into the definition and design phases without much organizational work. This urgency, while understood, can be the downfall of a project before it really begins." The time spent in the start-up of a project creates clarity and a well-defined structure for the achievement of the project objectives from the beginning. The initiation ensures that the project scope is well understood and the required personnel are identified before they can be estimated for in the following stage of planning.

The project initiation stage often results in standardized templates of project planning and reporting that a project manager and his team can use in the subsequent stages of the project.

b. Project Planning

The project initiation stage begins with a meeting between a few individuals who will impact or be impacted by the project. Developing a project plan, perhaps the most important element of project management, is a daunting task that requires expertise and patience. It is imperative that a representative of the personnel to be engaged in the project be present during the planning stage, as they will most probably be familiar with the detailed project activities. Gilbreath (1986) argues that "people perceive failure when expectations are not met, when actual accomplishment falls short, for some reason, of expected or planned accomplishment." The expectations that follow from planning and results can only be meaningful when they are compared to the prior expectancies set by the objectives during project initiation.

The failure or success of a project hinges on the thorough preparation of the plan, as this step entails a detailed budget for the project work breakdown structures, which entail work processes and human resource requirements. Gido and Clements argue that "individuals who think planning is unnecessary or a waste of time invariably need to find time later on to re-do things." This part of a project can, therefore, make or break the

project. This is best described by Chyla (2003), who contends that project managers need to realize that each project has certain unique characteristics, requiring a specific approach to attain quality end products. He further argues that this unique quality should be determined during planning and be ensured through quality control. Proper planning is apparently a basis for quality product delivery; and if resources for the project are fully planned for within the economic confines of the organization then, a quality product would result. Resource planning in this phase includes:

(1) The planner's duty. The duty of any planner is to ascertain before the project begins that the demands of the project can be met by the available resources. Morris and Pinto contend that "resource planning consists of matching the required resources with the available resources." Prioritization of the vital processes ensures that the resources are used sparingly and efficiently. Budgeting, work breakdown structures, and risk assessment templates are the result of planning and give a very good estimate of the funds and people needed for all the activities of the project. According to Wysocki et al. (1995), an activity is a random variable. The varying skill-level of workers, unexpected events, such as a lack of spares, and mistakes or reworking are some of the reasons the authors advance for the unreliability of time estimates.

(2) Milestones. Mochal and Mochal (2003) contend that the insertion of milestones into a project at the planning stage signifies the completion of a major deliverable or a set of major deliverables. They argue that milestones should be of utmost interest to managers and sponsors, since milestones provide a high-level snapshot of how the project work-plan is being tracked. The sponsors and the stakeholders can therefore just track the process of the project against a milestone date without a deep understanding of the activities required to reach the milestone.

c. Execution and Controlling of the Project

The project implementation starts once the planning phase is completed. At this stage, the resources in terms of personnel and budget are made available. Resources include the working space as well as the equipment to be used in the project. Chyla (2003) argues that the implementation should have milestones that are established for both the contract and the acquisition-process phases as well as for the production

activities. He further argues that risk management is an integral part of the implementation process. He describes risk management as a "measure of the probability of not achieving defined project goals." There is a need, therefore, when carrying out the project, to have an eye on the threats to the project as it commences. Lientz and Rea (2000) contend that there are often several problems with the implementation of a project: management often tries to pin down the budgeted costs and schedule estimates as final ones; there is deviation from the project plan due to impatience to get results; and management might fear that the project chosen is too complex and many pressure the project team. The project manager should impress upon the management team from the start of the implementation process that budget plans are not "set in stone" and can vary slightly.

d. Project Control

The control of a project is often taken for granted by most project managers, but it ensures that events happen as planned and avoids a lot of pitfalls. According to Cleland and King (1983), the term "control" carries negative connotations of external wills being imposed on a project, which could not be further from the truth. Control methods apply to three baselines of the project: technical astuteness, staying within budget, and maintaining solid business practices during the project delivery.

Cleland and King (1983) further contend that it is advisable to draw an analogy of pilots who accept control-tower, directions even though they are the ones in charge of the airliner. They contend that the control tower serves as control system that ensures safety, prevents confusion, and makes the job easier. Different types of work require different types of knowledge bases for project managers, for projects such as building construction or vehicle maintenance to a pharmacologist overseeing the development of a drug. Devaux (1999) argues that all the foregoing projects have actually got many things in common. They each have a schedule with a strict deadline; resources in limited quantities that need to be targeted, scheduled, and tracked; and a budget that must be planned and tracked. Each one also faces unforeseen circumstances to which his ability to respond and adapt is a key factor in the project. Control measures "advise" the project manager of the extent of deviations and result in corrective action or an

alternative course of action that will put things on course. Forsberg et al. (1996) argues that project control can be divided into proactive control and reactive control. They define proactive control as a standardized system or process of control, within which every aspect to be controlled has a variance-detection system. In contrast, reactive control is corrective in nature and thus reacts to any unacceptable variance, such as a deviance from specification or a cost overrun.

e. Project Evaluation

O'Sullivan (2004) states, "project evaluation is research, but it is a specialized form of research." Evaluators often research specific project effects to understand the program being evaluated, not merely to generalize back to a theory. The authors advise that an evaluator should clarify the purpose of the evaluation, as most requests for evaluations are "fraught with hidden agendas." He goes on to warn that the rationale for an evaluation may be naïve, misguided, or motivated by internal or external politics. Carayannis et al. (2005) argue that a postmortem project review or a post project review process is an absolutely essential exercise to be conducted for all projects. They contend that the lessons learned from this exercise can provide a consolidated body of data and information that serves as baseline historical information for future projects.

The inclusion of senior management and other project managers is vital in the review process as the lessons learned can then be disseminated immediately and be applied to other projects.

C. REFURBISHMENT

1. Introduction

Equipment owners and fleet managers have toyed around with the idea of reusing parts and equipment since mechanical equipment has been in existence. According to Gauthier et al. (2000), refurbishment is done in order to ensure the operational readiness of vehicles in storage. They argue for the refurbishment of expensive weapon systems, which are degraded by being stored for long periods and are surpassed by developments in new weapons. They go on to say that new technology is introduced for a fleet of weapons by two means: either as a series of upgrades of existing legacy systems or

bundled into a new replacement system. They therefore see refurbishment as a way of upgrading weapons to the level of technology of new weapons at a lower cost.

Very expensive projects have been undertaken by railway firms to offset the cost of new rail cars and locomotives. According to the International Quality and Productivity Center, numerous operators choose to refurbish their fleets as a way to bring down operating costs to increase passenger revenue by upgrading rail-coach comfort levels, and to increase the performance capabilities of the locomotives. Most train operators, like Scot Rail, South-West Trains, and Deutsche Bahn, have noted the importance of refurbishing. The main hindrance to most of the projects has been the "logistical and technical challenges that result in costly budget overruns."

When deciding whether to undertake the refurbishment of equipment, it is imperative that owners and managers clearly understand what the refurbishment is meant to achieve. The objectives may be wide-ranging, but it is necessary to justify all of them in economic terms if a robust business case for refurbishment is to be developed. The organizational transport strategy as well as stakeholders' role discussions helps to identify the objectives of refurbishment. And the role of those objectives within the transport needs of the various stakeholders then become apparent. Important questions to ask during the initial stages of refurbishment planning include:

- What business needs drivers the decision to refurbish?
- What are the technical requirements of refurbishment?
- What are the stakeholder's expectations?
- How should a refurbishment be completed?
- What are the future challenges to be addressed?

There are often several options when considering what to do with aging equipment at the end of its useful life. For most users, the option is to retire the equipment and auction it off, cannibalize it for spares, recycle it, or simply destroy it. However, for more capital-intensive equipment, simply getting rid of it is not easy choice to make. For equipment such as train locomotives, power stations, fire engines, or even

rare, highly valued vintage cars, a better option is refurbishment, reconditioning, or even retrofitting. Gillanders and Jenne (1988) argue that the benefits of refurbishment are:

- Lower capital cost as opposed to replacement with new equipment.
- The known reliability of existing equipment.
- Deferring the expenses of equipment disposal.
- Staff's training and familiarity with the existing equipment.
- Refurbishment creates an opportunity to provide feedback to the original equipment manufacturer (OEM), thereby contributing to the betterment of future designs.

Tanner et al. (2001) describe refurbishment as an "investment which brings benefits through the introduction of new technology by upgrading or updating existing equipment or extending its life. All the different parts of the equipment, electrical, mechanical and structural have to be taken into account when equipment is refurbished."

2. Stages of Refurbishment

An article from the *Maintenance Technology* magazine covering the refurbishment of large plant-motors states that the following steps are followed in refurbishment:

a. Preparation for Refurbishment

The preparation step often involves the transfer of the equipment identified for refurbishment to a designated area set aside for the refurbishment project. The equipment is clearly labeled for tracing purposes post-refurbishment.

b. Disassembly and Cleaning

The equipment is disassembled, visually inspected, its condition recorded, and certain characteristics observed (e.g., number of rotor bars, type of bearings installed). The parts are then cleaned, the components dried, and a post-cleaning search for mechanical defects is conducted. Usually, at this stage, tests such as Hipot, surge, core loss, growler, and bearing insulation tests are also carried out, as appropriate for the type and size of the motor to be refurbished.

c. Decide on Repairs, Carry Out Repairs, and Re-assemble the Equipment

At this stage, the project leader and the shop supervisor confer on out-of-scope repairs and any modifications to be made. Any authorized electrical and mechanical modifications, repairs, and restorations (including dip, over-spray or cure-winding insulation) are also made at this stage. Post-refurbishment shop tests (e.g., motor circuit analysis or vibration analysis) are then performed. When the equipment performance is deemed satisfactory post-inspection, the equipment is returned to the owner.

d. Transfer to User and Support Equipment

At this point, the refurbished equipment is transferred to the owner, installed, and post-installation tests are conducted. Follow-up adjustments are also availed as required.

The five steps, or stages, in the refurbishment of equipment are the same for any mechanical/electrical equipment, with only minor modifications to the schedule to include tests as well as outsourcing of complex processes or processes that might prove too expensive to carry out within the organization itself.

3. Case Studies in Refurbishment

a. Hollywood Refurbishes

Local agencies recognize the need to refurbish equipment and to postpone buying new equipment. Recently, Hollywood, Florida Fleet Management Division of Public Works, posted an article in the *American City and County Journal* (2004) about its refurbishment projects. The division has the responsibility to diagnose, repair, and upgrade 845 pieces of equipment, including lawn tractors, cranes, storm-water vehicles, and trucks. The department has a $4 million budget to carry out the maintenance of all the equipment, an amount that has proven to be insufficient. Only $2 million is budgeted for the equipment replacement. This is not sufficient at the rate it fails. Therefore, refurbishment is carried out to increase the life spam of the equipment.

The article reports that because of salty, air corrosion is a problem and claims that the refurbishment savings are dramatic. The internal mechanisms of a 1994

tractor were recently refurbished, a process that involved disassembly, sandblasting (to remove paint and rust), and reconditioning some parts or fitting new ones. The refurbishment cost $5,150, enabling the department to put off for two years the purchase of a new tractor at $12,000. Other refurbishment projects carried out by the division include a 1974 Mack cab and tractor, a front-end loader, and garbage trucks. Another refurbishment project was a John Deere front-end-loader, which had its body panels replaced by a contractor for $5,381. The tractor was rewired for $1,250, which saved the division a total of $19,500. Some of the 2004 refurbishment projects were done internally; some were outsourced to contractors. The total savings were $180,000.

b. Space Industry: Launch Vehicle Recycling

The refurbishment and recycling of space launch vehicles is a well accepted cost saving practice at the National Aeronautics and Space Administration (NASA). This is because the launch vehicle is not scrapped after a single use: a few of its parts are replaced and the vehicle is reused.

Recently, NASA has focused its attention on decreasing the launching cost. Launching vehicle refurbishment has, therefore, come under intense scrutiny as a means to reduce expenses. However, Wertz (2004) contends that the belief that reusable launching vehicles are cheaper alternatives is a fallacy. He presents a model that compares the cost of a reused vehicle and a nonrecyclable one. According to Wertz, refurbishment cost includes the costs of inspection, cleaning, maintenance, retesting, and recertification of the vehicle being refurbished. It is a well known fact in any transportation system, he argues; that the cost of vehicle refurbishment increases with the age of the vehicle. He states that this is true for "virtually all transportation systems." To support this argument, he reasons that "the more the vehicle ages, the more the number of parts will be replaced and the harder it is to locate some parts," as some of the original manufacturers will go out of business. In the case of a launching vehicle, he notes that, because the solid rocket booster sinks to earth when the vehicle returns, the cost of refurbishment is increased remarkably by the need to replace the booster. Judging from the model he presents, Wertz concludes that expendable vehicles will continue to have a great economic advantage over reusable vehicles. It is worth noting that age, fatigue,

stress, and strains on the vehicle result in reduced reliability, as the structure of the vehicle weakens, increasing the chance of catastrophic failures that will add to the cost of the vehicle life cycle.

c. Refurbishment in DOD-Service Life Extension Program

Many support equipment items and weapons in the Department of Defence were purchased in the 1970s and 1980s, and most of this equipment will reach the end of its expected life in the next few years unless modernization, refurbishment or replacements are made. The pressure on the DOD budget and equipment from military engagements in Iraq and Afghanistan necessitates that a short term solution to maintain reasonable availability of equipment be found. The program that DOD has come up with is called service life extension program (SLEP). The SLEP program entails mapping out of equipment maintenance strategies for modernizing, sustaining, and even replacing most of the equipment. The Air force has developed such a strategy for the sustenance of the KC135 tanker aircraft. The Air force strategy is aimed towards modernizing the aircraft and availing parts to sustain it. The weakness in sustaining the aircraft is the disconnect between this short-term solution to improve availability and the long term solution of acquiring absolutely new aircraft to replace the aging fleet. This lack of coordination has lead to increased operating costs for the old equipment as it is kept beyond its economical life as new systems take very long to field. Maintenance programs such as SLEP are also prone to fund cuts due to the dynamic priorities and competition for funds with new acquisitions.

An exemplary case of a SLEP program is presently being undertaken by the Navy to upgrade its nuclear submarine fleet, W76-1/Mk4A, stockpile. These submarines were designed and produced between 1972 and 1987. They had a life expectancy of 20 years but most of them have surpassed the original estimated life. The navy is compelled to deploy the fleet as acquisition has been slow due to long time to acquire new ones. Aging concerns, on availability of spare parts as well as safety concerns are mitigating factors for refurbishment and modernization. The SLEP website for this project gives the following reasons as the driving factors for the refurbishment:

The drivers for refurbishment are fourfold:

(1) The W76/Mk4 is considered as the most critical element of US strategic deterrent and its upkeep should be ensured and not allowed to degrade by aging problems;

(2) The W76/Mk4 Dual Revalidation Program has shown that even though components are aging as expected, there are some negative changes brought about by the aging;

(3) The equipment has aged so much that the failures have become unpredictable leading to degradation that cannot be easily reversed by normal maintenance procedures.

(4) The Navy is prepared to keep the stockpile for an average age of 30 years after which the submarines will be replaced. The refurbishment option has been approved and the initial studies on the feasibility, safety and risk analysis of the project has concluded it is a cost effective exercise. The time to refurbish the fleet also meets the life extension requirements for the W76/Mk4 as required by the Navy.

A refurbishment and modernizing of equipment such as these submarines places an emphasis on improving the contribution of the equipment to the mission capabilities cost effectively and with a reasonable turn around time of the fleet.

d. Australian Defence Force Refurbishment Project

To deliver the necessary capabilities to the Australian Defence Force (ADF), the Defence Material Organization (DMO) organizes its acquisition projects by their respective timelines. (Detailed information pertaining to the refurbishment projects for the ADF appears on their website.) They are usually part of a long-term plan, the Defence Capability Plan (DCP), which normally lasts ten years. The present DCP covers the period 2004-2014. The refurbishment exercises that are planned for the period comprise the upgrade of three hundred and fifty M113A1 armored personnel carriers to a higher standard. The refurbishment will be specific to Australia and covers significant improvements to the vehicles' firepower, protection, mobility, and habitability; it will

involve the provision of new amour kits, new turrets, and a new drive-train and suspension. Two vehicles in the pilot project have already been completed by the contractor, Tenix Defence. The Australian defence force uses contractors to modify/refurbish most of its tanks, instead of acquiring new ones.

D. SUMMARY

It is worth noting that refurbishment of any kind is a major project that it is better carried out by employing the tenets of project management. A refurbishment process involves quite a lot of planning and evaluation, and it is apparent that a haphazard approach can result in project failure. When there are clear objectives, there are also clear measures of failure and success.

III. BDF (MER) FLEET MANAGEMENT PRACTICES AND ORGANIZATIONAL CULTURE

A. BDF (MER) MAINTENANCE PRACTICES AND RESPONSIBILITIES

The Mechanical Engineers Regiment (MER) is responsible for the repair of all ground transport and motor vehicles in the Botswana Defence Force. The repair practices in the BDF were adopted from the Botswana government repair department, the Central Transport Organization (CTO). The BDF has no official repair/transport policy document. Thus, most repair practices are justified according to the original CTO repair manuals. The MER has attempted to close this policy gap by publishing internal standard-operating procedures (SOPs), which are regulations gleaned mostly from the CTO manuals. The SOPs manual is an internal document that is not officially recognized by BDF headquarters; hence, it is hardly ever referred to in any official policy correspondence.

