A MICROCOMPUTER BASED VEHICLE MANAGEMENT INFORMATION SYSTEM

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ABSTRACT

This dissertation describes the design and operation of a vehicle management information system. The system is based on a microcomputer and is aimed at the small to medium sized fleet operator. It is designed specifically for cleansing vehicles and accounts for the various factors which characterise these vehicles.

The program itself is made up of eight modules, each performing a specific function. The operation of each is demonstrated in a worked example. Included are the output reports which contain information on workshop activities, costs incurred, vehicle and fleet performance measures and a replacement decision.

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Eric Doctor

Eric Martin Doctor.

19th day of JANUARY, 1983.

ACKNOWLEDGEMENT

I would like to thank the University of the Witwatersrand and the Council for Scientific and Industrial Research for the financial assistance received in the form of bursaries. Also, to my supervisor, Mr. John Bicheno, without whose guidance and assistance this project would not have been possible. Finally, to my parents, Hans and Daphne, for all the encouragement over the years.

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1. INTRODUCTION

The management of a fleet of vehicles is becoming increasingly important as the cost of owning and operating the vehicles increases. For many organisations a substantial portion of their capital investment and running expenses go towards acquiring and maintaining their vehicle fleet. Effective management in this area can thus result in large cost savings.

This need for more effective management has resulted in a number of computer based vehicle management information systems. These systems are designed, however, to deal with a large number of vehicles and require extensive computing facilities. The smaller fleet operator must join one of the commercially available shared computing facilities, if he wishes to benefit from the advantages of a computer based system. In this way, however, he loses some control over his fleet and does not benefit from the major advantage which is immediate access to information for decision making. This project attempts to fill this gap by designing a system based on the relatively inexpensive microcomputer.

A comprehensive system must, in addition to providing information relating to costs, also focus attention on vehicle performance. This is particularly important for the waste disposal vehicles of a public cleansing department. These vehicles are required to provide a certain minimum level of service under conditions of increasing costs. This system is designed for these vehicles, although it could be used for other types with some modifications.

1. INTRODUCTION

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2. LITERATURE SURVEY

2.1 Vehicle Management Information System

There is much to be found in the literature on the design and requirements of a general management information system. This is not the case, however, for the more specific vehicle management information system. The literature which is available deals mainly with the economic aspect of vehicle management viz. the vehicle replacement decision. Although it is an important topic (and is dealt with in the next section), it does not give a complete picture.

Vorster(1), in a research thesis, has developed a systems approach to the management of civil engineering construction equipment. The approach can be equally well applied to the management of a fleet of vehicles. The model developed, for this systems approach, is one of three interdependent functions viz. the economic, mechanical and operational aspects which cannot be treated separately. Furthermore, performance criteria are established at the boundaries of these aspects which provide the information required to control the system. The criteria and suggested measures of performance are as follows:

a) Reliability - This criterion occurs at the interface between mechanical and operational aspects. Two figures of merit are suggested and are defined as follows:

i) freq. of failure/100 operating hours = $\frac{V}{W} * 100$

where V = number of unscheduled repair actions
and W = number of hours worked by the vehicle.

ii) availability = $\frac{T - I}{T}$

where T = total shift time
and I = time for which vehicle is incapable of work due to repair or service.

These performance measures provide information for evaluating the effectiveness of maintenance and repair actions. In addition, they indicate the consequential costs of failure incurred (as opposed to the tangible costs) and should thus be used to supplement the replacement decision.

b) Repairability - This is the criterion between the economic and mechanical aspects. The suggested figures of merit are:

i) Repair ratio = $\frac{RH + MH}{W}$

where RH = number of man hours spent on repair actions
and MH = number of man hours spent on maintenance actions.

The repair ratio indicates the total effort required to keep the vehicle working.

ii) Maintenance ratio = $\frac{MH}{W}$

which indicates the maintenance effort before failure occurs.

iii) Mean time to repair = $\frac{RH}{V + S}$

where S = number of scheduled repair actions.

This indicates the complexity and magnitude of repair actions. These figures should be used in conjunction with the actual repair and maintenance costs incurred by each vehicle in order to determine suitable maintenance programmes. Also, to initiate a replacement decision when the information indicates that it is not economically feasible to repair a particular vehicle.

c) Profitability - This criterion arises between the economic and operational aspects and determines the vehicle cost per unit of output. However, data relating to work output is difficult to collect and an alternative measure is recommended:

$$\text{Field utilisation} = \frac{W}{T - I}$$

This measure of performance indicates the extent to which a vehicle is being used and thus also, over an extended period, the extent to which the vehicle investment is being employed.

These figures of merit are considered necessary for a systems approach to vehicle management. The extent to which the existing computer based systems supply this information can be seen by considering an example. The system reviewed here is the Fleetmaster(2 & 3). Three types of input documents are required:

a) Inventory form which is a comprehensive list of data relating to each piece of purchased equipment.

b) Fuel ticket from the pumps indicating fuel issued to each vehicle.

c) Repair order form from workshop giving details of repairs undertaken.

This input data is used to produce a number of management reports, a few of which are produced on request, the rest on a monthly basis. The reports can roughly be divided into six categories corresponding to the six modules which go to make up the system. These are:

a) Equipment inventory

b) Fuel

c) Repair

d) Billing

e) Preventative maintenance

f) General

Based on the given input data, the figures of merit for the reliability and profitability criteria given above cannot be calculated. (The British installation(3) however, plans for enhancement modules but only as a final phase of the implementation.) The majority of output reports, although fairly detailed, can only serve an administrative function. The exceptions are those reports from the repair module as well as the performance reports from the general module (which are classified as management reports). Yet, even in these cases, performance measurements are based on the limited input data and in most cases is merely the appropriate repair and maintenance cost. (Examples of the output reports are shown in Appendix 1.) Finally, the vehicle replacement decision is not considered.

2.2 Vehicle Replacement Models

The economic models discussed here are based on minimising vehicle costs. Models based on profit maximisation are not readily applicable to the

public service of waste collection.

The simplest replacement model is one that considers only the present vehicle and determines its economic life by balancing the capital and operating costs as follows:

$$\text{Average cost } A(x) = \frac{P + C(x)}{x}$$

where x = age of vehicle
P = capital cost
and $C(x)$ = cumulative operating cost up to period x.

The minimum average cost is then found by differentiating with respect to x and setting the result equal to zero. The period corresponding to the minimum cost is the economic life and the vehicle should be replaced when it reaches this age. The model can be improved by taking into account salvage values and the time value of money(4).

The model ensures that the historic costs of the present vehicle are minimised. However, in making a replacement decision we are concerned with minimising future costs and not the sunk costs over which we have no control. Thus the future costs of the existing vehicle (or defender) as well as the costs associated with a replacement vehicle (or challenger) must be considered.

The MAPI and discounted cash flow methods are two models which consider the future costs of both the defender and challenger. The models are similar in that both use a cost of capital to obtain present values which are then translated to equivalent annuities (alternatively called the uniform

equivalent) for each period. In both cases that period which gives the minimum annuity is termed the economic life.

The MAPI method (5,6&7) deals separately with the challenger and defender. The equivalent annuity per period for each is calculated using the appropriate capital cost, operating inferiority and loss on salvage value. The minimum annuity in each case is called the adverse minimum (A.M.). The replacement decision is then determined by comparing the two A.M.'s. If the A.M. of the challenger is less than that of the defender then replacement is signalled.

The MAPI method is based on two simplifying assumptions:

a) 'The present challenger accumulates operating inferiority at a constant rate over its life.' This operating inferiority represents the increase in costs due to deterioration and obsolescence. The rate of increase is the difference between next periods operating costs for the defender and challenger divided by the defender's age. Thus the assumption presumes that the operating inferiority of the challenger will resemble that of the defender and that it will occur at a constant rate.

b) 'All future challengers have the same adverse minima.' This implies that the best succession of vehicles which is headed by the present challenger is a chain of vehicles with like adverse minima.

The discounted cash flow method (6,8&9) determines the equivalent annuities by considering future flows of capital, operating expenses and salvage values. The procedure is to calculate the minimum equivalent annuity at the economic life for the challenger.

This figure is then compared with the cost of keeping the defender for one more period and if smaller replacement is indicated. (The economic life for the defender by this method is always only one more period since capital costs are sunk.) A more exact solution is to consider the two exclusive strategies viz. immediate replacement or replacement in one period and their corresponding cash flows(10). The details are shown in Appendix 2. Replacement is indicated if:

$$\left(- S_{d_0} + \frac{EA_{\min c}}{r} \right) < \left(C_{d_1} - S_{d_1} + \frac{EA_{\min c}}{r} \right) * PVF_1$$

where S_{d_x} = defender salvage value at period x

C_{d_1} = defender operating cost in period 1

$EA_{\min c}$ = minimum equivalent annuity for challenger

PVF_1 = present value factor at the cost of capital r for first period.

Note that for no defender salvage values the result is the same as before.

The data requirements for the discounted cash flow approach appear more extensive than for the MAPI method, requiring estimates of operating costs per period up to the economic life. Dean and Smith(11) argue that the requirements are similar if a linear inferiority gradient is assumed in the cash flow approach as is done with MAPI. (In fact they show that for this case both methods give the same result.) They also point out that in the cash flow approach this simplification is not forced upon the analyst and when future costs do not seem likely to be linear, more realistic estimates can be used. For cleansing vehicles, a trend has been found in

the change of operating costs with age (12). A plot of:

$$\frac{\text{cumulative operating costs}}{\text{purchase price}} * 100 \text{ vs age in months}$$

can be fitted with a curve of the form:

$$k_0 + k_1 * x + k_2 * x^2$$

with a correlation coefficient of approximately 0.7.

The operating costs discussed so far are those tangible costs which are incurred in owning and operating a vehicle e.g. repair and maintenance costs. It is generally agreed that the intangible costs e.g. downtime and obsolescence also have an effect on the replacement decision and should be taken into account (1,8&13). Mehra(8) includes downtime by substituting the cost of hiring a 'fill in' vehicle. However, Vorster(1) in his systems approach suggests that only the tangible costs be considered in the replacement analysis and vehicle reliability be examined separately.

The decision to replace a vehicle is an indication that the average cost is now minimised and will begin to rise. However, the replacement investment must first compete on a cost/benefit basis with other investment proposals for the limited investable funds(7). This requirement is an advantage of the cash flow model since it can be used for ranking all types of proposals. The MAPI method requires extensive modifications if it is to be used for non-replacement investments (11).

Finally, the analysis must not be left until it is too late. The test for replacement should be made according to the following guidelines(9):

a) With the appearance of new technology which indicates obsolescence.

b) When nonroutine repairs are required indicating deterioration.

c) As the vehicle approaches its original economic life estimate.

d) For those vehicles still in service after they have been indicated for replacement, frequent testing is necessary.

3. THE SYSTEM

The system is designed to supply information, in the form of output reports, which is considered necessary for effective vehicle management. This includes the measures of performance and the replacement decision which were discussed in Chapter 2. However, the system is designed specifically for the management of cleansing vehicles. For this reason, the design also takes into account certain features which characterise these vehicles:

a) The vehicles are single purpose machines requiring a large capital investment. This leads to a high usage rate and coupled with the stressful conditions under which they operate, a high breakdown rate is incurred. Measures of performance and workshop related information are thus important.

b) Detailed day to day costing for each job is not required since the type of work involved is fairly constant. Cost related information is thus considered only on a monthly basis. In addition, taxation which normally affects the replacement decision is not a consideration.

c) Since all vehicles are required to perform the same function, the performance of particular fleets can be meaningfully compared and used as an additional management tool. Thus the output information is extended to cover not only vehicles but also fleets of vehicles.

The system is designed to be used on a micro-computer and to take advantage of the graphics capabilities which are a feature of these small machines. A graphics presentation allows output

information to be examined far quicker and more effectively than can be done with the conventional listing of data in tables.

The microcomputer used in this project is the Hewlett-Packard HP85. However, during the development of the program the model HP86 became available and the program was completed on the new machine. The HP86 uses a relatively fast disc drive for storing and retrieving data compared to the slower magnetic tape used in the HP85. The changeover thus resulted in large time savings during testing and in program operation. The programming language used on this microcomputer is BASIC.

The system is best understood by considering separately the inputs, the outputs and the processing required. The output information is supplied by various types of reports:

a) Weekly report - A short report produced on an approximately weekly basis. It gives the number of shifts worked, spare, in service and in repair for each vehicle as well as the daily availability. This is useful for the short term operations side of the vehicle management.

b) Monthly report - A more detailed report which is produced on an approximately monthly basis. This includes details of vehicles in the workshop, frequency of breakdowns, statistics on repair length of stay and maintenance and availability. This report is useful for short term planning and supplies the required workshop related information.

c) Vehicle performance - A report produced on request indicating the performance of any particular vehicle. The information available includes the figures of merit previously discussed

as well as details of distance travelled, fuel used and costs incurred. In all cases past values are stored and are output together with the present figure. A list of the vehicle characteristics can also be obtained.

d) Fleet performance - Similar to the vehicle performance report except that a particular fleet is examined.

e) Replacement - A decision is made for a particular vehicle or fleet on whether to replace or retain.

f) Details for any date - Although not essential, it may be useful to know the status of a particular vehicle on a certain date.

The inputs required to supply the above information are:

a) Status data - The daily status (i.e. working, spare, service etc.) for each vehicle is required and is input in the form of a status code. An example is shown in Table 1.

Table 1 - Example of Status Data.

Vehicle	Date	Status	Code
1	17/1/83	working	1
2	17/1/83	spare	2
3	17/1/83	service	3

Although for some industrial vehicles status data is maintained on an hourly basis, for cleansing vehicles it is based on daily shifts.

b) Cost data - The monthly costs corresponding to the user defined status repair codes are entered for each vehicle.

c) Fuel and distances - The fuel used and distance travelled by each vehicle are entered with the cost data.

d) Basic data - A number of vehicle and fleet characteristics are requested and must be entered by the user. An example is shown in Table 2.

Table 2 - Example of Basic Data.

Vehicle 1 -	Purchase date	1/6/75
	Registration number	BCD367T
Fleet 1 -	Number of vehicles	15
	Vehicle make	BMW

e) Replacement data - Where this is not forecast using available data it must be entered by the user.

The processing required to produce the outputs from the inputs is fairly extensive. To facilitate the programming, and bearing in mind the limited memory available on the microcomputer, the program has been divided into eight modules. Each module performs a different function which are shown in Fig. 1.

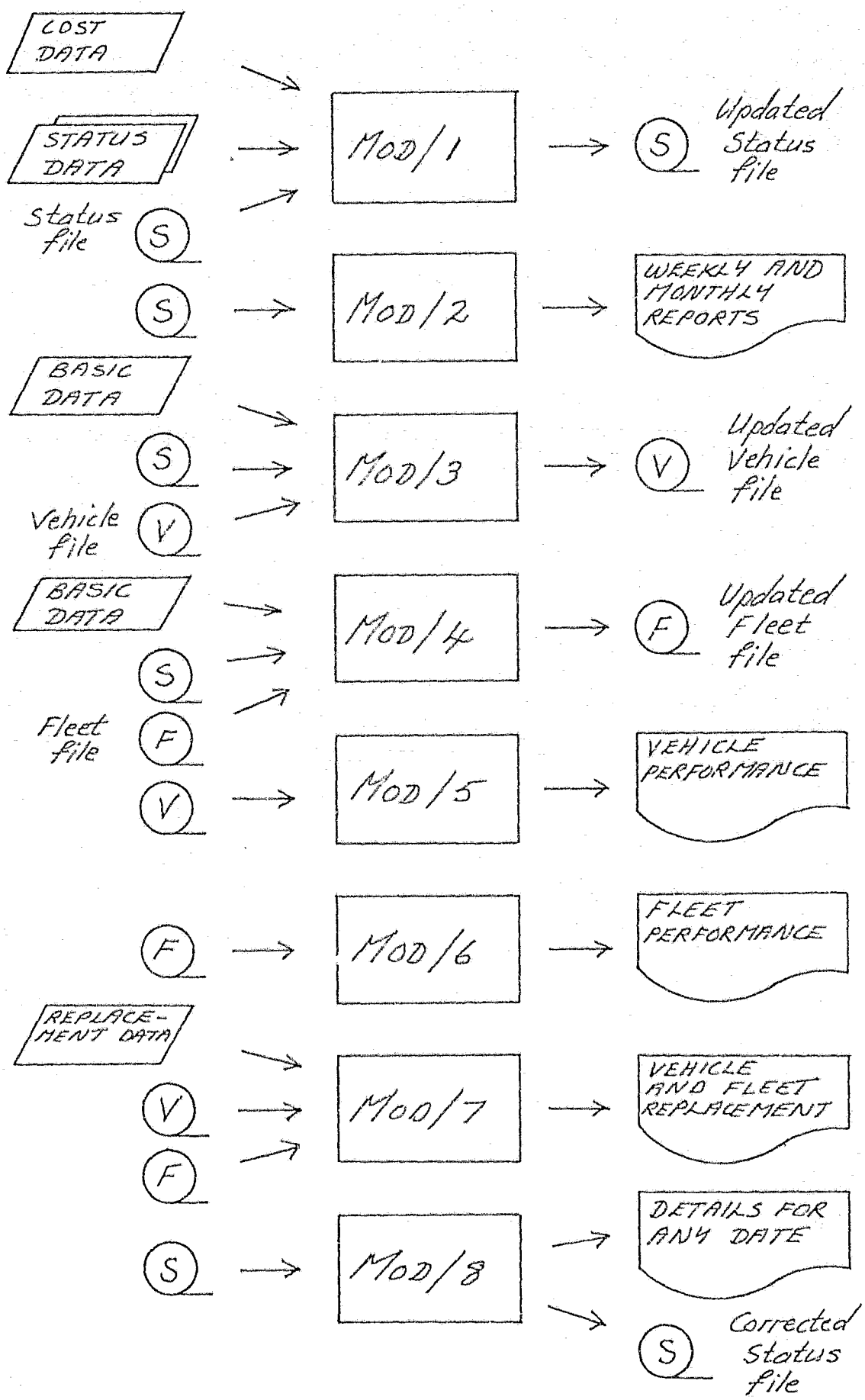
In designing the program, two overall objectives have been kept in mind. These are:

a) The program must be 'user friendly'.

b) It must fit in with existing systems.

The first objective is achieved in that the program clearly specifies what is required of the user during program operation. The program makes frequent use of menus so that one can branch to desired portions of the program. Also, incorrect keyboard entries do not result in program termination but give the user

Figure 1 - Inputs, outputs & processing required



another opportunity to enter the correct data. The second objective is achieved by only requesting input data that is normally available in the day to day running of a cleansing department. No standard input forms are specified as is done in the larger systems and vehicles can be specified by their existing code numbers. The various types of repair actions are specified by the user.

