

Operator and Customer Trade-offs in Public Transport Route Design.

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Abstract:

Public transport systems are typically expected to play a multitude of roles within urban areas. First, they are often expected to serve a social service function by providing transport for those without access to private cars. Second, they are increasingly being expected to operate as economically and financially viable entities, recovering more of their costs from the fare-box, in order to reduce the drain on the public purse. Third, they are often seen as providing environmental relief for urban areas, by carrying more passengers at less environmental cost per passenger. Finally, they are often seen as shapers of future urban forms, by influencing the patterns and directions of urban growth.

Trying to design, or re-design, public transport systems within this set of (sometimes conflicting) objectives can therefore be a challenging process. This paper attempts to make a contribution to this process by first describing a model of trade-offs in public transport design based on the "architect's triangle" concepts of trade-offs in quantity, quality and cost. The paper then proposes a more detailed model of public transport route design, and describes the implementation of this model in a pedagogical spreadsheet format. Results from application of this model are then described to highlight the trade-offs between various design parameters which need to be faced in the design, or re-design, of a public transport route.

The paper concludes by emphasising the interactions between the operator and customer needs in the public transport design process. It stresses that the linkage between these two viewpoints should not be broken by institutional or regulatory means. In particular, it argues that operators should retain control over both the level of service offered to customers and the fares that can be charged for different levels of service. Only in this way can continued innovation be fostered to design services which meet the social and environmental objectives of the community at a reasonable economic cost.

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1. INTRODUCTION

Public transport systems are typically expected to play a multitude of roles within urban areas. First, they are often expected to serve a social service function by providing transport for those without access to private cars. Second, they are increasingly being expected to operate as economically and financially viable entities, recovering more of their costs from the fare-box, in order to reduce the drain on the public purse. Third, they are often seen as providing environmental relief for urban areas, by carrying more passengers at less environmental cost per passenger. Finally, they are often seen as shapers of future urban forms, by influencing the patterns and directions of urban growth. Trying to design, or re-design, public transport systems within this set of (sometimes conflicting) objectives can therefore be a challenging process, involving a wide range of trade-offs.

2. TRADE-OFFS IN PUBLIC TRANSPORT SYSTEMS

In outlining the trade-offs in public transport services, consider a framework that is often referred to as the "architect's triangle". That is, in any project or process, there is a three way trade-off between quantity, quality and cost, as shown in Figure 1. For example, in building a house and commissioning an architect, you can specify any two of these factors, but not the third. You can say how big a house should be and what quality you want, but then the architect will tell you what it will cost. Alternatively, you can specify the size you want and how much you are willing to spend, and the architect will then tell you what quality you can get. Finally, you could indicate the quality and cost, but then the architect will tell you how big a house you can have. However, you can't get a 50 square house with marble staircases for \$100,000.

The same trade-offs occur in public transport. Whilst we might like to say we want a big system of high quality which provides for all people, and be able to contain the cost, it's generally not possible. What we must do is to decide what are the two most important factors, and then let the third factor vary accordingly. This trade-off process becomes clearer if we expand on the basic triangle of Figure 1.

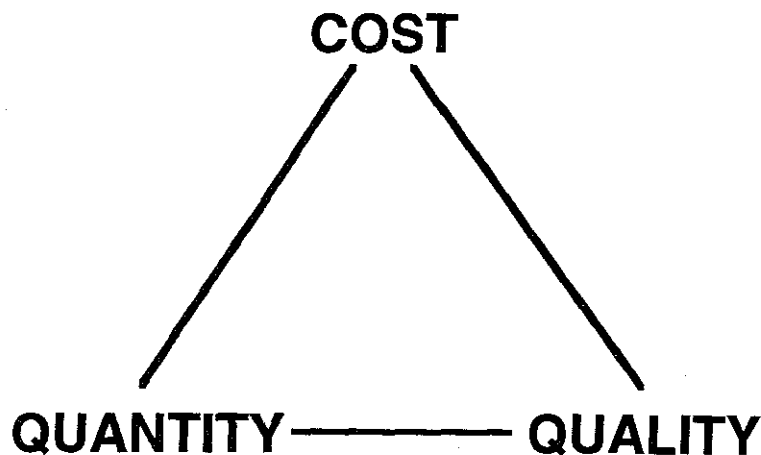


Figure 1 The "Architect's Triangle"

Cost Efficiency and Cost Effectiveness

If we start by expanding slightly on the triangle, three points emerge, as shown in Figure 2. The first point is that the level of service offered by a public transport system is a combination of quantity and quality; the size of the system and the quality of service it provides. There are two other features of Figure 2 which are important - cost efficiency and cost effectiveness in delivering services. Cost efficiency means how well the physical system can be operated to deliver a given quantity of services, whether or not those services are needed. Cost effectiveness, on the other hand, measures how well travellers' needs can be satisfied - how effective is the public transport system in providing the quality of service people actually want. The difference between cost efficiency and cost effectiveness is reflected in the Victorian State Government's current slogan of "From an public transport system to a public transport service" - i.e. from cost efficiency to cost effectiveness.

Cost efficiency is looking at public transport from a supplier's point of view - how well can the organisation run the physical system? Cost effectiveness, on the other hand, is saying how well transport services can be delivered which are actually going to perform a useful function, irrespective of what physical means are used to achieve that function. We need to clearly distinguish the difference between cost efficiency, which is an internal organisational measurement, and cost effectiveness, which is an external community-related measurement. The only way of breaking the shackles imposed by the architect's triangle is by increasing the cost-efficiency (by productivity improvements) or by improving the cost-effectiveness (by better market research to ascertain the real needs of potential users).

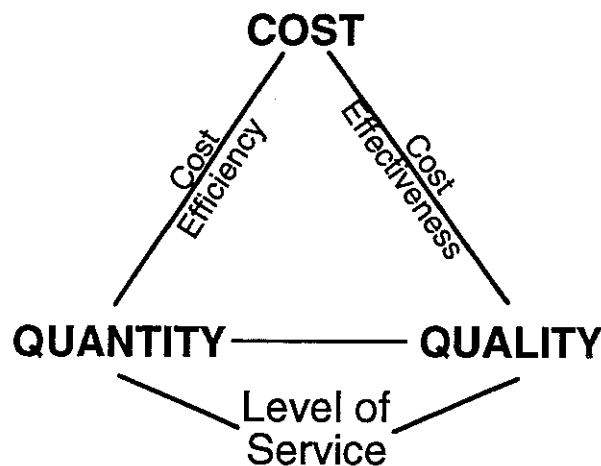


Figure 2 Cost-Efficiency versus Cost-Effectiveness

What, then, is meant by quantity and quality? If we look at quantity, as in Figure 3, we see that there is a trade-off in two dimensions - the spatial quantity (how geographically large the system is) and the temporal quantity (for how long a time the system runs during the day and week, and with what frequency it runs). Obviously, there's not much point in putting a large spatial system out in the field unless there are vehicles running on it for some time period.