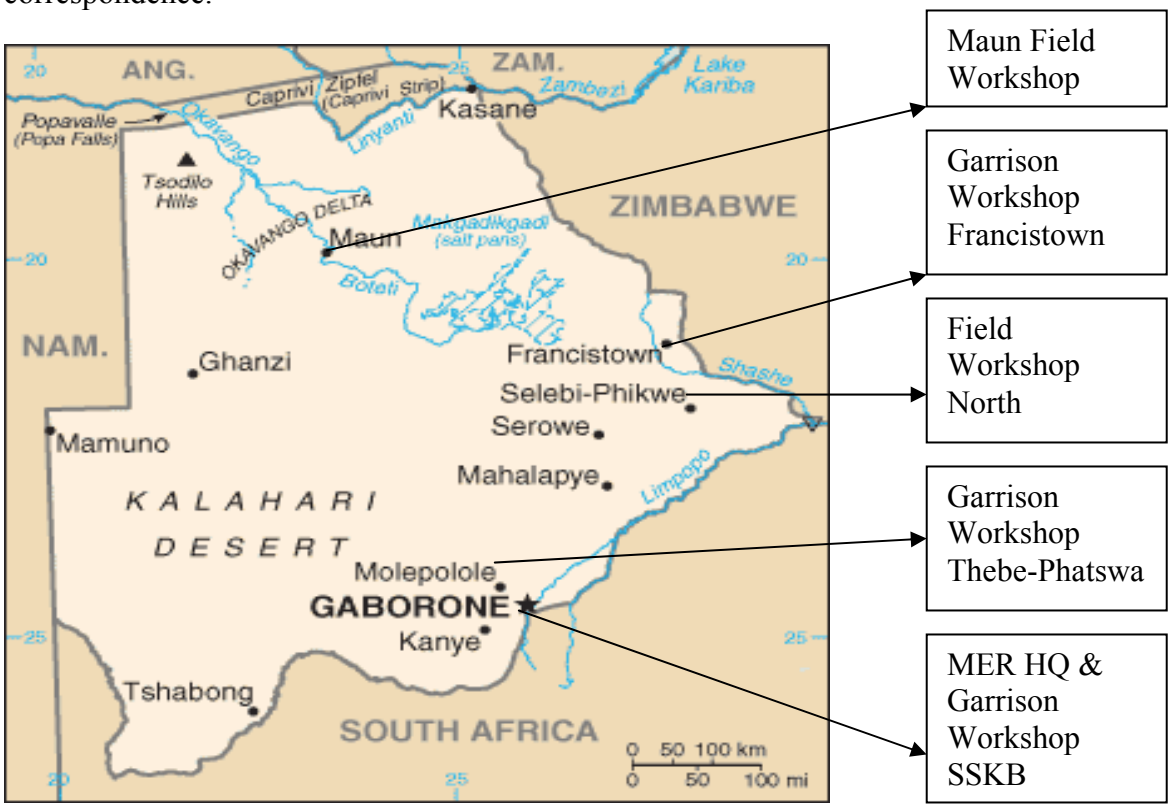


Figure 1. MER Unit Locations in Botswana

To efficiently and effectively support BDF garrisons and operational bases throughout Botswana, regional-divisional garrison workshops (GW) and field workshops (FW) are co-located with the fighting units. Each workshop is led by a lieutenant colonel or major. The MER is led by a brigadier, the Chief of the Mechanical Engineers (CMER), co-located at BDF headquarters in Gaborone, Botswana's capital city. The geographical locations of the MER units in Botswana are shown in Figure 1 above.

The garrison workshops are strategic repair centers that support the permanent garrisons. These geographically located divisions are autonomous and are headed by lieutenant colonels. They depend on the MER headquarters, however, for the bulk of their spares. The unit responsible for sourcing the spares en masse is the Material Management Group (MMG) and it is part of the MER headquarters. The MER sub-units are locally supported by an MMG branch co-located with each of the divisions (sub-units). These MMG sub-units are warranted to procure parts and services locally for less than BWP10,000 (approximately US $2,000) per consignment, which can be varied by the chief of the Mechanical Engineers Regiment.

B. BDF (MER) BUSINESS PRACTICES

1. Procurement of Vehicles

Procurement of vehicles for units of the BDF begins when the units include their transport needs in the annual budget estimates that they submit to the BDF headquarters. The Botswana Defence Force commander who was appointed as procurement officer collates a unit's equipment needs, consisting of both equipment replacement and developmental acquisitions. The procurement officer checks the quantities and categories against the allocated budget and makes recommendation to the BDF commander. On approval by the commander, the list to be procured is prepared. A thorough technical description of the equipment identified tender's instruction is handed to the Public Procurement and Asset Disposal Board (PPADB) through the BDF internal tender board. The new PPADB is a parastatal under the Ministry of Finance and Development Planning and functions as the tender adjudicating board. Tendering companies submit their sealed tenders to the Board and the BDF procurement officer collects the tenders for consideration by an internal board appointed by the procurement office. The approved list

of suppliers is forwarded to the PPADB for approval. On approval by the PPADB, the companies approved are then made a general purchase order (GPO) in the amount they tendered for and given directions to supply as they tendered. The delivery period is also stated in the order.

2. Maintenance Procedures

A repair originates with the transport office of the unit, which is responsible for requiring repairs. The unit transport officer prepares a job request form for the vehicle and delivers it to the inspection office of the Mechanical Engineers. The inspector first checks the vehicle for visible damages, cleanliness, tools, lights, and spare wheel, then thoroughly inspects the vehicle for mechanical dysfunction as requested in the job card, and prepares a job card. At this stage, the inspector can recommend outsourcing but normally the vehicle is handed over to an internal section. The whole process of repair is presented in the diagram (Figure 2).

When admitting vehicles for either preventative or corrective maintenance, it is imperative that the repair shop fully inspects the equipment and records the date the equipment is accepted for repairs. The parts that are replaced and their cost are logged. The hours a mechanic spends on a particular job is also noted, so to calculate the labor intensity of the job. The release date of the vehicle back to the user is also noted. All this information helps in determining the cost of repairs, the reliability and the availability data of the equipment.

The Mechanical Engineers Regiment outsources (normally referred to as sub-contracting) some of their repairs to reduce the vehicle off-road time and to relieve the limited manpower the regiment has. The decision to outsource repairs to private companies is normally made at the initial inspection phase, when the vehicle is accepted into the Mechanical Engineers unit.

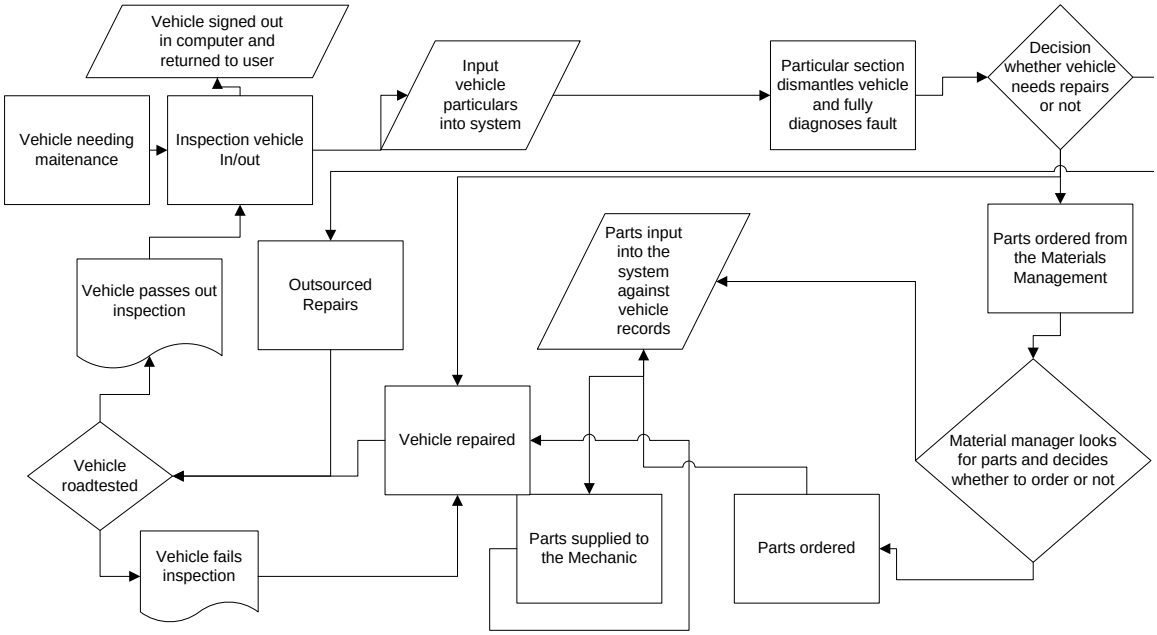


Figure 1. MER Maintenance flow Chart

3. Procurement of Spare Parts for Repairs

The procurement tradition and regulations in the MER are a legacy of the central government supplies regulations and procedures (1988). The BDF does not have an official procurement procedure; it follows the central government regulations to the letter. A recent and major addition to the procurement process was the formation of the Public Procurement and Asset Disposal Board (PPADB) in 2001. The board was formed with a mandate to provide for the procurement of works, supplies, and services and for the disposal of public assets. The PPADB procedures are covered very well by Mompati (2005).

The main outcry that has emanated from the MER since the formation of the PPADB is that the procedures for the acquisition of parts through the board are protracted (see the diagram) resulting in the return of funds to the central government as the budget outlay is done yearly and departments are given funds to disburse over the twelve months. Failure to expend the funds over the twelve months (fiscal year) results in their forfeiture to the government.

These situations render most equipment off-road for extended periods as most of the critical mechanical equipment is sourced from Western countries. Mompati (2005) provides an in-depth analysis of the problem that the foregoing presents in BDF procurement endeavors. The MER consolidates the orders from its sub-units for parts that need to be ordered from overseas companies through the MMG and distributes them on delivery. The main overseas procurement lead-time is six to eight months and the part prices are dear, as compared to locally supplied equipment. Transportation costs and transaction costs from the suppliers are major expenses because only parts of the BDF consolidate their orders. Instead, some separate orders from overseas suppliers are made by the Air Arm, Corps of Armament Depot (CAS), for arms and ammunition. Other BDF units source their spare parts from Western countries such as Belgium, Germany, the United Kingdom, the United States, France, and others. This adds a huge premium to the cost of spares.

4. Disposal of Vehicles and Mechanical Equipment

The Botswana Defence Force has adapted Central Transport Organization (CTO) procedures for the disposal of its mechanical equipment. The advent of the PPADB should have ushered in new rules and regulations to be followed by the government departments, but the board has been largely silent and very slow in addressing the disposal procedures. Proper disposal of government equipment at the end of its useful life is done accordingly to the archaic supplies procedures and regulations and the internal documents that the BDF can glean from the CTO.

Disposal of vehicular equipment begins with the Chief of Mechanical Engineers identification of equipment for boarding and the preparation of a list for the BDF commander's consideration. The commander appoints a board of survey charged with inspecting the equipment to ascertain that it qualifies for "boarding out" according to a set criteria mainly adapted from the CTO. The list of vehicles approved for disposal by the board is then forwarded to the Chief of Mechanical Engineers and subsequently handed to the PPADB for approval. An independent auctioneer is also recommended to the PPADB after a tender list is prepared. After approval, the vehicles are boarded out from the fleet, arranged, and given lot numbers. The Chief of Mechanical Engineers

together with the appointed auctioneer set, the date for an auction sale. Two weeks before the sale, the list of vehicles to be auctioned is advertised in the *Government Gazette* as well as two private newspapers, and the public is given two working days to view the equipment. All purchased vehicles and plants are paid for immediately after the auction. The funds collected are deposited with the central government, not the Botswana Defence Force.

5. Budgeting Procedures in BDF

The budget procedure for a Botswana Defence Force Regiment follows a bottom-up budgeting approach. The procedure begins with a MER sub-unit, a garrison workshop or a field workshop, preparing its budget estimates for the following fiscal year. The workshop forwards the estimates to the MER chief who collates them, making alterations to the budget as he sees fit. The budget is then forwarded to the BDF commander where all units' estimates are consolidated. The budgets for individual units are altered as a result of this consolidation. The consolidated budget is referred to the ministry of finance which collates all the government departments' budgets for executive-branch perusal and approval. The approved budget is then forwarded to the Botswana parliament for appropriation approval. Normally very little if any changes are made at the parliament level, a factor best described by Molomo (2001):

> The role of the legislature is also well defined. It not only pronounces the existence of the military but also approves the military budget proposed by the executive as well as other policy positions. Through budget allocations, parliament has the most potent weapon of controlling the manner in which the executive directs the military. However, in the case of Botswana this check and balance is non-existent as parliament is totally controlled by the Botswana Democratic Party (BDP). However, in theory the BDF is accountable to the populace through parliament.

C. SUMMARY OF CHAPTER III

This chapter's objective was to provide a background of the business practices of the Botswana Defence Force Mechanical Engineers Regiment (MER). The chapter covered policy issues concerning vehicle repair philosophy, financial management and budgeting, procurement of parts, equipment, and services, as well as disposal procedures for obsolete equipment.

IV. DATA COLLECTION AND ANALYSIS

A. GENERAL

This chapter analyzes the data from the Ellipse asset management software tracking the maintenance of the post-refurbishment support data for the refurbished trucks. It contains an analysis of the collected data for representative truck statistics from the project as well as the raw data collected from the refurbishment site. The main purpose is to perform analysis of alternatives post the project phase to determine if indeed refurbishment was the best course of action *vis-à-vis* the procurement of new vehicles.

Through the next paragraphs, the authors:

- Introduce the data resources of the project.
- Describe the methodology and assumptions of conducting the data analysis.
- Carry out the data analysis of the refurbished trucks reliability, life cycle costs, and refurbishment cost.

B. DATA RESOURCES

1. Acquiring the Data

The project data was collected through several means: official project documents, verbal interviews, survey questionnaires, phone calls, emails, print-outs of refurbished-truck maintenance records, and finally, a visit to the project area. The project documents were collected during that visit and the survey was mailed to the participants, users, middle project managers, and the Chief of Mechanical Engineers. The data gathered from the project documents includes a project overview consolidated from the correspondence file; several briefings carried out by the refurbishment staff; costs of individual parts, which helped in estimating the overall cost of refurbishing a single truck; as well as general refurbishment operations information.

A sample of twenty-seven refurbished-trucks maintenance records were collected from the Minicom Ellipse asset-and–works-management database to carry out the descriptive analysis. The Mincom Ellipse asset database is maintained by the Mechanical

Engineers Regiment. The database has a user interface for the vehicle inspection staff, who receive the vehicles into the MER and recommend their repair schedules. The MER is divided into functional repair sections having an interface to the whole system where they input the repair data as well as the spare parts used in repairs. The Material Management Group has an interface to input the parts ordered for the repairs by the repair section pf a particular vehicle. Project management information data was collected from the project files and from verbal interviews with project managers on our visit to the project site in Gaborone. Additional information about repair times for different truck jobs, policies of repair procedures, and estimates of the labor costs of some components was collected from the Central Transport Organization. The information from the Ellipse print-outs provided the cost data and reliability data.

In addition to the data from the foregoing sources, additional documents, records, and a postal survey were used for qualitative analysis. The survey questionnaires were originally sent out by email with the responses returned through a mail service (DHL). Three sets of questionnaires were sent out. One questionnaire was sent to the CMER, one to the project managers (from the ranks of sergeant to captain), and one to the trucks' users.

The data on personnel status was obtained from the planning and parade-state data from the refurbishment site. The remuneration/salary data was obtained from the government of Botswana white paper on salaries, dated 2003.

Appendix B provides a sample of the print–out of maintenance record from the Ellipse data management software.

2. The Data Accuracy

The main problem which was encountered with the collected data was the inadequacy of the information on the downloaded job cards from the Mincom database. Most of the maintenance cards were missing the man-hours, and the material costs for some vehicles were also omitted. Many job orders were not closed as soon as the vehicle was checked out of the MER, a discrepancy that meant that the downtime in the Mechanical Engineers Regiment had to be estimated using standard hours from the CTO.

This introduced uncertainty into the data, which may affect the final results of the analysis, as the admin and logistic times were difficult to estimate. The records show scanty data entry for the two years post-refurbishment, which was prior to our use of the Ellipse database. This surely results in a lower figure for the life-cycle cost of the refurbished trucks, as some had no entries while others had a few entries reliability and for the cost data of maintenance.

C. DATA ANALYSIS METHODOLOGY

The analysis methodology of the project covers two major areas: quantitative analysis and qualitative analysis. The quantitative analysis determines the general logistical criteria of the refurbished trucks. It includes the determination of the operational availability, the expected life-cycle cost of the refurbished trucks, and a comparison of the life-cycle cost of new trucks to that of the refurbished trucks. In addition to these criteria, a descriptive analysis was conducted to identify major trends and attributes of the refurbished trucks.

The analysis evaluates the project according to project management principles and reliability, measures such as the mean time to failure, the availability to the user unit, and the elapsed time to maintain the trucks. The cost implications of refurbishing a truck and its life-cycle costs are also explored. The discussion of the quantitative results, the qualitative observations emanating from the participant survey analysis, and refurbishment documentation will follow the analysis.