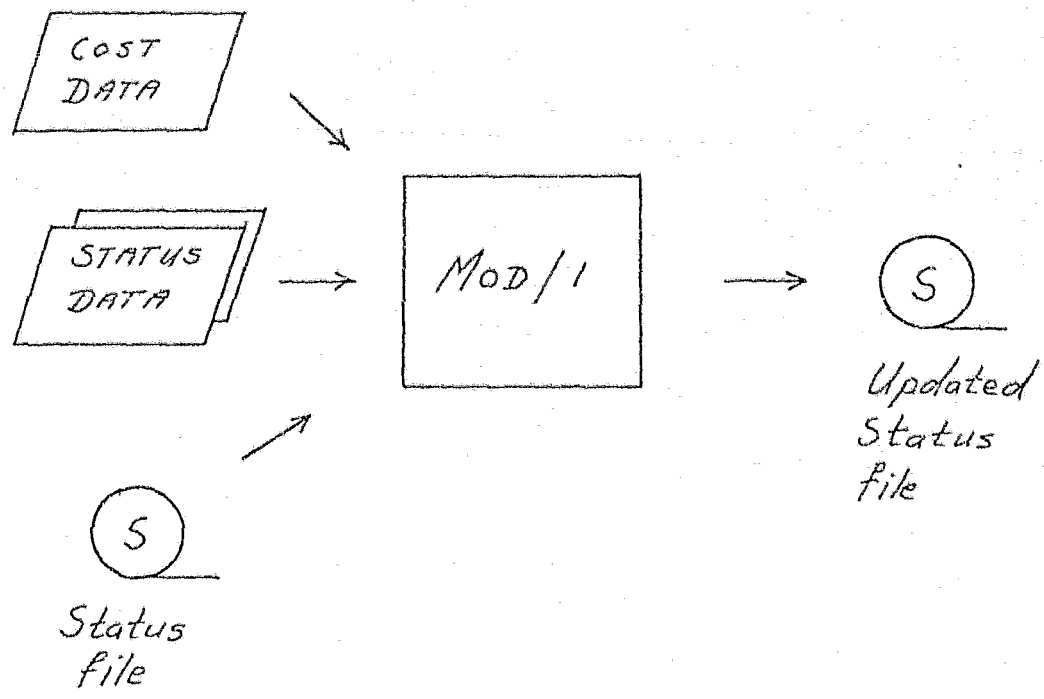
It must be emphasised that the accuracy of the information obtained is dependent on the input data. The user must ensure the validity of data being entered since the program can only check for obvious coding errors. To prevent unauthorised changes, a password is required to correct the status and cost data once it has been entered.

4. THE MODULES

4.1 Module 1

The first module (mod/1) arranges the daily status data and monthly cost data, keyed in by the user, into a status file which is then stored on a magnetic disc. The status file contains the status and cost data for all the vehicles for one month. A status file is therefore created at the beginning of each month and is updated as the status data is obtained, normally on a daily basis. The cost data is then entered at the end of the month. This procedure is shown in Fig.2.

Figure 2 - Mod/1



The flowchart for module 1 is shown in Fig.3. Three main menu selections are possible. Branch 1 is used to create a new status file at the beginning of each month while branch 2 is used on a daily basis to update an existing status file. Branch 3 is used at the end of each month to enter the cost data for the period.

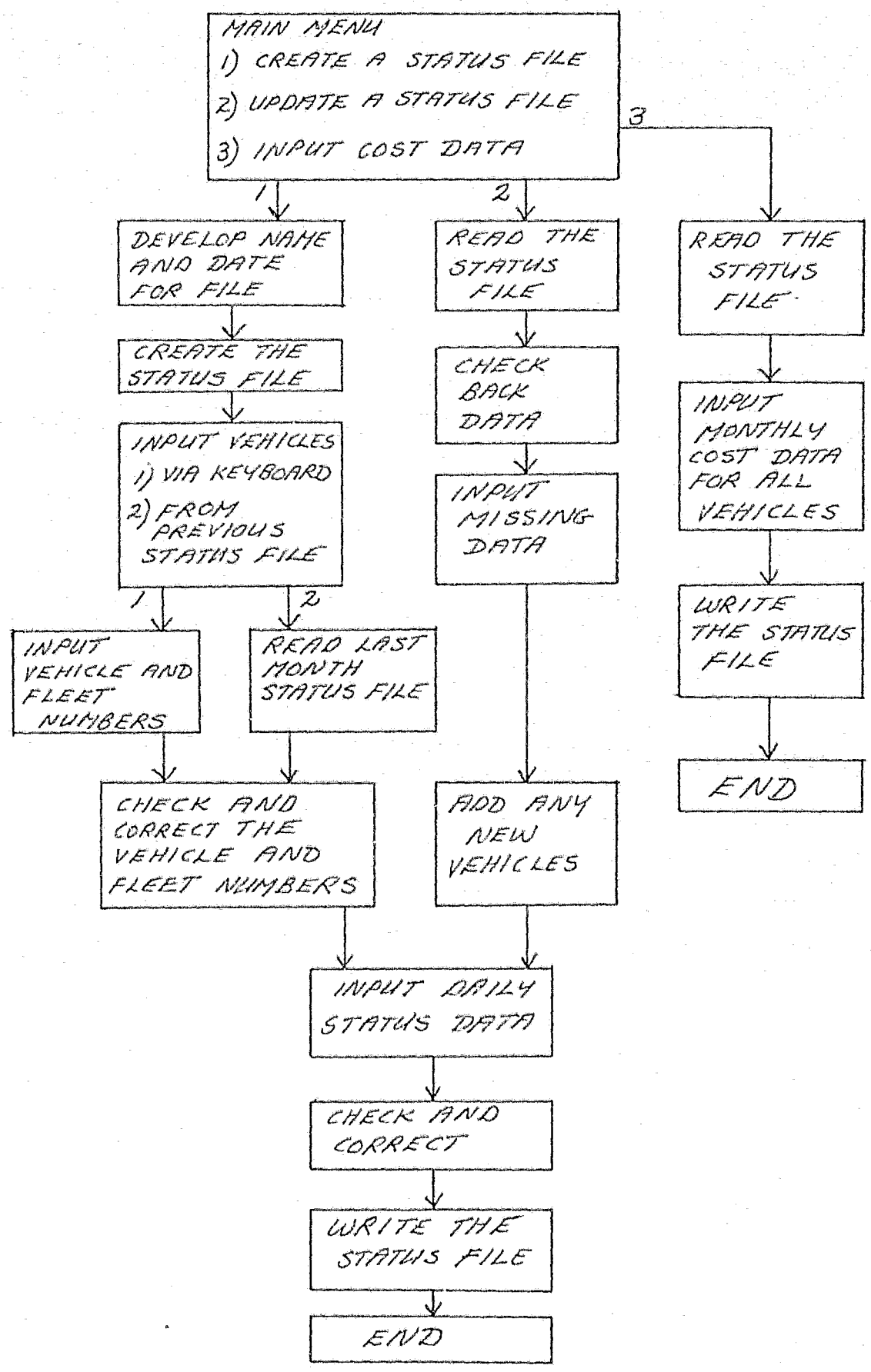
The status data is the daily status of each vehicle and is in the form of a status code. The possible codes are shown in Table 3.

Table 3 - Status codes

Code	Status
1	working (single shift)
2	spare
3	service (routine)
4-33	repair
90	working but breakdown during shift
91	breakdown before leaving depot
95	working (double shift)
96	working (treble shift)
97	scrapped / no longer there / just bought
98	weekend / holiday
99	data still to be added

A single status code from the list is assigned to each vehicle every day. If double or treble shifts are worked on any one day, then this is accounted for by codes 95 and 96. Codes 90 and 91 are used for a vehicle breakdown. The former is used if the breakdown occurs during a working shift, the latter

Figure 3 - Mod/1 flowchart



for a vehicle which breaks down before leaving the depot. In addition, for calculations, code 90 is considered a working shift while code 91 is taken as a repair shift. Code 97 is used for vehicles that join or leave during the month. For a vehicle that is acquired, code 97 is automatically entered for the days of the month prior to its arrival. For a vehicle that is scrapped, transferred or which for any other reason is no longer available, the user must enter code 97 for the days after its departure. Codes 4 to 33 inclusive are specified as repair codes. Repair actions can thus be broken down into a maximum of 30 types and these need to be specified initially by the user. An example of repair codes is shown in Table 4.

Table 4 - Example of Repair Codes

Code	Repair
4	Engine
5	Body
6	Shovel
7	Transmission
8	Fuel
9	Electrical
10	Hydraulics
11	Brakes
12	Chassis
13	Insurance

The choice of repair codes should be given careful consideration and the following points should be kept in mind when making a final decision:

a) Repair categories should not be too narrowly defined since no useful information can be obtained if a particular repair is only performed once or twice before a vehicle is scrapped. Thus, for example, a single repair code for brakes would be better than separate codes for brake discs, pads, cable, fluid etc.

b) Repair codes must also be used for various costs that may be incurred and for which a record is required but for which there is no specific repair action. This is important for costs which need to be included in the replacement analysis.

c) The fuel used by each vehicle is dealt with separately. It should therefore only be considered if a record of fuel costs is required.

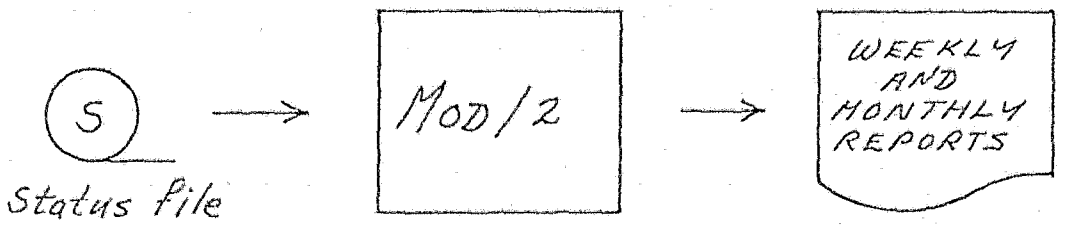
The cost data required as input are the monthly costs incurred by each vehicle. These costs must correspond to the 30 repair codes as defined by the user. Also included in this section is the monthly fuel consumed in litres and the distance travelled in kilometres by each vehicle.

The status and cost data entered into module 1 is not processed in any way but is simply arranged into a status file. These files when complete are then used as inputs to modules 2, 3, 4 and 8. They should not be erased at any stage after completion since they provide a complete record of the status of any vehicle on any day.

4.2 Module 2

Module 2 makes use of the status file from module 1 to produce weekly and monthly reports. This procedure is shown in Fig.4.

Figure 4 - Mod/2

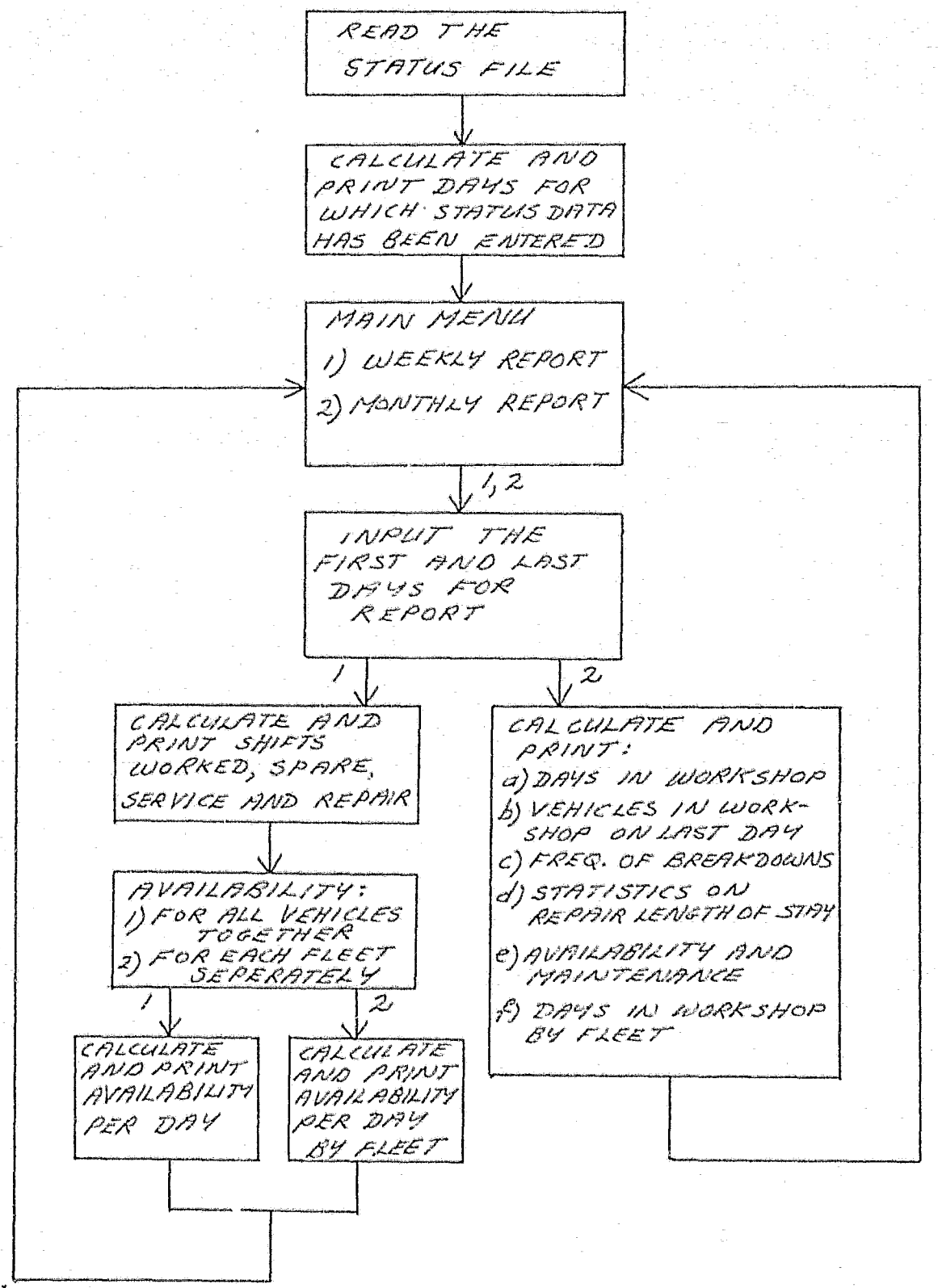


A flowchart of the program is shown in Fig. 5. The weekly and monthly reports should be produced, as their names imply, at the end of each week and month. However, the reports can be produced at any time and covering any period specified by the user. The status file does not have to be complete to generate a report.

The weekly report includes the following information (see Appendix 3 for equations and methods of calculation):

a) The total number of shifts worked, spare, in service and in repair for each vehicle during the previous week. This gives an overall picture of operations and indicates for which vehicles a more detailed vehicle performance report is necessary. (This report is discussed later in module 5.) If routine services are planned for, then this also provides a check on which vehicles have been serviced.

Figure 5 - Mod/2 flowchart



b) Vehicle availability for each day of the week. This gives an indication as to whether sufficient capacity exists. Usually a known number of vehicles will be required for a particular day of the week and thus the actual values can be compared with required values. Shortfalls in capacity can then be dealt with, up to a point, by employing double or treble shifts.

The monthly report includes the following information (see Appendix 3 for equations and methods of calculation):

a) The total days spent in the workshop for each vehicle. This can be used to initiate a more detailed vehicle performance report. The information also provides feedback on required workshop capacity.

b) The vehicles in the workshop on the last day of the month and the length of stay up to this point. Thus plans for the following month can take into account those vehicles which will not be available. Also, the remaining time required in the workshop can be calculated if the average time for a particular repair action is known. Alternatively, the mean repair length of stay can be used.

c) Frequency of breakdowns during shift and before leaving the depot per 100 shifts worked by fleet. This information indicates whether the service and repair actions currently being employed are adequate.

d) For each fleet the mean and standard deviation of the repair length of stay. The size of the mean value indicates the effort required in repair actions. This is useful since a vehicle breakdown can then be accurately planned for. The standard deviation indicates the spread of values around the mean.

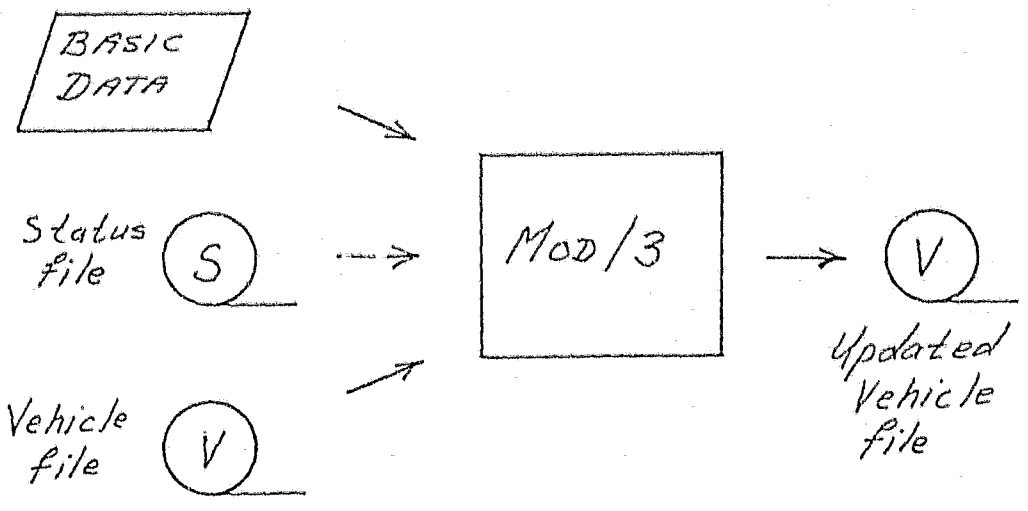
e) For each fleet, the pe ntage availability, maintenance ratio and perc tage field utilisation. These three measures are used for making an inter-fleet comparison in terms of reliability, repairability and profitability. The values should only be used as a guide since other measures are also required for a complete picture. (The fleet performance report gives these other figures of merit.)

f) For each fleet, the number of days spent in the workshop and the percentage of total workshop days by code. This is useful for deciding on what checks to include in a routine service for a particular fleet.

4.3 Module 3

Module 3 takes as input the monthly status file, processes the data and stores the results in a number of vehicle files. These files, one for each vehicle, are used in later modules for vehicle performance and replacement. This procedure is performed at the end of each month when the current status file is complete and is shown in Fig.6. Also required is the basic data which gives the characteristics of a particular vehicle.

Figure 6 - Mod/3



The flowchart for module 3 is shown in Fig.7. The main menu gives five possibilities. Selection 1 is used to create a vehicle file and input the basic data. This is done initially for each vehicle and whenever new additions are acquired so that a vehicle file exists for every vehicle listed in the current status file. The basic data not immediately available can be updated at any future time by means of choice 2. The third selection is used to update the vehicle files at the end of each month when the current status file is complete. All existing vehicle files are then updated at the same time. Selection 4 gives the user an opportunity to correct an error in a vehicle file due to incorrect data in the status file and selection 5 prevents a vehicle file from being updated when the associated vehicle is no longer available.

