NATIONAL COOPERATIVE TRANSIT RESEARCH & DEVELOPMENT PROGRAM

Report 11

Small Transit Vehicles How to Buy, Operate, and Maintain Them

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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Small Transit Vehicles How to Buy, Operate, and Maintain Them

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AREAS OF INTEREST

- Administration
- Socioeconomics
- Maintenance
- (Public Transit)

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TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
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Administrators, engineers, and many others in the transit industry are faced with a multitude of complex problems that range between local, regional, and national in their prevalence. How they might be solved is open to a variety of approaches; however, it is an established fact that a highly effective approach to problems of widespread commonality is one is which operating agencies join cooperatively to support, both in financial and other participatory respects, systematic research that is well designed, practically oriented, and carried out by highly competent researchers. As problems grow rapidly in number and escalate in complexity, the value of an orderly, high-quality cooperative endeavor likewise escalates.

Recognizing this in light of the many needs of the transit industry at large, the Urban Mass Transportation Administration, U.S. Department of Transportation, got under way in 1980 the National Cooperative Transit Research & Development Program (NCTRP). This is an objective national program that provides a mechanism by which UMTA's principal client groups across the nation can join cooperatively in an attempt to solve near-term public transportation problems through applied research, development, test, and evaluation. The client groups thereby have a channel through which they can directly influence a portion of UMTA's annual activities in transit technology development and deployment. Although present funding of the NCTRP is entirely from UMTA's Section 6 funds, the planning leading to inception of the Program envisioned that UMTA's client groups would join ultimately in providing additional support, thereby enabling the Program to address a large number of problems each year.

The NCTRP operates by means of agreements between UMTA as the sponsor and (1) the National Research Council as the Primary Technical Contractor (PTC) responsible for administrative and technical services and (2) the American Public Transit Association, responsible for operation of a Technical Steering Group (TSG) comprised of representatives of transit operators, local government officials, State DOT officials, and officials from UMTA's Office of Technical Assistance.

Research Programs for the NCTRP are developed annually by the Technical Steering Group, which identifies key problems, ranks them in order of priority, and establishes programs of projects for UMTA approval. Once approved, they are referred to the National Research Council for acceptance and administration through the Transportation Research Board.

Research projects addressing the problems referred from UMTA are defined by panels of experts established by the Board to provide technical guidance and counsel in the problem areas. The projects are advertised widely for proposals, and qualified agencies are selected on the basis of research plans offering the greatest probabilities of success. The research is carried out by these agencies under contract to the National Reserch Council, and administration and surveillance of the contract work are the responsibilities of the National Research Council and Board.

The needs for transit research are many, and the National Cooperative Transit Research & Development Program is a mechanism for deriving timely solutions for transportation problems of mutual concern to many responsible groups. In doing so, the Program operates complementary to, rather than as a substitute for or duplicate of, other transit research programs.

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NOTICE

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, or the Urban Mass Transportation Administration, U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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The Transportation Research Board evolved in 1974 from the Highway Research Board which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

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FOREWORD

By Staff
Transportation Research Board

This manual will be useful to transit managers responsible for the procurement, operations, and maintenance of small buses less than 35 ft in length. The manual, and a companion research report, containing small-bus, maintenance cost data developed from a substantial data base, should be of interest to analysts.

One of the important decisions facing both rural and urban transit decision-makers is whether to invest scarce funds in more expensive or less expensive small transit buses. Available small buses (i.e., ranging from van conversions to 31-ft heavy-duty small buses) are highly diverse in both capital costs and technology. Their uses are also highly diverse, spanning the range from large transit fleets in major urban areas to small rural operators, and including fixed-route, demand-responsive, shuttle and other services. The complexity of both needs and possible solutions has led to many poor choices of buses for continuity in design and development; perceived problems in bus operation, maintenance, and reliability; a lack of clear definition of bus demand; and little standardization within realistic price ranges. Consequently, no guidelines exist with which transit providers, seeking to purchase or replace small buses, can make objective decisions concerning the best bus type to be procured.

A manual has been developed based on a method to determine life-cycle costs that are, in turn, based on a data base for 187 buses representing 17 transit agencies distributed geographically throughout the United States. The method's strength lies in its sensitivity to such factors as duty cycle and climate, among others. It calls for the analyst to (1) determine capacity requirements, and (2) document the characteristics for working environments. Through the use of simple equations and cost data provided in tables, the analyst is led to the generic type of bus (van, body on van chassis, body on truck chassis, purpose built bus) providing the lowest life-cycle cost. Ranges in life-cycle cost for a given bus type may also be determined. Furthermore, the manual provides guidance in the selection of such options as different types of engines and auxiliary equipment including wheelchair lifts. Information that is useful in bus maintenance planning and the development of effective maintenance operating procedures is also provided.

Inasmuch as maintenance costs were found to vary with changes in duty cycle, an analyst can use the research results to tailor operations appropriate for small buses within a transit system.

A companion research report contains printouts of the data base and results of regression analyses. For availability, contact the Director, Cooperative Research Programs, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

CONTENTS

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The research reported herein was performed under NCTRP Project 30-1 by Arthur D. Little, Inc. P. Ranganath Nayak was the principal investigator. The other authors of this report are: Ashok B. Boghani, Douglas W. Palmer, and Philip G. Gott.

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SMALL TRANSIT VEHICLES

HOW TO BUY, OPERATE, AND MAINTAIN THEM

SUMMARY

An important decision facing many transit managers in small urban or rural areas is how to choose from among several types of small buses. Several factors can influence the choice: the trade-off between capital cost and operating cost; the ease with which the buses can be operated; and their maintenance requirements, among others. This manual is based on information developed in Project 30-1, and is aimed at developing data as well as an analysis framework to guide the procurement, use, and maintenance of small buses. The manual provides a procedure that combines quantitative cost information with guidance on qualitative factors in an easy-to-use, step-by-step workbook.

Since operations and maintenance cost data are scarce, the research project focused on developing sound data in this area. Operations and maintenance cost data were acquired and analyzed for 187 buses operating at 17 different transit systems, for a period accounting for 1,200 bus-months of operation, 2.37 million bus-miles, and over 5,000 separate maintenance events.

This analysis shows that maintenance costs can vary from a low of 0.17 labor-hours per 100 bus-miles to a high of 1.69 labor-hours per 100 bus-miles, combined with a materials cost ranging from \$1.20 per 100 bus-miles (in 1983 dollars) to \$9.80 per 100 bus-miles. The wide range in costs results from variations in the following factors: the type of bus (van, body on van chassis, body on truck chassis, or purpose-built); the make of the bus; the severity of the duty cycle to which the buses are subjected; the severity of the climate in which the buses operate; and the accumulated mileage of the bus. Detailed data are presented in this manual on the quantitative effect of these factors. In operations costs, the two significant elements are labor and fuel. Labor costs for operators can be easily estimated by each transit manager based on local labor wages and fringe benefits and are not, therefore, presented in the manual. Fuel consumption data, on the other hand, are not as easily available, and are presented in the manual. Fuel efficiency can vary from a low of 3.6 miles per gallon for purpose-built buses to a high of 8.9 miles per gallon for vans. Significant variations around these numbers can result from differences in duty cycle and engine type (gasoline or diesel).

The data described above are used in a life-cycle cost (LCC) analysis in the manual. The result of this LCC analysis is one important factor to be taken into account in choosing a bus.

Additional factors that must be taken into account in buying a bus include the type of fuel that is to be used; the nature of auxiliary equipment that is desired (especially wheel-chair lifts); the maneuverability of the buses; the availability of spare parts; and the facilities needed to maintain the bus. Qualitative information and guidelines are presented in the manual on each of these factors.

In summary, the procedure for selecting a bus involves the following steps.

1. For each bus type, determine how many buses are required in order to provide the desired level of service.
2. For each bus type, perform a life-cycle cost analysis (LCC).

3. Evaluate qualitative factors, such as those listed above.
4. Integrate the quantitative LCC analysis with the evaluation of qualitative factors to arrive at a choice.

As in many other situations, the dictum *caveat emptor* (buyer beware!) operates in the purchase of small buses. There are numerous pitfalls at the level of such details as the fastening of seats to floors, the size of the radiator, or the design of door-closing mechanisms. This manual could not and thus does not provide guidance in these areas, because they are too many in number and too varied in nature to allow the development of condensed knowledge and recommendations. A buyer who is inexperienced in the detailed specification of buses would be well-served by fleshing out the information gained from the manual with expert assistance as well as by reading the research report on which the manual is based. Assistance can be sought either from others who have prior experience with the use of small buses or from experts in bus technology.

The research report on which this manual is based is available in hard copy at a cost of $10.00 or on microfiche at a cost of $5.00. Requests should be made to the Program Director, Cooperative Research Programs.

CHAPTER ONE

INTRODUCTION

OBJECTIVE

This manual will provide the purchaser of small transit vehicles, with the background knowledge, guidance, and operating cost information needed to purchase, operate, and maintain a fleet of vehicles in a manner that will yield low life cycle costs. Because life cycle costs are strongly influenced by the duty cycles that vehicles experience and by the climate, the manual presents cost information that can be tailored to the unique characteristics of individual transit systems.

WHO CAN BENEFIT FROM THIS MANUAL

This manual is intended primarily for the use of present or potential operators of small transit vehicles (those less than 30 ft long) who are preparing to purchase one or more such vehicles. It will be especially useful for those who have little or no experience in vehicle selection.

HOW TO USE THIS MANUAL

The following chapters provide a step-by-step procedure for the selection of economical vehicles. The procedure begins, in Chapter two, by illustrating how to select the basic vehicle types that can fulfill the service demands of a transit system—primarily a function of the vehicle size required. Chapter Three shows the purchaser how to narrow the choice of bus types on the basis of cost, and then how to make the final selection of bus type, make, and model from a consideration of features available and qualitative factors (see Chapters Four and Five) which one must evaluate for himself. Chapter Six discusses how to make the final vehicle selection. The maintenance aspects of small transit vehicles are discussed in Appendix A. A workbook is provided in Appendix B to assist in performing the required calculations and to serve as a respository of information that has been collected. Because many of the calculations will be done several times (say, once for every route), it may be desirable to make several copies of the workbook and only write on the copies.

Before attempting the calculations, it is important to read the manual and review the workbook thoroughly. They contain a significant amount of cost information and are as self-contained as possible. However, this initial review will give a bird's-eye view of the entire vehicle selection process. It will also identify specific information about the operational characteristics of an individual transit system that one will need to have on hand before beginning.

• Transit system service data (needed for Chapter Two): the number of seat miles to be provided and the average number of stops per mile, to help in determining appropriate numbers and types of buses which will be suitable. A characteristic known as duty cycle is also determined from these data and used in Chapter Three.

• Information regarding the climate in one's area (Chapter Three).

• Typical maintenance labor cost, driver cost, and fuel cost (Chapter Three).

Although a range of vehicle purchase prices is provided in the manual, the calculations will be considerably more accurate if price information is obtained directly from the vehicle manufacturers or dealers. Also, general information on vehicle characteristics should be obtained from the dealers.

Caution: The analysis of vehicle life-cycle costs (Chapter Three) should be used only as a guide in the selection of a vehicle. The cost information contained in Chapter Three was developed from an extensive analysis of the costs of over 300 buses. However, differences in costs arising from variations between bus makes and models, as well as the quality of maintenance and methods of operation, can substantially alter costs from those calculated in Chapter Three. Therefore, the reader is urged to temper the quantitative analysis of that chapter with one's own experience (or that of others in the transit industry) as well as with the guidance given in Chapters Four and Five.

BASIC APPROACH

The selection procedure consists of six steps. The workbook will assist one in performing each step. For the reader's convenience, each step described below corresponds to a section in the workbook.

Step 1—Establish Bus Routes (Described in Chapter Two)

The first step in developing a transit system is to establish bus routes. The manual will help one to define the area the system must serve, identify the type of service to be provided, and develop bus routes.

Step 2—Select Candidate Bus Types and Numbers of Buses for Your Fleet (Described in Chapter Two)

The life cycle cost determinations of this manual are focused on the type of bus being contemplated. Therefore, it will be necessary to identify which bus types can provide the number of seats and features each route the transit system requires. Figure 1 shows the bus types considered in this manual. The four bus types are:

1. Van—A standard light duty automotive vehicle with no extensive body modifications beyond an after market raised roof or the addition of a wheelchair lift.
2. Body on van chassis—A light duty van chassis with a full passenger body.
3. Body on truck chassis—A complete bus body built onto a truck chassis supplied by a major vehicle and engine manufacturer.
4. Purpose built—A bus built onto a chassis or frame specifically designed for that purpose and built by the bus builder.

In the procedure described in this manual, bus size as determined by the number of seats can provide a rough indication of what bus types can be considered and how many buses might be needed. If a single vehicle whose seating capacity was adequate is being replaced, it may be desirable to replace it with another of the same size. The types of buses that are suitable are then relatively easy to determine.

Once the initial bus types have been identified, one must consider factors that will limit or rule out the use of one or more bus types for service in one's area. For example, a purpose-built bus may be too tall to fit under a bridge on its route, or its turning radius may be too large for easy maneuvering in a central city area. Accomplishing this step will provide a list of candidate bus types and numbers of buses for a fleet.

Step 3—Determine Vehicle Costs (Described in Chapter Three)

This step will determine the life-cycle costs (summation of purchase price, total maintenance costs, driver costs, and fuel costs expected during life of the bus) of the candidate bus types selected and will enable the development of total life-cycle costs of each fleet of buses so that a comparison can be made of the relative system costs for each bus type.

Step 4—Select Features (Described in Chapter Four)

The fourth step enables the selection of the features to be incorporated in the bus fleet. Each feature offered by the manufacturer (e.g., fuel type, accessories for the disabled, auxiliary heat exchangers, etc.) has certain cost, maintainability, and service quality ramifications. The information provided in this manual will guide one through the pros and cons of the selected features.

Step 5—Assess Qualitative Issues (Described in Chapter Five)

The fifth step requires consideration of the qualitative issues involved in bus selection. These issues include: the parts supply and support systems, the service manuals and information, the quality of construction, the vehicle maintainability, the warranty terms and support, and the past experience.

Step 6—Make the Final Decision (Described in Chapter Six)

The final step will permit an evaluation of the trade-offs identified in Steps 3, 4, and 5. In this step, priorities are set forth and a decision is made, in essence, with respect to how much each item of the trade-offs is worth. One must also consider the sources of funding, addressing such questions as: "Do you have a substantial maintenance budget but only limited funds for new vehicles?" or, "Can you afford a high initial price because of the availability of a grant or other funding?" This will help the purchaser make the final decision on vehicle selection.

