THE COSTING OF BUS SERVICES IN ADELAIDE

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ABSTRACT:

The paper describes a study conducted in Adelaide to develop a method of estimating the cost of bus services for planning studies. The study was in four sections. First a set of unit cost rates was established which related to the resources deployed within the bus system. Second, a method was produced to ascertain the level of each resource needed to operate any given future bus service. Third, the marginal costs of extra buses operating for different periods of the day were developed and fourth, the average costs of the existing bus routes were determined. The method planned to maintain up-to-date cost rates and resource estimates is also described.

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INTRODUCTION

During the 1970's the South Australian State Transport Authority Bus and Tram Division (STA) has taken over financial responsibility for a substantial number of services previously run by private companies, doubling the size of its bus fleet to over 700 in the process. Over a similar period there has been a general change in attitudes towards public transport and the Government is therefore looking at ways of improving public transport in Adelaide.

In order to plan new services most effectively, an understanding of the causes of costs and revenues of bus operations is needed, together with the cost implications of changes in level of service provided. The STA is able to determine such costs and they do carry out ad hoc studies of service additions and changes. Such data are seldom available to planners as a matter of course. It is not sufficient to rely on simple average cost per bus kilometre which may be obtained from Annual Reports as no allowance is made for variations in costs between different times of day, days of the week or different routes.

These deficiencies were recognised and in March 1976 R. Travers Morgan were appointed by the Director-General of Transport to carry out a preliminary investigation of possible improvements to the method of costing. After considering the report of this investigation, the Director-General subsequently appointed Travers Morgan to undertake a Bus Costing Study.

The study was divided into four parts:

(i) derivation of unit cost rates;
(ii) resource estimation and crew scheduling;
(iii) estimation of marginal costs; and
(iv) estimation of average costs,

which are described in more detail below.

Unit Cost Rates

The costing method recognises three distinct cost categories:

(i) crew costs - the cost of operators wages and on-costs;
(ii) direct operating costs - the minimum avoidable cost of running buses other than crew costs; and
(iii) overhead costs - those items not already included in the previous costs. (This definition of overheads may differ from that normally employed in accounts).

The resources within each cost area were:

(i) crew costs - hours worked and penalty hours;
(ii) direct operating costs - bus kilometres operated; and
(iii) overhead costs - peak buses operated, bus hours operated and route kilometres operated.

The unit cost section of the study was thus concerned with attributing the STA operating costs between each of these resources and hence obtaining a unit cost rate for each resource.

Resource Estimation

Before a particular service or group of services can be costed using the unit costs, the quantity of each resource required by the service needs to be ascertained. Thus the costing study had to develop methods of estimating the resources needed to operate proposed or existing services.

Marginal Costing

In marginal costing the resource requirements of any proposed or existing service are combined with unit cost rates to obtain the marginal cost (or saving) related to the addition (or removal) of the service from the STA bus system. In this way alternative public transport options can be compared from the point of view of operating cost.

Average Costing

As distinct from marginal costing, average costing is not concerned with changes to the level of operation of bus services but rather with the costs of the various parts of the bus system. Thus the operating costs of different routes, times of day and days of the week are identified in this section.

The relationship between different parts of the study is illustrated in Fig. 1. In the remainder of the paper we discuss each stage in turn, concluding with a comment on updating the method in the future.

UNIT COST RATES

In this section we describe the way in which the unit cost rates for each resource item of the costing method are derived.

Platform Staff Costs

To estimate the cost of providing crews for buses one needs to know how the operators' shifts are organised to cover all the bus services. The work performed by bus crews is defined by a set of schedules, the content of which is governed by the Award conditions for the crews.