Normally, in considering these factors, there is a trade-off inherent in providing a given quantity of public transport services. One can have a big spatial system, but not run very often on it, or one can go for a smaller spatial system, but run a higher frequency service.

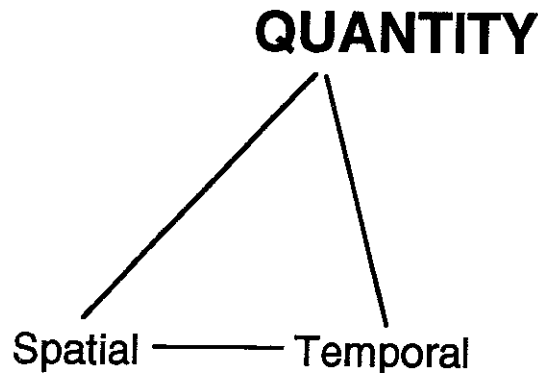


Figure 3 The Quantity of Public Transport Services

Quality of service, as shown in Figure 4, has a larger number of dimensions and is a more complex system which we don't fully understand. Two main aspects of quality are the accessibility it provides to various activities to a range of people, and the "style" in which such access is provided. Obviously, the quality of the public transport system, in terms of how well it caters for the specific access requirements of various groups is of critical importance to the provision of public transport services for the aged and handicapped.

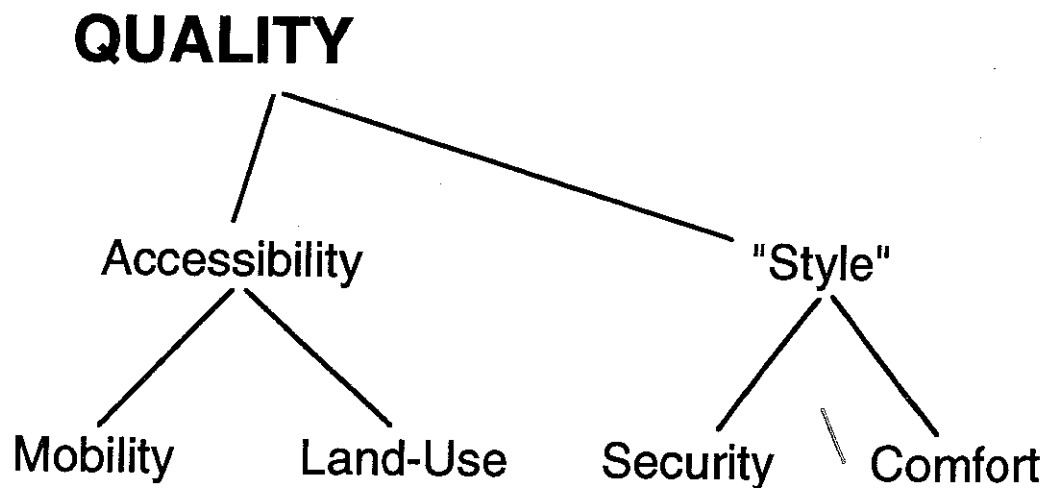


Figure 4 The Quality of Public Transport Services

In terms of "style", Figure 4 lists just two of the factors that could come up under this heading - security and comfort. There is clearly a much longer list of other things which contribute to what is called "the style" of the system, which affect people's perception of the quality of the system, and which must be addressed if we are to have a system which people would want to use.

Revenue and Expenses

In considering the other apex of the architect's triangle, i.e. the cost, the first thing we need to say is that, as shown in Figure 5, when we talk about cost, we are really talking about net cost - that is, the difference between revenue and expenses, not just the expenses. The net cost (if it is negative) is what you have available to provide quality and quantity.

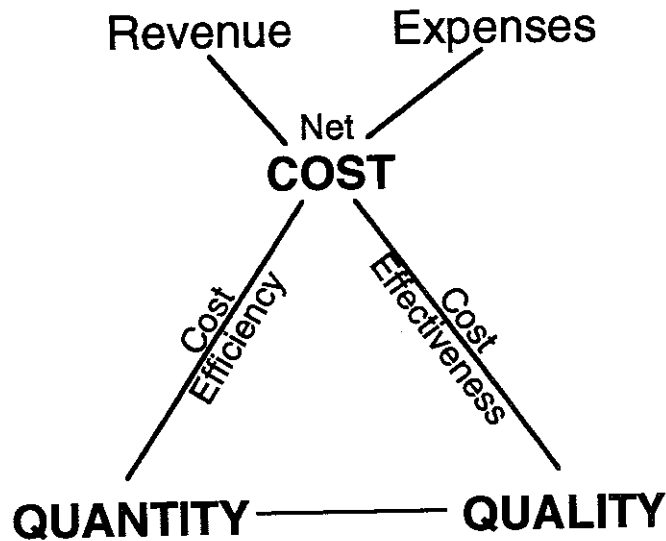


Figure 5 Net Cost at the Head of the Architect's Triangle

Revenue and expenses can be explored to demonstrate a variety of issues. We often think of revenue as being fares, but we should not restrict ourselves to just considering fares as the sole source of revenue. As shown in Figure 6, there is a wide range of ways in which a public transport operator can obtain revenue.

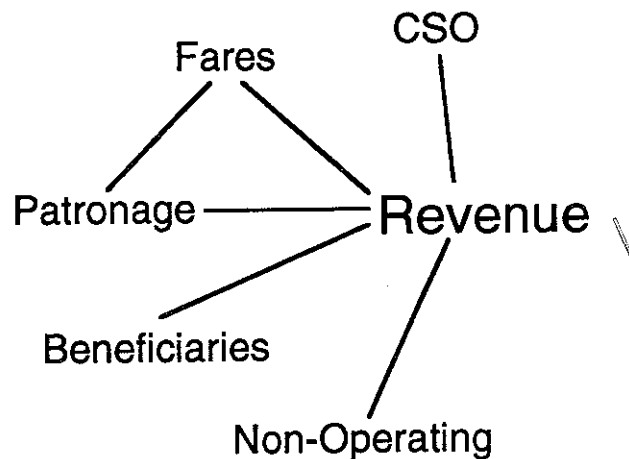


Figure 6 A Variety of Revenue Sources

Obviously, fares are one way, but we should note the trade-off between fares and patronage. Naturally, the revenue coming in from fares is the product of patronage and fares, assuming that each patron pays a fare, but there is also going to be a trade-off. If

you go for higher fares, you will lose some patronage. How much is a matter of debate, research and empirical analysis. If you want high patronage and high fares at the same time, it may not be incompatible if you have a quality service, or if people have little choice but to use public transport. Both these conditions give rise to a low elasticity of demand with respect to fares.