D. DATA ANALYSIS AND RESULTS

1. Quantitative Analysis

a. Logistics Measures

(1) Operational Availability. Operational availability depends upon maintainability, which includes factors outside the design environment, such as an insufficient number of spare parts, poorly trained inspection and maintenance personnel and alack of proper tools and procedures to perform the maintenance actions. Achieving excellent maintenance requires sound planning, engineering, testing, excellent maintenance conformance, an adequate support system [logistics] for spare parts, people, and training. An information database is vital as an archive of the historical maintenance

of equipment. According to the Defence Standard 00-06 of Ministry of Defence (United Kingdom), "operational availability is the probability that a system, when used under stated conditions in an ideal environment without consideration for preventative action, will operate satisfactorily at anytime." The availability is calculated from the data gathered from the Ellipse software package and indicates that most of the trucks are brought for maintenance when a major component has failed. The formula employed to calculate the operational availability is:

$$\text{Ao} = \frac{MTBM}{MTBM + MDT}$$

where:

Ao:	the operational availability of a system, subsystem or component.
MTBM:	the mean time between maintenance.
MDT:	the mean downtime of maintenance.

The mean time between maintenance (MTBM) includes all corrective and preventive actions (compared to the MTBF which only includes the meantime between failures). The mean down-time includes all times associated with the system being down for corrective maintenance (CM), including logistic, administrative delays (compared to mean time to repair [MTTR] which is the repair time only). The MTTR is calculated by taking into consideration the times needed to implement each of the corrective maintenance and preventative maintenance tasks for the system for each level of maintenance. The MTBM includes self-imposed downtime for preventive maintenance, which is scheduled and, therefore, eliminates extended downtime if well planned by the maintenance agency.

By applying the operational availability formula, the operational availability of each truck is calculated for all its maintenance procedures over a three-year period. The result of the calculation is shown in Table 1 below:

Table 1. Operational Availability of Refurbished Trucks

Truck N#	***851***	***853***	***872***	***887***	***902***	***913***	***958***	***980***	***1156***
Ao	56.4%	92.6%	96.5%	94.3%	86.0%	69.3%	85.4%	86.1%	84.1%
Truck N#	***1168***	***1195***	***1260***	***1267***	***1279***	***1402***	***1418***	***1649***	***1650***
Ao	87.3%	70.0%	78.9%	86.8%	94.3%	61.1%	98.2%	62.4%	83.2%
Truck N#	***1904***	***1906***	***1923***	***2019***	***2036***	***2039***	***2040***	***2704***	***5169***
Ao	90.6%	60.0%	91.6%	92.5%	85.5%	65.0%	94.6%	98.4%	91.7%

From Table 1, operational availability descriptive statistics were calculated to give an average availability figure for all the trucks. Table 2 summarizes the descriptive statistics of the trucks availability.

Table 2. Descriptive Statistics of Operational Availability for All Trucks

Measure	*Ao Value*
Mean	83.06%
Median	86.07%
Range	41.95%
Minimum	56.41%
Maximum	98.36%

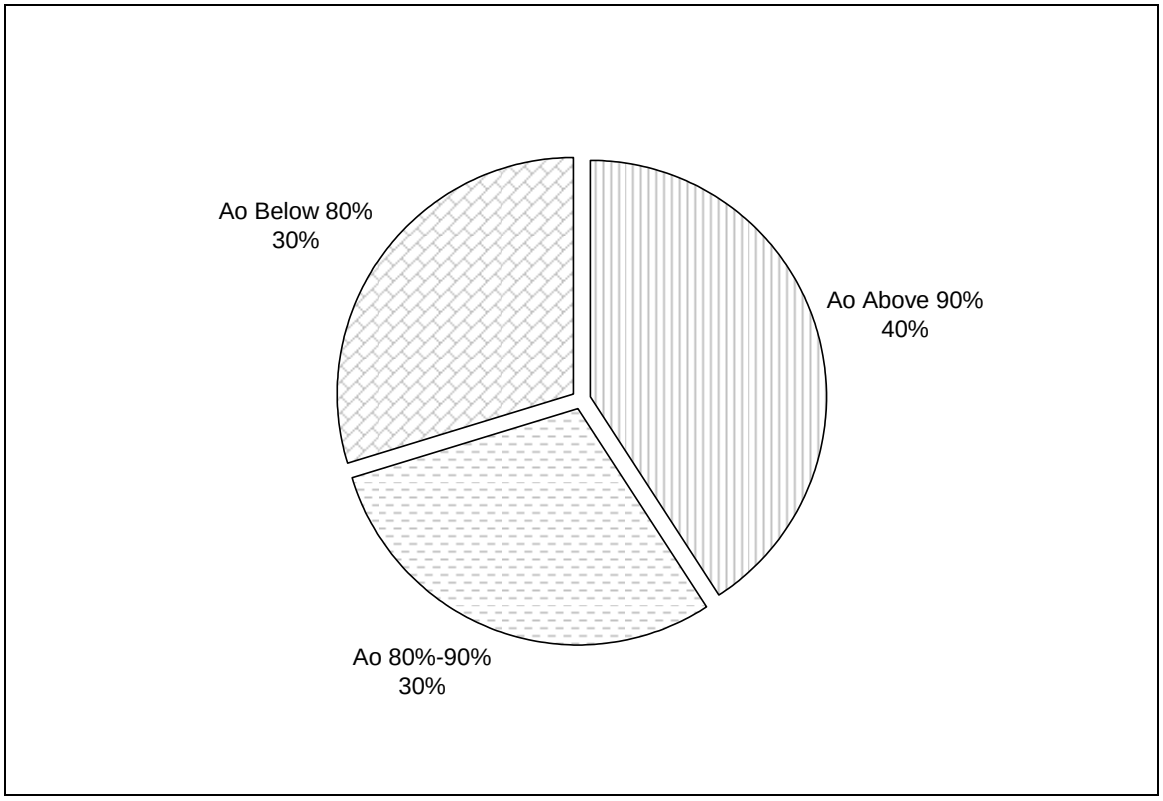
The above results give an average operational availability of the sample trucks (Ao) as:

Ao = 83.08%

The availability of the trucks has a mean figure of approximately 83 percent. This is an unsatisfactory performance for trucks of a mean age of three years after refurbishment. The main objective of the refurbishment of the trucks was to improve availability to be consistently above 90 percent at least for the first few years after refurbishment.

Figure 3 shows the distribution of Ao. The availability figures for the trucks were then grouped into several ranges of percentage availability in order to visualize their availability after three years of operation. We found that 40 percent of the sample trucks were above 90 percent operational availability, 30 percent were between 80 percent and 90 percent, and the rest 30 percent of the trucks were below 80 percent operational availability.

Figure 3. Distribution of Ao Amongst Different Trucks



(2) Trucks' Mean Time Between Maintenance (MTBM). The mean time between maintenance was found to be high for trucks of a mean age of three years after refurbishment. Table 3 shows the MTBM of all sample trucks.

Table 3. MTBM of Refurbished Trucks (in days)

Truck N#	***851***	***853***	***872***	***887***	***902***	***913***	***958***	***980***	***1156***
MTBM (Days)	27	84	107	57	59	51	40	83	63
Truck N#	***1168***	***1195***	***1260***	***1267***	***1279***	***1402***	***1418***	***1649***	***1650***
MTBM (Days)	55	26	29	80	92	29	148	39	78
Truck N#	***1904***	***1906***	***1923***	***2019***	***2036***	***2039***	***2040***	***2704***	***5169***
MTBM (Days)	27	33	161	79	71	27	82	27	143

From Table 3, the MTBM descriptive statistics were calculated to give an average MTBM figure for all the trucks. Table 4 below summarizes the descriptive statistics of the trucks' MTBM.

Table 4. Descriptive Statistics of MTBM for All Trucks

Measure	*MTBM Value (days)*
Mean	71
Median	63
Range	145
Minimum	28
Maximum	173

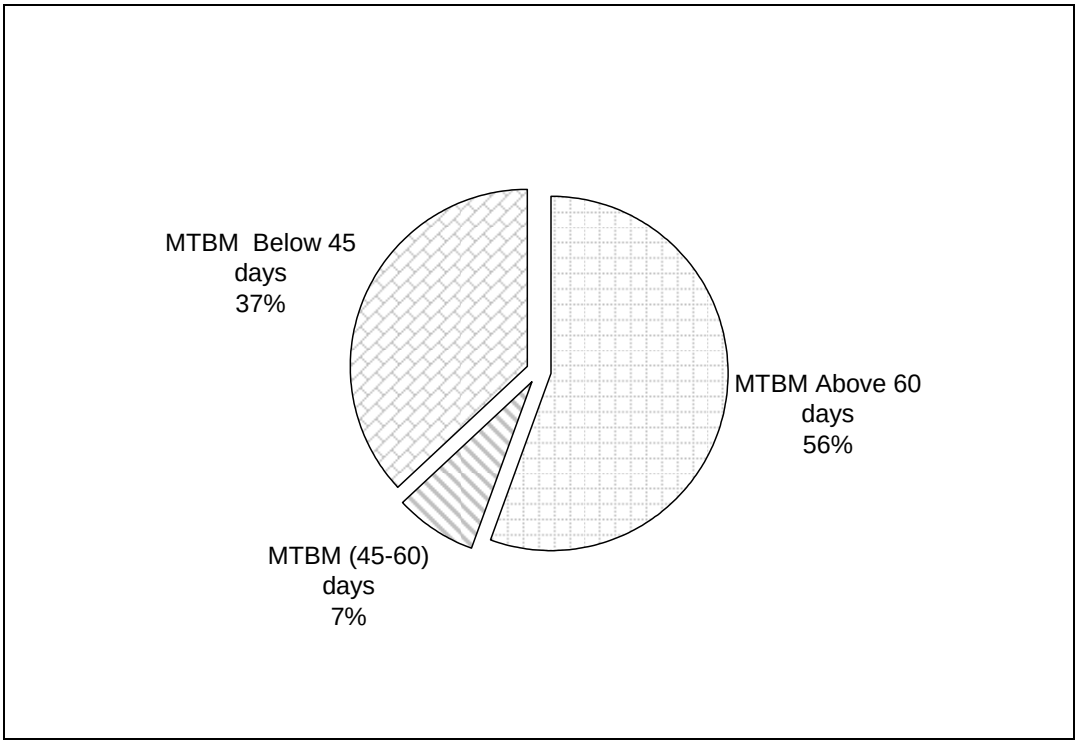
The results in Table 4 give us an average MTBM of the sample trucks as:

<u>MTBM = 71 working days</u>

This value is considered very high for the trucks of a mean age of three years after refurbishment. Figure 4 shows the distribution of MTBM. The MTBM figures for the trucks were then grouped into several ranges of MTBF in order to visualize their MTBM after three years of operation. It was found that 56 percent of the sample trucks had one failure in more than sixty working days, 7 percent had one failure

every forty-five to sixty working days, and the rest (37 percent) of the trucks had one failure in less than forty-five working days.

Figure 4. Distribution of MTBM Amongst Different Trucks



b. Life- Cycle Cost Analysis

The cost analysis was carried out on the data as outlined in Garrison and Noreen (2003) (page 646, exhibit 14-7). The items considered for the cost analysis were:

- **Spare parts**. The spare-parts costs were adapted from the refurbishment project estimates for the costs of spares to refurbish a single vehicle.
- **Personnel costs**. The personnel costs are inclusive of all costs for direct labor and supervision. The pay structure for the BDF is applied from the Botswana government-scheme white paper on salaries, dated 2003. The average monthly salary was calculated to get a typical salary for a "blue-color job." Personnel were assumed to work eight hours a day and twenty days a month.

- **Man hours**. From the Mercedes-Benz refurbishment project documentation, it was estimated that it takes six hundred man-hours to refurbish a truck. This means approximately four men will complete one truck in a month.
- **Transportation costs**. Spare parts for the project were sourced from South Africa and Germany. An express freighting company was employed to haul the spares from South Africa, while, in some cases, a German army plane was used to airfreight the parts from Germany. The transport cost for the parts is estimated at BWP15,000 per truck.
- **Cost of utilities**. The cost for telephone, facsimile, electric and water bills, static plant repairs, and maintenance (crankshaft grinding machine, boring/honing machine, hoist, etc.) due to the increased use in the refurbishment project was also included in the cost estimates. The amount is estimated at BWP60,000 per annum.
- **Operational life-cycle cost post-refurbishment**. The annual cost of ownership of a refurbished truck was calculated by averaging out the annual cost for all the trucks sampled. The trucks were refurbished in 2002. The annual operational cost will certainly increase with the number of years they are in service beyond refurbishment. An incline value of 25 percent was assumed for each year in service due to aging. For the new trucks, the annual maintenance cost was assumed to increase by 15 percent, but it is expected that the new trucks will have a lower incline rate in the first two years because of thorough and regular preventive maintenance by the manufacturer while the trucks are still under warranty. A BWP20,000 salvage value was assumed for a truck due for refurbishment. The life cycle cost is incomplete, as data for the fuel consumption of the trucks were not collected. It is assumed that the latest model of an equivalent truck is more fuel efficient than older refurbished trucks.

(1) **Calculation of life cycle cost**. According to the Life Cycle Cost Analysis Handbook, (1999), the life cycle cost is defined as the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system over a period of time. The life-cycle cost of the trucks was estimated based on the average annual maintenance cost of each truck under study. The study

period is ten years. Appendix C shows a table of the estimated life-cycle cost of refurbished trucks and the expected life-cycle cost of a new truck. A comprehensive model description is found in appendix B which explains the used method of calculation of the life cycle cost for the trucks.

It was found that the estimated life-cycle cost of a refurbished truck is:

LCC_R = BWP499,200

And the life cycle cost of a new truck is:

LCC_N = BWP449,397

(2) **Refurbished Trucks Readiness Analysis.** The main goal of the refurbishment project was to increase the Mercedes-Benz fleet readiness by maintaining a high operational availability of the trucks. It is assumed that the refurbished trucks would emulate the reliability of new trucks. This assumption was a fallacy. The Ao for the refurbished trucks is 83 percent. If we assume that, in total, a hundred trucks were refurbished then only eighty-three out of the one hundred refurbished trucks are available at any given time and seventeen trucks are off-road. If we required 95 percent availability for mission fulfillment then out of the one hundred trucks we expect ninety-five to be mission capable. If we can only have 83 percent available (using refurbished trucks) the following situation unravels:

(i) The refurbished truck operational availability. A_0 of the refurbished trucks was found to be 83.08 percent

This means that out of a hundred refurbished trucks, only eighty-three trucks will be fully mission capable.

(ii) New truck operational availability. We assumed that a new truck will have two maintenance jobs per year, with five days per job.

Then

MTBM = 5.75 months

MDT = 0.25 months

Therefore

Ao= 5.75/ 6 = 96%

This means that out of a hundred new trucks, ninety-six trucks will be fully mission capable.

(iii) Results

To maintain the same level of readiness offered by a hundred refurbished trucks we need only eighty-seven new trucks at 96 percent to have eighty-three mission capable trucks. Instead of having one hundred trucks, we need only lesser new trucks. Therefore at 83 percent for new trucks to maintain this availability we need.

100-87= 13 less new trucks than refurbished trucks.

This represents the savings we could have realized by buying new trucks.

Therefore, the savings is:

(LCC of refurbished truck x 100) – (LCC of new truck x 87)

= 499,200 x 100 – 449,397 x 87

Savings to be realized by procuring eighty-seven new trucks as opposed to having a hundred refurbished trucks

Savings = BWP10,822,453

(3) Make or buy calculation. The following computations were performed using data gleaned from the refurbishment procurement records and estimates from the procurement headquarters for the acquisition of new equipment. A

guidance manual on man-hours for mechanical jobs, as recommended by CTO internal unpublished document was also used as a reference for labor cost. Table 5 summarizes the buy – make cost.

Table 5. Make - Buy Cost Comparison

Cost Element	Refurbished Truck	New Truck
Truck Cost	20,000	375000
Refurbishment Cost	80000	0
Material Shipment	15,000	0
Transportation (Trucks)	1,500	0
Indirect cost	1,000	0
Labor Cost	48,000	0
Total Cost	165500	375000

c. Failures Descriptive Data Analysis

(1) The type, frequency, MDT, and material cost of trucks' observed failures. The trucks' failures that were found during the observation period are shown in Table 6. These failures were gleaned from the job cards for the sampled vehicles from the Ellipse asset management software.