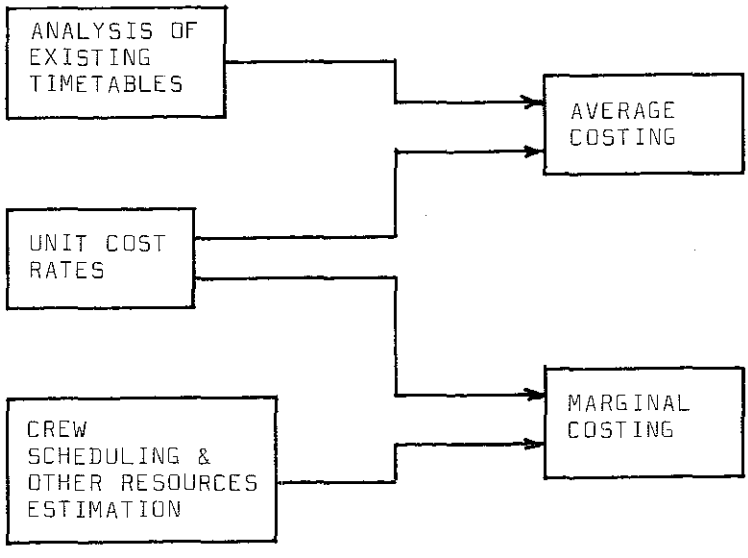

FIGURE 1 LOGIC OF THE STUDY

In Adelaide the Award allows for three types of shift to be worked:

(i) morning straight shifts of about 8 hours (maximum 9 hours on week days) with a meal break after at most 5 hours;
(ii) late finishing or afternoon straight shifts again of about 8 hours with a meal break; and
(iii) broken shifts which can have a total spread (time from start to finish) of up to 12 hours but which have at least a 2 hour break in the middle and a maximum work content of 9 hours.

Crew costs are estimated from two resources, crew hours worked and crew penalty hours. The cost rate per hour worked included on-costs such as leave provisions and uniforms as well as wages; penalty hours are costed at wage rates only. Thus to cost the crew component of bus services it is necessary to estimate crew hours worked and penalty hours for the service.

Because of the Award requirement for a 40 hour minimum week of five shifts, each shift worked attracts approximately 8 hours of working time but penalty rates usually make the paid time greater than this.

The penalty payments defined in the Award are:

(i) an overtime penalty of 50% for all work in excess of $8\frac{1}{4}$ hours on any shift (or in excess of 40 hours in a week);

(ii) a shift allowance of 15% for all time worked before 0700 and after 1700 (shifts starting after 1300 have all their time paid with the 15% penalty);

(iii) a spread penalty of 50% for all spreads (first sign on to last sign off) in excess of $9\frac{1}{2}$ hours and of 100% for all spreads over $10\frac{1}{2}$ hours (usually broken shifts); and

(iv) a Sunday penalty of 100%, a Saturday penalty of 50% and a public holiday penalty of 150% for all hours worked.

The effect of these penalty payments on an average shift is illustrated in Table 1 which gives hours worked and penalty hours by shift type by day.

TABLE 1: CREW HOURS WORKED AND PENALTY HOURS BY DAY BY SHIFT TYPE

	Morning Shifts		Broken Shifts		Afternoon Shifts	
Day	Worked Hours	Penalty Hours	Worked Hours	Penalty Hours	Worked Hours	Penalty Hours
Sunday	8	8	-	-	8	8
Weekday	8	0	8	1.5	8	1
Saturday	8	4	-	-	8	4

The unit cost of crew hours is composed of wages plus certain on-costs, namely leave provisions, payroll tax, tickets and uniforms.

In the costing method all on-costs are attributed to the basic working week and hence to hours worked (payroll tax is also attributed to penalty hours).

Totalling wages plus all on-costs gives the cost per hour worked and the wages cost plus payroll tax alone give cost per penalty hour. In September 1977 prices the rates are:

(i) crew cost per hour worked=$5.54
(ii) crew cost per penalty hour= $4.70

These unit costs can be applied to the average shift lengths (Table 1) to obtain the cost of the average shifts, shown in Table 2.

TABLE 2: CREW COST PER SHIFT BY DAY AND TYPE OF SHIFT

Day	Morning Shift	Broken Shift	Afternoon Shift
Sunday	$80	-	$82
Weekday	$46	$53	$51
Saturday	$62	-	$61

Direct Operating Costs

We define direct operating costs as those costs which are directly related to bus kilometres operated. Clearly fuel and oil costs fall into this category as do wear and tear on tyres and tubes. Thus fuel, oil, tyres and tubes are all included in direct operating costs. Further, the STA pay a Highways Contribution based on the number of bus kilometres operated and this is also included in direct operating costs.