We should, however, also think of other sorts of revenue. CSOs (Community Service Obligations) have been seen as one form of revenue for public transport operators - by contracting out to do a particular job that someone wants done (in this case, the community, via a government). Clearly, CSO payments for the transport of the aged and the handicapped are highly relevant.

There are other sources of revenue such as non-operating revenue, including advertising revenue. But there is also a major potential revenue source which we call "beneficiaries". We sometimes think of the main beneficiaries of public transport as being the users, but they are not the only beneficiaries. There are lots of other people who benefit from a public transport service but who don't use it. This includes businesses and land owners who benefit by having a public transport system providing access to their piece of land, their office building or their block of apartments. There are a lot of beneficiaries who are not currently providing revenue for the provision of the public transport system, but who are deriving significant benefit from it. One should be able to think of ways that these benefits could be measured and captured. In doing so, we need to think about how much revenue we can bring in from this source, as well as the costs involved in doing so.

If we look at the other side of the equation, as shown in Figure 7, there are a whole range of different kinds of expenses. There are obviously overheads (fixed costs to be met before we provide any services), operating costs - some of which are fixed just to get the services out there, while others are variable depending on how much service is provided. There are also non-operating expenses which public transport systems have faced in the past which really have nothing to do with operating the system.

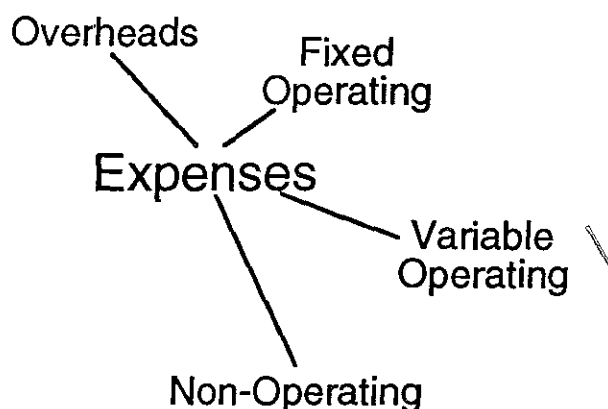


Figure 7 The Expenses of Public Transport Service Provision

The various types of expenses can be broken down even further and, when put together with the other components already described, they form a complex mosaic of public transport operations as shown in Figure 8.

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(Community Service Transport operators - by contrast, in this case, the transport of the aged and disabled).

including advertising and public relations. We call "beneficiaries" those who are being the users, but also those who benefit from a service, such as land owners to their piece of land, or businesses who are part of the transport system, but who do not think of ways that these can be improved or how much they are involved in doing so.

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Service Provision

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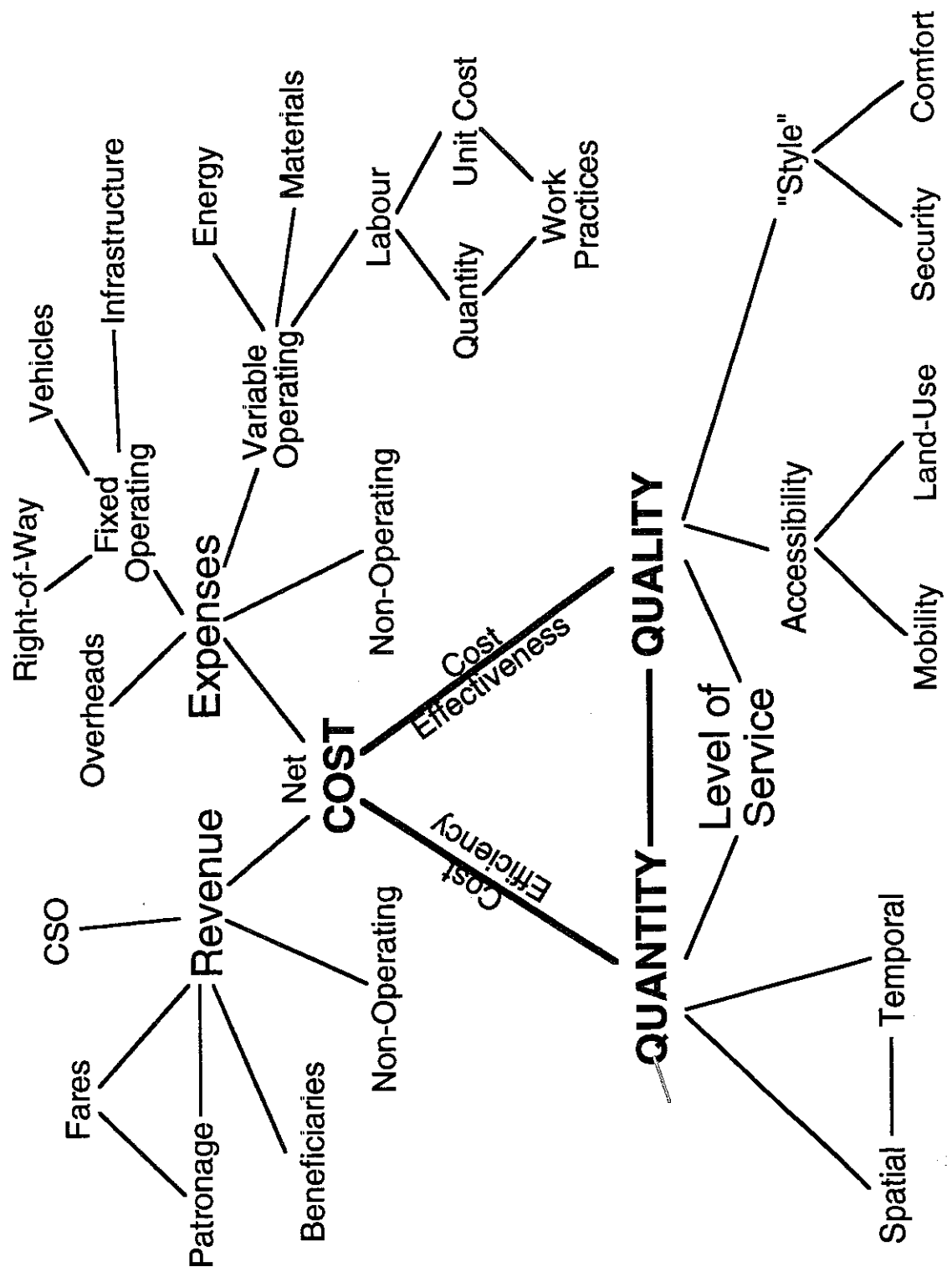


Figure 8 The Public Transport System Trade-off Diagram

What should be evident from Figure 8 is the interacting nature of the components of this process. We cannot unilaterally decide to alter one of the components, because of the linkages, through the architect's triangle, with the other parts of the process. For example, we cannot decide to increase the quality of the system unless we have considered how it will affect the quantity and/or cost of the system. If we want to hold the (net) cost constant, then such quality increases can only come about by reducing the quantity of public transport service provided. Alternatively, if we want to maintain the quantity of service provided, then this can only be done by increasing the (net) cost of the service. This, in turn, may result in the need for increased revenue or decreased expenses.

