

IMPROVEMENT OF MAINTENANCE MANAGEMENT
SYSTEM
A CASE STUDY

ON
WALIA INTERCITY BUS SERVICE ENTERPRISE

By
Teklehaimanot Tadele

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Advisor: Dr.-Ing Demiss Alemu

ADDIS ABABA UNIVERSITY,
SCHOOL OF GRADUATE STUDIES, FACULTY OF TECHNOLOGY,
MECHANICAL ENGINEERING DEPARTMENT

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ABSTRACT

This thesis seeks to provide a greater depth into the exploration of the subject “Vehicle Maintenance Management System” (VMMS). It is found that improved maintenance helps to increase revenues of a firm by increasing vehicle or equipment performance and availability. Most importantly, firms must have maintenance policies and strategies so that the whole firm will be directed in the same direction to reduce equipment down time.

The purpose of this thesis is to improve the existing maintenance management system and maintenance efficiency of the enterprise under consideration.

The establishment of effective and efficient maintenance management system is the mechanism by which controllable costs are reduced and equipment availability is increased. Controllable costs are the costs incurred due to improper decision during purchasing process by selecting incompatible and cheap price items with out considering reliability and maintainability, and costs incurred due to poor maintenance management system practiced during operation. Thus, the main objective of this thesis is to examine the existing maintenance of **Walia Intercity Bus Service Enterprise (WIBSE)** and recommend better maintenance management system that enhances vehicle availability with reasonable maintenance cost. The author believes upon implementation of the recommended maintenance management system, availability of vehicles for transportation and useful life are expected to increase due to minimizing of down time and abuse.

CHAPTER 1: INTRODUCTION

1.1 Background

Business enterprises use complex equipment to deliver products and services. The failure of their equipment can cause serious social and economic consequences. However, maintenance activities on these equipments are often neglected, either for short-term cost savings from lower maintenance activities or due to lack of awareness on importance of maintenance by top management.

However, various organization are starting to realize that cost-effective maintenance results in better efficiencies, higher availability of equipment and more profit and savings with regards to their strategic and operational objectives.

Equipment failures are rectified through corrective maintenance actions while preventive maintenance actions are used to reduce the recurrence of failure.

All these maintenance actions resulted additional cost. Therefore, maintenance must be done so as to achieve the objectives of the organization, making a rational between corrective and preventive maintenance. The enterprise under consideration (Walia Intercity bus service Enterprise) is one of the organizations engaged in bus transportation service. The enterprise has more than 12 years of experience in road transportation service. It plays indispensable role in linking the major centers in the country. But from time to time the enterprise faced with increasing down time of vehicles, higher repair costs, too many obsolescence, and financial losses

1.2 Statement of the problem

In many vehicle maintenance providers, in Ethiopia, the vehicle maintenance record keeping and failure analysis culture is very poor. Maintenance is performed without any manual procedure on breakdown based; this decreases the economic service life of vehicles and lacks critical information on the vehicles' status, for its replacement or disposal.

Walia Intercity Bus Service Enterprise follows reactive and minor lube type of maintenance. This causes higher down time, road call accidents and more obsolete vehicles. As a result the enterprises cumulative loss reaches 42 million Birr. This is because; the maintenance procedure is not according to the points which can be derived from proper maintenance

record and analysis. Hence the thesis work seeks to improve the current maintenance management system.

1.3 Objective of the thesis

As a result of effective and efficient maintenance management, it is possible to prolong the physical, technical and economic service time of vehicles/equipment. Thus the main objective of this thesis is to analyze the current system of vehicle maintenance management system of WIBSE and to recommend improved vehicle maintenance management system. In this thesis, the design and implementation of rational maintenance system, work standardization procedure, and appropriate organizational structure with efficient personnel who can accomplish the task encountered is recommended.

1.4 Methodology

In order to achieve the objectives of the thesis, the methodologies followed are:

(a) **Literature survey**:-To be familiar with the concepts of maintenance, maintenance management system and performance improvement, literature review was carried out. Articles and journals are also reviewed to reinforce the current maintenance practices of the enterprise

(b) **Data collection**: - review of available data in WIBSE such as general operating costs and maintenance costs, types of maintenance practices, frequency of break down including road calls, resource consumption are collected and examined. Direct observation on maintenance process of the enterprises and non structured interviews with technical personnel, supervisors, store men as well supply and maintenance managers assist to identify the problems.

(c) **Existing system analysis and system design**: - after identifying the problems in the enterprise, recommendations are presented which enable to improve the maintenance management system.

1.5 Organization of the paper

The thesis consists of seven chapters that discuss the means and modalities that enable to establish and implement effective and efficient maintenance management system. The first chapter deals with introduction in which the background and objectives of the thesis work are briefly pointed out, besides, the methodologies applied are enlightened.

Chapter two is concerned with the literature review on maintenance and maintenance management system. This chapter comprises different authors work on maintenance and maintenance management.

In Chapter three, the existing maintenance management system of WIBSE is assessed by the help of data collected from the enterprise and its existing problems and strengths are discussed.

Chapter four discusses standardization and codification system. The benefits that can be obtained by establishing good standardization and codification in maintenance work are presented.

Chapter five mainly deals with preventive maintenance programs and their implementation to increase WIBSE vehicles availability. The factors to be considered in developing and implementing maintenance planning, scheduling and controlling systems are presented.

In chapter six the existing organizational structure of WIBSE is presented and discussed inline with the issue to be addressed, the existing staff in the maintenance department is analyzed. Based on the existing situation, appropriate and reasonable organizational structure is recommended. Furthermore, the type of training required to develop and upgrade the enterprise's working personnel and the training institutes available in the country to conduct the necessary training are identified.

In the final chapter (chapter 7), conclusion and recommendations to implement the proposed maintenance management system are made.

***All calendars related to WIBSE are in Ethiopian calendar ***

CHAPTER 2: LITERATURE REVIEW

2.1 The status of maintenance

In the United States, it was estimated that in 1979 over \$200 billion was spent on maintenance. However, more disturbing than the amount was the fact that approximately one-third of that total was spent unnecessarily. As we continue to the present, there has been no significant change in maintenance policy, indicating the unnecessary cost trend is probably still one-third and the largest change in the maintenance costs is the amount. Since 1979 maintenance cost has risen between 10 and 15% per year. If this amount is calculated, it is very likely that the maintenance expenditures in the United States are now over one-half a trillion dollars per year. Where do these unnecessary costs occur in maintenance? How can they be controlled? These questions can best be answered by looking at some statistics. According to Wireman [15 & 16]:

Less than 4hr/day (out of a possible 8) are spent by maintenance crafts men performing hands-on work activities. This figure is even more alarming when it is realized that the majority of maintenance organizations are performing as few as 2 hr of hands-on work. It is not that these individuals are lazy or shrinking job responsibilities. It is the fact that they are not provided the necessary resources by management to perform the assigned job tasks. Providing these resources becomes important to increasing maintenance productivity and producing substantial maintenance labor savings. If we would view maintenance salaries as a resource, \$20 per hour is paid and only utilizing this resource at a 50% level; that is a tremendous cost waste.

Only about one-third of all maintenance organization uses a job planner to plan maintenance activities. Most experts agree this is one of the largest potential for cost savings in the maintenance area. It is estimated that planned versus unplanned work may have a cost ratio as high as 1:5 performing a \$100 planned work could save as much as \$400 over performing the same job in unplanned mode.

The majority of all maintenance organizations either are dissatisfied with or do not have work orders systems. This is one of the critical indicators of the status of a maintenance organization. If a maintenance organization does not have a work order system in place that works properly, it is impossible to measure or control maintenance activities.

Of companies that have work order systems (one-third of all companies) only about one-third track the work orders in a craft backlog format (actual 10% of total organizations). This format will permit the manager to make logical staffing decisions based on how much work is projected for each craft. Being able to justify employment levels to upper management is a necessary function of good maintenance management.

Of companies that have work order system, only one third compared their estimates of the work order labor and materials to the actual figures. Again, this means only about 10% of all organizations carry out some form of performance monitoring. Successful maintenance management requires performance monitoring.

Of the companies with work order system that allows for feedback, only one-third, again about 10% of all companies, perform any failure analysis on their breakdowns.

Most of the other companies are just parts changers. For an operation to be cost effective, good practice in failure analysis must be followed.

Over time, another key indicator, in the United States averages about 14.1% of the total time worked by maintenance organizations. This figure is almost three times what it should be. Since maintenance is working so much overtime, it again indicates the reactive situation that is standard in the industry. Reducing overtime is essential if a maintenance organization is to be truly cost effective.

Preventive maintenance, another major part of any successful maintenance program, is presently satisfying the needs of about 22% of the maintenance organizations. This again illustrates major problems for the maintenance organizations. Without successful preventive maintenance programs, maintenance can only react to given situation. Preventive maintenance allows the organization to plan better and reduce maintenance costs. Over three-fourths of the organizations need major improvements in this area.

Related to preventive maintenance, almost three-fourths of the organizations have some form of lube routes and procedures. While this fact seems to be positive on the surface, it is not. Many of the organizations feel that preventive maintenance is nothing more than lube routes and procedures. So once they have these developed, they stop. However, preventive maintenance encompasses much more than lube-routes. To be successful, maintenance organizations must go beyond the preliminaries and fully develop preventive maintenance programs.

One final fact related to preventive maintenance is the lack of coordination between operations/ facilities and maintenance. Almost three-fourths of all organizations experience problems in coordinating preventive maintenance with the operations/facilities group. The problem is with communication. Either the maintenance organization has not communicated the need for the preventive maintenance or the operation/facilities group is not listening. Good, credible communication must be established if preventive maintenance is to be effective.

Second only to maintenance labor is the cost of maintenance materials. Depending on the type of operations / facility maintenance, materials can range between 20 and 70% of the maintenance budget.

To manage maintenance successfully, materials must be given close scrutiny.

Many companies try to remedy maintenance materials problems by over stocking the storeroom. This is a problem because most will not take in to account that inventory carrying costs are over 30% of the price of the items per year. So, for example, the cost of carrying \$1 million inventory is over \$300,000.00 per year. It is for this reason the inventories must be kept low, while still providing for a satisfactory level of service.

A third point of concern for maintenance materials is that maintenance is only responsible for their inventory in about 50% of the organizations. This means the other 50% of the time, another body is telling maintenance department what they should stock and how many they can issue.

While most thus agree that maintenance costs are high, they do not know how high they are for their own site. In most cases, the costs of maintenance repairs are calculated as the cost of maintenance labor and the maintenance materials to effect the repair. What larger figure that is not added is the cost of lost production/service. The range for this cost may be from 2 to 15 times the cost of the maintenance repair. The average is usually 4 to 1. So while a maintenance repair in labor and materials may be 10,000.00, the actual cost is really closer to 50,000.00. In fact, it is estimated that in the next several years the annual maintenance cost will exceed the amount spent on yearly new capital investment.

2.1.1 The essential of maintenance

“Components, sub-units, subsystems, systems of equipment and vehicles are designed, manufactured and assembled from processes raw materials and energy by the aid

of human labor and necessary tools. Their manufacturing and assembling process follow scientific laws in an economic way that will be achieved by maximizing performance and quality vehicles reducing costs. Furthermore, in order to continuously perform their intended mission or be available to perform their mission when needed, the following factors have to be analyzed and determined thoroughly during, manufacturing and assembling process. These factors are:

Reliability:-The ability of an item to perform a required function under stated conditions for a stated period of time. With this regard, during designing, manufacturing and assembling activities, care must be taken in order to maintain high reliability of operations at an accepted added cost.

Maintainability:-The ability of an equipment/vehicle under stated conditions of use to be retained or restored to a state in which it can give its original performance, when maintenance is performed under stated conditions and using stated procedure and resources.

Availability:-The ability of equipment/vehicle to function properly, despite occurrence of failures, disturbances and limitations in the maintenance resources.

Human factor (ergonomics): -human factors refer to the design of a system or a product/service with the human being in mind that is the design for operability and ease of maintenance. Considerations include physical dimensions of the human body, human sensory factors (sight or vision, hearing, feel or touch, smell, physical factors the effects of environmental stress on the body) and psychological factors pertaining to the human mind emotions, traits, attitudinal response, and behavioral patterns as they relate to job performance.

With the above consideration, during designing, manufacturing and assembling of parts, components, sub units, subsystems and systems of equipment or a vehicle are manufactured for a limited life span. If errors are committed during designing, manufacturing and assembling process, the expected life span of the machine systems, sub systems, sub-units and components will be less than the expected life. Thus, in order to prolong the expected service life of equipment/vehicle or rectify the intended problem encountered especially during manufacturing and assembling, it is necessary to conduct maintenance activities on equipment/vehicles.

2.1.2 Definitions of Maintenance

Maintenance can be defined as those activities required to up-keep a facility in as built condition, so that it continues to have its original productive capacity [4]

Depending on designer limitation of life span, manufacturer recommendations, age and service conditions of equipment/vehicle, it is possible to adopt the particular maintenance types along with their implementation interval.

According to the Oxford Dictionary, “maintenance is defined as, ‘the act of maintaining or the state of being maintained; the work of keeping something in proper condition; upkeep’”. In the context of industrial sector, maintenance can be defined as actions to control the deterioration process leading to the failure of a system, which is often called “preventive maintenance”, and the restoring of the system to its operational state through corrective actions after the occurrence of failure, often called “corrective maintenance”.

From the above definitions, it can be seen that maintenance is necessary to keep any product or system, with a finite life span, operating at an acceptable level, so as to support the needs of the user or organization.

Maintenance may be categorized in to the following major types [4]:

1. As required maintenance: “as required maintenance is simply doing maintenance works as the need develops (arise). This type of maintenance is applied for non-critical equipments.

2. Corrective maintenance: corrective maintenance covers all maintenance activities that are carried out in order to correct (repair) a fault in equipment/ vehicle. It may include emergency or break down maintenance.

3. Conditioned based maintenance: is a maintenance activity conducted to prevent failures before it happens using sensing, measuring, or condition monitoring devices to detect wear stages.

4. Preventive maintenance: PM is done to prevent the occurrence of failures and to detect failures before they develop to break down or disturbances in operation (product/service).

Preventive maintenance has become a term with broad definition. The generic definition of PM is any planned maintenance activity that is designed to improve equipment life and avoid any unplanned maintenance activity. In its simplest form it can be compared to the service schedule for vehicle. There are certain tasks scheduled at varying frequencies, all designed to keep the vehicle from experiencing any unexpected breakdowns.

PM activities that help to avoid failure of equipment are listed in [14] as follows:

- Equipment inspections to uncover deficiencies before failure and in sufficient time to plan deliberate repairs;
- Non-destructive testing techniques (predictive maintenance) to detect equipment deterioration and monitor equipment to note abnormal operation;
- Routine maintenance such as lubrication to reduce friction that causes heat, wear, misalignment, or seizure;
- Routine, cleaning and adjusting done in conjunction with inspection or lubrication, or performed by frontline operators;
- Replacement of minor components to reduce chances of more important components failing;

It is recommended that maintenance being cause and effect situations, it is logical that efforts be directed towards correction of the causes, rather than continuing to treat the effects [9]. Therefore, it is feasible and economical to adopt a mechanism by which maintenance is conducted to prevent the cause of failures and detect the failures before it occurred. It is recommendable to adopt preventive maintenance when:

- Corrective maintenance cannot be justified
- Condition based maintenance cannot be applied and
- As required maintenance effects cannot be tolerated

In preparing this thesis, concepts are drawn and ideas are incorporated from various works of different authors whose contributions have been significant in the development of maintenance function, and maintenance management. The works of the authors' quoted in [9], [4], [15, 16& 23], [6], [7] and [12] can be summarized as follows:

- Maintenance department shall be organized based on some universal truths and modified to adopt it to different sizes and sections according to the following parameters:
 - Plant size and type
 - Company policy
 - Industry wide and sectional precedent
 - Particular technical, geographical and personnel situations involved
 - State of training and reliability work and

➤ Available facilities

- Maintenance work shall be as much as possible preventive
- Maintenance planning and control system is crucial for implementation and cost effectiveness of maintenance
- Computerized maintenance management system is necessary
- Maintenance system can be centralized or decentralized

Theories and facts described in their work relevant to maintenance management system are assessed and adopted to solve the identified problems of vehicle maintenance of WIBSE.

The objectives of standardization, codifications and their application or economic benefits, which are adopted in this thesis work are stated, [2]. Additionally, he has shown the three categories of equipment life. These are economic life, profit life, and physical life. “The physical life is the age which the equipment/vehicle is exhausted and can no longer produce/give service. At this point it will usually be abandoned or scraped; Profit life is the life over which it can earn a profit; retention beyond that point will create loss. The economic life of a machine/vehicle is the life, which maximizes profit over the lifetime of the enterprises.

The framework of maintenance workflow system and the accompanying formats in their work is presented in, [3] & [4]. These systems and formats with that of WIBSE vehicle maintenance management system were used in development of maintenance work flow system of WIBSE. Ideas and concepts relevant to forecasting of spare parts requirement is incorporated in this thesis [17]. In a similar manner the objectives of spare parts management that have been shown in [5] works are assessed and relevant concepts are incorporated.

Dolce [1] listed in his work basic factors that have to be considered in vehicles replacement strategy. The replacement strategy was based on analysis of life cycle costs. The concepts are assessed and incorporated in this work.

In motor vehicles fixed-time replacement of major parts is becoming complex due to accelerated wear of these parts, as a result of operation in hazardous condition or abuse by drivers in addition to deviations of useful life from the mean. Thus in most service manuals of motor vehicles and earth moving equipments, a preventive maintenance program based on fixed time replacement of fast moving items, gaskets, filters, seals, lubricants and condition based replacement or overhaul of complex items and sub-units are recommended.

The replacement or inspection intervals are given in mileage or distance traveled in KM for vehicles, and in operating hours for earth moving equipments and or other equipments.

In general, most literature on maintenance states that the objectives of maintenance management shall be to develop systematic procedure of planning, execution and evaluation of maintenance with objectives of increasing equipment/ vehicle availability by decreasing down time due to breakdowns.

2.2 Maintenance Management System Objectives

Maintenance management is concerned with the good control of the maintenance function and its related areas in order to best assist the objectives and goals of the entire organization. It is a combination of all technical and administrative actions to retain an item in, or restore it to the state which it can perform its requirements under normal stated operating conditions. In short, maintenance management can simply be defined as managing the maintenance activities to ensure the availability of equipment and facilities and keeping the downtime to a minimum. As such, maintenance management supports the effective operation process by eliminating and reducing the frequency and severity of equipment failures.

With the changes in the maintenance and the management techniques, there is a need to provide an integrated approach that pulls together all of the design tools and maintenance tools that exist into an integrated whole. This requirement is in the form of Maintenance Management System, which when properly organized and established, is able to provide personnel at all levels access to real-time information.

2.3 Maintenance Management System Framework

The fundamental approach of Maintenance Management System can be viewed as a closed loop which is repeated in a continuous improvement program of maintenance and information procedures. The Deming concept of Plan-Do-Check-Act is a common approach [22] used by firms for recording of data, accounting for costs, developing management information, updating equipment information, providing work ordering system, control of preventive maintenance program and providing management control reports. Brief reviews of the events that occur during each of the loop are as indicated below:

Plan: make plans to improve a given activity;

Do: carrying out the plans;

Check: follow-up or feedback actions;

Act: making corrections if necessary.

This sets out a systematic approach for businesses to adhere to so as to ensure good planning, productivity and efficiency of maintenance. To ensure that a Maintenance Management System functions properly, several other sub-systems are necessary. These sub-systems includes topics such as equipment breakdown analysis, planning and scheduling of maintenance work, budget and forecasting, inventory control, training, accounting, work order system, work standards, and data collections. The list mentioned is not exhaustive but is considered to be more critical in the proper functioning of a Maintenance Management System.

2.3.1 Work Order Records/systems

A Work Order System is the essential tool for keeping track of documents used to record equipment maintenance tasks and provides the most important source of information for the maintenance analysis and the writing of PM procedures. In other words, a good work order system, with management commitment to its use, should produce quantifiable feedback on overall maintenance performance, job and plant cost, and equipment history. These above mentioned documents are called work order forms and there are several types and uses for them, according to the particular needs of each company. The basic purposes of the Work Order System according to Herbaty [13] are as indicated below:

- To provide a means for screening and authorizing work.
- To provide cost data segregated in a logical manner.
- To provide feedback information on repetitive failures for analysis purposes.
- To provide a tool to facilitate planning and scheduling of maintenance work.
- To facilitate control of productivity and performance of predictive and preventive maintenance.

In most instances, different organization has varying needs. Therefore, the work order system and its form used will vary across firms. Some general guidelines that apply to all systems are listed as follows [24]:

- Work order forms should be numbered and at least three copies are needed in connection with the control system.
- Only authorized supervisors approved by management can initiate work requests. A list of designated supervisors' names should be supplied to the work order section of the maintenance department.
- Work orders are initiated only in the maintenance department. The work request and/or work order form should be the basis for transmitting of information to all crafts concerned.
- The work order is the basis for reporting time and material charges.
- The work order is the basis for accumulating records of job estimates and actual costs for control and for improving estimates.
- The work order is the basis for work backlog reporting to control the size of the maintenance work force.
- Despite the general guidelines mentioned above, certain functions are still vital for achieving an efficient work order system as mentioned by Wireman [16] and Herbaty [13]. These functions include work order number and definitions, work order scheduling, setting job priorities and work order forms.

Work Order Number and Definitions

The work order number acts as a collection point for all information about the equipment requesting maintenance work. A number is assigned to each maintenance work request, be it planned, unplanned, emergency, or preventive maintenance. This number identifies the specific maintenance request, the equipment's maintenance charges (labor, material, etc.) and its history information. With the number defined on the work order form, the definition and description of the work to be performed and its priority rating must be assigned.

The setting of the priorities of jobs will be discussed under Setting Job Priorities.

Work Order Scheduling

Proper scheduling of the work request will enable estimation of many variables required for the maintenance work such as man-hours, the skill type, and the materials required. This helps the scheduler in better planning of the maintenance workforce and also estimation of the cost involved.

Setting Job Priorities

In the case of a priority rating system, it brings objectivity and professionalism into the planning and scheduling of maintenance work. For example, the customer requesting should set this assigned rating but the priority rating may be reassessed and possibly changed according to some set guidelines. The priority and type of work should be coded to ensure consistency in assigning of the priority rating and identifying of the importance of the work. For instance, a more urgent repair work for equipment with a higher priority rating will affect the scheduling of other jobs.

Summary Reports

Information from the work order forms of completed jobs are input into the reports. Maintenance department will then use the information to tabulate and churn out summary reports in order to look at areas like maintenance cost, equipment criticality determination, maintenance costs by type, equipment failure analysis, etc

Standards and improvement goals can be set with the information supplied by the summary reports. Any below standard values can be investigated by referring to the individual work order. Furthermore, the summary reports can also be used to assist in compiling various reports, such as the Annual Equipment maintenance Report, the Monthly Parts Usage Report by Equipment and the monthly year-to-date. Major Problem Reports Herbaty [13], which highlight information for the long term or a specific period of time. Annual equipment maintenance report summaries the cost incurred for the year by equipment number.

The format for such a report is as shown in table 2.1

Table2. 1Format for Annual Equipment Summary Report [13]

Equipment No.: XXXXXXXX						
Work Order No	Description	Labor (Hr)	Labor (\$)	Parts (\$)	Outside Service(\$)	Total (\$)
x-xxx	Replace drive motor	xx	xx	xx	xx	xx
Total		xx	xx	xx	xx	xxx

Monthly Year-To-Date (YTD) Major Problem Report

This report is used for current maintenance reporting information of individual equipment. With these reports, it provides a quick and easy means of surfacing principle maintenance

problem areas. The format of the report can be in terms of equipment downtime or maintenance cost. Examples of each of the format are table 2.2 & 2.3

Table2. 2Format for maintenance cost YTD summary report [13]

Equipment No	Description	YTD Down time Occurrence (DO)	YTD Maintenance Costs (MC)	%Column (MC) to total (MC)
X-XXXX	XX	XX	XX

Table2. 3Format for equipment/vehicle down time YTD summary report [13]

Equipment No	Description	YTD Down time Occurrence (DO)	YTD Maintenance Costs (MC)	%Column (DO) to total (DO)
X-XXXX	XX	XX	XXX

This is a report to help surface maintenance problems by arranging the annual issues per stock item in descending order and is indicated in table 2.4

Table2. 4Format for monthly parts usage report by vehicle/ Equipment [13]

Equipment No.: XXXXX						
Part No	Description	# of Work orders	Total Quantity Issued	Average Unit price	Total price	Percentage of Total cost
1	Gears	XX	XX	XX	300	67
2	Rollers	XX	XX	XX	1000	22
3	Bearings	XX	Xx	XX	460	10
4	Rope	XX	Xx	XX	20	0.6
5	Nuts	XX	XX	XX	10	0.2
6	Bolts	XX	XX	XX	10	0.2
Total					4500	100

2.3.2 Understanding Maintenance Planning

In the implementing of a maintenance plan, the terms preventive maintenance and predictive maintenance are often used by those working in the maintenance engineering

department. With the implementation of preventive maintenance and predictive maintenance, planning and scheduling of maintenance work will ensure lower cost and better quality of the maintenance work than when maintenance work is performed on an emergency or unscheduled basis.

2.3.3 Planning

Planning is the determination of all necessary elements required to perform a task in advance of performing the job. It is the heart of good inspection and preventive maintenance. Good planning ensures proactive maintenance strategies to provide effective maintenance to the equipment. All maintenance work should be planned so that the quality and cost effectiveness of the work is assured. To put it simply, planning is to provide an accurate description of what is needed, e.g. manpower, tools, materials, and equipment, at the proper time before the job is started. Good planning of maintenance function should include:

- A general plan on the distribution of labor throughout the various departments under “normal” operating conditions.
- Detailed planning and scheduling of major events taking place during the year such as major overhauls or rebuilds, large construction jobs, major preventive maintenance tasks and vacations of maintenance workforce. Preventive maintenance tasks should include routine maintenance, preventive maintenance, general repairs and emergency maintenance.
- Required spare parts, tools and other supply

From the standpoint of the business organization, the planning can be divided into three basic levels, namely long range planning, short range planning and daily job planning [13].