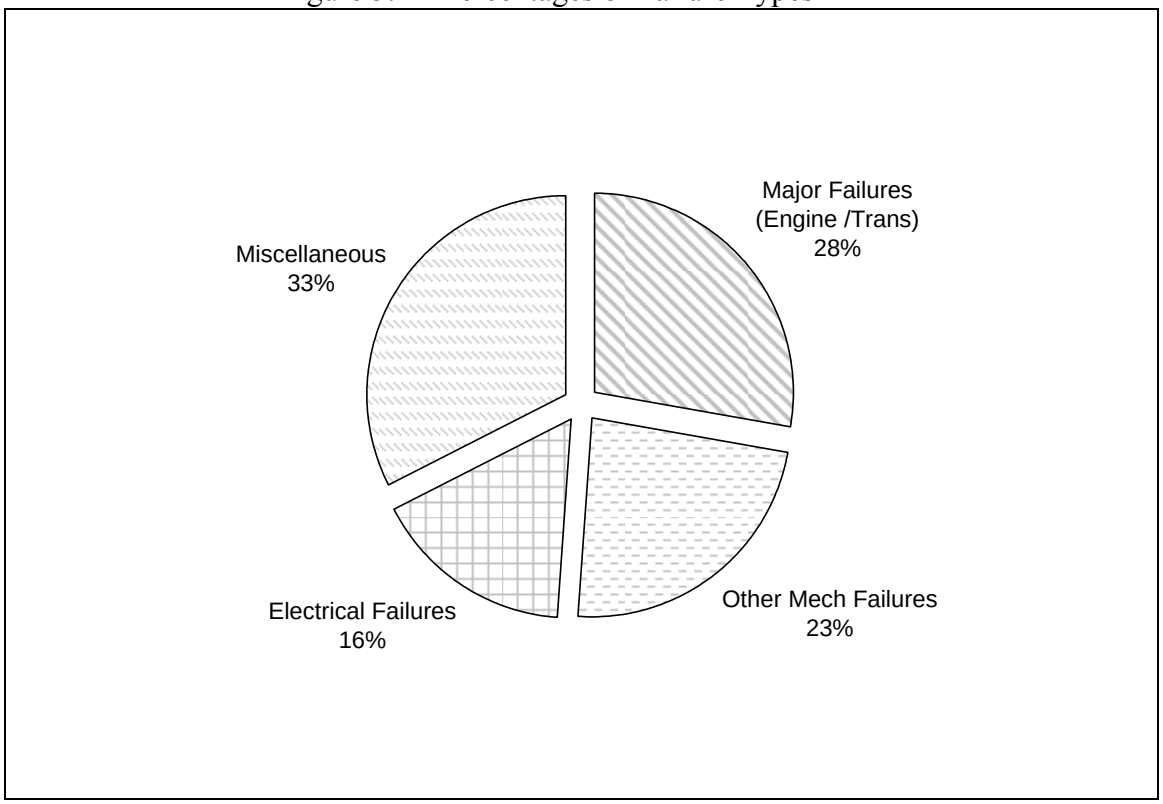
Table 6. Observed Trucks' Failures

ID	*Failure Type*	*MDT (days)*	*Mean Material Cost*	*Frequency*	*Percentage*
1	Acc-Cable	9	350	1	0.7%
2	Air Comp	31	1200	1	0.7%
3	Air Con	15	500	1	0.7%
4	Air lock	1	0	1	0.7%
5	Battery Replacement	3	420	7	5.1%
6	Bonnet Cable	24	100	1	0.7%
7	Bonnet Catcher/Hook	18	1704	4	2.9%
8	Box Oil Seal	24	30	1	0.7%
9	Brake System	18	423	10	7.4%
10	Charging Sys	14	10	4	2.9%
11	Clutch Pedal	6	92	3	2.2%
12	Clutch Sys	9	399	4	2.9%
13	Cylinder Head Gasket	3	150	1	0.7%
14	Down Pipe Leak / Gasket	4	55	3	2.2%
15	Electric Horse Cable	1	100	1	0.7%
16	Electrical	4	44	6	4.4%
17	Engine Failure	23	273	9	6.6%
18	Ferrels	1	0	1	0.7%
19	Fuel Pipes Leak	9	400	1	0.7%

20	Fuel Pump	5	1200	2	1.5%
21	Fuel Tank Leak	13	600	2	1.5%
22	Gear Box	25	2000	4	2.9%
23	Gear Lever	6	300	1	0.7%
24	General Maintenance	9	3281	15	11.0%
25	Hand Brake Valve	4	0	1	0.7%
26	Hoses Leak	2	30	1	0.7%
27	Hub Oil Seal	2	32	1	0.7%
28	Hydraulic Sys Leak	11	0	3	2.2%
29	Idling Adj.	13	90	4	2.9%
30	Ignition Switch	1	500	1	0.7%
31	Journal Oil Seal	21	500	1	0.7%
32	Manifold Cracked	4	1000	1	0.7%
33	Miscellaneous	8	360	16	11.8%
34	Pedal Sys Sticking	1	0	1	0.7%
35	Radiator	26	0	3	2.2%
36	Speedo clock	17	1000	3	2.2%
37	Starting Sys	10	612	3	2.2%
38	Steering Play	5	0	1	0.7%
39	Stopper Cable	2	100	1	0.7%
40	Tie Rod Ends	32	90	1	0.7%
41	Tightening / Lubrication	17	0	1	0.7%
42	Tires	15	807	6	4.4%
43	Universal Joints	10	90	3	2.2%

To better visualize the most common types of failures, they were grouped into four groups. The first group included major types of failures, such as engine and transmission failures. A second group included other mechanical failures, such as clutch system, starting system, and brake system failure. A third group included all electrical failures. The final group included all different types of failures. Figure 5 shows the percentage of each group out of all observed failures.

Figure 5. Percentages of Failure Types



(2) *Engine and Transmission Failures*. Major component failures are worth studying because they are the most expensive to repair. They are also indicative of the workmanship in the project and could indicate subsequent user abuse. An engine or gearbox failure at low mileage normally indicates poor workmanship. For major unit aggregates that were outsourced, there is need to follow up warranty on these and thus save maintenance funds. The tables below show the engine and transmission failures according to kilometers driven.

Table 7. Statistics of Engine Failure

Measurement	***Km Reading***
Mean	10904
Median	10156
Range	8249
Minimum	7710
Maximum	15959

Table 8. Statistics of Transmission Failure

Measurement	***Km Reading***
Mean	9990
Median	11123
Range	14204
Minimum	1755
Maximum	15959

The mean time (in terms of km) between failures of major components is approximately 10,000 for both the engine and the transmission. This indicates that the trucks fail around the time they are due for their first preventative maintenance. This makes the faults very difficult to prevent. The minimum failure for the transmission occurs at only 1,755Km indicating poor workmanship, while the engine fares better at a minimum of about 7,700 km.

2. Qualitative Analysis.

a. Preface

The project success was measured along three criteria that were applied and validated in previous research by Dvir et al. (2003). These criteria were:

- Meeting planning goals (success at the project manager level)
- End-user benefits
- Top management view of project success

In the case of a refurbishment project, it will be such things as the potential for future inclusion of the refurbishment of selected vehicles in a fleet management strategy to increase equipment availability, Ao. To determine whether the project satisfied these criteria, a project site visit was made and survey questionnaires covering users, top management, and middle managers for the project were distributed.

b. Survey Questionnaires Analysis

(1) Middle Management Survey. A survey was conducted as described in Appendix D. The average experience of the middle managers in the

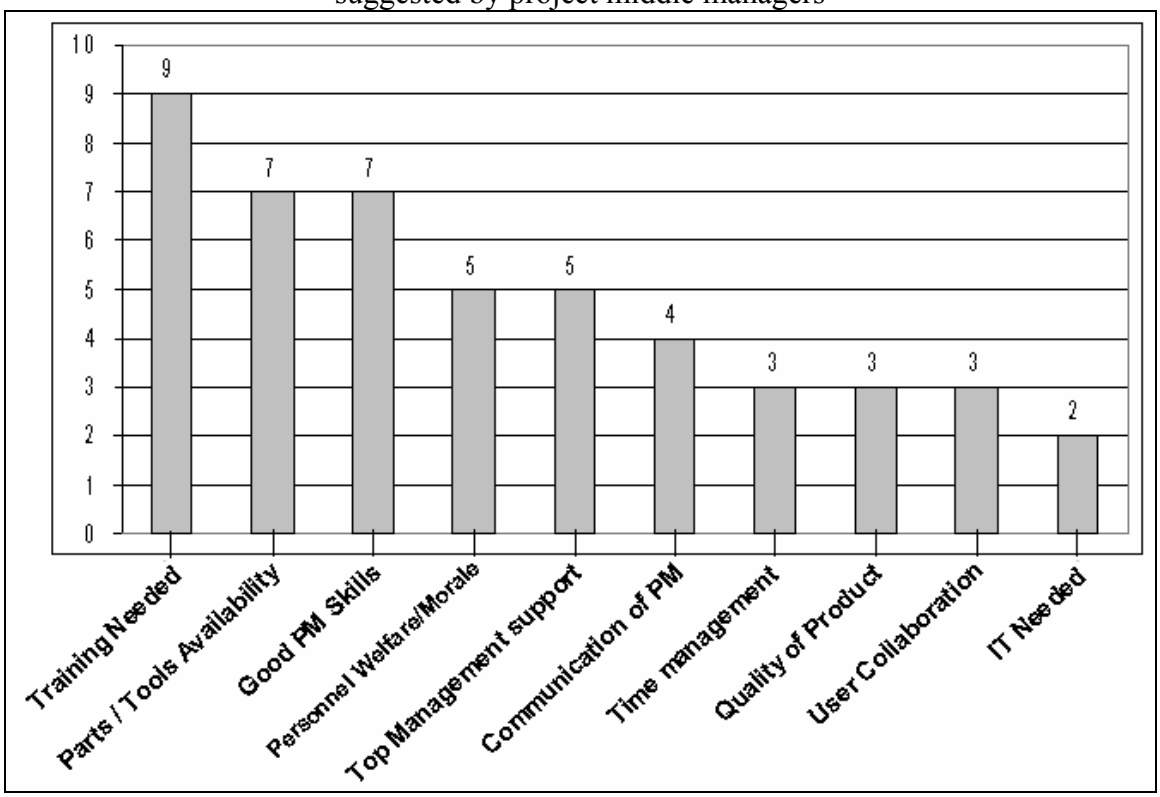
refurbishment project was seven years. Only two of the middle managers had a prior experience of project failure; in both cases the failure was attributable to financial reasons.

Table 9. Descriptive Statistics for Meeting Project Goals

Success measures	Min	Max	Mean	SD
Project Mission	4	5	4.86	0.378
Top management support	4	5	4.86	0.378
Project planning	4	5	4.86	0.378
User/customer Consultation	3	5	4.71	0.750
Personnel Management	4	5	4.85	0.380
Communication	5	5	5	0
Trouble shooting techniques	5	5	5	0
Achievement	4	5	4.71	0.49
Recognition	3	5	4.85	0.38

To address the factors that the middle managers regarded as lacking in the project and that they felt had to be addressed; an open-ended questionnaire was posted to the respondents. In all there were forty-two suggestions of ways to improve the project. These are summarized under ten main groupings and presented in a bar chart to better visualize their modal values. Figure 7 shows responses to the questionnaire items that addressed the possible improvements suggested by project middle managers (sergeant to w/officer).

Figure 6. Responses to the questionnaire items that addressed the possible improvements suggested by project middle managers



The last part of the questionnaire was also an open-ended section which set out to solicit the project manager's opinions. The project managers repeated most of the reasons summarized in Table 7. Additionally, they made the following suggestions:

- **Sick leaves**. The organizational culture of personnel absenteeism due to sick leave, which is conveniently taken prior to public holidays, was cited as a drawback.
- **Clear allotment of duties**. This was cited as a major problem, as the managers felt that at times some of the personnel lingered around with no clear purpose for a whole day.
- **Spare parts**. The managers felt that the spare parts have to be ordered regularly and should be available when needed. It was apparent from their remarks that the parts shortage was a factor at some stage of the project.

- **Quality**. Comments on quality were made by a small group of managers, who were tasked with the post-refurbishment support of vehicles distributed to users. There were few suggestions that the users should be involved and trained in caring for the trucks. Thorough inspections at every stage and adherence to planned times for a given stage of the project also came up in the survey.
- **Communication**. Most middle managers suggested that they should be involved in meetings for progress feedback on the project.

(2) **Mercedes-Benz Truck Users' Survey** In order to gauge user satisfaction and project success, the truck users were posted a survey/questionnaire (included in Appendix D). There was a very poor response from users, only 50 percent of the surveys sent out were returned. The comments from the users form the basis of the analysis, as opposed to numerical statistical analysis. The involvement of the users in the project seems to minimal. The objectives of refurbishment were murky to the users, as they were not involved. Most users seemed to consider the project a normal part of repairs. Quality issues mentioned were the high consumption of engine oil, the unreliability of the engine cut-off switch, and the durability of the canvas. The quality of support of the trucks was also a major grievance of the users. Out of a score of five, all the users gave post-refurbishment support a score of two.

(3) Top Management Survey. One survey questionnaire was sent to the current Chief of the Mechanical Engineers, Colonel E.M. Senai. The aim of the survey was to get the top management's opinion of the planning, execution, and success of the project. Three principal themes emerged from the data: cost benefit analysis and planning, after-service support of the trucks, a collaborative planning approach to achieve expected availability figures for the refurbished trucks and perceived benefits of the project. Table 10 presents each theme, together with illustrative quotations.

Table 10. Themes, Subthemes, and Illustrative Quotes: High Echelon Planning and Control

Themes and sub-themes	*Illustrative quotes*
Cost Benefit Analysis/Planning	
Project identification	"The project was identified as a successor to another similar project. Option was chosen due to unavailability of funds."
How project helped BDF in implementing projects	"The project will give a better understanding of the complexities of the refurbishment project finances required and of cost benefit."
General Observations	"A detailed project study is necessary before a project commences."
What parts of the project did not work well?	"Time, in the sense that we did not meet the target and the project could not be extended due to lack of funds."
Service support of refurbished trucks/collaborative approach with users	
Structures set up to support users	"Effective after-service support, i.e., team of technicians in a specialized mobile lorry. There are existing procedures and structures."
Evaluation of products	"None has been done."
What worked best?	"Their workmanship was the best; there were minimal return jobs."
User units' involvement at planning stages	"None"
User units involvement at delivery of trucks	"None"
Training/transfer of knowledge	
Important things to do	"Improve management and technical skill"

c. Refurbishment Site Visit

Prior to the questionnaires above, a site visit was conducted and several oral interviews were carried out as well as gathering paperwork on the refurbishment. The following observations from the site visit are worthy noting:

(1) Planning. There was no indication of intensive prior planning before the project was implemented. In an official internal document from the Chief of the Mechanical Engineers Regiment to the BDF headquarters, recommending approval for the refurbishment personnel to be accommodated in private housing, because of a lack of accommodation for the refurbishment workers pooled from sub-units of MER to work on the project at MER headquarters, the commander observes:

> Admissibly, this issue was probably not given the attention it deserved in pre-planning of the project and as such this problem arose with time.

(2) Personnel turn-over. An at least 25 percent turnover of personnel was the norm in the project, as the commander noted in the same correspondence as cited above:

> It was resolved to continually rotate about 25% of these members on a yearly basis as such, providing on-the-job training for MER personnel and at the same time curbing monotony of the job which might lower production.

(3) Project Requirements. Spare-parts provision problems: It was apparent from the conversations that were held with some of the middle management that the provision of spare parts at times impacted negatively on the project. This is vividly captured in an undated MER internal memo that reports:

> It took the refurbishment section approximately five months to refurbish eight trucks. Production has been slow because it took a while for Mercedes-Benz South Africa (MBSA) to furnish us with the correct spare parts. The reason MBSA gave for the delay was that they did not have all the spares we ordered in stock and consequently had to order from Germany. Even up-to-date spares have not reached South Africa from Germany.

(4) Project Control. In our perusal of the project contract that was signed between the government of Botswana and Germany, it was apparent that the project manager was a German colonel attached to the project as part of the agreement. The BDF officer delegated by the MER was merely a liaison officer between the Germans and the MER command, and had a very minimal decision-making role. There were no job descriptions for the project managers in the project file, nor was there any formalized work-breakdown structure for all personnel engaged in the project. The foregoing became apparent in the correspondence that the German personnel had with the CMER. In one correspondence the advisor states:

> The order of events will be established together with the Chief of MER. It is intended to hand over the final truck during the ceremony by the German ambassador to the BDF high command.

That observation leaves the purported project manager out of the equation and reveals the actual situation: the colonel was indeed in charge of the project. The financial aspects of the project were apparently under the German advisory team's control. An audit of the project accounts does not appear in the files. A conversation with the BDF project staff also revealed that major decisions lay with the German staff, as they held the strings to the "project purse."

(5) Project visibility. This was apparently one of the refurbishment project's major problems. In correspondence from the German Advisory Group, dated 14 April 2003, to the CMER, the head of the German group notes:

> The situation regarding the stock control/management in the Mercedes-Benz project warehouse is unsatisfactory. In June 2002, some discussions with MER and Mincom representatives were conducted on how to integrate our store into the logistical system. In order to solve this problem and enhance our refurbishment work, we need stock management software as soon as possible.

Another reason resounded by the middle project managers and general staff, especially those who were involved in rework, was their inability to access the fleet management system Mincom Ellipse database. Access to the database of vehicles for jobs needing rework were have identified earlier as breakdowns in the geographically removed MER units' input to the defective equipment in the Ellipse

system, which was available in the Wide Area Network (WAN) for the Mechanical Engineers Regiment (MER). Rework could then have been quickly carried out, preventing cannibalization of the trucks.