In the short term, we may be able to avoid this trade-off by being able to find improved productivity in some part of the system to increase the cost efficiency, or by better market research to enable us to deliver more appropriate services which are desired by consumers. In the long run, however, such slack in the system will be used up and we will need to confront the trade-offs again. In both the short-term and the long-term, we need to have a better understanding of how public transport systems actually work in order to better appreciate the trade-offs to be made in the planning and design of public transport systems.

3. A MODEL OF PUBLIC TRANSPORT OPERATIONS

There are many different ways of modelling public transport operations. There is a conventional approach, which hasn't been applied much in Australia in recent years, which is based on the development of a network model. This is essentially a highway based modelling scheme, which has been adapted for public transport use on the assumption that the same type of network can apply in a public transport system as well. However, while this type of model might be acceptable for aggregate sketch modelling studies, it is not appropriate for developing an understanding of the complexities of a public transport service. What is needed is an alternative way of thinking about public transport and how we might look at the interactions in the system.

An overall conceptual model of public transport systems, leading on to a somewhat more detailed understanding of the interactions displayed within a public transport system, is shown in Figure 9.

This model is centred around the demand for a service, in particular the "spatio-temporal" demand, meaning that it is measured over space and over time. This is a critical issue in terms of public transport services, since the temporal availability of public transport services is very different to the temporal availability of car-based transport services. There are inputs into the design, designated by the rounded boxes in Figure 9, and outputs from the service depicting the level of service to the passengers, and the operating characteristics of the system (in terms of vehicle operating characteristics and network operating levels). There are also measures of the financial performance of the system, because if the service is to run as a commercial enterprise, then it is not possible to just assume that it is going to take care of itself financially.

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Figure 9 A Conceptual Model of Public Transport Operations

Consider, then, a starting point in the diagram to illustrate the process. In the diagram, the rounded boxes are the inputs to the process, i.e. those things over which the designer has some control. The square boxes are the intermediate or final outputs of the process; they are the consequences of decisions that have been made in one of the rounded boxes. Consider, then, 'stop placement'; what's going to govern where you put the stops? Basically, you will want to put the stops where the people want to get on the vehicle. This may sound overly simplistic, but note that this statement already conveys a "demand orientation", whereby you think of what the passengers want, rather than a "supply orientation", in which you think of only what is more convenient for the operator.

The placement of stops will, in turn, affect how far the passengers have to walk to the stops. Let's say they are making a trip from home; if you know where the passengers live, then you know where to put the bus stops and, as a result, can work out how long it takes them to get from their home to the bus stop. Having decided on stop placement, then that has determined the number of stops; probably the simplest relationship in the entire model shown in Figure 9. The number of passengers who are going to a particular stop to board the vehicle will depend on where you put the stops and where the passengers are coming from. If you know the number of passengers per stop, then you can determine the stop time per stop, i.e. how long the vehicle stays stationary while the passengers are boarding and alighting. Given that this process occurs at every stop, and given that you know how many stops there are, this will give you the total stop time along the route, which is one component of the passenger's total journey time.

Another component of the total journey time is what is called running time, which is the time the vehicle actually spends moving along the route. How quickly the vehicle moves along the route will depend on the spacing between the stops. With close stop spacing, the vehicle is able to spend less time at cruise speed, if indeed it can reach cruise speed in the distance available between stops. However, the closer you put the stops, the less walking time people are going to have, because you have more stops close to where they come from and go to. This results in our first trade-off situation. Do you want passengers to not walk very far but spend more time on the vehicle, or do you want to put the stops further apart, get the passengers quickly between those points on the vehicle, but have them walk further.

It has been found in many market research surveys that people dislike walking, more than they dislike being on the vehicle, for all sorts of reasons - exposure to the weather, physical exertion etc. So perhaps in making this trade-off, greater weight should be given to reducing walking time, rather than in-vehicle time.

These paragraphs have illustrated the way in which Figure 9 works. Each input variable gives rise to changes in one or more output variables, which in turn cause changes in still more variables. Sometimes these changes feed into changes in the pattern of demand, which then spawns further changes in the operating characteristics. In other situations, the chain of events creates a closed loop, giving rise to an internal trade-off situation.

The interactions between the various components of Figure 9 are explored in more detail elsewhere (Richardson, 1994), as are the various sub-models which fit into this overall

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process, e.g. access distance models, waiting time models, running time models. All of these sub-models and interactions have also been programmed into a spreadsheet model of bus route operations (TRC BusModel), which is used extensively by the author for educational purposes. Although the model describes a simplified route structure, it does convey the nature of the trade-offs to be faced in public transport route design and, when used interactively, can assist in gaining experience with route design. This model has been used to generate the trade-off scenarios which are described in the next section of this paper.

4. A PEDAGOGICAL BUS ROUTE SPREADSHEET MODEL

The TRC BusModel spreadsheet model implements the sub-models and interactions depicted in the model of public transport operations shown in Figure 9. It does so in the context of a bus route operating in a simplified catchment area, as shown in Figure 10.

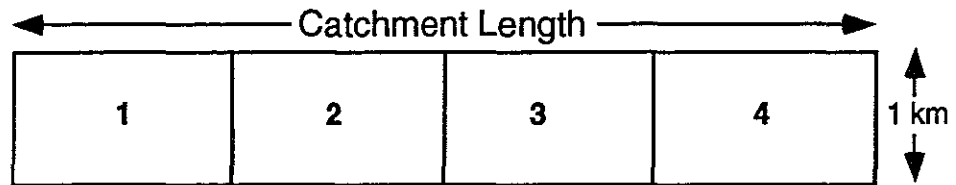


Figure 10 The Simplified Bus Route Catchment Area

It is assumed that the route runs in a straight line through the centre of the four zones in the catchment area, and that the stops will be spaced evenly along the route. The catchment area is assumed to be 1 km wide, but may have a variable length. Major signalised intersections occur at regular spacing along the route. There is a moderate degree of traffic congestion at these intersections and along the route. However, it is possible to install priority bus lanes and priority bus signals so that the bus can proceed immediately to the stop line without waiting in a queue.