Insurance is sometimes considered to be within this category but the STA take out provisions from the Profit and Loss Account for insurance on a formula which does not directly involve bus kilometres. For this reason we have not included insurance here.

For September 1977, the direct operating cost elements were as given in Table 3. Thus the present direct operating cost is 4.60 cents per bus-kilometre.

Overhead Costs

We define overhead costs to be those cost items in the STA Profit and Loss (P & L) Account which do not fall into the categories of crew costs or direct operating costs. Thus they include all costs of staff other than bus crews, all maintenance and office costs, insurance, interest and depreciation charges.

TABLE 3: UNIT DIRECT OPERATING COSTS (SEPTEMBER 1977 PRICES)

Item	Cents per Kilometre
Fuel and Oil	4.07
Tyres and Tubes	0.52
Highways Contribution	0.01
TOTAL	4.60

To include these costs in our costing method, it was necessary to address ourselves to two questions:

(i) with what measures of the scale of STA's operations do the various items of cost vary? and
(ii) how will the various items of cost vary with a change in the scale of operations, i.e. continuously, in a step function, etc?

By way of example, interest payments on capital loans will increase if STA buy more buses, and the change will occur with just one extra bus. Likewise running repairs to vehicles will increase if the buses operate for more hours and only small changes in the numbers of hours will increase the cost of running repairs. For some cost items the choice of units to which they should be attributed, and the change to the scale of STA's operations required to affect the cost item is less clear.

We adopted the approach of jointly checking through every overhead item of the P & L Account with STA and considering for each item, which factors within the Authority influenced that expenditure. Four factors were found to be relevant:

(i) number of peak vehicles in traffic;
(ii) number of bus hours operated;
(iii) number of depots; and
(iv) number of route kilometres.

Initially a statistical analysis was tried to determine the most appropriate resource item for each cost category which could not readily be related to one of the above factors. However, the resources are so closely related (for example, in statistical terms peak buses and bus hours had a R^2 of 0.96)

that statistical techniques were thought unlikely to yield definitive results. Further, the 6 years (1971-1976) data available related to only two distinct situations, pre-takeover of private operators with about 400 peak buses and post-takeover with about 700.

As a result, the interpretation of the statistical analyses was limited to an examination of the partial correlation coefficients which measure the relationship between cost categories and a single resource after removing the effects of other resources. This gave a guide, for the particularly uncertain categories, as to which resource had the greatest influence on a cost item.

We then considered the scale of change required to produce a change in the cost item. From the causal analysis it was usually evident when even small changes would influence the cost; where this was not the case past figures were examined, in particular the expansion due to the incorporation of the ex-private services, to determine the order of change required.

Table 4 shows how the final scheme of attribution would have been reflected in the financial year 1976/77 for STA Bus and Tram Division. In this, 61% of overhead costs are found to vary with peak vehicles and 39% with bus hours. In order to obtain the marginal overhead cost of an extra peak bus or bus hour, one needs to divide the total costs by peak buses in traffic or total bus hours. However, using a whole year's costs will mask increases during the year and will understate present costs.

TABLE 4: ATTRIBUTION OF 1976/77 OVERHEAD COSTS ($ MILLION)

Category	Attribute to Peak Vehicles	Attribute to Vehicle Hours
Traffic Operations (excluding Crew)	0.915	0.511
Maintenance	2.464	3.291
General Expenses	1.753	1.466
Interest and Depreciation	3.288	0.0
Sundry Revenue	-0.116	-0.021
TOTAL OVERHEADS	8.304	5.247

The production of marginal unit cost rates is therefore based on one month's results and is performed by using a computer program written specifically for this purpose. The program extracts all the appropriate costs from the P & L data other than the depreciation and interest charges related to passenger vehicles.

Depreciation and interest have to be considered separately (for costing increased services); Profit and Loss Account figures naturally reflect the average cost of all the present STA buses and are inappropriate.

Resulting from the analysis of scale of change for overhead costs changes we determined that certain cost items would only change with increases in the fleet of several buses (that is, they were step functions rather than continuous). This resulted in five levels of cost rate depending on the scale of change. These unit cost rates are given in Table 5. The final category, 70 or more buses, is used as a proxy for depot - related costs; if a depot were introduced with fewer than 70 new buses this rate would still apply. The rate per route kilometre is $1.54 per kilometre per week, which applies to new routes only, and covers small capital items such as shelters and signs.

