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ALLOCATING SHARED COSTS IN FINANCIAL MODELS

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ABSTRACT: As we move into the nineties the management of public transport enterprises are being held more accountable for the business they operate. The financial importance of the business will continue to grow as government revenue contributions are much more closely tied to the service provided. As a result of this pressure financial details are being sought at ever increasing levels of detail typically at the route level for different time periods throughout the week. One of the great difficulties in developing an accurate route cost model is the methodology used to handle the shared costs such as vehicle ownership, garage and maintenance facilities and administrative costs. This paper proposes a method which allocates the cost in proportion to the average vehicle use.

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Introduction

As we move into the nineties the management of public transport enterprises are being held more and more accountable for the business they operate. No longer is management concerned only with the operational side of the business. The situation for many managers today is that the financial performance of the business is just as important or even more important than the operational side of the business. The financial importance will continue to grow as government revenue contributions are much more closely tied to actual financial performance with the additional threat of services being subject to competitive tendering. As a result of this pressure financial details are being sought at ever increasing levels of detail, typically at the route level for different time periods throughout the week.

One of the difficulties in developing an accurate model for costs at the route level is the method used to handle costs which are not specific to a particular route such as vehicle ownership, garage and maintenance facilities and administrative costs. The method used for the allocation of these shared costs can have a major impact on the apparent profitability or otherwise of the services operated. Shared costs are not an insignificant percentage of fully distributed costs, typically 30-40% of the total cost.

Traditional approaches have either allocated the costs in a uniform manner throughout the day or allocated all of these shared costs to the peak period with the off-peak periods bearing none of these costs. This paper examines the implications of the traditional approaches compared with an approach where the shared costs are allocated in proportion to the actual use in the particular time period. Although the method is applied to bus operations, the results can be easily applied to other modes of public transport.

Background

Public transport authorities commonly calculate unit cost figures related to the number of vehicles operated, the number of vehicle hours of operation and the number of vehicle kilometres operated. Table I shows such a table of unit costs per kilometre for the State Transit Authority on New South Wales.

It is interesting to note that authorities are now presenting units costs in their annual reports (State Transit Authority 1991). The appearance of unit costs in annual reports show that significant importance is placed on their calculation.

Table I Unit Cost per Kilometre of Operation for STA (NSW) 1990/91

Expenditure	**$ Per KM**
Wages and salaries	1.93
Employee entitlement	0.75
Operations, Maintenance & general	0.85
Distillate/gas	0.26
Tyres and tubes	0.02
Interest	0.07
Rent	0.04
Depreciation and amortisation	0.23
Public and marine risk	0.08
Finance charges on leases	0.07
TOTAL EXPENDITURE	$ 4.30

Source: Page 67 Annual Report 1990~91 State Transit

Hypothetical Bus Depot

Let us consider the example of the manager of a fictitious government bus depot at "Newtown". Analysis of the financial accounts yield the annual cost of the operations of the "Newtown" depot broken into a number of categories as shown in Table II. In addition to the financial information, operational data as outlined in Table III is obtained.

Table II Yearly Financial Data for the "Newtown" Depot

Driver costs including on-costs	$7,500,000
Fuel and tyres	$1,500,000
Maintenance staff and materials	$2,500,000
Bus ownership including registration depreciation and amortisation	$2,500,000
Depot costs include staff, cleaning, office and etc	$3,000,000
Agency costs including planning, marketing, and administration	$3,000,000
TOTAL	$20,000,000

Table III Yearly Operational Data for the "Newtown" Depot

Peak number of buses	100
Number of hours of operation	250,000
Number of kilometres of operation	5,000,000

From these figures the manager is aware that the business is costing $20M per year to operate. In the past the amount of revenue earned would have been subtracted from the cost of the operations and the shortfall made up by way of a government contribution. There is now considerable pressure to reduce the amount of government contributions.

The challenge for the manager is to use the data that they have available and convert it into a useful management tool to assist in improving the performance of the business as well as assisting in claims for government contributions where appropriate. A first step in this process is to develop a set of unit costs.