Long Range Planning

Long range planning is to provide plans for future activities and improvements to the maintenance function and can be for a period of five years or more. The primary purpose of long range planning is to keep the maintenance objectives, policies, and procedures updated so as to support the objectives of the company. Long range planners, usually reporting directly to the president or vice president, must have good knowledge of sales and operation forecast. As such, they are either from the upper management level or can be the maintenance manager.

Short Range Planning

Short range planning is concerned with the annual plan of operation of the maintenance function. This plan will specify how the maintenance workforce will operate during the coming year and will also provide detailed plans for major rebuilds or overhauls, upgrading, construction jobs, vacation planning, and also any changes to the production plan. Short-range plans should include preventive maintenance of periodic inspection, shutdown planning, general repairs and non-destructive testing which is commonly known as predictive maintenance. The list of common actions for short range planning is as indicated below

- Periodic Inspection
- Daily Job Planning
- Shutdown Planning
- Analysis of Job
- General Repairs
- Common PM Actions

It can be emphasis that good planning of the maintenance function will assure productive use of the available resources such as manpower, materials, equipments, etc. It will also ensure that maintenance actions are on schedule, and that the execution is carried out effectively and productively. Planning of the maintenance function must be performed throughout the three levels of planning, namely, long range, short range and daily planning. The various actions in each level of planning will require decision making and consensus among all involved before implementation. This is to achieve overall commitment and team spirit, even during times of trouble.

2.3.4 Scheduling

Scheduling is an important tool for ensuring high labor productivity and the orderly accomplishment of maintenance tasks and actions. Scheduling is the action to arrange for the availability of all the planned elements prior to the job execution. Two-way communication between the operation and the maintenance department is critical so as to ensure that any maintenance plans are made known to the operation department in advance. It is equally important to ensure that the planned elements or resources are properly scheduled so as to perform the job adequately. The typical elements required to perform a job are listed below [13]:

- Labor
- Material
- Equipment
- Safety Lockouts

- Tools

- Instructions

To ensure that all the planning effort is efficiently implemented, all the various maintenance actions and tasks such as general repairs and overhauls, preventive maintenance, lubrications, and routine maintenance must be all scheduled. Scheduling of maintenance work can be divided into two main types, namely long range scheduling and short range scheduling. The definition and properties of these two methods of scheduling are as indicated below:

Long Range Scheduling

Long range maintenance scheduling, or master scheduling, is sometimes referred to as working ahead of the schedule or forecasting. Forecasting is often employed in conjunction with planning to help identify the desirable implementation dates, which often can be as long as ten weeks ahead. This lead-time will ensure that the required personnel are made aware of the proposed timing of the job and also allows for sufficient time for the planning actions to be performed on time [14].

Short Range Schedule

Short-range schedule can be divided into weekly or daily schedules and is constructed from the long-range schedules to provide for the orderly introduction of emergency work as it occurs and the routine maintenance work. Short-range schedule permits the comparison of labor and material resources with work requirements. As such, in the event that there are more emergency repair works in a week, the subsequent weeks or weeks' schedule can be modified to complete unfinished work from the current week's schedule [14]. According to Niebel [24], about 85% of the weekly schedule is based on general repairs and overhauls, preventive and routine maintenance work while the remaining 15% is held open for emergency work. However, if emergency work is occurring regularly and utilizing more than 15% of the work force, an effort should be made to determine the causes.

Weekly Scheduling

In the planning of a weekly schedule, it is often useful to employ a two-week schedule [14]. The reason is that the planning function will not only provide for the work to be completed in the current week, but also for the subsequent week. In this way, there will always be a backlog of two weeks of work orders scheduled according to the priority. In the event of no

emergency work being requested and the weekly schedule is running ahead of time, advance planned work can be brought forward for scheduling [13].

The second week schedule is more of an announcement used to point out subsequent jobs and tasks that is coming up. Weekly schedule meetings should be held to assist the planners and the related departments on the types of works that have been scheduled and also to confirm that all the required craft, materials and tools are available [14]. It must be understood that the weekly schedule should be realistic and should provide for an allowance for absenteeism. This will prevent the occurrence of lack of manpower required to perform the weekly scheduled tasks. “Approval” of the recommended weekly schedule in advance by operation is a good way of ensuring that successful execution of a well planned schedule.

Daily Schedule

The daily work schedule is compiled from the weekly schedule by the maintenance supervisor and is to be distributed the day before the schedule task. The need for such a schedule is due to unforeseen changes in the planned weekly schedule. The reasons may be due to some planned work taking more time than anticipated, shortages in materials or parts, high rate of absenteeism or unexpected high rate of emergency work [24].

From this daily schedule, the jobs are assigned to craftsmen through work orders. The work orders will provide all relevant details such as materials, special tools, a checklist of items requiring performing of maintenance work, and also a feedback column. The daily schedule allows for better control of the maintenance workforce and also caters to any emergency repairs to be performed so as to keep the downtime or severity of the equipment to a minimum.

Scheduling Format

In the process of scheduling maintenance work for any time frame, the planner/scheduler must have taken into consideration several areas as to Herbaty [13]:

- Allocating of manpower
- Scheduling of work
- Managing capacity and workload fluctuations
- Managing of the manpower pool
- Estimating
- Control of backlog

Allocating Manpower

In allocating manpower, the first step of the scheduling process is to prepare a labor assignment sheet for each of the area maintenance units/groups as it is essential in the

preparation of the short or long-range schedule. These sheets, showing the distribution of labor by craft, should be updated monthly and should include areas such unit capacity, routine assignments, unavailable time, non routine assignments. A typical labor assignment sheet is shown in Figure 2.1. The various areas on the labor assignment sheet are explained as follows:

Unit Capacity: This is the number of permanently assigned personnel times 8 hours a day. Pooled personnel or external contractors should not be included in this figure.

Routine Assignments: Routine assignment should be divided into two categories namely, fixed assignments and variable assignments

Fixed: Assignments can further be divided into preventive maintenance assignments and other fixed assignments. The preventive maintenance assignments are normal preventive work performed on equipment that is stated in the preventive maintenance instructions. The manpower needed according to prior planning should be set aside and left undisturbed. For other fixed assignments, which are known maintenance work such as lubrication, replacement of minor parts, janitorial work, etc and manpower can easily be calculated and set aside.

A. <u>Unit Capacity</u>	<u>Hours per day</u>
10 men x 8 hours/day	80
Overtime	<u>0</u>
	80
B. <u>Routine Assignments</u>	
1. Fixed	
a. PM	8
b. Other	8
2. Variable-trouble calls	<u>8</u>
	24
C. <u>Unavailable Time</u>	
Absentees, vacations, sick leave, training, union business, etc	8
D. <u>Non routine Assignments</u>	
Time available for special work orders	
A-B-C= D	48

Each area Forman should prepare a separate labor assignment sheet for each trade

Figure2. 1 Labor Assignment Sheet Format [13]

From figure 2.1, the variable routine assignments are often of unknown magnitude and the amount of manpower required for this type of work depends largely from past experience. Examples of variable routine assignments include minor maintenance, operating surfaced preventive maintenance, emergencies and minor repair.

Unavailable Time: This is the average time spent by the crew on absenteeism, vacations, sick leave, coffee time, union business, etc. This figure can be obtained from past experience and knowledge of the current situation.

Non Routine Assignments: A non routine assignment determine the amount of labor available for any non routine jobs, and is equal to the equation as indicated below.

Non routine assignments = Unit capacity – Routine assignments – Unavailable time.

This category of work comprises practically all of the preplanned workload and is the major scheduling task of the planner/scheduler.

Managing Capacity and Workload Fluctuations

The workload in any maintenance unit can be subdivided into fixed and variable categories. Fixed categories include preventive maintenance and routine maintenance while variable assignments include minor and major repairs, absences, vacation and sick leave according to Herbaty [13]. The labor capacity available for any of these fixed and variable loads is itself a variable as labor availability can be affected by:

- Absenteeism, vacations and sick leaves
- Labor transferred to higher priority jobs
- Labor transferred to emergency jobs
- Inability to obtain material or equipment

In other words, the labor capacity to meet the needs and demands of any load is dynamic and constantly changing. Therefore, the labor capacity must be constantly and closely monitored and adjusted to balance the load and capacity. Some common remedies include working overtime, borrowing men with similar crafts from manpower pool and seeking external contractors.

Estimating

Estimating should be performed on all non-routine work orders. As to Herbaty [13] the main purposes and reasons of estimating are:

- To facilitate scheduling of the week's work
- To provide a basis for checking job productivity. The estimated and actual job costs will show up on the completed work order printout. Any major difference in the values can be due to incorrect estimating or other reasons.
- To provide a basis for work order approval as unknown cost figures will make approval difficult.
- For backlog control. The summation of each work order estimate provides a measure of the size of the backlog.
- To help in controlling low productivity caused by incorrect crew allocation.

Scheduling of Work

Scheduling of tasks depends mainly on the criticality and priority of jobs, and the amount of manpower available. Routine and preventive maintenance tasks should have priority over others as unmentioned equipment will have higher chance of failure, thereby creating additional problems or failures. All necessary tools, materials and equipments for the

performing of maintenance tasks should be made available before scheduled work order is released.

Managing the Manpower Pool

The maintenance workforce will be divided into units or groups and each led by a foreman. The workload for these groups will vary on any given day and this is due to breakdowns, changes in priorities, nature of jobs, and a wide variety of other reasons. Furthermore, the group capacity available to perform the work will also vary for various reasons such as absences, vacations, sick leaves, transfers to emergency or higher priority jobs, terminations, etc. Therefore, planning and scheduling of maintenance work must take into account all these manpower factors and make necessary adjustments to balance load capacity. The adjustments that can be performed are as indicated below:

Insufficient Capacity/Excess Load

- Overtime
- Inter-unit transfer
- Outsourcing
- Allocation of manpower pool labor
- Delay, reduce or cancel work

Excess Capacity/Insufficient Load

- Schedule more backlog work
- Bring forward selected preventive maintenance tasks
- Schedule deferred maintenance tasks

The above mentioned adjustments are some suggestion and will not definitely work for any individual business. Careful considerations must be taken into account before coming to a conclusion.

Control of Backlog

A record of backlog should be maintained so as to plan for vacations, to facilitate the work planning effort and to make decisions on manpower including the need to hire fire or alter the human resources in each maintenance group. Absence of documentation of backlog may result in overload of tasks and may degrade the condition of the unspecified equipments [13].

2.3.5 Maintenance Cost Control

Preventive maintenance is an operating cost necessary in ensuring that operational targets are met. The benefits of an improved maintenance helps to increase revenues by increasing equipment performance due to high efficiency, improve return of assets by reducing the

need for expensive capital upgrades and increasing output due to high availability. In terms of operation, maintenance will to increase enable the uptime or availability of equipment, to ensure attaining of high productivity and quality level. Budgeting is paramount importance to control the various necessary costs in maintenance. Often is done by comparing man-hours used, labor cost accrued, material cost accumulated, and total cost committed. The output of these costs is equipment, buildings or facilities maintained, activities performed, or jobs completed. In order to control cost, effective use of labor, tools and materials must be adhered to ensure a smooth operation of production equipment. There are some common facts that people should know about maintenance cost control as indicated below according to Tomlinsong [14]:

- Most maintenance departments have a relatively stable work force, and total labor cost variations are primarily due to overtime.
- Material costs are determined by volume of equipment that must be maintained and the speed at which the equipment consumes spare parts and materials. Therefore, an increase of emergency repairs will require more spare parts and materials than normal routine and preventive maintenance programs.
- Labor costs in maintenance are incurred by the need to install spare parts and performing the various maintenance tasks. However, a maintenance department doing mostly emergency work usually works less productively as more labor is consumed and the quality of work will tend to be poor as the works are performed in reactive mode.
- Maintenance supervision tends to help in control of costs due to the efficiency with which spare parts and materials are installed. Thus, the control of labor on their quality and performance will become a vital maintenance activity.
- Better control of individual jobs is achieved through planning and scheduling. The result will be completed jobs in less elapsed time, often with a reduction in cost and with less consumption of manpower. Another significant improvement is that downtime will be reduced and uptime is increased.
- With quality supervision, maintenance supervisors are able to control the quality of t job and also maintain the potential benefit of planning. Supervision also tends to result in better productivity and quicker completion of work.

- Successful cost control requires a work order information system that provides information to judge performance and guide corrective actions.

Overall, it is vital for businesses to administer a system of good maintenance cost control to assist in controlling of the labor and materials resources.

Reducing Maintenance Cost

With good planning and scheduling of the maintenance efforts, the maintenance department should look at ways of reducing the overall maintenance cost without affecting the efficiency of the maintenance function.

With good implementation of procedural maintenance actions, the discovery of problems before failure occurs is possible. The final result will be less costly repair and less downtime. This will indirectly reduce the rate of repairs and lower the use of spare parts. Furthermore, a good repair history record that highlights the chronic, repetitive problems and leads to their permanent correction can be helpful.

It is important for a business to impose a strict adherence to a regular PM Service schedule to help to extend equipment life. Operation can also contribute to reducing the rate of parts consumption by making equipment available for scheduled major repairs, as this is also a sign of confidence in the maintenance program. One direct cost that will affect the maintenance function is labor. In situation of immerse absenteeism, overtime is required for planned jobs. This explains why successful businesses often have good human resource system that curbs absenteeism which will affect the overall productivity and morale of the firm.

To summaries, a successful cost reduction program requires the following to be established according to Tomlison [14]:

- Maintenance work must be approved before it is performed.
- All the maintenance work must be planned according to its scope, criticality, cost, etc.
- Planned work must be prioritized
- Planned and prioritized work must be scheduled
- Schedule of major work should be subjected to labor allocation and deferred if not certain.

- Use of manpower should be scrutinized; performance to be measured and any questionable use of labor should be justified by maintenance supervision.

From the above, we can see that immense planning efforts are required to contribute to a successful cost reduction.

Maintenance Controls

Control of the maintenance function is vital to achieve the set targets and objectives. During the performance auditing, several questions should be raised for the maintenance controls.

These questions, as determined by Wireman [23] include:

1. Is the maintenance utilization report used?
2. Is crew absenteeism closely monitored?
3. Does overtime exceed 5% of the total man-hours worked?
4. Are external contractors used for routine jobs?

For the first two questions, the reply should yield positive answers while negative answers to the last two questions will be desirable. In the event of discrepancies, actions needs to be taken in the indicated area and the planning and control areas should be firmed up. Emphasis should be placed on improving planning and increasing craft efficiencies. Improvements on planning and scheduling functions must be made if productivity of employees has to increase.

For excessive overtime scenario, a common situation known as “fire-fighting” or reactive style of maintenance is occurring and this is not cost effective at all. More often, the maintenance crews are rushing to finish up on repair works and thus, overtime is needed to ensure that all routine and preventive maintenance are performed. A solution will be to place more emphasis on PM and predictive maintenance such as equipment testing and inspections to help detect imminent failures in advance. By uncovering the problems early, the emergency repair rate will be lowered eventually and the gradual improvement of the excessive overtime situation. Wireman [23] also cited that the use of external contractors on routine or repetitive jobs is a waste of resources and should be avoid wherever possible.

If the workload is such that the workforce cannot cover the routine jobs, there may be a need to increase the staff number or to revamp the manpower utilization to remedy the situation. As such, external contractors should only be used on large projects or when in-house expertise is unavailable temporarily. If the expertise of a certain craftwork is creating a

loophole of requiring constant external contractor work, a good solution will be to select personnel to undergo craft training to fill the gap.

Maintenance Backlog

According to Tomlison [14], there are two purposes for having maintenance backlog. They are to keep track of the rate of new maintenance work being generated and also to help in determining the proper size and mix of the types of craftwork of the workforce. An increase in the amount of backlog may be due to poor work order planning, poor record keeping, and poor scheduling practices. The following questions should be asked while considering the maintenance backlog:

- a. Does the backlog forecast the required downtime?
- b. Is the work prioritized for each craft?
- c. Are the priorities properly applied and reliable?
- d. Is the backlog used to control the size of the workforce?

The answer to the questions should reflect the conditions of the work order backlog. The work requests should be planned and scheduled each day, considering the priorities, the require completion dates, the availability of craft workers, materials, and equipment.

In the event that backlog becomes a problem, assigning accountability for the different functions should help to eliminate the problem. However, it must be remembered that that inefficient maintenance operation for years cannot be expected to change overnight. A gradual implementation program must be used to help ease the old habits so that personnel will have the time to adapt and change. Another solution will be to increase the size of workforce to counter the increasing amount of backlog. However, this solution doesn't counter the "root" of the problem; that is the rational for the increase of backlog. Adding of personnel can sometimes worsen the situation, as the imminent problems are not solved.

CHAPTER 3: ANALYSIS OF THE EXISTING SYSTEM

3.1 Back ground of Walia Intercity Bus Service Enterprise (WIBSE)

In 1950's road transportation was one of the most profitable sectors in Ethiopia. More individuals and unions appear to this sector and relatively free market was emerging. This phenomenon had continued till command economy came in to action in middle of 1970's. During the Dergue regime private public transportation was nationalized and by adding to government buses "Public Transport Corporation was established" by proclamation No.107/69. After governmental change, in 1986 public transport corporation was split into technique ,city bus service and cross-country service. As a result Walia intercity bus service enterprise was established in 1987 by council of ministers regulation No.188/86 to provide cross country transport services with initial paid up capital of **16,942,000** and authorized capital of **21, 690,000**.

Initial financial situation:

1. Asset

Amount in cash		Birr 1,890,000
Deposit to be paid for loan		12,690,000
Receivable	Birr 900,000	
Building	5,122,000	
Spare parts	<u>33,129,000</u>	39,151,000
Buses	24,827,000	
Others	<u>22,844,000</u>	<u>47,671,000</u>
Total amount		<u>101,402,000</u>
Local loan	25,715,000	
Foreign loan	<u>58,745,000</u>	84,460,000
Capital		16,942,000
		<u>101,402,000</u>

2. 155 long served, 32 out of service, 35 new totals of 222 buses

3. 1280 permanent workers out of which 25 with degree and diploma

Mission: To provide cross-country bus services and other related works to achieve the set objectives

In order to achieve the specified objectives, WIBSE has to implement system with a proper maintenance management system. It is found that improved maintenance helps to increase revenues by increasing vehicle performance and eventually the economic performance of the firm. Most importantly, firms must align the maintenance objective with firm's other objectives to maximize results as plans and goals of the whole firm will be directed in the same direction. Further more implementation of improved maintenance system needs top management commitment. Due to lack of well established maintenance management and other reasons, which are beyond the scope of this thesis the enterprise is subjected to accumulated cumulative loss of Birr 42 million.

The problem encountered due to, improper maintenance management system practiced in WIBSE are summarized as follows:

- Higher frequency of break down of buses (Table 3.1 & 3.3)
- High frequency of road calls due to break down, hence customer dissatisfaction (Table 3.1 & 3.3)
- High fuel and oil consumption with a consequently of low performance (table 3.6)
- Higher than normal repairing cost

Decreasing of the equipment or vehicle expected service life is mainly caused by the failure of major components of the vehicles, (See tables 3.2 and 3.4 for cause of failure). After some time they become out of operation. Frequent break down, accident and lack of preventive maintenance contributed a lot to decrease the vehicles service life. The other problem is just fixing or replacing the failed parts in the vehicle with out considering related parts. This is one of the causes of higher break down frequency. The absence of good maintenance management is evidenced in the following:

- Higher down time of vehicles, higher operating cost and low revenue, hence low profit (Appendix- B)
- More vehicles are in poor and bad condition (table 3.7)
- Difficult to forecast spare parts requirement as a result of more down time due to stock out (table 3.5)
- High lead time to repair and too many obsolete vehicles

In order to avoid the prevailing problems due to poor and in efficient management of fleet and spare parts, it is necessary to establish appropriate maintenance management system. Furthermore since no equipment or vehicle is lasting forever, a replacement plan of vehicles and equipments should be implemented parallel to proper maintenance of vehicles at hand.

The other reason widely known by technical personnel but over looked by managers is driver's contribution to vehicle condition. If a vehicle is driven unwisely, no matter how it is new, its service life is shortening rapidly. So drivers should be trained to on the consequence of improper driving. Furthermore drivers are responsible for minor maintenance.

Therefore in order the enterprise to survive in the market the problems have to solve and for this it is necessary to establish an effective and efficient maintenance management system.

The thesis objective originates from such clearly observed facts.

3.2. Data collection and analysis

Table3. 1General working condition of buses in 1997 budget year

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Average
Operable buses	104	103	103	103	105	106	107	107	107	107	107	107	105.5
Planned Operable buses	83	85	87	83	85	87	90	92	94	83	85	87	86.75
Actual Operable buses	89	86	85	88	84	87	89	88	83	87	82	82	85.8
Frequency of breakdown	564	551	558	511	446	494	569	582	511	471	446	438	511.75
Road call	27	34	27	29	24	28	35	39	27	28	29	26	29.4
Frequency of repair	545	539	543	491	431	480	558	563	498	454	429	426	496.4
Unprepared frequency	29	30	33	35	35	33	29	37	30	37	41	27	33.87
Accident	23	19	18	16	21	13	15	23	14	19	18	15	17.8
Buses idle for 30 days	15	17	18	15	20	19	17	18	23	20	24	25	19.25
Buses idle b/n 3-29 days	40	32	36	37	30	35	33	31	29	43	37	36	34.9
Buses repaired below 3days	49	54	49	51	55	52	57	58	55	44	46	46	51.58
Planned repair	1	2	1	2	2	2	1	1	3	2	3	3	Total= 23
Total down time bus days	1010	1162	1066	1024	1124	1028	1041	1141	1089	1168	1299	1287	1119.9
Availability	67.17	62.4	65.5	66.9	64.3	67.9	67.57	64.5	66.1	63.6	59.5	59.9	64.6

Table3. 2 Road breakdown (road call) failures by system in 1997 budget year

	Air	Motor	Diff	G.box	Cooling	Brake	EE	Fuel	Steer	P. Train	Susp	Clutch	Acc	Turbo	Others
July	6	4	1	3	1	8	2	2	0	0	0	0	0	0	0
Aug	0	2	3	2	3	6	1	0	1	5	3	2	0	0	1
Sep	4	7	2	0	0	4	1	1	0	1	3	2	0	0	2
Oct	6	5	2	3	1	3	3	3	0	0	1	0	2	0	3
Nov	6	4	2	0	3	3	2	1	0	2	3	0	0	0	1
Dec	5	6	2	0	1	4	1	2	0	4	0	0	2	1	1
Jan	6	10	1	1	2	4	6	1	0	1	2	0	0	2	0
Feb	8	8	0	5	6	1	2	2	1	2	1	0	0	1	0
Mar	4	7	0	3	4	1	1	2	1	1	2	0	0	1	0
Apr	8	9	0	2	1	3	1	1	0	2	1	0	0	1	0
May	3	8	2	1	3	2	1	2	0	2	2	0	1	0	1
Jun	6	7	0	2	1	1	5	1	0	0	1	0	0	0	2
Total	67	77	15	22	26	40	26	18	3	20	19	4	5	5	11
%	18.7	21.5	4.2	6.1	7.2	11.1	7.2	5.2	0.83	5.6	5.3	1.1	1.3	1.3	3

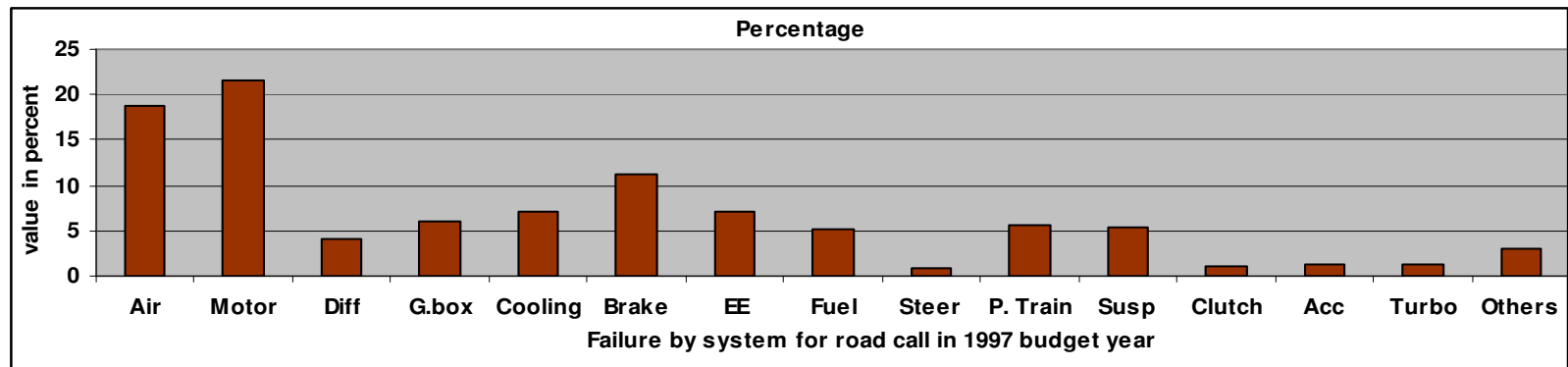


Figure3. 1 Failures by system for road breakdown in 1997

* EE =Electric; G.box= Gear box; P.Train= Power train; Steer=Steering; Acc=Accident; Diff=Differential; Susp= Suspension

Table3. 3 Working conditions of buses in 1998 budget year

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Average
Operable buses	105	105	106	106	106	109	109	114	115	109	109	109	108.5
Planned Operable buses	89	91	93	83	84	86	87	87	88	89	83	85	87.08
Actual Operable buses	80	84	83	75	74	80	74	66	67	63	57	54	71.4
Frequency of breakdown	490	479	489	445	447	465	455	444	520	465	555	497	479..25
Road call	32	35	33	29	29	32	32	30	25	29	27	26	29.9
Frequency of repair	475	460	471	436	434	453	440	433	509	449	536	485	465.08
Unprepared frequency	15	19	18	9	10	12	15	11	10	6	19	12	
Accident	19	28	20	14	12	14	10	16	26	18	11	14	16.83
Buses idle for 30 days	25	21	23	31	32	29	35	43	42	45	46	46	34.8
Buses idle b/n 3-29 days	47	41	45	38	34	34	27	41		22	11	22	32.8
Buses repaired below 3days	33	43	38	37	40	46	47	30		42	84	51	44.6
Planned repair			5	3			5	7	3			3	Total=26
Total down time bus days	1002	1212	1397	1398	1370	1317	1511	1315	1522	1415	1380	1250	1340
Availability	68.2	61.52	56.32	59.72	59.91	59.72	53.79	61.55	55.5	56.72	57.8	61.8	59.07