The basic data which is required for each vehicle file is a list of the vehicle characteristics and includes the following items:

a) Purchase date for the body and chassis

b) Purchase price for the body and chassis

c) Make

d) Model

e) Registration number

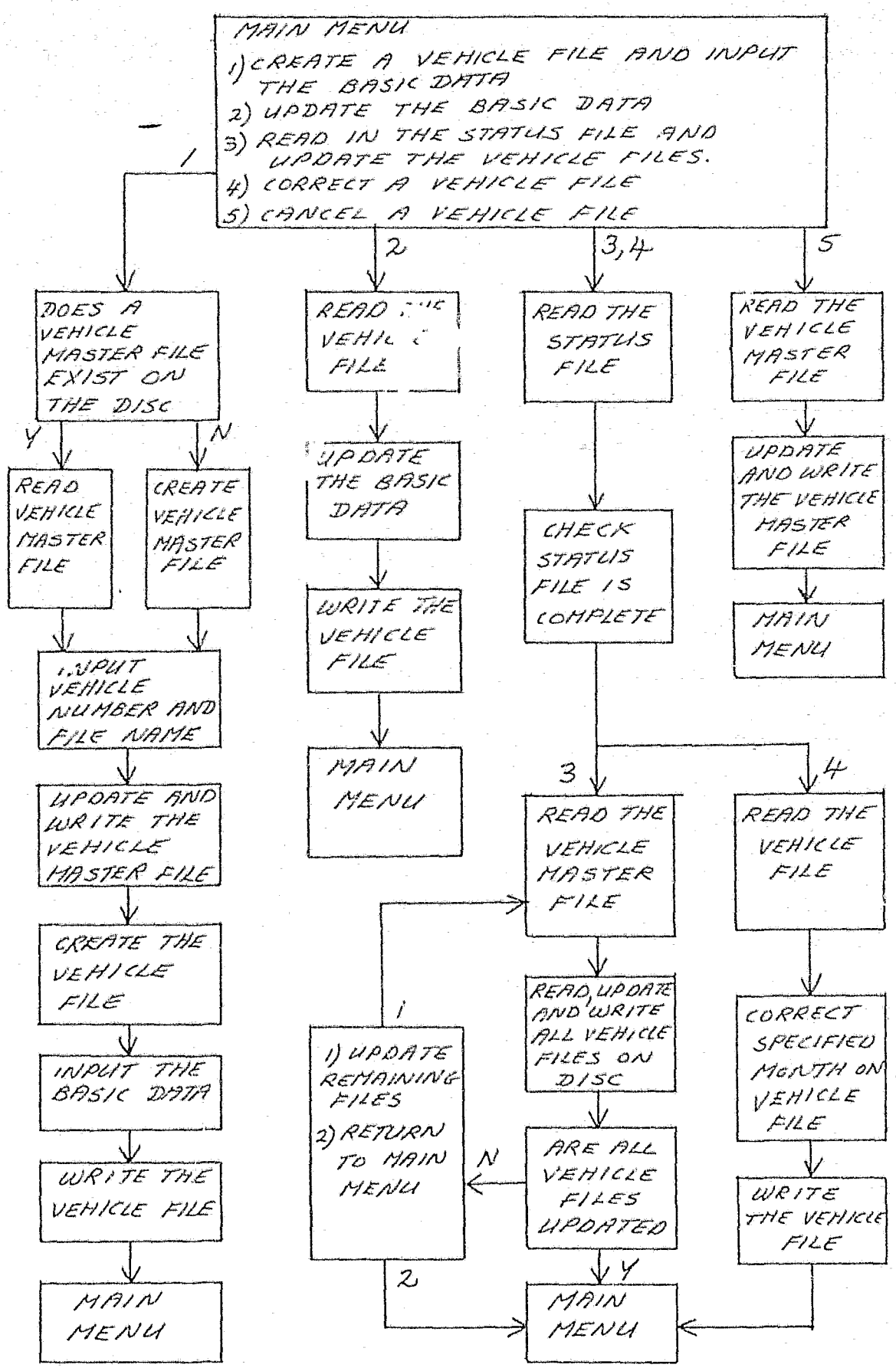
f) Engine number

g) Fleet number

h) Current location

The status data is first processed before it is stored in the vehicle files. The program summates the daily data for each vehicle into a monthly figure under each of the following categories:

Figure 7 - Mod/3 flowchart



a) Code 1

b) Code 2

c) Code 3

d) Code 90

e) Code 91

f) Code 95

g) Code 96

h) Codes 4 to 33

i) Mean time to repair

j) Average repair time

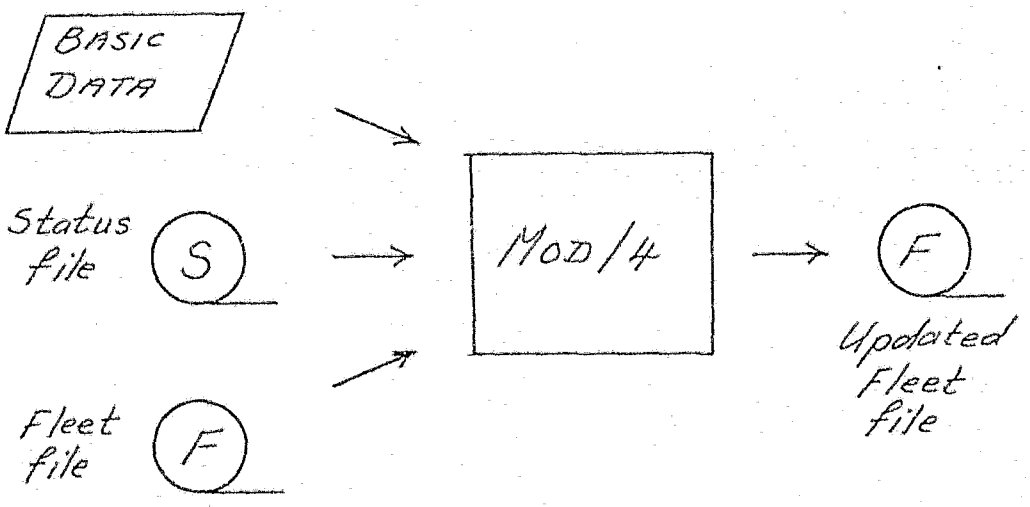
Categories i and j must be computed and stored at this stage since they cannot later be obtained from the other eight condensed basic categories. The daily data of the status file is required for their calculation. (See Appendix 4)

The resulting vehicle file is identified by a vehicle file name which must be distinguished from the vehicle number. The reason for this is twofold: Firstly, the system is designed to be used with a minimum number of modifications to the existing structure. Thus existing vehicle numbers which contain a large number of numerals can continue to be used. Secondly, so that vehicle and fleet files (discussed later in module 4) can be clearly identified as such, the first character in the file name is specified as either a 'V' or 'F' respectively. It is unnecessary to keep track of which file names correspond to which vehicles, since a master file is created on each disc for this purpose.

4.4 Module 4

Module 4 performs the same functions as module 3, but whereas module 3 deals with vehicle files, we are here concerned with fleet files. These files, one for each fleet, are used in modules 6 and 7 to examine fleet performance and replacement. Fig.8 shows the inputs and outputs to module 4.

Figure 8 - Mod/4



The flowchart for module 4 is the same as that for module 3 and is shown in Fig.7. The discussion in module 3 is also valid here, except that the basic data for the fleet file consists of the following items:

a) Number of vehicles in fleet

b) Vehicle numbers in fleet

c) Purchase date

d) Purchase price for the fleet and per vehicle

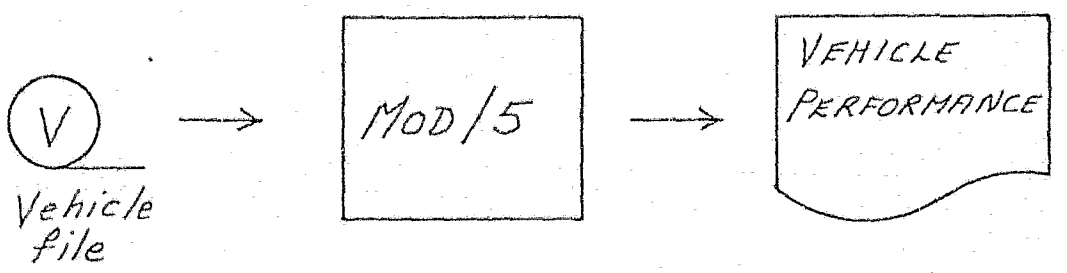
e) Vehicle make

f) Vehicle model

4.5 Module 5

Module 5 uses the vehicle files as input to produce vehicle performance reports as shown in Fig.9. The program can be run at any time to generate an output report.

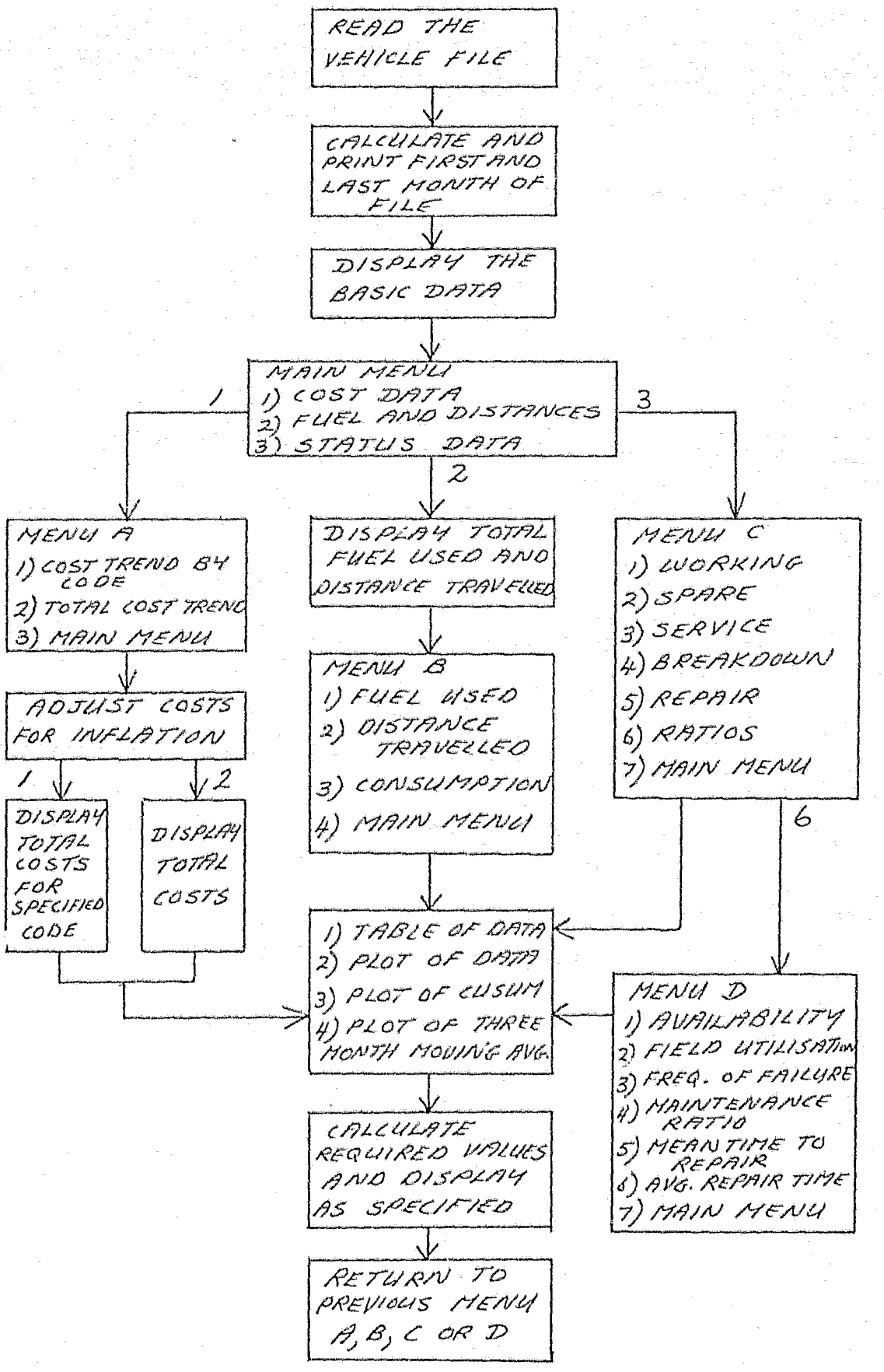
Figure 9 - Mod/5



The input vehicle file contains a considerable volume of information and if we consider the management of fifty different vehicles then it is apparent that some means of filtering and condensing the information is required. However, this requirement for including only selected information in the output report conflicts with the objective for a general system requiring the minimum number of modifications. The problem is solved by allowing the user to specify what information is required in the report. The vehicle file is accessed quickly on the computer monitor and that information which needs special attention is specified for inclusion in the output report.

The program flowchart is shown in Fig.10. The information from the vehicle file is arranged in

Figure 10 - Mod/5 flowchart



three sections corresponding to the three main menu selections. These are:

a) Cost data (excluding the fuel and distances). This includes the total cost trend as well as the cost trend by code (i.e. 4 to 33). The values can also first be adjusted for inflation, past amounts being brought up to present value. The inflation rate is specified by the user as a monthly percentage. A guide to this figure is given in reference 14.

b) Fuel and distances. This is the fuel used and distance travelled as well as the fuel consumption (litres/100 kilometres).

c) Status data. This includes the shifts spent working, spare, in service and in repair and the number of breakdowns per month. Also included are the figures of merit previously discussed. The calculations used in processing this information are shown in Appendix 5a. The mean time to repair and the average repair time discussed in module 3 can also be examined here. These figures are useful for determining the optimum number of 'servers' required in the workshop for repair actions. (See reference 15 for details on finite source queues.)

The above information can be presented by four different methods:

a) A table of the values

b) A plot of the values

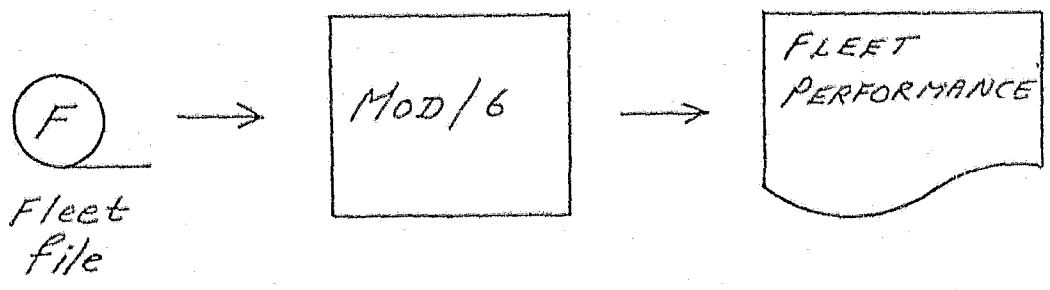
c) A plot of the three month moving average to smooth the values. (See Appendix 5b for the method of calculation.)

d) A plot of the cusum which is used as a visual aid for monitoring the variable under consideration. (See Appendix 5b for the method of calculation.) A reference value must be specified by the user which should be chosen near the process average. The slope of the cusum then gives the value of the variable with zero slope (i.e. a horizontal line) indicating the reference value. A change in the value of the variable then corresponds to a change of slope in the cusum. Thus small departures from the average can be easily detected and changes that occur can be related to actual events. (A full explanation on cusums is given in reference 16.)

4.6 Module 6

Module 6, which is similar to module 5, produces fleet performance reports using the fleet files as shown in Fig.11. The calculations and discussion used in module 5 are also applicable here.

Figure 11 - Mod/6

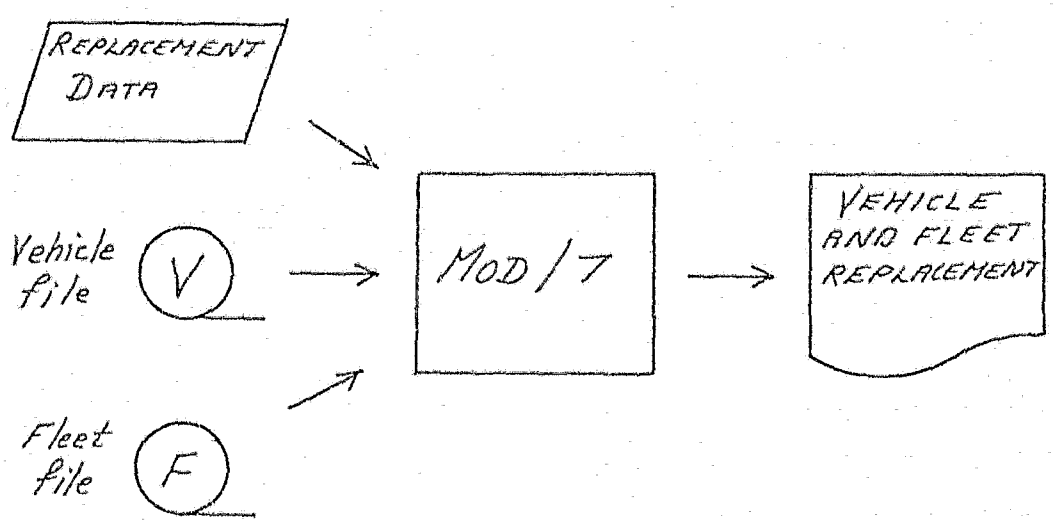


The program flowchart is the same as that for module 5 (see Fig.10) except that there is an additional menu where appropriate. This gives a choice of using either total values for the fleet or average values per vehicle which are obtained by dividing the total values by the number of vehicles in the fleet.

4.7 Module 7

Module 7 deals with vehicle and fleet replacement. The module can be run at any time but a replacement analysis should be initiated according to the guidelines given in Chapter 2.2. The inputs and outputs to the module are shown in Fig.12.

Figure 12 - Mod/7



The replacement procedure adopted is the discounted cash flow method. The input data required is, for the defender, the next period operating cost and the salvage values now and at the end of the first period. For the challenger, it is the present capital cost and future operating costs and salvage

values for each period up to its economic life. A discounting test rate is also required. The calculations are based on a period equal to one month since the cost data is available on this basis.

The program flowchart is shown in Fig.13. A particular vehicle or fleet file is first read depending on whether vehicle or fleet replacement is to be considered. The required data is then calculated or requested as follows:

a) The next month operating cost for the defender can be either forecast or input by the user. Forecasting is done by one of two methods viz. second order regression or exponential smoothing. The first uses the method of least squares on the cost data to find the coefficients of the second order equation. This method can be used since cumulative operating costs can be fitted by a second order equation as previously discussed. The equation is reproduced here:

$$\frac{\text{Cumulative } C_x}{\text{Purchase price}} * 100 = k_0 + k_1 * x + k_2 * x^2$$

where C_x = defender operating cost in month x

(Appendix 6a gives details of the method used.) The second forecasting method is exponential smoothing corrected for trend. A smoothing constant and trend smoothing constant must be specified by the user. (Appendix 6b gives further details of the method used.) For both methods the costs used can first be adjusted for inflation. Also, any codes and their corresponding costs can be omitted from the forecast.

b) The operating costs for the challenger are required for all periods up to its economic life. These costs can be specified by three different methods. The