TABLE 5: UNIT COST RATES FOR OVERHEADS (SEPTEMBER 1977 PRICES)

Level of Change	Rate per Peak Bus Per Week	Rate Per Bus Hour
Less than 6 Buses	$322	$3.41
6 to 14 Buses	$373	$3.41
15 to 34 Buses	$385	$3.63
35 to 69 Buses	$403	$3.63
70 or more Buses (or a new depot)	$433	$3.75

Unlike crew costs and direct operating costs, all overheads will not immediately change with a change in level service. It is appropriate at this point therefore to comment on the lag before the various marginal costs are incurred. Clearly the vehicle interest charges and depreciation will

have immediate effects. Some of the overhead costs will have a very small lag, for example running repairs, cleaning and lubrication. Others will take longer; however, we would expect all items included in the marginal costs to take effect within six months to a year.

CREW SCHEDULING AND RESOURCE ESTIMATION

For marginal costing work one needs to know how changes to the level of service will affect the resources needed to run the bus system. The resources involved are those on which the basic costing is founded, namely:

(i) peak buses and bus hours operated;
(ii) crew hours worked and crew penalty hours; and
(iii) bus kilometres operated and route kilometres.

The method used to estimate these resources varies with the way in which the service is specified. When the service is defined as a frequency by period of the day and if the operational round trip time and distance can be estimated, then a straightforward process is used. For more complex, irregular services a different approach is needed.

We consider an example where the desired level of service can be described in terms of a frequency (or headway) together with the operational round trip time and distance. The time and frequency may possibly vary throughout periods of the day. In the example the weekday service required is as follows:

(i) early morning (0600 to 0730) - a 30 minute headway with 65 minutes operational round trip time;
(ii) morning peak (0730 to 0900) - 10 minute headway and 75 minute operational round trip time;
(iii) day base (0900 to 1600) - 15 minute headway and 75 minute operational round trip time;
(iv) evening peak (1600 to 1800) - 10 minute headway and 75 minute operational round trip time; and
(v) night base (1800 to 2200) - 30 minute headway and 65 minute operational round trip time.

The first stage of our estimating is to estimate the number of buses required by time of day. This is done by using the formula:

$$\text{Buses required} = \frac{\text{Operational round trip time}}{\text{Headway}}$$

In all cases the answer must be rounded up to the next whole number (for example, 4.4 becomes 5 buses). The operational round trip time includes layovers and thus represents the

elapsed time from when a bus leaves the terminus until the time when it is ready to leave the same terminus next time around.

In the example the buses needed are thus:

(i) early morning - 3 buses
(ii) morning peak - 8 buses
(iii) day base - 5 buses
(iv) evening peak - 8 buses; and
(v) night base - 3 buses

From this information we know immediately that the bus requirement is 8 buses.

To estimate crew resources a method based on the STA's own Staff estimation process is used. The approach is described in the following paragraph and illustrated in Fig.2.

We begin with the night base where there are 3 buses. Afternoon shifts are used to man these night buses so that 3 afternoon shifts are needed. Each of these will require a meal break and one extra afternoon shift is employed to provide meal reliefs for every 3 or fewer basic afternoon shifts. In this case, therefore, one extra afternoon shift is needed making 4 in all. These 4 afternoon shifts will also be used to help cover the evening peak, which needs 8 buses in total. The 4 buses of the evening peak not manned by afternoon shifts are covered by broken shifts. The broken shifts are utilised to work both the morning and evening peaks so we can immediately say that they will also man 4 buses in the morning peak. This still leaves 4 buses remaining in the morning peak and these will be manned by 4 morning shifts. Unlike the case of afternoon shifts, extra shifts are not needed to provide meal relief for morning shifts as the broken shifts provide this cover. However, we still need to look at the day base, where 5 buses are used. The 4 morning shifts will work 4 of these buses but we need to employ an extra morning shift for the 5th bus. (In practice this 5th morning shift may also help with meal reliefs).

Thus the shift requirements are:

(i) 5 morning shifts;
(ii) 4 broken shifts; and
(iii) 4 afternoon shifts.