Table3. 4 Road breakdown (road call) failures by system in 1998 budget year

	Air	Motor	Diff	G.box	Cooling	Brake	EE	Fuel	Steer	P. Train	Susp	Clutch	Turbo	Others
July	4	4		7	5	3	1	1	1	1	1	-	3	-
Aug	4	9		2	3	6	4	2	-	2	1	1	1	-
Sep	3	7	1	3	3		4	4	-		3	3	-	2
Oct	1	10	1	1	1	-	4	-	2	-	-	-	2	-
Nov	1	7		1	3	1	2	3	1	2		1		-
Dec	5	6		1	2		4		1	3	3	2	3	-
Jan	2	7	-	-	4	5		2	2	2	3	1	1	-
Feb	3	7	-	-	4	5			1	2	2	2	--	4
Mar	3	3	-	-	-	3	4	4	1			-		4
Apr	2	4	1	2	2	3	1		11	3	3	-	1	5
May	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun	2	5		1	4	2	4	1	1		-	1		2
Total	30	69	3	18	31	28	28	19	9	15	16	11	11	17
%	9.8	22.6	0.98	5.9	10.1	9.2	9.2	6.2	3	4.9	5.2	3.6	3.6	5.6

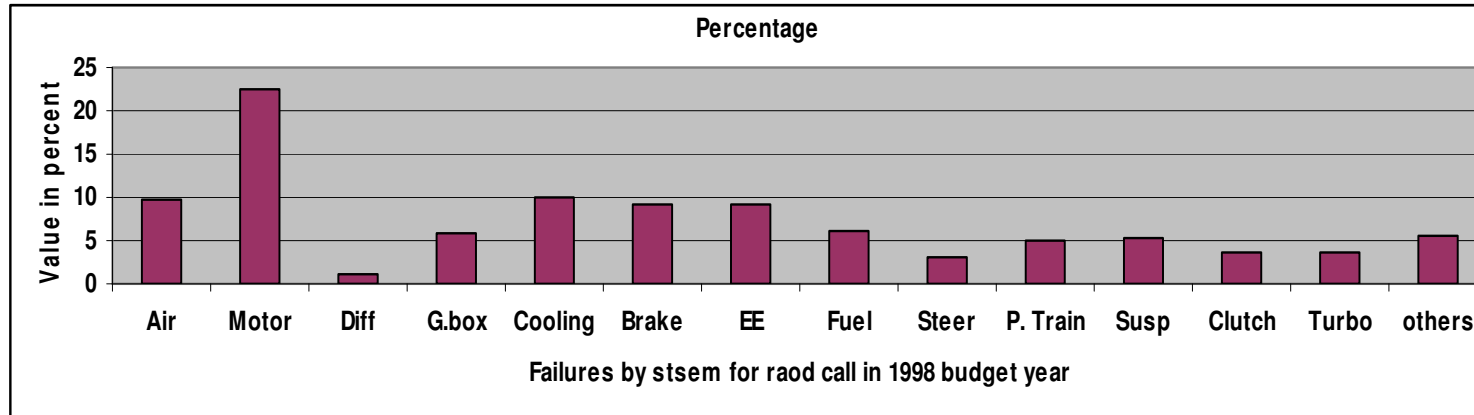


Figure3. 2 Failures by system for road breakdown in 1998

Table3. 5 Reasons for max bus day (30 day) down time in1997 and 1998 budget years

1997	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total (%)
Shortage of spare	12	6	2	6	11	10	8	2	7	6	5	16	(38.6)
Repairing process	3	11	16	9	9	9	7	13	8	11	7	5	(45.8)
Miscellaneous	-	-	-	-	-	-	2	3	8	3	12	4	(15.7)
1998													
Shortage of spare	9	6	9	12	16	19	16	31	36	16	39	43	(70.0)
Repairing process	13	9	5	4	10	8	-	8	5	-	6	-	(18.9)
Miscellaneous	3	5	5		4	1	11	1	1	5	1	3	(11.1)

Table3. 6 Fuel and lubricant consumption analysis in the year indicated (source, [19] & [20])

Description		Standard	Actual	Deviation	Loss Amount in Birr
fuel consumption	1998	2.5km/litre	2.03km/litre	19%(below)	19% of 6,480,312=(1,231,259)
	1995	2.5km/litre	2.09km/litre	16%(below)	16% of 5,585,338=(893,654)
	1994	2.5km/litre	2.10km/litre	16%(below)	16% of 4,758,870=(761,419)
Oil and lubricant	1998	648,031	549,705	15%(under)	98,326
	1995	558,534	634,058	13%(above)	(75,524)
	1994	517,210	671,000	26%(above)	(135,319)

3.3 Walia Intercity Bus Service Enterprise vehicles status

Due to traditional documentation and reporting system of vehicles history, it is difficult to conduct a detailed analysis of vehicles status. The maintenance department of WIBSE has no record showing status of vehicles. Vehicles status can be easily identified if planned maintenance is implemented or performance testing of engines is taken place. But here the type of maintenance taking place is break down and minor lube therefore status of vehicles is drawn from operational condition of the vehicles taken from 1998 report and plan of 1999. Accordingly the status is as follows:

Table3. 7 Quantity and status of equipments and vehicles in WIBSE

S.No	Description	Status and Quantity				
		Good	Fair	Poor	Bad	TOTAL
1	Mercedes	26	21	18	40	105
2	DAF	14	8	22	18	62
3	Fiat	2	-	4	11	17
	Total	42	29	44	69	184
	Percentage	22.8%	15.8%	23.9%	37.5%	100

The vehicles, which are operable and are ranked in the top in revenue and lower frequency of breakdown, are categorized as good. Normally new and well-maintained vehicles are classified in this category. These vehicles are earned reasonable income within the poor maintenance management system, had they maintained preventively better performance could be recorded. The vehicles, which are operable and out of operation that required minor repair and easily recoverable (those vehicles which are operable but with higher repair cost due to high frequency of break down and lower revenue) are classified as fair. These vehicles can be maintained and corrected by minimum cost and low technical complexity. The main problem is lack of preventive maintenance and management. Those vehicles that are operable and out of operations that require major repair and overhaul (vehicles which are out of operation awaiting major over haul) are categorized as poor. These vehicles need thorough and accurate cost estimation before major overhaul to ensure that the annualized repair and other cost in the remaining service life does not exceed depreciation and costs of new vehicle. The remaining vehicles, which are out of operation (These vehicles are out of operation for years and subjected to sun and rain), can be categorized in bad status. It is not economical to repair these vehicles; definitely the cost of repair will exceed 60% of the cost of new vehicle, therefore it is better to sell these bad status vehicles. From these buses the enterprise plans to sell 19 of them at estimated salvage value of 78,000 Birr each and 7 small cars at estimated value of 35,000 Birr. The remaining vehicles which can not sell may use for spare parts by cannibalization wherever possible. Proper categorization of vehicles in different status helps to provide cost effective maintenance work. The enterprise should identify the vehicles status thoroughly in a regular way. Designing and implementation of disposal system is also an issue to be addressed by WIBSE vehicles management system.

Due to lack of disposal system more vehicles are stopped out of service for years against sun and rain, hence depreciated.

From the status list it is clearly seen that there is a problem of maintenance management system. This is observed in high percentage of vehicles in poor and bad status, which exposes to higher cost due to its maintenance complexity and higher down time.

3.4 Competition analysis

There are thirteen transport associations consisting of 1085 buses engaged in cross-country road transportation service. The federal road transport authority controls the tariff and route distributions.

All concerned associations are prepared and report availability of their buses to the authority, then based on the number of buses, route is distributed fairly, “the more technically fit buses a company has the more routes is assigned to it”. Further more route distribution is based on the consideration of road conditions i.e. buses serving in uncivilized road will shift to asphalt road and vice versa in the next allocation. In case the assigned buses are absent due to some reasons, reserves or buses with shortage of passengers are reassigned. If a bus does not operate for a month, it could not include in the next month route allocation.

Table3. 8 Competitors in the sector

Name of Org.	Number of buses	Name of Org.	Number of buses	Name of Org.	Number of buses
Africa and Alem	338	Medihn	72	Hibret	17
Ethiopia	148	Nib	85	G.T.S	30
Adis Alem	114	Andinet	15	Selam	13
Fetan	85	Eshet	39	Walia cooperative	129

When bus comes out of maintenance, it will be a reserve and included in the next months route allotment. Route allocation is starts at every 17th day of a month. After the road transport authority route distribution is announced, the operation department of WIBSE takes its part and sends the buses to technical department once again for inspections and checkup. The technique department prepares the buses for the required route. This time the monthly routes available are 125 long distance, 34 medium distance, 6 short distance and 51 rotations. Let’s have a look (table 3.9) at route coverage condition.

Table3. 9 WIBSE route allotted and coverage

year	Route Allocation			Coverage in %
	No of Route assigned	Covered	Uncovered	
1997	5,579	3,505	2,074	63%
1998	4,792	2,784	1874	58%

In 1998 the market loss due to uncovered routes is above **Birr 8,531,999** this is because of shortage of vehicles due to down time and road break down, hence in efficient in maintenance (PM). Further more if we see in the data in (table 3.9) above 37% of allotted route is not covered. This shows poor quality of maintenance work done, because from the very beginning route is assigned according to the report of technically fitted vehicles a company has. The market share of WIBSE in 1998 is 6.7% only, which is low, and this share is covered only 58% with own buses. Therefore WIBSE top management should give more focus on the maintenance management system otherwise continuing in the current manner could result in financial collapse.

Table below shows how the operation revenue is decreasing due to in efficient maintenance.

Table3. 10 Salary and related expense in relation to operation revenue

Year	Salary and related expense in million	% Out of total expense	% Out of operation revenue
1994	8.6	37.5	40.6
1995	8.8	35.8	41.5
1998	10	52	55

As it can be seen that revenue is decreasing whereas expenses are increasing, this shows excess employee and decreasing maintenance efficiency. From past three years record the availability of buses has been only 57%. Further more it is rapidly decreasing at alarming rate.

Table3. 11 Fuel and lubrication consumption

Year	Oil& lubricant	Fuel cost/Liter	Fuel consumption in liters	km covered	KM/Liter (Fuel)	No of passengers
1994	671,000	2.59	1,578,328	3,325,000	2.10	930,400
1995	634,058	2.69	1,840,625	3,851,000	2.09	1,128,700
1998	549,705	4.37	1,482,909	3,009,750	2.03	845,000

In 1995 with average of 4% price increment, 16% more KM covered and transporting passengers 21% more than 1994; however the company uses less oil and lubricant. This shows either resources are abused or used simply without proper control.

3.5 Disposal and replacement plan

Walia intercity bus service enterprise has no set/stated replacement plan as well as disposal system. Due to lack of scrap policy there are 79 buses stopped out of service for a long time against sun, rain and other natural degrading factors (See table 3.12 for age of vehicles). If a vehicle is not economical to repair for operation, it should be sold or disassemble for spare parts on time.

Table3. 12 Current buses available by brand, age and quantity in number

Description	Number	Brand type		Year imported and service			
				Type	Qty. In number	Year imported	Service
Working in On/Off	73	Mercedes	105	Mercedes	50	1978	21
Waiting for maintenance	32	DAF	62	Mercedes	37	1979	20
				DAF	62	1980	19
Out of service	79	Fiat	17	Mercedes	18	1987	12
Total	184		184	Fiat	17	1987	12

During the last 12 years, the enterprise did not buy any bus but above half of the current vehicles are either completely stopped or operating with difficulties. WIBSE has to have a replacement plan to sustain its survival and competency in the sector. It is quite sure that with the current status of vehicles and maintenance system it is not possible to be profitable and competent. So that, in parallel to the implementation of improved maintenance management system, the old vehicles should be soled and replaced step by step. The replacement plan should include the following factors:

- The economic life of a vehicle;
- Purchased year and current status;
- Frequency of repair due to breakdown and downtime

The replacement plan should also consider the operation and maintenance plan to be implemented, available routes and future trends of the transport sector etc. There may be two options either few quality vehicles with higher efficiency and low maintainability and hence higher profit per bus for short time or higher maintainability vehicles, which can have reasonable profit for long time by maintaining as per the recommendation of the

manufacture. Forecasting future needs based only on past trend has its own limitation. Therefore, forecasting should include the following factors:

a. The capacity of overall company-in maintenance, operation and others. The capacity should determine based on the vision, mission and objective of the enterprise.

b. Availability of current routes and the future trends of road transportation- This includes available routes; future expected routes, trend and expected quality of passengers service, road condition and competitors strength and weakness etc.

c. Variation of operation-the development of technology from time to time resulted in easy and safer operation of equipment and vehicle. Nowadays there are comfortable buses with better speed and safety, so if the current system of route distribution by government is completely changed to free market, there is no means for passengers to use old and uncomfortable buses especially for long distances.

d. Requirement of manpower training-depending on the new coming vehicles/equipments and the technology employed on their manufacturing, there is some variation in operation, maintenance and safety improvement from time to time. To use the newly purchased equipment/vehicle properly, it is mandatory to plan why, where, and how to train the technicians and drivers/operators who are going to operate and maintain them. The current manpower distribution (table 3.13) shows most of the manpower in the enterprise are at low education level.

Table3. 13 Employee distributions in educational level, service time, age, sex and location in the company

Age		Educational level		Service time		Location	
Range	%	Range	No	Range	No	Department	%
18-25	2	Reading & writing	134	0-2	33	Technique	24
26-35	5	1-8	230	3-5	13	Operation	48
36-45	38	9-12	298	6-10	6	Finance & Adm	28
45-55	51	Vocation & Tech.	166	11-15	58	Sex	
Above 55	4	Diploma	23	16-20	222		
		First degree	10	21-25	201	Male	687
				>25	207	Female	188

Numbers of employees Permanent =875

Contract=138

Most of the technical personnel are working for more than 20 years with out scheduled training, hence they are solely depending on their experience, and this contributes a lot to the lower maintenance efficiency of the department. Furthermore, since there is no performance measure for incentives and promotion, technicians are working to cover the working hours

without any consideration of maintenance quality. These reveals in high maintenance frequency and road break down of vehicles. There are excess workers; the enterprise should examine the overall requirement of manpower in quantity and skill.

5. Work shop and spare parts planning-the capacity of workshops and spare parts requirement should be included in the replacement plan. The tools needed for maintenance and training in composition and quantity shall be purchased with the vehicle/equipments.

6. Life cycle cost-life cycle cost is the total cost incurred during the actual life of the product. Hence life cycle cost includes the acquisition cost as well as future cost for operating and support of the product until it is finally discarded. Therefore, it is useful to include the concepts of life cycle costing in vehicle replacement plan to compare different alternative products and to adopt maintenance and support staffing.

3.6 Vehicle makes of WIBSE

The different makes and types of WIBSE, vehicles are presented on the table below

Table3. 14 Makes and models of WIBSE

S.No	Equipment type	Make
1	Transport bus	Mercedes
2	Transport bus	DAF
3	Transport bus	Fiat
4	Support vehicle	Ford
5	Support vehicle	Toyota
6	Support vehicle	Isuzu
7	Support vehicle	Suzuki
8	Support vehicle	Mercedes

As one can see from the table there are few varieties of brands of vehicles types. There are three main vehicle makes for buses. Furthermore, these vehicles have similar systems and components. WIBSE has an advantage to exploit the few varieties of vehicles by having few specialized technical personnel. In the case of more varieties, each vehicle composed of different systems and components require different specifications to operate and maintain, hence more technical personnel or with multi skill personnel are required. To maintain these vehicles, it requires either to have a few well trained and experienced technical personnel, or an equivalent number of technical personnel who are capable, skillful and well trained so as to operate and maintain them.

Having a few trained technical personnel is a system developed by which similar system and components in different equipments makes and brands are maintained and operated by single technical personnel. In this maintenance strategy, a technician who can make trouble shooting and maintain an electrical system of DAF buses should also inspect and maintain Mercedes, Fiat and so on. This strategy requires excessive training to upgrade the technical capacity of the technical and operators in order to cop up with the technology employed in the imported equipment operation and maintenance.

The other alternative is to have number of technical personnel that matches with existing brands. In this case, each vehicle makes have their own respective specialized technician who can operate and maintain different components and systems. This maintenance strategy needs relatively more number of technicians and operator for each equipment brands, which causes higher maintenance labor, training and overheads.

From the above assessments made on the existing system of WIBSE it is found out that none of the alternatives stated above are employed. The enterprise has excess technicians and other workers but no proper management and training to maintain the fleets effectively and efficiently that is why the costs related to salary is increasing while operation revenue is decreasing (see table 3.10). For all these problems the decision and solution is expected from the management. Due to poor maintenance management all profitable and non-profitable buses are repaired without any priority hence high owning cost is revealed. Owning cost is the cost of incurred for the purchase and possession. Owning cost consists of depreciation cost, interest, insurance and taxes (table3.15). Therefore, it is strongly recommended that WIBSE should device a mechanism by which it can hire and retain a few multi skilled technical personnel, who can maintain the existing equipment and vehicles.

Table3. 15 Income statements for the year 1998 budget year

In 1000

Description	1998	Total	Continued		
Route revenue	18,113		Transport and handling		
Coordination commission	3,678		Depreciation	917	
Other revenue	<u>2,127</u>	23,918	Insurance	870	
<u>Expenses</u>			Interest	617	
Salary and wages	7,426		Utilities		
Over time	875		Tele, telex and postage		
Traveling and perdium	1,592		Rent		
Fuel and lubricant	7,030		Stationary and off supp		
Spare part and repair	3,180		Others	1,502	25,394
Tyre and tubes	1,385		Net loss		1,476

Besides, it should train technical personnel and supervisors to equip them with sufficient skills to develop and apply effective maintenance system. For the first and foremost management guidance and monitoring is compulsory. This helps WIBSE to utilize the vehicles to the required capacity. In general, having few multi-skilled technical personnel, few brands (makes) of vehicles and equipments enable the enterprise in developing low cost of operation, maintenance and down time.

3.7 Vehicle maintenance management system

As one can understand from the past brief explanation regarding vehicle status, WIBSE face a problem of maintenance systematization. This was revealed by high percentage of bad and poor status of vehicles owned by WIBSE. The higher percentage of bad and poor status of fleet resulted in large owning cost and down time cost, hence no profit but continuously loss that attributed to lack of proper maintenance management system.

The existing maintenance of WIBSE mainly can be categorized in to the following two types:

Break down maintenance-as the topic indicates, breakdown maintenance is the system in which equipment/vehicle is run or operated until breakdown. This is one of the main types of maintenance system practiced in WIBSE. The main causes of the implementation of breakdown maintenance system in the enterprise are:

- Lack of company wide vision ,hence lack of strategic plan in long term
- Lack of proper maintenance management system
- Lack of training as well as commitment of all employees
- Lack of sufficient budget to purchase necessary spare parts for periodically maintenance and service
- Lack of information:
 - The reasons for the break down, since no record analysis
 - How to carry out the repairs
 - How to acquire the spares
 - Who is qualified enough to undertake the repair
 - The exact fund from which payment has to be made for these works.
- Unpredictability of failures of components

- Gradual wear and tear of parts, which can be eliminated to a large extent by regular inspection known as preventive maintenance.

Minor lubrication change maintenance program (lube maintenance)-Minor lubrication maintenance program includes the tasks of changing hydraulic oil engine oil, differential oil, brake fluid, oil filters, belts, air cleaners and greasing of components. It is the second type of maintenance system practiced by the enterprise. In this case, vehicles are not overhauled until it breaks down, except that with the lubrication change program in which it takes longer for the vehicle to break down. This is regularly practiced only for some time, and then slowly fades. After some time, things are forgotten and the attention for the routine lubrication program is missed. Workers are not interested in periodic maintenance as a whole and management is not considered PM as basic principle furthermore top management considers that maintenance is departments' task. Consequently, due to improper maintenance systems prevailing in WIBSE, the vehicles minor lubrications change programs are taken place with the break down maintenance system.

The disadvantage of existing system of WIBSE is that they are mainly conducted at higher cost and more downtime.

These are mainly composed of:

- (a) Higher owning cost due to short service life of vehicles
- (b) Higher operating costs which is caused by
 - Excessive fuel consumption and lubrication
 - Frequent repairs due to breakdown
- (c) Higher vehicle downtime cost due to low availability
- (d) Shortage of manpower to conduct preventive maintenance due to more breakdown jobs
- (e) More road break down, hence, higher maintenance cost and loss of customer satisfaction, cost for assigning another bus.
- (f) Higher spare part consumption

Overhaul: - In WIBSE over hauling is taking place after a vehicle is disabled due to higher frequency of breakdown and performed without thorough estimation of costs with respect to the expected service.

Having evaluated the existing maintenance systems as well as their cause and effects, it is strongly recommended that WIBSE must develop effective and proper vehicle

maintenance management system. It is necessary to train the maintenance personnel and inspectors/planners to understand the use and advantages of preventive maintenance, maintenance planning and scheduling. Management is responsible for changing the existing system in to proper and effective maintenance system and continuously monitored.

3.8 Situation of planning and control system

The existing maintenance practices are breakdown and minor lube. In the absence of PM it is too difficult to control and plan activities properly. Thus, it is compulsory to consider the problems of maintenance planning and control system with the prevailing situation of maintenance management system. The improvement of maintenance management system of WIBSE should be in planning, control and analysis of maintenance costs such as, labor cost, spare parts cost, fuel and lubricant and others. Maintenance planning requires forecasting of inspection time, repair schedules, manpower and spare parts requirements. Maintenance works can be forecasted, if vehicle/equipments are included in preventive manner. Various manufacturers recommend inspection programs with fixed time replacement and cleaning of fast moving items such as filters, seals, air cleaners etc. and conditioned based replacement of other inspected parts. These program also include tasks such as cleaning, lubricating, adjusting and have to be carried out in definite mileage or operating hours. When preventive maintenance is institutionalized, the program can be corrected in to plans. The planning task will also include forecasting spare parts and manpower requirement.

3.9 Situation of Spare parts

Since the existing system is almost breakdown and minor lube change program, it is obvious that there is no effective and efficient way of spare parts planning and control system. It was seen in table 3.5 that many vehicles are idle the whole month waiting for spare parts. Further more spare parts are purchased depending on budget without requirement forecasts; hence money is waste on dead stock. The requisition is prepared for the need of spare parts by break down maintenance and lubrication change. The other main problem is purchasing of non-genuine parts, this causes higher frequency of breakdown. No reliable and regular suppliers are available. There are also large amounts of dead stock in store because of

mismatch between requirement and the purchased item. The main cause of this problem is improper materials

Table3. 16 Wrongly purchased spare parts and unused as per the requirement

Year purchased	purchased spare parts and available in stock (unused)		
	Transfer to	Amount (Birr)	Total
Before 1997	1997	4,559,634	6,309,271
1997	1998	438,360	
1998	1999	1,311,277	

requirement planning (see table 3.16). For example Birr **6,309,271** is tied due to wrong spare parts purchased, this is because spare parts are bought in bulk based on the budget. On the other hand above 50% of vehicles down time is caused by shortage of spare parts. This shows lack of coordination between supply and maintenance departments. Since we have said that there is low management concerns, corrective action is not been taken on time in the maintenance department rather continues to the current worse situation.

3.10 Work shop capacities

WIBSE has a main workshop in Lideta with estimated area of 20,000 meter square this accommodates the main office of the enterprise and all maintenance activities; 52,000 square meters and a book value of 960,000 Birr Diabako depots in Keira. Lideta workshop is the main one, which provide for all maintenance activities including major overhaul. This compound includes the main office of the enterprise. There is also 2500 square meter in Shashemane town built for workshop and dispatching office purpose by expending above 100,000 Birr but, it is idle without service. This time Diabako depot is used for major overhauls and parking of in-operable buses and parking lot for out side companies. There are no regular workers assigned here but when major over haul is to be taking place workers are assigned.

Rebuilding works of the enterprise is outsourced to Anbesa city bus service; Akaki spar parts Share Company and Ambo machine shop. When components need to be rebuild, it takes more time. This problem can be solved either providing the facility in the enterprise itself or by having long term contract with reliable partner.

The workshop main activities include:-Painting, tyre repair, electrical repair, body and chassis, engine and gearbox, running gear repair, top and major overhaul etc. It is simple to

say all maintenance activities except rebuilding of components such as grinding of crankshaft, valve seat re-facing, cylinder head re-facing ,and cylinder re-boring etc. are done in-house.

3.10.1 Workshop facilities

In organizations that are engaged in road transportation like WIBSE, the importance of sufficient workshop is inevitable. In this aspect WIBSE has sufficient workshop area with proper ventilation and light intensity, but the problem is, the shops are not well organized. Cabinets and benches are not provided; consequently components are put in the floor improperly. Some of the sections such as engine and gearbox repair, painting and others look like stores of obsolete items due to improper cleanness, hence low working atmosphere. Tools and parts are not properly kept in toolbox but everywhere dispersed. This is also cause safety problems and waste of time to find tools and parts. Cranes and pulleys are old and with out proper safety. Now it is better to purchase hydraulic jacks and modern lifting equipments.

Generally even if there is sufficient workshop area, shop organization and tool handling is very poor, hence, great attention is required.

Store:-there is one main store for stocking spare parts under the supply department. In the store there are spare parts and stationery items. Spare parts are stored in-group and according to part number. The group identifies to which type of spare is belonging i.e. DAF, Mercedes, Fiat, Small cars, and workshop equipment or stationery items. Under each group parts are stored in part number. Store keeping and arrangement is good because these are also kept in shelves and parts number. In addition to the part number it is recommended to put spare parts in alphabetical order to facilitate easy finding of parts with out wasting time. Cycle counting of Spare parts is every year, but it is recommended to be in half a year base

Having presented the existing situation of workshops, equipments and tools of WIBSE, the following comments and recommendations are made:

- There are sufficient workshop equipment and machinery to assist the current maintenance and repair activities. But it is observed that the equipment and machinery are very old and working beyond their service life, this influences the quality of maintenance and efficiency of technical personnel. Therefore it is

recommended to purchase new and precise equipments and hand tools with in the budget provided year by year.