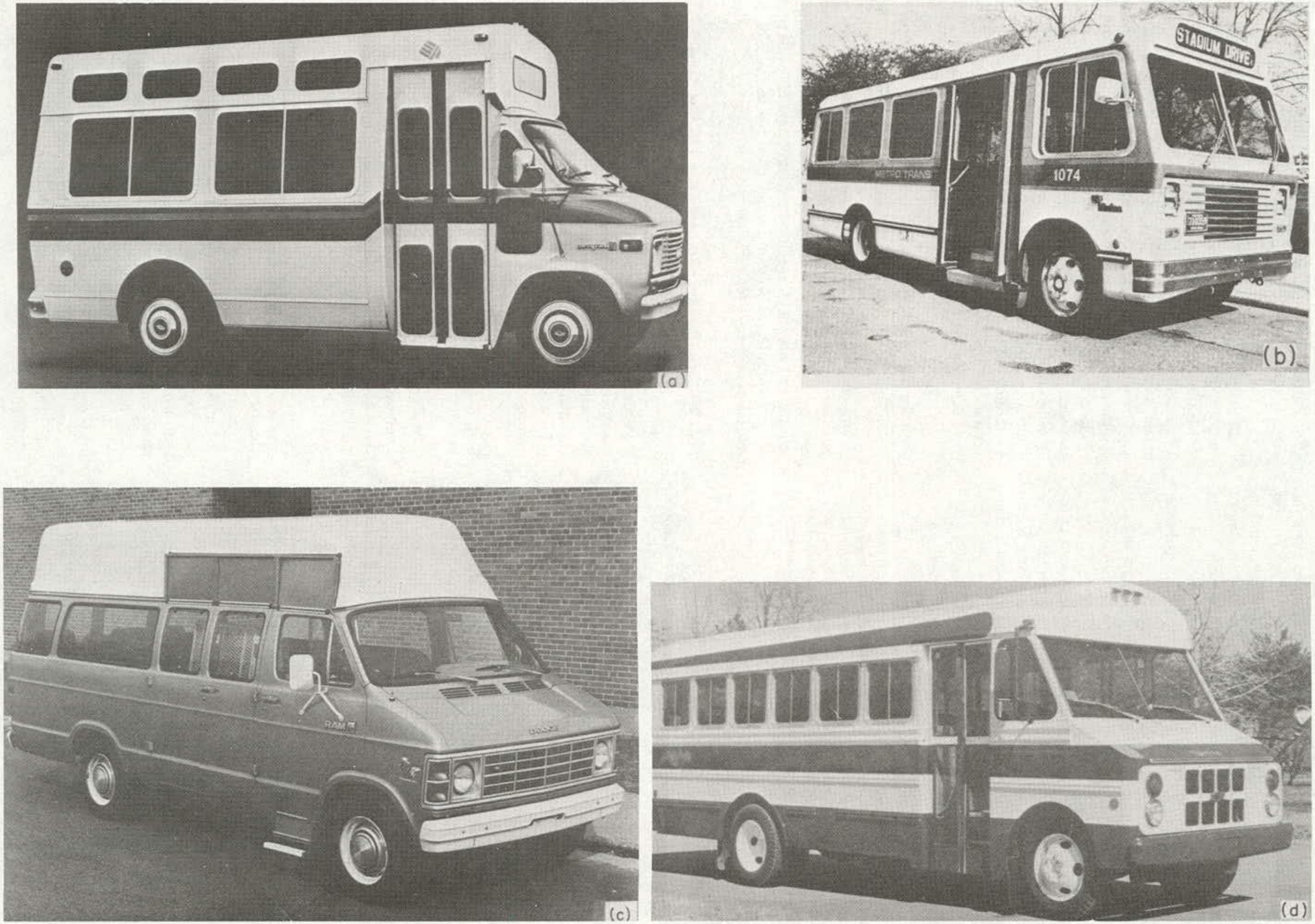

Figure 1. Four types of small buses: (a) body on van chassis, (b) purpose built, (c) van, and (d) body on truck chassis.

CHAPTER TWO

SELECTION OF VEHICLE TYPE/SIZE

This chapter provides guidelines in planning a small bus operation and in selecting buses that can meet one's particular requirements. If the purchaser already has an existing system, he may be able to make an initial selection of bus types and numbers required for a new acquisition without having to go through the discussion of this chapter. In that case, proceed directly to subsection D of this chapter. On the other hand, if he is designing a system with fixed-route service, the following discussion is applicable. If the system being designed is the demand/response type, there are other publications, such as *NCHRP Report 262,* available for guidance.

A. ESTABLISH SYSTEM ROUTING/TIME TABLE (TABLE 1)

The type of vehicle and its size are influenced by the number of routes needed, the number of passengers to be transported on each route, and the frequency of service. As a simple example, it would not be desirable to consider a 40-passenger vehicle if the expected average peak load is 25 passengers. Thus the first task in planning a transportation system is to define the area the system must serve, identify the major trip destinations within that area, and estimate the population in that area. Second, on the basis of the goals of the system, identify the type of service to be provided—fixed schedule and route, flexible schedule and route, or fixed schedule and flexible route. Third, estimate the number of bus routes needed—roughly one route for every 5,000 to 10,000 residents.

Now one is ready to begin thinking about the layout of the routes. First, identify all streets that are suitable for bus traffic. Second, determine from the destination points and the suitable streets whether a grid system (a combination of north-south and east-west routes) or a hub and spoke system (all routes meet and exchange passengers at a central transfer point downtown) will best meet one's needs. Third, identify transfer points. Last, consider where the buses can turn around at the end of a line—without having to back up—to return to the point of origin.

Now rough out a preliminary route map. Look for linear routes (those that operate outbound and inbound in the same street)—they are the most productive. As a second choice, select routes that loop through a residential neighborhood at the end of the line (lollipop routes) but travel to and from downtown on the same street. Avoid, where possible, full loop routes—routes that go outbound on one street and inbound on another. This type of route has proven to be the least attractive in generating ridership. Summarize route selection in Section 1 of the workbook in Appendix B.

Next, it is necessary to establish headways (the time in minutes between bus departures) for each route. Headways affect the permissible length of a route and the number of buses needed to opeate each route. Use headways that are an even fraction of an hour (Table 2) because repeating schedules will be easier for riders to memorize. Headways of 15 min or less do not

Table 1. Route-planning guidelines.

		Things to Consider
1.	Area to be served	Neighborhood, village, township, city, county, metropolitan area, state
2.	Major trip destinations	Downtown, shopping centers, medical centers, schools, university, business district, industrial park
3.	Type of service	Fixed schedule/fixed route requires minimum population of 25,000. For smaller populations consider fixed schedule/flexible route. Reserve flexible schedule/flexible route for special circumstances; e.g., for paraplegics, retarded children.
4.	Suitability of streets	Proximity to trip destinations. Proximity to population to be serviced -- in fixed route systems boarding points should be within 1/4 mile of dwellings. Street width -- should be wide enough to let two buses pass.
5.	Route system type	Hub and spoke; grid; service to any point within a zone.
6.	Transfer points	Central terminal, shopping center, downtown intersections
7.	Routes	Bus turnaround areas, service areas coverage, zone boundaries, linear, partial (lollipop) loop, full loop, 2-way streets rather than 1-way.
8.	Headways	Even fraction of an hour roundtrip time (running time plus layover time) zone cycle time
9.	Route adjustments	Roundtrips should equal one headway or even multiple of a headway

Table 2. Standard headways which produce repeating time tables.

Headways (minutes)	Buses/Hour
60	1
30	2
20	3
15	4
12	5
10	6
6	10
5	12

Table 3. Establishing ridership levels.

Step	Things to Consider
1. Establish Population Characteristics	Age, income levels, car ownership, student population, and type of housing
2. Determine Convenient Walking Distance	500 ft (1/10 mile) if socioeconomic status above average, 700 ft (1/8 mile) if socioeconomic status average, 1000 ft (1/5 mile) if socioeconomic status below average.
3. Estimate Population Within Convenient Walking Distance of the Route (catchment area)	The population characteristics and convenient walking distance.
4. Determine Catchment Factor	Route Type — Catchment Factor Loop — 0.14 - 0.17 Lollipop — 0.20 - 0.23 Linear — 0.22 - 0.24 Use higher number in the range for: low-income residents, multiple-family dwellings, high age level, low car ownership, or students. Use lower number in the range for: high-income residents, single-family dwellings, low age level, high car ownership.
5. Calculate Average Weekday Ridership (No. of fares collected)	Multiply population in the catchment area by catchment factor for the route.

increase ridership appreciably, so use such short headways only if passenger loadings require them. As a starting point, a 30-min headway represents a good balance between the need for frequency and the need to control operating costs.

Adjust the preliminary route map by modifying route lengths as necessary to match headways. Compute the round-trip time for a route by adding the scheduled time (minutes) for: running outbound, end-of-line layover, running inbound, and central terminal layover. A bus, under normal traffic conditions, travels about 15 mph (1/4 mile per minute). To the extent practical, add or subtract mileage and increase or reduce layover time so as to make the round-trip time an even multiple of the standard headway. These adjustments facilitate future scheduling decisions. Enter the headway and timetable information in Section 2.1 of the workbook. Calculate number of buses required by dividing peak-hour round-trip time by peak-hour headway and rounding off to the next larger integer.

B. ESTIMATE RIDERSHIP LEVELS (TABLE 3)

At this point the route system should be fairly well defined and one can begin to estimate the ridership level (number of fares collected). To do this, it is necessary to convert the overall population estimate that was obtained earlier to more specific kinds of people information—ages, income levels, car ownership, and type of housing. Such information can be obtained from census data or from statistics compiled by the city planning department. Enter this information in Section 2.2 of the workbook.

Next, estimate the number of people who live within convenient walking distance of the route (the catchment area). If socioeconomic status data are available, use Table 3; otherwise measure the population within 1/8 mile on either side of the route. Determine the "catchment factor" as given in Table 3. Enter both catchment area and catchment factor in the workbook. This factor can be used to convert area population to ridership level. Here note that the ridership level is the number of fares collected on an average weekday. It may or may not be equal to the number of people who ride the buses from the population under consideration. In fact, many people will take two rides and thus pay two fares each day. In that case, the ridership level would be two times the number of people riding the bus.

To estimate the average weekday ridership on a system, multiply the population in the catchment area by the catchment factor for the route, as shown in Section 2.2 of the workbook.

C. ESTIMATE THE BUS SIZE YOU NEED

To determine how large a bus is needed for a system, construct a time table (to establish the number of peak and off-peak trips), compute the number of trips that would be required if each trip carried a peak-hour load (equivalent loads), compute the average number of passengers carried on a peak-hour trip, and set loading standards (the number of people to be carried sitting or standing).

For the time table, list each inbound and outbound trip for each day of the week that service is offered. Use one list for the Monday through Friday schedule, and when appropriate, separate lists for Saturdays, and for Sundays, and Holidays. Since the weekday requirements will be decisive in selecting a bus, use the Monday–Friday time table to identify the number of trips each day during peak hours (8–8:59 a.m., 5–5:59 p.m.), base period hours (6–7:59 a.m., 9 a.m.–4:59 p.m.) and evening hours (6 p.m.–midnight). Count only the buses leaving from the originating point of the route. Enter the bus frequency in Section 2.3 of the workbook.

To compute equivalent loads, assume that most trips will operate loaded in one direction only: inbound in the morning and outbound in the afternoon. Count the number of trips inbound before noon and the number of trips outbound after noon. Assign weights to each trip operating in the loaded direction as follows:

peak hour — 1.0
base period — 0.5
evening — 0.25

These weights reflect the fact that base period trips carry about half the passengers of a peak-hour trip, and evening trips about a quarter of that number. Calculate the equivalent loads for a route from the following equation:

$$N \times W = EL$$

where

N = number of trips in the peak direction in the time period (peak, base, or evening);
W = weight assigned for the time period (1.0, 0.5, or 0.25); and
EL = equivalent loads for the time period.

Add the equivalent loads for each time period to obtain the total equivalent loads for a route. These calculations can be done in Section 2.3 of the workbook.

Next, calculate the number of passengers you expect to ride on a single peak-hour trip. Divide the forecast average weekday ridership (which was calculated in Section 2.2 of the workbook) by the number of equivalent loads scheduled on the route. The resulting figure is the number of passengers forecast to ride a single peak-hour trip in the peak direction, as shown in Section 2.3 of the workbook.

The bus which was selected should have a passenger capacity sufficient to accommodate this expected peak hour, peak direction load without crowding. If the type of service to be operated normally accommodates standing passengers, a seating plan must be selected in order to be able to define an acceptable ratio of standing passengers to seated passengers. In general, a 2 and 1 seating plan (two seats on one side of the aisle and one on the other) provides greater flexibility in handling peak-hour demand, without the necessity of scheduling additional buses, while a 2 and 2 seating plan provides a higher percentage of riders with a seat. In a bus with a 2 and 1 seating plan, the total passenger capacity of the bus can be estimated at 1.5 times the number of seats available. With a 2 and 2 seating plan, total passenger capacity can be assumed to be about 1.25 times the number of seats installed. Thus, to compute the number of seats required, divide the forecast number of peak direction passengers on a peak-hour trip by 1.5 (in the case of a 2 and 1 seating plan), or by 1.25 (in the case of a 2 and 2 seating plan). These calculations can be done in Section 2.4 of the workbook.

The length of bus needed to accommodate the forecast peak direction peak-hour passenger load is then estimated from the number of seats required. Estimate the number of rows of seats needed by dividing the total seat requirement by 3 in the case of a 2 and 1 seating plan, or by 4 in the case of a 2 and 2 seating plan, as shown in Section 2.4 of the workbook. The overall length in feet of the bus needed can be estimated by multiplying the number of rows of seats by 3 ft. This assumes a seat pitch of 30 in., and considers the space required for the driver and the doors.

For example, if the forecast peak-direction peak-hour passenger load is 45 passengers, and a 2 and 1 seating plan is assumed, a bus with space for 30 seated passengers and 15 standees is required. With 3 seats per row and 30 seats, there will be 10 seat rows. Assuming an overall spacing of 3 ft per row, the smallest suitable bus would be 30 ft long. Compare the required bus capacity, number of seats, number of rows, and length with those of the buses under consideration. Make an initial selection from this comparison, as shown in Section 2.5 of the workbook. Test the usefulness of the bus size that has been selected by repeating the calculations in this section for the next less frequent headway, and the next more frequent headway. Adjust bus size or headway, as necessary, to obtain an optimum combination of the two.

D. IDENTIFY LIMITATIONS TO YOUR BUS SELECTIONS

Although the buses selected may be the correct size, other considerations may eliminate some. The most important considerations are the following:

- Size limits (height, width, length, turning radius): Will the bus be able to clear overpasses and fit on all bridges? Will it be able to turn corners on all streets or within the dimensions of a terminal? Length and rear overhang (that portion of the body behind the rear wheels) are especially important factors. The longer the rear overhang, the greater the outward movement of the rear of the bus when turning. This makes maneuvering in tight situations difficult. A lane width of twice the bus width could be required for turning a bus with a long rear overhang in a sharp corner. If there are narrow streets or it is necessary to operate in areas where frequent swerving around parked cars is required, one might want to avoid buses with long rear overhangs.
- Weight limits: Is the bus too heavy for any of the bridges, overpasses, or roads over which it must travel? Is the pavement at bus stops durable? Frequent starts and stops of heavy buses at curbside have been known to destroy some pavements in as few as 50 stops/starts.

This information should be available from the manufacturers of the different buses. Once this step is performed, one will have a list of candidate buses. Section 2.6 of the workbook can be used in performing this step.

E. ALTERNATIVE BUS FLEETS

A list of bus types (sizes) and the number of buses of each type which satisfies one's needs will now be available. Organize these options into the summary table shown at the end of Section 2 of the workbook.

CHAPTER THREE

ESTIMATION OF OPERATION AND LIFE-CYCLE COSTS

Having gone through the previous two chapters, one should have arrived at various options of bus types and their numbers which will meet particular requirements. This chapter will help the purchaser determine and compare the life-cycle costs and the average cost per mile of these options.

In order to perform such a cost analysis, the following information is required:

Table 4. Bus cost and life estimates (1984).

Bus Type	Average Cost	Cost Range	Maximum Life Estimate (miles)	Average Purchase Cost per Mile at Maximum Life Mileage
1. Van and Modified Van	$ 10,000	$ 5 - 16,000	100,000	$0.10
2. Body on Van Chassis	25,000	18 - 40,000	100,000	$0.25
3. Body on Truck Chassis	35,000	18 - 60,000	175,000	$0.20
4. Purpose Built	90,000	33 -120,000	1,000,000	$0.09

To obtain average cost for your year of purchase, multiply the above cost by the inflation multiplier shown below:

Purchase Year	Inflation Multiplier
1985	1.05
1986	1.10
1987	1.16
1988	1.21
1989	1.28
1990	1.34
1991	1.41
1992	1.48
1993	1.55
1994	1.63
1995	1.71

Table 5. Definitions of system characteristics.

Climate	
The climate data can be obtained from the U.S. National Oceanic and Atmospheric Administration reports.	
Mild Climate:	On average, less than 20 inches of snow and less than 4000 degree days* per year.
Moderate Climate:	On average, more than 4000 degree days and less than 100 days of precipitation per year.
Severe Climate:	On average, more than 20 inches of snow, more than 4000 degree days, and more than 100 days of precipitation per year.
Duty Cycle	
Mild Duty Cycle:	On average, fewer than or equal to 1 stop per mile, e.g., a rural elderly and handicapped route.
Moderate Duty Cycle:	On average, more than 1 but fewer than 3 stops per mile, e.g., a demand/response city route.
Severe Duty Cycle:	On average, more than or equal to 3 stops per mile, e.g., a fixed city route.