Because the unit cost rates include an allowance for annual, sick and gazetted leave, these resource figures do not have to be increased to provide leave and sickness cover.

It has already been ascertained that 8 peak buses are needed. We now need to estimate the number of bus hours. From the bus requirements and the durations of the periods, bus hours operated can be calculated as:

(i)	early morning	1.5 hours	x 3 buses	= 4.5 bus hours;
(ii)	morning peak	1.5 hours	x 8 buses	=12.0 bus hours;
(iii)	day base	7 hours	x 5 buses	=35.0 bus hours;
(iv)	evening peak and	2 hours	x 8 buses	=16.0 bus hours;
(v)	night base	4 hours	x 3 buses	=12.0 bus hours

for a total of 79.5 bus hours.

	Morning Peak	Day Base	Evening Peak	Night Base
Number of buses required	8	5	8	3
Afternoon shifts to cover night base				3
Afternoon shifts to provide meal relief				1
Total afternoon shifts				4
Afternoon shifts covering evening peak			4	
Broken shifts needed			4	
Broken shifts covering morning peak	4			
Morning shifts to cover morning peak	4			
Morning shifts covering day base		4		
Extra morning shifts needed		1		

FIGURE 2 ESTIMATION OF NUMBER OF WEEKDAY SHIFTS REQUIRED

Bus kilometres are based on the number of trips. Here we look at the individual buses:

(i) 3 buses operate all day and they each achieve one round trip early morning, 8 round trips between 0730 and 1800 ($10\frac{1}{2}$ hours divided by 75 minutes) and $3\frac{1}{2}$ round trips between 1800 and 2200 (4 hours divided by 65 minutes). Total for these 3 buses = (3x1)+(3x8)+(3x3.5)= 37.5 round trips;

(ii) 2 buses operate from 0730 to 1800 each therefore achieving 8 round trips ($10\frac{1}{2}$ hours divided by 75 minutes)
Total for these 2 buses = 2x8=16 round trips; and

(iii) 3 buses operate in the peaks achieving one round trip in the morning peak and $1\frac{1}{2}$ round trips in the evening peak.
Total for these 3 buses = 3x2.5=7.5 round trips.

Grand total round trips are therefore 61 and from a map the distance of a round trip can be estimated. Assuming a round trip distance of 20 kilometres, gives total bus kilometres of 61x20=1220 kilometres.

We must finally estimate crew hours worked and crew penalty hours. To do this the information given in Table 1 is used to give hours worked and penalty hours. In the example, we have:

(i) morning shifts - 40 hours worked and no penalty hours;

(ii) broken shifts - 32 hours worked and 6 penalty hours; and

(iii) afternoon shifts - 32 hours worked and 4 penalty hours.

To the hours worked an allowance for standby shifts needs to be added which amounts to 6%. Thus total hours worked are 110 and penalty hours are 10 hours.

For the example the following requirements are thus determined:

(i) 8 peak buses and 79.5 bus hours;
(ii) 110 hours worked and 10 penalty hours; and
(iii) 1220 bus kilometres;

Applying the unit cost rates and assuming that the service does not run on a new stretch of route, the daily cost is:

(8 buses @ \$74.6)+(79.5 bus hrs. @ \$3.41)+(1220 kms @ 4.6c)+(110 worked hrs. @ \$5.54)+(10 penalty hrs. @ \$4.70)=\$1580 per day.

If a new route is involved, the route kilometre cost should be added, as mentioned previously.

Weekend Scheduling

It is also possible to estimate resource requirements for weekend services. There are ample spare buses at the weekend so that no peak vehicle cost is incurred. All other resources are needed and in particular one needs to consider the way in which buses are manned.

As with weekday scheduling, the number of buses required is first estimated and this is done using the formula given previously. The process of estimating bus hours and bus kilometres is also as for week day services. Crew resources should be considered separately for Sunday and Saturday services.

For Saturday services there are two tiers of service, from about 0700 until 1400 and from about 0600 until 2400. Any buses working wholly within the 0700 until 1400 period (i.e. with depot-to-depot times of no more than 8 hours) will require one morning shift per bus plus one extra morning shift to provide meal relief for every 4 or fewer basic shifts.