- Since preventive maintenance is taken as a main means to solve the maintenance problems, it is necessary to purchase equipments and tools, which help to accomplish preventive maintenance. Specially to know vehicles status, it is better to have engine diagnostic and performance testing equipments or provide this in contract base taking either of the economical one.
- Due to absence of special tools and testing instruments in the shop of WIBSE, conditions of vehicles are not properly monitored, as a result higher frequency of breakdown maintenance are occurred. Service shops with no special tools like WIBSE, there are events that parts are broken unnecessarily, burnt or struck by a large hammer, which may decrease hardness or deform, increase charge of exchange parts during disassembling. In similar manner there is unstable tensioning or fittings, causing imperfect and expensive services at the time of assembling. This cannot be avoided even with skilled technicians in the absence of proper tools and equipments. These are main problems that WIBSE currently facing. So it is recommended to equip the workshops with modern equipments and tools.

The existing situation of WIBSE can be concluded as compared to Basic principles of transportation service

Table3. 17 Comparison between standard principle and actual performance of WIBSE

Description	Standard principle	Actual performance of WIBSE
1.Serviceabilty	High	Low
2.Utilization	High	Low
3.Garage status	Low	High
4.Distance covered	High	Low
5.Up lifted passengers/freight	High	Good
6.Load factor	High	Good
7.Revenue per vehicle	High	Low
8.Fuel consumption	Low	High
9.Tyre expense	Low	High
10.Spare parts expense	Low	High
11.Oilconsumption	Low	High
12.Maintenance cost	Low	High
13.Other costs	low	High

CHAPTER 4: STANDARDIZATION AND CODIFICATION

4.1. Application of standardization

Standardization is briefly described as grouping of similar equipments and vehicles according to their application, model or size [2].

Categorization of equipments and vehicles by their application (duties) are the major classes in which equipment of similar function are grouped together. In the case of WIBSE the revenue buses are grouped in one category and the supporting light vehicles in another category. In the same way the remaining workshop equipments and tools are grouped in their respective category. Further classification of WIBSE's vehicles can be conducted depending on their make and model to suit for maintenance and spare parts planning. The classification of size based on weight, power of engine, passenger carrying capacity (seats) and some other engineering measures are some of the bases for vehicles and equipments standardization. Thus, the categorization of equipments/vehicles in to sub-classes that helps to utilize the same parts and subassemblies are one of the final goals of standardizing system development.

As we have seen, the vehicles can be classified as for their purpose, makes, models and duties. It could be Mercedes, Fiat, DAF, small cars and workshop equipment and tools. Since there are few varieties of vehicles, standardization is not a big problem for WIBSE, but it is wise to understand that coding is even more facilitating. In this section the factors that should be considered in establishing the system and the merit of its effective and efficient applications are to be forwarded.

Having excessive brands, models and makes needs:

- More budget to purchase and supply spare parts
- More number of technicians/higher multi-skilled
- Higher efficiency in maintenance management system
- Difficulty to have more sufficient suppliers of spares parts

From the current situation, it was observed that there is no big problem due to excessive variety of vehicles or equipments.

Excessive variety and lack of standardization creates the following problems:

- Larger downtime due to waiting for spare part

- Larger lead time of spare orders
- Higher maintenance cost due to small lot size of spare parts
- Higher paper works to order parts
- Higher number of deadline equipment/vehicle that are waiting for repair and spare parts supply
- Higher investment cost
- Higher stock value
- Higher lead time of spare orders etc.
- In order to minimize such problems, it is necessary to develop and implement good standardization.

4.2 Economic benefits of standardization

The economic benefits gained through establishing and implementing standardization system are presented below:

Reduction in the investment of equipment and spare parts: when equipment and vehicles are closed related by good standardization, it is possible to reduce investment costs. Investment cost reduction is obtained by holding lower stock values of spare parts that can be utilized to minimum down time cost.

Cheaper and less difficult to adequate supply of spare parts: standardization helps to reduce the paper work to order and purchase parts. Due to fewer values of stored parts and subassemblies while effective standardization system is developed and carrying cost is undoubtedly reduced.

Small stock values of subassemblies and repair kits to be stored: when well-organized and good equipment standardization system is developed, it is possible that parts and repair kits are commonly utilized. This helps to store minimum stock values of parts and subassemblies that may be stored if the owned equipment varies in size, model and make that cannot utilized parts commonly.

Lower maintenance cost: when owned equipment/vehicles are closely related, the technician will maintain similar equipments and vehicles and become specialized in repairs as well as in trouble shooting. Thus, standardization aids to lower training cost than when equipment and vehicles varies in size, make and model.

Lower operating cost: when equipment and vehicles are closely related in size, make and model, it is easier to replace operators in case of illness, absence or retirement. Thus, effective and efficient standardization resulted in lower training of operators and overhead cost. But due to lack of maintenance management system WIBSE did not use such advantages. Even though WIBSE has no several varieties of vehicles, standardizing the existing system will benefit now and in the future. Further it remedies some of the problems in maintenance management system.

Hence, it is recommended that WIBSE should develop a good standardization system based on their:

- Application,
- Function
- Make, size and
- Model

This can undoubtedly contribute to minimize the existing problems of maintenance management system.

4.3 Codification and its application

Equipment codification: equipment codification is a systematic grouping of equipment/vehicles in WIBSE to give particular identification. In the enterprise, even if there are few varieties of equipment and vehicles with limited makes, purpose, model and size, it is very important to develop codification. There are various systems of codification that can be adopted. Numerical as well as alphabetical codes can be used for the purpose of identification of different items.

The main objectives of codification can be stated as follows:

- To control expenses at source. This can be obtained by developing an identical number in such a way that all costs are recorded on the bases of particular identification number given to each vehicles;
- To control the duplication of parts
- To control and supervise maintenance
- To assist in equipment and vehicle standardization
- To identify easily the equipments or vehicles owned by WIBSE and
- To facilitate computerization of maintenance management.

4.3.1 Application of codification in WIBSE

WIBSE has tried to establish codification system for types of failure, repair classes, types of lubrication and others (See table 4.1). This codification is numerically assigned to systems, failure types, work accomplished and type of oils. But they did not codify vehicles/equipments, office and stationery items.

Table4. 1 Existing codes of WIBSE

Part Failure Codes	System Cods	Work Accomplished Codes	Oil Type Codes
10 Bent	01 Heating & Ventilation System	01 Adjust	01 Engine Oil
11 Bind Sticks	02 Cab And Sheet Metal	02 Clean	02 Gear Box
12 Broken	03 Instruments & Gauges	03 Exchange New	03 Differential
13 Chipped	11 Axles Front- Non Driven	04 Exchange Rebuilt	04 Clutch
14 Cracked	12 Axles Rear-Non Driven	05 Exchange Used	05 Brake
15 Foreign Material Present	13 Brakes	06 Inspect	06 Steering
16 Glazed	14 Frames	07 Lubricate	
17 Insufficient Lubrication	15 Steering	08 Overhaul	
18 Leaking	16 Suspension	09 PM-A	
19 Loose	17 Tires, Tubes, Liners & Valves	10 PM-B	
20 Lubrication Or Oil Soaked	18 Wheels, Rims, Hubs & Bearings	11 Maintenance &Repairs	
21 Misadjusted	19 Automatic Chassis Lubricator	12 Tire Repair	
22 Misaligned	21 Axles Driver -Front Steering	13 Tire Replacement	
23 Not Connected	22 Axles Driver-Rear	30 Work Incomplete	
24 Out Of Balance	23 Clutch	Repair Class	
25 Out Of Round	24 Drive Shaft	01 Reg. Repair	
27 Overheated	26 Gear Box- Main &Standard	02 Accident	
28 Parts Improperly Installed	27 Gear Box Main & Automatic	03 Road Call	
29 Part Omitted	28 Auxiliary Transmission	04 P.M	
30 Poor Fit	31 Charging System	05 Drivers Report	
31 Poor Material Finish	32 Cranking System	06 Pre Delivery	
33 Registers Incorrectly	33 Ignition System	07 Warranty	
34 Rough	34 Lightning System	08 Management Decision	
35 Rusted Or Corroded	41 Air Intake System	09 Tires	
36 Seized	42 Cooling System	Cause Of Repair	
38 Shorted	43 Exhaust System	01 Accident Reported	
39 Soiled Or Stained	44 Fuel System	02 Accident Non Reported	
40 Stripped	45 Engine Assembly	03 Part Failure	
41 Torn Or Punctured	51 General Accessories	04 Rework	
42 Warped	52 Electrical Accessories	05 Mfg. Defect	
43 Weak	53 Expendable Items	06 Fuel/Oil Consumption	
44 Worn	57 Spare Tire Mounting	07 Vandalism	
45 Wrong Part	71 Body	08 Natural/ Unknown	
46 Lost Or Missing	72 Doors	09 Tire Damage/Wear	
47 High Pressure	78 Trm & Misc Hardware		
48 Low Pressure	79 Safety Devices & Equipments		

A codification system that takes in to consideration the location of equipment/vehicle, its class and sub-class is recommended to benefit from the objectives of codification. The coding is presented in the following tables.

Table4. 2 Proposed Departmental codes (location)

Code	Assigned departments/ office
W0	General manager (belongs to the enterprise)
W1	Maintenance department
W2	Logistics department
W3	Finance and personnel administration
W4	Plan and follow up
W5	Internal audit and inspection
W6	Operations department

Table4. 3 Equipment main class codifications

Code	Assigned equipment/vehicle class
1	Supporting light vehicles
2	Heavy duty vehicles(buses)
3	Workshop equipments
4	Office facilities and utilities
5	Workshop tools
6	Spare parts

In the proposed codification system, the code recommended to represent equipment/vehicle/ sub-classes follows the code assigned to main classes. Equipment/ vehicles having the same equipment main class are supposed to have similar functions. Therefore, it can be applicable to adopt similar maintenance plan or cycles depending on manufacturer recommendations, working conditions and age for the equipment/vehicle categorized in the same main class. This simplifies the task of maintenance activities. Besides, maintenance planning and control activities can be easily done by computer

In addition to the above advantages, WIBSE can easily identify the equipment/ vehicle/ to order parts and hold in stock by the aid of the code assigned to subclasses. The vehicles and equipment subclasses and their code shall be presented as under:

Table4. 4 Codification of sub-classes

Code	Assigned sub-classes
11	Pick up single cabin
12	Pickup double cabin
13	Mini bus
21	Mercedes bus
22	DAF buses
23	Fiat buses
31	Work shop machines
32	Work shop equipments
41	Office furniture
42	Stationery equipments
43	Communication items
50	Workshop tools
61	Mercedes spare
62	DAF spare
63	Fiat spare
64	Light vehicles spare

In the designation the first digit represents the enterprise asset, second departmental location; the third digit stands for main class and the fourth one represent sub-class classifications. The remaining is for identification number.

Example1: W1-11(234) represents: W-walia intercity bus service property (asset); 1-belong to the maintenance department; 1-supporting light vehicle 1-pickup single cabin; 234-identification number

Example 2: W0-22 4055- In this case W- walia intercity bus asset; 0-belongs to the enterprise; 2-heavy duty vehicle (bus) 2-DAF; 4055 bus number (identification number)

Spare parts for light vehicle can be further classified in model of car and this is left for the department to code in suitable manner.

For the preventive maintenance proposed in this thesis, corresponding codes are proposed in table 4.5 below

Table4. 5 Preventive maintenance programs codes

Description	Code	Description	Code
Preventive program1 for light vehicle	MP1-LV	Preventive program1 for heavy duty vehicle	MP1-HVD
Preventive program2 for light vehicle	MP2-LV	Preventive program2 for heavy duty vehicle	MP2-HDV
Preventive program3 for light vehicle	MP3-LV	Preventive program3 for heavy duty vehicle	MP3-HDV
Preventive program4 for light vehicle	MP4-LV	Preventive program4 for heavy duty vehicle	MP4-LV
Preventive program5 for light vehicle	MP5-LV	Preventive program5 for heavy duty vehicle	MP5-HDV

CHAPTER 5: DESIGN OF VEHICLE PREVENTIVE MAINTENANCE

Preventive maintenance is a must for all equipment and passenger-carrying vehicles are no exception. A strict maintenance and inspection program is as necessary as fuel in the tank, if the vehicle is expected to provide dependable service. Properly maintained equipment last longer, cost less to operate, is involved in fewer accidents and provides more trouble-free service. Effective preventive maintenance (PM) services must be performed repeatedly as governed by preventive maintenance intervals and schedules.

5.1 Maintenance planning and control system

It was observed that maintenance planning and control system was not developed and practiced so as to utilize the existing vehicles in proper manner. For the effective and efficient implementation of preventive maintenance system, it is mandatory to plan, schedule and control every maintenance activity done in the enterprise. Planning scheduling and controlling preventive maintenance activities are the basis for increased maintenance productivity and motivating the maintenance workers. Here it should be noted that there are other problems beyond the scope of this thesis, which needed further studies.

5.1.1 Maintenance planning

Planning is the determination of all necessary elements required to perform a task in advance of the job start time. It is the heart of good inspection and preventive maintenance; therefore, it is necessary for the maintenance personnel to know the volume of task to be performed by the equipment/vehicle each year, month, week and day in order to plan true preventive maintenance. This helps the maintenance personnel to identify the time when the vehicle is free to under take maintenance. Thus, the cooperation and coordination of operation department with the maintenance department including supplies department is the key for the successful performance of planed maintenance. The requirement of maintenance planning emanates from the fact that planned activities are more cost effective than unplanned maintenance.

In order to plan and schedule good preventive maintenance system, the following factors have to be analyzed and considered:

- Availability of required materials and stores information;

- Availability of technical personnel
- Age of vehicles and /or equipments;
- Availability of necessary tools;
- Vehicle and equipment history
- Working environment or condition;
- Manufacturers recommendation;
- Criticality of vehicles and/or equipment;
- Type of training and/or skill manpower to assist maintenance
- The task performed by the vehicle related to time
- Quality of fuels and lubricant used
- Budget allocation.

In addition to the above factors, it is necessary to discuss the objectives of preventive maintenance with the management to get valuable support for the successful accomplishment of the plan. This enables the management to institutionalize preventive maintenance policy and provide necessary support in releasing budget resources requirements.

The devotion and dedication of maintenance personnel and the supporting staff are the main factors for the successful accomplishment of planned maintenance. Understanding of the objectives and methods to be applied while PM is conducted can assist the development of effective maintenance plan.

From the current practice in WIBSE, it is very difficult to obtain vehicle history for the purpose of planning preventive maintenance, this is because the history is simply a recorded of what was repaired, replaced in breakdown maintenance. Most of the records available are kept for the sake of report not for maintenance improvement or for later use .To start with preventive maintenance through investigation and performance testing of each vehicle have to taken place then after set the preventive maintenance program depending on:

- Manufacturer recommendation;
- Status and age of the vehicle
- Working condition;
- Criticality of the component of vehicle.

-Assign places at which maintenance can be performed alternatively:

- Own workshop
- Dealers workshop

- Private workshop
- Field service with mobile workshop

-Time when maintenance is to be taken place

Availability of technicians for the maintenance work:

- Required tools and instruments
- Required materials,
- Required safety;
- Maintenance procedure
- Standard repair time
- Accurate store information;

Based on the above factors and the existing realities, maintenance plan of WIBSE's vehicles and equipments can be developed from their PM programs and maintenance cycles. Each equipment or vehicle has its own specific maintenance programs adopted from manufacturer recommendation. However, in order to simplify the paper work and minimize the time required to prepare each maintenance program for each vehicle, it is necessary to standardize maintenance programs for vehicle or equipments that are in the same category. One of the benefits obtained when effective standardization is established is that maintenance programs and planning will be simplified. In the following sections maintenance programs of categories of vehicles is presented.

5.1.1.1 Maintenance programs of vehicles

Maintenance programs are as an input for preparation of maintenance plan. Maintenance program is the set of maintenance activities that are planned to be accomplished in a definite interval. Each maintenance program is based on the following factors:

- Manufacture recommendations based on service life of major components;
- Operation conditions.
- Age of the vehicle/equipment;
- Criticality of vehicle or equipment;
- Quality of lubricant and fuel applied;
- Maintenance history of vehicle or reported data;

Although, it is impossible to present exhaustively all activities conducted during each maintenance programs, only the major tasks that should be performed on all equipment and

vehicles of the same category are proposed. The information presented for different maintenance programs are compiled and organized from various manufactures operation manuals, discussions held with senior technicians and drivers, and the realities currently observed in WIBSE. For effective and efficient accomplishment of PM program in the enterprise, the inspectors/planners should identify all activities that are required during a particular PM program and write down on accompanying sheet of workshop repair order.

a) Daily inspection:-it is necessary to conduct daily inspection on each vehicle /equipment by operator. The following general inspections shall be conducted daily:

- Steering oil (for power steering type)
- Air pressure in tyres
- Air pressure indicator for brakes and other accessories
- Fuel, coolant levels
- Crankcase oil level (both before and after starting of operation)
- Leakage and cracks
- Belt tension
- Loosen bolts and nuts
- Safety items (brakes, lights, horns), etc.
- Greasing or lubricating of some functional components as required
- Brake and clutch fluid
- Hydraulic fluid level
- Checking battery cables
- Checking of windshield washer fluid level
- Checking of cab tilt locking
- Checking of instrument panel
- Checking of wheel nut tightness
- Transmission case oil level
- Cleaning and adjusting of functional components as required

In order to implement daily in section it is necessary to train drivers and prepare instructions in Amharic. Daily inspection is the base for PM development in any industry using vehicles and equipments

b) Maintenance program for light duty vehicles (small vehicles), Main class: 1

As it was explain in the previous sections, light vehicles are categorized under vehicles main class (1).

Although the type of maintenance programs and their frequency depends on manufacturer recommendations, the type of vehicle/equipment and working conditions, the following general maintenance programs are recommended to be established and conducted in WIBSE for vehicles categorized in (1)main class.

i) Maintenance program one for light duty (MP1-LV)

Although the intervals at which the type of maintenance is conducted vary with manufacturing recommendation, working conditions, age, etc., it is supposed to be conducted at every 4000 kilometers or two and half months whichever comes first.

MP1-LV includes:

- All activities which are recommended to be accomplished in daily inspection; and
- Checking battery electrolyte level;
- Checking operation of starting/ changing circuits;
- Checking of all hoses for leakage, bends, etc;
- Changing engine oil;
- Rectification of leakage
- Checking and tightening of all bolts and nuts (suspension and others)
- Checking of all lubrication system;
- Checking and changing of air cleaner element as required.

ii) Maintenance programs two for light duty vehicles (MP2-LV)

This maintenance program takes place every 8,000kilometrs or about five months whichever comes first. The activities proposed to be performed pertaining to this section is:

- All activities accomplished in PM1-LV; and
- Checking and adjusting of fan belts;
- Inspecting and changing of glow plugs as required;
- Draining of fuel sediment;
- Changing of fuel filter;
- Changing, inspecting and changing, if necessary, brake lining;
- Cleaning, inspecting and changing, if necessary, brake pad;
- Inspecting and adjusting of front and rear suspensions;
- Tightening bolts and nuts on chassis and body

iii) Maintenance program three for light duty vehicles (MP3-LV)

This type of preventive maintenance is performed every 16,000 kilometers or ten month. The activities performed during this type of PM program include:

- Maintenance program MP2-LV;
- Checking and adjusting of valves as required;
- Checking and adjusting brake system;
- Checking and adjusting suspension system;
- Checking and adjusting power train;
- Checking fuel lines and servicing the system's components;
- Checking and servicing of all electrical lines and systems;
- Checking or changing knuckle seal and knuckle bearings, if necessary;
- Changing steering gear oil
- Inspecting and changing, if necessary, injector nozzle or spark plugs and contact points;
- Inspecting and changing, of steering tie rod ends.

iV) Partial over haul (MP4-LV)

This type of preventive maintenance program is supposed to be conducted every 50 months (4 year and two months) or at 80,000 kilometers whichever comes first based on vehicle condition. The type of maintenance prolongs the service life of the engine before conducting full overhaul. In order to implement this type of maintenance program, it is compulsory to inspect the vehicles engine performance and analyze or evaluate vehicles repair history. The activities accomplished during partial overhaul include:

- All activities performed during MP3-LV; and
- Facing valves seats;
- Changing valve seats;
- Changing valve guide (after inspection and if necessary)
- Changing head gaskets;
- Changing piston rings;
- Changing connecting rod bearings;
- Cleaning combustion chamber;
- Facing cylinder head (if necessary)
- Changing timing belt (depending on manufacturer instruction)

V) Full over haul (MP5-LV)

This type of maintenance takes place in order to upgrade the vehicles' engine performance deteriorated due to longer service life. The maintenance activities accomplished during MP4-LV include complete engine overhaul and rebuilding of deteriorated parts. It is

supposed to be conducted at every 160,000 kilometers or 8-9 year, depending on the vehicle conditions.

The activities accomplished during full over haul of vehicles include:

- All activities performed during MP4- LV; and
- Changing piston assembly
- Re-boring or changing the liner, if necessary;
- Changing connecting rod and main bearings;
- Changing trust washers;
- Changing oil seals;
- Changing all gaskets;
- Facing or changing valves, if necessary;
- Changing oil pump gear;
- Inspecting and grinding of the crankshaft, if necessary;
- Inspecting and changing connecting rod bushing, if necessary;
- Inspecting and changing tappets, if necessary;
- Inspecting and changing camshaft-timing gears, if necessary;
- Changing camshaft bearings;
- Replacing of clutch friction plate;
- Inspecting and changing water hose and water pump, if necessary;
- Checking gear shifting lever synchronizers, if necessary;
- Overhaul of fuel injection pump;
- Checking and overhauling of differential gear;
- Checking and overhauling steering gear and linkages

c) Maintenance program for heavy-duty vehicles, Main class: 2

Heavy-duty vehicle refers to buses of WIBSE, which are a combination of 62 seats of Mercedes, DAF, and Fiat buses.

The code for these buses is M stands for Mercedes, F for Fiat and D for DAF. Even if the makes and models of these vehicles is different, it is possible to give general maintenance program which can slightly modified according to manufacturers recommendation.

i) Maintenance programs one for heavy-duty vehicles (MP1-HDV)

This type of maintenance program shall be supposed to be conducted at every 7500 kilometers or at about one and half months, but due to the current situation of the buses, it is

proposed to be conducted at every 6000 kilometers or three weeks whichever comes first.

The activities of MP1- HDV should include the following:

- Daily inspection;
- Retightening of intake and exhaust manifold mounting;
- Retightening of each part for turbo charger;
- Retightening of suspension u-bolt and spring band;
- Replacing of gear box oil for the new unit and after over haul;
- Replacing of different gear oil for the new unit and after overhaul;
- Replacing of power steering oil the new unit after overhaul;
- Checking of power steering reservoir dust cover;
- Checking of battery electrolysis
- Changing engine oil;
- Changing oil filters;
- Lubrication all necessary components;
- Checking of all hose for bends and leakages;
- Checking of clutch pedal clearance;
- Checking of lubrication systems function;
- Retightening of fan mounting bolt;
- Checking and changing of air cleaner element, if necessary

ii) Maintenance program two for heavy duty vehicles (MP2-HDV)

This type of maintenance program is supposed to be accomplished at 12,000 kilometers or at about every one and half months whichever comes first. The activities conducted while MP2-HDV is performed include:

- Maintenance program MP1-HDV;
- Checking of fan belts and adjusting;
- Check and if necessary, replace glow plug;
- Inspecting, correcting or replacing battery;
- Lubricating steering knuckles, propeller shafts;
- Inspecting and correcting front and rear suspensions;
- Tightening bolts and nuts on chassis and body;

iii) Maintenance program three for heavy duty vehicles (MP3-HDV)

This type of maintenance program is supposed to be conducted cover 48,000 kilometers or every ten-month whichever comes first. The activities to be conducted here include the following:

- MP2-HDV
- Checking and replacing brake pads and lining'
- Checking and adjusting of suspension;
- Checking and adjusting power train;
- Checking for all leakage and loosen components;
- Checking fuel lines and servicing the system's complements;
- Checking and servicing of electrical lines and systems;
- Checking knuckle seal and knuckle bearings, if necessary;
- Changing hub seals and replaces wheel bearings and grease;
- Change steering gear oil;
- Inspect all guards and shields;
- Rubber hose for air compressor should be replaced;
- Rubber hose for exhaust brake should be replaced;
- Rubber parts foe exhaust brake cylinder should be replaced;
- Rubber hose for air and hydraulic line should be replaced;
- Rubber parts for air valves (brake valve, parking brake control valve, relay valve), etc should be replaced;
- Rubber parts for hydraulic cylinder should be replaced;
- Brake chamber diaphragm should be replaced;
- Checking and changing of transmission filter, air cleaner, power steering filter element
- Checking and if necessary overhauling water pump;
- Inspecting and changing, if necessary, steering tie rod ends;
- Adjusting and if necessary replacing clutches.

iV) Partial over haul for heavy duty vehicles (MP4-HDV)

This type of maintenance activity is supposed to be conducted at every 144,000 kilometers or at about every two and half years whichever comes first, to increase the vehicles performance. It prolongs the service life of the engine before under taking of full over haul. The type of activities performed during partial overhaul includes:

- MP3-HDV;
- Changing of rubber hoses for transmission gear oil and cooling system;
- Changing of fuel hoses;
- Facing valve seats;
- Changing valve seals;
- Changing valve guide (if necessary)
- Changing head gaskets;
- Changing piston rings;
- Changing connecting rod bearings;
- Cleaning of combustion chamber;
- Facing cylinder head (if necessary);
- Overhauling of fuel injection pump and replacing nozzles.

V) Full overhaul for heavy-duty vehicles (MP5-HDV)

This type of maintenance shall be conducted at about every 288,000 kilometers or about five years depending on the condition of vehicles. The inspected and reported conditions that help in decision making to undertake full overhaul shall include but not limited to lowered compression pressure, decrease oil pressure, the increment of blow by gas, hard starting of engine, decrement of engine output power, excessive fuel and oil consumption and higher noise than normal. Full overhaul takes place in order to improve the vehicles performance. It is expected to bring the vehicles after MP5 to at least 80% of the new engine performance.