The route to be used in the example in this paper has a total route length of 16km. Assuming that the morning peak passenger demand is spread uniformly between 7.00am and 9.00am, the current demand for the bus service is as shown in Table 1 (in terms of trips per hour).

Table 1 Base Case Origin-Destination Demand Matrix

Origin Zone	Destination Zone				Total Boarding
	1	2	3	4	
1	0	20	60	200	280
2	20	0	20	100	140
3	20	20	0	100	140
4	40	20	20	0	80
Total Alighting	80	60	100	400	640

This demand is based on an existing fare structure of 30¢ per zone of travel, i.e. travelling from zone 1 to zone 2 would cost 30¢, travelling from zone 4 to zone 2 would

cost 60¢ and so on. However, the patronage level is not independent of the fares, with a fare elasticity of -0.4 for the market served by the service. There is also an elasticity with respect to budgeted door-to-door travel time of -0.7, where walking time has a weighting factor of 2 and waiting time has a factor of 3. Budgeted travel time is defined as the sum of the mean and standard deviation of travel time, thereby making an allowance for the amount of time a traveller would need to budget in order to arrive on time, most of the time.

In designing the bus system, the vehicle options described in Table 2 are available, although the actual values in this table could be varied at the discretion of the designer. One-third of the purchase price is allocated to the morning peak period (which is the period for which you are designing). The remaining two-thirds of the cost are allocated to the evening peak and the off-peak. Assume that there are 250 operating days in the year, and that straight-line depreciation is used.

Table 2 Bus Design Characteristics

	A	B	C
Bus Type	40 Seater/1 Door	70 Seater/1 Door	100 Seater/2 Doors
Purchase Price	\$80,000	\$180,000	\$300,000
Operating Cost	80¢/km	110¢/km	150¢/km
Stop Time b = boardings a = alightings	$2 + 2.5b + 1.0a$	$3 + 2.5b + 1.0a$	$\max \begin{bmatrix} 4 + 2.0b \\ 3 + 1.0a \end{bmatrix}$
Accel/Decel Rate	8 kph/sec	6 kph/sec	5 kph/sec
Cruise Speed	80 kph	78 kph	70 kph
Bus Life	5 years	8 years	11 years

The model is best used in an interactive manner, with a specific design objective in mind. For example, the designer can make changes to the input parameters in order to achieve a bus service with the highest level of profitability. Alternatively, the model can be used to test the sensitivity of a range of output parameters to variations in one or more input parameters. This latter mode of operation has been used to generate the results to the described in the remainder of this paper.

The Effect of Variations in Stop Spacing

As described earlier in this paper, changes in the spacing of stops will have a range of effects on the operation of the bus service and on the level-of-service offered to passengers. The most immediate effect will be that the access and egress times will change as shown in Figure 11, with longer access times for higher values of stop spacing. Figure 11 assumes that passengers walk through a rectangular grid of streets to reach the bus stop, rather than walking in a straight line from their origins to the bus stop.

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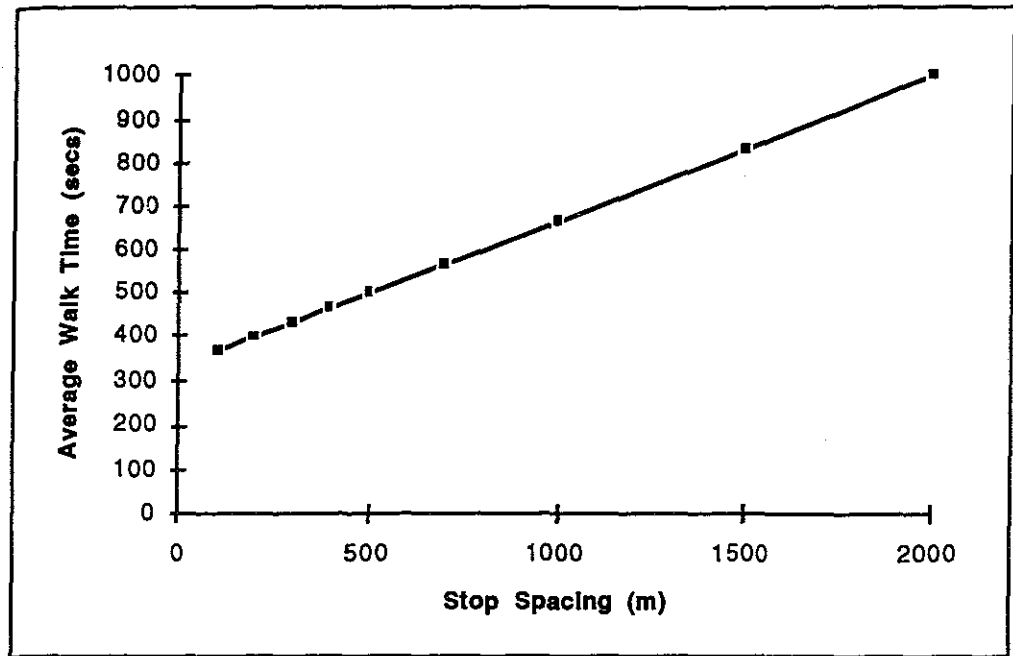


Figure 11 The Effect of Stop Spacing on Walk Time

In addition, however, changes in stop spacing will also affect the average running speed of the bus and hence the total running time along the route. For passengers, this equates to longer in-vehicle times for their trips. The effect of stop spacing on total running time from start to end of the route is shown in Figure 12. It can be seen that very close stop spacing (less than about 200m) produces extremely long running times, because the bus never has the chance to reach its cruising speed.