*"Degree-days" is determined as the sum of (65°F - average temperature during the day) for each day that the average temperature is less than 65°F.

- Bus type, its capital cost, its life estimate (if accurate numbers for these items are not available—refer to Table 4 for estimates).
- Salvage value of each bus type.
- Average driver salary.
- Number of drivers to be employed for each option (based on the number of buses and schedule).
- Cost of fuel (gasoline or diesel, whichever is appropriate) in one's area.
- Maintenance labor cost in $/hr.
- System characteristics, in terms of duty cycle and climate (refer to Table 5 for definitions of these).
- Yearly mileage expected (from Chapter Two).

Section 3 of the workbook has a fill-in table (Table 3.1) in which this information needs to be recorded. It then shows how to calculate a simplified life cycle cost and cost per mile for each option. In developing this table, it has been assumed that the purchaser's options are to buy different numbers of different types of bus. Thus, the cost estimates must be developed for each bus type under consideration. The life cycle cost per bus will then be multiplied by the number of buses in the fleet to obtain a total cost estimate. If the purchaser's fleet is going to include buses of different types, this table should still be filled in. How the average cost/mile and total life cycle cost for a mixed fleet are calculated will be shown later.

Note that the objective of this cost analysis is to give a quick cost comparison of the options selected. There are several approaches used by economists to analyze such costs, but the two approaches used most often are called:

- A discounted cash flow or net present value (NPV) analysis.
- Life-cycle cost (LCC) approach.

The first approach is more accurate of the two but requires making assumptions on future inflation rates, interest rate on money borrowed, and average "discount rate." In addition, even the seat-miles that are planned will need to be discounted, which is not a widely used concept, at least in the transit industry. Thus, the life-cycle cost approach was used in this manual.

Begin filling in the workbook Table 3.1 by writing bus model in the first column and its type (van and modified van, body on truck chassis, body on van chassis, or purpose built) in the second. The information obtained above should be filled in columns 3, 4, 5, 6, 7, 8, and 14. Bus life in years (col. 9) is obtained simply by dividing bus life in miles (col. 5) by anticipated yearly service mileage (col. 4). Bus miles per gallon (mpg) for column 10 can be obtained from Table 6. The total fuel cost for the life

Table 6. MPG table. (*Source Arthur D. Little Survey*)

Bus Type	Fuel Type	Average MPG
Van and Modified Van	Gasoline	8.9
Body on Van Chassis	Gasoline	6.5
Body on Truck Chassis	Gasoline	5.1
Purpose Built	Gasoline Diesel	3.6 6.1

Note:

- Total bus frontal area (width x height) and the roundness of the corners influences fuel economy at speeds as low as 35 mph. Rounded corners, square backs, and small frontal areas are preferred and can be expected to yield above average fuel economy.
- In stop and go service, acceleration forces use up most of the fuel. Weight has an enormous influence on fuel economy in typical bus service. Lighter vehicles can be expected to have significantly better fuel economy.

of the bus is then obtained by multiplying cost of fuel (col. 8) by bus life in miles (col. 5) and dividing by mpg (col. 10). Similarly, total driver cost for the life of the bus can be obtained by multiplying average annual salary of a driver by bus life in years (col. 9) and by number of drivers needed (col. 6/col. 7).

The total maintenance cost (col. 13) is somewhat more difficult to determine. Table 7 describes how this could be estimated. Finally, the expected salvage value should already have been entered in column 14. Once this is done the total life cycle cost per bus is found by simply adding the capital cost (col. 3), total fuel cost (col. 11), total driver cost (col. 12), and total maintenance cost (col. 13), and subtracting the salvage value (col. 14) from the total. The cost per mile is the total life cycle cost (col. 15) divided by bus life in miles (col. 5).

As mentioned earlier, the total life cycle cost of a fleet can be obtained by multiplying total life cycle cost per bus (col. 15) by the total number of buses in the fleet. This calculation can be done in Table 3.3 of the workbook. For a fleet consisting of different bus types, this would involve calculating the total cost for each bus type and adding costs together. In this case, the average cost per mile of the fleet would be:

$$\text{Average Cost Per Mile} = \frac{n_1 \times \text{(cost per mile of bus type A)} + n_2 \times \text{(cost per mile of bus type B)} \ldots}{n_1 + n_2 + \ldots}$$

where n_1 = number of buses of type A, and n_2 = number of buses of type B, etc.

Once these calculations are completed, the summary table in the workbook (Table 3.3) should be filled in. This table and the factors described in the next two chapters will provide the information that is needed to help select the best option for one's requirements.

Table 7. Procedure for calculating total maintenance cost.

In order to calculate the total maintenance cost of a bus type, you need to calculate the cost for each year of its life and then add the costs in workbook Table 3.2.

To calculate the maintenance cost for a particular year, follow the procedure described below:

Step 1	Look up from Table 8 labor hours of maintenance needed per 100 miles of service, corresponding to your climate, duty cycle, and bus type. Enter this number in column 2 of Table 3.2 of the workbook.
Step 2	Look up from Table 8, the materials cost of maintenance needed per mile of service, corresponding to your climate, duty cycle, and bus type. Fill in this in column 3 of Table 3.2 of the workbook.
Step 3	Fill in labor cost (column 4) and mileage per year (column 5) from the information obtained earlier.
Step 4	Fill in the year's starting miles (previous years starting miles plus mileage last year) in column 6.
Step 5	Look up mileage factors for labor hours and materials cost from Table 9 and fill in columns 7 and 8.
Step 6	Look up inflation factor for material cost from Table 10 and enter in column 9.
Step 7	Calculate the total maintenance cost for that year as shown in column 10.
Step 8	Repeat the above steps for every year up to the bus life.
Step 9	Add up the annual maintenance costs to obtain total maintenance cost over the bus life.
Step 10	Transfer this number to column 13 in Table 3.1 of the workbook.

Table 8. Maintenance cost tables.

(a) Labor Hour

Climate	Duty Cycle	Van or Modified Van	Body on Van Chassis	Body on Truck Chassis	Purpose Built
		Labor Hours per 100 miles			
Mild	Mild	0.17	0.46	0.61	0.29
	Moderate	0.22	0.57	0.77	0.38
	Severe	0.27	0.71	0.96	0.50
Moderate	Mild	0.22	0.46	0.79	0.31
	Moderate	0.28	0.57	0.99	0.41
	Severe	0.35	0.71	1.23	0.54
Severe	Mild	0.30	0.46	1.08	0.33
	Moderate	0.38	0.57	1.36	0.44
	Severe	0.48	0.71	1.69	0.58

(b) Materials Cost

Climate	Duty Cycle	Van of Modified Van	Body on Van Chassis	Body on Truck Chassis	Purpose Built
		Materials Cost Per Mile (1983 cents)			
Mild	Mild	1.2	4.3	5.9	2.6
	Moderate	1.3	4.7	6.5	3.9
	Severe	1.4	5.2	7.1	6.0
Moderate	Mild	1.2	4.3	6.1	2.6
	Moderate	1.4	4.7	6.8	3.9
	Severe	1.5	5.2	7.5	6.0
Severe	Mild	1.6	4.3	8.1	2.6
	Moderate	1.8	4.7	8.9	3.9
	Severe	2.0	5.2	9.8	6.0

Table 9. Mileage factors.

Mileage at Start of the Year	Mileage Factor for Labor Hour				Mileage Factor for Materials Cost			
	Van or Modified Van	Body on Van Chassis	Body on Truck Chassis	Purpose Built	Van or Modified Van	Body on Van Chassis	Body on Truck Chassis	Purpose Built
0 - 10,000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10,000 - 20,000	1.00	1.05	1.05	1.01	1.00	1.1	1.01	1.01
20,000 - 30,000	1.00	1.11	1.10	1.02	1.00	1.2	1.03	1.02
30,000 - 40,000	1.00	1.16	1.14	1.03	1.00	1.3	1.04	1.03
40,000 - 50,000	1.00	1.22	1.19	1.04	1.00	1.4	1.05	1.04
50,000 - 60,000	1.00	1.27	1.24	1.05	1.00	1.5	1.06	1.05
60,000 - 70,000	1.00	1.33	1.29	1.06	1.00	1.6	1.08	1.06
70,000 - 80,000	1.00	1.38	1.34	1.07	1.00	1.7	1.09	1.07
80,000 - 90,000	N/A*	1.44	1.38	1.08	1.00	1.8	1.1	1.08
90,000 - 100,000	N/A*	1.49	1.43	1.09	1.00	1.9	1.12	1.09

*All vans in the survey had less than 80,000 odometer miles.

Above 100,000 miles, use the following formulas:

$$\text{Mileage factor for labor hours} = 1 + \frac{n}{100} \times \frac{\text{mileage}}{10{,}000}$$

$$\text{Mileage factor for materials cost} = 1 + \frac{m}{100} \times \frac{\text{mileage}}{10{,}000}$$

where:

	Van or Modified Van	Body on Van Chassis	Body on Truck Chassis	Purpose Built
n =	0	5.5	4.8	1
m =	0	10	1.3	1

Table 10. Inflation factors for material cost.

Calendar Year	Inflation Factor
1984	1.05
1985	1.10
1986	1.16
1987	1.27
1988	1.28
1989	1.34
1990	1.41
1991	1.48
1992	1.55
1993	1.63
1994	1.71
1995	1.80
1996	1.89
1997	1.98
1998	2.08
1999	2.18
2000	2.29

(assumes 5% inflation rate)

CHAPTER FOUR

SELECTION OF FEATURES

Now that the costs of the different bus options are known, the purchaser may want to consider two more factors before making a final decision. These are:

- Features to have on the bus selected.
- Qualitative differences between the buses under consideration.

This chapter will aid in selecting the features, while the next chapter will assist in evaluating the qualitative issues. Section 4 of the workbook will be useful in organizing the information collected and decisions made.

A. ENGINE AND FUEL TYPES

Manufacturers are now able to offer a variety of diesel engines as well as gasoline power plants. Note that not all of the new diesel engine offerings are built to the same durability standards as the heavy duty diesel used in purpose built buses. Those engine designs for light or medium duty vehicles (passenger cars and van trucks, for example) may have significantly lower design lives than the traditional heavy duty diesel. Features to look for which *may* indicate a lower life expectancy than traditional heavy duty diesels are:

- Cylinder bores directly in the cylinder block instead of in a replaceable liner.
- Nonroller camshaft followers.
- Indirect injection—the use of a small-prechamber into which the fuel is injected instead of injecting it directly above the piston (direct injection).

Indirect injected diesel engines may be considerably more efficient than gasoline-fueled engines. They are, however, anywhere from 5 to 15 percent *less* efficient than direct injected diesel.

The use of a diesel can result in up to a 100 percent improvement in fuel consumption of gasoline-fueled bus types 1, 2, or 3. A diesel engine normally provides its maximum fuel economy benefit over gasoline engines under idling conditions. The more idling time included in the duty cycle, the greater will be the fuel consumption reduction accompanying the switch to diesel fuel.

Diesel fuels have far greater lubricity than gasoline. As a result, all else being equal, the wear parts of a diesel-fueled engine should last longer. However, under stop-and-go driving, such as in a transit system, the diesel engine produces significantly more soot than a spark-ignited engine. This soot contaminates the oil and results in more rapid wear of certain engine parts. To offset this effect, more frequent oil changes are required.

Because of relatively low demand, diesel fuel tends to spend more time in storage than does gasoline, increasing the opportunity for it to pick up water. Diesel-fueled vehicles should be equipped with water filters which require periodic service. A herbicide should also be added to the fuel to kill any plant life that can grow in and clog a diesel fuel system. Fuel that is properly treated can be ordered from one's supplier.

The acceptable fuel particle contaminant size varies from one engine to the next. Engines requiring finer filtration than others may be vulnerable to on-road fuel-system plugging unless steps are taken to ensure adequate filtration. The best way to accomplish this is to install fuel base filters on the delivery pumps to filter the fuel just before it is put into the tanks.

Finally, No. 2 diesel fuel (the most common grade) tends to form a wax precipitate in cold weather (+10 F and below). This precipitate tends to plug the fuel filter. Below −10 F, so much wax forms that the fuel will be essentially solid. The use of No. 1 fuel or "cloud point depressant" additives to the No. 2 diesel fuel will be required in cold climates. As an alternative, some transit authorities equip their vehicles with fuel heaters and start them every few hours during cold weather when the vehicles are not on the road. The availability of fuel additives or No. 1 fuel should be assessed if in a cold climate and staff or funding is not available to keep starting diesels.

Gaseous fuels such as propane or natural gas also offer somewhat reduced maintenance costs because of longer spark plug life, reduced deposits, and no oil contamination. However, be certain that there are no restrictions to the access of gaseous-fueled vehicles to areas where transit vehicles travel. Codes may prohibit access to areas such as bridges, tunnels, indoor parking areas, and certain downtown business areas.

Both diesel and gaseous fuel systems have unique service needs which a mechanic who is familiar only with gasoline engines may not be able to provide. The vehicle manufacturer should be able to provide one with the details. Be certain that the required skills and tools are available locally or be prepared to invest in the required mechanic training and special tools. The local availability of replacement parts should also be explored.

B. ACCESSORIES FOR THE DISABLED

The following accessories are often available in a small bus:

- Wheelchair lifts/ramps.
- Wheelchair restraints.

Carefully study the trade-offs between the benefits these devices provide and the impact they would have on the purchase, operations, and maintenance costs.

A wheelchair lift allows a wheelchair user to access bus service by providing a platform on which the wheelchair user can "wheel-on" and then lifting the platform to bus floor level so that the chair can be wheeled into the bus. Two types of lifts are available: electro-hydraulic and electro-mechanical. Both require substantial electrical power. Therefore, buses equipped with lifts should also be fitted with heavy duty batteries and alternators. Other variations are lifts located outside or inside the bus, and lifts that are rear-door mounted or side-door mounted.

A lift located outside the bus does not take up any space inside the vehicle, but is exposed to weather that may create freezing problems in winter. Also, a lift stored outside may need to be cleaned often.

A lift that is mounted on the rear door is better in areas where streets are narrow or have ditches, snow, or tall grass on the sides. For most urban services, however, a side door lift is preferable, because a rear door would be dangerous in city traffic.

Although lifts provide access to a very important segment of the population, their inclusion would also mean additional procurement costs, driver training, and maintenance. Also, additional spare parts will need to be kept to keep the lifts operational.

A less expensive option is a ramp. However, a wheelchair user cannot climb up a ramp without some help. Also, snow or rain can make a ramp slippery, thereby raising the possibility of injury to not only the wheelchair user but also the user's assistant.

Wheelchair restraints are required in vehicles which accommodate them to keep the wheelchair and its occupant in place in case of a sudden stop or an accident. Typical devices available are belts to secure both the wheelchair and its occupant, a wheel rim holder to hold the wheelchair, a T-bar that is a horizontal bar holding the wheelchair frame, and a lateral grab bar that is attached to the vehicle behind the large wheels. The features to weigh are the ability of the restraint to secure most types of wheelchairs in use, its mechanical complexity, and the extent of driver help required in using the restraint.

Provision must be made for the security of the driver station while the driver is absent attending a wheel chair boarding. In the interest of reliability it is not desirable to run off the engine and remove the keys; alternative means should be investigated and specified.

C. TWO-WAY RADIO

Two-way FM radios are another accessory to consider when acquiring small buses. These radios are very useful in reporting delays, emergencies, and problems with the bus or passengers. However, there are several factors to be considered before acquiring them. First, these radios are expensive to acquire and maintain. Second, a person would be needed to communicate to the buses from a central location, which would add substantially to the cost of operating the radio system. Third, a license would be needed from the FCC to operate the two-way FM radio.

D. AUXILIARY POWERTRAIN HEAT EXCHANGERS

In typical transit service, engine and automatic transmission lubricants tend to run much hotter than in normal highway service. Continued stop-start driving causes the engine to run at higher than normal loads during acceleration a very high percentage of the total operating time. At the same time the torque converter in the automatic transmission is slipping, generating a considerable amount of heat. Since the vehicle speeds are low, the normal air flow over the engine and transmission sumps is not able to carry away much of the heat generated, and the oils can get excessively hot.