(6) Analysis of alternatives. There appears to be little analysis to compare the option of a refurbishment of trucks to the option to purchase trucks and to determine the effect of each alternative on truck availability to units. The only reference to an assessment of alternatives to improve reliability occurs in a speech by the CMER:

> In 1996, the price of a new Mercedes-Benz truck was about BWP227,800. At an inflation rate of 6 percent, the cost of a new truck would be around BWP410,000 after seven years. The cost of repairing a truck is BWP120,000; BDF contributes 30 percent which brings the cost to BWP40,000 per truck. This means BDF saves 80 percent by refurbishing these trucks as opposed to a new one.

The above justification ignores that the refurbished truck is susceptible to workmanship defects, difficulty in procuring spare parts as the refurbished trucks are out of production. The assumption of lower cost of ownership ignores the high operational costs of aged inventory in terms of labor and downtimes for repair. The project does not regard the option of buying new equipment and long term impacts of the refurbishment option compared to acquiring new trucks.

(7) Project status**.** Project management training was not done prior to commencement of the project. This failing was expressed by many of the middle managers interviewed. The progress of the teams was also left to a team leader closely supervised by the German team. Project-tracking methods such as the Gantt chart were not in use and even project management software was lacking.

(8) Corrective Action. Although the vehicles were well tested and even verified by an external examiner, rework was common. The mechanics responsible for rework blamed this on the users' abuse of the equipment. An unwillingness to release mechanics from the project for rework was also quoted as a major factor affecting corrective action for defective equipment. From conversations with the senior staff, warrant officers, it appears that, originally, vehicle standardized-parts kits were bought that were prepacked by the manufacturer by the truck serial numbers.

However, as the refurbishment wore on, this practice was scrapped and deemed an expensive habit. The process switched to only changing parts that were deemed necessary. According to the middle managers, this compromised quality as, to save funds, most parts were not changed. A record of this practice was found among the inspection job-cards of vehicles that were refurbished during the first phase of the project, when trucks were allotted standardized kits and costs were easy to estimate because repairs and the cost of refurbishment were standard for each truck.

E. SUMMARY OF CHAPTER IV

This chapter analyzes the survey/questionnaires that were sent to the users, the project middle managers, and the CMER. The CMER was a *de facto* project executive as he was the project sponsor and the eyes and ears of the project for the BDF headquarters. The following points can be deduced from the survey and the analysis of the paperwork from the project site-visit:

- Training. Training in project management techniques was needed, especially for the middle management personnel involved in the project.

- Spare parts. Spare parts were either in short supply or were wrongly supplied by the suppliers.

- Auditing. Little or no auditing was carried out, either during or after the project, of project funds, resources, and adherence to government contracting policies.

- No software or any other project tracking tool was in use. Its use could have improved the management of time and personnel constraints.

- Planning. Users' input was absent, eliminating a contribution that is invaluable in assuring buy-in and in improving care and regular maintenance.

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V. DISCUSSION OF RESULTS

A. GENERAL

This chapter will discuss and evaluate the project using the qualitative and quantitative data analysis from the Chapter. IV

A summary of the discussion will conclude the chapter.

B. DISCUSSION AND EVALUATION

The primary reason behind any evaluation is the need to improve the delivery of subsequent projects by using past experience. A process of continual evaluation can be an important part of project delivery, guiding and informing the project toward ideal process efficiency. Present-day project delivery has improved because funding organizations now often require continuous evaluations to ensure that funds are not only being efficiently, but also effectively, spent. In addition, projects are often evaluated to assess the impact of a project, finding the project strengths as well as weaknesses during its tenure so as to adjust resources to keep it on budget and on time.

The analysis in chapter VI mainly concentrated on the availability of the refurbished products and the strengths and weaknesses revealed by the responses to the questionnaires by the product users, the managers of the project, and the project executive officer, the Chief of the Mechanical Engineers Regiment.

The following chapter discusses the analysis of the data and other observations that became apparent during the conduct of the project. The study examined a Mercedes-Benz project carried out by the Botswana Defence Force Mechanical Engineers Regiment. This project was chosen so as to study the application of project management techniques applied by a governmental organization in a fairly heavy manufacturing environment. The effect and benefits evaluation as a learning tool were explored. Life-cycle concepts, logistics availability measures, and estimated costs, were used to determine the success of the project in improving fleet availability.

The data for the project was downloaded from the Ellipse asset management software used by the Mechanical Engineers Regiment of the Botswana Defence Force. A

site visit to the refurbishment project area provided official correspondence (letters, memorandums and meeting minutes) and literature on the project. Several governmental publications on salary, costing data, and policies and regulations were also referenced in order to explain some of the pertinent policy issues and fleet management practices. Logistics availability and failure of major systems analysis were done and are presented in Chapter IV.

In this chapter, the implications of the results of the analysis of the data, the responses to the questionnaires, and the site visit observations are discussed. All those findings form the basis of the recommendations. We conclude the following tenets of project management, culture aspects, and policies need attention by the BDF if it is to be involved in future projects.

1. Project Planning

The study of the documents and the correspondence on the project that were obtained from the project site visit indicate that very little in-depth planning was done before the project began. The project manager was not involved at an early stage of planning. An intensive plenary meeting that included all the stakeholders should have preceded the project's beginning. That planning session should also have included all the financial and physical profiles of the project, which appear to have been omitted from the initial planning. Due to a lack of project-management training, milestones were not set at the initial stage, and thus there was no determination of the deliverables that should have been achieved at each milestone. The project was a chance for the BDF to build a capability for refurbishment by training project managers in the requisite skills to run a project of the size that then was carried out. There was a turnover of project managers, one every two years, which led to great volatility in the work environment. This project was also a great opportunity for the planners to better equip the aged engine-reconditioning workshop appropriately for the project. The needed equipment could have been identified by benchmarking the present workshop against existing commercial engine-reconditioning workshops levels. This was a guaranteed possibility, as the German government was willing to sponsor the workshop upgrading. Instead, the equipment often broke down, leading to expensive outsourcing that could have been done

internally had there been a plan to purchase the newest equipment and train personnel to use it before the project got underway.

2. Parts Availability

The trucks being refurbished were seventeen years old on average. They were no longer manufactured after the late 1980s either in South Africa or in Germany. Thus, procuring parts for the trucks was difficult during the refurbishment project, and it will prove even more difficult later, because the trucks are estimated to have 7-10 years of service after their refurbishment, The shortage of spares was indicated in the project manager's answers to the questionnaires and also in the MER internal correspondence regarding the refurbishment. The length of downtime for vehicles awaiting maintenance proves this assertion, with some trucks having downtimes exceeding fifty days.

3. Product Life-Cycle Costs

Merely finishing the refurbishment process and releasing truck to the users should not be regarded as the sole measure of project success. Much as the refurbished trucks are symbolic of what such a project can produce, they should not be taken as a sign of complete success. Another major feat is keeping the trucks running and available to the users for the time stated in the project objectives at a reasonable cost to the government. The make-versus-buy comparison described in the last chapter shows that refurbishing a truck is cheaper than acquiring a new truck. This argument alone seems to have been the justification of the project. But according to the life-cycle costs; the difficulties foreseen by the project managers, and the vintage of the trucks, that should *not* have been the sole consideration. An in-depth analysis of the project should have been done at the planning stage that included an analysis of the life-cycle cost of a new truck versus a refurbished truck over its estimated future life. The probability that refurbished trucks enable the BDF fleet to achieve its mission should also have been explored. From an analysis of their subsequent three years of operation, the refurbished trucks indicate an overall availability of less than 90 percent. The life-cycle costs of a refurbished truck surpass the costs of a new truck before a predicted seven-year lifetime. Another aspect to be considered is that opting for a refurbished truck foregoes the advantages, such as safety that come with the latest models. All new models of Mercedes-Benz trucks come with an

anti-lock braking system, better crash-behavior dynamics, and improved ergonomics, plus much more fuel efficiency than a product seventeen years ago. The data on fuel consumption of the refurbished trucks was obtained from the running logbook of the refurbished trucks. The data shows inefficiency in fuel consumption as compared to new trucks. New trucks have new engine technology, designed specifically to run on diesel, with low sulfur and nitrogen compounds. This assures that the engines have cleaner by-products and lower fuel and lubricant consumption rates.

The failure to involve the truck users in the planning phase is an omission that can have a very negative impact on a project's direction as well as its outcome. What was apparent from the users' survey was their lack of knowledge of the refurbishment project objectives. The users also complained about the post-refurbishment maintenance support of the trucks. The middle-manager surveys indicated that they also had qualms about the level of care that the users provided the trucks, which was mainly emphasized by the technicians involved in the rework of the trucks during their refurbishment. The lack of care by users of refurbished trucks may indicate the users' general lack of support of the whole project.

The low availability of the refurbished trucks was a hindrance to the attainment of the mission and costly to the BDF. Procuring new trucks would have saved BDF from having inventory awaiting repairs in an off-road state at the rate of seventeen vehicles per one hundred refurbished, as indicated in the calculation of the cost of unavailability calculated in chapter IV. The calculation indicates that the BDF could have saved an excess of three million pula (BWP3m) by buying new vehicles as compared to refurbishing. The trucks awaiting repairs are a cost to the BDF because they do not contribute to the fulfillment of the mission while off-road. The funds used to refurbish them could have been used to procure new, more reliable trucks.

4. Tasks and Network

The middle managers noted a general lack of management techniques both verbally during the site visit and in writing in the survey questionnaires. A use of both wall charts and software, so that project management can keep track of tasks and milestones is essential in such a huge project. Also important are the work-breakdown

structures prepared at the planning stage and followed diligently by managers to keep the project on track. The managers also complained about a "culture of absence" due to sick leaves, especially on the working day preceding a public holiday. This is a culture that needs to be routed out by a careful evaluation of each workers contribution to the group effort as a whole. For a middle manager to be just another technician is not good enough: managers have to be trained efficient project-management and personnel management techniques. Personnel turnover from the refurbishment project was about 25 percent per year. This was done in order to train the maximum number of the Mechanical Engineers Regiment technicians. The project learning curve was, therefore, very steep, as new personnel were continuously being introduced, which had negative impact on the project.

5. Funding

The German government funded the refurbishment. The funds were not transferred directly to the BDF; they were accessed from a fund set up for the project. This enabled the project manager to have versatility in the purchase of spare parts and vehicle outsourcing. However, when the project is carried out with the BDF as sponsor, it gets bogged down by lengthy tender-bid procedures for the purchase of parts. Some procedures can take up to six months because there is a hierarchy of officials who must review the tenders before they can be approved. Also the funds are available for one fiscal year for appropriation. For a project straddling many years, as the refurbishment project was, it is very difficult, because the government finance rules require that the funds be retired at the end of every fiscal year. Most of the funds would be retired, therefore, before parts could be procured. A lack of versatility in the assessment of funds hampers the timely delivery of a project. It may even make it impossible to carry it out.

6. Capacity Building

There is a need to have permanent easily deployable, civilian manpower at a Mechanical Engineers Base workshop. That would provide the Mechanical Engineers with the versatility necessary for such labor intensive projects as refurbishment project. That versatility might also improve the turnover of engines and gearboxes that are not engaged in any major project. The highly trained pool of technicians would be cyclically trained for specific refurbishment projects, which would make them much more highly

capable. This project had a huge turnover because most of the personnel were drawn from MER units outside Gaborone. Thus, their accommodation and transfer allowances were substantial.

7. Ellipse Software System

The Mechanical Engineers has the Ellipse asset-management system networked in all its sub-units. It is not only a good asset-management system, but also an excellent fleet-management system as well. However, a system is as good as the information that gets fed into it. The information being fed into the MER's system is mostly erroneous, which can result in faulty maintenance status. There were cases in which a post-refurbishment vehicle stayed on the shop floor for sixty-three days. In many such cases, this research discarded information because the supposed waiting time in the workshop was simply a glaring lack of up-dating of the information in the system. Oftentimes, the cost of the parts fitted in the vehicles is not entered on the job cards. Also, the standard time that a mechanic spends doing some standardized repair jobs is not reflected in the job cards. This leads to very inefficient mechanics, because they have no guide or cross-check mechanism to feedback their performance. The inclusion of the labor hours as well as the cost of parts would enable the Mechanical Engineers to decide if a truck should be outsourced or not, which could potentially save the BDF both a lot of money and man-hours.

C. SUMMARY OF THE CHAPTER

The chapter covered the weaknesses of the project planning and suggested a collaborative approach to the planning projects. The chapter also discussed the auditing of projects and variance analysis during the project. The current personnel management and future approaches to project personnel management were discussed. The modification of prevailing government budgeting policy to better accommodate projects of this nature was also discussed. The project outcomes were discussed as a major determination of project success. The practice of assuming that product delivery in end of itself was success was discussed and discouraged. Life-cycle costs and the performance

of a product of a refurbishment project were discussed as vital parts of the whole refurbishment endeavor. It seems fitting to end this chapter with the following saying by Pierre Abelard:

> The beginning of wisdom is found in doubting; by doubting we come to the question, and by seeking we may come upon the truth.

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VI. CONCLUSION AND RECOMMENDATIONS

A. ANSWERS TO RESEARCH QUESTIONS

1. Primary Question

Was the Mercedes-Benz Trucks Refurbishment Project worth the pain?

The refurbishment project was not worth the pain doing it because of three main factors:

- The availability of the trucks has fallen to 83 percent in the three years since their refurbishment.
- The mean time between maintenance of the refurbished trucks is low. The MTBM for the sample of twenty-seven trucks is seventy-one days. This indicates that a repair of some of the refurbished trucks is sought every two months.
- The life-cycle cost of ownership of a refurbished truck is more than the cost of a new truck at three years of age. This, added to the two factors of low availability and the short time between maintenance for the refurbished trucks, makes buying a new truck a much more prudent decision than refurbishing.

2. Subsidiary Questions

a. Project Planning

(1) Were there any clear objectives that the Mercedes-Benz refurbishment set out to achieve?

It seems that the project objectives were limited to cost saving and the training of BDF mechanics. There was insufficient focus on improving the BDF fleet readiness. Before a company or group takes on any project, it must identify the project requirement and objectives and then keep them as its top priorities. The failure to determine clear objectives may well lead to the failure of the project and the loss of any benefits. A good project manager would begin by identifying the problem, the requirements, and the objectives to be achieved. Therefore, we see that MER management should have taken into consideration the possibility that the refurbishment of the trucks would not fulfill the desired outcome: improving the BDF fleet readiness.

That objective, however, was not emphasized in all refurbishment tasks and phases. So what should MER have done to ensure that the objective of improving BDF fleet readiness was emphasized?

To insure that the project requirements were emphasized during all the project phases, the MER should have assigned project manager who was responsible for that and for all the other project issues, including all project resources. Furthermore, the MER should have evaluated the project benefits by conducting tests and evaluations of the refurbished trucks to monitor their performance. Although saving costs is an important objective, it must not be made a high priority all the time. After all, the failure of projects also means budget losses.

(2) Was the planning of the project done thoroughly so the project would run according to schedule and stay within budget?

The planning phase of the project was *not* thoroughly carried out. The inadequacy of the parts-availability aspect for the maintenance of Mercedes-Benz trucks of an average age of fifteen years should have rang alarm bells in the planning phase. Even just this single oversight is a clear indication that the planning was done haphazardly. The work-breakdown structures routinely used by middle managers and even the project manager were also largely absent. The project-manager responsibilities were practically nonexistent: he functioned primarily as a de-facto liaison officer between the BDF and the German team and had no defined profile. In addition, there were no audits to police either the timing or the finance of the project. The project was in effect "flying by instrument"

b. Project Control

- Were there any control measures in place during the delivery of the project in regard to the budget, personnel issues, and the issue of internal repairs or the outsourcing of components that could not be repaired internally? Were the time constraints and financial management monitored?

The study of the refurbishment-project documentation did not reveal any financial feedback by the German team to the CMER. Auditing of the project finances was not done during the project. Personnel issues were well handled, however, because

the project was run within the confines of military discipline, and serious personnel issues never arose. However, the pooling of personnel from the MER sub-units was an accommodation headache because the personnel had dual housing: they kept their primary housing with their subunits. Relocation allowances for personnel were difficult to resolve, which resulted in personnel being awarded allowances under a financial category reserved for on-the-job trainees.

Outsourcing was done at the prerogative of the German team, which had access to the funds. This did not follow the normal BDF outsourcing procedures as the tender procedures for the refurbishment job did not go through the normal tender procedures.

c. Project objectives

Were the objectives of the project met? Has user satisfaction been ensured?

The project objective of achieving a lesser cost than that of acquiring new trucks was achieved, as was obvious by the initial cost of the project. However, the refurbished trucks have not performed as they were expected to operate for an additional ten years. The end users' satisfaction, as we discovered from the questionnaires, was not as expected. Some MER managers argued that the users were not operating their trucks with caution. We think that, if that was true, it was because of the interior feeling of the users that their trucks were like other old trucks no more.

d. Lessons Learned from the Project

What are the lessons learned from the project? Will the lessons have any bearing on any future projects of a similar nature?

There are many major lessons that can be learned from the project. The most important one is that, for every project the BDF MER undertakes there must be a competent project manager, irrespective of the project size and budget. A good project manager would have written official warrants, the benefit, or advantage, of which is to ensure that there is someone who is well familiar and knowledgeable about the program. He should be given expectations of clear deliverables with unambiguous measures such

as date and budget, and should be charged with the establishment of procedures and techniques to manage the program. Those procedures entail reporting on budget status, project production status, labor, and any predicted milestones.