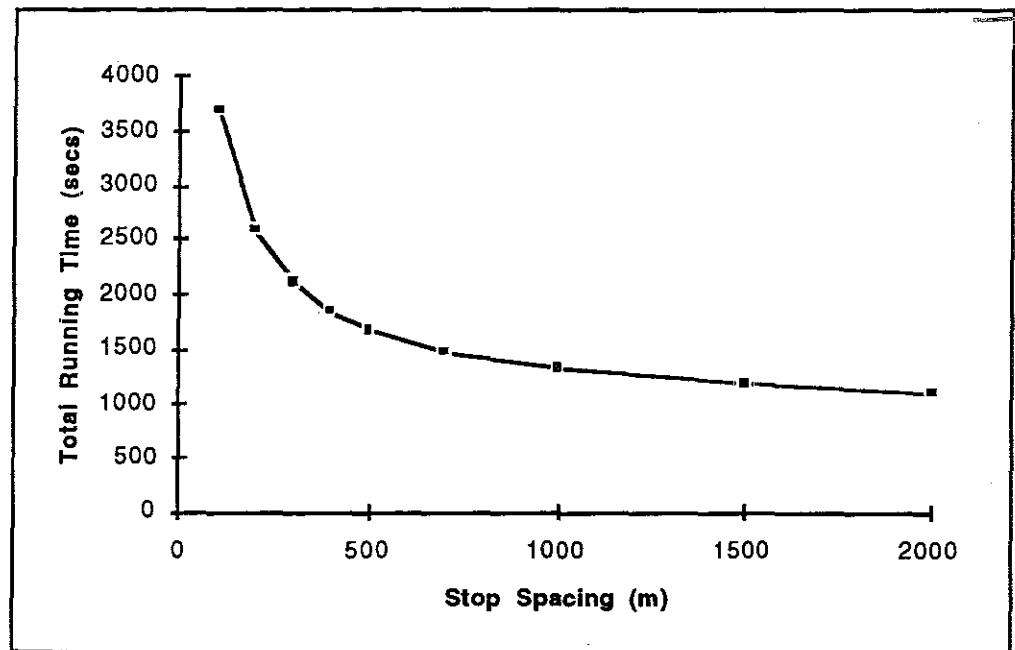


Figure 12 The Effect of Stop Spacing on Total Running Time

The in-vehicle time for each passenger also includes time spent waiting at stops for other passengers to board. As the stop spacing decreases, so the number of required stops also increases, even though less time is spent at each stop because the passengers are spread across more stops. The end result, however, is that the total time devoted to stopping at bus stops increases with closer stop spacing, as shown in Figure 13.

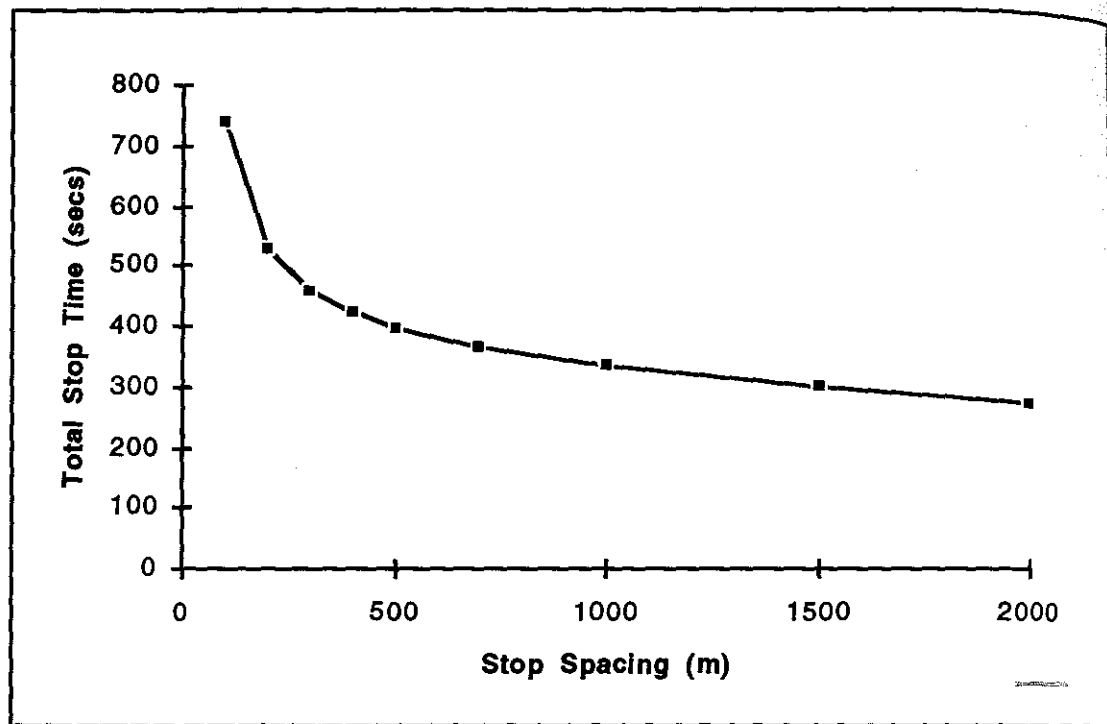


Figure 13 The Effect of Stop Spacing on Total Stop Time

By trading off the increase in access time (as stop spacing increases) with the decreases in in-vehicle time for each passenger (made up of running time and stop time), and after adding in the waiting time and the signal delay time (which don't change with stop spacing), the total door-to-door trip time for each passenger can be calculated. An allowance can also be made for the variability in this travel time (which is calculated by sub-models within TRC BusModel) to arrive at an estimate of the total time which must be allowed by a passenger if they wish to arrive at their destination at a given time, on a given proportion of occasions. This travel time has been termed budgeted travel time (Richardson, 1980). The variation of budgeted door-to-door travel time with changes in stop spacing is shown in Figure 14. It can be seen that from the point of view of level of service offered to the customer, in terms of budgeted door-to-door travel time, an optimal stop spacing exists (for this catchment area structure) at about 400-500m.

The changes in budgeted door-to-door travel time shown in Figure 14 bring about changes in patronage, as expressed through the elasticity of demand with respect to travel time. This results in changes in patronage, as the stop spacing changes, as shown in Figure 15.

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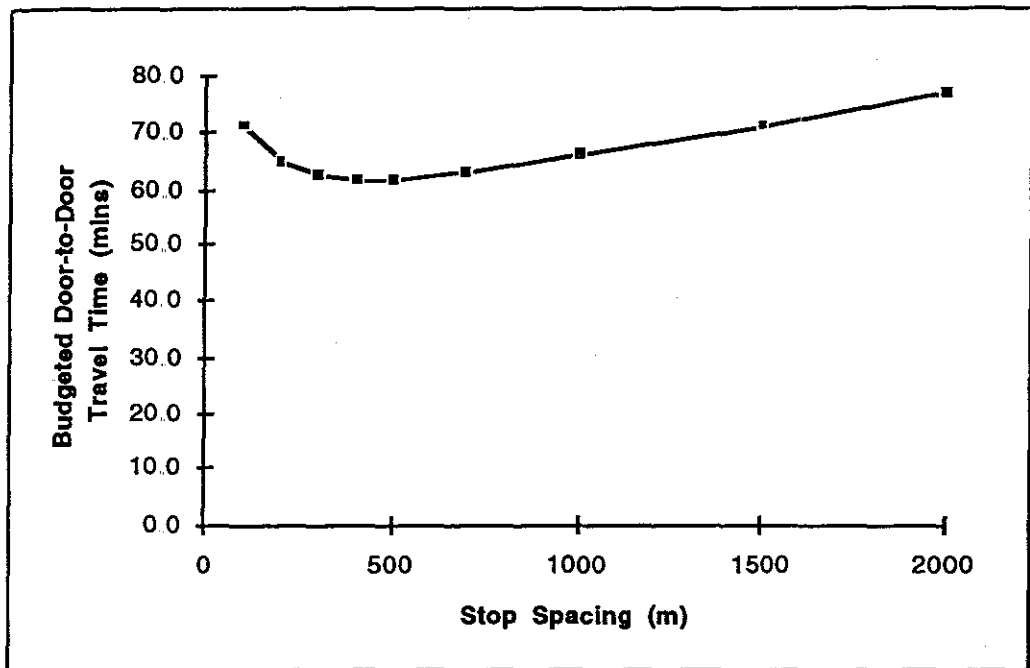