The activities required to be conducted in full overhaul of the buses are:

- MP4-HDV
- Changing piston assembly (piston and piston pin)
- Changing piston rings;
- Re-boring or changing the liner, if necessary;
- Changing connecting rod and main bearings;
- Changing trust washers;
- Changing oil seals;
- Changing all gaskets;
- Facing or changing valves, if necessary;
- Changing oil pump;
- Inspecting and grinding crankshaft, if necessary;
- Inspecting and changing tappets, if necessary;
- Inspecting and changing camshaft and crankshaft timing gears, if necessary;
- Overhauling of gearbox;
- Overhauling of deferential gear;

- Overhauling of steering gear;
- Inspecting and changing water hose and water pump, if necessary

d) Maintenance program for workshop equipments

This type of maintenance refers to the garage equipments, machines and instruments. This can be extracted from the respective manuals and manufacturer's recommendation. The preventive maintenance for these equipments is prepared based on the operation hours. This is left to be prepared by the maintenance department in the same manner as the vehicles maintenance programs.

5.1.2 Maintenance scheduling

Maintenance schedules are prepared for preventive maintenance activities. It is the sequential arrangements by which maintenance is going to be conducted. In general, maintenance scheduling comprises the task to be performed, when to be performed? Where to be performed? Who will perform the task? And the required resources and estimated completion time. The schedule consists of vehicle number and the date of inspection and estimated completion time.

Preparation of maintenance scheduling requires an experienced planner who can put every maintenance activities according to their chronological order, decide required human and material resources and estimate completion time of the activities. Therefore, for the successful accomplishment of PM in WIBSE, it is mandatory to establish maintenance scheduling procedure.

The craft worker's staffing should be determined strictly by the backlog of work for each craft. Craft backlog is the amount of work that is documented as needing to be performed by the craft. The work that is counted in the backlog is only the work that is ready to schedule or that can be performed at present time. The formula to calculate the backlog is as follows:

$$\text{Back log (inweeks)} = \frac{\text{Total planned hours readyto schedule}}{\text{True craft capacity}}$$

The true craft capacity is the total hours scheduled for the craft for a week minus scheduled interruptions. Scheduled interruptions should include average hours spent on emergencies, absenteeism, vacations, and routine or preventive maintenance work. This leaves the total

hours that the craft will actually deduct from the backlog. Illustrative example for (permanent crew =10 and contract crew =2):

Total employee hours scheduled for next week (10 x 40 hours)	= 400 hours
Total over time to be worked (average for last three months)	=40 hours
Total contract labor (2x 40 hours)	<u>=80 hours</u>
Gross labor hours available	= 520 hours
Average emergency work (say 50% for the last three months)	= 260 hours
Average absenteeism/week	=10 hours
Average vacation hours/week	=10 hours
Average routine (non backlog) hours/week	<u>=40 hours</u>
Total deductions	=320 hours
Gross minus deduction	=200 hours

These 200 hours represent what can realistically be expected to be completed from backlog work for the week. This is the number that should be used to determine the true backlog. The calculation would be as follows (assume 2000 hours in the backlog)

Example 1

$$Back\ log = \frac{2000\ hours}{520\ hours} = 3.8\ weeks$$

Example 2

$$Back\ log = \frac{2000\ hours}{200\ hours} = 10\ weeks$$

In the first example it is impossible to complete the work on the backlog given the constraints placed on the craft time available. But in the second example 10 weeks is required to complete the work considering scheduled interruptions and emergencies

Maintenance cycles of vehicles of LV vehicles

Each maintenance program that is conducted on each vehicle / equipment comprises maintenance cycles of vehicles or equipments. Maintenance cycle is the maintenance types that are taking place until full overhaul is conducted on the vehicle or equipment in chronological order. In other words, maintenance cycle is the period between two successive major overhauls of the vehicle or equipment. Examples on maintenance cycles of WIBSE vehicles are presented below:

i) Maintenance cycle for Light duty (LV), Main class: 1

Vehicle category: 1

Vehicle type: Supporting vehicle

$$\text{No of maintenance program per cycle} = \frac{\text{Mileage of one complete cycle in km}}{\text{PM interval in km}} = \frac{288,000 \text{ km}}{6,000 \text{ km}} = 48$$

The maintenance program is as follows:

MP1-MP2-MP1-MP2-MP1-MP2-MP1-MP3-MP1-MP2-MP1-MP2-MP1-MP2-MP1-MP3-MP1-MP2-MP1-MP2-MP1-MP2-MP1-MP2-MP1-MP4-MP1-MP2-MP1-MP2-MP1-MP2-MP1-MP3-MP1-MP2-MP1-MP2-MP1-MP2-MP1-MP3-MP1-MP2-MP1-MP2-MP1-MP2-MP1-MP5

The time of completion of maintenance cycle is 288,000km or about five years

In similar manner it can be developed inspection intervals for garage equipments, machines and instruments according to manufacturer recommendation and operating hours.

Determination of maintenance programs, maintenance cycles and maintenance schedules for each vehicle or equipment simplify the task of maintenance planning. Maintenance planning can easily be determined (derived) from maintenance programs and maintenance cycles. Maintenance planning may be prepared for the life of the vehicle or equipment or working budget year. WIBSE is recommended to prepare annual vehicle and equipment maintenance plan. Annual maintenance plan has to be broken down to quarterly, monthly, weekly and daily maintenance works to be done. The following maintenance planning samples help the maintenance department of WIBSE to prepare and adopt their annual vehicle preventive maintenance plan.

Vehicle main class: 1

Vehicle type: Support vehicle (Subclass: 13)

Vehicle makes: Mercedes

Vehicle model: 300GD

Year purchased: Unknown

Plate No: 3-17054

Mileage: 8000km as of June 30/1998 E.C

Monthly mileage: 1600km

PM interval: 4000km

Last maintenance type: PM2

Position in the cycle: 2

The maintenance (PM) program for the year 1999 E.C is as in the table 5.1 below:

Table5. 1 Annual maintenance schedule for the vehicle indicated above

Date to be conducted	Mileage in km	PM programs	Position in the cycle
July 1/1998	8000	MP2	2
Sept, 15/1999	12000	MP1	3
Dec, 1/1999	16000	MP3	4
Feb, 15/1999	20,000	MP1	5
May,1/1999	24,000	MP2	6
July, 15/1999	28,000	MP1	7
Sept,1/2000	32,000	MP3	8

The sample preventive maintenance plan proposed for the buses for the year 1999 by the aid of preventive maintenance programs discussed in the previous section is presented below:

Vehicle main class: 2

Vehicle type: Transport bus (Sub class: 21)

Vehicle makes: Mercedes

Vehicle model: 360A

Year purchased: 1987

Bus No: 4155

Mileage: 6150 km as of June 30/ 1998 E.C

Monthly mileage: 8000km

Last maintenance type: MP1

Position in the cycle: 1

Table5. 2 Maintenance schedule for the bus indicated above for the year 1999

Date to be conducted	Mileage in km	PM programs	Position in the cycle
July 23, 1998	12000	MP2	2
August 16, 1998	18000	MP1	3
September 9,1999	24000	MP2	4
October 02, 1999	30,000	MP1	5
October 25, 1999	36,000	MP2	6
November 18, 1999	42,000	MP1	7
December 11, 1999	48,000	MP3	8
January 04, 1999	54,000	MP1	9
January 27, 1999	60,000	MP2	10
February 20, 1999	66,000	MP1	11
March 13, 1999	72,000	MP2	12
April 06, 1999	78,000	MP1	13
April 29, 1999	84,000	MP2	14
May 22, 1999	90,000	MP1	15
June 15, 1999	96,000	MP3	16
July 8, 1999	102,000	MP1	17

The same thing can be developed for garage equipments and instruments. This is left for the maintenance department to develop according to the discussed criteria.

The purpose of presenting the samples of annual maintenance plan is to assist the WIBSE's maintenance department to conduct effective and efficient maintenance plan depending on the existing situation.

Improvement of maintenance programs

Currently recommendations are forwarded to start PM programs at definite kilometers or hours of operation mainly based on manufacturer recommendation, working conditions and ages of the vehicles. For the future, it is also important to conduct the analysis of composition of used lubricant in order to decrease or increase the maintenance interval based on condition of vehicles. In a similar manner, it is possible to set the necessary operational mileage or hours of intervals at which engine and transmission oil changing programs are taking place.

5.1.3 Maintenance controlling

For the successful accomplishment of planned maintenance, it is necessary to establish the mechanism by which each planned maintenance input and output activities are controlled.

This has to be done to check whether or not the activities performed are adhered to the objectives set with the limited resources allotted.

Maintenance is controlled based on the following maintenance major input and out put activities. These are;

- Cost incurred;
- Activities required;
- Performance;
- Resource utilized;
- Safety required.

a) Cost controlling: the most neglected part in maintenance activities conducted in WIBSE is the cost incurred due to improper management and lack of top management concern in maintenance of the buses. Drivers and operation department do not want to stop the vehicle for preventive maintenance purpose for the sake of daily payment and short term profit respectively. Technicians are not also willing to conduct routine maintenance rather they are interested in break down maintenance. These cumulative problems make maintenance more complex, more down time and maintenance costs are very high and in some vehicles total operation revenue is less than total cost. The operation of vehicle till breakdown results higher maintenance cost that can be minimized by implementing of preventive maintenance system.

Major maintenance costs that can be controlled include:

-Direct maintenance cost:

- Labor cost;
- Material cost;

- Indirect cost

- Down time cost and
- Overhead cost

Cost recording and comparison system is not established at all in WIBSE. Absence of cost recording and analyzing is the main cause that most of the enterprises vehicles are utilized in the condition of incurring high operation and maintenance cost.

b) Controlling activities required: Most of the activities conducted in WIBSE are not performed or forecasted by planner or skilled personnel. For this reason, it is not possible to control the activities performed on vehicle or equipment and the time each maintenance activity require. All maintenance activities are conducted by trial and error. Furthermore

once maintenance task is ordered and estimated there is no follow up and reasoning for on time completion. The replacement of parts and repair is determined after the break down occurred and the parts are physically checked. For this reason vehicles to be repaired will take longer period than planned. If the parts required are not available in the stock the problem becomes more severe. The top management complains the maintenance department with out appropriate support. Management should give more attention to solve the problem from its root.

In order to improve the existing problem in maintenance activities conducted in WIBSE, establishment of preventive maintenance system is indispensable. Then, it will be possible to control implementation of maintenance activities and set standard time for each job.

Thus, it is recommended that WIBSE should develop the mechanism by which the maintenance activities, maintenance time and spare parts requirement are earlier determined..

c) Performance control: we can see performance control from the technical personnel assigned to conduct the maintenance activities and the vehicle/ equipment maintained point of view. Lack of training and management in WIBSE resulted in low performance of technical personnel. This can be reflected from the fact that most of the technical personnel are not following maintenance procedures but simply by experience and old method. In modern maintenance policy any technical personnel has to follow a certain procedure to maintain, repair or replace parts since this increases maintenance efficiency. Procedures are available in manuals. Proper troubleshooting is not conducted in the enterprise to identify and rectify the problem occurred in the vehicle. The problem solving methods, maintenance activities and procedures are determined from the experience of technical personnel who are assigned to rectify the problem.

After the rectification of the problems identified by mechanic assigned, the maintained vehicle will come to the garage without giving service as expected. The reliability of the maintained vehicle to give service is the second method of evaluating maintenance performance.

It is necessary to device a system by which the productivity and service quality of each technician and the workshop as a whole can be evaluated. The performance indicators of the maintenance department should include the following:

Maintenance costs- the greater the maintenance cost the lower the efficiency

Yearly down time- greater the down time lesser is the efficiency

Service life- greater the service life higher is the efficiency

The performance, which is cumulative of the above, should be the basis for productivity and quality to give incentives and promotions.

d) Resource control: in WIBSE and of course in everywhere resources are limited; they have to be controlled and managed efficiently and effectively. Due to lack of control of technical personnel, tools, and materials assigned to a particular maintenance are wasted unwisely. Therefore, it is compulsory to distribute properly and manage the available resource of the enterprise. The effective and efficient management of resources minimizes the cost incurred due to wastage of resources and increase maintenance productivity.

e) Safety control: safety is one of the most neglected areas that have to be controlled while maintenance is conducted in everywhere. Due to lack of safer working areas in WIBSE, there are enormous resources wasted and damaged. Thus, it is essential to conduct training in the areas where safety problems are evident. Most of the shops working areas in WIBSE are looks like traditional garages, which are not safer to conduct good maintenance work.

5.2 Maintenance workflow system

For successful accomplishment of maintenance activities, it is necessary to develop and implement a clearly known workflow system and use different recording formats. This simplifies the task of maintenance and enhances productivity. Due to improper maintenance flow system the problems that are observed is as follows:

- Lack of standard formats to be used by all personnel;
- Inefficient and ineffective implementation of maintenance workflow system;
- Inadequate reporting system to department heads and managers;
- In sufficient record system;
- Lack of accurate job descriptions for each technical personnel including supervisors;
- Occurrence of frequent accidents;
- Lack of coordination between workers, department, and top management;
- In efficient maintenance work done;
- Lack of clearly identified maintenance flow;

- Lack of management system.

In addition to the above mentioned problems, the technical personnel and the department as a whole did not try to work based on manuals and procedures, rather based on their experience without any analysis of the maintenance efficiency.

In general, the existence of the above and other problems cause low productivity of WIBSE's technical personnel. Therefore, it is strongly recommended that the enterprise should develop a standard and uniform maintenance workflow system with accompanying formats. This will help to compromise conflicting ideas during maintenance work processing.

Maintenance activities pass through different steps and require good decision on each step. This requires not only technical personnel but also maintenance manager to take correction action in relation to the objectives of the enterprise. The procedures in which maintenance activities pass should be known and controlled by the proper concerned people. Therefore, the duties of maintenance manager, workshop supervisors, inspectors/planners, foremen, mechanics and drivers/operators in the process of maintenance and repair have to be clearly identified and controlled

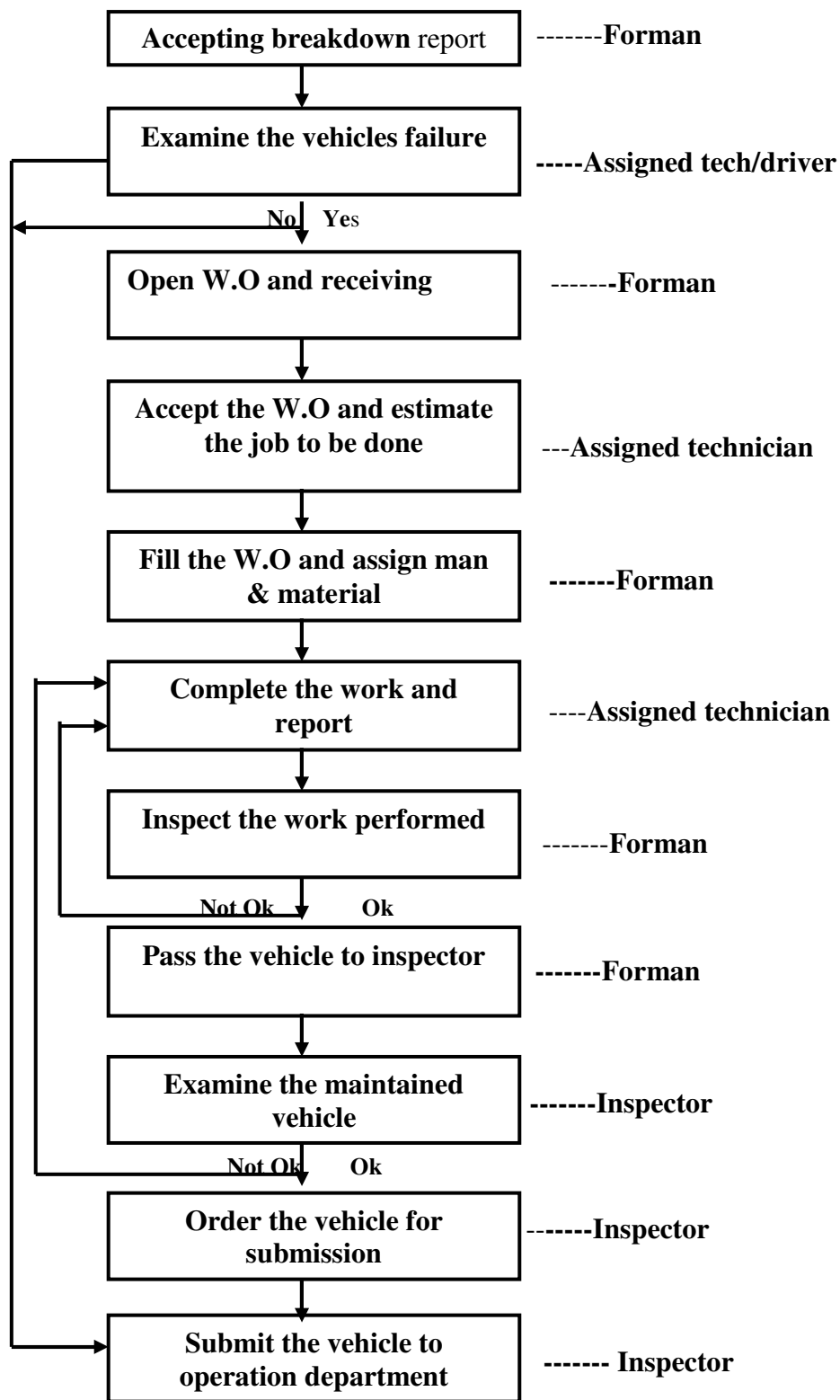


Figure5. 1 The existing work flow system

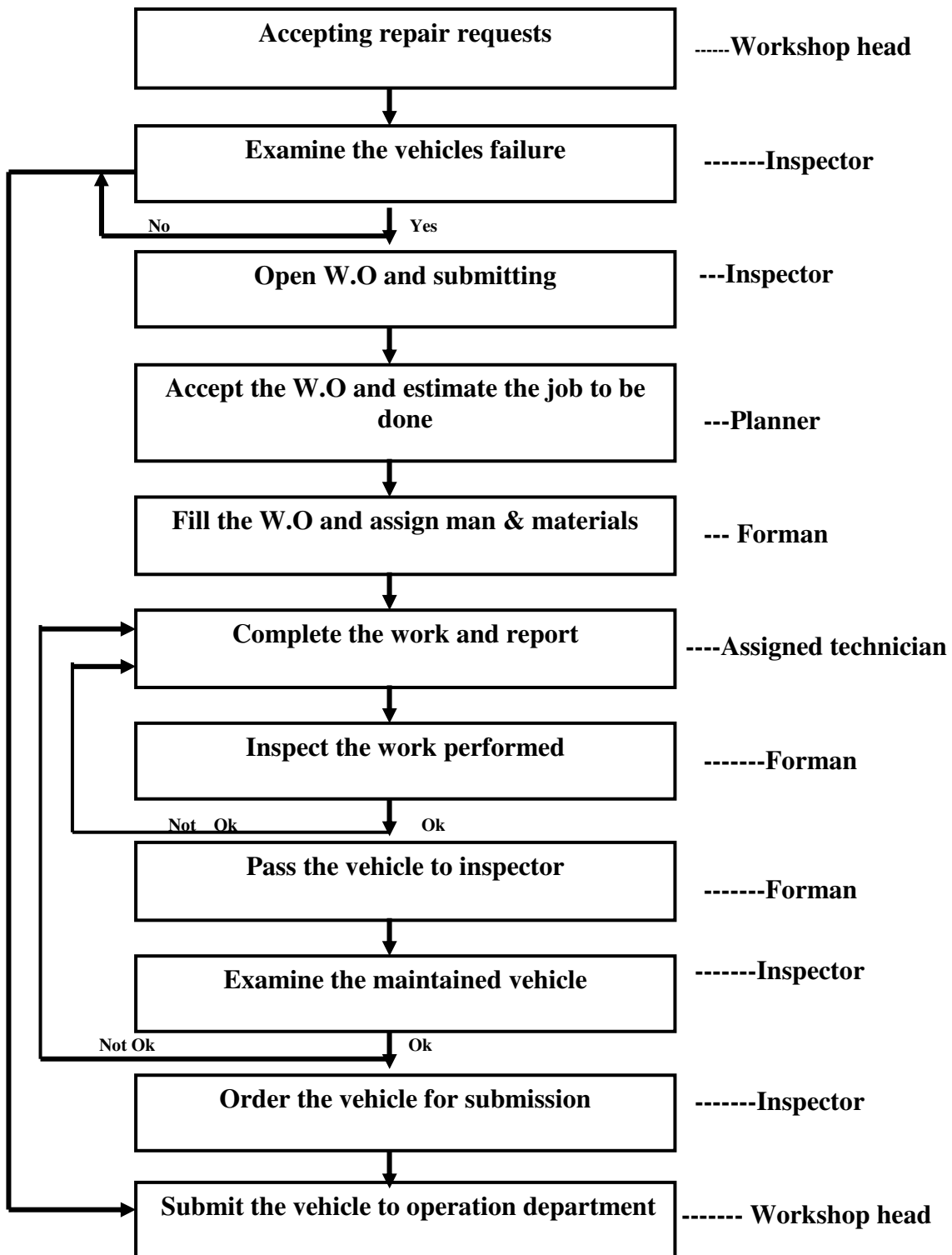


Figure5. 2 Recommended workflow systems

Depending on the type of task to be accomplished and urgency, maintenance work request or service may originate from drivers/operators, mechanics, workshop foremen, workshop supervisors and operations managers. In normal working condition, drivers, supervisors, planners and controllers can be request for preventive maintenance.

After receiving the request for service prepared by relevant personnel, the workshop supervisor or workshop head assigned the technical personnel who can inspect the vehicle to be maintained or repaired so as to prepare work repair order (Refer Fig 5.3 for major activities conducted in maintenance workflow system). The inspectors are required to propose to the workshop supervisor where maintenance can be performed. This has to be approved by the workshop supervisor or head. The vehicles of WIBSE could be repaired or maintained in one of the following:

- Lideta work shop
- Diabako work shop
- Field repair in the case of road break down
- Private/governmental workshops

By analyzing the job required on the work order prepared by the inspector/planner, the shop supervisor determines where the maintenance activities have to be performed.

The task that requires special techniques beyond WIBSE's technical personnel capabilities has to be sent to private workshops or contractors. These work orders have to be approved by workshop manager confirming that the task is beyond the technical capabilities of the maintenance department. The maintenance activities that are performed in WIBSE's workshop are approved and controlled by maintenance department. Almost all of maintenance activities are performed in the Lideta workshop and Diabako. When road break down is reported, the driver tells operation department to take action for the passengers. The operation department reports to the maintenance department with the type of break down and its severity from the driver's point of view. Accordingly the department decides whether the vehicle is to be repaired by sending the mechanics and materials, in private garages or to be towed and bring to Addis Ababa for maintenance.

5.2.1 Request for service

Based on driver's request, vehicle under complaint will be inspected by the technical personnel and then a request for maintenance or repair is prepared. The following information should be provided in the request for service:

- Vehicle/ equipment;
- Vehicle identification number;
- Vehicle service meter, type mileage or operation hours;
- The type of service or maintenance required.
- The components to be serviced or maintained and other necessary information, which may assist the service activities

The workshop head approves the request depending on the standard or conditions set for the request type of maintenance. After approval of request for service, the maintenance clerk prepares repair order. Table 5.3 illustrates the sample formats developed for request service.

Repair order:-The format is filled based on the information obtained from the driver/inspector or the technical personnel who verified the problem. This is a written communication by which the maintenance personnel are authorized to perform the maintenance activities. The format is filled with the necessary information required to service or repair the vehicle. It is believed that any information required to assist maintenance should be described in shop repair order. In general, the objectives of shop repair order shall be summarized as;

- It is used for assigning and controlling of maintenance activities;
- It is used for estimating and recording a maintenance cost;
- It is used to collect data necessary for producing management reports;
- It is used for transmitting job instructions.

Maintenance clerks or shop clerks can open shop repair order. This has to be approved by workshop supervisor or delegated foremen in order to authorize the repair work and request the materials or parts required for the repair.

The inspectors inspect the vehicle and write maintenance instruction on shop repair order and pass it to shop supervisor. The approved repair order is then sent to the foreman who assigns maintenance crew. A copy of the work order is given to the crew leader as job assignment ticket. Upon completion of the work, the foremen complete the work order and pass it to the inspector. The inspector after making check the rectification of the fault passes

the repair to the maintenance clerk where information is transmitted to the history card in the record section.

Finally, a gate pass will be issued and the vehicle is driven out of the maintenance shop.

The information that should be included in a closed shop repair orders are:

- Date of repair;
- Request for service number;
- Work order number;
- Accumulated downtime;
- Activities to be completed;
- Priority of work;
- Total cost;
- Actual labor used;
- Actual material consumed;
- Year-to-date costs;
- Vehicle/equipment identification number;
- Repair location;
- Meter reading and type;
- Out of service date;
- In shop date;
- Out shop date;
- Repair time;
- Down time category;
- Repair type;

Parts requisition and issue ticket (PRI):- parts requisition and issue ticket (PRI) is the format by which workshop technical personnel and warehouse staffs are communicating with each other. It is used for requesting and issuing parts and materials required for repair. PRI is prepared by workshop personnel whom, the material for repair is requested from the stock. If the requested parts are available in stock, they are issued depending on the quantity and description indicated in PRI. In case, where parts requested on PRI are not available in the stock, purchase order is prepared (Refer Table 5.5 for sample of PRI).

Parts return ticket: - It is necessary to develop the format by which issued parts can be returned to the stock. Thus, parts return ticket (PRT) shown in table 5.6 is recommended.

Cannibalization: - Generally cannibalization is not taken as a good solution, but some times it may be applicable when the required parts are not found in stock and in local market. Before cannibalization is authorized, it is necessary to conduct cost/ benefits analysis. Based on the analysis, proposal for cannibalization must be prepared and approved by the general manager.

Recording sheet: - in order to identify easily the types of failures and their frequency, it is necessary to use the history card in which each failure is recorded and monitored. Every

occurrence of failures has to be recorded and incorporated in maintenance history. Vehicle/equipment failure sheet will supply the following basic information:

- Establish fault areas on vehicles to know conditions leading to service breakdowns or harmful depreciations;
- To compute vehicle availability factor;
- To assist in maintenance planning and control.

Monthly maintenance report by vehicle (table 5.7) and annual maintenance report by vehicles (table 5.8) are recommended for effective control of implementation and maintenance cost.