Any buses working longer hours but no more than 12 hours depot-to-depot can be covered by 2 morning or afternoon shifts. Buses with depot-to-depot times longer than 12 hours will require two shifts, one morning and one afternoon, plus one extra shift per 3 or fewer basic shifts for meal relief.

The hours worked and penalty hours for Saturday shifts are given in Table 1 to which should be added an extra 6% of hours worked to cover standby shifts.

Nearly all Sunday services fall within the period 1230 to 2300 and can be manned by 2 shifts, including meal relief. In the event of greater spreads, the resource requirement will be 2 shifts plus one extra shift for every 3 or fewer basic shifts. The shifts will require the hours worked and penalty hours shown in Table 1 for Sunday shifts, with again an additional 6% added to hours worked to cover standby duties.

Balance Between Weekday and Weekend Services

Operators employed by STA work a five shift week. The total shifts to operate a particular service per week are calculated as five times the typical weekday shifts plus Saturday shifts plus Sunday shifts. Division of total shifts by five and rounding up then gives the number of extra crew required, ignoring leave cover. The difference between total shifts needed and five times the basic crew requirement represents spare shifts. This is considered when calculating the 6% standby allowance to avoid double counting - if 6% of actual shifts is less than the spare shifts then the spare shifts cover all the standby - otherwise they may cover part of the standby.

Using Timetables to Estimate Resources

Often in the course of bus service planning, it is necessary to produce a specimen timetable. In such cases the number of buses required, bus hours operated and bus kilometres can be estimated directly rather than using the methods described above. Further, when an irregular service is being considered (e.g. some rail feeder services) then the production of an initial timetable is essential as the formula for buses cannot be readily applied.

MARGINAL COSTS

Using the costing method described above, it is possible to produce the marginal costs of example levels of service. In illustration, consider the marginal costs of peak services, off-peak services and weekend services.

Services which include operations in the peak periods are:

(i) a peak only bus involving 4 hours operation;
(ii) a working day bus involving 11 hours operation; and
(iii) an all day bus involving 18 hours operation.

All these services require an extra bus and incur bus hour costs and bus kilometre costs pro rata to the length of time in operation.

The crew requirements for each period on the scheduling method already described is illustrated in Fig.3. Peak only services require a single broken shift. A pair of working day services require one morning, one afternoon and one broken shift. A pair of all day services require 5 1/3 straight shifts.

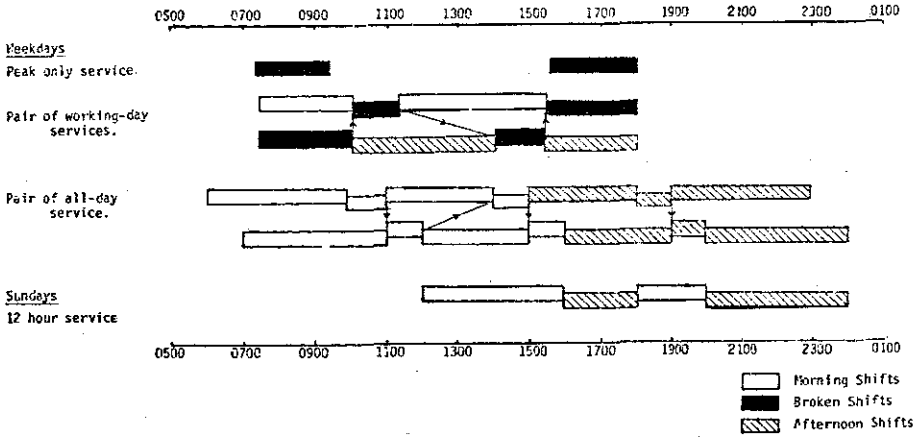

FIGURE 3: NOTIONAL SCHEDULING FOR MARGINAL COST CALCULATIONS

The total cost or savings of changing the level of operations by one bus for each type of weekday peak service are given in Table 6. The cost per bus is based on vehicle utilisation five days per week. The following points emerge from the Table:

TABLE 6: MARGINAL COSTS OF CHANGING SERVICES ON WEEKDAYS: DOLLARS PER BUS OPERATED PER DAY (SEPTEMBER 1977 COSTS)