Figure 13 - Mod/7 flowchart

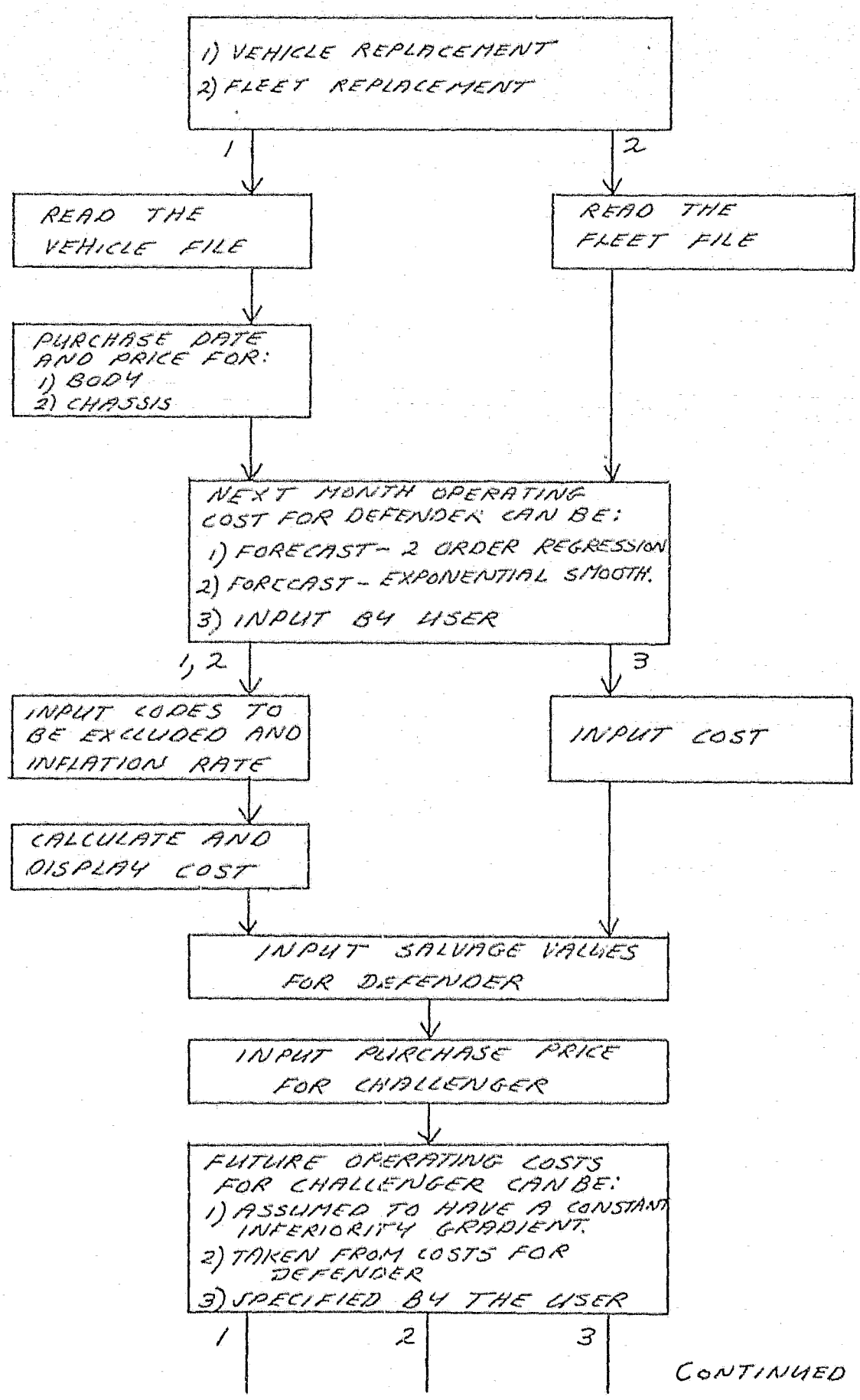
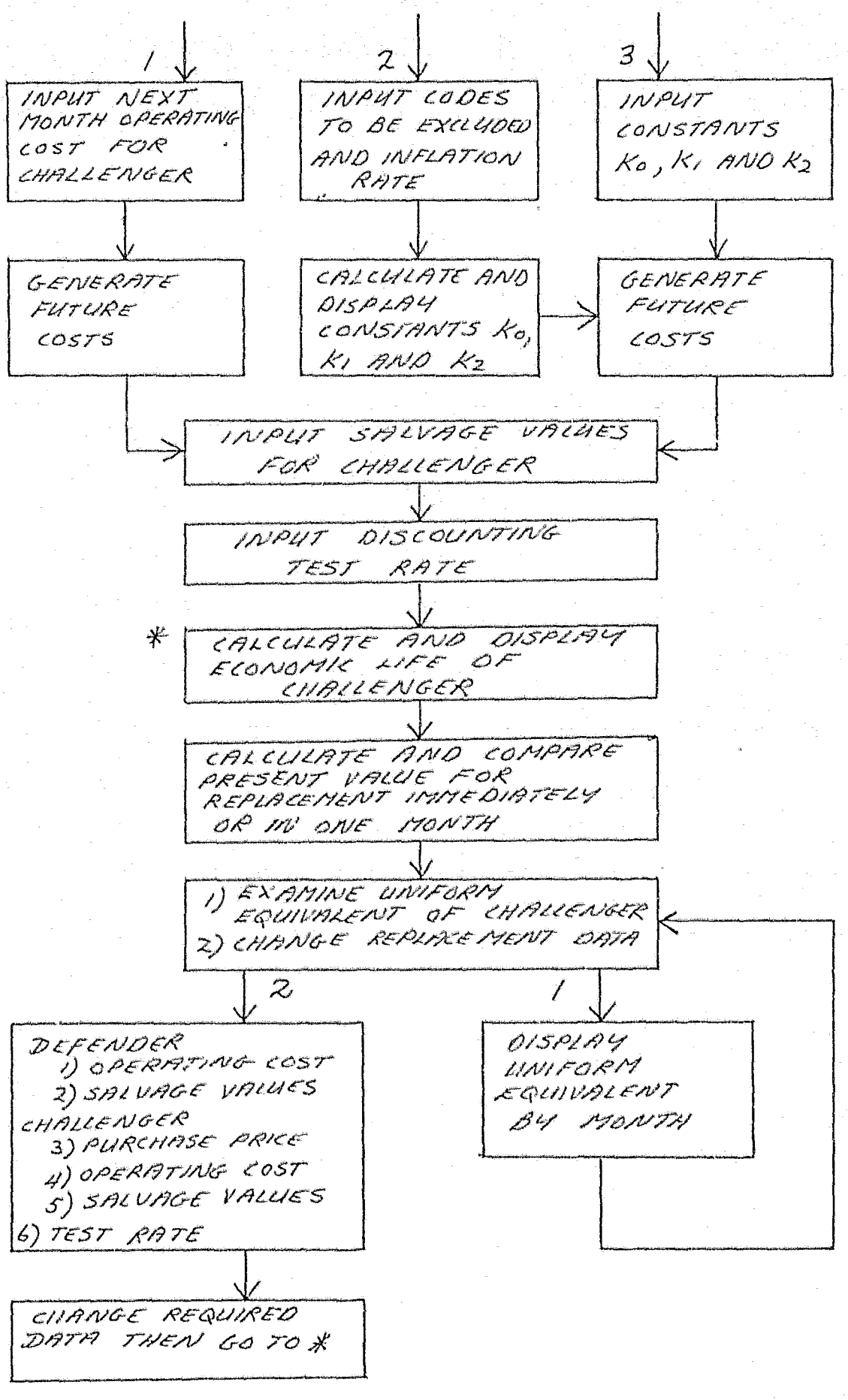


Figure 13 - Continued



first assumes a constant inferiority gradient which is the basis of the MAPI method. The user specifies next month's operating cost and subsequent months are then determined by:

$$C_x^* = C_1^* + \frac{(x - 1) * (C_1 - C_1^*)}{\text{age of defender}}$$

where C_x^* = challenger operating cost in month x.

The second method assumes that the operating costs are the same as those incurred by the defender over a similar period in its life. A second order equation is fitted to the defender cost data as is done in part a) above. The equation is then used in reverse with the purchase price of the challenger, beginning with x=1, to generate costs for the challenger. (This method is shown in Appendix 6a.) In the third method, the user must specify the constants k_0, k_1 and k_2 for the equation given in part a) above. The equation then generates the costs. (Appendix 6c gives typical values for the constants.)

c) Salvage values for the defender are required for the present time and at the end of the first month. For the challenger future values are required up to its economic life. For this reason salvage values are only requested at the end of each year and these are assumed to decrease linearly over the months between adjacent years. (Over the first year, the values decrease from the purchase price to the first salvage value and, over the last year, they decrease from the last salvage value specified to zero. If no salvage values are specified however, then the values do not reduce to zero over the first year.) The values can be specified for a maximum of five years into the future since after this period their

effect is minimal. Also, all values should be in terms of the present value of money.

d) The purchase price of the challenger and the discounting test rate must be specified by the user. The purchase date and price for the defender, which are required for the forecasting methods, are read directly from the vehicle or fleet file.

The replacement decision is made by considering the two exclusive strategies viz. immediately replacement or replacement in one period as previously discussed. The processing required is a calculation of the challenger's economic life and corresponding minimum equivalent annuity. This result is then used to determine the present value of cash flows for each of the two strategies. The more cost effective strategy is then adopted. The method is shown in Appendix 6d. Note that taxation is not included since it does not affect public service vehicles.

Provision is made to check the sensitivity of the resulting replacement decision to changes in the input data. The user may change any item of data to obtain a new set of results. This feature also allows the various forecasting methods to be used and compared.

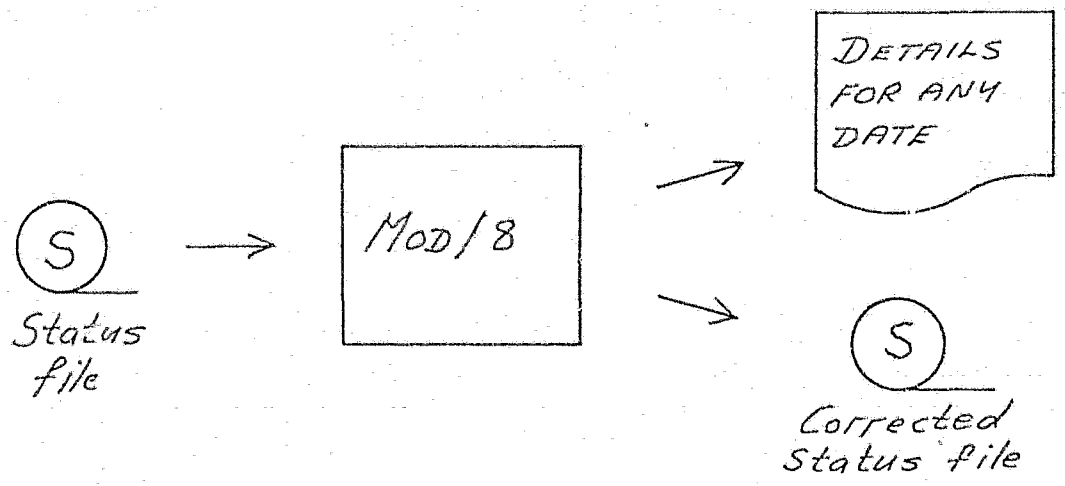
Finally, it must be noted that the replacement decision is based on estimates and forecasts of the future. It should therefore be used only as a guide and not as a rigid rule. In addition, downtime costs have not been included in the model and thus the reliability (from module 5 or 6) must also be considered in making a final decision. The reliability of the defender will be lower than that

of the challenger. Thus downtime costs will be greater for the defender and this factor will favour replacement. All investment proposals are also required to compete on a cost/benefit scale for the limited investable funds before the defender can finally be replaced.

4.8 Module 8

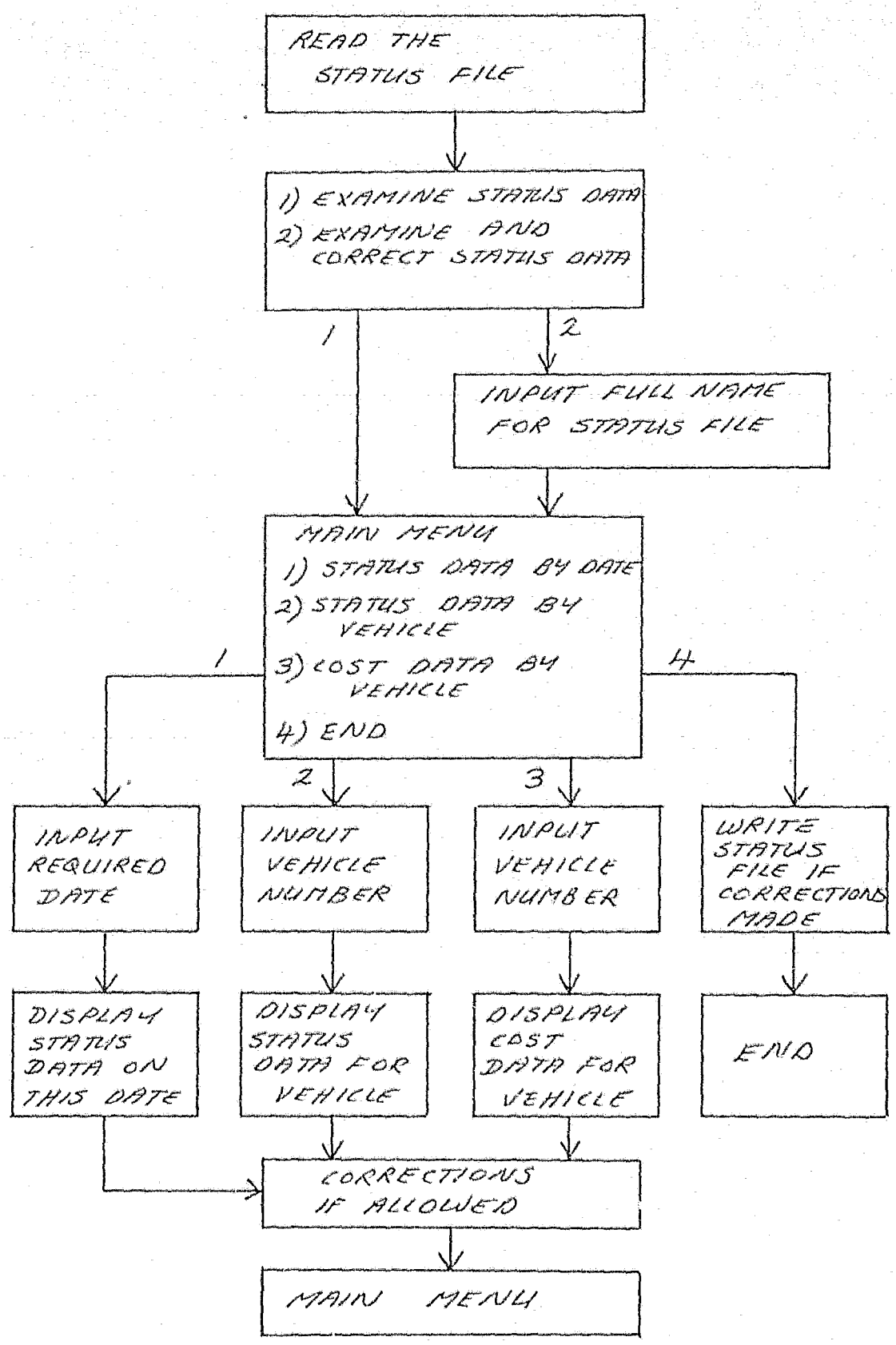
Module 8 makes it possible to examine and correct both the status and cost data. The procedure is shown in Fig.14.

Figure 14 - Mod/8



The program flowchart is shown in Fig.15. The program can be run at any time to examine the status and cost data. The module thus provides a complete record of the fleet operations. In addition, incorrect data used in updating the vehicle and fleet files can be corrected by first using this module followed by module 3 or 4. To provide a certain amount of data integrity, the status full file name must be entered before the data can be corrected. (The status full file name is specified by the user when creating a status file in module 1.)

Figure 15 - Mod/8 flowchart



5. SYSTEM OPERATION

This section is an example of the modules in operation. Only the main branches in each are shown to give an idea of how they operate and fit together to form a complete system. Modules 4 and 6 are not shown since although the processing is different the operation is similar to that in 3 and 5 respectively.

The following symbols are used in the example : A row of +++++ indicates that the computer monitor is cleared and triangular brackets <<< >>> enclose sections which are normally sent directly to the printer. The additional explanatory remarks, indicated by the word Rem, refer to the adjacent part of the program.

5.1 Module 1

```
++++++++++++++++++++++++++++++++++++++++

_____ _____

   VEHICLE MANAGEMENT SYSTEM

   MODULE 1 : VEHICLE STATUS

_____ _____

PRESS 'END LINE' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++++++

   YOU MAY :                          | Rem: Main menu

1) CREATE A NEW STATUS FILE

2) UPDATE AN EXISTING STATUS FILE

3) INPUT THE COST DATA

   WHICH (1,2 OR 3)
?
1                                     | Rem: This selection
                                      | is performed at the
++++++++++++++++++++++++++++++++++++  | beginning of each
                                      | month.
ARE YOU SURE ?
```

```
THIS IS DONE ONLY ONCE A MONTH
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

FOR THIS STATUS FILE :

ENTER MONTH (1 TO 12)
?
1
ENTER YEAR (82 TO 99)
?
83

THIS FILE WILL BEGIN ON
1 JAN  1983
OK ? (Y/N)
?
Y

++++++++++++++++++++++++++++++++++

ENTER NAME FOR STATUS FILE
(NAME WILL BE --8301)

ENTER FIRST TWO CHARACTERS
?
QW
FILE NAME WILL BE QW8301
OK ? (Y/N)
?
Y

++++++++++++++++++++++++++++++++++

GIVE A FULL NAME FOR STATUS
FILE QW8301
(MAX 20 CHARACTERS)
?
TESTING


<<<FULL NAME FOR STATUS :>>>
<<< TESTING >>>

<<< STORE THIS NAME IN A SAFE PLACE >>>


++++++++++++++++++++++++++++++++++


__________________________________
```

Rem: Initialising arrays.

Rem: Last four characters of status file name are year and month of file.

Rem: This name is used as a pass-word to correct status data at a later date.

```
        INSERT DISC TO HOLD
          STATUS FILE
-----------------------------------

THEN PRESS 'E/L' TO CONTINUE
?

<<< STATUS FILE QW8301 >>>
<<< NOW EXISTS ON THIS DISK >>>'

++++++++++++++++++++++++++++++++++++

THE VEHICLES TO GO ON FILE CAN BE :

1) ENTERED THROUGH KEYBOARD

2) OBTAINED FROM PREVIOUS STATUS FILE

   'WHICH (1 OR 2)
?
1

++++++++++++++++++++++++++++++++++++

ENTER NO OF VEHICLES TO GO ON
FILE AT THIS STAGE (MAX 50)
?
10

++++++++++++++++++++++++++++++++++++

FOR VEHICLE  1

ENTER VEHICLE NUMBER
?
3101

ENTER FLEET NUMBER
?
31

++++++++++++++++++++++++++++++++++++

FOR VEHICLE  2

ENTER VEHICLE NUMBER
?
3102
```

Rem: The disc inserted must remain in the drive until the next disc instruction. This applies to all modules.

Rem: The status file is created on the disc.

Rem: The vehicle and corresponding fleet numbers are now put on the status file. To prevent errors in later modules it is important to enter these numbers correctly.

Rem: The system is designed for a maximum of fifty vehicles and 20 fleets. However, if all procedures are repeated then additional vehicles can be accounted for.

Rem: This is repeated for all ten vehicles.

```
++++++++++++++++++++++++++++++++++
THE VEHICLES TO GO ON FILE CAN BE :
1) ENTERED THROUGH KEYBOARD
2) OBTAINED FROM PREVIOUS STATUS FILE
   WHICH (1 OR 2)
?
2
++++++++++++++++++++++++++++++++++

----------------------------------

     INSERT TAPE CONTAINING
       STATUS FILE --8212

----------------------------------

THEN PRESS 'E/L' TO CONTINUE
?
```

Rem: The menu is repeated to illustrate selection 2.

```
++++++++++++++++++++++++++++++++++

DO YOU KNOW LAST MONTH STATUS FILE NAME
(Y/N)
?
Y
ENTER FILE NAME
?
AS8212

++++++++++++++++++++++++++++++++++

ROW    VEHICLE NO      FLEET NO
----------------------------------
 1       3101             31
 2       3102             31
 3       3103             31
 4       3201             32
 5       3202             32
 6       3203             32
 7       3204             32
 8       3205             32
----------------------------------

NOTE ROW IF ANY ERRORS.
PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

ROW    VEHICLE NO      FLEET NO
```

Rem: This status file is now read to obtain the vehicle and fleet numbers.

9	3301	33
10	3302	33
11	3401	34

```
ANY ERRORS ?
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++++

   YOU MAY :

1) LIST TABLE
2) CHANGE DATA
3) DELETE DATA
4) ADD DATA
5) CONTINUE

   WHICH (1,2,3,4 OR 5)
?
3

++++++++++++++++++++++++++++++++++++

ENTER ROW TO BE DELETED
?
11

++++++++++++++++++++++++++++++++++++
```

ROW	VEHICLE NO	FLEET NO
1	3101	31
2	3102	31
3	3103	31
4	3201	32
5	3202	32
6	3203	32
7	3204	32
8	3205	32

```
NOTE ROW IF ANY ERRORS.
PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++
```

ROW	VEHICLE NO	FLEET NO
9	3301	33
10	3302	33

```
ANY ERRORS ?
(Y/N)
```

```
?
N

++++++++++++++++++++++++++++++++++

DO YOU WISH TO ENTER DATA NOW
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

ARE YOU READY TO ENTER DATA
FOR FIRST DAY  830101
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

FIRST DAY  830101
----------------------------------

VEHICLE  3101
STATUS DATA
?
98

++++++++++++++++++++++++++++++++++

FIRST DAY  830101
----------------------------------

VEHICLE  3102
STATUS DATA
?
98
```

Rem: Status data which is available can be entered at this stage.