Figure 14 The Effect of Stop Spacing on Budgeted Travel Time

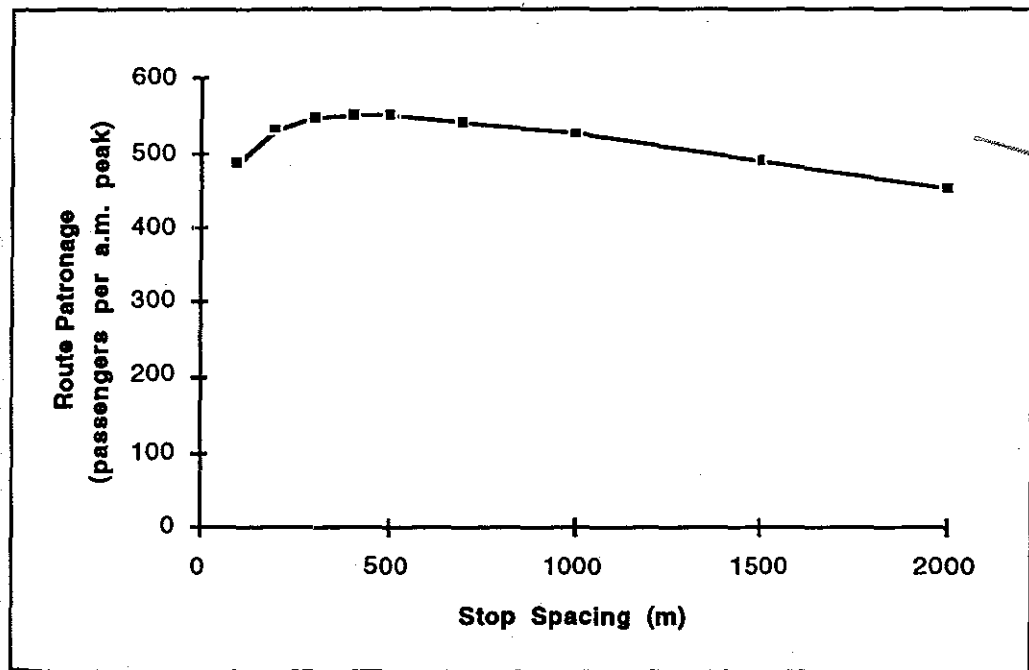


Figure 15 The Effect of Stop Spacing on Route Patronage

The changes in patronage, and in particular the changes in the time needed for buses to return to the start of the route after starting a run, necessitate a change in the required fleet size to service this route at the desired frequency, as shown in Figure 16. Because of the vastly increased running times for buses at close stop spacings, this requires a substantial increase in the required fleet size to service close stop spacings.

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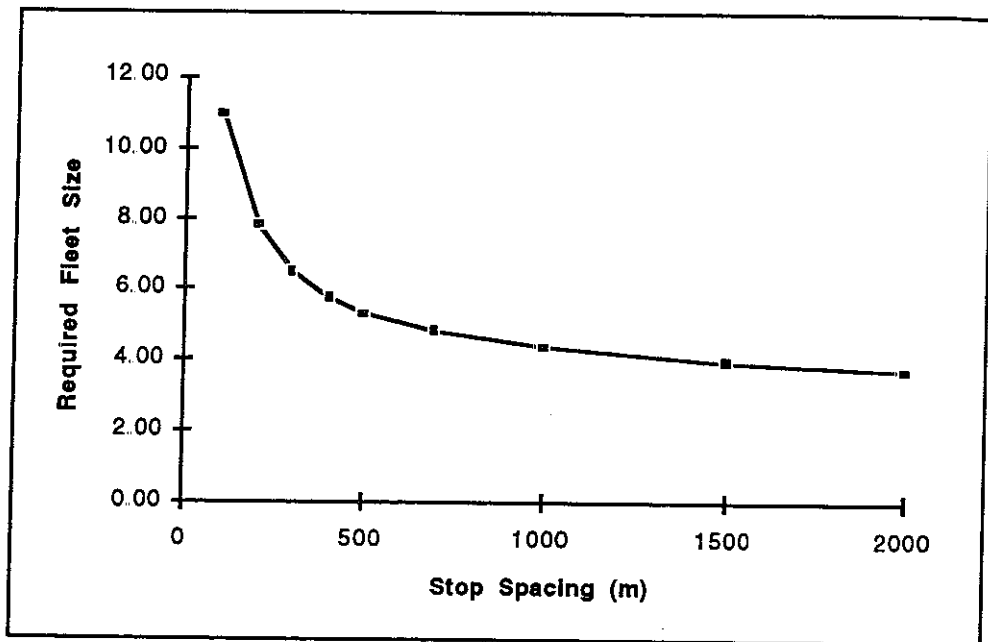


Figure 16 The Effect of Stop Spacing on Required Fleet Size

The various changes noted above, as a result of changes in the stop spacing, have two major impacts on the financial bottom-line of the operation. First, because of the increase in patronage as the stop spacing is increased to about 500m, there is a corresponding revenue increase. Second, because of the continuing reduction in fleet size as the stop spacing is increased, there is a reduction in operating cost as the stop spacing is increased. When these two factors are combined, there is a change in the annual operating profit of the service as shown in Figure 17.