Unit Costs

Unit costs are an integral part of a cost model. They provide the link between the cost of providing the service and the revenue earned by services provided. For example for every kilometre of operation it may cost $4.00 to provide that service. In simpler models unit costs have generally been calculated on a per vehicle basis, a per hour of operation basis and a per kilometre basis (U.S. Department of Transportation 1984). Generally the costs that are deemed to vary mostly on a per kilometre are quoted on a per kilometre basis, the costs that vary on a per hour basis quoted on a per hour basis and the fixed or overhead costs quoted on a per bus basis. For example fuel use is generally quoted on a per kilometre basis under the premise that if a kilometre of service is not provided then the fuel is not used, while vehicle registration costs are generally quoted on a per vehicle basis under the premise that the cost will still be incurred while the vehicle is owned irrespective of the amount the vehicle is used.

For the "Newtown" depot unit costs could be calculated on a per bus, per kilometre and per hour basis as shown in Table IV.

Table IV Unit Costs for the "Newtown" Depot

	per bus	per hour	per km
Driver Costs	$75,000	$30.00	$1.50
Fuel and Tyres	$15,000	$6.00	$0.30
Maintenance	$25,000	$10.00	$0.50
Bus ownership	$25,000	$10.00	$0.50
Depot costs	$30,000	$12.00	$0.60
Agency Costs	$30,000	$12.00	$0.60
TOTAL	$200,000	$80.00	$4.00

From Table IV it can be seen that it costs $200,000 per vehicle per annum or $80.00 per hour of vehicle operation or $4.00 per kilometre of operation. Whilst the figures in Table IV may provide a useful insight by reporting the same cost in a number of ways, when used in modelling, the cost for an item of expenditure can only appear once or else double counting will appear. If the unit cost for drivers is taken as both $30.00 per hour and $1.50 per kilometre and used in a model, the model will double count the cost of drivers. For this reason it is convenient to use a single unit rate for each item of cost in models although the correct result could still be obtained, for example by allocating 50% of the total cost on a per hour basis and 50% on a per kilometre basis.

Each item of cost for the "Newtown" depot has been deemed to vary according to one of the three unit measures adopted. These unit costs and the way they vary are shown in Table V.

Table V Unit Costs Allocated According to Way the Cost Varies

	per bus	per hour	per km
Driver Costs		$30.00	
Fuel and Tyres			$0.30
Maintenance			$0.50
Bus ownership	$25,000		
Depot costs	$30,000		
Agency Costs	$30,000		
TOTAL	$85,000	$30.00	$0.80

From Table V it can be seen that it costs $85,000 per vehicle per annum and $30.00 per hour of vehicle operation and $0.80 per kilometre of operation. Whilst the per hour and per kilometre unit costs can be easily applied to a route model, the per bus cost is more difficult to allocate, yet its size ($85,000 per bus) points to the importance of correct allocation.

Alternative Methods of Allocating the Per Bus Unit Costs

The challenge is to use the unit costs in a way that is simple whilst at the same accurately reflecting the way the costs impact on the business. A survey of transit agencies in the USA found that none used models that distinguished between the cost of providing service by time of day and the day of week (Transport Research Board 1988). While it is desirable that a model should consider the variations throughout the day and the week, a simple approach that can capture some of this variation is beneficial.

The per vehicle unit costs have usually been allocated equally throughout the entire period of operation or allocated solely to the peak periods. The first approach under-estimates the real cost of providing services in the peak periods and over estimates the cost of providing services in the off-peak periods as many of the costs would be avoided if the peak services were not operated. The second approach over-estimates the cost of providing services in the peak periods and under-estimates the cost of providing services in the off-peak periods as some of the costs are incurred as result of the off-peak operations and should not be attributed to the peak period. What is required is an approach that is a combination of both of these approaches.