Rem: This is repeated for all ten vehicles.

```
++++++++++++++++++++++++++++++++++

VEH NO              STATUS
----------------------------------
 3101            98 WEEKEND/HOL
 3102            98 WEEKEND/HOL
 3103            98 WEEKEND/HOL
 3201            98 WEEKEND/HOL
 3202            98 WEEKEND/HOL
 3203            98 WEEKEND/HOL
 3204            98 WEEKEND/HOL
 3205            98 WEEKEND/HOL
----------------------------------

NOTE VEH NO OF ANY ERROR
```

```
PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++

VEH NO              STATUS
------------------------------------
 3301             98 WEEKEND/HOL
 3302             98 WEEKEND/HOL
------------------------------------

NOTE VEH NO OF ANY ERROR
ANY CHANGES (Y/N)
?
N

++++++++++++++++++++++++++++++++++++


++++++++++++++++++++++++++++++++++++

ARE YOU READY TO ENTER DATA
FOR DATE SUNDAY    830102
(Y/N)
?
N

++++++++++++++++++++++++++++++++++++

____________________________________

   INSERT DISC CONTAINING
     STATUS FILE QW8301
____________________________________


THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++

STATUS FILE QW8301 WRITTEN

UPDATE COMPLETED
```

```
++++++++++++++++++++++++++++++++++

   YOU MAY :

1) CREATE A NEW STATUS FILE

2) UPDATE AN EXISTING STATUS FILE

3) INPUT THE COST DATA

   WHICH (1,2 OR 3)
?
2

++++++++++++++++++++++++++++++++++
```

Rem: This selection is normally performed on a daily basis.

```
INSERT DISC CONTAINING
STATUS FILE

THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

DO YOU KNOW THE STATUS FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
QW8301

++++++++++++++++++++++++++++++++++

THE FILE JUST READ IS
NAME :QW8301
FIRST DATE (YYMMDD):  830101
NO OF VEHICLES ON FILE =  10

IS THIS THE FILE YOU REQUIRE
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

CHECK BACK DATA

ENTER DATA AS PROMPTED
```

Rem: This checks for the status code 99.

```
PRESS 'E/L' IF DATA UNKNOWN


PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

DATE FRIDAY     830128
----------------------------------

VEHICLE  3201
STATUS DATA :
?
1

++++++++++++++++++++++++++++++++++

THE VEHICLES NOW ON FILE ARE:

 1 ) 3101        2 ) 3102
 3 ) 3103        4 ) 3201
 5 ) 3202        6 ) 3203
 7 ) 3204        8 ) 3205
 9 ) 3301        10 ) 3302


ARE ANY NEW VEHICLES TO BE
ADDED (Y/N)
?
N

++++++++++++++++++++++++++++++++++

ARE YOU READY TO ENTER DATA
FOR DATE MONDAY     830131
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

DATE MONDAY     830131
----------------------------------

VEHICLE  3101
STATUS DATA
?
1


++++++++++++++++++++++++++++++++++

MONTH COMPLETE
NO MORE DAYS CAN BE ADDED
```

Rem: Status data for the first thirty days has already been entered.

Rem: The status data is now entered as shown before.

```
------------------------------------

  INSERT DISC CONTAINING
    STATUS FILE QW8301

------------------------------------


THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++

STATUS FILE QW8301 WRITTEN

UPDATE COMPLETED
```

```
++++++++++++++++++++++++++++++++++++

   YOU MAY :

1) CREATE A NEW STATUS FILE

2) UPDATE AN EXISTING STATUS FILE

3)     UT THE COST DATA

   WHICH (1,2 OR 3)
?
3

++++++++++++++++++++++++++++++++++++

------------------------------------

      INSERT DISC CONTAINING
          STATUS FILE

------------------------------------

THEN PRESS 'E/L' TO CONTINUE
```

Rem: This selection is performed at the end of each month.

```
?

++++++++++++++++++++++++++++++++++

DO YOU KNOW THE STATUS FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
QW8301

++++++++++++++++++++++++++++++++++

THE FILE JUST READ IS
NAME :QW8301
FIRST DATE (YYMMDD):  830101
NO OF VEHICLES ON FILE =  10
----------------------------------

IS THIS THE FILE YOU REQUIRE
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

FOR THE MONTH JAN  1983
ENTER CODES AND COSTS AS PROMPTED


PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

VEHICLE  3101
----------------------------------

ENTER REPAIR CODE (4 TO 33 OR 0 TO END)
?
15

ENTER CORRESPONDING COST
?
420.15

++++++++++++++++++++++++++++++++++

VEHICLE  3101
----------------------------------

ENTER REPAIR CODE (4 TO 33 OR 0 TO END)
?
0

++++++++++++++++++++++++++++++++++
```

Rem: A maximum of five codes and their corresponding costs can be entered for each vehicle per month.

```
VEHICLE  3101
-----------------------------------

FUEL CONSUMPTION (LITRES):
?
368

DISTANCE TRAVELLED (KILOMETRES) :
?
1723

+++++++++++++++++++++++++++++++++++

VEHICLE  3101
-----------------------------------
CODE                COST/VALUE
-----------------------------------
  15                  420.15
  0                   0
  0                   0
  0                   0
  0                   0
 FUEL                 368
 KMS                  1723

ANY ERRORS ?
(Y/N)
?
N -

+++++++++++++++++++++++++++++++++++

VEHICLE  3102
-----------------------------------

ENTER REPAIR CODE (4 TO 33 OR 0 TO END)
?
5
```

Rem: This is repeated for all ten vehicles.

```
STATUS FILE QW8301 WRITTEN
```

5.2 Module 2

```
++++++++++++++++++++++++++++++++++

_____________________________________

   VEHICLE MANAGEMENT SYSTEM

          MODULE  2

   WEEKLY & MONTHLY REPORTS

_____________________________________

PRESS 'END LINE' TO CONTINUE
?

++++++++++++++++++++++++++++++++++


_____________________________________

     INSERT DISC CONTAINING
        THE STATUS FILE

_____________________________________


THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

DO YOU KNOW THE STATUS
FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
QW8301

++++++++++++++++++++++++++++++++++

THE FILE JUST READ IS:
```

```
NAME :QW8301
FIRST DATE YYMMDD : 830101
NO OF VEH ON FILE:  10

-----------------------------------
IS THIS THE FILE YOU REQUIRE
 Y/N
?
Y

+++++++++++++++++++++++++++++++++++
```

```
<<<
THE FIRST DAY YOU CAN GET REPORTS FROM IS
SATURDAY    1   JAN   1983

THE LAST DAY YOU CAN GET REPORTS TO IS
MONDAY      31   JAN   1983

-----------------------------------
DAYS FOR WHICH DATA HAS NOT YET
BEEN ENTERED

NONE
>>>
```

Rem: These are the days for which status data has been entered.
Rem: This checks for code 99.

```
+++++++++++++++++++++++++++++++++++

                MAIN MENU
                _________

    SELECT :


1) WEEKLY TYPE REPORT
2) MONTHLY TYPE REPORT
3) END VEH/2



    WHICH (1,2 OR 3)
?
1

+++++++++++++++++++++++++++++++++++

ENTER FIRST DATE FOR REPORT
(YYMMDD)
?
830124
CONFIRM THIS DAY IS A
MONDAY
(Y/N)
?
Y
```

```
++++++++++++++++++++++++++++++++

ENTER LAST DATE FOR REPORT
(YYMMDD)
?
830130
CONFIRM THIS DAY IS A SUNDAY
(Y/N)
?
Y

++++++++++++++++++++++++++++++++

<<<

**********************************

     WEEKLY REPORT

**********************************

START DAY MONDAY       24  JAN  1983

END DAY   SUNDAY       30  JAN  1983

_____________________________________
```

VEH NO	TOTAL SHIFTS WORK	SPRE	SERV	REP
3101	7	0	0	2
3102	3	1	0	2
3103	5	0	0	2
3201	2	0	0	4
3202	4	0	0	3
3203	8	0	0	0
3204	5	0	0	1
3205	6	0	0	0
3301	5	0	0	2
3302	4	0	0	2

```
_____________________________________

>>>

++++++++++++++++++++++++++++++++++++

WOULD YOU LIKE DAILY AVAILABILITY :


1) FOR ALL VEHICLES TOGETHER
2) FOR EACH FLEET SEPARATELY


   WHICH (1 OR 2)
?
1
```

```
++++++++++++++++++++++++++++++++++

<<<
NO OF VEHICLES AVAILABLE

ON MONDAY       24  JAN       6
ON TUESDAY      25  JAN       6
ON WEDNESDAY    26  JAN       8
ON THURSDAY     27  JAN       7
ON FRIDAY       28  JAN       8
ON SATURDAY     29  JAN       7
ON SUNDAY       30  JAN       0

>>>
```

```
++++++++++++++++++++++++++++++++++

WOULD YOU LIKE DAILY AVAILABILITY :


1) FOR ALL VEHICLES TOGETHER
2) FOR EACH FLEET SEPARATELY
```

Rem: The menu is repeated to illustrate Selection 2.

```
   WHICH (1 OR 2)
?
2

++++++++++++++++++++++++++++++++++

<<<
FOR MONDAY      24  JAN
FLEET        VEHS AVAIL
 31              2
 32              4
 33              0

FOR TUESDAY     25  JAN
FLEET        VEHS AVAIL
 31              1
 32              4
 33              1

FOR WEDNESDAY   26  JAN
FLEET        VEHS AVAIL
 31              2
 32              4
 33              2

FOR THURSDAY    27  JAN
FLEET        VEHS AVAIL
 31              2
 32              3
 33              2
```

```
FOR FRIDAY      28  JAN
FLEET         VEHS AVAIL
 31               2
 32               4
 33               2

FOR SATURDAY    29  JAN
FLEET         VEHS AVAIL
 31               3
 32               3
 33               1

FOR SUNDAY      30  JAN
FLEET         VEHS AVAIL
 31               0
 32               0
 33               0

>>>

++++++++++++++++++++++++++++++++++

              MAIN MENU
              _________

   SELECT :


1) WEEKLY TYPE REPORT
2) MONTHLY TYPE REPORT
3) END VEH/2



   WHICH (1,2 OR 3)
?
2

++++++++++++++++++++++++++++++++++

ENTER FIRST DATE FOR REPORT
(YYMMDD)
?
830101
CONFIRM THIS DAY IS A
SATURDAY
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

ENTER LAST DATE FOR REPORT
(YYMMDD)
?
830131
CONFIRM THIS DAY IS A MONDAY
(Y/N)
?
```

Y

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

<<<

****

MONTHLY REPORT

****

VEH NO	TOTAL DAYS IN WORKSHOP
3101	6
3102	5
3103	4
3201	5
3202	10
3203	7
3204	5
3205	2
3301	13
3302	10

VEHS IN WORKSHOPS ON
MONDAY 31 JAN

VEHICLE	CODE	DAYS IN
3202	13	4
3204	10	2
3301	4	2
3302	91	1

FREQ OF BREAKDOWNS DURING SHIFT
PER 100 SHIFTS

FLEET	
31	1
32	2
33	8

FREQ OF BREAKDOWNS BEFORE
LEAVING DEPOT PER 100 SHIFTS

FLEET	
31	1
32	0

33 12

REPAIR LENGTH OF STAY STATS

FLEET NO	MEAN DAYS	STD DEV DAYS
31	1.7	.4
32	3	1
33	2.5	1.4

AVAILABILITY AND MAINTENANCE

FLEET NO	AVAIL %	MAINT RATIO	FIELD UTIL%
31	83	4	81
32	78	3	74
33	54	1	49

FAULT ANALYSIS

FLEET 31

FAULT CODE	DAYS IN WKSP	% OF WKSHP DAYS
3	8	53
5	2	13
7	2	13
15	2	13
91	1	6

FLEET 32

FAULT CODE	DAYS IN WKSP	% OF WKSHP DAYS
3	8	27
5	3	10
8	8	27
10	2	6
13	4	13
15	1	3
20	3	10

FLEET 33

FAULT CODE	DAYS IN WKSP	% OF WKSHP DAYS
4	5	21
6	1	4
7	2	8
11	5	21
14	1	4
16	2	8
17	4	17
91	3	13

>>>

5.3 Module 3

```
++++++++++++++++++++++++++++++++++++++

______________________________________

   VEHICLE MANAGEMENT SYSTEM

   MODULE 3 : VEHICLE RECORD

______________________________________

PRESS 'END LINE' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++++   |
                                        |
   YOU MAY:                             |     Rem: Main menu

1) CREATE A VEHICLE FILE AND INPUT THE BASIC DATA

2) UPDATE THE BASIC DATA

3) READ IN THE STATUS FILE AND UPDATE THE VEHICLE FILES

4) CORRECT A VEHICLE FILE

5) CANCEL A VEHICLE FILE

6) END

      WHICH (1,2,3,4,5 OR 6)?
1

++++++++++++++++++++++++++++++++++++++

ARE YOU SURE?
VEHICLE FILES ARE ONLY CREATED
ONCE FOR A PARTICULAR VEHICLE.
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++++++   |
                                        |     Rem: Initialising
PLEASE WAIT                             |     arrays.
```

```
++++++++++++++++++++++++++++++++++

_____________________________________

      INSERT DISC CONTAINING
          VEHICLE FILES
_____________________________________

THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

DOES A VEHICLE MASTER FILE EXIST ON THIS DISC (Y/N)
(ENTER U IF UNCERTAIN)
?
N
ASSIGN A NUMBER TO THIS DISC (MAX 4 CHARACTERS)
?
1
THE VEHICLE MASTER FILE ON THIS DISC WILL BE KNOWN AS MV1
IS THIS O.K. (Y/N)
?
Y

<<< VEHICLE MASTER FILE MV1 >>>
<<< NOW EXISTS ON THIS DISC >>>

++++++++++++++++++++++++++++++++++

ENTER VEHICLE NUMBER
?
3101
FOR THIS VEHICLE ENTER A VEHICLE FILE NUMBER
(MAX 5 NUMBERS)
?
11

++++++++++++++++++++++++++++++++++

VEHICLE:  3101

FILE NAME: V11


IS THIS O.K.(Y/N)
?
Y

<<< VEHICLE FILE V11 >>>
```

Rem: If a master file does exist then it is read.

Rem: The vehicle file is created and the master file is updated to include this new vehicle.

```
<<< NOW EXISTS ON THIS DISC >>>

++++++++++++++++++++++++++++++++++

VEHICLE  3101
----------------------------------

FOR THIS VEHICLE ENTER THE BASIC DATA AS PROMPTED
(ENTER -1 IF UNKNOWN)

PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

VEHICLE  3101
----------------------------------

PURCHASE DATE?
(BODY & CHASSIS)

BODY :(YYMMDD)
?
790708

CHASSIS :(YYMMDD)
?
810101

++++++++++++++++++++++++++++++++++

VEHICLE  3101
----------------------------------

PURCHASE PRICE?
(BODY & CHASSIS)

BODY:
?
30000

CHASSIS:
?
40000

++++++++++++++++++++++++++++++++++

VEHICLE  3101
----------------------------------

MAKE?
(MAX 4 CHARACTERS)
?
BMW

++++++++++++++++++++++++++++++++++

VEHICLE  3101
```

```
------------------------------------

MODEL?
(MAX 4 CHARACTERS)
?
528I

++++++++++++++++++++++++++++++++++

VEHICLE  3101
------------------------------------

REGISTRATION NUMBER?
(MAX 7 CHARACTERS)
?
EMD123T

++++++++++++++++++++++++++++++++++

VEHICLE  3101
------------------------------------

ENGINE NUMBER
?
-1

++++++++++++++++++++++++++++++++++

VEHICLE  3101
------------------------------------

FLEET NUMBER?
?
31

++++++++++++++++++++++++++++++++++

VEHICLE  3101
------------------------------------

CURRENT LOCATION?                    |
(MAX 4 CHARACTERS)                   |
?                                    |
JHB3                                 |   Rem: The vehicle
                                     |   file is written.
++++++++++++++++++++++++++++++++++   |

   YOU MAY:

1) CREATE A VEHICLE FILE AND INPUT THE BASIC DATA

2) UPDATE THE BASIC DATA

3) READ IN THE STATUS FILE AND UPDATE THE VEHICLE FILES

4) CORRECT A VEHICLE FILE

5) CANCEL A VEHICLE FILE

6) END
```

```
        WHICH (1,2,3,4,5 OR 6)?
2

++++++++++++++++++++++++++++++++++++

------------------------------------

      INSERT DISC CONTAINING
         VEHICLE FILES

------------------------------------

THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++

WHAT IS THE VEHICLE NUMBER
?
3101

++++++++++++++++++++++++++++++++++++

DO YOU KNOW THE VEHICLE FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
V11

++++++++++++++++++++++++++++++++++++

VEHICLE  3101
------------------------------------

CHANGE BASIC DATA AS PROMPTED
(-1 IF UNKNOWN)

PRESS 'END LINE' FOR NO CHANGE


PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++

VEHICLE  3101
------------------------------------

PURCHASE DATE?
(BODY & CHASSIS)
```

Rem: The vehicle file is read.

```
BODY :(YYMMDD)
 790708
?

CHASSIS :(YYMMDD)
 810101
?
```

Rem: This proceeds as before.

```
++++++++++++++++++++++++++++++++++++

   YOU MAY:

1) CREATE A VEHICLE FILE AND INPUT THE BAS C DATA

2) UPDATE THE BASIC DATA

3) READ IN THE STATUS FILE AND UPDATE THE VEHICLE FILES

4) CORRECT A VEHICLE FILE

5) CANCEL A VEHICLE FILE

6) END

      WHICH (1,2,3,4,5 OR 6)?
3

++++++++++++++++++++++++++++++++++++

_____________________________________

     INSERT DISC CONTAINING
          STATUS FILE
_____________________________________

THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++
```

```
DO YOU KNOW THE STATUS
FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
QW8301

++++++++++++++++++++++++++++++++++++

THE STATUS FILE JUST READ IS:

NAME : QW8301
FIRST DATE (YYMMDD) :  830101
NO. VEHICLES ON FILE :  10

IS THIS THE CORRECT STATUS
FILE (Y/N)
?
Y

++++++++++++++++++++++++++++++++++++

CHECK STATUS FILE
PLEASE WAIT

++++++++++++++++++++++++++++++++++++
```

Rem: This checks that the status and cost data are complete.

```
------------------------------------

     INSERT DISC CONTAINING
        VEHICLE FILES

------------------------------------


THEN PRESS 'E/L' TO CONTINUE
?


++++++++++++++++++++++++++++++++++++

DO YOU KNOW THE NAME OF THE VEHICLE MASTER FILE (Y/N)
?
Y
ENTER FILE NAME
?
MV1

++++++++++++++++++++++++++++++++++++

THE NEXT OPERATION WILL TAKE APPROXIMATELY 8 MINUTES
IF NO ERRORS OCCUR

++++++++++++++++++++++++++++++++++++
```

Rem: The master file is read.

```
PLEASE WAIT

++++++++++++++++++++++++++++++++++

NUMBER OF VEHICLE FILES UPDATED:  8

TOTAL VEHICLE FILES:  10

----------------------------------

   YOU MAY :

1) UPDATE REMAINING FILES

2) RETURN TO MAIN MENU

   WHICH (1 OR 2)
?
2

++++++++++++++++++++++++++++++++++

ARE YOU SURE (Y/N)
NORMALLY ALL FILES ARE UPDATED AT THE SAME TIME.
?
N

++++++++++++++++++++++++++++++++++

NUMBER OF VEHICLE FILES UPDATED:  8

TOTAL VEHICLE FILES:  10

----------------------------------

   YOU MAY :

1) UPDATE REMAINING FILES

2) RETURN TO MAIN MENU

   WHICH (1 OR 2)
?
1

++++++++++++++++++++++++++++++++++



----------------------------------

INSERT REMAINING DISCS

----------------------------------


THEN PRESS 'E/L' TO CONTINUE
?
```

Rem: The vehicle files on the master file are read, one at a time, updated and written. In each case a check is run to ensure that the status file used for updating is the correct one.