The second lesson we learned is that the BDF should not decide on such projects without a comprehensive cost study of both the project and the final product outcomes. The truck readiness results indicate that the trucks will offer low operational availability as well as a high life-cycle cost of ownership. A thorough analysis of alternatives (AOA) could have identified the acquisition of new trucks as a better approach to raising availability. The MER focused on the explicit cost of the project while ignoring the implicit cost. The implicit cost of the project was the cost of the trucks' availability in the long run. The BDF needs to establish a research office within the BDF logistic branch to thoroughly explore projects of such magnitude as the Mercedes-Benz project and the acquisition of major equipment before the BDF commits itself. This would ensure a higher earned value for projects.

B. RECOMMENDATIONS

1. BDF Policy Analysis Office

The BDF logistics command should engage logistics units to come up with an overall policy document on how the acquisition of equipment and its maintenance should be handled. This would guide major project appraisals, such as the Mercedes-Benz project planning, which might have borrowed from well-researched best practices been involved in a whiff of decision making. Having a single overarching policy has the following advantages:

- *Ease of Access***.** Currently, there are myriad documents that have been written over the years (some may contradict one another), Central Government policy documents, and even some internal standard-operating procedures that are readily available. None of the documents offer a one-stop service for a manager to use to make informed decisions.

- *Responsiveness and Cost Effectiveness*. A consolidation of documentation would offer the ability to quickly update existing documents and

procedures, enabling quick responses to users seeking clarification of any new policy issue. There would also have fewer errors, and consistent decisions would be made, which would lead to less costly decisions for the government.

- *Accountability*. Clearly written and easily available policies are easier to enforce and hold individuals accountable.

2. BDF Transportation Audit

The BDF should carry out an intensive fleet audit to determine the transport needs for the units. The amount of transport that BDF units need had not been established prior to the refurbishment project. Units' needs should be closely scrutinized and their transport adjusted accordingly.

3. Project Management

Project managers should be both technically capable and well versed in project-management practices and procedures. A fully fledged course in production management or industrial management or a shorter course on quality management and project management should be identified for future project managers.

4. Refurbishment on an On-Going Basis

The BDF should carry out limited refurbishment on a limited basis. A reliability-centered maintenance (RCM) system would involve the mapping of the mean time between failures for certain components, which could then be pooled and reconditioned en masse. Painting of selected equipment could also be done. It could be done halfway through the expected equipment life and limited to critical parts only. This would extend the equipment's reliable life by a few years and ensures that the equipment is not unnecessarily kept in the inventory until it's too difficult to support with spare parts.

5. Transport Officers

Transportation officers should be sufficiently technically trained and fully tasked to look after the fleet according to the pertinent policy and procedures. This would enable the BDF to hold them accountable for equipment neglect.

C. RECOMMENDATIONS FOR FUTURE STUDY

- Fuel Consumption. A comparison of the fuel consumption figures for trucks with mileage exceeding CTO suggested a necessity for boarding out a mileage cut-off of ten years for the trucks kept by the BDF beyond the suggested mileage period. The comparison should then be added to the life-cycle cost after it has been converted to an annual consumption per truck. The life-cycle cost of ownership could then be recalculated to determine whether it makes a perceptible difference in the life-cycle cost.

- Response of BDF to the findings of this research. A positive BDF response would be manifested in a better approach to projects, that is, making changes as per the findings of this study. If there is no change, then the BDF has gained very little "organizational learning" from this experience.

- Audit of BDF vehicle distribution. An audit would provide a guide as to when to refurbish current equipment or to buy new equipment. Units might be oversubscribed with equipment; maybe there is no need to carry out refurbishment after all.

APPENDIX A. THE MERCEDES BENZ TRUCKS REFURBISHMENT PROJECT DATA

A. PROJECT SUMMARY

- The project was set up in 1996 to refurbish one hundred Mercedes-Benz trucks with an average age of ten to fifteen years in the Botswana Defence Force (BDF) fleet.

- The project was carried out in two phases. Phase one was the refurbishment of fifty trucks. Phase two was the refurbishment of the other fifty trucks. The first phase of the project ended in June 1998, the second phase in July 2002.

- Purpose of the project. The trucks were at the end of their projected-service life cycle. The Federal Republic of Germany government provided the supervisors for and the sponsorship of the project. The BDF Mechanical Engineers Regiment (MER) recommended the project as more economically viable than procuring new trucks, due to a reduced budget for development of the fleet.

B. PROJECT PARTICIPANTS

1. Sixty BDF participants: one captain, three lieutenants and other ranks.

2. Federal Republic of Germany participants: two warrant officers and one officer.

C. REFURBISHED TRUCKS DATA

- One hundred Mercedes-Benz trucks, series LP911 and LA1113.

- Acquired by BDF between 1980 and 1985

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APPENDIX B. LOGISTICS MEASURES AND LIFE CYCLE COST CALCULATION MODELS

A. INTRODUCTION

A Microsoft Excel model was used to analyze the gathered maintenance-records data from the Mincom Ellipse software and the data gathered from existing documents on refurbishment cost. The sample size was twenty-seven refurbished trucks. The printouts of maintenance records for the sample trucks were collected, and data from them was fed into the model. The downloaded maintenance data covered a period of about three years. The goal was to carry out descriptive statistics of maintenance records, calculate the logistics measures of the trucks, and calculate the life-cycle cost of the refurbished trucks and the life-cycle cost of a new truck for a comparison analysis.

B. MODELS DESCRIPTION

1. Maintenance Records Model

The maintenance models were set up in such away that each truck had a maintenance model. The input data from the Mincom maintenance records included:

- Failure type
- Job start date (Inspection into the Maintenance Workshop)
- Job end date (Inspection out of the Maintenance Workshop)
- Truck's kilometer reading
- Material cost to repairing the truck plus the man-hours or an estimate of the man-hours to repair the truck.

Output from the maintenance model:

- Maintenance downtime
- Labor cost
- Total maintenance cost

The logistics and cost measures for each truck were calculated and tabulated in order to find the sample logistics measures.

The following measures were calculated for each truck:

- Mean time between maintenance ($\overline{MTBM}$). $\overline{MTBM}$ was calculated by finding an average of the time between each maintenance.

$$\overline{MTBM} = \frac{\sum TBM_i}{F - 1}$$

Where:

$\overline{MTBM}$: Mean time between maintenance

$TBMi$: Time between sequential maintenance of the i-th failure

F: Total number of failures of the truck

- Mean downtime ($\overline{MDT}$). $\overline{MDT}$ was calculated by averaging the downtime of failures.

$$\overline{MDT} = \frac{\sum DT_i}{F}$$

Where:

DT_i: Downtime of maintenance job

- Operational availability (Ao). The operational availability was calculated by using the formula given in chapter IV:

$$\text{Ao} = \frac{MTBM}{MTBM + MDT}$$

- Total maintenance cost (TMC). The total maintenance cost is the sum of all maintenance costs for each job.

$$TMC = \sum MC_i$$

MCi = (material cost + labor cost) for the i-th job

Where:

TMC: Total maintenance cost

MC_i: Maintenance cost for the i-th job

- Average monthly maintenance cost (AMMC). The average monthly maintenance cost was calculated by dividing the TMC by the number of months of the observation period.

- Average annual maintenance cost (AAMC). The average annual maintenance cost was estimated by multiplying AMMC by twelve months.

- Labor cost. The labor cost was not entered in the Mincom Ellipse system; therefore, the labor cost was calculated by multiplying the total number of elapsed hours for each job by the labor rate per hour. The labor rate per hour in the BDF is BWP20. There are eight working hours per day, five working days per week. The labor cost was calculated as follows:

For jobs that lasted more than seven days:

Labor cost = (out-shop date – in-shop date +1) x 5/7 x 8 x 20

For jobs that lasted less than seven days:

Labor cost = (out-shop date – in-shop date +1) x 8 x 20

- Mean Annual Maintenance cost per truck (MAMC). The mean annual maintenance cost per truck (MAMC) was calculated by dividing the sum of all the average annual maintenance costs of all the sample trucks by the number of trucks.

$$\text{MAMC}=\sum AAMC_n / 27$$

Where:

$\sum AAMC_n$: average annual maintenance cost for the n-th truck

MAMC: is the base cost for estimating the life-cycle cost of the refurbished trucks

- Operating cost (Op). The operating cost is the estimated cost of fuel consumed per truck per year.

$$Op = Km_m \times FCR \times P$$

Where:

Op: operating cost for the truck.

Km_m : the average driven kilometers per truck per year.

FCR: fuel consumption rate

P: fuel price

2. Life-Cycle Cost Model

The life-cycle cost model calculates the estimated cost of ownership of the refurbished trucks and of the new trucks for ten years time period. The purpose in doing this was to compare the life-cycle costs of both refurbished and new trucks. In Chapter IV, the life-cycle cost assumptions were introduced. For the refurbished trucks, the annual maintenance cost was assumed to increase by a value of 25 percent annually due to aging. For the new trucks, the annual maintenance cost was assumed to increase by a

value of 15 percent annually. It is expected that the new trucks will have a lower incline rate in the first two years due to thorough and regular preventive maintenance by the manufacturer while the trucks are still under warranty. A BWP20,000 salvage value is assumed for a truck due for refurbishment.

a. Refurbished Trucks' Life- Cycle Model

The refurbished trucks' life-cycle model is based on the estimated mean annual maintenance cost (MAMC) of the sample trucks in addition to the initial cost of refurbishment. The estimated life cycle of the refurbished trucks is ten years, including the observation period. The input data for the life-cycle model for the refurbished trucks is:

- Refurbishment cost. The refurbishment cost was calculated by the BDF MER to be BWP165,500 per truck. (1 BWP=$5.5)

- Mean annual maintenance cost (MAMC). From the maintenance models, MAMC = BWP11,996.

- Transportation cost. This is the cost of transporting the trucks from their units, and the spare parts from Germany and South Africa, per truck refurbished. It is estimated to be BWP1,500.

- Indirect cost. The cost of utilities while refurbishing and maintaining the trucks. It includes electricity, water, phone bills, fax bills, and the maintenance of static equipment such as hoists and engine and gearbox overhaul machines.

- Operating Cost. The cost of running the trucks includes the expected cost of fuel consumption. It is based on the average kilometers driven per year per truck, the fuel consumption rate of a refurbished truck, and the fuel price. The average kilometers driven per truck per year were 9,000Km. The fuel consumption rate for a refurbished truck is estimated as five kilometers per liter.

- Maintenance incline rate. The annual incline in maintenance cost of a refurbished truck. Assumed to be 25 percent annually.

b. New Trucks' Model

The new trucks' life-cycle model is based on an estimated initial annual maintenance cost (MAMC) in addition to the initial cost of acquiring new trucks. The estimated life-cycle of new trucks is ten years. The input data for the life-cycle model for the new trucks is:

- Acquisition cost. The acquisition cost was taken from the initial project data. For the sake of comparison, the acquisition cost of the new trucks was fixed at BWP375,000 per truck.

- Annual maintenance cost (AMC). The new trucks were assumed to be under warranty for the first two years. The only maintenance cost during those two years would be a preventive maintenance cost to the manufacturer. In the authors, experience and according to the gathered data, the preventive maintenance for a new truck is done twice a year. Each preventive maintenance exercise is estimated to cost BWP2,000. Therefore, the annual maintenance cost will be AMC = BWP4,000.

- Transportation cost. The cost of transporting the trucks for maintenance from their units to the dealers for repair. The cost is estimated at BWP1,500.

- Indirect cost. This includes the cost of utilities while maintaining the trucks, arranging for service, costs of items other than service not covered by warranty, and other miscellaneous costs.

- Operating Cost. This is the cost of operating a new truck annually; it includes the expected annual cost of fuel consumption for a truck. It is based on the average kilometers driven per year per truck, the fuel consumption rate of a refurbished truck, and the fuel price. The average expected kilometers per truck per year are 9,000Km. The fuel consumption rate for a new truck is estimated as ten kilometers per liter.

- Maintenance incline rate. This is the annual incline in maintenance cost for any truck: assumed to be zero percent in the first two years and 15 percent annually.

C. SAMPLE MINCOM ELLIPSE SYSTEM PRINTOUTS

Figure 7. Mincom Ellipse Printout for a Sample Truck

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-----------------------------------------------------------------------------------------------------------------------------------
Req.By: MODISE,                                    BDF MER LIVE PRODUCTION                                    Page:          334
Run on: 05/09/05  at: 15:49:33                                                                                Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                           Version:   5.2.13.005
-----------------------------------------------------------------------------------------------------------------------------------

00000040 REFURBISH M/BENZ TRUCK                      Equip Ref     : 24ITRUCK91
                                                                     MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                User Status   :
 Originator: 0000097534 MODISE,                      Out of Service: 19/06/98          Shutdown Data
 Orig. Pri.:                                         Date Required :                    Id       :
 Date Raise: 27/06/02                                Plan Start    :                    Equip Ref:
 Cost Cntr/: AB00C00013                                   Finish   :                    Type     :
   Account   DCOMPANY DUNIT DSUBUNIT MERCEDES B           Stat Type:
 Assign To :                                              Stat Val.:        0.00      Fail Part :
 Maint Type: RB REFURBISHMENT                             Priority :                  Completion Data
 Std Job No:            District:                    Unit of Work  :                     By     : 0000097534
 Comp Code :                                         Units Required:       0.00          Date   : 07/12/98
                                                           Complete:       0.00          Code   : AC ALL COMPLETE
                                                     Units Inv/Chge:       0.00       % Complete:      0.00
 Mod Code  :                          Resrce Hrs       Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                     Est:        0.00        0.00        0.00         0.00         0.00         0.00         0.00
 Project No:                     Act:                    0.00        0.00         0.00         0.00         0.00         0.00
                                                     Orig. Doc. No.:
 Related WO:                                         Orig. Doc Type:
 Reallocation Data:
   Account :                                         CR Exp Ele    :
   Project :                                         Method        :                  Quoted Value :        0.00
   WkOrder :                                         Frequency     :                  Limit Value  :        0.00
   Var Acct:                                         Billable Ind. :                  Margin %     :     0.00
   Cust. No:
 Work Group: REFURB                                  Creation Date : 27/06/02         Highest Task :    1
             REFURBISHMENT,PLANNING SSKB             Last Mod Date : 24/03/04         No. of Tasks :    1
                                                     Final Cost    :                  Paper Hist.  :
                                                     Extended Desc :

 Job Codes : BDPAN BODY AND PANEL        NW
             WT                          OV

 TASKS

   001 REFURBISH M/BENZ TRUCK
       Work Group   : REFURB  REFURBISHMENT,PLANNING SSKB                    Assign To   :
                                                                             Early Start :
       Job Desc.    :                                                        Early Finish:
       Safety Instr :                                                        Float Days  :
       Compl. Instr :                                                        Unit of Work:
       Compl. Code  : AC ALL COMPLETE                                        Units Reqd  :       0.00
       Compl. Text  :                                                        Units/day   :       0.00
       APL                                                                   Units Plan  :       0.00
       Plan Start   :                                                        Units Compl :       0.00
       Plan Finish  :                                                        Est Mach Hrs:       0.00
       Plan Stat Ty :                                                        Act Mach Hrs:       0.00
       Plan Stat Val:         0.00
```

Figure 8. Mincom Ellipse Printout for a Sample Truck

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Req.By: MODISE,                                   BDF MER LIVE PRODUCTION                                   Page:          335
Run on: 05/09/05  at: 15:49:33                                                                              Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                         Version:   5.2.13.005

00006493 ATTEND MAIN TANK LEAKEGEM/B BDF913          Equip Ref     : 24ITRUCK913
                                                                       MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                User Status   : OH ON HAND
 Originator: 0000091096 NTELECHA,                    Out of Service:                    Shutdown Data
 Orig. Pri.:                                         Date Required :                     Id       :
 Date Raise: 02/12/03                                Plan Start    :                     Equip Ref:
 Cost Cntr/: B2BD24IM05                                   Finish   :                     Type     :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB1113             Stat Type:
 Assign To :                                             Stat Val.:        0.00       Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                   Priority :                   Completion Data
 Std Job No:            District:                    Unit of Work  :                     By     : 0000092185
 Comp Code :                                         Units Required:       0.00          Date   : 02/12/03
                                                          Complete:       0.00          Code   : AC ALL COMPLETE
                                                     Units Inv/Chge:       0.00       % Complete:      0.00
 Mod Code  :                            Resrce Hrs      Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                       Est:       0.00         0.00         0.00         0.00         0.00         0.00         0.00
 Project No:                       Act:                    0.00         0.00         0.00         0.00         0.00         0.00
                                                     Orig. Doc. No.:
 Related WO:                                         Orig. Doc Type:
 Reallocation Data:
   Account :                                         CR Exp Ele    :
   Project :                                         Method        :                  Quoted Value :         0.00
   WkOrder :                                         Frequency     :                  Limit Value  :         0.00
   Var Acct:                                         Billable Ind. :                  Margin %     :      0.00
   Cust. No:
 Work Group: GWFH/R                                  Creation Date : 02/12/03         Highest Task :    1
             GWF HEAVY REPAIR SECTION                Last Mod Date : 29/12/03         No. of Tasks :    1
                                                     Final Cost    :                  Paper Hist.  :
                                                     Extended Desc :

 Job Codes :

 TASKS

   001 ATTEND MAIN TANK LEAKEGEM/B BDF913
       Work Group   : GWFH/R  GWF HEAVY REPAIR SECTION                    Assign To   :
                                                                           Early Start :
       Job Desc.    :                                                     Early Finish:
       Safety Instr :                                                     Float Days  :
       Compl. Instr :                                                     Unit of Work:
       Compl. Code  : AC ALL COMPLETE                                     Units Reqd  :       0.00
       Compl. Text  :                                                     Units/day   :       0.00
       APL                                                                Units Plan  :       0.00
       Plan Start   :                                                     Units Compl :       0.00
       Plan Finish  :                                                     Est Mach Hrs:       0.00
       Plan Stat Ty :                                                     Act Mach Hrs:       0.00
       Plan Stat Val:         0.00
```