Type of Service	Crew Resources: Shifts A.M.	Shifts Broken	Shifts P.M.	Hours Worked	Penalty Hours	Cost ($): Bus Hour Cost	Vehicle Cost	Crew Cost	Direct Op.Cost	Total Cost
1. All day (18 hours)	1.33	0	1.33	21.33	1.33	61.38	64.40	124.42	17.14	267
2. Working Day (11 hours)	0.5	0.5	0.5	12	1.25	37.51	64.40	72.36	10.47	185
3. Peak only (4 hours)	0	1	0	8	1.5	13.64	64.40	51.37	3.81	133

(i) The cost of a peak only bus service is half the cost of an all day bus service;
(ii) The cost of a working day service is 69% of the cost of an all day bus service; and
(iii) Per bus hour, the marginal cost of a peak only service ($33.25/hour) is more than double the marginal cost of an all day service ($14.83/hour).

We can estimate the marginal costs of operations in the early morning/late evening, between the peaks and during all off-peak periods by considering the balance between all day, working day and peak services. Thus:

Total off-peak = All Day less Peak only=$267-$133=$134
Between peak = Working Day less Peak only=$185-$133=$52
Early AM/Late PM = All Day less Working Day=$267-$185=$82

The following results emerge:

(i) The marginal cost of off-peak services is the same as that of peak only services; and
(ii) The marginal cost of the early morning/late evening service is one third that of the all day service, and is considerably more than the cost of a between peak service (of the same duration).

Saturday and Sunday services differ from weekday services in the following major respects:

(i) No peak bus (vehicle ownership) marginal costs are incurred by weekend services;
(ii) No broken shifts can operate at weekends and thus the scheduling may need to change; and
(iii) Crew costs become predominant because of high penalty rates.

Table 7 gives the marginal costs (and savings) of weekend services, together with weekday all-day services for comparison. It can be seen that Saturday services cost almost the same as weekday services, the extra Saturday crew cost being offset by the saving in vehicle ownership costs. Sunday services, although only covering 12 hours and incurring no vehicle costs, cost 81% of all-day services on a weekday.

AVERAGE COSTS

In order to estimate average costs we analysed the working timetables of the present services and extracted the resources used to operate each route, or group of routes. Because average costs are based on resources at present employed they benefit from efficiencies in STA's scheduling where buses and crews are shared between routes. In marginal costing,

TABLE 7: MARGINAL COSTS OF ALL DAY SERVICES BY DAY OF WEEK (SEPTEMBER 1977 COSTS)

Day of Week	Crew Resources: Shifts A.M.	Broken	P.M.	Hours Worked	Penalty Hours	Cost ($): Bus Hour Cost	Vehicle Cost	Crew Cost	Direct Op.Cost	Total Cost
Sunday (12 hours)	1.0	0	1.0	16	16	40.92	0	163.84	11.43	216
Weekday (18 hours)	1.33	0	1.33	21.33	1.33	61.38	64.40	124.42	17.14	267
Saturday (18 hours)	1.33	0	1.33	21.33	10.67	61.38	0	168.32	17.14	247

unless a group of routes were being considered buses and shifts would be allocated solely to one route. Also, average costs will normally be lower than marginal costs assuming that new buses will be purchased at present prices whereas average costs are based on the average purchase price of the present fleet.

By applying these unit cost rates to the resources identified in the analysis of timetables, we were able to estimate the weekly cost of each service in the system.

UPDATING THE METHOD

The work undertaken in 1977 will be rendered out of date in two circumstances:

(i) if unit costs increase; and
(ii) if the pattern of utilisation of crews is changed.

The first of these eventualities will be covered by the use of a computer program which was specially designed to link in with the STA accounts system and to extract the unit cost rates from a month's Profit and Loss Account Figures. This program will be run for 3 months once or twice a year and the average unit rates over the 3 months will be used until the next update.

The pattern of utilisation will only change if the Award changes significantly with, for example, meal breaks being compulsory after 4 hours. This problem will be overcome by adopting as the basis of the crew scheduling the revised staff estimation procedure developed by STA following the change. Because two Department of Transport project officers were closely involved in the development of the scheduling method, this modification to the scheduling should be capable of being undertaken within the Department.

Thus the general method described in this paper has been designed to be sufficiently flexible to adopt itself to changes in both cost rates and bus operations organisation.

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