Rem: This is only used if for some reason the vehicle files on a particular disc were not updated. These can be updated and this selection used to return to the main menu.

```
++++++++++++++++++++++++++++++++++

DO YOU KNOW THE NAME OF THE VEHICLE MASTER FILE (Y/N)
?
Y
ENTER FILE NAME
?
MV2

++++++++++++++++++++++++++++++++++

THE NEXT OPERATION WILL TAKE APPROXIMATELY 2 MINUTES
IF NO ERRORS OCCUR

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

   YOU MAY:

1) CREATE A VEHICLE FILE AND INPUT THE BASIC DATA

2) UPDATE THE BASIC DATA

3) READ IN THE STATUS FILE AND UPDATE THE VEHICLE FILES

4) CORRECT A VEHICLE FILE

5) CANCEL A VEHICLE FILE

6) END

      WHICH (1,2,3,4,5 OR 6)?
4

++++++++++++++++++++++++++++++++++++

ENTER MONTH OF ERROR
(1 TO 12)
?
12

ENTER YEAR
(81 TO 99)
?
82

++++++++++++++++++++++++++++++++++++
```

Rem: The remaining files are updated.

Rem: This selection is used for correcting a vehicle file which was updated with a status file containing an error. The status file must first be corrected using module 8.

INSERT DISC CONTAINING
STATUS FILE

THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++

DO YOU KNOW THE STATUS
FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
AS8212

++++++++++++++++++++++++++++++++++++

THE STATUS FILE JUST READ IS:

NAME : AS8212
FIRST DATE (YYMMDD) : 821201
NO. VEHICLES ON FILE : 11

IS THIS THE CORRECT STATUS
FILE (Y/N)
?
Y

++++++++++++++++++++++++++++++++++++

CHECK STATUS FILE
PLEASE WAIT

++++++++++++++++++++++++++++++++++++

ENTER THE VEHICLE NUMBER
FOR WHICH ERROR WAS MADE
?
3101

++++++++++++++++++++++++++++++++++++

Rem: This checks that the status and cost data are complete.

INSERT DISC CONTAINING
VEHICLE FILES

THEN PRESS 'E/L' TO CONTINUE
?

```
++++++++++++++++++++++++++++++++++

DO YOU KNOW THE VEHICLE FILE NAME (Y/N)
?
N

++++++++++++++++++++++++++++++++++

DO YOU KNOW THE VEHICLE MASTER FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
MV1

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

   YOU MAY:

1) CREATE A VEHICLE FILE AND INPUT THE BASIC DATA

2) UPDATE THE BASIC DATA

3) READ IN THE STATUS FILE AND UPDATE THE VEHICLE FILES

4) CORRECT A VEHICLE FILE

5) CANCEL A VEHICLE FILE

6) END

      WHICH (1,2,3,4,5 OR 6)?
5

++++++++++++++++++++++++++++++++++

ARE YOU SURE
A VEHICLE FILE IS ONLY CANCELLED WHEN IT IS
NO LONGER LISTED IN THE CURRENT STATUS FILE
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

ENTER VEHICLE NUMBER
?
3401

++++++++++++++++++++++++++++++++++
```

Rem: This illustrates how a vehicle file can also be accessed via the master file.

Rem: The master file is read and the vehicle file name determined. The vehicle file is then read, corrected and written.

Rem: This is used for cancelling a vehicle file from the master file. This procedure is automatic when a vehicle file is complete i.e. after 60 months. The vehicle file is not erased and can still be used in the other modules but it must then be accessed by its file name and not by the master file.

```
-----------------------------------

     INSERT DISC CONTAINING
        VEHICLE FILES

-----------------------------------


THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

DO YOU KNOW THE VEHICLE MASTER FILE NAME
(Y/N)
?
Y
ENTER FILE NAME
?
MV2
```

Rem: The master file is read, the vehicle removed, and then written.

5.4 Module 5

```
+++++++++++++++++++++++++++++++++++++++

-----------------------------------------

        VEHICLE MANAGEMENT SYSTEM

     MODULE 5 : VEHICLE PERFORMANCE

-----------------------------------------

PRESS 'END LINE' TO CONTINUE
?

+++++++++++++++++++++++++++++++++++++++

-----------------------------------------

        INSERT DISC CONTAINING
         BINARY PROGRAM GDUMP

-----------------------------------------

THEN PRESS 'E/L' TO CONTINUE
?

+++++++++++++++++++++++++++++++++++++++

-----------------------------------------

        INSERT DISC CONTAINING
           THE VEHICLE FILE

-----------------------------------------

THEN PRESS 'E/L' TO CONTINUE
?
```

Rem: This program dumps a graphics display to the printer.

```
++++++++++++++++++++++++++++++++++

WHAT IS THE VEHICLE NUMBER
?
3101

++++++++++++++++++++++++++++++++++

DO YOU KNOW THE VEHICLE FILE NAME (Y/N)
?
Y
ENTER FILE NAME
?
V11

<<<

**********************************

VEHICLE 3101

**********************************

DATA IS AVAILABLE FOR :
 32 MONTHS

FIRST MONTH :JUN 1980

LAST MONTH :JAN 1983

>>>


++++++++++++++++++++++++++++++++++

           BASIC DATA
           ----------
PURCHASE DATE: BODY  780708
               CHASSIS  800101
PURCHASE PRICE: BODY  30000
                CHASSIS  40000
VEHICLE: MAKE BMW
         MODEL 528I
REGISTRATION NUMBER EMD123T
ENGINE NUMBER -1
FLEET NUMBER  31
CURRENT LOCATION JHB3

PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

           MAIN MENU
           ---------

   CHOOSE :

1) COST DATA
```

Rem: The vehicle file is read.
Rem: This is the only section in the module which is printed directly.

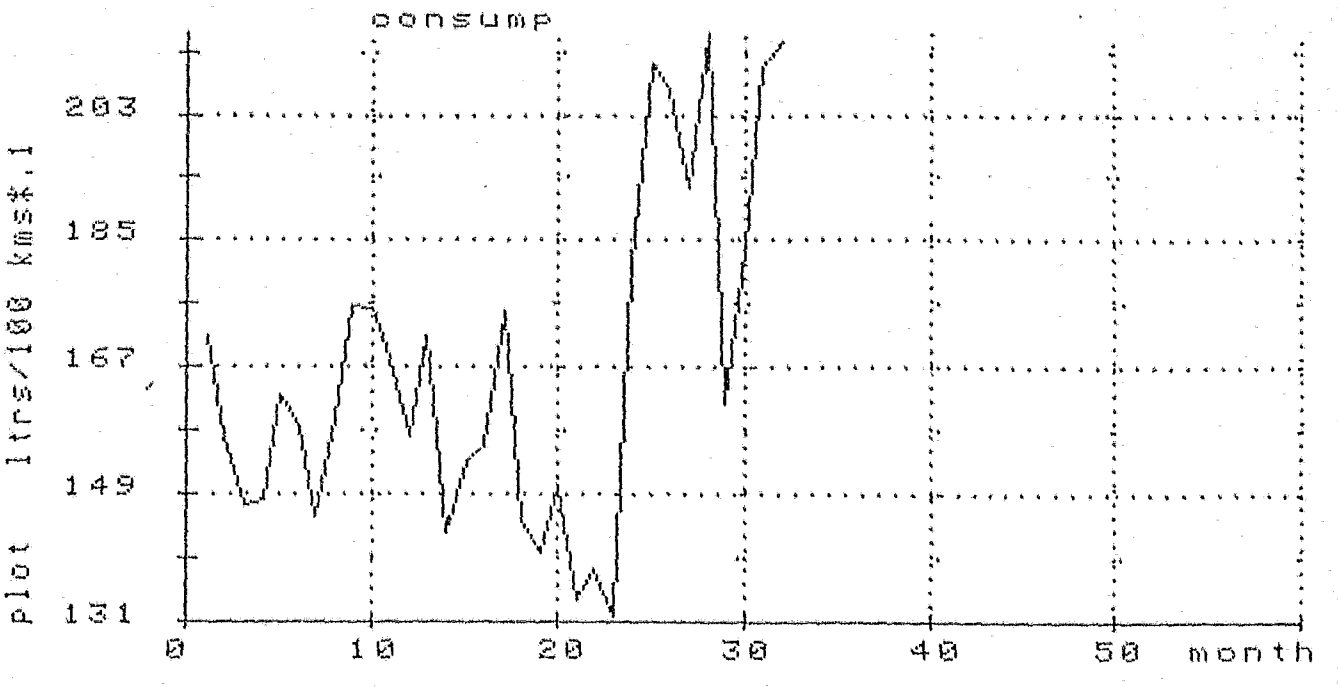
```
2) FUEL AND DISTANCES
3) STATUS DATA
4) END VEH/5

   WHICH (1,2,3 OR 4)
?
1

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) COST TREND BY CODE
2) TOTAL COST TREND
3) MAIN MENU


   WHICH (1,2 OR 3)
?
1

++++++++++++++++++++++++++++++++++

WHICH CODE
?
15
ARE COSTS TO BE ADJUSTED
FOR INFLATION (Y/N)
?
Y
ENTER MONTHLY INFLATION RATE (%)
?
1.2

++++++++++++++++++++++++++++++++++


TOTAL COSTS FOR CODE  15
   4821.95


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT
?

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) TABLE OF DATA
2) PLOT OF DATA
3) PLOT OF CUSUM
4) PLOT OF 3 MONTH MOVING AVG.
5) NONE
```

Rem: For any item to be examined this is always the final menu.

```
   WHICH (1,2,3,4 OR 5)
?
1

++++++++++++++++++++++++++++++++++

++++++++++++++++++++++++++++++++++

    month      code :  15 (rand)
----------------------------------

      1          111.63
      2          0
      3          0
      4          217.71
      5          0
      6          0
      7          0
      8          161.11

PRESS 'END LINE' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

    month      code :  15 (rand)
----------------------------------

      9          116.96
      10         129.36
      11         212.23
      12         0
      13         155.67
      14         232.06
      15         398.39
      16         101.91

PRESS 'END LINE' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

    month      code :  15 (rand)
----------------------------------

      17         0
      18         0
      19         0
      20         0
      21         29.93
      22         0
      23         116.06
      24         232.13

PRESS 'END LINE' TO CONTINUE
?
```

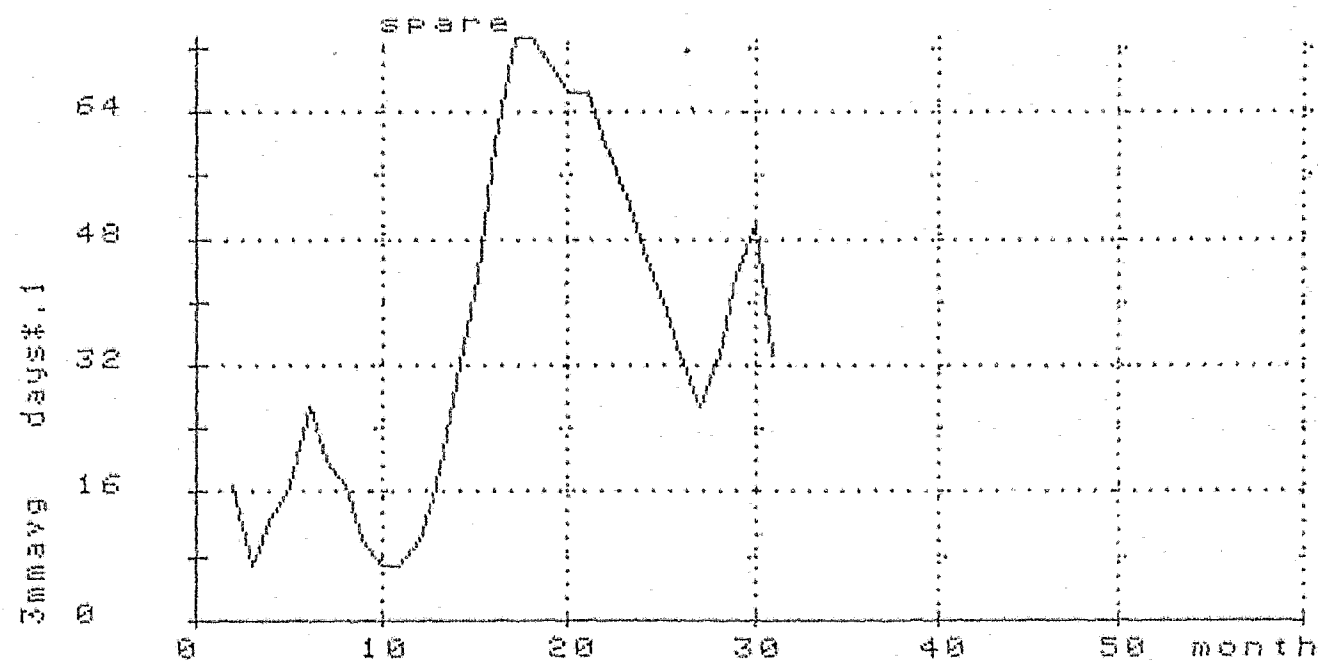
```
++++++++++++++++++++++++++++++++++

    month      code :  15 (rand)
----------------------------------

      25          353.3
      26          309.91
      27          223.97
      28          360.92
      29          306.78
      30          331.82
      31          299.96
      32          420.15

PRESS 'END LINE' TO CONTINUE
OR 'P' FOR PRINTOUT
?


++++++++++++++++++++++++++++++++++

   CHOOSE :

1) COST TREND BY CODE
2) TOTAL COST TREND
3) MAIN MENU


   WHICH (1,2 OR 3)
?
3

++++++++++++++++++++++++++++++++++

            MAIN MENU
          ------------

   CHOOSE :

1) COST DATA
2) FUEL AND DISTANCES
3) STATUS DATA
4) END VEH/5


   WHICH (1,2,3 OR 4)
?
2

++++++++++++++++++++++++++++++++++

TOTAL FUEL USED TO DATE
   8791 LITRES

TOTAL DISTANCE TRAVELLED TO DATE
   52839 KMS
```

```
PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT
?

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) FUEL USED
2) DISTANCE TRAVELLED
3) CONSUMPTION
4) MAIN MENU

   WHICH (1,2,3 OR 4)
?
3

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) TABLE OF DATA
2) PLOT OF DATA
3) PLOT OF CUSUM
4) PLOT OF 3 MONTH MOVING AVG.
5) NONE

   WHICH (1,2,3,4 OR 5)
?
2

++++++++++++++++++++++++++++++++++
```



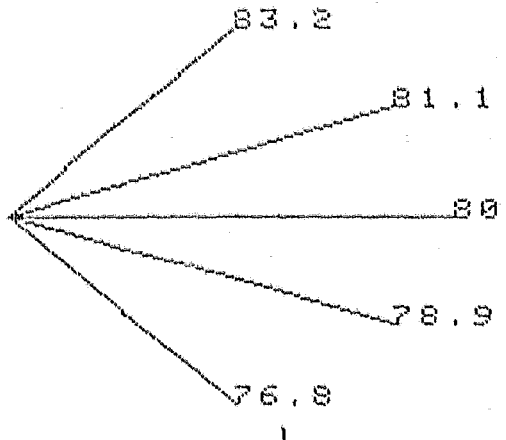
```
++++++++++++++++++++++++++++++++++++

   CHOOSE :

1) FUEL USED
2) DISTANCE TRAVELLED
3) CONSUMPTION
4) MAIN MENU


   WHICH (1,2,3 OR 4)
?
4

++++++++++++++++++++++++++++++++++++

            MAIN MENU
            ---------

   CHOOSE :

1) COST DATA
2) FUEL AND DISTANCES
3) STATUS DATA
4) END VEH/5


   WHICH (1,2,3 OR 4)
?
3

++++++++++++++++++++++++++++++++++++

   CHOOSE :

1) WORKING
2) SPARE
3) SERVICE
4) BREAKDOWN
5) REPAIR
6) RATIOS
7) MAIN MENU


   WHICH (1,2,3,4,5,6 OR 7)
?
2

++++++++++++++++++++++++++++++++++++

   CHOOSE :

1) TABLE OF DATA
2) PLOT OF DATA
3) PLOT OF CUSUM
4) PLOT OF 3 MONTH MOVING AVG.
5) NONE
```

```
   WHICH (1,2,3,4 OR 5)
?
4

++++++++++++++++++++++++++++++++++++
```



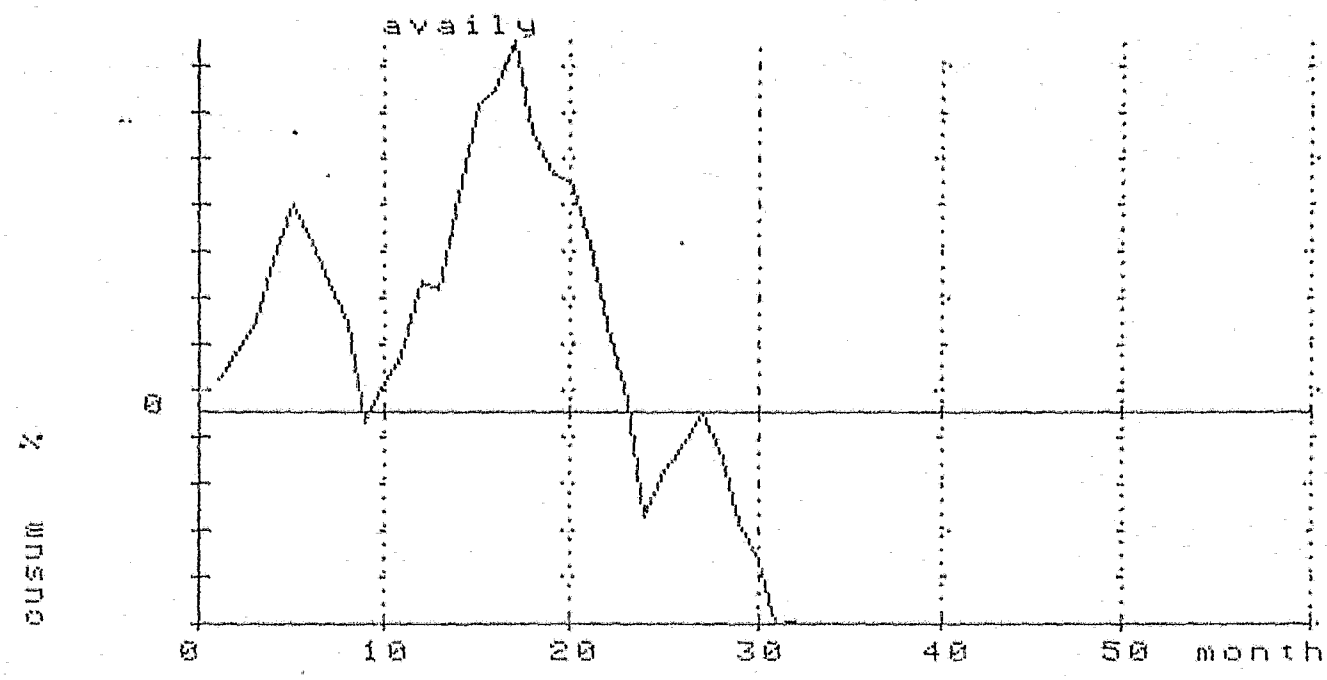

```
++++++++++++++++++++++++++++++++++++

   CHOOSE :

1) WORKING
2) SPARE
3) SERVICE
4) BREAKDOWN
5) REPAIR
6) RATIOS
7) MAIN MENU


   WHICH (1,2,3,4,5,6 OR 7)
?
6

++++++++++++++++++++++++++++++++++++

   CHOOSE :

1) AVAILABILITY
2) FIELD UTILIZATION
3) FREQ. OF FAILURE
4) MAINTENANCE RATIO
5) MEAN TIME TO REPAIR
6) AVERAGE REPAIR TIME
```

```
7) MAIN MENU

   WHICH (1,2,3,4,5,6 OR 7)
?
1

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) TABLE OF DATA
2) PLOT OF DATA
3) PLOT OF CUSUM
4) PLOT OF 3 MONTH MOVING AVG.
5) NONE

   WHICH (1,2,3,4 OR 5)
?
3

++++++++++++++++++++++++++++++++++

WHAT IS THE REFERENCE VALUE

(THE AVERAGE VALUE IS :
 78.6 )
?
80

++++++++++++++++++++++++++++++++++

          PRESS 'E/L' TO CONTINUE      ?
```



Rem: This scale is not included in any printout.

```
++++++++++++++++++++++++++++++++++
```




```
VALUE =  BO  +  3.931 * TAN(A)
   WHERE A = ANGLE IN DEGREES



++++++++++++++++++++++++++++++++++

   CHOOSE :

1) AVAILABILITY
2) FIELD UTILIZATION
3) FREQ. OF FAILURE
4) MAINTENANCE RATIO
5) MEAN TIME TO REPAIR
6) AVERAGE REPAIR TIME
7) MAIN MENU

   WHICH (1,2,3,4,5,6 OR 7)
?
```

Rem: The monitor and printer use different scaling units. Thus for a cusum plot on the monitor, the previous diagram is used, where the line gradients are 30 and 60 degrees from the horizontal. For a printout, the equation is used with A measured from the horizontal and positive upwards.

```
++++++++++++++++++++++++++++++++++

   CHOOSE :

1) TOTAL VALUES
2) AVERAGE VALUES PER VEHICLE

   WHICH (1 OR 2)
?
```

Rem: This menu which is taken from module 6 is an additional menu allowing total values for the fleet or average values to be used where appropriate.