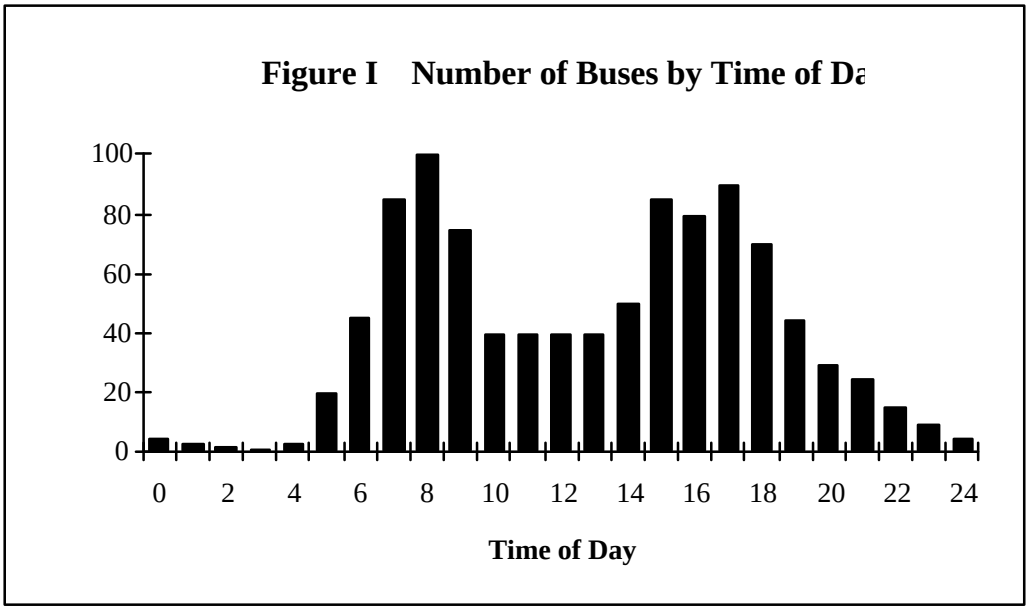


Figure I shows the varying fleet requirements for the "Newtown" depot throughout the entire day. For ease of calculation it is assumed that the depot has these fleet requirements 5 days per week for 50 weeks of the year and in every hour of operation the buses all operate at the same speed. With this assumption and the information contained both in Figure I and Table III the results of following three approaches of allocating the unit cost per vehicle are outlined.

Allocation Equally Throughout the Day

The easiest approach to allocating the unit cost per bus is to allocate the cost on equal basis throughout the day. This approach is equivalent to converting the unit cost per bus to a unit cost per vehicle hour of operation. Implicit in this approach is the assumption that the cost of provision of the service late at night is the same as the cost of provision during the peak period.

For the "Newtown" depot from Table VI it can be seen that cost per bus per hour of operation is $80 per hour.

Table VI Allocating the Unit Cost per Bus Equally Throughout the Day

Time Period	Number of Buses	Per Hour Cost	Per Km Cost	Per Bus Cost	Total Cost	Average per bus per hour
0:00 - 0:59	5	37,500	20,000	42,500	100,000	80
1:00 - 1:59	3	22,500	12,000	25,500	60,000	80
2:00 - 2:59	2	15,000	8,000	17,000	40,000	80
3:00 - 3:59	1	7,500	4,000	8,500	20,000	80
4:00 - 4:59	3	22,500	12,000	25,500	60,000	80
5:00 - 5:59	20	150,000	80,000	170,000	400,000	80
6:00 - 6:59	46	345,000	184,000	391,000	920,000	80
7:00 - 7:59	85	637,500	340,000	722,500	1,700,000	80
8:00 - 8:59	100	750,000	400,000	850,000	2,000,000	80
9:00 - 9:59	75	562,500	300,000	637,500	1,500,000	80
10:00 - 10:59	40	300,000	160,000	340,000	800,000	80
11:00 - 11:59	40	300,000	160,000	340,000	800,000	80
12:00 - 12:59	40	300,000	160,000	340,000	800,000	80
13:00 - 13:59	40	300,000	160,000	340,000	800,000	80
14:00 - 14:59	50	375,000	200,000	425,000	1,000,000	80
15:00 - 15:59	85	637,500	340,000	722,500	1,700,000	80
16:00 - 16:59	80	600,000	320,000	680,000	1,600,000	80
17:00 - 17:59	90	675,000	360,000	765,000	1,800,000	80
18:00 - 18:59	70	525,000	280,000	595,000	1,400,000	80
19:00 - 19:59	45	337,500	180,000	382,500	900,000	80
20:00 - 20:59	30	225,000	120,000	255,000	600,000	80
21:00 - 21:59	25	187,500	100,000	212,500	500,000	80
22:00 - 22:59	15	112,500	60,000	127,500	300,000	80
23:00 - 23:59	10	75,000	40,000	85,000	200,000	80
Total	1000	7,500,000	4,000,000	8,500,000	20,000,000	80

Allocation Entirely to the Peak Periods

An alternative approach to allocating the unit cost per bus is to allocate the costs only to the peak periods. Implicit in this approach is the assumption that all overhead costs such as vehicle ownership, administration and agency cost are incurred by the services that operate in the peak periods and none of these costs are incurred because of the services that operate in the off-peak periods.