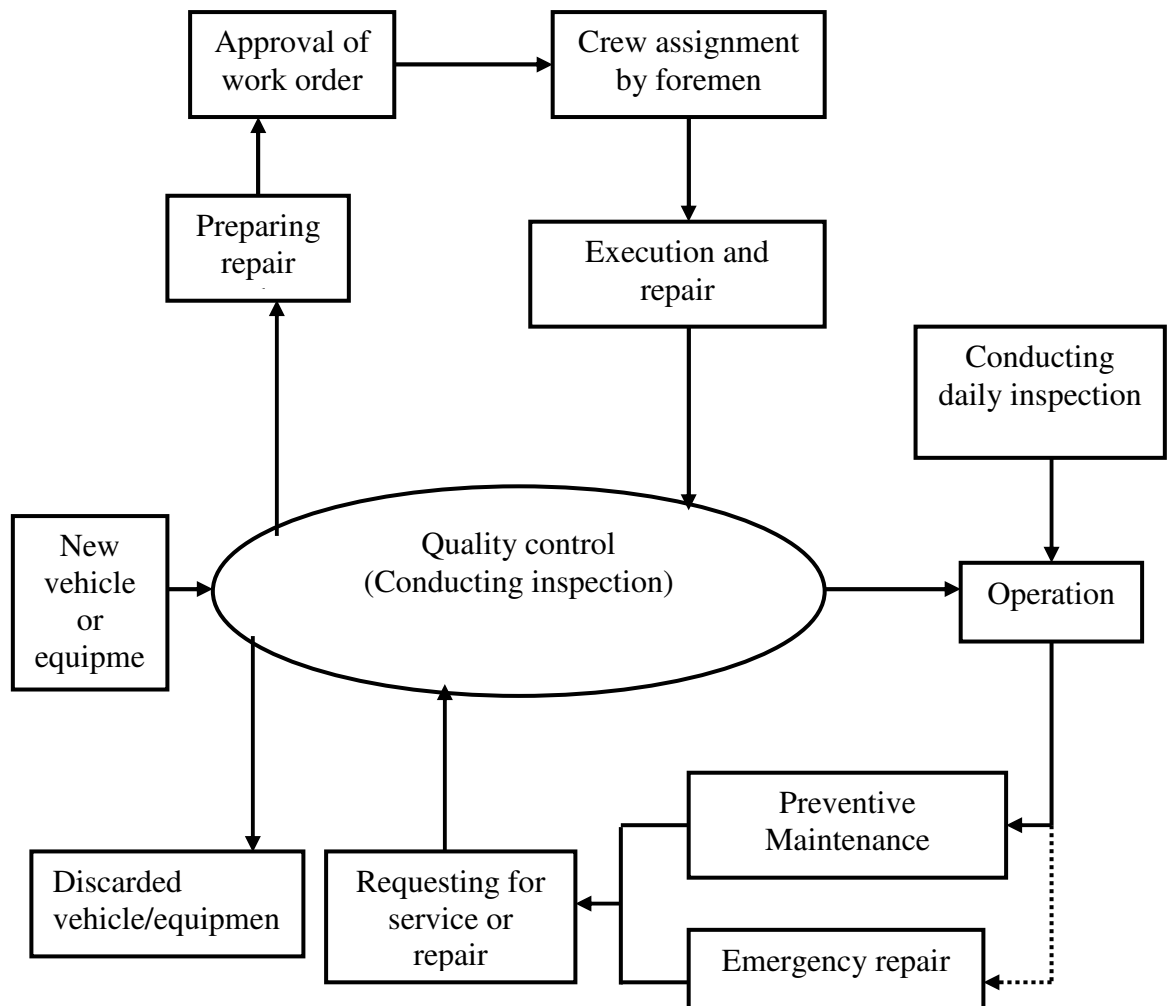


Figure5. 3 Major activities in maintenance workflow

Table5. 3 Requests for Service
Walia Intercity Bus Service Enterprise request for service

No _____
 Date _____

Type of vehicle _____ Assigned section _____ WIBSE No _____
 Meter status _____ Meter reading _____ Meter type _____

Engine		Differential		Electrical		Cond Of Equip.	
	No Power		Noisy		Plugs & Ignition		Cab Body
	Knocking		Shifting		Lights		Body Damage
	Overheating		Oil Leakage		Horn		W/Shield Wipers
	Smoking		Universal Joints		Battery		W/Shield Washers
	Oil Leakage	Steering			Alternator		Gauges
	Oil Pressure		Free Play		Starter		Window Glass
Clutch			Hard		Wiring/Rewind		Mirrors
	Chatters		Shimmy	Fuel			Cleanness
	Grabs		Wanders		Leaks		Safety Equip
	Slips	Under Carriage			Pump & Injectors		Dump Body
	Free Travel		Axle		Lines	Others	
	Grinds		Spring Assembly		Carburetor		All air Systems
Transmission			Tow Chain		Tanks		
	Shift Control	Brakes		Cooling			
	Leaks Oil		Grabs		Leaks		
	Disengage		Squeal		Fans & Belts		
	Noisy		Air Pressure		Water Pump		
Wheel Assembly			Ineffective		Expansion Tanks	PM Service	
	Wheel & Seal		Do Not Release		Thermostat		Service Due
	Hubs		Pedal Travel	Exhaust		MP1-LV	MP1-HDV
	Bearings		Parking	Muffler		MP2-LV	MP2-HDV
	Tires			Tailpipe		MP3-LV	MP3-HDV
	Wheel Lugs			Leaks		MP4-LV	MP4-HDV
				Rattlers		MP5-LV	MP5-HDV

Comments _____

Name _____ Name _____ Name _____ Name _____

Title _____ Title _____ Title _____ Title _____

Sign _____ Sign _____ Sign _____ Sign _____

Date _____ Date _____ Date _____ Date _____

Driver **Requester** **Approved by** **Received by**

Table5. 4 Shop repair order
Walia Intercity Bus Service Enterprise

No. _____

Date _____

Type of vehicle _____ assigned section _____

ID.No _____ Meter Reading _____ Meter type _____

Date _____ Date out _____ Down Time _____

Request for service No. _____ Request for service Date _____

Out of service Date _____

Type of maintenance				
PM	Partial over haul	Body		Corrective
Break down	Complete overhaul	Chassis		Condition monitoring
	Accident	Transmission		

Mark (x) in the box required to be done

Workdescription _____

No.	Work Description	Employee ID.NO	Standard time	Actual time	Labor cost(Birr)	Repair code
Total						

Item No.	Parts Description	Part Number	Qty.	Cost (Birr)		Remark	Priority	P.R.I Number
				Unit	Total			
							Top Urgent	
							Urgent	
							Normal	

Required corrective maintenance: 1) engine 2) brake 3) clutch 4) transmission 5) electrical system 6) wheel and suspension 7) fuel system 8) differential 9) body 10) cooling system 11) lubrication system etc.

Item No	Fuel & Lubricant	Unit	Qty.	Cost (Birr)		Item No.	Description	Cost (Birr)	Cause of Repair
				Unit	Total				Normal
									Accident
						1	Labor		Part replacement
						2	Parts		Comeback
						3	Fuel &Lub		Rework
						4	Washing		Abuse
						5	Others		Wear out
						Total			
						Total year to date cost			Material defect

Name _____ Name _____ Name _____ Name _____ Name _____

Title _____ Title _____ Title _____ Title _____ Title _____

Sign. _____ Sign. _____ Sign. _____ Sign. _____ Sign _____

Date _____ Date _____ Date _____ Date _____ Date _____

Inspected by **Authorized by** **Checked by** **prepared by** **Approved by**

Table5. 5 Requisition and issue ticket

No.		Walia Intercity Bus Service Enterprise Parts requisition and Issue ticket				Ticket No.		
SR.No						Store Acc.No.		
Shop Acc. No						Date issued		
By shop personnel					By store personnel			
No.	Item Description				Quantity	Inventory	Unit price	Total price
	Manufacturer	Part Name	MFR part No.	Quantity Ordered	Delivered	Code No.		

Name _____	Name _____	Name _____	Name _____
Title _____	Title _____	Title _____	Title _____
Sign. _____	Sign _____	Sign _____	Sign _____
Date _____	Date _____	Date _____	Date _____
Requested by	Approved by	Issued by	Received by

Table5. 6 Parts Return Ticket

ID. No.		Walia Intercity Bus Service Enterprise Parts requisition and Issue ticket				Ticket No.		
SR.No						Store Acc.No.		
PRI No.						Date Returned		
By shop personnel					By store personnel			
No.	Item description				Quantity Returned	Inventory code No.	Unit price	Total price
	Manufacturer	Category	MFR part No.	Quantity Issued				

Name _____ Name _____ Name _____
 Title _____ Title _____ Title _____
 Sign. _____ Sign _____ Sign _____
 Date _____ Date _____ Date _____
Returned by **Approved by** **Received by**

Table5. 8 Annual maintenance reports by vehicle

Walia Intercity Bus Service Enterprise

Vehicle/Equipment Maintenance Work shop Annual Maintenance Report by Vehicle

No.	Bus No	Mileage In Km	PM Frequency	Corrective Maintenance Frequency	Over Haul	Body Repair	Man-hours	Down time in days	Labor cost	Spar& Material cost	Other Maint. cost	Total cost

Name _____ Name _____ Name _____
 Title _____ Title _____ Title _____
 Sign. _____ Sign _____ Sign _____
 Date _____ Date _____ Date _____
Prepared by **Checked by** **Approved by**

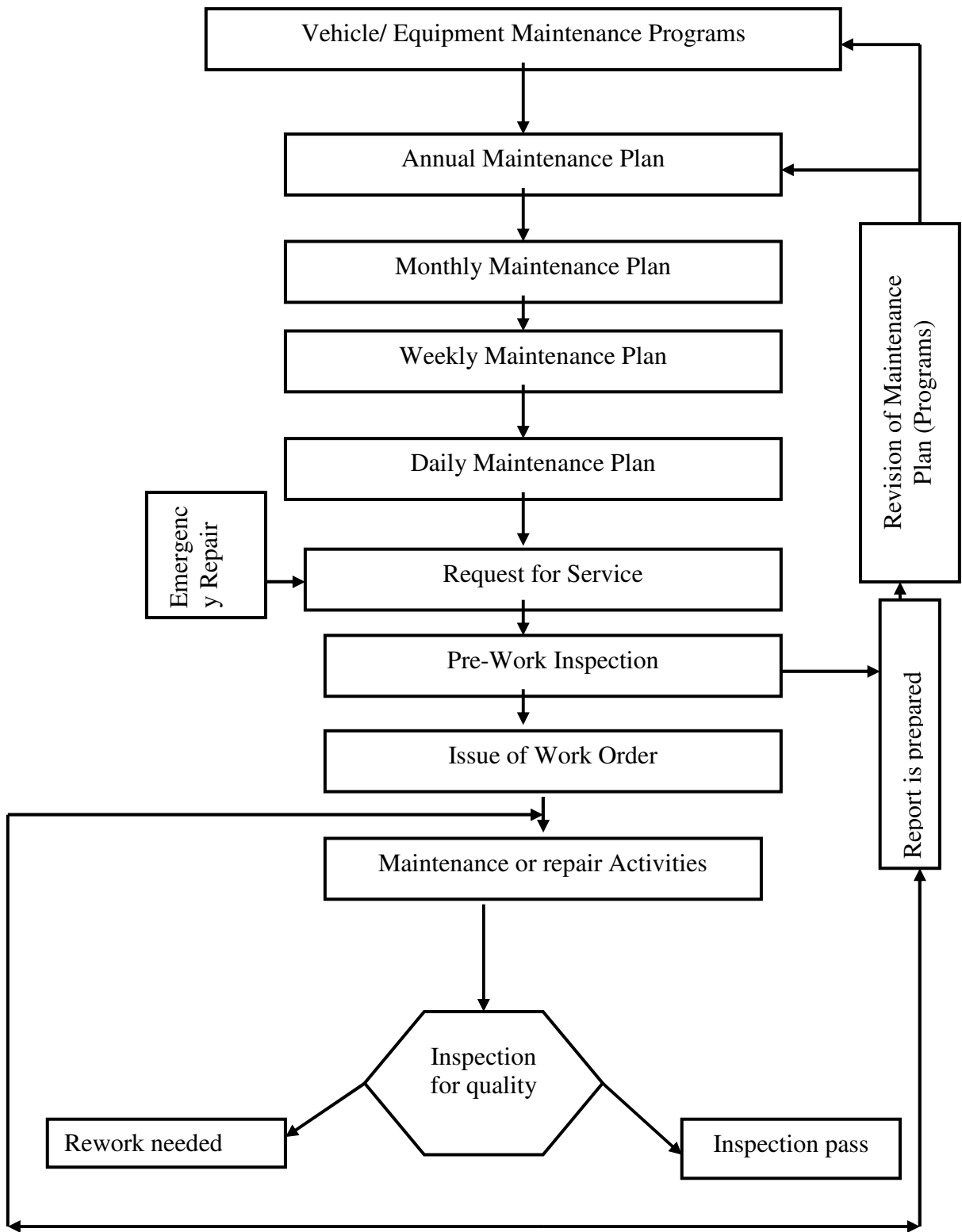


Figure5. 4 Maintenance Planning and Control System

5.3 Spare parts planning and control system

Due to absence of efficient maintenance management system, it is hard to plan and purchase most of the spare parts required for WIBSE's vehicle repairs. The development of effective and efficient maintenance planning and control system is one of the major inputs, which enables to forecast the spare parts requirement. Thus, the maintenance department technical personnel (planners) which are assigned to maintenance planning and control task should identify and propose the parts required for every PM and repair programs. Furthermore, the information obtained from maintenance personnel, operators, and vehicle life history should enable to increase the spare parts availability in WIBSE.

5.3.1 Classification of spare parts

In order to plan the purchase of spare parts required for PM and repair activities to be accomplished in WIBSE, it is helpful to classify the required parts in such way that they can be easily managed and identified. It is relevant and appropriate to apply the FSN approach analysis to the spare parts required for vehicles and other garage equipments PM and repairs. In FSN approach **F** stands for fast moving spare parts that are utilized frequently. **S** represents the slow moving (utilization) of the spare parts that are used in the enterprise vehicles and garage equipments PM and **N** for non-moving parts or dead inventory items.

Fast moving spare parts: - this represents such spares that are replaced periodically while PM is conducted on each vehicle. Frequency of their replacement is very high compared to slow moving and no-moving spare parts. The enterprise can make purchase order depending on the requirement that is obtained from the maintenance planning and control unit.

The absence of parts that are categorized in fast moving class can cause the interruption of PM activities or may cause the reuse of worn out parts and similar parts which are not exact spares that may lead to the damage of vehicles. This is one of the causes of frequent breakdowns revealed in WIBSE. Therefore, it is recommended to place purchase order at an appropriate time by considering the lead time and safety stocks that can help PM activities performed in WIBSE prior to the acquisition of new spare parts. It might be rational to make two annual orders of fast moving items.

Slow moving spare parts:-the utilization of slow moving spare parts is relatively moderate compared to non-moving parts. Replacement of such types of spare parts depends on the existing situation of the inspected component(s) or sub-unit(s) and their function. It is advantageous to order the parts categorized in this class prior to their utilization. The parts categorized in this class are required for heavy maintenance and overhaul. The order of slow moving parts should be on maintenance plan and spare part issue statistics to reduce tied-up capital.

Non-moving spare parts:-this class comprises parts that are not replaced while PM is conducted on different vehicle/equipments. They are used only during accidents, seizing of engine, and during damages that require major overhaul. Most of the parts categorized in this group are costly. Insurance components are categorized in this class. Therefore, it is good to recommend that such parts should be stored in small amount or not at all.

Efficient supply of parts will also require systemization of the workflow in the store. Towards this goal, a spare parts control system based either on a stock card or a computerized stock control system is necessary. The stock card services to record receipts, issues and makes a balance as well as to determine stock value. The maintenance department must know the balance of spare parts. Further it is necessary to use the spare parts in first come first out manner because if spare parts are stored for a longer time it may depreciate or rust.

CHAPTER 6: WORKSHOP ORGANIZATION AND MAINTENANCE INFORMATION SYSTEM

Considering that WIBSE is engaged in public road transport service in cross country which covers long distances, it is necessary to have centralized as well as branch maintenance centers (mobile maintenance) or contractor to maintain/repair its fleets in the case of road break down. The repair branch or contractors are to be selected after through study of cost effectiveness.

WIBSE workshops are centralized and in this case maintenance functions such as planning, scheduling of maintenance activities, work specifications, documentation, maintenance costing, all type of maintenance activities, procurements of parts and contracting out maintenance are kept under direct control of the head situated in the same place. In this case for peak work loads in particular sections the maintenance department can organize and mobilize maintenance personnel and resources from the other sections wherever possible to distribute the loads. This enables to utilize manpower and resources effectively and efficiently.

6.1 Capacities of WIBSE workshops

In this section, mainly the organizational structure and staff planning of the maintenance department are discussed. Recommendations will be forwarded based on practical situation that are practiced, forecasted for future expectations and the past experience of the enterprise. The existing workshop is equipped with old workshop equipments, which does not help to provide good preventive, corrective and condition monitoring activities. This is because the equipments are outdated and the maintenance activities taking place till now is mainly breakdown maintenance. Furthermore the workshop is not equipped for rebuilding parts, so that the enterprise contract out different rebuilding activities to other workshops such as Anbessa garage, Ambo machine shop and Akaki Spare Parts Share Company. This creates problems such as increasing down time of vehicles waiting for rebuild parts.

Since April 1999, the enterprise tries to reform the company as a whole and great focus is given to maintenance because the vehicles availability is becoming very low hence, it is a question of whether the enterprise continues its existence or not.

6.2 Organizational structure and manpower

From the organizational structure shown in fig 6.1 the maintenance department has no direct supervising over the supply department, which purchase and supply spare parts. The relation may be advisory type. The supply department is responsible for purchasing, stocking and distributing of all types of items such as spare parts, stationery items, office furniture, workshop equipment, machines as well as fuel and lubricant.

Purchasing of spare parts has to be controlled by the maintenance department hence; the spare part portion of the supply department should under the maintenance department. Otherwise the problem of mismatching between requirement and purchased items is continuing as in the past years (see tables 3.5 and 3.16).

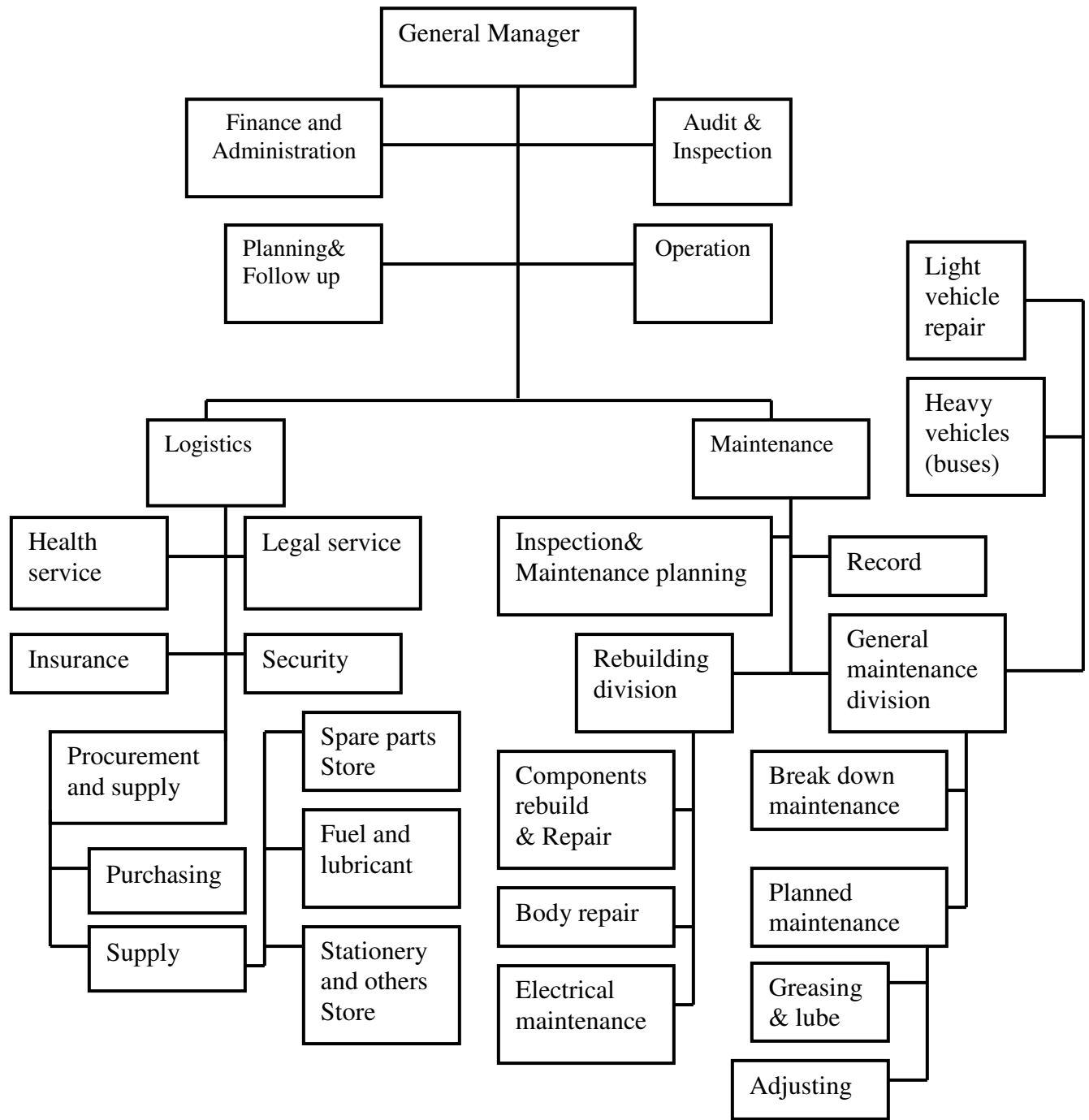


Figure6. 1 Existing Organizational structure of WIBSE

6.2.1 Maintenance Department

The maintenance department is responsible for all types of maintenance of vehicles and machines. Planning and control of all preventive and break down maintenance of the fleet are conducted by direct supervision of the supervisors. When operation department reports road call, the concerned maintenance people examine the action to be taken based on the reported phenomena. All types of maintenance including overhauling are performed by the enterprise itself. But rebuilding of parts such as crankshaft, camshaft, cylinder re boring etc. are taken place in Anbesa, Ambo machine shop and Akaki spare parts.

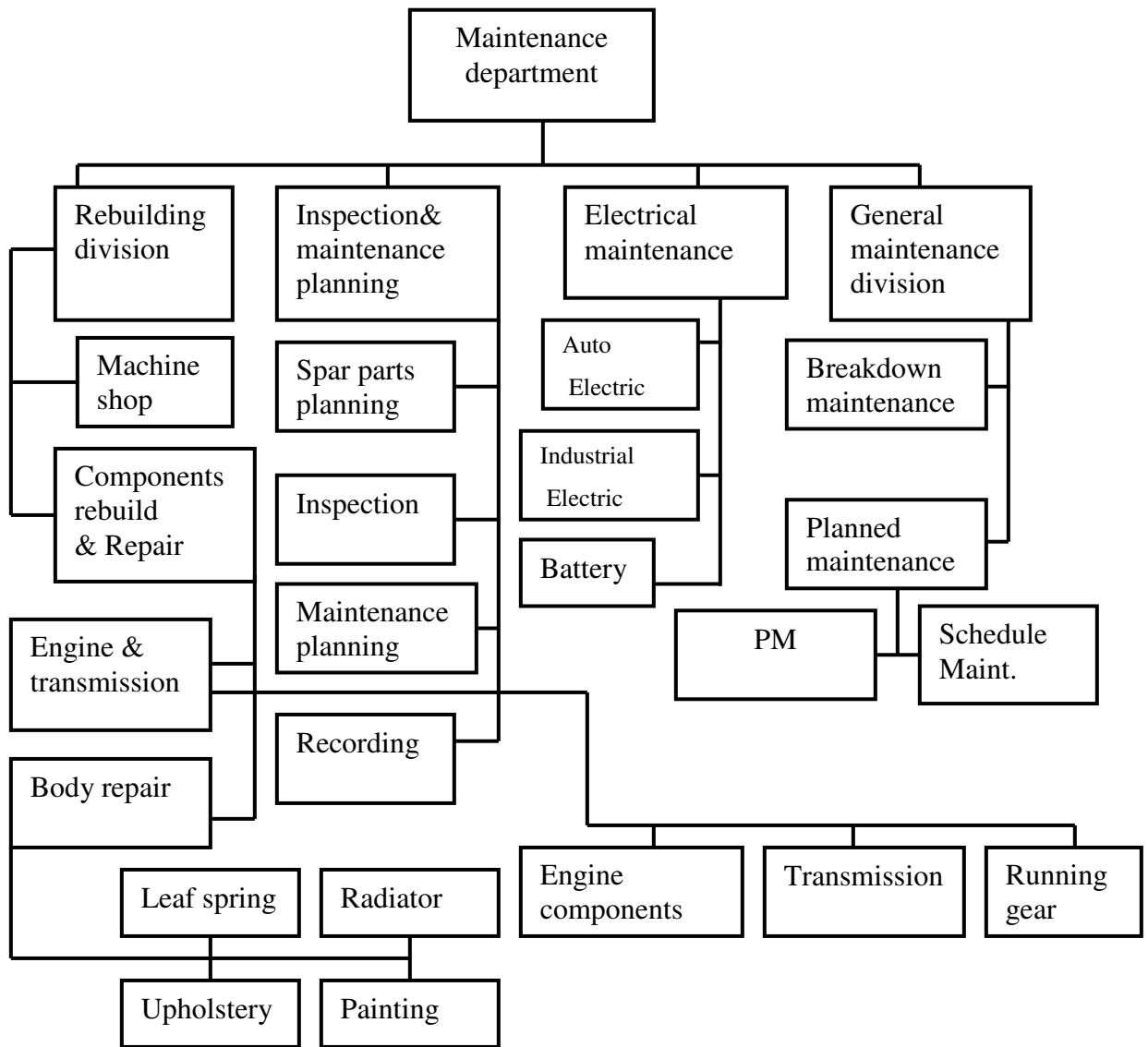


Figure6. 2 Recommended structure of maintenance department

Table6. 1 Existing manpower in the maintenance department of WIBSE

S/N	Job Title	No of Workers
Break down maintenance		
1	Road call coordinator	1
2	Maintenance Forman	2
3	Lead Mechanic	4
4	Mechanic	43
5	Lead tyre man	1
6	Tyre man	15
7	Maintenance clerk	3
Leas & service bus maintenance		
1	Forman	1
2	Lead mechanic	1
3	Mechanic	3
Light vehicles maintenance		
1	Mechanic	4
Preventive maintenance		
1	PM Forman	1
2	Lead mechanic	1
3	Mechanic	5
4	Vehicle washing & greasing lead	1
5	Grease man	6
6	Oil & grease clerk	1
7	Vehicle washer	20
Engine repair shop		
1	Engine repair Forman	1
2	Lead mechanic	1
3	Mechanic	11
Injection Pump repair shop		
1	Injection Pump repair	1

2	Lead Injection Pump repair	1
3	Injection Pump repair man	3
Unit repair shop		
1	Mechanic	4
Machine shop		
1	Lead machinist	1
2	Machinist	4
Body shop		
1	Body shop Forman	1
2	Lead body man	1
3	Body man	16
4	Leaf spring repair man	3
5	Radiator repair man	2
6	Upholstery man	5
7	Carpenter	3
8	Painter	3
Electric shop		
1	Electric Forman	
2	Lead electrician	1
3	Auto electrician	8
4	Battery man	1
5	Industrial electrician	2
6	Electronics technician	1
7	Maintenance clerk	2
Inspection & quality control service		
1	Inspector	6
2	Crane operator	1
Maintenance information & planning		
	Maintenance information & planning clerk	6
Total		203

The workmen are working in two shifts but as it was already seen in the previous section (chapter 3 tables 3.13) that there is excess manpower, for this operation revenue is decreasing while salary related expenses are increasing (table 3.10). The organization is working on two-shift basis, which is not recommended. In order to be profitable, WIBSE should change the two shift working system into one shift working system while reducing workers. This enables to have few qualified workers with better payment. Furthermore the enterprise

should select the busses in good condition and maintain buses in the fair status to make good. On the other hand it has to dispose buses which are old and non profitable. Based on the above consideration the (42 good status + some selected from the fair status) should be selected and for these buses the following manpower are recommended.