5.5 Module 7

```
++++++++++++++++++++++++++++++++++++

------------------------------------

VEHICLE MANAGEMENT SYSTEM

MODULE  7 : REPLACEMENT

------------------------------------

PRESS 'END LINE' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++

SELECT :

1) VEHICLE REPLACEMENT
2) FLEET REPLACEMENT

   WHICH (1 OR 2)
?
1

++++++++++++++++++++++++++++++++++++

------------------------------------

      INSERT DISC CONTAINING
       THE VEHICLE FILE

------------------------------------

THEN PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++++++
```

Rem: This menu determines whether a vehicle or fleet file is read.

```
WHAT IS THE VEHICLE NUMBER
?
3101

++++++++++++++++++++++++++++++++++

DO YOU KNOW THE VEHICLE FILE NAME (Y/N) --
?
Y
ENTER FILE NAME
?
V11

++++++++++++++++++++++++++++++++++

YOU MAY EXAMINE FOR REPLACEMENT

1) BODY
2) CHASSIS

   WHICH (1 OR 2)
?
1

++++++++++++++++++++++++++++++++++

FOR DEFENDER  3101
ENTER DATA AS PROMPTED


PRESS 'E/L' TO CONTINUE
?


++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------

THE OPERATING COST FOR NEXT MONTH CAN BE

1) FORECAST - SECOND ORDER REGRESSION
2) FORECAST - EXPONENTIAL SMOOTHING
3) INPUT BY USER

   WHICH (1,2 OR 3)
?
1

++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------
ENTER ANY CODE NUMBERS TO BE
EXCLUDED FROM COST FORECAST
(ENTER 0 TO END)

CODE :
```

Rem: The vehicle file is read.

Rem: This menu is used only for selecting which purchase date and price to use from the basic data.

```
?
20
CODE :
?
21
CODE :
?
0
++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------
ARE PAST OPERATING COSTS AND
PURCHASE PRICE
TO BE ADJUSTED FOR INFLATION
(Y/N)
?
Y
ENTER MONTHLY INFLATION RATE (%)
?
1.2

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

 CONSTANT= -4.0844
 1 DEGREE COEF= -.4764
 2 DEGREE COEF=  .0284

CORRELATION COEF=  1

STD ERROR OF ESTIMATE=  .453
----------------------------------
NEXT MONTH OPERATING COST :
    1545.71


PRESS 'E/L' TO CONTINUE?

++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------
ENTER SALVAGE VALUES :

PRESENT
?
5000
END OF NEXT MONTH
?
4000

++++++++++++++++++++++++++++++++++

FOR CHALLENGER
```

```
?
20
CODE :
?
21
CODE :
?
0

++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------
ARE PAST OPERATING COSTS AND
PURCHASE PRICE
TO BE ADJUSTED FOR INFLATION
(Y/N)
?
Y
ENTER MONTHLY INFLATION RATE (%)
?
1.2

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

++++++++++++++++++++++++++++++++++

 CONSTANT= -4.0844
 1 DEGREE COEF= -.4764
 2 DEGREE COEF=  .0284

CORRELATION COEF=  1

STD ERROR OF ESTIMATE=  .453
----------------------------------
NEXT MONTH OPERATING COST :
    1545.71


PRESS 'E/L' TO CONTINUE?

++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------
ENTER SALVAGE VALUES :

PRESENT
?
5000
END OF NEXT MONTH
?
4000

++++++++++++++++++++++++++++++++++

FOR CHALLENGER
```

```
ENTER DATA AS PROMPTED

PRESS 'E/L' TO CONTINUE
?

++++++++++++++++++++++++++++++++

CHALLENGER
--------------------------------
ENTER PURCHASE PRICE
?
50000

++++++++++++++++++++++++++++++++

CHALLENGER
--------------------------------
OPERATING COSTS CAN BE :

1) ASSUMED TO HAVE A CONSTANT INFERIORITY GRADIENT

2) TAKEN FROM COSTS FOR DEFENDER

3) SPECIFIED BY THE USER

   WHICH (1,2 OR 3)
?
1

++++++++++++++++++++++++++++++++

CHALLENGER
--------------------------------
ENTER OPERATING COST FOR NEXT MONTH
?
400

++++++++++++++++++++++++++++++++

CHALLENGER
--------------------------------
ENTER SALVAGE VALUES

END OF YEAR 1
?
10000
END OF YEAR 2
?
5000
END OF YEAR 3
?
0

++++++++++++++++++++++++++++++++

ENTER THE YEARLY TEST RATE (%)
?
15
```

```
++++++++++++++++++++++++++++++++++

        ++++DEFENDER++++
NEXT MONTH OPERATING COST= 1545.71
SALVAGE VALUE : PRESENT= 5000
                NEXT MONTH= 4000
        ++++CHALLENGER++++
PURCHASE PRICE= 50000
OPERATING COSTS  400  420.8  441.7  462.5 ......
SALVAGE VALUE AFTER : 1 YEAR= 10000   2 YEARS = 5000
     3 YEARS= 0   4 YEARS= 0   5 YEARS= 0

YEARLY TEST RATE= 15 %

PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

CHALLENGER
----------------------------------

ECONOMIC LIFE (MONTHS)  82

MINIMUM UNIFORM EQUIVALENT  2079.3


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

STRATEGY 1 : RETAIN DEFENDER FOR 1 MORE MONTH
   PRESENT VALUE =  161866

STRATEGY 2 : REPLACE DEFENDER IMMEDIATELY
   PRESENT VALUE =  161344


THUS THE DEFENDER CAN BE
CONSIDERED FOR REPLACEMENT


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

YOU MAY

1) EXAMINE UNIFORM EQUIVALENT FOR CHALLENGER
2) CHANGE REPLACEMENT DATA
```

```
3) END MOD/7

   WHICH (1,2 OR 3)
?
2

++++++++++++++++++++++++++++++++++

   YOU MAY CHANGE :

1) DEFENDER : OPERATING COST
2)            SALVAGE VALUES
3) CHALLENGER : PURCHASE PRICE
4)              OPERATING COST
5)              SALVAGE VALUES
6) TEST RATE

   WHICH (1,2,3,4,5 OR 6)
?
1

++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------

THE OPERATING COST FOR NEXT MONTH CAN BE

1) FORECAST - SECOND ORDER REGRESSION
2) FORECAST - EXPONENTIAL SMOOTHING
3) INPUT BY USER

   WHICH (1,2 OR 3)
?
2

++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------
ENTER ANY CODE NUMBERS TO BE
EXCLUDED FROM COST FORECAST
(ENTER 0 TO END)

CODE :
?
20
CODE :
?
21
CODE :
?
0

++++++++++++++++++++++++++++++++++

DEFENDER  3101
----------------------------------
ARE PAST OPERATING COSTS
```

```
TO BE ADJUSTED FOR INFLATION
(Y/N)
?
Y
ENTER MONTHLY INFLATION RATE (%)
?
1.2

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

ENTER SMOOTHING CONSTANT
?
.1
ENTER TREND SMOOTHING CONSTANT
?
.2

++++++++++++++++++++++++++++++++++

AVERAGE ERROR= -62.2

ERROR STD DEVIATION=  280.1
----------------------------------
NEXT MONTH OPERATING COST IS :
     1573.9


PRESS 'E/L' TO CONTINUE
?


++++++++++++++++++++++++++++++++++

       ++++DEFENDER++++
NEXT MONTH OPERATING COST= 1573.9
SALVAGE VALUE : PRESENT= 5000
                NEXT MONTH= 4000
       ++++CHALLENGER++++
PURCHASE PRICE= 50000
OPERATING COSTS  400  421.3  442.7  464 ......
SALVAGE VALUE AFTER : 1 YEAR= 10000   2 YEARS = 5000
     3 YEARS= 0   4 YEARS= 0   5 YEARS= 0

YEARLY TEST RATE= 15 %

PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++
```

```
CHALLENGER
----------------------------------

ECONOMIC LIFE (MONTHS)  80

MINIMUM UNIFORM EQUIVALENT  2096.3


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?

++++++++++++++++++++++++++++++++++

STRATEGY 1 : RETAIN DEFENDER FOR 1 MORE MONTH
   PRESENT VALUE =  163237

STRATEGY 2 : REPLACE DEFENDER IMMEDIATELY
   PRESENT VALUE =  162704


THUS THE DEFENDER CAN BE
CONSIDERED FOR REPLACEMENT


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

YOU MAY

1) EXAMINE UNIFORM EQUIVALENT FOR CHALLENGER
2) CHANGE REPLACEMENT DATA
3) END MOD/7

   WHICH (1,2 OR 3)
?
2

++++++++++++++++++++++++++++++++++

   YOU MAY CHANGE :

1) DEFENDER : OPERATING COST
2)            SALVAGE VALUES
3) CHALLENGER : PURCHASE PRICE
4)              OPERATING COST
5)              SALVAGE VALUES
6) TEST RATE

   WHICH (1,2,3,4,5 OR 6)
?
4

++++++++++++++++++++++++++++++++++

CHALLENGER
----------------------------------
```

```
OPERATING COSTS CAN BE :

1) ASSUMED TO HAVE A CONSTANT INFERIORITY GRADIENT

2) TAKEN FROM COSTS FOR DEFENDER

3) SPECIFIED BY THE USER

   WHICH (1,2 OR 3)
?
2

++++++++++++++++++++++++++++++++++

CHALLENGER
----------------------------------
ENTER ANY CODE NUMBERS TO BE
EXCLUDED FROM COST FORECAST
(ENTER 0 TO END)

CODE :
?
20
CODE :
?
21
CODE :
?
0

++++++++++++++++++++++++++++++++++

CHALLENGER
----------------------------------
ARE PAST OPERATING COSTS AND
PURCHASE PRICE FOR THE DEFENDER
TO BE ADJUSTED FOR INFLATION
(Y/N)
?
Y
ENTER MONTHLY INFLATION RATE (%)
?
1.2

++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

 CONSTANT= -4.0844
 1 DEGREE COEF= -.4764
 2 DEGREE COEF=  .0284

CORRELATION COEF=  1

STD ERROR OF ESTIMATE=  .453


PRESS 'E/L' TO CONTINUE?
```

```
++++++++++++++++++++++++++++++++++++

        ++++DEFENDER++++
NEXT MONTH OPERATING COST= 1573.9
SALVAGE VALUE : PRESENT= 5000
                NEXT MONTH= 4000
        ++++CHALLENGER++++
PURCHASE PRICE= 50000
CUM OPERATING COSTS = PRICE/100*(K0+K1*X+K2*X^2)
    WHERE PRICE = 50000  AND  K0=-4.084   K1=-.4764   K2= .0284
SALVAGE VALUE AFTER : 1 YEAR= 10000   2 YEARS = 5000
     3 YEARS= 0   4 YEARS= 0   5 YEARS= 0

YEARLY TEST RATE= 15 %

PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++++

CHALLENGER
------------------------------------

ECONOMIC LIFE (MONTHS)  68

MINIMUM UNIFORM EQUIVALENT  1689.3


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++++

STRATEGY 1 : RETAIN DEFENDER FOR 1 MORE MONTH
   PRESENT VALUE =  131000

STRATEGY 2 : REPLACE DEFENDER IMMEDIATELY
   PRESENT VALUE =  130064


THUS THE DEFENDER CAN BE
CONSIDERED FOR REPLACEMENT


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++++

YOU MAY
```

```
1) EXAMINE UNIFORM EQUIVALENT FOR CHALLENGER
2) CHANGE REPLACEMENT DATA
3) END MOD/7

   WHICH (1,2 OR 3)
?
2

++++++++++++++++++++++++++++++++++

   YOU MAY CHANGE :

1) DEFENDER : OPERATING COST
2)            SALVAGE VALUES
3) CHALLENGER : PURCHASE PRICE
4)              OPERATING COST
5)              SALVAGE VALUES
6) TEST RATE

   WHICH (1,2,3,4,5 OR 6)
?
4

++++++++++++++++++++++++++++++++++

CHALLENGER
----------

OPERATING COSTS CAN BE :

1) ASSUMED TO HAVE A CONSTANT INFERIORITY GRADIENT

2) TAKEN FROM COSTS FOR DEFENDER

3) SPECIFIED BY THE USER

   WHICH (1,2 OR 3)
?
3

++++++++++++++++++++++++++++++++++++

CHALLENGER
----------

(CUMULATIVE COSTS/PRICE)*100=K0+K1*X+K2*X^2
    WHERE X=AGE IN MONTHS

ENTER K0
?
1
ENTER K1
?
.5
ENTER K2
?
.04

++++++++++++++++++++++++++++++++++
```

```
        ++++DEFENDER++++
NEXT MONTH OPERATING COST= 1573.9
SALVAGE VALUE : PRESENT= 5000
                NEXT MONTH= 4000
        ++++CHALLENGER++++
PURCHASE PRICE= 50000
CUM OPERATING COSTS =. PRICE/100*(K0+K1*X+K2*X^2)
    WHERE PRICE = 50000  AND  K0= 1   K1= .5   K2= .04
SALVAGE VALUE AFTER : 1 YEAR= 10000   2 YEARS = 5000
     3 YEARS= 0   4 YEARS= 0   5 YEARS= 0

YEARLY TEST RATE= 15 %

PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

PLEASE WAIT

++++++++++++++++++++++++++++++++++

CHALLENGER
----------------------------------

ECONOMIC LIFE (MONTHS)  56

MINIMUM UNIFORM EQUIVALENT  2488.1


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

STRATEGY 1 : RETAIN DEFENDER FOR 1 MORE MONTH
   PRESENT VALUE =  194194

STRATEGY 2 : REPLACE DEFENDER IMMEDIATELY
   PRESENT VALUE =  194048


THUS THE DEFENDER CAN BE
CONSIDERED FOR REPLACEMENT


PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

YOU MAY

1) EXAMINE UNIFORM EQUIVALENT FOR CHALLENGER
2) CHANGE REPLACEMENT DATA
3) END MOD/7

▌
```

```
   WHICH (1,2 OR 3)
?
1

++++++++++++++++++++++++++++++++++

CHALLENGER
----------------------------------
MONTH   UNIFORM EQUIV
 1          4228.3
 2          4227.5
 3          4226.7
 4          4225.9
 5          4225
 6          4224.2
 7          4223.4
 8          4222.6
 9          4221.8

PRESS 'E/L' TO CONTINUE?
```

Rem: The intermediate months are not shown here.

```
++++++++++++++++++++++++++++++++++

CHALLENGER
----------------------------------
MONTH   UNIFORM EQUIV
 55         2488.3
 56         2488.1
 57         2488.4

PRESS 'E/L' TO CONTINUE
OR 'P' FOR PRINTOUT?


++++++++++++++++++++++++++++++++++

YOU MAY

1) EXAMINE UNIFORM EQUIVALENT FOR CHALLENGER
2) CHANGE REPLACEMENT DATA
3) END MOD/7

   WHICH (1,2 OR 3)
?
```

5.6 Module 8

```
++++++++++++++++++++++++++++++++++

----------------------------------

   VEHICLE MANAGEMENT SYSTEM

    MODULE 8 : STATUS DATA

----------------------------------

PRESS 'END LINE' TO CONTINUE
?

++++++++++++++++++++++++++++++++++

ENTER REQUIRED MONTH AND YEAR
(YYMM)
?
8301

++++++++++++++++++++++++++++++++++


----------------------------------

     INSERT DISC CONTAINING
     THE STATUS FILE --8301

----------------------------------


THEN PRESS 'E/L' TO CONTINUE
?


++++++++++++++++++++++++++++++++++

DO YOU KNOW THE STATUS FILE NAME
(Y/N)
?
Y
ENTER FILE NAME
?
QW8301

++++++++++++++++++++++++++++++++++
```

Rem: The status file is read.

```
  YOU MAY :

1) EXAMINE THE STATUS FILE
2) EXAMINE AND CORRECT THE STATUS FILE


   WHICH (1 OR 2)
?
2

++++++++++++++++++++++++++++++++++

ENTER FULL FILE NAME FOR STATUS FILE
?
TESTING

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) STATUS DATA BY DATE
2) STATUS DATA BY VEHICLE
3) COST DATA BY VEHICLE
4) END


   WHICH (1,2,3 OR 4)
?
1

++++++++++++++++++++++++++++++++++

ENTER REQUIRED DATE
(YYMMDD)
?
830114

CONFIRM THIS DAY IS A FRIDAY
(Y/N)
?
Y

++++++++++++++++++++++++++++++++++

DATE : 14 JAN 1983
----------------------------------
 VEH NO          STATUS

 3101          1  WORKING
 3102          1  WORKING
 3103          2  SPARE
 3201          1  WORKING
 3202          1  WORKING
 3203          3  SERVICE
 3204         95  DOUBLE SHIFT

NOTE VEH NO FOR ANY CORRECTIONS
PRESS 'E/L' TO CONTINUE?
```

Rem: This is used as a password. Selection 1 above does not require this entry.

```
++++++++++++++++++++++++++++++++++

DATE : 14 JAN 1983
----------------------------------
 VEH NO            STATUS

 3205           90 B/D DURING SH
 3301           1  WORKING
 3302           1  WORKING

PRESS 'C' TO MAKE CORRECTIONS OR
PRESS 'P' FOR PRINTOUT OR
PRESS 'E/L' TO CONTINUE?

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) STATUS DATA BY DATE
2) STATUS DATA BY VEHICLE
3) COST DATA BY VEHICLE
4) END

   WHICH (1,2,3 OR 4)
?
2

++++++++++++++++++++++++++++++++++

ENTER VEHICLE NUMBER
?
3101

++++++++++++++++++++++++++++++++++

VEHICLE :  3101
----------------------------------
 DATE              STATUS

 830101         98 WEEKEND/HOL
 830102         98 WEEKEND/HOL
 830103         3  SERVICE
 830104         3  SERVICE
 830105         3  SERVICE
 830106         1  WORKING
 830107         95 DOUBLE SHIFT

NOTE DATE FOR ANY CORRECTIONS
PRESS 'E/L' TO CONTINUE?

++++++++++++++++++++++++++++++++++

VEHICLE :  3101
----------------------------------
 DATE              STATUS
```

```
 830108          1  WORKING
 830109         98 WEEKEND/HOL
 830110          1  WORKING
 830111          1  WORKING
 830112         95 DOUBLE SHIFT
 830113          1  WORKING
 830114          1  WORKING

NOTE DATE FOR ANY CORRECTIONS
PRESS 'E/L' TO CONTINUE?


++++++++++++++++++++++++++++++++++

VEHICLE :  3101
----------------------------------
 DATE              STATUS

 830115          1  WORKING
 830116         98 WEEKEND/HOL
 830117          1  WORKING
 830118         91 B/D BEFORE SH
 830119         95 DOUBLE SHIFT
 830120          1  WORKING
 830121          1  WORKING

NOTE DATE FOR ANY CORRECTIONS
PRESS 'E/L' TO CONTINUE?
```

```
++++++++++++++++++++++++++++++++++

VEHICLE :  3101
----------------------------------
 DATE              STATUS

 830122          1  WORKING
 830123         98 WEEKEND/HOL
 830124         15 REPAIR
 830125         15 REPAIR
 830126          1  WORKING
 830127          1  WORKING
 830128         95 DOUBLE SHIFT

NOTE DATE FOR ANY CORRECTIONS
PRESS 'E/L' TO CONTINUE?


++++++++++++++++++++++++++++++++++

VEHICLE :  3101
----------------------------------
 DATE              STATUS

 830129         96 TREBLE SHIFT
 830130         98 WEEKEND/HOL
 830131          1  WORKING

PRESS 'C' TO MAKE CORRECTIONS OR
PRESS 'P' FOR PRINTOUT OR
```

```
PRESS 'E/L' TO CONTINUE?

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) STATUS DATA BY DATE
2) STATUS DATA BY VEHICLE
3) COST DATA BY VEHICLE
4) END

   WHICH (1,2,3 OR 4)
?
3

++++++++++++++++++++++++++++++++++

ENTER VEHICLE NUMBER
?
3101

++++++++++++++++++++++++++++++++++

VEHICLE :  3101
----------------------------------
 CODE                COST/VALUE

  15                   420.15
  33                   222
 FUEL                  368
 KMS                   1723

PRESS 'C' TO MAKE CORRECTIONS OR
PRESS 'E/L' TO CONTINUE?

++++++++++++++++++++++++++++++++++

   CHOOSE :

1) STATUS DATA BY DATE
2) STATUS DATA BY VEHICLE
3) COST DATA BY VEHICLE
4) END

   WHICH (1,2,3 OR 4)
?
4

++++++++++++++++++++++++++++++++++


++++++++++++++++++++++++++++++++++

END
```

Rem: This selection is important since if corrections have been made the status file is now written.