In applying this method to the "Newtown" depot the first problem encountered is in the definition of the peak period. From the operating data each time period needs to be defined as being a peak or off-peak time period. There is some degree of arbitrariness about this process for services operated in the shoulder periods of the peak. For the Newtown depot the time periods commencing at 7am, 8am, 9am, 3pm, 4pm, 5pm & 6pm could be classified as the peak period. Using this definition of the peak period there are 585 vehicle hours of operation or 58% of the total vehicle hours during the peak period. From Table VII it can be seen that cost per bus per hour of operation is $104 per hour in the peak period and $46 per hour in the off-peak period.

Table VII Allocating the Unit Cost per Bus to the Peak Periods

Time Period	Number of Buses	Per Hour Cost	Per Km Cost	Per Bus Cost	Total Cost	Average per bus per hour
0:00 - 0:59	5	37,500	20,000	0	57,500	46
1:00 - 1:59	3	22,500	12,000	0	34,500	46
2:00 - 2:59	2	15,000	8,000	0	23,000	46
3:00 - 3:59	1	7,500	4,000	0	11,500	46
4:00 - 4:59	3	22,500	12,000	0	34,500	46
5:00 - 5:59	20	150,000	80,000	0	230,000	46
6:00 - 6:59	46	345,000	184,000	0	529,000	46
7:00 - 7:59	85	637,500	340,000	1,235,043	2,212,543	104
8:00 - 8:59	100	750,000	400,000	1,452,991	2,602,991	104
9:00 - 9:59	75	562,500	300,000	1,089,744	1,952,244	104
10:00 - 10:59	40	300,000	160,000	0	460,000	46
11:00 - 11:59	40	300,000	160,000	0	460,000	46
12:00 - 12:59	40	300,000	160,000	0	460,000	46
13:00 - 13:59	40	300,000	160,000	0	460,000	46
14:00 - 14:59	50	375,000	200,000	0	575,000	46
15:00 - 15:59	85	637,500	340,000	1,235,043	2,212,543	104
16:00 - 16:59	80	600,000	320,000	1,162,393	2,082,393	104
17:00 - 17:59	90	675,000	360,000	1,307,692	2,342,692	104
18:00 - 18:59	70	525,000	280,000	1,017,094	1,822,094	104
19:00 - 19:59	45	337,500	180,000	0	517,500	46
20:00 - 20:59	30	225,000	120,000	0	345,000	46
21:00 - 21:59	25	187,500	100,000	0	287,500	46
22:00 - 22:59	15	112,500	60,000	0	172,500	46
23:00 - 23:59	10	75,000	40,000	0	115,000	46
Total	1000	7,500,000	4,000,000	8,500,000	20,000,000	80

Allocation in Proportion to Average Use

A new approach to allocating the unit cost per bus is to allocate the costs in proportion to the number of hours each bus is used. Implicit in this approach is the assumption that all overhead costs are incurred for all times of the day that buses are in operation although for each individual hour of operation one hour of operation in a peak period costs more than an hour of operation in the off-peak period.

A method of allocation which initially appears attractive is to allocate the actual costs incurred by the specific bus (such as registration, depreciation and amortisation) to the bus route in proportion to the time the bus is actually operated on the particular route. There are a number of problems with this approach. Firstly as a result of the complex scheduling there may be a considerable amount of inter-working (the same bus operating on a number of different routes throughout the day). Secondly a bus may be allocated a different piece of operational work each day. Thirdly there is a number of additional buses that are part of the total fleet which are needed in case of emergencies such as breakdowns. Fourthly the actual allocation of older or newer buses to specific routes can make large differences in the results.

The method proposed considers the total number of buses needed to fulfil the operational requirements in each time period. The actual differences between individual buses are not taken into consideration for the reasons as outlined above, rather one hour of operation by an individual bus is deemed to be equivalent to an hour of operation by a different bus. If the depot operated two or more distinct types of buses for example, standard and articulated buses, which were allocated to specific routes then separate unit costs could be obtained for these different types of vehicle and the same procedure applied to the different vehicle types.

The Method

The calculation for the allocation of the unit cost in proportion to the average use of the bus consists of a number of steps. This is outlined below with reference to the "Newtown" depot example.