Table6. 2 Recommended manpower requirements for one shift

Heading	Job Title	Qty	
Maintenance Department	Manager	1	
	Secretary	1	
	Office boy/girl	1	3
Maintenance Division	Manager	1	
Breakdown Maintenance			
	Maintenance Chief	1	
	Lead Mechanic	2	
	Mechanic III	3	
	Mechanic II	3	
	Mechanic I	3	
	Lead Tyre man	1	
	Tyre Man	4	
	LV Mechanic II	1	
	LV Mechanic I	1	
	Maintenance Clerk	1	20
PM and planned maintenance	Lead mechanic	1	
	Maintenance Chief	1	
	Mechanic III	7	
	Mechanic II	9	
	Vehicle washer	6	
	Grease Man	2	26
Rebuild Division	Manager	1	
	Maintenance Clerk	1	
Component Rebuild & Repair			
	Engine Shop chief	1	
	Lead Mechanic	1	
	Mechanic III	4	
	Mechanic II	4	
	Lead Injection Pump Repair	1	
	Injection Pump Repair Man	2	
	Lead Machinist	1	
	Machinist	2	16
Body repair			
	Body Repair Chief	1	
	Lead Body Man	1	
	Body Man	8	
	Leaf Spring Repairer	3	
	Radiator Repairer	2	
	Upholstery Man	2	

Heading	Job Title	Qty		
	Carpenter	3		
	Painter	1	21	
Electrical Maintenance				
	Electrical Maintenance Chief	1		
	Lead Electrician	1		
	Auto Electrician	5		
	Battery Man	1		
	Industrial Electrician	1	9	
Inspection & Maintenance Planning	Manager	1		
	Inspector Supervisor	1		
	Maintenance Inspector	3		
	Crane Operator	1		
	Maintenance Planner & Controller	4		
	Data Encoder	2	12	
	Total	110		110

6.3 Training

In organizations where equipments, vehicles and or machines are available to be maintained, continuous training is indispensable to cope up with the dynamic advancement of technology in order to compete with the market change. The important of training becomes compulsory if new vehicles and or equipments are imported. Even if the vehicles and equipments of WIBSE are not new and variety of makes and models are relatively less, training is still holds valued to maintain the existing vehicles in an efficient and effective manner. The enterprise's technical personnel have not taken any training for long time. Some of the prevailing problems in WIBSE are:

- Frequent accident occurrences;
- Lack of motivation;
- Low productivity of the maintenance department;
- Improper stock management and spare parts planning;
- Lack of maintenance planning;
- Ignores PM;
- Work done is solely depending on experience;
- Low supervisory activities;
- Lack of top management focus to maintenance;
- Improper handling of tools, equipments and vehicles

To minimize the effects of the above problems that face the enterprise, the establishment and implementation of effective and efficiently training programs will be one of the important solutions.

6.3.1 Level of training requirements

In order to develop and implement planned and efficient training program, it is vital to know the types and level at which training should be conducted. The author recommends the following training:

a) Top management training

Top management training includes all department heads and the general manager, which is decision makers of the enterprise and could have save the enterprise from the accumulated loss. The author recommends the training required for this people after examining the problems revealed in the enterprise top management. The course may include:

- Transportation leadership
- Facilitating change through team building
- Total quality management and BPR
- Integral performance management for business sector
- Strategic planning and management for business sector
- Transport management and customer service

b) Supervisory level training

The supervisory level training includes the training required for maintenance manager and other top-level management people who have direct or indirect impact on vehicle/equipment maintenance management system in the enterprise. This type of training shall be required for all mechanical engineers that are assigned to manage and run the maintenance department. For the development of good maintenance management system in WIBSE, it is compulsory to train all mechanical engineers and senior diploma holders who are in the higher position to accomplish the tasks that are related to maintenance management by conducting supervisory level training. From the existing realities, the staff assigned to run and manage maintenance is solely on experience. Thus, it is necessary to conduct supervisory level training. The proposed supervisory level training shall be related but not limited to the following:

-Maintenance management

- Maintenance planning
- Maintenance priorities
- Maintenance control

-Vehicle/equipment management systems;

-Inventory management system;

-Human resource management;

-Time management;

- Industrial safety;

-Maintenance facility management;

-Computer application in maintenance management

-Trouble shooting techniques using electronic instruments

c) Middle level maintenance training

In this category of training all shop foremen, inspectors, and senior mechanics and technicians are participating. They are responsible for workshop leadership in which they are assigned and decide on the technical matters they face in their day-to-day activities. The type of training that is conducted for middle level maintenance supervisors must be a combination of on-job training and classroom training. The training programs that are required to be conducted to all middle level maintenance supervisors include:

- Industrial safety condition;
- PM scheduling;
- Cost estimation and quality control system;
- Maintenance priorities;
- Maintenance reporting;
- PM types and their accomplishment;
- Maintenance facility management;
- -Maintenance records and documentation system;
- Time management;
- Employee/workers/ personnel management;
- Condition monitoring

d) Maintenance training for operation level

All of WIBSE shop clerks and workshop technicians are grouped under this heading. The main objectives of conducting an appropriate training for such class is remedy the existing problems in decreasing maintenance and operational expenses. Basic knowledge is to be

given to the working personnel grouped in this category. By developing planned training system, WIBSE will be able to enhance maintenance activities and to increase the potential of vehicle availability. The types of training to be included here are:

- Shop safety and hazard prevention
- Time management
- Trouble shooting techniques
- Hydraulic and pneumatic principle
- Maintenance of equipments

e) Operators and drivers training

Most maintenance organizations or departments are overlooked operators and drivers. But it is indispensable that vehicle drivers play great role in increasing or decreasing the service life of vehicle /equipment. Improper handling and driving shorten vehicle life faster. Furthermore operators and drivers are in the first line to perform primary (routine preventive maintenance and inspection). Therefore it is strongly recommended that WIBSE should include drivers and machine operators in the training program. The training program to be included here are:

- Proper and Safe driving and passengers handling;
- How to perform Routine inspections and top-up if necessary before and after operation;
- How to repair minor faults during road breakdown;
- Road calls reporting and accident prevention;
- Techniques of trouble shooting by sounds and other operating conditions

6.3.2 Possible training institutions

There are governmental and private institutions that can provide the mentioned training in the country. They have the ability for preparing training both by assigning skill instructors, as well as coordinating the manpower and the materials, which are essential for the training, required. But there are problems of identifying what type of training is required to enhance maintenance productivity and motivation. More over, financial constraints also limit training in higher-level programs to be conducted in the country and abroad.

The following governmental and private organizations can provide the required training, as the author believes:

- Addis Ababa University
- Ethiopian Management Institute

- Defense Engineering College
- Nazareth Technical College
- Road Transport Authority
- Ries Engineering Share Company
- National Motors Corporation
- Automotive Manufacturing Company of Ethiopia (AMCE) S.Co
- Motors and Engineering Company of Ethiopia (MOENCO) S.Co
- Mesfin Industrial Engineering S.Co
- Ethiopian society of Mechanical Engineers (ESME)
- Ethiopian Society of Industrial Engineers (ESIE)

6.4 Maintenance information system

In order to utilize the vehicles properly, it is mandatory to develop and implement efficient and effective maintenance information system by WIBSE. The establishment of maintenance information system helps to organize and control the enterprise's manpower, vehicles/equipments so as to increase performance and maintenance productivity.

For the appropriate maintenance information system development in WIBSE, computer could be recommended to assist information processing. Therefore, it is necessary to introduce computer system in the maintenance department information system. All data should be properly filed and distributed to concerned personnel on time.

The adoption of maintenance information system will enable to accomplish the following activities promptly.

- Maintenance planning and budgeting;
- Inventory management;
- Repair and maintenance activities report;
- Performance report;
- Maintenance cost
- Vehicles and equipments history records;
- Lifecycle costs of vehicle;
- Spare parts records;
- Spare parts order.

Maintenance activities should report to top-level management including daily shop accomplishments that needs attention of the management. Furthermore the report should reflect the basic performance indicators of maintenance department. In WIBSE, maintenance data is compiled once in three months and some time at the end of the month. The method of gathering data is not organized, and it is for the sake of reporting. There is

no analysis and examining of reports to take actions for improvement.. The author recommends using the benchmark in (appendix-A) for data gathering and reporting. The information supplied assists in improving the observed problems and maintenance management system.

Information can flow from bottom-up and top-down direction. The maintenance information, which passes from bottom to top, helps the management to know the existing situation of lower level workers and the department's performance level. Management can take corrective actions wherever necessary by analyzing the information obtained from the lower level.

In similar manner, information will flow top to down to the departments, from the departments to the lower workers. This is basically emanated from the report obtained from the lower and new policies and regulations to be implemented are passed by top-level management. The information that flows from top-level management can include:

- Maintenance planning;
- Training programs;
- Policies regarding replacement and discarding of vehicles/equipment;
- Spare parts planning and status;
- Promotion and demotion of staff and
- Recruitment of new staffs.

It is very important to adopt efficient and effective maintenance information system, which enables to minimize the existing problems regarding vehicle life history, maintenance records, and maintenance cost and vehicles management.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

From the previous chapters it can be concluded that WIBSE is not performing as per the objective of its establishment. Instead of contributing to the nation's development; the enterprise uses asset of the country for serving its employee. *The external audit report of 1995 states "the enterprise's accumulated loss has reached to 231% of the paid up capital. Consequently, the viability of the enterprise is doubtful, as according to proclamation 25/84, the loss of 75% of the capital may be a ground for the dissolution of the enterprise."* During the past 12 years the enterprise did not have any profit record. Instead cumulates its loss to above Birr 42 million. One of the main causes of the problems is lack of proper vehicle maintenance management system. This problem can be minimizing by:

- Implementing preventive maintenance
- Having replacement and disposed
- Proper spare parts planning and control system
- Use of proper technology and adopt appropriate training
- Having reasonable manpower and sound organizational structure
- Improving recording and reporting methods with flat information system
- - Motivating employees

The existence of high percentage of poor and bad status of vehicles reveals the problem of maintenance management system. Vehicles in poor status are allocated to operation without proper maintenance in order to cover the route allotted; as a result considerable numbers of vehicles are operating with financial loss. Lack of preventive maintenance, shortage of spare parts, low quality of spare parts, and absence of performance measurement, improper data recording and analysis are evidenced.

Higher frequency of repair and accidents caused deterioration of the vehicles from time to time; consequently most of the vehicles do not give the expected service after repaired. It is sufficient to see the serviceability of the vehicles in 1998 budget year which is 57%. Therefore the problem is severe; it is a question of survival. Technical personnel are working solely on their experience without training. Furthermore there are excess employees with non motivating salary.

7.2 Recommendations

In order to solve the existing problems of maintenance management of WIBSE, it is recommended to implement the preventive maintenance program recommended. Successful implementation of the program and other related works is highly dependent on the commitment of top management and availability of resources (budget, skill manpower and reliable suppliers for spare parts). The main tasks to be performed in the implementation process are expressed as follows:

Step 1: Conduct a panel for department heads and open a discussion about the existing problems in maintenance. The general manager or the maintenance department head could present the prevailing problems in maintenance. At this time the major problems that contribute to the current situation of maintenance problems and related issues will be discussed. In the seminar it is expected that participants should come to a conclusion that the problems could be solved as per the author's recommendation and may add some points for better improvement.

Step 2: Having completed step one successfully, form a committee with the authority of monitoring, control and steer the implementation of sound maintenance management. The members of the team should include:

- General Manager (chair person)
- Maintenance manager (vice chair person)
- Supply and purchase manager (secretary)
- Finance manager (member)
- Operation manager (member)
- Planning and follow up (member)

The steering committee has the authority to alter resources and priorities without lengthy bureaucratic process, since the top management is included.

Step 3: Estimate and allocate the necessary budget and resources to run the required activities such as:

-Preventive maintenance program and spare parts to perform the PM. Plan and conduct training on maintenance and spare parts planning and scheduling which are basics for PM implementation.

- Collect and prepare manuals and procedures
- Order spare parts based on the PM and predicted corrective maintenance

Step 4: Establish task groups that can perform and lead different activities to implement sound maintenance management system. Among them a team consists of inspectors and supervisors experienced in vehicle inspection and testing is must. This team is playing great role in investigating the status of the vehicles.

Step 5: Collect/purchase and identify references, manuals and other important documents/records necessary for conducting preventive maintenance programs.

Step 6: Conduct orientation and training to the task groups about the problems revealed in the maintenance and solutions to be implemented. Within the constraints conduct training and discussions as much as possible.

Step7: Prepare and distribute formats to conduct PM activities/programs. Think for possible automation of data processing of maintenance activities such as database control of annual preventive maintenance and spare parts requirement planning.

Step 8: Start PM program for the vehicles in good status. Inspect and test the vehicles in the fair status and Perform maintenance on them depending on the inspection report selectively.

Step 9: After selection and maintenance, cumulate the fair vehicles to the PM program (start PM program on fair vehicles)

Step 10: Estimate the cost of maintenance for each poor status vehicle. Based on the inspection and cost estimation, partial/ complete overhauling and or the top team should decide scraping of these vehicles. Here in addition to the cost estimation, availability of spare parts for the maintenance type to be performed on the poor vehicles should be considered. Take care here; overhauling, reconditioning and rebuild of poor vehicles should compare with the expected service and revenue. Author recommends selling the poor status vehicles and purchasing few new buses.

Step11: Prepare a replacement plan for vehicles and other garage equipments as well as disposal policy for the bad status vehicles. For replacement plan a long-term loan may be possible if budget is not available.

Step 12: Evaluate and monitor the program for implementation as per the objective set.

Note. PM program is an investment; so for short time do not decide by comparing the expenses and revenues. But it is wise to observe improvements in:

- Frequency of break down
- Availability/ serviceability
- Vehicle down time
- Accident occurrences/ road call

- Fuel, oil and lubricant consumption relative to performance and
- Availability of spare parts when needed.

Step 13: Finally revise and take correction action for deviation from the set objective.

Think about maintenance productivity. Performance based incentives should be designed and implemented for better output and maintenance quality.

Strong relation with outsourcing contract maintenance and supplies of spare parts is mandatory to implement the program. Replace the old workshop equipments and machines by new one to increase the maintenance efficiency of technicians.

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APPENDIX-A: MAINTENANCE BENCH MARKS

Indicators	Goal(world class)	Current situation(Walia)
I. Maintenance organizations		
1. Maintenance organizational chart	Current and complete	No chart
2. Job description available for	All maintenance positions including supervisors	No clear job description
3. Maintenance planner to hourly employee ratio	1 to15-20, 1 to 10-15	No dedicated planner
4. Maintenance organizational assignment	Responsibility fully documented	Not as required
5. Maintenance organizational effort and attitude	Excellent , pride in workmanship at all levels	Poor
6. Maintenance shop/work area location	Perfect	Good
7. Maintenance shop work area layout	Perfect	Good
8. Maintenance tools/equipments quality and quantity	Perfect	Quantity good but poor quality
19. What % of maintenance personnel tied to a pay incentive plan based on output/performance	All	Not available at all
II. Maintenance work orders		
1. What % of maintenance man-hours are reported to a work order	100%, 75%	No such system
2. What% maintenance materials are charged against a work order No when issued	100%, 75%	75%
3. What % of total jobs performed are covered by work orders	100%,75%	75%
4. What % of incomplete work orders are kept filed by vehicle number	100%, 75%	75%
5.What % of work orders are filed by vehicle number upon completion	100%,75%	75%
6.What % of work orders are available for history data analysis	100%,75%	No such system
7.What % of work orders are checked by the supervisor for quality and completeness	100%, 75%	75%
8.What % of work orders are generated from PM maintenance inspections required down time, craft hours ,materials etc	80-100%, 60-80%	No except some minor lube
III. Training programs		

1. Supervisory training		No training
2. Planner training/inspector	Have public seminars providing instructions on Maintenance planning and scheduling practices for W.O planning and execution of Spare parts planning and scheduling practices	Generally there is no scheduled training Under this heading. Major improvement is required.
3. General quality and productivity training	Include top management, line supervisor, hourly Workers and support personnel	No scheduled training
4. Maintenance craft training	Training is tied to pay and progression program	Irregular and far from standard
5. Maintenance training intervals (frequency)	Less one year, (12-18 months)	Irregular and far from standard
6. Format of maintenance training	Training is mix of class room and lab exercise	Not applicable since no training
7. Maintenance program instructors	Should be done by outside expert	Not applicable since no training
8. The quality and skill level of maintenance workforce and supervisory group	Perfect	Poor
IV. Preventive maintenance		
1. PM includes:	-Lubrication check lists -Person specifically assigned to the PM program -Detailed inspection lists PM diagnostics	Except some routine maintenance there is no preventive maintenance so it is not possible to quantify PM works
2. What % of PM inspection/task checklists are Checked for completeness	90%, 75-90%, at least 60-75%	Difficult to quantify
3. What % of PM is checked against a vehicle history annually to ensure good coverage	More than 90%, 75-90%, 60-75%	Not at all
4. What % of PM are completed within one week of the due date	More than 90%, 75-90%, 60-75%	Not applicable since no PM
5. What determines the frequency of PM inspection or tasks/service intervals	Condition based, run time and fixed calendar	Run time for lube maintenance; Frequency of break down for over hauling
6. What % of PM actual and results are checked annually for time and materials accuracy	More than 90%, 75-90%, 60-75%	No at all
7. Who is responsible for performing PM tasks	Dedicated PM personnel, specific individuals In each crew/ section	Any assigned mechanic
V. Maintenance inventory and purchasing		
1. What % of time are materials in store when required by maintenance department	More than 95%, 80-90%, 70-80%	65%

2. Who controls what is stocked as maintenance Inventory items	Maintenance department	Maintenance but with out accurate plan
3. Maintenance catalog is produced in:	Alphabetic and numeric, only either of them	Number only
4. What % of maintenance store items is issued to work order or Acc. No up on leaving the store	More than 95%, 90-95%, 80-90%	95%
5. What % of maintenance store items are specified maximum and minimum levels	More than 95%, 90-95%, 80-90%	Not at all
6. A reorder list is sent to purchasing	Daily, every 1-3 days, weekly	Non regular
7. What % of the time are maintenance stores inventory levels updated daily up on receipt of materials	More than 95%, 90-95%, 80-90%	
8. What % of items are checked for at least one issue every six month	More than 90%, 80-90%, 70-80	Once in a year
VI. Maintenance reporting		
1. What % of the time are maintenance reports distributed on a timely basis to the appropriate Personnel	More than 90%, 75-90%, 60-75%	Not specified
2. What % of the time are the reports distributed with in one day of the end of time period specified In the report	More than 90%, 75-90%, 60-75%	Not specified
3. Are the following reports produced:	-Vehicle downtime in order of highest to lowest to total hours(weekly or monthly) -Vehicle downtime in order of highest to lowest in total lost production dollars(weekly or monthly) -Maintenance cost for vehicle in order of highest to lowest(weekly or monthly) -MTTR and MTBF for vehicles	No
4. Are the following points evident in PM reports:	-PM overdue report in order of oldest to most recent -PM cost per vehicle in descending order -PM hours versus total maintenance hours per item as expressed as a percentage -PM cost versus total maintenance costs per vehicle expressed as percentage	No

<p>5.Are these evident in the reports:</p>	<ul style="list-style-type: none"> -Time report showing hours worked by employee divided by work order -Time report showing hours worked by craft in each section -Time report showing total hours spent by craft on emergency/preventive/normal work -Time report showing total over time hours compared to regular hours 	<p>Not at all</p>
<p>6.are the following planning reports produced:</p>	<ul style="list-style-type: none"> -Total work order costs estimated versus total work order actual costs by individual work order, by supervisor, or by craft -Backlog report showing the total hours to schedule versus the craft capacity per week -A planning efficiency report showing the hours and materials planned versus the actual hours and materials used per work order -A planning effectiveness report showing the number of jobs closed out that were 20% over or under the labor or material estimates by planner and supervisor 	<p>No such reports at all</p>
<p>7. Are the following scheduling reports evidenced:</p>	<ul style="list-style-type: none"> -Hours worked as a scheduled compared to Actual hours worked -Weekly crew or craft capacity averaged for last 20 weeks -Total number of maintenance work orders scheduled compared to the actual number of Work orders completed -Number of work orders spent on preventive maintenance compared to emergency maintenance and normal maintenance 	<p>No such reporting system</p>
<p>8.Are the following inventory reports produced:</p>	<ul style="list-style-type: none"> -Stock catalog by alphabetical and numerical listing -Inventory valuation report -Inventory performance report showing stock outs and level of service, turnover rate, etc. -Inventory where used report 	<p>Catalog buy number only</p> <p>No report on turn over</p>

9.Are the administrative report produced as follows:	-Monthly maintenance costs versus monthly maintenance budget with a year to date total -Comparison of labor and material costs as of age of total maintenance costs -Total cost of outside contractor usage broken down by contractor	There is no such reporting system
VII. Maintenance planning and scheduling		
1. What % of non emergency W.O are completed Within four weeks of report	More than 90%, 75-90%, 60-75%	Work is emergency
2. Is W.O planning include : craft required, material required, tools required, specific job instruction or plan	W.O should include all listed points	Include but not accurate
3. What % of planned W.O delays due to poor or Incomplete plan	Less than 10% at most 10-20%	Almost all
4. Who is responsible for planning W.O	Dedicated maintenance planner or supervisor	Supervisor and technicians
5.Maintenace job schedules are issued	Weekly or biweekly	Non regular
6. When job is completed, the actual time, material down time and other information are reported by	The crafts men performed the job; the supervisor of the group	Supervisor of the group
7. What % of the time are the actual compared to the estimates for monitoring planning effectiveness	More than 90%, 75-90%, 60-75%	No such monitoring practice

**APPENDIX-B: REVENUE AND EXPENSE PER BUS FROM
JULY 01/97 TO JUNE 30/98 E.C**

Bus No	Total Revenue	Fuel	Tyre	Oil & Lub	Sp.Part	Others	Total Expense	Net I/L
4044	429,027	137,394	22,595	8,125	25,768	24,521	218,403	210,624
4148	405,543	134,350	8,252	11,978	45,083	23,913	223,576	181,967
4094	372,037	104,752	21,465	6,900	26,514	31,982	191,613	180,424
4112	264,382	55,446	9,631	3,998	18,208	14,162	101,445	162,937
4039	339,373	65,585	8,877	5,440	15,595	89,491	184,988	154,385
4149	277,187	44,310	5,490	1,954	15,390	62,379	129,523	147,664
4089	314,516	75,360	2,397	4,789	19,359	76,091	177,996	136,520
4045	466,335	137,721	32,520	6,450	18,158	155,133	349,982	116,353
4153	332,846	112,511	22,120	8,021	61,287	26,232	230,171	102,675
4157	345,877	121,477	17,092	9,570	37,082	59,234	244,455	101,422
4130	247,103	95,882	8,597	8,853	24,295	9,405	147,032	100,071
4062	334,796	118,436	16,516	5,068	51,397	47,630	239,047	95,749
4125	190,930	45,026	5,774	2,859	22,678	20,178	96,515	94,415
4161	449,803	169,237	42,823	5,324	36,584	13,274	267,242	92,561
4081	348,805	106,768	29,054	10,934	32,640	79,945	259,341	89,464
4158	247,213	89,913	6,267	6,952	38,709	16,262	158,103	89,110
4015	236,388	67,864	8,848	2,433	25,793	43,736	148,674	87,714
4143	181,583	36,591	30	5,434	11,775	40,452	94,282	87,301
4152	263,071	43,424	2,564	4,596	18,842	106,602	176,028	87,043
4163	181,696	23,230	3,123	1,636	25,105	44,401	97,495	84,201
4070	358,013	134,354	30,716	7,382	50,720	51,038	274,210	83,803
4151	384,586	131,660	39,597	6,277	62,391	61,616	301,541	83,045
4138	379,687	91,617	26,694	5,731	30,308	142,788	297,138	82,549
4033	172,111	54,871	1,867	4,854	13,440	17,167	92,199	79,912
4055	275,930	77,883	7,119	6,769	27,955	76,944	196,670	79,260
4108	322,739	99,865	24,584	6,601	69,575	43,049	243,674	79,065
4137	293,672	98,291	17,558	3,194	68,186	28,223	215,452	78,220
4126	329,327	112,333	6,829	11,954	27,576	93,300	251,992	77,335
4134	193,140	49,418	12,067	4,644	21,709	29,265	117,103	76,037
475	155,359	51,782		3,222	4,490	20,614	80,108	75,251
4087	324,671	128,264	19,539	5,011	59,266	38,231	250,311	74,360
4142	181,514	74,235	132	4,080	30,060		108,507	73,007
4123	241,714	75,951	17,316	5,113	55,622	16,147	170,149	71,565
4048	160,363	49,107	6,692	2,480	13,553	18,184	90,016	70,347
4103	320,909	106,378	35,484	7,848	37,835	65,152	252,697	68,212
4113	231,712	99,218	29,331	5,503	31,050		165,102	66,610
4140	183,479	74,314	16,834	4,460	24,700	1,093	121,401	66,516