These conditions can lead to improper lubrication and reduce the life of the oil and of elastomeric components (such as seals and hoses). The use of air conditioning in transit vehicles further aggravates this problem. The net result can be considerably reduced engine and transmission life.

Therefore, some consideration should be given to the manufacturer's requirements for heavy-duty cooling of the oils in both the engine and transmission. Coolers should preferably be water-to-oil units to ensure adequate heat exchange at low vehicle speeds. Oil-to-air coolers should be fitted in the engine cooling fan air stream. Note that vehicles equipped with heavy-duty diesels usually have an engine oil-to-water heat exchanger already fitted as standard equipment. Note also that the standard transmission oil-to-water heat exchangers found in the cold radiator tank of most light-duty vehicles equipped with automatic transmissions generally are not adequate for this service.

Where no satisfactory heat exchangers are fitted by the manufacturer, it is strongly recommended that the purchaser fit an auxiliary heat exchanger. The initial costs of the vehicle should then include the cost of engine oil and transmission oil coolers.

E. BRAKES

Stop-and-go transit system service is very demanding of the brake system. Brake friction material replacement intervals well under 10,000 miles are common. Any vehicle considered should be equipped with a high number of square inches of braking area (so-called "swept area") to maximize brake life. The ratio of swept area to gross vehicle weight (GVW) will provide a reasonable guide to brake life. The manufacturers should be able to provide swept area and GVW for the vehicles. In general, the higher this ratio, the greater the brake life.

Prospective purchasers should carefully weigh the pros and cons of upgrading chassis capacity (gross vehicle weight) to obtain higher swept areas. The larger brakes may be accompanied by stiffer suspensions which might provide rougher ride and may lead to premature chassis failure.

Disc-brake friction materials (pads) are generally easier and faster to replace than drum-brake friction materials (shoes). However, resurfacing of a disc brake rotor can involve more extensive servicing of the wheel bearings. Drum resurfacing, on the other hand, usually involves simple removal of the drum with no other operations involved. If experience has shown that frequent resurfacing of disc-brake rotors is required, it may be desirable to consider drum brakes all around, provided that a high ratio of swept area to GVW is maintained.

F. TRANSMISSION

Automatic transmissions are almost universally used for transit service. They are much less subject to operator abuse or misuse, and if adequately cooled, offer acceptable life. New designs that employ lock-up torque converters are expected to offer even longer life and improved fuel economy because of reduced slippage. Continuously variable units which may be offered in the near future will probably exhibit even longer life and better fuel economy due to reduced heat build up and better engine control, respectively.

G. REAR AXLE OR FINAL DRIVE RATIO

A choice may be offered of rear axle or final drive ratios. With any given transmission, the higher the numerical ratio the better the gradeability (ability to start on grades). Therefore if one plans to run vehicles in hilly terrain, a higher than standard numerical ratio may be desirable. However, higher numerical ratios also increase engine speeds and, on highway runs, could significantly reduce engine life and increase fuel consumption.

Numerical ratios that are lower than standard tend to reduce gradeability but can improve fuel economy. If operating terrain is mostly flat, an increase of 5 to 15 percent fuel economy can be expected with a reduction in numerical ratio of 20 percent. However, if there are many stops per mile or operation is in hilly terrain, one may be trading off transmission and engine life for fuel economy because excessive torque converter slippage and heat buildup could result, or even engine lugging. Acceleration will also be reduced, especially with full loads.

Unless the ability to control the use of the vehicle in special service is assured, deviations from the manufacturers standard rear axle or final drive ratio may not be cost-effective. In any event, one should not deviate from the standard ratio by more than one step from the available ratios provided by the manufacturer unless service requirements have been carefully analyzed and advice has been received from the chassis manufacturers' technical staff.

H. RETARDERS

If vehicles are run in hilly terrain, it may be desirable to consider the use of a retarder. These are hydrodynamic braking devices attached to the driveshaft which, when applied, turn an impeller inside a fluid, absorbing vehicle energy by heating the fluid. Retarders have been shown to significantly improve brake life, especially in highly loaded vehicles operating in hilly terrain. Not enough experience has yet been obtained to determine if retarders are cost effective in "normal" transit service.

If vehicles are run in hilly terrain and brake costs are significantly higher than normal (see Table 11), it may be desirable to consider purchasing a retarder.

Table 11. Typical brake system costs for small transit buses.

(cents per mile)

Van and Modified Van	Body on Van Chassis	Body on Truck Chassis	Purpose Built
1.2	3.5	6.1	4.0

(assumes labor cost at $10 per hour)

I. TIRES

The key issue in the selection of tires is whether to purchase cross ply tires or the more expensive radial tire. Radials have been proven to offer improved fuel economy, greater life, and more retreads per casing. They do, however, cost more initially. If it is found that tire casings are being destroyed by pot holes, vandalism, or curb damage before they wear out, radials may not be a cost-effective selection. However, if the tires are expected to wear out instead of having a casing failure, radial tires are very likely to be a low-life-cycle-cost choice, provided that they are retreaded.

The next chapter discusses the qualitative issues to be considered while making a decision on the bus to acquire.

CHAPTER FIVE

QUALITATIVE ISSUES

Several qualitative issues must be considered when deciding on the type of small bus to purchase. The following qualitative issues are discussed in this chapter.

- The parts supply/support systems.
- The service manuals/information.
- The quality of construction.
- The vehicle maintainability.
- The warranty terms/support.
- The past experience.

Section 5 of the workbook in Appendix B provides space for entering qualitative information on each of the bus types under consideration. It will be required to rate each bus type for each qualitative issue on a scale of 1 to 10, with 1 indicating very bad and 10 indicating very good.

A. PARTS SUPPLY/SUPPORT SYSTEMS

With most small buses, a large number of manufacturers may have produced the parts that go into the vehicle, particularly the body. One should therefore review very carefully the availability of replacement parts for the body and its hardware. In many cases, this review will reveal that the vehicle manufacturer does not stock replacement parts for vehicles that are not in current production. The original part manufacturer must be relied on for replacement parts. This creates an extra step in the parts procurement process, and delays vehicle repair. The ideal situation, of course, is to have a well-stocked dealer of that vehicle close by. An alternative to this is for the purchaser to maintain a substantial inventory. Such an inventory is usually costly, although it is effective in minimizing down time. A judgment should be made on the trade-off between down time and the increased cost of additional inventory.

In any case, carefully assess the availability of replacement parts. Be sure, also, to confirm that an adequate inventory of parts for older vehicles is available, not just for current production.

B. SERVICE MANUALS/INFORMATION

A major problem in the service industry is the availability of accurate service information. This is especially true of the service bulletins that supplement a manufacturer's repair manual. These service bulletins describe how special or recurrent problems can be solved. They also document repair procedures on "running changes"—changes made to a vehicle during its production that are not included in the manual. Unless it is intended to have a factory-authorized dealer do almost all of one's service work, make sure that service manuals and service bulletins will be made available to you or your service contractor for all vehicle systems, including those unique to candidate vehicles.

Parts manuals are also very useful. They help speed the parts ordering process, reduce mistakes, and they will aid the parts inventory system. These manuals also have very clear diagrams showing how systems are assembled, and are frequently very helpful to the mechanic making the repairs.

C. QUALITY OF CONSTRUCTION

The quality of construction of the small transit vehicles appears to vary greatly. Some manufacturers use construction techniques suitable for light duty use, such as motor homes and recreational vehicles. Others use techniques well suited to heavy loads and transit system service. When judging vehicle construction, check these characteristics:

- *Electrical system—Look* for color-coded wiring. Some vehicles have been assembled without color-coded wiring. This makes servicing very difficult. Other manufacturers use poor-quality connections that cause frequent problems. *Check* installed alternator capacity. In some cases the alternators provided have not been able to keep up with the electrical load of the added lights, radios, lifts, and other accessories.
- *Framing—Look* for metal. Steel or aluminum metal body framing is usually preferable over wood because screws tend to

loosen and back out of wood. *Look* at cross sections. Large cross sections in the framing are desirable to reduce body flexing, especially around windows that otherwise may leak or even break.

- *Chassis—Check* the chassis GVW rating. The chassis (not the body) manufacturer's rated load for the chassis, expressed as gross vehicle weight (GVW), must not be exceeded by the combined load of the body, driver, all the fuel, and a full passenger load. Make sure that the chassis GVW rating is adequate. *Check* axle loading. The distribution of the load on each axle should not overload either front or rear axles or the tires. *Check* seat mountings. Seat mountings have been cited as needing improvement in some vehicles.

D. VEHICLE MAINTAINABILITY

In determining the maintainability of a vehicle, a major consideration next to overall maintenance costs is the time required for servicing a vehicle. Servicing time is influenced by:

- The accessibility to the mechanic of the major components of the vehicle or of parts that are frequently replaced, such as: oil filters, air filters, spark plugs, belts, and light bulbs.
- The availability of appropriate service tools.
- The suitability of service facilities.

The issues considered in the preceding pages (i.e., parts/support availability, the quality of service manual, and the quality of construction) also affect vehicle maintainability. Other factors to consider include the following:

- Imported small buses require someone—either the operator or individual mechanics—to acquire a new set of metric tools and a supply of metric fasteners. Are these available? Who will pay for them?
- Though a vehicle may be streamlined, eyecatching, and attractive, are facilities, parts, and skills available to repair any body damage that may occur?
- Are lifts in the maintenance shops capable of lifting a small transit vehicle? Many lifts found in service stations are incapable of lifting a small bus, and lifts used to lift larger trucks or buses may not have sufficient wheelbase adjustment for the smaller buses. Ceiling height may not be adequate for anything other than vans.
- A garage may be well equipped to rebuild large bus brakes, including the turning of drums, but the operator may discover that the brake lathe being used will not adjust to the smaller drums or disc brakes used on smaller buses. The reverse may also be true.
- Although diesel or gaseous fuels can reduce fuel cost, use of these fuels should not be considered unless one is familiar with this technology, because decisions will have to be made such as: Is the capability to repair diesel or gas engines available? What special training or skills are required? Special tools? Are they available in-house? Are local subcontractors prepared to give service needs top priority? Is road-call capability available if the vehicles run out of fuel?
- Does the engine compartment allow easy access to all engine components or will a contortionist be required to service them? What about the transmission? Air conditioning system? Brakes?

The only way to answer many (or all) of these questions is to examine each vehicle type closely. Appendix A to this manual provides guidelines for the maintenance aspects of small bus purchase and operation.

One last point to consider in evaluating vehicle maintainability is its air conditioning system. Air conditioning systems have become a necessity to attract and maintain ridership in warmer climates. These systems have also frequently been the cause of a number of maintenance problems.

The purchaser is urged to check candidate vehicle air conditioning system installations for the following:

- Brand name. Are air service and parts support available locally?
- Has a heavy-duty engine water radiator and cooling fan been installed to handle the added heat load from the condenser?
- Is the mounting system secure? Roof-mounted units especially have been known to break loose or cause roof leaks.
- Does the installation reduce the accessibility to the engine to the point where labor costs for engine service will rise? A skilled mechanic should be able to make this judgment after a review of bus designs being offered.

E. WARRANTY TERMS/SUPPORT

Virtually all manufacturers provide some sort of mechanical warranty on their products. Major manufacturers are even starting to warrant against rust through. In reviewing a manufacturer's warranty, it is very important to note *how* the manufacturer intends to honor the warranty. Some manufacturers will require that a vehicle be returned to the factory for authorized repairs. Others have a dealer or distributor network that is authorized to perform warranty work. The candidate vehicle warranties should be examined to make sure that the terms are practical and implementable by one's transit authority.

F. EXPERIENCE

In the study from which the cost data in Chapter Three were developed, the most powerful parameters governing vehicle operating costs were found to be vehicle make and model. The experience of the purchaser's own transit system or those with which he is familiar can provide guidance in making judgments regarding the ability of different vehicle makes and models to survive the required duty cycle and climate. Manufacturers do have significantly different design philosophies and manufacturing capabilities. Those differences manifest themselves in different performance and durability characteristics. If experience with a product has shown that it has worked well, chances are that brand will continue to prove to be a reliable source of vehicles.

G. CLIMATOLOGICAL FACTORS

In areas of extreme climate conditions, vehicles should be selected and equipped to deal with the weather.

In hot climates:

- Is the air conditioning system well mounted and of adequate capacity?
- Cooling systems must be the largest offered by the manufacturer. Both engine and transmission should have auxiliary heat exchangers for maximum durability.

In cold climates:

- Is there adequate clearance around the drive wheels for tire chains?
- Are reliable step heaters/driers installed?
- Diesel fuel heaters will reduce the chances of fuel "freeze up" when the weather gets below +10 F.
- Auxiliary water-heated cabin heaters are likely to be needed.

CHAPTER SIX

DECISION PROCESS

The previous three chapters have analyzed the three important aspects of selecting the right small bus for the purchaser's requirements:

- The life-cycle cost.
- The availability of the features needed.
- The qualitative factors.

The final decision on the type of bus to select will depend on all three aspects as discussed in this chapter.

A. ESTABLISH PRIORITIES

The final selection process will involve a series of trade-offs. Perhaps one is faced with decisions between basic vehicle types, different fleet sizes, an array of features, and personal, qualitative assessment of various small transit bus characteristics. These trade-offs can best be made by establishing priorities and then comparing each candidate bus against them. The bus or buses that fulfill the top priority items at the lowest cost, and in which one has the most confidence, should be the best bus for the transit system. The tables provided in the workbook (Tables 3.3, 4.1, and 5.1) will help the purchaser perform the trade-offs. It may be necessary to refer to Chapters Three, Four, and Five while filling in these tables. The final selection can be entered in Section 6 of the workbook.

Of course, the features selected and the quality of bus and services provided by the manufacturer will affect the cost of purchasing, maintaining, and operating these buses. A detailed breakdown of how much the effects of each factor would be is difficult to determine. The cost estimates provided in Chapter Three are based on a survey of a large number of small buses (about 300), a sample which included buses with different quality and features. Thus the maintenance and operating cost estimates arrived at would be "average" costs. The purchaser should anticipate lower costs for a better than average quality bus with fewer features and higher costs for a lower quality selection with a large number of features. One's own past experience and the experiences of other transit authorities will help in the assessment of whether or not a particular make and model of bus will have higher or lower than average life-cycle costs.

B. FUNDING CONSIDERATIONS

The most difficult trade-offs to make is between low initial cost and low life-cycle costs. As with most durable goods, those which are the most expensive to purchase tend to last longest and are ultimately the lowest in total costs. Yet transit systems typically do not have the large financial resources required to purchase high-priced vehicles.

The information in this manual is based on actual transit system experiences throughout the continental United States. The cost information is believed to be indicative of the relative cost performance of the various bus types. If a system cannot presently afford the lowest life-cycle cost because of its high initial cost, the information in this manual should be used to select the lowest life-cycle cost vehicle that can be *afforded.* With year-by-year upgrading of the fleet, reduced operating costs will eventually allow one to acquire the lowest life-cycle vehicle type for his transit system.

C. TRACKING THE PERFORMANCE OF YOUR SELECTION

The selection and purchase of new transit vehicles is a lengthy process. The use of this manual is only a first step along this process. Each transit system has its own unique duty cycle, maintenance philosophy and capabilities, as well as driver, rider, and management characteristics. These play a major role in the overall performance of the vehicles, a performance this manual can only approximate.

Keeping accurate records of each vehicle's performance and establishing functional cause and effect relationships will better prepare one to make future vehicle selection and purchase decisions. This may also identify the fact that some of the vehicle's "problems" are caused by nonvehicle-related factors such as inappropriate maintenance activities. The development, utilization, and periodic review of each vehicle's performance can provide a priceless information data base which should be fed back into the guidelines of this manual to help in future vehicle selection as well as in the maintenance and operation of one's present fleet.

APPENDIX A

MAINTENANCE OF SMALL TRANSIT VEHICLES

INTRODUCTION

This appendix is meant to familiarize the reader with the maintenance aspects of small bus purchase and operation.