Step 1 Determine the number of buses required in each time period. This information is displayed pictorially in Figure I and is the second column in Tables VI and VII.

Step 2 Sort the list of vehicle requirements for each time period into ascending order commencing with the period with the minimum vehicle requirement through to the period with the maximum vehicle requirement. In the example the 3am time period has the minimum requirement with 1 bus required, the 2am period has the second lowest vehicle requirement with 2 vehicles and the 8am time period has the maximum requirement where 100 vehicles are required.

Step 3 For each time period, a bus that commences operation in that time period is calculated to be utilised for the remaining time periods. For the first time period in the list a bus that commences operation in that time period the calculation is based on the vehicle being used for the entire day. For a vehicle that commences operation in the second time period the vehicle is calculated as being utilised for the remaining part of the day which in this case is a full day except one time period. This process is repeated throughout the entire day until the last time period where the vehicle is utilised for only one time period. In the example for the 3am time period the bus is utilised for 24 hours, for the 2am time period the bus is utilised for 23 hours and the 8am time period the bus is utilised for only 1 hour.

Step 4 For the specific vehicle the cost is allocated equally across the hours of operation for that particular vehicle. If the vehicle is used for 10 hours then each hour of the operation attracts 1/10 of the cost. In the example a vehicle that commences operation in the 3am time period, each hour of operation incurs 1/24 (or 0.042) of the cost, while a vehicle that commences operation in the 8am time period for each hour of operation incurs all the cost in the time period.

Step 5 The calculation obtained in step 4 is for a vehicle that commences operation in the particular time period. This is a marginal use calculation figure for a vehicle that commences operation in the particular time period. For time periods other than for the first time period the vehicles in use at that particular time will be a combination of vehicles that commenced operations in the time period as well as vehicles that commenced operations in earlier time periods. For each time period the marginal proportions of every vehicle in operation at that time are added together and averaged across the vehicles in operation. In the example for the 3am time period which is the first time period the average is the same as the marginal use which is 1/24 or 0.042. For the 2am time period the average is (1/24 + 1/23)/2 or 0.043. This calculation is performed for all the time periods.

Results of the Allocation

For the Newtown depot the results of applying this method are shown in Table VIII. From Table VIII it can be seen that the method yields a different cost for each time period. Those time periods which have fewer vehicles in operation have a lower cost, as the vehicles used in these periods are utilised for more hours throughout the day and the unit cost per vehicle can allocated over a greater number of hours of operation.

The differences in the cost between the different off-peak periods is reasonably small. There is a large difference between the costs of operation in the peak periods with the 6pm period costing $77 per hour per bus (including the per hour and kilometre costs) while the 8am period costs $121 per hour per bus. The difference is because of the large number of vehicles which are required for only a small amount of time. There are 10 buses which are required for only one hour of operation in the 8am period.

Table VIII Allocating the Unit Cost per Bus in Proportion to Average Usage

Time Period	Number of Buses	Per Hour Cost	Per Km Cost	Per Bus Cost	Total Cost	Average per bus per hour
0:00 - 0:59	5	37,500	20,000	19,601	77,101	62
1:00 - 1:59	3	22,500	12,000	11,101	45,601	61
2:00 - 2:59	2	15,000	8,000	7,237	30,237	60
3:00 - 3:59	1	7,500	4,000	3,542	15,042	60
4:00 - 4:59	3	22,500	12,000	11,101	45,601	61
5:00 - 5:59	20	150,000	80,000	90,580	320,580	64
6:00 - 6:59	46	345,000	184,000	258,135	787,135	68
7:00 - 7:59	85	637,500	340,000	805,576	1,783,076	84
8:00 - 8:59	100	750,000	400,000	1,868,076	3,018,076	121
9:00 - 9:59	75	562,500	300,000	614,326	1,476,826	79
10:00 - 10:59	40	300,000	160,000	206,191	666,191	67
11:00 - 11:59	40	300,000	160,000	206,191	666,191	67
12:00 - 12:59	40	300,000	160,000	206,191	666,191	67
13:00 - 13:59	40	300,000	160,000	206,191	666,191	67
14:00 - 14:59	50	375,000	200,000	300,635	875,635	70
15:00 - 15:59	85	637,500	340,000	805,576	1,783,076	84
16:00 - 16:59	80	600,000	320,000	699,326	1,619,326	81
17:00 - 17:59	90	675,000	360,000	1,018,076	2,053,076	91
18:00 - 18:59	70	525,000	280,000	543,492	1,348,492	77
19:00 - 19:59	45	337,500	180,000	248,691	766,191	68
20:00 - 20:59	30	225,000	120,000	145,476	490,476	65
21:00 - 21:59	25	187,500	100,000	117,143	404,643	65
22:00 - 22:59	15	112,500	60,000	65,580	238,080	63
23:00 - 23:59	10	75,000	40,000	41,969	156,969	63
Total	1000	7,500,000	4,000,000	8,500,000	20,000,000	80