Bus No	Total Revenue	Fuel Expense	Tyre Expense	Oil& Lub	Sp.Part	Others	Total Expense	Net I/L
467	176,471	80,010		3,819	8,666	17,746	110,241	66,231
4141	214,429	54,350	5,485	4,715	33,202	50,681	148,433	65,996
4133	184,140	75,284	1,529	7,834	20,920	13,417	118,984	65,156
4084	459,359	88,530	52,665	6,838	47,603	201,623	397,259	62,100
4131	202,049	53,485	5,608	4,597	31,392	45,875	140,957	61,082
4090	180,087	58,128	15,770	4,719	25,004	17,418	121,039	59,048
4155	186,112	75,589	19,884	3,741	15,653	13,496	128,363	57,749
4164	171,559	38,123		2,213	3,284	70,982	114,602	56,957
4119	112,251	14,474		1,092	924	39,474	55,964	56,287
4129	94,103	12,722		845	4,444	22,350	40,361	53,742
4167	359,430	133,703	25,836	7,577	66,533	72,890	306,539	52,891
4162	155,313	55,349	11,538	5,589	20,092	10,757	103,325	51,988
767	100,764	14,384	0	1,503	229	34,686	50,802	49,962
4023	151,832	56,027	8,010	5,671	9,709	23,782	103,199	48,633
4056	171,444	66,417	6,311	5,124	45,679	57	123,588	47,856
4034	249,766	68,511	2,588	6,497	17,710	107,090	202,396	47,370
4059	131,888	57,327	4,761	3,195	20,378		85,661	46,227
4075	115,205	32,834	7,378	16,823	3,114	9,703	69,852	45,353
4122	169,254	40,376	7,076	2,998	53,813	19,963	124,226	45,028
4014	93,942	27,869	0	675	2,325	18,924	49,793	44,149
4147	140,717	48,211	7,209	4,956	28,469	9,911	98,756	41,961
4160	165,026	51,984	16,342	3,033	34,562	18,682	124,603	40,423
4021	114,785	15,642	0	333	841	57,657	74,473	40,312
4066	241,681	80,620	15,969	5,785	73,092	28,157	203,623	38,058
4166	143,839	48,715	11,459	3,340	29,245	92,759	185,518	37,271
4032	78,959	11,355	1455	1,047	1,278	27,000	40,680	36,824
4114	157,729	36,744	6,880	3,648	11,218	28,213	86,703	35,742
4146	59,714	7,529	132	719	2,338	15,197	25,915	33,799
4128	48,204							32,006
4025	62,252	19,585	2,095	2,121	3,404	5,942	33,147	29,105
4102	153,986	49,965	7,551	4,296	32,104	32,864	126,780	27,206
4022	86,770	31,321	7,271	1,336	7,176	15,969	63,073	23,697
4144	131,691	51,603	5,242	3,226	49,136		109,207	22,484
4150	51,728	15,362	1,649	1,990	679	11,137	30,817	20,911
4136	198,961	66,570	14,405	3,256	64,094	30,433	178,758	20,203
4017	71,625	22,730	1,594	1,721	11,187	15,230	52,462	19,163
4080	41,380	10,974		8,148	3,147	207	22,476	18,904
4132	174,015	68,778	19,826	4,853	53,025	10,199	156,681	17,334
4058	44,572	16,039	4,569	11,794	3,417	35,819	71,638	16,197
4154	210,197	90,055	6,983	6,173	74,913	17,101	195,225	14,972
4031	68,625	24,315		1,445	2,073	30,089	57,922	10,703
476	8,270				986	650	1,636	7,284

Bus No	Total Revenue	Fuel Expense	Tyre Expense	Oil& Lub	Sp.Part	Others	Total Expense	Net I/L
4117	65,726	16,541	7,997	1,814	16,941	15,682	58,975	6,751
4052	185,543							6,653
4042	6,576							5,927
4127	9,736	1,322	331	375	1,074	828	3,930	5,806
4082	41,103							4,291
4145	137,795	37,018	11,625	3,355	60,839	21,499	134,336	3,459
4139	3,106							3,082
4027	3,112							3,078
4159	2,995							2,603
4115	21,550	9,207	2,210	1,304	4,293	3,010	20,024	1,526
4116	163,756	70,389	17,119	5,191	41,384	28,242	162,325	1,431
478	1,633							1,385
460	1,570							1,319
472	1,356							1,090
790	2,445	455		638	680	579	2,352	93
4060	6,590	5,118			170	1,210	6,498	92
4049								-86
4019	15,909	7,594		747	4,545	3,144	16,030	-121
4050								-138
4047	24							-140
795	2,415	1,802		134	927		2,863	-448
4067								-949
4054	18,808							-3,820
4018	121,330	48,731	10,508	5,007	45,487	19,307	129,040	-7,710
4156	84,457	21,644	1,890	3,973	64,951		92,458	-8,001
794	2,824	8,859		526	1,461	85	10,931	-8,107
4107	27,848	21,888	5,460	959	1,267	6,505	36,079	-8,231
4026	35,795	19,557	5,460	3,027	12,793	5,198	46,035	-10,240
4118	74,078	30,743		3,443	39,119	12,003	85,308	-11,230
4111	115,928	37,503	16,490	3,586	49,590	22,596	129,765	-13,837
4069	69,623	23,948	395	2,495	35,343	21,713	83,894	-14,271
4135	59,158	34,248	5,460	2,889	31,482	80,550	154,629	-14,921
4061	28,169	34			16,702	28,823	45,559	-17,390
4053	153,214	105,840	8,421	10,933	29,253	18,474	172,921	-19,707
4063	2,854	4,028		1,176	31,984	228	37,416	-34,562
4068	15,380			931	5,770	159,907	166,608	-151,228
Total	18,353,967	5,672,876	963,375	438,225	2,611,811	3,411,547	13,097,834	5,079,507

* I=Income, L= Loss *

APPENDIX C: COMPARISON OF REVENUE AND NET INCOME

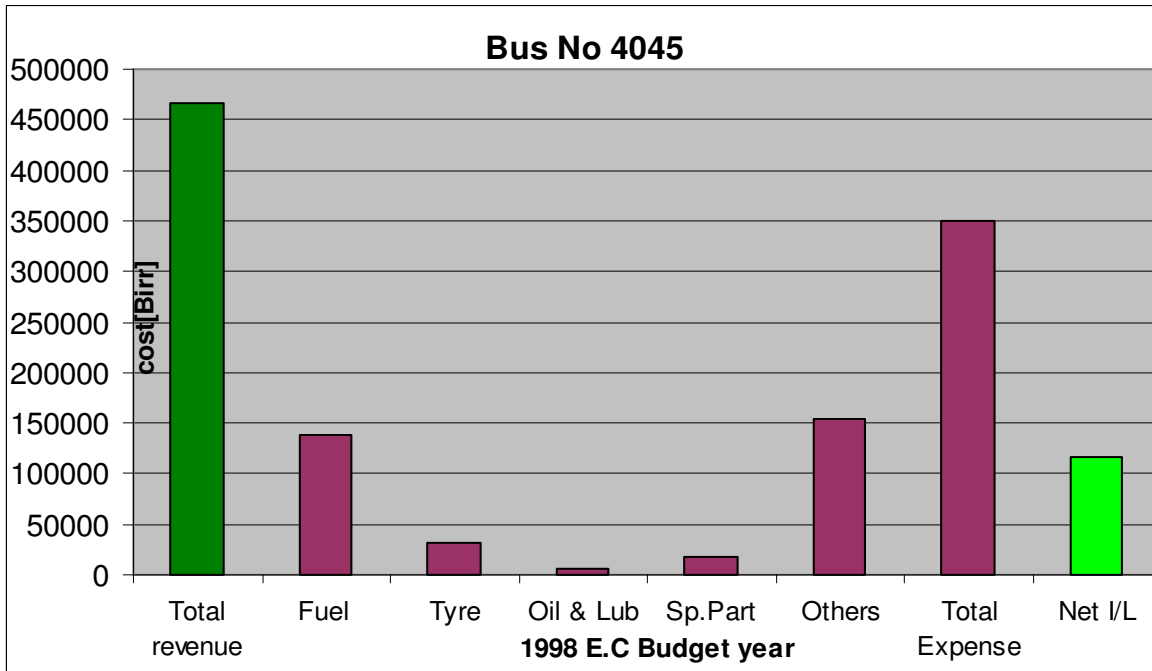


Figure first rank in revenue and eighth rank in net income

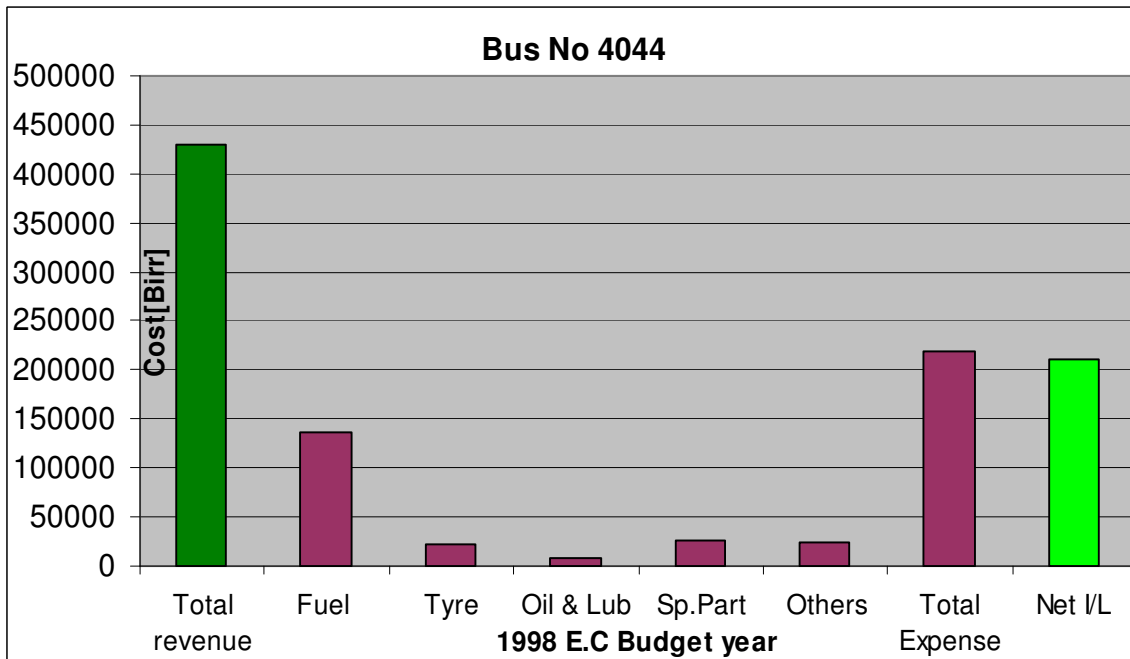


Figure first rank in net income and fourth rank in revenue

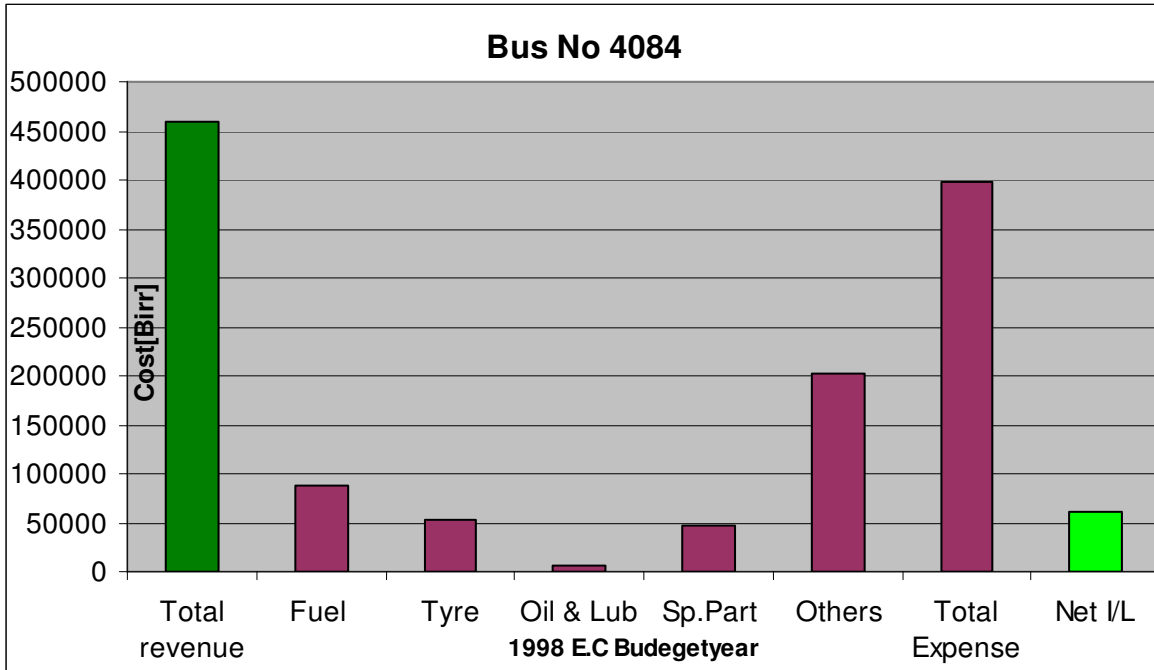


Figure second rank in revenue and 41st rank in net income

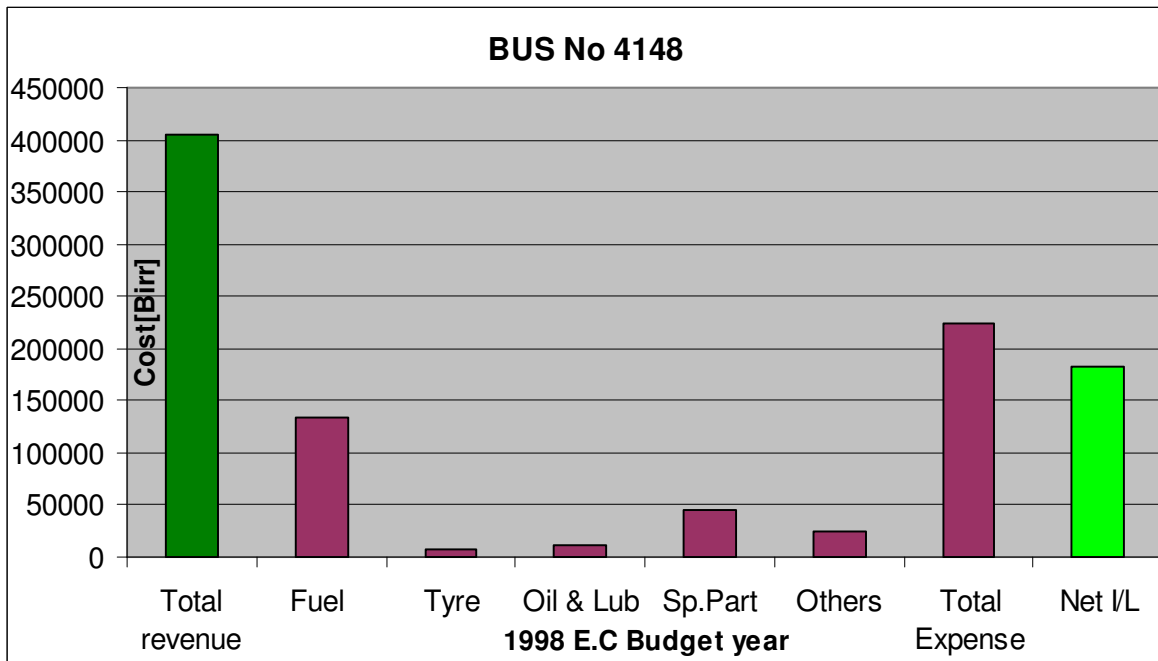


Figure second rank in net income and fifth rank in revenue

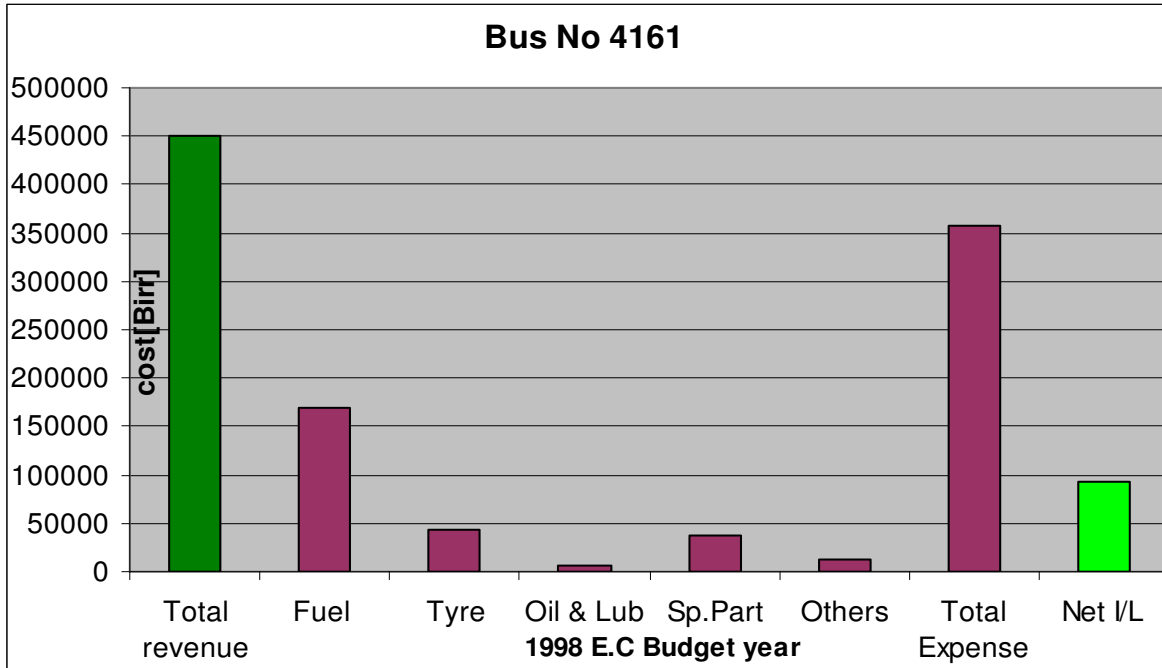


Figure third rank in revenue and fourteenth rank in net income

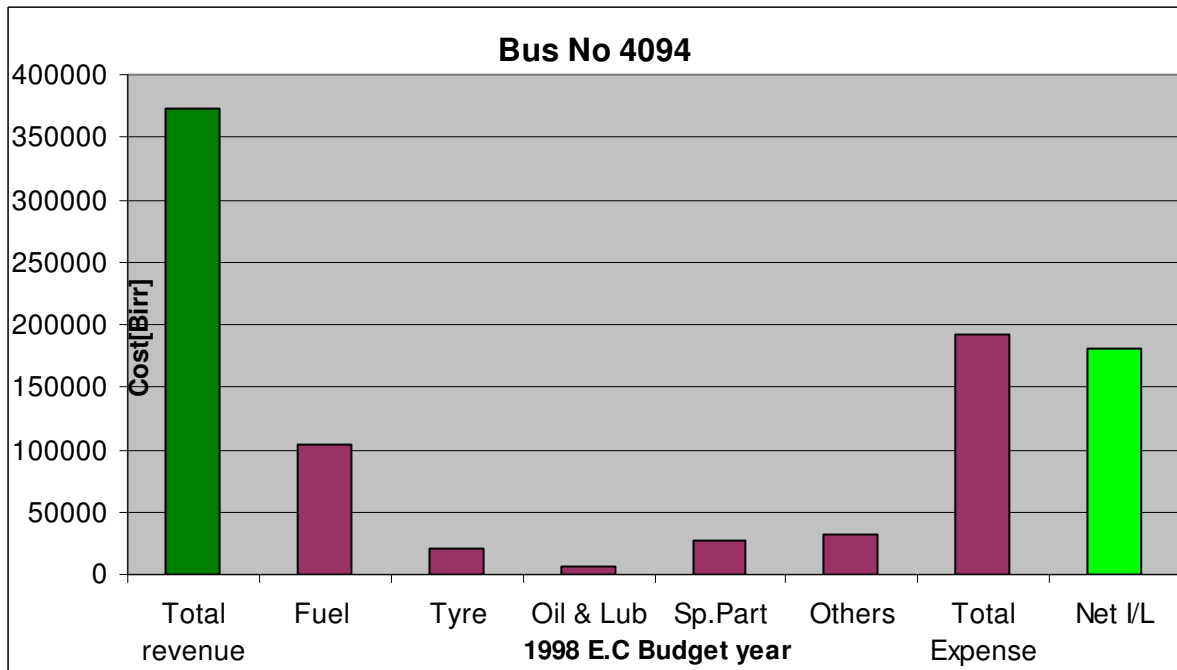


Figure third rank in net income and eighth rank in revenue

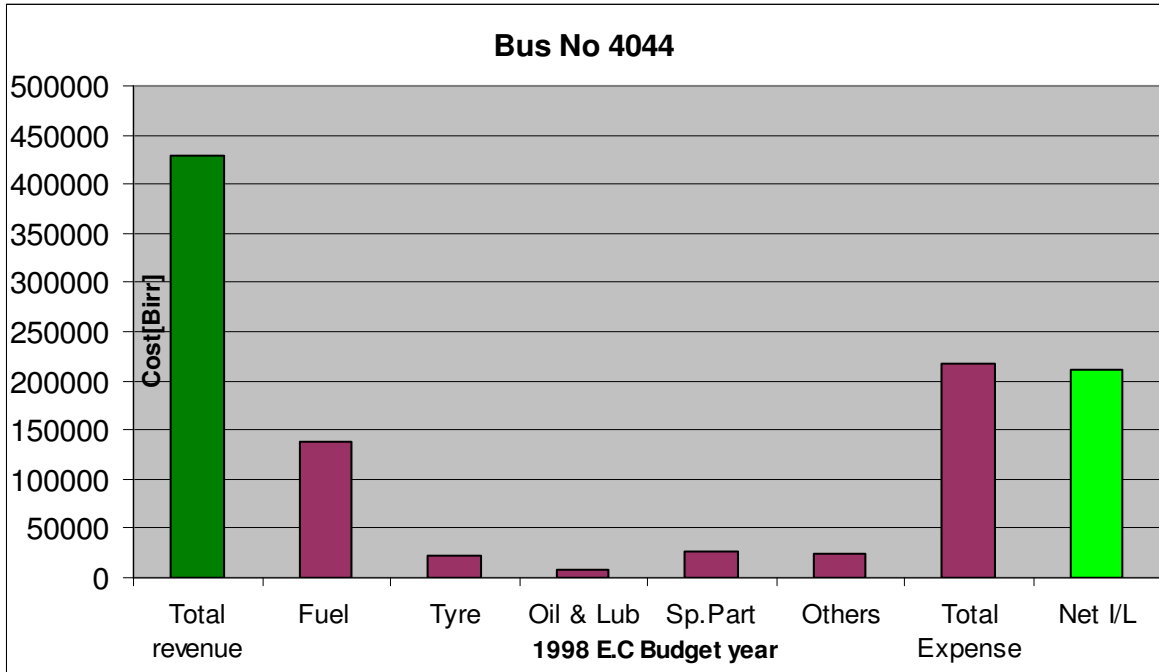


Figure fourth rank in revenue and first rank in net income

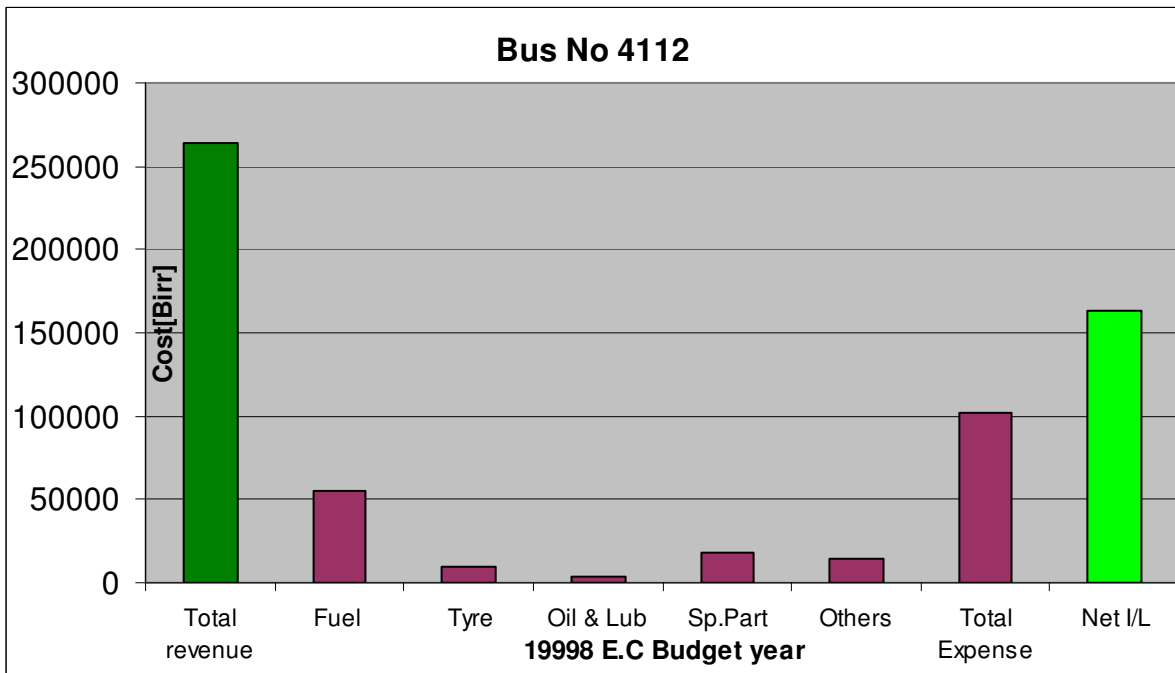


Figure 45th rank in revenue and fourth in net income