Figure 9. Mincom Ellipse Printout for a Sample Truck

```
Req.By: MODISE,                                   BDF MER LIVE PRODUCTION                                   Page:          336
Run on: 05/09/05  at: 15:49:33                                                                              Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                         Version:   5.2.13.005

00008188 ATTEND TO CHARGING SYSTEM BDF 913 M/BENZ      Equip Ref      : 24ITRUCK913
                                                                        MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                  User Status    :
 Originator: 0000091096 NTELECHA,                      Out of Service: 03/08/05          Shutdown Data
 Orig. Pri.:                                           Date Required :                    Id       :
 Date Raise: 24/03/04                                  Plan Start    :                    Equip Ref:
 Cost Cntr/: B2BD24IM05                                     Finish   :                    Type     :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB1113                Stat Type:
 Assign To :                                                Stat Val.:        0.00      Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                      Priority :                   Completion Data
 Std Job No:            District:                      Unit of Work  :                     By      : 0000091352
 Comp Code :                                           Units Required:      0.00          Date    : 03/08/05
                                                            Complete:       0.00          Code    : AC ALL COMPLETE
                                                       Units Inv/Chge:      0.00       % Complete:      0.00
 Mod Code  :                          Resrce Hrs      Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                     Est:        0.00        0.00        0.00         0.00         0.00         0.00         0.00
 Project No:                     Act:                    0.00        0.00         0.00         0.00         0.00         0.00
                                                       Orig. Doc. No.:
 Related WO:                                           Orig. Doc Type:
 Reallocation Data:
   Account :                                           CR Exp Ele    :
   Project :                                           Method        :                   Quoted Value :        0.00
   WkOrder :                                           Frequency     :                   Limit Value  :        0.00
   Var Acct:                                           Billable Ind. :                   Margin %     :      0.00
   Cust. No:
 Work Group: GWF/ELC                                   Creation Date : 24/03/04          Highest Task :    1
             GWF ELECTRICAL SECTION                    Last Mod Date : 03/08/05          No. of Tasks :    1
                                                       Final Cost    :                   Paper Hist.  :
                                                       Extended Desc :

 Job Codes : NC    NO CODE              SC    NO CODE
             NC    NO CODE              MT    NO CODE

 TASKS

   001 ATTEND TO CHARGING SYSTEM BDF 913 M/BENZ
       Work Group    : GWF/ELC GWF ELECTRICAL SECTION                    Assign To   :
                                                                         Early Start :
       Job Desc.     :                                                   Early Finish:
       Safety Instr  :                                                   Float Days  :
       Compl. Instr  :                                                   Unit of Work:
       Compl. Code   : AC ALL COMPLETE                                   Units Reqd  :       0.00
       Compl. Text   :                                                   Units/day   :       0.00
       APL                                                               Units Plan  :       0.00
       Plan Start    :                                                   Units Compl :       0.00
       Plan Finish   :                                                   Est Mach Hrs:       0.00
       Plan Stat Ty  :                                                   Act Mach Hrs:       0.00
       Plan Stat Val:
```

Figure 10. Mincom Ellipse Printout for a Sample Truck

```
Req.By: MODISE,                                   BDF MER LIVE PRODUCTION                                  Page:          337
Run on: 05/09/05  at: 15:49:33                                                                             Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                        Version:   5.2.13.005

00008189 ATTEND TO CHARGING SYSTEM BDF 913 M/BENZ      Equip Ref     : 24ITRUCK913
                                                                       MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                  User Status   :
 Originator: 0000091096 NTELECHA,                      Out of Service: 16/04/04          Shutdown Data
 Orig. Pri.:                                           Date Required :                    Id       :
 Date Raise: 24/03/04                                  Plan Start    :                    Equip Ref:
 Cost Cntr/: B2BD24IM05                                     Finish   :                    Type     :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB1113                Stat Type:
 Assign To : 0000092185 WALOKA,                             Stat Val.:        0.00      Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                      Priority :                  Completion Data
 Std Job No:            District:                      Unit of Work  :                     By     : 0000091352
 Comp Code :                                           Units Required:      0.00          Date   : 16/04/04
                                                            Complete:      0.00          Code   : AC ALL COMPLETE
                                                       Units Inv/Chge:     0.00       % Complete:      0.00
 Mod Code  :                            Resrce Hrs      Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                       Est:        0.00        0.00         0.00         0.00         0.00         0.00         0.00
 Project No:                       Act:                    0.00         0.00        10.00         0.00         0.00        10.00
                                                       Orig. Doc. No.:
 Related WO:                                           Orig. Doc Type:
 Reallocation Data:
   Account :                                           CR Exp Ele    :
   Project :                                           Method        :                  Quoted Value :         0.00
   WkOrder :                                           Frequency     :                  Limit Value  :         0.00
   Var Acct:                                           Billable Ind. :                  Margin %     :      0.00
   Cust. No:
 Work Group: GWF/ELC                                   Creation Date : 24/03/04         Highest Task :    1
             GWF ELECTRICAL SECTION                    Last Mod Date : 28/04/04         No. of Tasks :    1
                                                       Final Cost    :                  Paper Hist.  :
                                                       Extended Desc :

 Job Codes : START STARTING SYSTEM       PR
             NC                          MT

 TASKS

   001 ATTEND TO CHARGING SYSTEM BDF 913 M/BENZ
       Work Group   : GWF/ELC GWF ELECTRICAL SECTION                          Assign To   : 0000092185 WALOKA
                                                                               Early Start :
       Job Desc.    :                                                          Early Finish:
       Safety Instr :                                                          Float Days  :
       Compl. Instr :                                                          Unit of Work:
       Compl. Code  : AC ALL COMPLETE                                          Units Reqd  :       0.00
       Compl. Text  :                                                          Units/day   :       0.00
       APL                                                                     Units Plan  :       0.00
       Plan Start   :                                                          Units Compl :       0.00
       Plan Finish  :                                                          Est Mach Hrs:       0.00
       Plan Stat Ty :                                                          Act Mach Hrs:       0.00
       Plan Stat Val:
```

Figure 11. Mincom Ellipse Printout for a Sample Truck

```
Req.By: MODISE,                                  BDF MER LIVE PRODUCTION                                  Page:          338
Run on: 05/09/05  at: 15:49:33                                                                            Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                       Version:   5.2.13.005

 0010253 GEN SERVICE M/BENZ BDF913                    Equip Ref     : 24ITRUCK913
                                                        MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                 User Status   : AL AWAITING LABOUR
 Originator: 0000091352 ODUETSE,                      Out of Service: 13/07/04            Shutdown Data
 Orig. Pri.: P3 NORMAL                                Date Required :                      Id       :
 Date Raise: 02/07/04                                 Plan Start    :                      Equip Ref:
 Cost Cntr/: B2BD24IM05                                    Finish   :                      Type     :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB111                Stat Type:
 Assign To :                                              Stat Val.:         0.00       Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                    Priority :                     Completion Data
 Std Job No:            District:                     Unit of Work  :                       By     : 0000095288
 Comp Code :                                          Units Required:       0.00            Date   : 13/07/04
                                                            Complete:       0.00            Code   : AC ALL COMPLETE
                                                      Units Inv/Chge:       0.00         % Complete:      0.00
 Mod Code  :                              Resrce Hrs      Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                         Est:        0.00         0.00         0.00         0.00         0.00         0.00         0.00
 Project No:                         Act:                     0.00         0.00       178.49         0.00         0.00       178.49
                                                      Orig. Doc. No.:
 Related WO:                                          Orig. Doc Type:
 Reallocation Data:
   Account :                                          CR Exp Ele    :
   Project :                                          Method        :                     Quoted Value :         0.00
   WkOrder :                                          Frequency     :                     Limit Value  :         0.00
   Var Acct:                                          Billable Ind. :                     Margin %     :      0.00
   Cust. No:
 Work Group: GWFSER                                   Creation Date : 02/07/04            Highest Task :    1
             GWF SERVICE SECTION                      Last Mod Date : 13/07/04            No. of Tasks :    1
                                                      Final Cost    :                     Paper Hist.  :
                                                      Extended Desc :

 Job Codes : LUBRI LUBRICATION           PR
             SM                          MT

 TASKS

   001 GEN SERVICE M/BENZ BDF913
       Work Group   : GWFSER  GWF SERVICE SECTION                                  Assign To   :
                                                                                   Early Start :
       Job Desc.    :                                                              Early Finish:
       Safety Instr :                                                              Float Days  :
       Compl. Instr :                                                              Unit of Work:
       Compl. Code  : AC ALL COMPLETE                                              Units Reqd  :       0.00
       Compl. Text  :                                                              Units/day   :       0.00
       APL                                                                         Units Plan  :       0.00
       Plan Start   :                                                              Units Compl :       0.00
       Plan Finish  :                                                              Est Mach Hrs:       0.00
       Plan Stat Ty :                                                              Act Mach Hrs:       0.00
       Plan Stat Val:         0.00
```

Figure 12. Mincom Ellipse Printout for a Sample Truck

```
Req.By: MODISE,                                   BDF MER LIVE PRODUCTION                                   Page:          339
Run on: 05/09/05  at: 15:49:33                                                                              Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                         Version:   5.2.13.005

00012463 ATT BONNET CATCHER AND HOOK                Equip Ref     : 24ITRUCK913
                                                                    MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                               User Status   : AL AWAITING LABOUR
 Originator: 0000091352 ODUETSE,                    Out of Service: 08/12/04          Shutdown Data
 Orig. Pri.: P3 NORMAL                              Date Required :                    Id       :
 Date Raise: 12/10/04                               Plan Start    :                    Equip Ref:
 Cost Cntr/: B2BD24IM05                                 Finish    :                    Type     :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB1113            Stat Type:
 Assign To :                                            Stat Val.:        0.00       Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                  Priority :                   Completion Data
 Std Job No:            District:                   Unit of Work  :                     By     : 0000095288
 Comp Code :                                        Units Required:       0.00         Date   : 08/12/04
                                                        Complete:       0.00         Code   : AC ALL COMPLETE
                                                    Units Inv/Chge:     0.00         % Complete:      0.00
 Mod Code  :                          Resrce Hrs      Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                     Est:        0.00        0.00         0.00         0.00         0.00         0.00         0.00
 Project No:                     Act:                    0.00         0.00      2238.49         0.00         0.00      2238.49
                                                    Orig. Doc. No.:
 Related WO:                                        Orig. Doc Type:
 Reallocation Data:
   Account :                                        CR Exp Ele    :
   Project :                                        Method        :                Quoted Value :         0.00
   WkOrder :                                        Frequency     :                Limit Value  :         0.00
   Var Acct:                                        Billable Ind. :                Margin %     :      0.00
   Cust. No:
 Work Group: GWFH/R                                 Creation Date : 12/10/04       Highest Task :    1
             GWF HEAVY REPAIR SECTION               Last Mod Date : 08/12/04       No. of Tasks :    1
                                                    Final Cost    :                Paper Hist.  :
                                                    Extended Desc :

 Job Codes : LUBRI LUBRICATION          PR
             SM                         SV

 TASKS

   001 ATT BONNET CATCHER AND HOOK
       Work Group   : GWFH/R  GWF HEAVY REPAIR SECTION                    Assign To   :
                                                                          Early Start :
       Job Desc.    :                                                     Early Finish:
       Safety Instr :                                                     Float Days  :    0
       Compl. Instr :                                                     Unit of Work:
       Compl. Code  : AC ALL COMPLETE                                     Units Reqd  :      0.00
       Compl. Text  :                                                     Units/day   :      0.00
       APL                                                                Units Plan  :      0.00
       Plan Start   :                                                     Units Compl :      0.00
       Plan Finish  :                                                     Est Mach Hrs:      0.00
       Plan Stat Ty :                                                     Act Mach Hrs:      0.00
       Plan Stat Val:         0.00
```

Figure 13. Mincom Ellipse Printout for a Sample Truck

```
Req.By: MODISE,                                  BDF MER LIVE PRODUCTION                                  Page:          340
Run on: 05/09/05  at: 15:49:33                                                                            Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                       Version:   5.2.13.005

00014773 TRANSFER CASE MNT BROKEN                      Equip Ref     : 24ITRUCK913
                                                                       MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                  User Status   : AL AWAITING LABOUR
 Originator: 0000091352 ODUETSE,                       Out of Service: 03/08/05          Shutdown Data
 Orig. Pri.: P3 NORMAL                                 Date Required :                    Id       :
 Date Raise: 01/02/05                                  Plan Start    :                    Equip Ref:
 Cost Cntr/: B2BD24IM05                                     Finish   :                    Type     :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB1113                Stat Type:
 Assign To :                                                Stat Val.:        0.00      Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                      Priority :                   Completion Data
 Std Job No:            District:                      Unit of Work  :                     By     : 0000091352
 Comp Code                                             Units Required:      0.00          Date   : 03/08/05
                                                             Complete:      0.00          Code   : AC ALL COMPLETE
                                                       Units Inv/Chge:      0.00       % Complete:      0.00
 Mod Code                                  Resrce Hrs     Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                          Est:        0.00       0.00        0.00         0.00        0.00         0.00         0.00
 Project No:                          Act:                   0.00        0.00         0.00        0.00         0.00         0.00
                                                       Orig. Doc. No.:
 Related WO:                                           Orig. Doc Type:
 Reallocation Data:
   Account :                                           CR Exp Ele    :
   Project :                                           Method        :                    Quoted Value :        0.00
   WkOrder :                                           Frequency     :                    Limit Value  :        0.00
   Var Acct:                                           Billable Ind. :                    Margin %     :     0.00
   Cust. No:
 Work Group: GWFH/R                                    Creation Date : 01/02/05           Highest Task :    1
             GWF HEAVY REPAIR SECTION                  Last Mod Date : 03/08/05           No. of Tasks :    1
                                                       Final Cost    :                    Paper Hist.  :
                                                       Extended Desc :

 Job Codes : NC    NO CODE              NW    NO CODE
             WT    NO CODE              RP    NO CODE

 TASKS

   001 TRANSFER CASE MNT BROKEN
       Work Group   : GWFH/R  GWF HEAVY REPAIR SECTION                          Assign To   :
                                                                                Early Start :
       Job Desc.    :                                                           Early Finish:
       Safety Instr :                                                           Float Days  :    0
       Compl. Instr :                                                           Unit of Work:
       Compl. Code  : AC ALL COMPLETE                                           Units Reqd  :       0.00
       Compl. Text  :                                                           Units/day   :       0.00
       APL                                                                      Units Plan  :       0.00
       Plan Start   :                                                           Units Compl :       0.00
       Plan Finish  :                                                           Est Mach Hrs:       0.00
       Plan Stat Ty :                                                           Act Mach Hrs:       0.00
       Plan Stat Val:         0.00
```

Figure 14. Mincom Ellipse Printout for a Sample Truck

```
Req.By: MODISE,                                   BDF MER LIVE PRODUCTION                                   Page:          342
Run on: 05/09/05  at: 15:49:33                                                                              Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                         Version:   5.2.13.005

00016279 ISSUE WITH TUBE AND TYRE                    Equip Ref      : 24ITRUCK913
                                                                      MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                User Status    : AL AWAITING LABOUR
 Originator: 0000095288 JOHANE,                      Out of Service: 17/06/05            Shutdown Data
 Orig. Pri.: P3 NORMAL                               Date Required :                      Id        :
 Date Raise: 31/03/05                                Plan Start    :                      Equip Ref:
 Cost Cntr/: B2BD24IM05                                   Finish   :                      Type      :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB1113              Stat Type:
 Assign To :                                              Stat Val.:        0.00        Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                    Priority :                     Completion Data
 Std Job No:            District:                    Unit of Work  :                       By      : 0000095639
 Comp Code : 7000                                    Units Required:       0.00           Date    : 17/06/05
    TYRES                                                  Complete:       0.00           Code    : AC ALL COMPLETE
                                                     Units Inv/Chge:       0.00          % Complete:       0.00
 Mod Code  :                          Resrce Hrs      Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                     Est:        0.00        0.00        0.00         0.00         0.00         0.00         0.00
 Project No:                     Act:                    0.00        0.00         0.00         0.00         0.00         0.00
                                                     Orig. Doc. No.:
 Related WO:                                         Orig. Doc Type:
 Reallocation Data:
   Account :                                         CR Exp Ele    :
   Project :                                         Method        :                     Quoted Value :         0.00
   WkOrder :                                         Frequency     :                     Limit Value  :         0.00
   Var Acct:                                         Billable Ind. :                     Margin %     :      0.00
   Cust. No:
 Work Group: GWFH/R                                  Creation Date : 31/03/05            Highest Task :    1
             GWF HEAVY REPAIR SECTION                Last Mod Date : 17/06/05            No. of Tasks :    1
                                                     Final Cost    :                     Paper Hist.  :
                                                     Extended Desc :

 Job Codes : MTCE  NORMAL MAINTENANCE     NW
             WT                           OK

 TASKS

   001 ISSUE WITH TUBE AND TYRE
       Work Group    : GWFH/R  GWF HEAVY REPAIR SECTION                          Assign To   :
                                                                                 Early Start :
       Job Desc.     :                                                           Early Finish:
       Safety Instr  :                                                           Float Days  :    0
       Compl. Instr  :                                                           Unit of Work:
       Compl. Code   : AC ALL COMPLETE                                           Units Reqd  :       0.00
       Compl. Text   :                                                           Units/day   :       0.00
       APL                                                                       Units Plan  :       0.00
       Plan Start    :                                                           Units Compl :       0.00
       Plan Finish   :                                                           Est Mach Hrs:       0.00
       Plan Stat Ty  :                                                           Act Mach Hrs:       0.00
       Plan Stat Val:          0.00
```