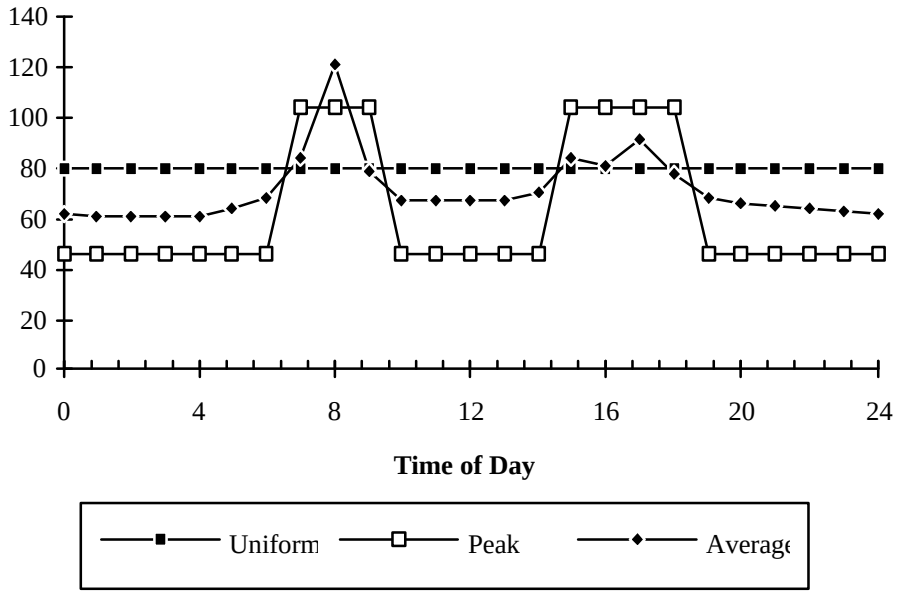
Comparison of the Methods

Three different methods have been used for the basis of the allocation of the unit cost per vehicle; a uniform allocation method, a peak period allocation method and an average use allocation method. A pictorial comparison of the three methods is shown in Figure II.

An agency seeking a government subsidy contribution will always wish to obtain the maximum contribution possible. At the same time the subsidising agency will seek to minimise the payments that it needs to undertake. Under most operating conditions the services for which agencies seek government contributions will be off-peak services. In these cases the agency will seek the highest amount of subsidy possible and would often argue for a figure derived from using the uniform method of allocation as this maximises the contribution. At the same time the government will generally argue for the peak period method of allocation on the premise that many of the overhead costs will be

incurred irrespective of whether the off-peak services are operated. The average use allocation method proposed in this paper for services operated in the off-peak periods yields results that are a compromise between those produced by the other two methods. This allocation method imposes significant cost penalties on the services operated at the height of the peak. This seems intuitively attractive as the additional vehicle requirements which are utilised for only a short period should attract a large cost as these additional vehicles have a major influence on factors such as depot size and other additional support services.

Figure II Comparison of the Methods



Conclusions

This paper has presented unit costs on per hour of operation, per kilometre of operation and on a per vehicle basis for the operation of a fictional bus depot which however could represent many government bus depots in Australian cities.

Two traditional methods for allocating the per vehicle unit cost have been examined in detail and a new method proposed which allocates the cost in proportion to the average vehicle use. This new method produces results which reflect the higher cost of operating services in the peak periods, while at the same time recognising that the off-peak are responsible for some of these costs. Such a method can be valuable in calculating the economic viability of specific bus routes and for ascertaining appropriate subsidy levels if applicable. In addition it can be used in conjunction with scheduling models in "what if" modelling scenarios.

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