In maintaining a fleet of vehicles, whether small buses or large, an operator has a choice of two basic maintenance concepts, preventive maintenance or failure repair. Preventive maintenance has been proven historically to be both more economical and efficient. Preventive maintenance is the preferred concept for small bus operators because:

1. More standby vehicles are required to maintain route schedules if no preventive maintenance programs exist.
2. Small transit systems typical peak-to-base ratios allow a more uniform availability of vehicles for scheduled inspections and repairs.

There are a variety of approaches to preventive maintenance programs. They are based on degrees of self-sufficiency of transit system maintenance capabilities.

1. A completely self-sufficient maintenance department.
2. A maintenance department partially dependent on outside contractors to perform specified maintenance tasks.
3. Outside contracting of all maintenance functions except for the limited capability of cleaning, fueling, and servicing.
4. Total dependence on outside contracting for the performance of all maintenance functions.

Every small bus operator should give serious consideration to these philosophies prior to purchase, and how compatible their intended vehicle purchases are with their existing or available maintenance capabilities.

This appendix will not be a complete maintenance manual. It will, however, remind the reader of the kind of maintenance questions to be asked when purchasing a small bus. For example:

- Many gasoline-powered buses have sophisticated engine and transmission control devices. These new control systems may require much more sophisticated analytical equipment than the vacuum gauge, tach/dwell meter and timing light traditionally used for engine diagnosis.
- Should a decision be made to buy propane or diesel-fueled buses? Does the operator's community in fact have these fuels available? Has a procedure been developed to rescue these vehicles running out of fuel on the road?
- Alternatively, has the operator considered the cost advantages of buying fuel in bulk, especially diesel?
- Foreign-designed and manufactured small buses may have a host of desirable features. They may also require someone—either the operator or individual mechanics—to come up with a new set of metric tools. Higher parts costs and availability as well as the availability of repair manuals and technical assistance are also considerations.
- Though a vehicle may be streamlined, eyecatching, and attractive, is the body so unique that it will be very difficult and/or time consuming for repair?
- Are the facility lifts capable of lifting a small transit vehicle? Many lifts found in service stations are incapable of lifting a small bus, and lifts used to lift larger trucks or buses may not have sufficient wheelbase adjustment for the small buses.

- A garage may be well equipped to rebuild large bus brakes, including the turning of drums, although the operator may discover that the brake lathe being used will not adjust to the smaller drums or disc brakes used on smaller buses. The reverse is also true.

These are the kind of questions that will be discussed in relation to not only maintenance philosophies, but maintenance policies, maintenance procedures, vehicle considerations, facility considerations, reporting and control techniques, personnel considerations, and other, special considerations as well.

PREVENTIVE MAINTENANCE

Before developing the particulars of vehicle maintenance and maintenance facilities it is important to understand the requirements of a preventive maintenance (PM) program. It is desirable to tailor preventive maintenance to an individual make and model of bus. The desirability of running a fleet of similar vehicles is therefore understandable. Also, the scheduling and performing of preventive maintenance become increasingly difficult as transit service requirements are increased, requiring additional buses to be available for dispatch and continued service. This last is not usually a problem for operators of small transit vehicles, however.

Mechanics that are required to repair only one make and model of bus will require less training and become more proficient than those repairing several different makes and models of vehicles. Additionally, an operator providing service with a limited spare ratio (vehicles available for maintenance) must have highly skilled technicians, so that defects can be quickly diagnosed and repaired.

The ideal fleet would be composed of one make and model of vehicle operating at a 10 percent to 15 percent spare ratio and providing one type of service. Unfortunately, few transit operators find themselves in this position. An operator should make every effort to maintain fleet homogeny and provide the maintenance department with a spare ratio that will allow maintaining the buses in a safe and cost-effective manner. Because of continuous new bus purchases, fleet homogeny can be maintained by making purchases using the same make and model of major components. In any event, spare ratios can be adjusted to fulfill the maintenance requirements for new vehicles.

The key to preventive maintenance is regular inspection and servicing of the buses, an important part of which is the driver's pre-trip inspection. Unfortunately, although many transit operators require their drivers to perform pre-trip inspections, few enforce the requirement. The result is that what pre-trips are performed are cursory at best. It is very possible that many road calls could be prevented if thorough pre-trip inspections were performed. Those properties making use of a pre-trip check would do well to review the checklist to ensure that items causing road calls are in fact required checks. For example, if a large percentage of road calls experienced are due to failed wipers, it may be advisable that wipers be checked during the pre-trip inspection.

One method of improving the quality of pre-trip inspections, maintenance, and record-keeping involves the use of a three-part NRC type combination pre-trip inspection, driver defect report, and short form repair order. Each driver initiates a pre-trip inspection every time he prepares to leave the garage. At the end of the trip, he retains one copy of the form, submits one copy to the dispatcher with his trip report, and one copy is left on the bus to notify Maintenance of defects discovered. This method serves several purposes, including:

- Providing a means to double check identification of work that should be done against work actually performed.
- Provides drivers an incentive to report impending failures because they know the repair shop will respond to their inputs.
- If a manager of maintenance requires that all pre-trips be turned in for review by a supervisor, Maintenance is assured all work performed is recorded (mechanics have been known to make repairs without recording the work accomplished).

As a further move to ensure that pre-trips are completed, supervisors should occasionally tour the bus parking area prior to the pull-out to ensure that inspections are being performed.

Another method of pre-trip bus inspection is that which is performed by the maintenance department. This type involves the mechanic checking out all buses every evening before they are dispatched the following morning. Though this method may be preferable for smaller transit properties and those properties not requiring pre-trip inspections, it must be remembererd that buses returning to the garage early and leaving again will not have a pre-trip performed, and mechanics may tend to overlook defects if they have to repair them, or if time is short and/or weather is poor.

To provide safe, reliable transportation and to lower maintenance operating costs, it is imperative that in addition to pre-trip inspections, Maintenance perform periodic, indepth vehicle inspections. Many properties base their inspection intervals on road call intervals. Thus, if an operator is experiencing mechanical breakdowns at 2,500-mile intervals, his inspection interval should be placed at 2,000 miles. The inspection intervals should be at a mileage less than the road call interval. It is acceptable to extend the oil change interval as a result of oil analysis, but the remainder of the bus inspection can not usually be extended.

If one were to check the inspection format used at 100 different properties, one would probably find 100 different formats. Any format is acceptable if it is complete, covers all areas of the bus, and is explicit. It is important that the inspection format be periodically updated, especially when new buses are acquired. Though many properties have newer buses, inspection formats often do not include equipment found on these buses such as wheelchair lifts, kneeling devices, radios, and air-operated parking brakes. Additionally, inspection formats should be reviewed periodically to ensure that those items causing road failures are being regularly inspected.

Finally, it is very important that those defects discovered during the inspection be repaired at that time or in the immediate future so that deferred maintenance does not become a problem. Good management dictates that either the inspection form be kept open or a work order initiated for defects found during inspection. After completion, the inspection form or work order should be filed in the individual vehicle history file and used to document and develop the life cycle cost experience with that particular bus type, make, and model.

MAINTENANCE PHILOSOPHIES

Operators of small buses may choose among four major maintenance philosophies, briefly described as:

- Self-Sufficiency
- Partial Dependence
- Limited Capability
- Total Dependence

Self-Sufficiency

Under this philosophy, the operator performs all maintenance on his small buses internally, from servicing them at night to rebuilding their engines. Advantages to this philosophy include scheduling control, quality assurance, and guaranteed capability.

By having all maintenance functions in-house, an operator can presumably schedule component change-outs or rebuilds at his convenience. Assuming he runs a quality shop, a full-spectrum maintenance operator can also be assured of the type of work being performed on any component. Total control also means that the operator need not worry about whether a specialty function is available elsewhere in the community.

While in-house capability is desirable for the above reasons, it is also expensive and, for most small operators, uneconomical. Expansion of a maintenance facility to include transmission rebuilding or radiator repair functions simply is not cost-effective for the typical small bus operator. Union pay scales for transit mechanics can often exaggerate these expenses, as well.

Partial Dependence

A partially dependent maintenance philosophy relies on outside contractors to perform specified maintenance tasks. These tasks are usually those which require highly specialized skills or unique repair/diagnostic equipment, or are infrequent in nature. Advantages of partial dependence compromise the comfort of complete self-sufficiency with economic reality. Maintenance functions which should economically be performed in-house—brake jobs, for example—remain in the shop. Those which can be performed less expensively outside, such as diesel fuel injection repair, are vended out.

Limited Capability

Under this philosophy all maintenance functions except for the limited cleaning, fueling, and routine servicing are contracted out. A good example might be a social service agency of limited means which arranges with a nearby transit system or auto dealer to maintain its equipment.

While vital maintenance functions now reside in someone else's charge, that someone else can still be held accountable through carefully drawn maintenance performance requirements. Also, limited capability means limited liability. Employees obligations and facility commitments for internal maintenance are not required. Should a maintenance contractor fail to perform, or become too expensive, the small bus operator may be able to take his business elsewhere. Such flexibility is usually not allowed an internal maintenance operator.

Total Dependence

Total dependence completes the outside contracting maintenance spectrum. In this last maintenance philosophy, all maintenance functions, including cleaning, fueling, and servicing, are contracted out. Reasons for such total dependence are usually economic. Not only might the small bus operator lack the capital and operating funds required to maintain his vehicles internally, an outside maintenance contractor might be able to purchase fuel at a much cheaper rate than the small operator.

Arrangements with Third Party Maintenance Services

Each operator needs to evaluate its position relative to available resources. For example, the city/town may have a garage that is underutilized, with mechanics capable of servicing small bus vehicles. If so, typical agreements involve charges to the small bus operator based on actual parts costs plus a modest markup (10 percent) and direct labor based on an agreed-on rate.

If contracting for municipal services is not an option, a combination of driver-performed light maintenance (e.g., changing headlights, wipers, fuses) and a contract with a local service station might be appropriate. Contracts with service stations might include a stated rate for routine maintenance (e.g., $15 for oil and filter change) and an agreed-on wage rate for major work with hours billed according to standard practice guide books. The operator should also include, in the contract, the maximum permissible markup of parts costs above wholesale prices.

As an alternative to the scenarios above, an operator might choose to sign a service agreement based on time and/or mileage with a local dealership. A cost and level of service comparison should be conducted by each operator before selecting the best course of action.

MAINTENANCE POLICIES

No maintenance philosophy is any more credible than the policies which carry it out. Many highly efficient transit operators have developed formal policies dealing with every aspect of the maintenance function. These policies generally include:

- Accident Response/Road Calls
- Body Maintenance
- Building Maintenance
- Cleaning/Servicing
- Component Changeout/Rebuild
- Inspection

Accident Response/Road Calls

A transit system's maintenance department usually becomes involved in bus accidents only if there is a requirement for an estimate of damage to the bus for insurance purposes or if it is thought that the bus had a mechanical problem that may have caused the accident. In the latter case, a maintenance manager or his delegate completely checks the vehicle out and reports his findings. Transit's experience has been that most claims of mechanical failure are attributed by the drivers to the braking system. Many transit organizations use a brake meter to test braking efficiency. As these devices are recognized by many states as providing an accurate measurement of braking efficiency, the subjective argument of "good" versus "soft" brakes is often avoided. To ensure the quality of brake overhauls, some maintenance managers require that each bus be road tested using a brake meter following brake overhaul. It is strongly recommended that each property not having access to a brake meter make every effort to acquire one.

At most properties, road calls are reported by a driver to a dispatcher by radio. The dispatcher then logs the road call information on his daily dispatch sheet. The dispatcher then notifies Maintenance of the road failure. Maintenance should then record the road call information on a road call report. After disposition of the road call, one copy of the report should be placed in the vehicle history file and the other copy is sent to the dispatcher to indicate action taken and for preparation of monthly road call reports. Some properties have drivers report road calls directly to the maintenance department. However, as road calls are direct indicators of maintenance efficiency, most transit managers prefer to use the dispatcher as a check to ensure that all road calls are reported. Road calls are defined by most transit operators as either a delay in service or a requirement for a mechanic to leave the garage. Urban transit operators throughout the country strive for road call intervals of 2,500 to 3,500 miles. To further define road calls and isolate trouble areas, many operators differentiate between maintenance chargeable and maintenance nonchargeable road calls. Nonchargeable road calls include those over which Maintenance would have little control, such as drivers' errors, sick passengers, flat tires caused by road hazards, or accidents. Also, some properties further delineate road calls by specific problems, such as brakes, air conditioning, accidents, etc. This differentiation allows the operator to isolate problem areas. Some operators have found that driver unfamiliarity with operating controls on new vehicles have caused more than 15 percent of one month's road calls. Steps have then been taken for additional driver training. Likewise, if an extraordinary number of road calls are for brake malfunctions, Maintenance may elect to perform weekly brake checks or modify the inspection program to include a more thorough inspection of the braking system.

Most transit managers require a monthly road call summary report that includes: miles per maintenance chargeable road call by category, miles per road call total, an exception report for buses experiencing two or more road calls for the same malfunction and action taken, and performance comparisons from previous time periods.

Properties operating several subfleets of vehicles may also require that road call information be broken out by vehicle type to isolate those subfleets that may be experiencing problems unique to those subfleets.

Care should be taken when comparing one property's road call records to another's that "apples are compared to apples." Much as when comparing maintenance cost per mile, road call definition and maintenance cost definition may vary from property to property.

Body Maintenance

Bus bodies and interiors should be maintained in a manner that promotes the image of public transit as an attractive, comfortable, safe, and efficient alternative to use of the private automobile. Towards this end, significant wear and damage should be dealt with expeditiously to assure a quality appearance.

For small bus operators, major bus body and structural repair, glass and upholstery work should be performed by outside vendors, as discussed under maintenance philosophies earlier. It is the responsibility of the maintenance supervisory to assure that scheduling of vehicles for outside repair be done as soon as practicable after determination of the work required.

Repair of typical minor body damage, such as chalked or scraped paint, body dents, and scratches, door and panel replacement, and interior wear should be performed by maintenance personnel. The maintenance supervisor is responsible for assuring that buses are regularly checked and subjectively assessed against the look and finish of a new bus. When buses do not favorably compare in their appearance, fit, and finishing, steps should be taken to bring them up to an acceptable level.

Particular care should be directed toward minimizing or correcting defects, flaws, or conditions existing after repair work that could constitute a hazard to bus operators, the riding public, or maintenance personnel. Examples would be rough or sharp panel and bracket edges, and protruding fasteners that could cut or snag clothing or skin; gaps at panels, seats and handhold areas where fingers could be trapped; and uneven floor seams or steps treads that could cause a person to trip. Maintenance personnel and operators alike must be aware that the responsibility for providing a safe vehicle rests with all employees.

Experience has shown that transit vehicles maintained at a high level of interior and exterior appearance are both indicative of and foster a positive staff attitude toward all phases of bus maintenance and operation. It has also been demonstrated that it is less costly to maintain buses at a high level of exterior and interior repair than to allow them to deteriorate to a level that requires major refurbishment.

Building Maintenance

To assure long service life and safe operation, high dollar equipment items such as vehicle lifts, bus washers, air compressors, air piston pumps, floor scrubbers, service trucks, and building support equipment (air conditioning units, furnaces) should be regularly inspected and serviced. Service intervals and service requirements for these items are sometimes available from equipment manufacturers. Preparation of an inspection format for each piece of equipment indicating what maintenance is required at weekly, monthly, and seasonal intervals should be prepared. Incorporating these inspection service requirements in the maintenance schedule and ensuring their completion is the responsibility of the maintenance manager.

In addition to regular inspection and servicing of the various shop equipment, the facility itself should be periodically inspected for signs of deterioration in the structural, electrical, and mechanical building systems. Building systems needing repair or servicing should be reported to the appropriate department so that the necessary work can be performed with appropriate skills. The vehicle maintenance department should not be responsible for making major repairs to building systems or stationary, complex equipment.