6. CONCLUSIONS

It is apparent from the work done that a micro-computer based system is adequate for a small to medium sized fleet. Although the system has not yet been used in the real environment of a cleansing department, it does perform satisfactorily under testing using synthetic data.

Existing systems, which require large computing facilities, can store and manipulate large amounts of detailed information. However, this is not essential for a smaller fleet and the use of a micro-computer has the advantage of a low purchase and operating cost. Only a single operator is needed for maintaining the system.

The system, which is written specifically for cleansing vehicles, could be modified for use with other types. For the same output information, the following changes may be required:

a) Input status data based on individual jobs as opposed to daily shifts.

b) Costs incurred also based on individual jobs instead of a monthly figure.

c) The inclusion of taxation in the replacement decision.

Appendix 1

Fleetmaster Reports

This Appendix gives examples of the output reports from the Fleetmaster system (?). The first report is output from the fuel module, the second from the repair module and the third from the general module.

RUN DATE: FEB 16, 1981
PERIOD ENDING: APR 30, 1980

LGORU / ICL FLEETMASTER

PROGRAM NUMBER: EMFP02
REPORT NUMBER: EMFR02

*** PUMP RECONCILIATION REPORT ***

PUMP NO.	PUMP UNIT	PUMP READING ON	PUMP READING OFF	PUMP READING PERIOD	GALLONS DISPENSED	GALLONS REPORTED ON FUEL TICKETS	GALLONS DIFFERENCE	FUEL TYPE
001	G	529324.0	539846.0	01/04/80 - 30/04/80	10522.0	2439.0	8083.0-	DERV
002	G	342932.0	342932.0	01/04/80 - 30/04/80	0.0	NONE REPORTED	0.0	DERV
003	G	380193.0	385694.0	01/04/80 - 30/04/80	5504.0	775.0	4729.0-	PETROL 3ST
004	G	105042.0	105042.0	01/04/80 - 30/04/80	0.0	NONE REPORTED	0.0	PETROL 3ST
005	L	230967.0	240407.0	01/04/80 - 30/04/80	2076.8	204.0	1872.8-	AUTO LPG
				** TOTAL **	18102.8	3418.0	14684.8-	

*** PUMP HEADINGS ARE REPORTED IN GALLONS OR LITRES AS APPROPRIATE.
*** ALL ANALYSES ARE REPORTED IN GALLONS.

RUN DATE: FEB 16, 1981
PERIOD ENDING: APR 30, 1980

LGORU / ICL FLEETMASTER

PROGRAM NUMBER: EMRP11
REPORT NUMBER: EMRR11

*** SHOP PERFORMANCE REPORT ***

SHOP NUMBER - 1

ITEM	THIS PERIOD	LAST PERIOD	THIS YEAR TO DATE	LAST YEAR TO DATE
NO. OF EMPLOYEES	3	3	3.0	0.0
LABOUR HOURS	312.0	170.1	482.1	0.0
EXPENDITURES (£)				
LABOUR	£2808.00	£1369.38	£4177.38	£0.00
PARTS	£1160.09	£392.49	£1552.58	£0.00
COMMERCIAL COSTS	£378.21	£382.09	£760.30	£0.00
TOTAL	£4346.30	£2143.96	£6490.26	£0.00
WORK PERFORMED				
REPAIR ORDERS	40	35	75	0
PM INSPECTIONS	9	0	9	0
ROAD CALLS	2	2	4	0
SCHEDULED REPAIRS	16	5	21	0
UNSCHEDULED REPAIRS	21	30	51	0
EMERGENCY REPAIRS	3	0	3	0
PERFORMANCE STATISTICS				
AVE. LAB. HR. / RO	7.8	4.9	6.4	0.0
AVE. £ / RO	£108.66	£61.26	£86.54	£0.00
% COMPLETED IN 24 HRS.	47	60	53	0
% COMPLETED 24-48 HRS.	10	16	12	0

RUN DATE: FEB 17, 1981
PERIOD ENDING: APR 30, 1980

LGORU / ICL FLEETMASTER

PROGRAM NUMBER: EMGP03
REPORT NUMBER: EMGR03

*** EQUIPMENT / ORGANIZATION PERFORMANCE REPORT ***

CLASS CODE - 3T - TIPPER TRUCK

ASSIGNED ORGANIZATION - 000030 - HGH SEC Hy DIvN

EQUIPMENT NUMBER/ DESCRIPTION	MILE/ HOUR CODE	MILES/ HOURS USED	PERCENT DOWN TIME	TOTAL REPAIR COST	TOTAL REPAIR ORDERS	MPG OR HPG	CPM/CPH OPER.	CPM/CPH MAINT.	CPM/CPH TOTAL	TOTAL OPER. + MAINT.
		THIS PERIOD / (LIFE TO DATE)								
D00045 OWN TIPPER LORRY 3T	M	417 (828)	24.3 (N/A)	193 (193)	1 (1)	14.9 (14.7)	0.07 (0.07)	0.46 (0.23)	0.53 (0.30)	222 (251)
D00046 OWN TIPPER LORRY 3T	M	517 (1044)	2.0 (N/A)	39 (39)	1 (1)	13.6 (13.7)	0.09 (0.08)	0.08 (0.04)	0.17 (0.12)	83 (123)
D00047 OWN TIPPER LORRY 3T	M	442 (880)	2.0 (N/A)	39 (39)	1 (1)	14.3 (14.1)	0.08 (0.08)	0.09 (0.04)	0.17 (0.12)	76 (108)
D00048 OWN TIPPER LORRY 3T	M	388 (913)	0.0 (N/A)	0 (0)	0 (0)	11.4 (13.4)	0.09 (0.08)	0.00 (0.00)	0.09 (0.08)	35 (70)
** ORGANIZATION - TOTALS		1764 (3665)	N/A (N/A)	271 (271)	3 (3)	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A (N/A)	418 (554)
- AVERAGES		441 (916)	7.1 (N/A)	68 (68)	1 (1)	13.6 (14.0)	0.08 (0.08)	0.16 (0.08)	0.24 (0.16)	105 (139)
**** CLASS - TOTALS		1764 (3665)	N/A (N/A)	271 (271)	3 (3)	N/A (N/A)	N/A (N/A)	N/A (N/A)	N/A (N/A)	418 (554)
- AVERAGES		441 (916)	7.1 (N/A)	48 (68)	1 (1)	13.6 (14.0)	0.08 (0.08)	0.16 (0.08)	0.24 (0.16)	105 (139)

Appendix 2

Replacement Decision

The replacement decision is made by considering two exclusive strategies viz. immediate replacement or replacement in one period. The cash flows for each, assuming that the present challenger is kept for its economic life and that future challengers are the same as the present one, will be:

Year :	0	1	2	3
A Immediate replacement	$-S_{d_0}$	$EA_{min\ c}$	$EA_{min\ c}$	...
B Replace in 1 period	-	$C_{d_1} - S_{d_1}$	$EA_{min\ c}$	...

where S_{d_x} = defender salvage value at period x

C_{d_1} = defender operating cost in period 1

$EA_{min\ c}$ = minimum equivalent annuity for challenger

At cost of capital r, a cash flow x in perpetuity is worth x/r. Thus the flows can be written:

Year :	0	1
A :	$-S_{d_0} + \frac{EA_{min\ c}}{r}$	-
B :	-	$C_{d_1} - S_{d_1} + \frac{EA_{min\ c}}{r}$

The present value for each strategy is therefore:

$$PV_A = -S_{d_0} + \frac{EA_{min\ c}}{r}$$

$$PV_B = \left(C_{d_1} - S_{d_1} + \frac{EA_{min\ c}}{r} \right) * PVF_1$$

where PVF_1 = present value factor at cost of capital for first period

Replacement is indicated if :

$$PV_A < PV_B$$

Appendix 3

Calculations for Module 2

In each case C_x = number of times code x is encounted on the days included in the report.

Weekly report:

a) Total shifts working = $C_1 + C_{90} + 2*C_{95} + 3*C_{96}$

Total shifts spare = C_2

Total shifts in service = C_3

Total shifts in repair = $C_4 + C_5 + C_6 + \ldots + C_{33} + C_{91}$

b) Number of vehicles available = $C_1 + C_2 + C_{90} + C_{95} + C_{96}$

Monthly report:

a) Total days in workshop = $C_3 + C_4 + C_5 + \ldots + C_{33} + C_{91}$

b) Vehicles in workshop: This gives all the vehicles in the workshop on the last day of the report which is not a holiday. This covers the vehicles with status codes 3, 91 and 4 to 33. The 'days in' is calculated by moving back from this date one day at a time until a code 1, 2, 90, 95, 96, 97 or 99 is encounted. Code 98 neither stops the count nor adds a day.

c) Frequency of breakdowns during shift per 100 shifts worked = $$\frac{C_{90} * 100}{C_1 + C_{90} + 2*C_{95} + 3*C_{96}}$$

If the denominator = 0 then the result is set equal to -1.

d) Frequency of breakdowns before leaving the depot per 100 shifts worked = $$\frac{C_{91} * 100}{C_1 + C_{90} + 2*C_{95} + 3*C_{96}}$$

If the denominator = 0 then the result is set equal to -1.

e) Repair length of stay: Each repair stay is a single code or sequence of codes consisting of either 4 to 33 or 91. The codes which terminate a stay are 1, 2, 3, 90, 95, 96 and 97 while 98 and 99 neither terminate nor add to a stay.

Let n = number of repair stays

and L_i = length of stay i

Then total days in repair $R = \sum_{i=1}^{n} L_i$

$$\text{Mean} = \frac{R}{n}$$

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} L_i^2 - \frac{R^2}{n}}{n}}$$

$$\text{f) Availability} = \frac{(\text{work} + \text{spare}) * 100}{\text{work} + \text{spare} + \text{repair} + \text{service}} \%$$

$$\text{Maintenance ratio} = \frac{\text{work}}{\text{repair} + \text{service}}$$

$$\text{Field utilisation} = \frac{\text{work} * 100}{\text{work} + \text{spare} + \text{repair} + \text{service}} \%$$

where work = $C_1 + C_{90} + 2*C_{95} + 3*C_{96}$

spare = C_2

service = C_3

and repair = $C_4 + C_5 + C_6 + \ldots + C_{33} + C_{91}$

g) Days in workshop for code x = C_x for x = 3,4,5, ...,33,91

$$\text{Percentage of workshop days} = \frac{C_x}{\Sigma C_x} * 100$$

Appendix 4

Calculations for Modules 3 and 4

The mean time to repair and average repair time for the month being updated are calculated in modules 3 and 4. The length and number of sequences, representing the time to a repair action, are calculated according to the following rules :

a) Codes 1,2,3,90, 95 and 96 add one day to the length.

b) Codes 4 to 33, 91 and 97 and the last day of the month all terminate a sequence.

c) Code 98 neither ends nor adds to a sequence.

Then if n = the number of time to repair sequences and L_i = length of sequence i

the mean time to repair = $\frac{\sum_{i=1}^{n} L_i}{n}$

For the average repair time :

a) Codes 4 to 33 and 91 add one day to the length.

b) Codes 1,2,3,90,95,96 and 97 and the last day of the month all terminate a sequence.

c) Code 98 neither ends nor adds to a sequence.

Then if n = the number of repair sequences the average repair time is n as above. In both cases if n = 0 then the monthly result is set equal to zero.

The same rules and equations are used in module 4. However, n is then the number of sequences for all vehicles in the fleet and the equation is only applied when all the vehicles have been taken into account. The result thus gives an average figure for a vehicle in the fleet.

Calculations for Modules 5 and 6

a) Status data - These calculations are based on the status data in the vehicle and fleet files. This data is stored on a monthly basis in ten different categories as discussed in module 3 and reproduced here:

Category	Data
1	C_1
2	C_2
3	C_3
4	C_{90}
5	C_{91}
6	C_{95}
7	C_{96}
8	$C_4 + C_5 + \ldots + C_{33}$
9	Mean time to repair
10	Average repair time

where C_x = number of times code x occurs for the month.

Shifts working $W = C_1 + C_{90} + 2*C_{95} + 3*C_{96}$

Shifts spare $Sp = C_2$

Shifts in service $Se = C_3$

Shifts in repair $R = C_4 + C_5 + \ldots + C_{33} + C_{91}$

Number of breakdowns $B = C_{90} + C_{91}$

$$\text{Availability} = \frac{W + Sp}{W + Sp + Se + R} * 100$$

$$\text{Field utilisation} = \frac{W}{W + Sp + Se + R} * 100$$

$$\text{Frequency of failure} = \frac{B}{W} * 100$$

If W = 0 then frequency of failure = B * 100

$$\text{Maintenance ratio} = \frac{W}{R + Se}$$

If R + Se = 0 then maintenance ratio = W

b) Three month moving average and cusum - For any item chosen to be examined a series of monthly values will be obtained. Let these be $x_1, x_2, \ldots, x_n$ where n is the number of months updated.

Then 3 month moving avg. for month i = $\frac{(x_{i-1} + x_i + x_{i+1})}{3}$

for i = 2 to n-1

and cusum for month i : $S_i = S_{i-1} + x_i - k$

for i = 1 to n

where k = reference value

and $S_0 = 0$

Calculations for Module 7

a) Second order regression:

This method is used for both the defender and challenger operating costs. A curve of the form:

$$y = k_0 + k_1 * x + k_2 * x^2$$

is fitted to the defender data:

$$Y_{x-L+N} = \frac{\text{cumulative } C_x * 100 \text{ versus } x}{\text{price}} \quad \text{for } x = L-N+1 \text{ to } L$$

where x = vehicle age in months

C_x = operating cost in period x

L = present vehicle age in months

N = number of months updated i.e. number of months for which data is available

The method of least squares is used to calculate the constants k_0, k_1 and k_2 as follows:

Let error $e_i = Y_i - y_i$

$$= Y_i - k_0 - k_1 * x_i - k_2 * x_i^2$$

The least squares criterion requires that the sum of the square error

$$S = \sum_{i=1}^{N} e_i^2 \quad \text{be a minimum}$$

Thus taking partial derivatives and setting the result equal to zero gives the normal equations:

$$k_0 * N + k_1 \Sigma x_i + k_2 \Sigma x_i^2 = \Sigma Y_i$$

$$k_0 \Sigma x_i + k_1 \Sigma x_i^2 + k_2 \Sigma x_i^3 = \Sigma x_i Y_i$$

$$k_0\Sigma x_i^2 + k_1\Sigma x_i^3 + k_2\Sigma\, x_i^4 = \Sigma x_i^2 Y_i$$

This system of equations is then solved by Gaussian elimination for k_0, k_1 and k_2. (See reference 17 for details.)

The error messages given are defined as follows(18):

$$\text{Standard error of estimate } S = \sqrt{\frac{\Sigma(\,Y_i - y_i\,)^2}{N - n - 1}}$$

where n = order of regression = 2

This can be written as:

$$S = \sqrt{\frac{\Sigma Y_i^2 - k_0\Sigma Y_i - k_1\Sigma x_i Y_i - k_2\Sigma x_i^2 Y_i}{N - 3}}$$

$$\text{Coefficient of correlation } r = \sqrt{\frac{\Sigma(\,y_i - Y\,)^2}{\Sigma(\,Y_i - Y\,)^2}}$$

where Y = the mean of Y_i

This can be written as:

$$r = \sqrt{\frac{k_0\Sigma Y_i + k_1\Sigma\, x_i Y_i + k_2\Sigma x_i^2 Y_i - (\Sigma Y_i)^2/N}{Y_i^2 - (\Sigma Y_i)^2/N}}$$

The next month operating cost for the defender is given by:

$$((k_0 + k_1*(L+1) + k_2*(L+1)^2) - (k_0 + k_1*L + k_2*L^2)) * \frac{\text{price}}{100}$$

Future operating costs for the challenger are given by:

$$((k_0 + k_1 * x + k_2 * x^2) - (k_0 + k_1 * (x-1) + k_2 * (x-1)^2) * \frac{price}{100}$$

for x = 1, 2, 3, ...

In this case price is the purchase price of the challenger.

b) Exponential smoothing:

A trend model is used to forecast the next month operating cost for the defender as follows(19):

$$S_t = a*D_t + (1 - a)*(S_{t-1} + T_{t-1}) \text{ for } t = 1 \text{ to } N$$

where D_t = defender operating cost for period t

S_t = smoothed average for period t ($S_0=D_1$)

a = smoothing constant between 0 and 1

N = number of months upated

and T_t = smoothed trend for period t ($T_0=0$)

$$= b*(S_t - S_{t-1}) + (1 - b)*T_{t-1}$$

where b = trend smoothing constant between 0 and 1

The forecast for period N+1 (i.e. the next month operating cost) is given by:

$$S_N + T_N$$

The error messages are defined as follows:

$$\text{Average error} = \frac{\sum_{t=2}^{N} \text{Forecast} - \text{Actual}}{N-1}$$

$$= \frac{\sum_{t=2}^{N} S_{t-1} + T_{t-1} - D_t}{N-1}$$

$$\text{Error standard deviation} = \sqrt{\frac{\sum_{t=2}^{N} (S_{t-1} + T_{t-1} - D_t)^2}{N-1}}$$

c) Reference 12 gives values for the constants k_0, k_1 and k_2 for the second order equation :

$$y = k_0 + k_1 * x + k_2 * x^2$$

for x in months as follows:

	k_0	k_1	k_2	Correlation coeff
Compactor	-8.1	.777	.068	.733
Tipper	8.4	.244	.0567	.703
All cleansing	1.51	.825	.0516	.693

d) The challenger's economic life and corresponding minimum equivalent annuity are calculated as follows:

Let P = purchase price

C_i = operating cost for month i

S_i = salvage value at end of month i

r = monthly discounting test rate

Then equivalent annuity for i periods is given by:

$$\left(P + \sum_{j=i}^{i} C_j * (1+r)^{-j} - S_i * (1+r)^{-i} \right) * \frac{r}{1-(1+r)^{-i}}$$

The economic life is the period which gives the minimum equivalent annuity. This figure is then used to arrive at a replacement decision, the details of which are shown in Appendix 2.

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