Figure 15. Mincom Ellipse Printout for a Sample Truck

```
Req.By: MODISE,                                   BDF MER LIVE PRODUCTION                                   Page:          341
Run on: 05/09/05  at: 15:49:33                                                                              Report:      MSR620A
                                                WORK ORDER ANALYSIS REPORT - DETAIL                         Version:   5.2.13.005

00018693 TIGHTEN BONNET AND GRILL BVOLTS                Equip Ref      : 24ITRUCK913
                                                                         MERCEDES  BENZ 1113 TROOPCARRIER
 W/O Type  : MT MAINTENANCE
 W/O Status: C Closed                                   User Status    : AL AWAITING LABOUR
 Originator: 0000091352 ODUETSE,                        Out of Service: 03/08/05          Shutdown Data
 Orig. Pri.: P3 NORMAL                                  Date Required :                    Id       :
 Date Raise: 11/07/05                                   Plan Start    :                    Equip Ref:
 Cost Cntr/: B2BD24IM05                                     Finish    :                    Type     :
   Account   BOTDEFFOR 2 BDE 24 INFAN MB1113                Stat Type:
 Assign To :                                                Stat Val.:        0.00       Fail Part :
 Maint Type: CM CORRECTIVE MAINTENANCE                      Priority :                   Completion Data
 Std Job No:            District:                       Unit of Work  :                    By     : 0000095288
 Comp Code :                                            Units Required:      0.00         Date   : 03/08/05
                                                            Complete:        0.00         Code   : AC ALL COMPLETE
                                                        Units Inv/Chge:      0.00       % Complete:      0.00
 Mod Code  :                          Resrce Hrs      Dur Hrs     Lab Cost     Mat Cost   Equip Cost   Other Cost   Total Cost
 Parent W/O:                     Est:        0.00        0.00         0.00         0.00         0.00         0.00         0.00
 Project No:                     Act:                    0.00         0.00         0.00         0.00         0.00         0.00
                                                        Orig. Doc. No.:
 Related WO:                                            Orig. Doc Type:
 Reallocation Data:
   Account :                                            CR Exp Ele    :
   Project :                                            Method        :                    Quoted Value :        0.00
   WkOrder :                                            Frequency     :                    Limit Value  :        0.00
   Var Acct:                                            Billable Ind. :                    Margin %     :     0.00
   Cust. No:
 Work Group: GWFH/R                                     Creation Date : 11/07/05           Highest Task :    1
             GWF HEAVY REPAIR SECTION                   Last Mod Date : 03/08/05           No. of Tasks :    1
                                                        Final Cost    :                    Paper Hist.  :
                                                        Extended Desc :

 Job Codes : MTCE  NORMAL MAINTENANCE     PR
             SM                           SV

 TASKS

   001 TIGHTEN BONNET AND GRILL BVOLTS
       Work Group   : GWFH/R  GWF HEAVY REPAIR SECTION                                  Assign To   :
                                                                                        Early Start :
       Job Desc.    :                                                                   Early Finish:
       Safety Instr :                                                                   Float Days  :     0
       Compl. Instr :                                                                   Unit of Work:
       Compl. Code  : AC ALL COMPLETE                                                   Units Reqd  :       0.00
       Compl. Text  :                                                                   Units/day   :       0.00
       APL                                                                              Units Plan  :       0.00
       Plan Start   :                                                                   Units Compl :       0.00
       Plan Finish  :                                                                   Est Mach Hrs:       0.00
       Plan Stat Ty :                                                                   Act Mach Hrs:       0.00
       Plan Stat Val:          0.00
```

D. MODELED MAINTENANCE RECORD OF A SAMPLE TRUCK

Figure 16. Modeled Maintenance Records for a Sample Truck

T#	913					Time	Labor	Material	Total
Job ID	Nom	KM	Inshop	O/shop		(days)	Cost	Cost	Cost
0	*Refurbishment*		6/27/02	6/27/02		0	0		
21	*Fuel Tank Leak*	6493	12/2/03	12/29/03		28	3200	***0***	3200
10	*Charging Sys*	8188	3/24/04	3/24/04		1	160	***10***	170
10	*Charging Sys*	8189	3/24/04	4/28/04		36	4114	10	4124
17	*Engine Failure*	10253	7/2/04	7/13/04		12	1371	178	1550
7	*Bonnet Catcher/Hook*	12463	10/12/04	12/8/04		58	6629	2238	8867
22	*Gear Box*	14773	2/1/05	3/3/05		31	3543	***2000***	5543
42	*Tyres*	16279	3/31/05	4/17/05		18	2057	***1200***	3257
41	*Tightning / Lubrication*	18693	7/11/05	8/3/05		24	2743	***0***	2743

E. REFURBISHED TRUCK LIFE-CYCLE COST MODEL

Figure 17. Refurbished Truck Life-Cycle Cost Model

Cost Calculation Elements	Value	year									
		1	2	3	4	5	6	7	8	9	10
Maintenance Incline Rate		0%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Operated Trucks	1	1	1	1	1	1	1	1	1	1	1
Ref Hours	600										
Labor /Truck	4										
Labor/hr cost	20.00										
Salvage value of Truck for Refurb.		20000									
Refurbishment Material Cost		80000									
Material Shipment		15000									
Transportation to Refub Site		1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Indirect cost		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Labor Cost		48,000									
Operating Cost		5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
Total Ref Cost	**165500**										
Annual Maintenance Cost	**11996**	11,996	14,995	18,744	23,430	29,287	36,609	45,762	57,202	71,503	89,378
Total O&M Cost		**182,896**	**22,895**	**26,644**	**31,330**	**37,187**	**44,509**	**53,662**	**65,102**	**79,403**	**97,278**
NPV (Total Cost of Ownership)	**499,200**										

F. NEW TRUCK LIFE-CYCLE COST MODEL

Figure 18. New Truck Life-Cycle Cost Model

Cost Calculation Elements	Value	year									
Maintenance Incline Rate		0%	0%	15%	15%	15%	15%	15%	15%	15%	15%
# of Operated Trucks	1	1	1	1	1	1	1	1	1	1	1
Unit Cost		375000									
Transportation		1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Indirect cost		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Annual Maintenance Cost	4000	4,000	4,000	4,600	5,290	6,084	6,996	8,045	9,252	10,640	12,236
Operating Cost		2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700
Total O&M Cost		384,200	9,200	9,800	10,490	11,284	12,196	13,245	14,452	15,840	17,436
NPV (Total Cost of Ownership)	449,397										

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APPENDIX C. THE PROJECT SURVEY QUESTIONNAIRES

A. USERS' QUESTIONNAIRE

MERCEDES-BENZ REFURBISHMENT PROJECT
USER'S QUESTIONER

THIS QUESTIONER IS INTENDED ONLY FOR RESEARCH PURPOSES

HOW DID THE PROJECT DO?
ANY COMMENTS ARE WELCOME
PLEASE FILL OUT THIS QUESTIONNAIRE AND RETURN IT TO THE MECHANICAL ENGINEERS

THANK YOU!

User's Questioner

1. Are you aware of the refurbishment project for the Mercedes Benz trucks?

Yes ☐ No ☐

2. Was your Unit involved in anyway in the planning for the Mercedes Benz Project?

1☐ 2☐ 3☐ 4☐ 5☐

Greatly involved Not involved at All.

3. Are you aware of the objectives or advantages of the Mercedes Benz Project?

1☐ 2☐ 3☐ 4☐ 5☐

Very much aware Not aware at all

4. Please rate the quality of the service you received from the Refurbished Mercedes Benz Trucks.

1☐ 2☐ 3☐ 4☐ 5☐

Disappointing Exceptional

5. Was the service you received for the truck maintenance prompt and efficient?

Yes☐ No☐

6. Please rate the quality of the mechanical service you get for truck repairs.

1☐ 2☐ 3☐ 4☐ 5☐

Disappointing Exceptional

7. Are the refurbished trucks reliable?

1□ 2□ 3□ 4□ 5□

Disappointing Exceptional

8. Compared to new trucks rate the reliability of new trucks?

1□ 2□ 3□ 4□ 5□

Disappointing Exceptional

9. How frequently do you use the Mercedes Benz trucks?

□3-5 times per month

□1-2 times per month

□Once every 2 months

□Other: _____

10. Compared to new trucks how do you rate the comfort in the refurbished trucks?

1□ 2□ 3□ 4□ 5□

Disappointing Exceptional

11. What improvements do you like most about refurbished trucks?

_____

_____

_____

12. What improvements do you recommend for future refurbishment projects?

_____

_____

_____

13. How many times have you driven a refurbished truck?

_____

_____

_____

14. Do you understand why refurbished was preferred as opposed to new trucks?

_____

_____

_____

15. Please share any additional comments or suggestions.

_____

_____

_____

End of Questioner

Your contact details

You may fill in your name and contact details below if you wish. (This is needed if you want us to contact you in connection with your comments.)

Name:

_____

Title/position:

_____

Organization:

_____

Telephone:

_____

Fax:

_____

Address:

_____

_____

Email: _____

How would you like to be contacted?

☐ Telephone

☐ Email

☐ Writing (fax)

☐ Any

B. MIDDLE MANAGEMENT'S QUESTIONNAIRE

Please note: This questionnaire is aimed at gathering important data that is needed for the evaluation, and the indicators project process. This information will be supplemented with data gathered through the refurbishment database and the Ellipse data base.

Name of organization:

MERCEDES BENZ REFURBISHMENT PROJECT: MANAGEMENT SURVEY

Address:

Name and rank in the Mechanical Engineers:

Telephone:

Refurbishment Project Management Questionnaire

BIOGRAPHICAL DETAIL

1. How many years have you been in the Project Management environment?

---

2. Have you experienced or heard of or come across a project that have failed? (Yes or No)

---

3. If Yes in the above, what were the failing factors (e.g. Financial, Team members, Management, Mission, Other – please specify)

MANAGERIAL QUESTIONS

4. Please indicate which of the following factors are critical to successful Project Management to prevent project failure. Please rate the factors on a scale of 1 to 5 (1: not important at all and 5: essential). If you can think of any other critical factors please specify on the lines provided.

CRITICAL FACTORS	**Rating**
A. Project mission - Clearly defined goals and general directions from the beginning.	
B. Top management support - Top management's support and provide the necessary resources and authority to ensure success.	
C. Project schedule/plan - A detailed specification of individual actions for project implementation.	
D. User consultation - Communication and interaction between the user units and the project manager and team.	
E. Personnel - Recruitment, selection and training of the project team	
F. Technical tasks - Availability of technology and expertise to complete tasks with success	
G. Communication - Networking all necessary parties and providing sufficient information to ensure successful project implementation.	
H. Trouble shooting - Contingency plans to handle unexpected crises and deviations from the original plans.	
I. Other? Specify ---------- ----------	

5. What steps would you as Project Manager implement to prevent the above-mentioned factors to ensure that a project would not fail?

---

6. What part, according to you, does client satisfaction play in Project Management?
(No / Some / Huge) – Please elaborate.

---

7. What steps do you as PM take to ensure proper Monitoring of a project? (Software etc.)

---

8. What difficulties do you experience on a regular basis regarding projects in the refurbishment process environment?

---

9. What do you do in improving these difficulties in Question 8?

---

10. What advice would you give to a young engineer in the PM environment?

End of Questioner

C. TOP MANAGEMENT'S QUESTIONNAIRE

REFURBISHMENT OF MERCEDES BENZ TRUCKS BY THE MECHANICAL ENGINEERS1996-2005:

PROJECT EVALUATION

EVALUATION QUESTIONNAIRE

FOR

PROJECT MANAGEMENT

Please note: This questionnaire is aimed at gathering important data that is needed for the evaluation, and the indicators development process. This information will be supplemented with data gathered through the refurbishment database and the Ellipse data base.

Name of organization:

TOP MANAGEMENT REFURBISHMENT PROJECT SURVEY

Address:

Rank and position in the Mechanical Engineers:

Telephone:

Name of project:

Aim(s) of project:

QUESTION 1

Objectives of project

1.1 Are you aware of financial estimates or Cost benefit analysis that was done before the project was commenced?

1.2 Please give a brief summary of activity in the last three years:

1.3 How was the need for this project identified? Why was it undertaken as an option as opposed to other alternatives?

1.4 Process objective: Was the project achieved within the initially planned time frame, budget?

Outcome Objective

1.5 What is the outcome objective that describes the measurable change that you expected to achieve with your **target availability** of Mercedes Trucks as a result of the project or intervention? Has it been achieved?

1.6 Is this project run in partnership with any other organization(s)? Which organizations? What is their contribution?

1.7 Are you aware of financial estimates or Cost benefit analysis that was done before the project was commenced?

1.8 How was the need for this project identified? Why was it undertaken as an option as opposed to other alternatives?

Project management

1.9 Were User Units represented in the planning stages of the project?

QUESTION 2

2.1 What parts/aspects of the Refurbishment of the Mercedes Benz trucks project do you think have worked the best?

2.2 Why do you think they have worked well?

QUESTION 3

3.1 What parts/aspects of the project do you think have ***not*** worked well?

3.2 Why do you think that they have ***not*** worked well?

QUESTION 4

4.1 Do you feel that the project has been good for the project managers as well as soldiers? Have they benefited from being involved in the project? (Please tick one of the boxes below to show your answer).

☐ Yes, definitely
☐ Yes, but not very much
☐ Not sure
☐ No

4.2 If you ticked one of the Yes boxes, how do you think the project has been good for the soldiers, and how have they benefited from the project?

4.3 If you ticked the No box, why do you think the project has not been good for the soldiers, and why have they not benefited from the project?

QUESTION 5

5.1 This project focused on Refurbishment of Mercedes Benz trucks. Do you think that the project helped BDF to have a policy, and how to put refurbishment into practice/implement it in the future to improve availability of equipment to Units? (Tick one of the boxes below to show your answer).

☐ Yes
☐ Not sure
☐ No

5.2 If you ticked the Yes box, in what ways has it helped the BDF to understand and put into practice/implement the policy?

5.3 If you ticked the No box, why do you think the project has not helped the BDF to understand and put into practice/implement the policy?

5.4 If you ticked the Not sure box, or the No box, do you have any suggestions about how BDF can be helped to understand how to implement the refurbishment better?

QUESTION 6

6.1 Do you think that the fleet managers with BDF Units know about the support they can get from the Mechanical Engineers, to help them to overcome the barriers to targeted availability in their Units? (Tick one of the boxes to show your answer).

☐ Yes
☐ Not sure
☐ No

6.2 Has your department/organization set up any structures and/or procedures to support Units to manage the upkeep of trucks and to keep their availability high? (Tick one of the boxes to show your answer).

☐ Yes
☐ No

6.3 If you ticked Yes, please describe/explain the structures and/or procedures that have been set up.

QUESTION 7

7.1 Do you feel that the project has helped your department/organization to work together with Units to overcome barriers to improving availability of trucks? (Tick one of the boxes to show your answer).

☐ Yes, we have started to work together collaboratively
☐ Not sure
☐ No, the project has not helped us to get Units to cooperate.

7.2 If you ticked Yes, please give examples of how you are working together with other departments/organizations to support Mechanical Engineers.

7.3 Do you feel that you have received enough of the right kind of training/capacity building through the project to support BDF Units and to carry out a better refurbishment project in the future? (Tick one of the boxes to show your answer).

☐ Yes
☐ Not sure
☐ No

7.4 If you ticked No, how much more training/capacity building, or what kind of training/capacity building do you need before another refurbishment project can be carried out to be able to support BDF Units better?

QUESTION 8

8.1 What do you think are the most important things which need to be set up or done in your department/organization to build and support inclusive availability of trucks to Units?

8.2 Participation:
Were the users involved in the delivery of the project?

8.3 Evaluation: Are you aware of evaluation of the project that has taken place? Are you satisfied with the results of the project?

QUESTION 9

9.1 Are there any other observations that you would like to share?

Are you aware of Statistics (pre/post project) on availability of the trucks that can indicate the success or failure of the project?

THANK YOU FOR TAKING YOUR TIME TO FILL THIS IN.

These questions will be used in writing a project evaluation report the Mercedes Benz refurbishment project. Hopefully you will be provided a copy.

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