Cleaning/Servicing

To provide attractive, clean, and reliable service, buses must be serviced and cleaned on a daily basis. When buses return from service in the early evening, fare vaults should be serviced; tanks should be fueled; engine oil, transmission fluid, and engine coolant should be checked; and the interior of the bus should be cleaned and the bus washed if necessary. At this time, driver defect reports should be retrieved from the vehicles and reported to the maintenance person in charge for disposition. Consumables dispensed (fuel, engine oil, and automatic transmission fluid) should be recorded on daily fuel and oil reports. This information, along with either scheduled route miles or hubodometer mileage per bus is critical to the preparation of inspection schedules, road call reports, and maintenance cost reports.

In addition to daily servicing and cleaning of the buses, the service and cleaning crew should also regularly clean the engine compartment prior to preventive maintenance inspections and thoroughly clean the interior of each bus on a regular basis. This thorough interior cleaning consists of washing the windows, cleaning the dashboards, wiping down ceilings, cleaning light fixtures, removing graffiti from seats and walls, and removing gum and other debris from the floor. Many properties incorporate this thorough cleaning of the vehicle and cleaning of the engine compartment with the preventive maintenance inspection.

Because they see each bus every evening, are familiar with fuel and oil usage of the buses, and drive the buses from the service areas to the storage bays, the service and cleaning crew can be invaluable in spotting defects that may otherwise go unnoticed. The service and cleaning crew should be encouraged to report buses with defects or vehicles leaking fluids or consuming excessive amounts of oil.

The maintenance supervisor should be primarily responsible for the cleanliness and availability of vehicles for dispatch. The supervisor should see that all personnel concerned with service and cleaning are thoroughly familiar with the various makes and models of the buses and their requirements for proper fueling, cleaning, and servicing. The supervisor should also be responsible for preparation of servicing and cleaning schedules and reports.

General fueling and servicing of vehicles should be accomplished during evening hours after the vehicles return from their scheduled routes. Vehicles should be brought from the parking area, fueled and serviced as required and then returned to the parking area. Vehicle interior and preinspection cleaning should normally be scheduled and completed during the day shift.

Component Changeout/Rebuild

To assure the availability of serviceable vehicles, components that would require more time to repair in the vehicle than the time to remove and replace should be changed-out when defective or, ideally, when indicators show failure is imminent. The only exception to this policy should be when all parts required to repair the component are available and a replacement component is unavailable. To facilitate changeout, it is necessary that spare components be kept on hand if they are not readily available through local vendors. After the defective unit has been replaced, it should be immediately rebuilt or exchanged for a serviceable unit and returned to stock for future use. Examples of some major spare components to be kept on hand are:

- Engine
- Transmission
- Turbocharger
- Starter
- Generator
- Air Compressor
- Air Conditioning Compressor
- Power Steering Pump

To minimize service breakdowns and expensive repairs, components should be changed out prior to failure. There are several methods by which the maintenance supervisor may be alerted that a particular component may need changing-out.

1. *Vehicle inspection*—Thorough major and minor inspections will identify components that are wearing out and need to be replaced.
2. *Daily servicing record*—By reviewing the service records on a daily basis, the supervisor will be able to schedule buses for repair that are using excessive oils, fuel, or coolant.
3. *Driver defect card*—Buses that are frequently written up for the same defect (examples: soft brakes, no power, clutch slips) may have a major component that is near the end of its useful life and requires changeout.
4. *Vehicle history card*—By periodically reviewing the vehicle history cards, the supervisor will be aware of vehicles with high mileage components and can take steps to ensure that the particular components remain serviceable or are replaced.
5. *Fleet defects*—Should several buses of a particular make and model develop similar problems, the maintenance supervisor should inspect the rest of the buses within that group of vehicles to ensure that enough spare components are on hand, should all the buses develop the same problems. He should also be alert to a probable cause of those failures. Perhaps some maintenance of repair operations is being performed improperly and causing these common system failures.
6. *Oil analysis*—Periodic oil analysis often alerts the operator to imminent internal engine and transmission failure. Many oil distributors and independent laboratories will provide this service.

Most transit properties perform some component rebuilding. Component rebuilding may be limited to simple components, such as water pumps and brake application valves, or may be quite extensive, including engine and transmission overhaul. Periodically examine the cost-effectiveness of the in-house rebuilding program versus rebuilt components purchased from outside vendors in order to assure highest dollar value and quality work. Many times carefully rebuilt parts will outlast brand new components. It is very difficult to decide which is more cost-effective regarding component rebuilding. Items to be considered when deciding the cost-effectiveness of an in-house major component rebuild program versus that of an exchange program with an outside vendor include:

- Competence of in-house mechanics to efficiently rebuild components.
- Availability of tools and test equipment to perform major rebuilds.
- The effect of in-house rebuilding on inventory levels.
- Labor costs, including overhead.
- Warranty provided by outside vendors.
- Component life of those items rebuilt in-house, versus that of components rebuilt by outside vendors, versus new parts.
- Availability of qualified vendors in the immediate area.
- Turnaround time, or that time required to rebuild an item in-house, as opposed to purchase from an outside vendor.

After careful study of the above factors, many properties adjust on a periodic basis the list of components to be built in-house versus those to be built by outside vendor. To compare the costs associated with each rebuilding program, detailed costing records must be maintained.

Inspection

There are three levels of inspection:

- Driver—Done daily
- Minor—Done weekly
- Major—Done in conjunction with manufacturer's lubrication intervals

To ensure safe, reliable service, it is imperative that buses be inspected at regular intervals. In addition to periodic state safety inspections, if required, buses should receive inspections by the operator at regular intervals. Minor inspections consist primarily of checks of safety-related items and general vehicle conditions, while major inspections should deal with required preventive maintenance.

Any defect found during either type inspection that would adversely affect safe operation of the vehicle should be repaired prior to the vehicle being released for service. Defects not affecting safe vehicle operation should normally be repaired prior to the vehicle being released for service. However, buses requiring parts not in stock, outside vendor services not immediately available, or excessive repair time may be released at the discretion of the maintenance supervisor, who should ensure that the vehicle is scheduled for repair at the earliest opportunity.

The driver's daily inspections have already been discussed. Though mechanic helpers may assist with inspections, mechanics should be responsible for completing an inspection form and ensuring that all work is performed properly.

Mechanics should be encouraged to take buses on periodic test drives. These inspection drives will aid in the diagnosis of faults noticed by the drivers. Because good mechanics can be sensitive to the way a vehicle performs, these inspection drives may result in the early detection of problems. Early detection can lead to the convenient scheduling of a repair and/or perhaps reduce the number of road calls as faults are detected before they put the bus out of service.

A minor inspection should be performed. The purpose is to check all operations of the vehicle and to make all required adjustments to ensure safe and proper operation of the vehicle during its scheduled service. A review of all raod calls every 6 months should be made to determine the adequacy of the inspection intervals.

A major inspection should generally be performed in conjunction with lubrication requirements. In addition to the items covered under the minor inspection, a complete servicing and lubrication of the vehicle should be performed at this time to extend the service life of the vehicle and its components.

It is estimated that each minor inspection should require an average of 2 to 4 man-hours to complete. This includes both the actual inspection and completion of minor repairs such as:

- Changing defective bulbs.
- Adjusting brakes.
- Topping off fluid levels.
- Tightening loose connections, fittings, and fasteners.

A major inspection may require up to 6 or 8 man-hours to complete, depending on the complexity of the vehicle and its maintenance requirements. As with minor inspections, the time allotted includes fluid changes and minor repairs. Engine oil should be analyzed for a period of at least one year. At the end of this time, sufficient data should be available to determine the correct interval for oil changes and oil analysis for the fleet. In addition, oil analysis data can lead to early identification of problems and will be of significant benefit in resolving questions relating to warranty liability.

Transmission oil samples should be analyzed at each major inspection for the first year for similar reasons as noted above.

MAINTENANCE PROCEDURES

Maintenance procedures describe the implementation of the maintenance policies established by management. They should document the subject, action required, when required, and by whom. A maintenance manager must make every effort to ensure that maintenance procedures are developed and adhered to if maintenance is to be a planned rather than reactive function. Regular maintenance procedures may include but not be limited to: preventive maintenance, component changeouts, retrofits, campaigns, engine compartment cleaning, oil analysis, and interior cleaning. To minimize scheduling requirements and unproductive movement of buses to and from repair areas, many maintenance departments have used preventive maintenance procedures to encompass several aspects of planned maintenance. For example, by making engine cleaning, interior cleaning, oil sampling and deferred maintenance repairs a part of preventive maintenance inspections, several maintenance requirements are fulfilled during one operation. Maintenance schedules are usually derived from bus mileage; thus, it becomes relatively easy for the maintenance manager to predict scheduled maintenance requirements and devleop standard procedures. Building maintenance procedures are usually scheduled on a weekly, monthly, or seasonable basis. Normally, vehicle maintenance procedures are scheduled on a weekly basis, though retrofits and campaigns may be scheduled over the course of one or more months. Maintenance schedules may be presented by means of a computer printout, a large wall scheduling board, or simply on notebook paper. It is a maintenance manager's responsibility to develop and follow practical maintenance schedules. Many transit organizations require that the manager or his subordinate prepare a weekly or monthly report of work scheduled and work completed.

Bus repairs should be performed by mechanics and mechanic helpers as directed by the maintenance supervisor. Upon receiving a service request from Transportation, or discovery of a defect during inspection or servicing, the supervisor should assign a mechanic and/or mechanic helper to perform the required repairs. Upon completion of the work, the supervisor should review the service request, ensure that all work has been satisfactorily completed according to the prescribed procedure, complete the charge sheet for entry to the maintenance records, and return the appropriate copy of the service request to Transportation.

FACILITY CONSIDERATIONS

Facilities and equipment provided for small bus maintenance can have either positive or negative impacts on the quality of maintenance and associated costs. There are few small bus operators in this country who could not lower their operating costs by reviewing their facilities, locating cost inefficiencies, and making the necessary corrections. For example, one wonders how many precious operating dollars are literally going up in smoke due to uninsulated ceilings and roofs, or how much time is being lost due to detrimental working environments, lack of tools, equipment and working space. When either reviewing, remodeling, or constructing a new maintenance facility, the following areas should be considered.

Interior Lighting

Interior lighting should be full spectrum fluorescent in the offices and at work stations. Lighting used in maintenance bays should not include low-pressure sodium vapor. This type lighting makes deciphering of color-coding very difficult, and is perceived as harsh light which has been documented to adversely affect morale and performance of employees. Design should admit natural light into work areas, or provide an acceptable substitute.

Exterior Lighting

Exterior lighting should be provided as a security and safety measure. High-pressure sodium vapor lighting should be considered for exterior illumination because it is generally less expensive to operate than mercury vapor.

Ventilation

Ventilation is critical in bus storage and repair areas. Conveniently located exhaust hoses should be available to attach to the exhaust pipes of buses which must be idled inside the garage for repair or diagnostic testing. The design of these devices should consider roof stack and under bumper exhaust pipes on standard buses. In areas where buses routinely stop with engines running, such as the inspection area and chassis wash, fixed automatic exhaust vents should be located to reduce interior air pollution. Repair pits and office areas, including storerooms, should be positively ventilated to reduce fume entry.

Heating

Heat should be maintained at 40 to 50 F in bus storage areas, 60 to 65 F in open work areas, and 68 F in shop office areas. Modern heating units and zone temperature controls can do much to lower heating costs.

Repair Pits or Depressed Areas

While cleanliness and safety factors are inherent disadvantages of repair pits, the ability to perform rapid under-bus repairs and the requirements for minimal ceiling clearances make repair pits feasible.

Vehicle Lifts

Though 19-ft unobstructed ceiling clearances and periodic maintenance of lifts are required, vehicle lifts are invaluable in making bus repairs. Two basic types of lifts are available: permanent in-floor installation or portable wheel lifts. Permanent lift installations are preferred because the initial cost is lower, there is less upkeep, and bus support stands are not required if the wheels are to be removed from the vehicle. Generally, pits are preferred in inspection and quick repair areas, and lifts preferred in those areas where major repairs are taking place. For conventional transit operators acquiring small buses, it is advisable to check existing lifts, as some large bus lifts may not have sufficient post adjustment for smaller buses. On the other end of the spectrum, many lifts found in service stations and auto dealers are incapable of lifting a small bus.

Repair Bays

Transit's general rule of one repair bay per 10 to 12 buses, excluding service and wash area, is unusual in fleets of fewer than 50 buses. Most fleets require at least two repair stalls; one is used for quick repairs and preventive maintenance inspection, while the other is used for long-term repairs. When new facilities are planned, it is wise to size the repair bays for the largest appropriate buses available. Today's operator of 25-ft vehicles may be running full-size buses within the next 5 years.

Site Circulation

Site circulation should be in a counter-clockwise direction to preclude blind turn requirements. It is essential that adequate space be provided for pull-outs and turning. This consideration is especially critical when entering or leaving bus washers, bus storage areas, and repair areas.

Bus/Chassis Wash

An area should be provided for washing bus exteriors and cleaning engine compartments. Though small transit properties may not require an automatic bus washer, space is still necessary for the hand cleaning of the exterior of the bus and for engine compartment cleaning using either a high pressure washer or a steam cleaner. If a bus washer is used in conjunction with the high pressure washer, it may be advisable to provide to water reclamation, depending on environmental protection requirements and water costs.

Reel Banks

Though considerable costs are associated with the initial installation and maintenance of reel banks and centralized lubricant disbursal, mechanics' time loss, work space loss, and generally unsightly clutter associated with drum dispensing of lubricants more than offset these costs. The provision of reel banks is especially important in the service and clean areas and the inspection area, because considerable quantities of fluids are dispensed in these areas.

Doors

To conserve energy, both personnel and bus access doors should be equipped with automatic closers.

Parts Storage

A minimum of 35 to 40 sq ft of parts storage should be provided for each vehicle in the fleet. Unfortunately, many maintenance facilities presently occupied are not designed with these requirements in mind. This has resulted in parts being stored throughout the facility, which is not conducive to inventory control, record-keeping, security, or space utilization. Many properties operating with inadequate storage facilities have seen fit to construct a secured parts storage area on the property for storage of bulky, slow-moving items to alleviate parts being stored throughout the facility.

Bus Storage

In cold climates, buses should be stored indoors when not in operation, since diesel-powered buses are hard to start in the winter months. For extreme northern climates, this holds true for gasoline engines as well. The temperature in diesel bus storage areas should be maintained above 35 F.

Body and Paint Repair

Though body work and minor paint touch-up may be accomlished in repair stalls, an OSHA-approved paint stall should be provided for extensive painting. Smaller properties may also use the paint stall for body repair. Of course, extremely small operators will not find a paint stall cost-effective.

Bus Washer

Larger fleets should give serious consideration to use of an automatic bus washer.

Chassis Wash

Provisions should be made for high pressure, hot water, or steam cleaning of bus engine compartments and air conditioning compartments. Smaller operators may also use this area for exterior cleaning of vehicles.

Service and Clean

A separate area should be provided for daily fueling, servicing, and cleaning of buses.

Revenue Retrieval

For security reasons, fareboxes should be serviced as the bus returns to the property.

Employee Parking

Parking should be provided on the site to maintain good community relations. For security reasons, employee parking should be separated from the Operations and Maintenance areas with limited personnel access provided to these areas.

Drivers' Lounge

As drivers often work split shifts or extra board duty, many properties provide a lounge for the drivers. These areas may be equipped with television sets, pool tables, or ping pong tables. As they are for the express use of the drivers, they should be separated from the mechanics' lunch area.

Mechanics' Restroom and Lunch Area

Locker and shower-equipped restrooms should be provided for both female and male personnel. A lunchroom separate from maintenance activities should be provided. This area can also be used for meetings and training.

Tire Shop and Storage

For those properties responsible for the repair of tires, a well-equipped tire shop, including a tire changer, balancer, regroover, and spreader, is required. Secured tire storage should also be provided.

Maintenance Offices

The maintenance office should be easily accessible to the repair areas and contiguous to the storeroom areas to provide some control over parts rooms that are not staffed.

Bulk Storage

All operators can benefit from the cost-savings associated with bulk storage of oil and diesel fuel. Larger operations may find it appropriate to provide bulk storage of automatic transmission fluid and engine coolant. One-thousand gallons storage per bus is preferred. Bulk engine oil, automatic transmission fluid, and coolant quantities will depend on local vendor charges.

Equipment

An operator wishing to tune a modern engine equipped with complex controls may find that the familiar vacuum gauge, tach/dwell meter, and timing light are not adequate. A more expensive computerized engine analyzer may be required.

For the larger operator acquiring small buses, a maintenance facility may be equipped to turn drums and rebuild large bus brakes. However, his standard brake lathe may not adjust to the smaller drums or disc brakes used on smaller buses. In general, therefore, the operator would be wise to thoroughly understand the maintenance and equipment requirements of the vehicle being considered for purchase.

REPORTING AND CONTROL TECHNIQUES

For small bus operators as well as large, the importance of an accurate, up-to-date, and complete maintenance reporting system cannot be overemphasized. Varying degrees of sophistication will be required, depending on the philosophy selected. Central to reporting and control techniques are:

- Record Keeping
- Reports
- Performance Indicators
- Inventory Control

Record Keeping

Accurate, easily retrieved records are essential for the following:

- *Budget preparation*—With continuing reductions in operating assistance, the old method of "adding 10 percent to last year's budget" and submitting it for approval may no longer be appropriate.
- *Warranty claims*—It is very difficult for a manufacturer to deny a warranty claim that is supported by repair orders, oil analysis reports, and road call reports.
- *Litigation purposes*—A transit operator's defense against a plaintiff's claim that poor maintenance was the cause of a bus accident involving personal injury is greatly enhanced if accurate, complete maintenance records are available.
- *Needs justification*—The maintenance manager's request for additional personnel or equipment will often be favorably viewed if documentation is available to support his request.
- *Approved equals*—If a maintenance department can support its claim that one piece of equipment is better than another with accurate cost records, the desired piece of equipment can oftentimes be acquired.
- *Report preparation*—Preparation of factual reports is extremely difficult unless the appropriate back-up data are available.
- Track vehicle performance.
- Aid in determining where to dispose of a vehicle.
- Assist in establishing life-cycle cost data for a given make/model.

Maintenance record-keeping systems may be manual, semi-automated, or completely automated. It should be noted here that if the transit operator is not committed to maintaining an excellent manual record-keeping system, it is not likely that automation will do much in the way of enhancing the system. Likewise, any operator contemplating an automated system must ensure that the maintenance department is involved in the process from the beginning so that maintenance record-keeping and information needs are met and the maintenance personnel will accept and use the system. Also, it is important for the operator to realize that unless an expensive and complex totally automated system is used, paper work probably will not be significantly reduced.

Transit properties use a multitude of various forms, procedures, and methodologies to maintain their individual record-keeping systems. Operating environments, maintenance philosophies, and service requirements often dictate the needs to be fulfilled by the various record-keeping systems. For example, warranty claims would not be as important to an operator using older buses as it would be to an operator using recently purchased new vehicles.

A key control technique for small bus operators is the driver defect card. The primary purpose of the driver defect card or report is to provide a means for the reporting of bus defects to Maintenance by the operators. Driver defect cards may be left on the bus for retrieval by the service and cleaning crew, submitted to the dispatcher or clerk for transferal to Maintenance, or submitted directly to the maintenance supervisor. Transit properties will often use the driver defect card to fulfill several requirements on one form, including a driver's pre-trip inspection or use of the driver defect card as a work order. When the defect card is also being used as a work order, the card is placed in the vehicle history file upon completion of the work.

Reports

Regardless of the type of record-keeping system employed, manual or automated, certain basic reports should be developed for transit management on a regular basis. Road call, cost, inspection, fuel and oil, exception, and summary reports can often give advance warning of maintenance areas that may develop into serious problems. Each transit manager, regardless of the size of the property, should expect to receive and review the following maintenance reports.

Road Call Summary Report

While road call summary reports for larger properties may contain very complex information, such as miles per chargeable road call, miles per nonchargeable road call, number of road calls by classification, number of road calls by subfleet, and percentage of repetitive road calls, smaller operators may require merely a listing of road calls for each bus for the previous month. Smaller transit operators can use road call summary reports to spot maintenance areas that may need to be addressed relative to inspection, maintenance, or operator training.

Inspection Summary Report

An inspection summary report should be prepared each month and include oil and fuel consumption of each vehicle, miles since the vehicle was last inspected, the type of inspection that is either due or has recently been performed, and vehicle life miles and miles traveled during the reporting period. To simplify reviewing the report, many properties report only those buses that are exceptions. That is, they are either overdue for inspection, or fuel consumption and/or oil consumption falls outside of preestablished consumption parameters.

Cost Report

Ideally, cost reports are presented in three formats: individual cost reports for each vehicle (for maintenance use), fleet summary cost reports, and cost exception reports (those vehicles having excessive maintenance costs for that reporting period). Cost reports should delineate vehicle cost per mile for labor, parts, fuel, and oil.

Ideally, labor and parts costs are broken down by category; i.e., brakes, air conditioning, and suspension, in addition to cause of repair, such as road call, warranty work, preventive maintenance inspection, vandalism, accident damage, or normal wear and tear.

This information, presented by vehicle, fleet summaries, and exception reporting, identifies for management those areas where improvements can be made. By comparing costs of one time period to another, it is possible to measure the effectiveness of the programs initiated and steps taken to improve various maintenance areas.

These reports can be prepared manually or by incorporating computer technology. The time required to prepare these reports is not as great as some maintenance managers would claim. If cost reports were prepared for each vehicle and updated on a daily basis, the time spent would probably be less than 1½ hours per day for the entire fleet.

Performance Indicators

In addition to receiving cost, road call and inspection summaries, it may be appropriate for management to receive maintenance performance indicator reports. Maintenance and management know that all buses are to be inspected at regular intervals, that a certain number of buses are required for the peak and base pull-out, all driver reported defects are to be repaired, a certain number of brake relines must be accomplished each week, a certain number of engines and transmissions must be rebuilt or replaced each year, and that goals have been set for an acceptable number of road calls and service delays. The question becomes, "Are these requirements and goals being met?" As a transit property can reliably predict yearly bus mileage, it is relatively easy to predict the number of brake relines, inspections, engine changes, and transmission changes that will be required during the year, and thus on a weekly or monthly basis. This also holds true for road calls and service requirements. A simple performance report contains a list of maintenance areas to be monitored such as road calls, spare buses, bad order buses, inspections performed, engine overhauls, transmission overhauls, interior bus cleans, or any item of particular interest to an individual property. In addition to the list of items, weekly targets are indicated and space is allowed for recording information for each day of the week. The results are totaled and compared to the goals set at the end of each week. As a maintenance manager is aware that the report is being reviewed on a daily basis by both an operations manager and possibly a general manager, it serves as a constant reminder of maintenance priorities.

It should be noted that each property has its own areas of interest. An operator in southern states may require a certain number of air conditioning services each week. It should also be noted that targets set and maintenance activities tracked should be periodically reviewed and adjusted as inspection intervals or procedures are modified, new buses are acquired, service is either expanded or decreased, or innovative maintenance practices are initiated. It should also be noted that mutually set goals and targets should be realistic.

Inventory Control

Inventory levels will be directly affected by the fleet mix and service provided. A fleet of various makes and models of buses will require that duplicative items be kept in stock. For example, spare starters may have to be kept in stock for each type of bus operated. Also, if service requirements are such that buses must be repaired immediately on breakdown, the operator may be required to maintain in his inventory parts that are seldom used. These parts would normally be ordered on an as-required basis if the spares ratio was such that a bus could remain out of service for the period of time necessary for delivery of the parts.

The function of ordering, receiving, stocking, and dispersing of parts is usually performed by the maintenance department in smaller transit operations. Ideally, one person would be assigned to perform these duties. In fleets of up to 50 buses, this person's duties could also include maintaining the record-keeping system and maintenance scheduling. In smaller operations with limited personnel, the maintenance manager may be required to perform these functions in addition to his other duties. It is preferable that a full-time storeroom/maintenance clerk be employed to keep records accurate and up-to-date, and to perform housekeeping duties in the storeroom.

It is also preferred that a stock card record-keeping system be used for inventory control. This system involves the use of a stock card for each individual part, which contains the part number, part description, price, and vendors. The remainder of the card is used to show transactions, receiving, ordering, and disbursal of each of the individual parts. A physical inventory should be performed at least once yearly, and every effort should be made to limit inventory levels to less than $2,500 per bus, depending on the maintenance philosophy selected. Inventory levels will be dependent on the amount of work being done in-house, spare ratios, and availability of parts locally. Storerooms are usually open on all shifts for mechanics to obtain parts. Ideally, access to the storeroom should be limited to the parts clerk and the maintenance supervisor. If staffing levels preclude this arrangement, it may be feasible to tag individual parts so that when mechanics withdraw a part from stock, they are merely required to remove the tag and enter the bus number on the tag. The parts clerk can then charge the individual buses with the parts used.

The storeroom and maintenance office should be contiguous so that updated parts manuals and maintenance manuals can be maintained in one area. Locating the maintenance office near the parts room also provides a measure of security for manuals and parts.

PERSONNEL CONSIDERATIONS

Obviously, the heart of a maintenance program for small buses is the people who maintain them, whether direct employees of a transit system, or an outside contractor. Primary personnel considerations discussed in this section will include:

- Organization/Staffing
- Job Descriptions
- Training

Organization/Staffing

Organization and staffing requirements will be somewhat dependent on the fleet mix (different makes and models of buses operated) and service requirements. Operators of bus types (Chapter Three) with high maintenance costs per mile can expect to require more mechanics than those with low costs. Similarly, an operator using 47 of a 50-bus mixed fleet for peak service requirements can expect to have additional staffing requirements in order to promptly repair buses that are required to meet service peaks.

General rule of thumb guidelines have evolved to calculate the number of maintenance personnel required to effectively maintain a bus fleet. These rules were drawn from current industry practice without any distinction between large and small bus requirements. However, as the bulk of the industry is concerned with full-size buses these numbers must be applied with caution to small buses. These formulae include:

- Three buses per maintenance employee. This may be misleading, depending on fleet use and type of service provided.
- 20 to 24 labor-hours per bus per 1,000 miles service provided.
- 12 to 14 persons per 1,000,000 miles service provided.

The 12 to 14 persons per 1,000,000-mile guideline is preferable. However, it assumes that all personnel assigned to maintenance including clerks, managers, and utility workers are counted in a normal fleet operating in a normal environment. Unfortunately, normal is difficult to define. Factors peculiar to individual properties must be considered when applying staffing guidelines, including:

- *Fleet mix*—A fleet of diversified makes and models will require additional personnel.
- *Facility and site circulation*—Considerable time can be lost if multiple bus moves are required on an irregularly shaped and crowded site.
- *Age of fleet*—Extremely old buses may require additional repairs. Also, new buses equipped with wheelchair lifts and air conditioning units that must be operable will require additional maintenance personnel.
- *Operating environment*—Temperature extremes, road surfaces, and topography will influence maintenance requirements.
- *Facility, tools, and equipment*—Buses stored outside during cold weather require more maintenance. Facility, tools, and equipment provided will impact maintenance efficiencies.
- *Outside services available*—A fleet operating in the proximity of a reputable dealer may contract for a portion of its maintenance overhaul work. Obviously, the degree and quality of outside help available will play a large part in influencing the maintenance philosophy selected, as discussed earlier.
- *Spare ratio*—A 50-bus fleet providing 47 bus peak service does not have the luxury of deferring maintenance until someone is available to make necessary repairs. Thus, this maintenance operation will probably require additional personnel.
- *Staff*—Experience, attitude, contractual agreements, and management philosophy will greatly affect staffing requirements.
- *Service requirements*—An operator providing extensive elderly/handicapped service and operating on routes requiring passenger pick-ups at each block will necessarily be required to perform additional maintenance on the buses because of the extreme wear and tear associated with high numbers of stops per mile.

Historically, transit has required that new maintenance employees, regardless of their qualifications, begin their careers as bus service persons or hostlers, with promotion to more skilled positions based strictly on seniority. This practice was rigidly enforced by both company policy and contractual labor agreements, making the transit industry very unattractive to otherwise well-qualified mechanics. Fortunately, in recent years many transit operators have revised company policy and renegotiated labor agreements to allow for promotion and job placement based on qualifications rather than seniority. Properties basing their promotions on qualifications have proven that having well-qualified people in various maintenance positions sometimes reduces staffing levels. Recently, transit operators, in an effort to recruit and retain qualified personnel on unpopular night and week-end shifts (when the buses are available to be repaired), have followed private industry's lead in offering week-end and night shift premiums.

Job Descriptions

Job descriptions for the prototypical operator of small buses are suggested for the positions of:

- Maintenance Supervisor
- Maintenance Clerk
- Mechanic

- Mechanic Helper
- Hostler

Maintenance Supervisor

- *Description of work:* Supervises a group of mechanics and workers engaged in the repair and servicing of diesel and gasoline powered buses and related support equipment.
- *Typical duties:*

  Reviews and analyzes all vehicle documentation including, but not limited to, preventive maintenance schedules, garage service requests, and vehicle history files; subsequently ensures that all records are properly and promptly processed.

  Plans, schedules, and assigns work to personnel performing repair, servicing, and maintenance of equipment.

  Ensures that inventory, equipment, and facilities are protected and maintained in a safe operating condition.

  Inspects and evaluates work performed and administers uniform working standards to mechanics and helpers.

  Insures prompt and efficient response to road calls.

  Maintains sound employee-management relations.

  Recommends improvements in work methods and procedures.

- *Supervised by:* Maintenance Manager
- *Supervision given:* Mechanics and Helpers
- *Qualifications:* High school graduate, degree in Engineering or Industrial Management preferred. Factory or trade school training essential. Minimum of 5 years electrical or mechanical repair experience with 3 years in a supervisory capacity; bus transit industry preferred. Or, any equivalent combination of education and experience.

Maintenance Clerk

- *Description of work:* Performs various clerical work for the Maintenance Manager and Maintenance Supervisors.
- *Typical duties* (include, but are not limited to):

  Bus assignment.

  Measure fuel and other liquid storage tank levels and maintain records of usage.

  Place orders to ensure that adequate maintenance supplies are on hand at all times.

  Compile and maintain daily maintenance performance reports.

  Record completed garage service requests and update vehicle history files.

  Schedule engine washes 2 days prior to inspection.

  Research vehicle files as requested by Manager or Supervisors.

- *Supervised by:* Maintenance Supervisor.
- *Qualifications:* Requires a high school education with some specialization in business courses or business school training.

Mechanic

- *Description of Work:* Required to perform skilled mechanical, electrical, and hydraulic work in the inspection, diagnosis, and repair of diesel and gasoline powered transit buses and related support equipment with minimum supervision.
- *Typical duties:*

  Diagnosis, repair, and preventive maintenance of charging, starting, cooling, braking, air conditioning, heating, suspension, fuel, air, steering, electrical, and power plant systems as well as accessibility equipment for handicapped passengers.

  Diagnosis and repair of automatic and manual transmissions.

  Removal and replacement of components such as power plant, transmissions, alternator, starter, and axles components.

  Diesel and gas engine tune-up.

  Service truck operation.

  Repair of minor body damage.

  Minor defect repair, such as adjusting brakes, changing tires, replacing lamps, adjusting doors systems, changing air bags, repairing oil, water, and transmission leaks.

  Accurate completion of garage service requests and other records as required.

  Cleaning shop and personal work areas.

  Safe and proper use of shop tools and diagnostic equipment.

- *Supervised by:* Maintenance Supervisor.
- *Qualifications:* High school graduate with trade school or factory training preferred. Must have complete set of tools and valid driver's license, as well as 5 years experience as a bus or heavy equipment mechanic.

Mechanic Helper

- *Description of work:* Required to perform mechanical, electrical, and hydraulic work in the repair of diesel and gasoline powered transit buses and related support equipment.
- *Typical duties* (include, but are not limited to):

Assisting mechanics in the diagnosis, repair, and preventive maintenance of charging, starting, cooling, braking, air conditioning, heating, suspension, fuel, air, steering, and electrical system malfunctions.

Assisting mechanics in the removal and replacement of components such as power plant, transmission, alternator, starter, etc.

Minor defect repair such as adjusting brakes, changing tires, replacing lamps, adjusting door systems, changing air bags, repairing oil, water and transmission leaks, etc.

Removal and replacement of flat glass, seats, etc.

Service truck operation.

Servicing buses as required.

Cleaning shop and personal work areas.

Safe operation of shop tools and equipment.

- *Supervised by:* (Initially, duties will be performed under direction and supervision of mechanic.) Maintenance Supervisor.
- *Qualifications:* High school graduate with trade school training preferred. Must have basic mechanic hand tools and valid driver's license. Basic knowledge of automatic mechanics preferred.

Hostler

- *Description of work:* Servicing and cleaning of buses and related support equipment.
- *Typical duties:* (include, but are not limited to):

On-site operation and servicing of buses and support vehicles, including checking and topping off all fluids and checking tire inflation.

Recording amounts of fluids consumed by vehicles.

Safe operation and proper care of shop equipment.

Directing incoming traffic.

Collecting, cleaning, sorting and racking of portable destination signs, as appropriate.

Steam cleaning engines, radiators, air conditioning condensors, battery boxes, chassis, etc.

All phases of bus cleaning including interior, exterior, engine compartment, and air conditioning condensors.

Cleaning work area.

- *Supervised by:* Maintenance Supervisor.
- *Qualifications:* Ability to follow oral and written instructions. Valid driver's license. High school graduate preferred.

Training

While transit operators are well aware of the necessity of well-trained mechanics, the cost and productive man-hour losses associated with an in-depth training program are extremely difficult for the small bus operator to deal with or accept.

Small bus operators generally rely on on-the-job training, in-house factory training, and a minimum of off-site factory training. Transit operators located near vocational/technical schools should encourage their employees to take advantage of the training offered by reimbursing employee tuition and book costs.

There are prepackaged training programs available consisting of reading material, cassettes, and viewers. Operators have placed these aids in employee lunchrooms and have found that mechanics will voluntarily make use of the training aids during lunch and coffee breaks. With the purchase of new vehicles and equipment, it is extremely important that the transit operator include, as part of the manufacturer's contract, provisions for thorough on-site training of maintenance personnel.

SPECIAL CONSIDERATIONS

In addition to the factors described above, other circumstances will affect the maintenance philosophy, policies, and procedures selected by a small bus operator. For example, a very small operator in the North might be more inclined to contract out the storage and maintenance of his vehicles than an operator of comparable means in the South, due to the greater financial commitment required for an indoor storage facility.

Operational considerations also play heavily on small bus maintenance requirements. For example, an extremely tight schedule looks efficient on paper. When applied to actual driving conditions, however, it can result in "jackrabbit starts" and "dynamite stops" as the driver labors valiantly to make his schedule. This mode of operation obviously translates into premature wear of brakes and other critical components, which in turn creates additional demands on the maintenance function.

One operational technique that lends itself nicely to small operators of small buses is the personal assignment of one vehicle to the same driver on a routine basis. When properly administered, such a technique can have a beneficial effect on maintenance through greater driver care and personal responsibility.

Two other topics not mentioned previously also warrant discussion in this section: oil analysis and tire repair.

Oil Analysis

Until recently, many fleet operators have been reluctant to embark on an oil analysis program because of the associated costs. However, it has been found that these costs are more than offset by the benefits derived from an oil analysis program including:

- Cost savings associated with the extended oil drain intervals as a result of oil analysis.
- Capture of warranty repairs that otherwise might have been lost.

• Isolating oil dilution caused by a fuel leak before damage is done.
• Identifying coolant leaks into the engine from the cooling system.
• Isolating defective components before they become unrebuildable.

With operators reporting oil drain intervals extended to 18,000 miles and up to 10 percent increases in engine life, it would appear that an oil analysis program is a viable maintenance aid. An operator should check with properties presently using oil analysis and various vendors to decide which program would be most appropriate for his property and situation before embarking on an oil analysis program. An oil analysis program should be integrated with a preventive maintenance program so that control can be maintained.

Tire Repair

Most transit operators lease tires from one of the major manufacturers. Under the lease agreement, the transit operators pay the manufacturer a fixed fee per mile of tire use. After an agreed-on tire mileage, charges for tires still in service are greatly reduced or eliminated. Likewise, tires that fail prematurely may be charged to the transit operator if cause of failure is deemed to be through operator negligence. Therefore, it is in the best interest of the transit operator to ensure that tire pressures are maintained, tires are returned to the manufacturer for recapping before cord damage occurs, and that drivers refrain from causing sidewall damage by curbing tires. Agreements with tire companies vary from transit operator to transit operator and range from a total tire service including tire changes, repairs, regrooving, and recapping, to a simple lease whereby the operator is responsible for all repairs, recapping, regrooving, and changing of tires. As tire manufacturers are reluctant to assign a tire repairman to a property on a part time basis, it is usually in the best interest of the small transit operators to use their own personnel for tire repair. Tire leasing is popular with transit properties for the following reasons:

• Much of the tire record-keeping chores are done by the manufacturer.
• The purchasing process associated with restocking tires is eliminated.
• As the original purchased price of a new tire is considerably less for the manufacturer than for the transit operator, tire costs may be decreased.
• Capital outlay for initial purchase of tires is eliminated.

Because of the costs associated with servicing the tire contract, manufacturers may be reluctant to lease tires to extremely small operators. In these cases, it may be possible for the small operator to purchase tires at a considerably less expense than a lease program. As tire lease programs are usually in excess of one year, the operator should carefully review the agreement and investigate his options regarding tire leasing.

SMALL BUS FLEET FACILITY MAINTENANCE REQUIREMENTS

The following estimated costs relate to maintenance facilities for small bus fleets (up to 25 buses) capable of performing various levels of maintenance. Before any realistic estimates can be made several factors must be considered including:

• Cost of real estate.
• Indoor or outdoor bus storage (weather).
• Area construction costs.
• Type of construction.

Experience has shown that construction costs for maintenance facilities have been *averaging* $60.00 per square foot (1983). The following facilities are based on a 25 bus fleet of 30-ft vehicles. The estimates *do not* include: bus storage, operations, cost of real estate, tools and equipment.

A. Completely Self-Sufficient

Area		
Repair Bays (3 @ 20 × 45)	2,700 sq ft	
Parts Room	750 sq ft	
Maintenance Administration	240 sq ft	
Service and Clean	2,100 sq ft	
Component Rebuild	800 sq ft	
Lube Room	150 sq ft	
Locker/Lunch, Restrooms	250 sq ft	
Tire Shop	150 sq ft	
Body Repair and Paint	1,000 sq ft	
	8,140 × $60/sq ft =	$488,400
	circulation 10% =	48,840
	Total	$537,240

B. Partially Dependent

Area		
Repair Bays (3 @ 20 × 45)	2,700 sq ft	
Parts Room	500 sq ft	
Maintenance Administration	240 sq ft	
Service and Clean	2,100 sq ft	
Lube Room	150 sq ft	
Locker/Lunch/Restrooms	220 sq ft	
	5,190 × $60/sq ft =	$354,600
	circulation 10% =	35,460
	Total	$390,060

C. Limited Capabilities

Area		
Repair Bays (3 @ 20 × 45)	900 sq ft	
Parts Room	150 sq ft	
Maintenance Administration	150 sq ft	
Service and Clean	2,100 sq ft	
Lube Room	120 sq ft	
	3,420 × $60/sq ft =	$205,200
	circulation 10% =	20,520
	Total	$225,720

Calculating the cost of operating the above hypothetical garages is dependent on location, labor costs, utility costs, etc.

APPENDIX B

WORKBOOK

CONTENTS

Section 1: Establish Bus Routes

This section comprises one table as follows.

Section 1. ***Establish bus routes.***

Area to be Served	Type of Service	Number of Bus Routes Needed

Section 2: Select Candidate Bus Types and Number of Buses

This section is composed of six subsections, Section 2.1–Section 2.6, and a summary table of alternative candidate bus fleets in Section 2.7.

Section 2.1 ***Set up headway and time table.***

Headway (see Table 2 of the Manual)

	Headway	Buses/Hr
Peak Hours (8:00-8:59 a.m., 5:00-5:59 p.m.)		
Base Period (6:00-7:59 a.m., 9:00 a.m. - 4:59 p.m.)		
Evening Hours (6:00 p.m. - midnight)		

Timetable

Route________ From________ To________

Monday Through Friday

Leave	Leave
________ a.m.	________ a.m.

Round trip time (peak hour) [ ] / Headway (peak hour) [ ] = [ ]a No. of Buses Required on the Route

a Round off to next larger integer

Section 2.2 ***Calculate weekday ridership*** (see Table 3 ***of the Manual***).

	500 ft	700 ft	1000 ft
Convenient Walking Distance	☐	☐	☐

Population within Convenient Walking Distance (catchment area) ☐

Route Type

Loop ☐

Lollipop ☐

Linear ☐

Population Characteristics

	high	low
Age Level	☐	☐
Income Level	☐	☐
Car Ownership	☐	☐
Student Population	☐	☐
Proportion of Single-family Dwellings	☐	☐

Catchment Factor (see Table 3) ☐

Catchment Factor ☐ x Population in the Catchment Area ☐

= ☐ b

Average weekday ridership

Look at the timetable (Section 2.1) and fill in the following:

Number of Inbound Trips Before Noon			Number of Outbound Trips After Noon							
Time	No.		Time	No.		Total				
8:00 - 8:59 a.m.	☐	+	5:00-5:59 p.m.	☐	=	☐	x	1	=	☐
										+
6:00-7:59 a.m. and 9:00-noon	☐	+	noon-4:59 p.m.	☐	=	☐	x	0.5	=	☐
										+
			6:00 p.m.-midnight	☐	=	☐	x	0.25	=	☐
			Equivalent Load		=					☐

Average weekday ridership (from Section 2.2) ☐ b

――――――――――――――――――――――――――― = ☐

Equivalent Load (from above) ☐

Number of passengers per peak hour trip in peak direction

Bus Capacity Required ☐ c = ←

Section 2.4 *Calculate number of seats, number of rows and bus length required.*

Bus Capacity Required (from Section 2.3) [c]

Check Seating Plan Selected
[ ] 2 and 1
[ ] 2 and 2

Bus Capacity Required [ ] / 1.5 (if 2 and 1 seating plan) or 1.25 (if 2 and 2 seating plan) = [d] No. of Seats Required

No. of Seats Required [ ] / 3 (if 2 and 1 seating plan) or 4 (if 2 and 2 seating plan) = [e] No. of Rows Required

No. of Rows Required [ ] × 3 = [f] Bus Length Required

Buses Under Consideration

Bus Make/Model	Capacity	No. of Seats	No. of Rows	Length

Requirements (from Section 2.4)

	Capacity	No. of Seats	No. of Rows	Length
Requirements (from Section 2.4)	c	d	e	f

Initial Bus Selection

Bus Make/Model	Number Needed

Number Needed: a (from Section 2.1)

You may want to go back to Section 2.1, change headway, and repeat the entire process:

Bus Make/Model	Number Needed

Questions

1. Will the bus be able to clear overpasses and fit on all bridges?

2. Will the bus be able to turn corners on all streets or within the dimension of a terminal?

3. Is the bus too leavy for any of the bridges, overpasses, or roads over which it must travel?

Initial Bus Slection (from Section 2.5)	Answers to above Questions						Candidate Bus Selection (those for which each Answer is yes)
	1		2		3		
	Yes	No	Yes	No	Yes	No	

Section 2.7 *Summary of alternative candidate bus fleets.*

Option	Bus Make/Model	Number of Buses
1		
2		
3		

In this section, you will calculate the cost of each candidate bus type you selected in the previous section. It comprises three tables:

Table 3.1 in which you will do overall cost calculations for every bus type you selected.
Table 3.2 in which you will figure the maintenance costs for *each* bus type for filling-in column 13 of Table 3.1.
Table 3.3 in which you can summarize the total life cycle cost and average cost per mile of each candidate bus type.

Table 3.1 *Cost estimate table.*

1 Bus Make/ Model	2 Bus Type	3 Capital Cost	4 Yearly Mileage Expected	5 Bus Life in Miles	6 No. of Drivers Assigned to This Bus Type	7 No. of Buses of This Type

Table 3.1 *Continued*

8	9	10	11	12	13	14
Cost of Fuel Per Gallon	Bus Life in Years = Col. 5/Col. 4	MPG	Total Fuel Cost = (Col. 8 x Col 5) / Col. 10	Total Driver Cost = Avg. Driver Salary x (Col. 9 x Col. 6) / Col. 7	Total Maintenance Cost (from Table 3.2)	Salvage Value

15	16
Total Life Cycle Cost Per Bus = Col. 3 + Col. 11 + Col. 12 + Col. 13 - Col. 14	Total Cost Per Mile = Col. 15/Col. 5

Table 3.2 *Calculation of cost of maintenance of bus type.*

1 Year	2 Labor Hours per 100 miles (Table 8)	3 Materials Cost per Mile (Table 8) (cents/mile)	4 Labor Cost (dollars/hr)	5 Mileage per Year	6 Starting Miles for the Year	7 Mileage Factor for Labor Hours (Table 9)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
go up to bus life						

Table 3.2 *Continued*

8 Mileage Factor for Materials Cost (Table 9)	9 Inflation Factor for Material Cost (Table 10)	10 Total Maintenance Cost for the Year = (Col.2 x Col. 4 x Col. 7 + Col. 3 x Col. 8 x Col. 9) x Col. 5/100

Total Maintenance Cost ________________

(Add every item in column 10)

Table 3.3 *Summary of vehicle costs.*

Option	Bus Type	Life Cycle Cost Per Bus (Columns 15, Table 3.1)		Total Number of Buses		Total Life Cycle Cost
1			x		=	
2			x		=	
3			x		=	

Cost Summary

Cost Element	Option 1 Bus Type ______	Option 2 Bus Type ______	Option 3 Bus Type ______
Total Life Cycle Cost (from above) Average Cost Per Mile (column 16, Table 3.1)			

This section includes just one table, Table 4.1, in which you enter your selection of various features available in small buses and note availability of the selected feature in each candidate bus type.

Table 4.1 *Summary of comparison of various options.*

	FEATURES AVAILABLE	Availability in		
Feature	Your Choice	Option 1 Bus Type __________	Option 2 Bus Type __________	Option 3 Bus Type __________
• Fuel (gasoline, diesel, gaseous)				
• Wheelchair lift - rear, front - inside, outside				
• Wheelchair ramp				
• 2-way FM radios				
• Auxiliary Powertrain Heat Exchanger				
• Air Conditioning				
• Brake System Type				
• Transmission				
• Final Drive Ratio				
• Retarders				
• Tire Type				

In this section, you will be asked to rate each bus type for the qualitative issues discussed in the manual. You may find a scale of 1 to 10 useful in expressing your opinion—1 can denote "very bad," while 10 can indicate "very good."

Table 5.1 ***Summary of comparison of various options.***

QUALITATIVE ISSUES — Rating*

Qualitative Issue	Option 1 Bus Type __________	Option 2 Bus Type __________	Option 3 Bus Type __________
Availability of Replacement Parts			
Adequacy of Service Manuals			
Quality of Construction			
- Electrical System			
- Framing			
- Chassis			
- Air Conditioning			
Vehicle Maintainability			
- Usefulness of Available Tools			
- Availability of Body Repair Facility			

QUALITATIVE ISSUES

Rating*

Qualitative Issue	Option 1 Bus Type __________	Option 2 Bus Type __________	Option 3 Bus Type __________
- Adequacy of Available Lifts			
- Adequacy of Brake Rebuilding Facility			
- Adequacy of Engine Repair Facility			
- Accessibility of Components			
- Availability of Air Conditioning Parts and Support			
Warranty Terms/Support			
Past Experience			

*Rate on the scale of 1 to 10 -- 1 very bad, 10 very good

Section 6: Final Selection

Finally, study Tables 3.3, 4.1, and 5.1, and select the bus which will provide an optimum combination of cost, availability of selected features, and qualitative assessment.

Section 6. ***Final selection.***

Bus Route	Bus Selected	Number of Buses
______	______	______
______	______	______
______	______	______
______	______	______

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