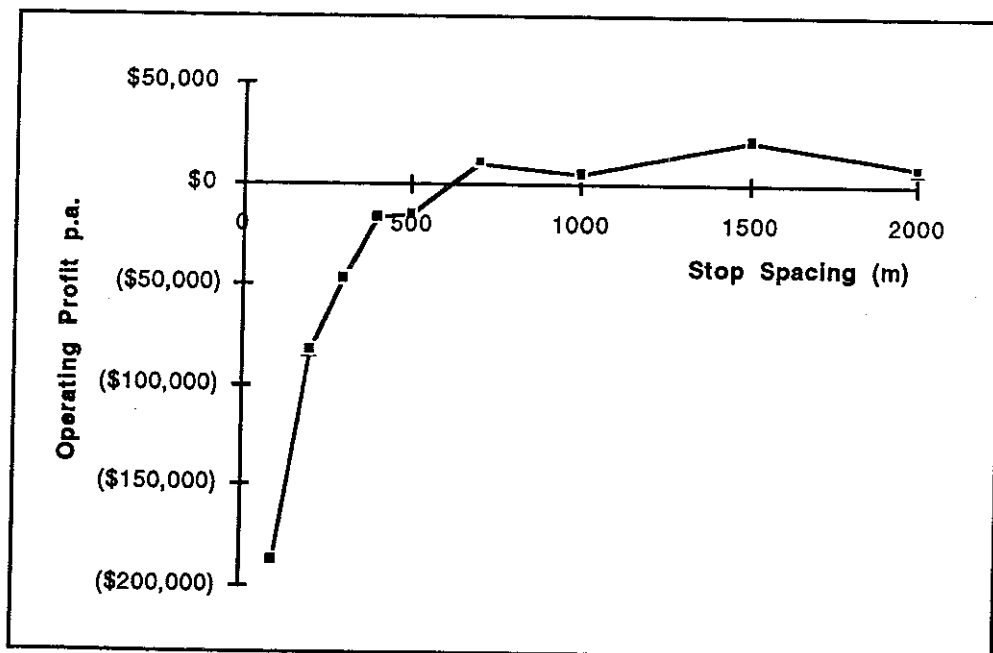


Figure 17 The Effect of Stop Spacing on Annual Operating Profit

It can be seen that the service makes an operating profit only when the stop spacing is greater than about 700m (and even then only a modest profit). Below 700m, the service makes a (sizeable) annual operating loss. The discontinuities observed in Figure 17 are due to the fact that the fleet size can only change by an integer number. The changes in operating cost therefore tend to be somewhat "lumpy".

The above example has demonstrated the sequence of changes that occur when one input parameter (in this case, stop spacing) is changed. Some of the changes are obvious (at least the direction of the change), but the model proves to be useful when combining the effects of counter-balancing changes which must be traded off against each other to obtain a net result. In this way, the second and third order effects can more easily be traced through the system, to see the final effects on patronage, revenue, cost and profit. The model also allows for the feedback effects which changes in patronage will have on the operation of the system.

The Effect of Variations in Fares

The TRC BusModel spreadsheet can also be used to trace the effects of other changes in system design. For example, the scenario described in the previous section assumed a fare structure of 40¢ per zone of travel, i.e. travelling from zone 1 to zone 2 would cost 40¢, travelling from zone 4 to zone 2 would cost 80¢ and so on. Under these conditions, it appears that the closest stop spacing at which a profit can be made is about 700m.

However, it is also possible to vary the fare structure and thereby estimate the effects of fare variations on patronage, revenue and profit, as shown in Figure 18. It appears that increased profitability can be obtained by increasing the zonal fares to 50¢ or 60¢ per zone. While less passengers are carried, the lost revenue from these passengers is more than made up for by the higher fares paid by the remaining passengers.

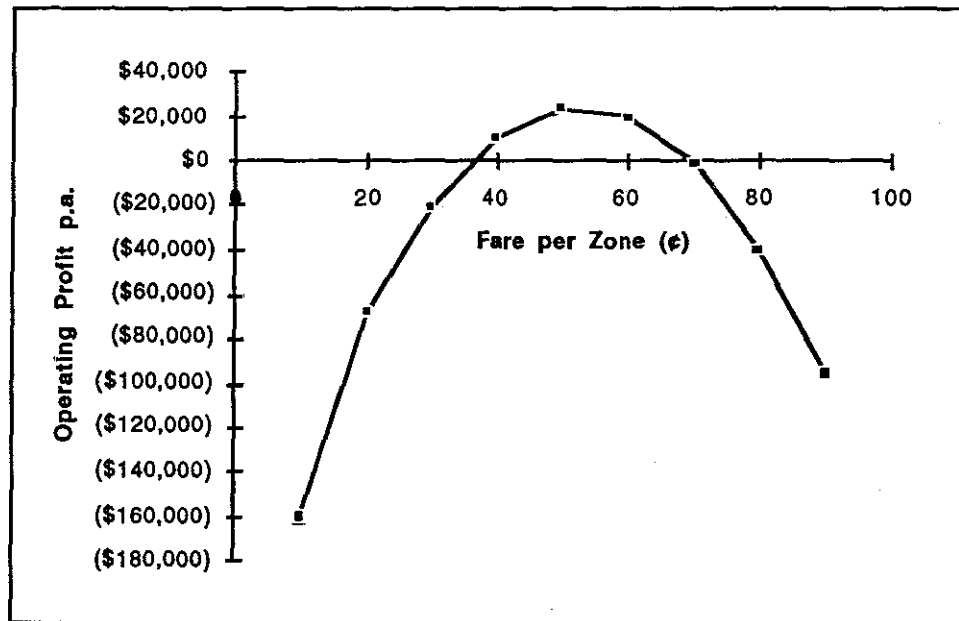


Figure 18 The Effect of Fares on Annual Operating Profit

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Operating Profit

The Effect of Variations in Headways

A further improvement in profitability can be obtained by experimenting with the frequency of the service. The above examples have used a fixed headway of 12 minutes. Perhaps it is possible to increase profitability by changing the service frequency (the inverse of headway). This can be easily done in TRC BusModel to produce the results shown in Figure 19.

It can be seen that decreasing the headway (increasing the frequency) produces a worse profitability situation compared to the existing headway of 12 minutes. On the other hand, increasing the headway, up to a headway of 20 minutes, increases the profitability. This is despite the fact that reductions in headway produce an increase in patronage, due to an improved level of service mainly because of decreased waiting times, while increases in headway produce a reduction in patronage. However, in order to operate a high frequency service, it is necessary to operate with a larger fleet size. Despite the increases in patronage, these are not enough to fill the extra buses and, as a result, the maximum load factor on the buses falls substantially (from 85% at a 12 minute headway to 40% at a 5 minute headway). Thus while some extra revenue is earned from the increase in patronage, this is more than offset by the large increase in operating cost for the bigger fleet. On the other hand, increases in headway drive away passengers because of the longer waiting times, but this reduction in revenue is more than compensated for by the reductions in cost in operating a smaller fleet.

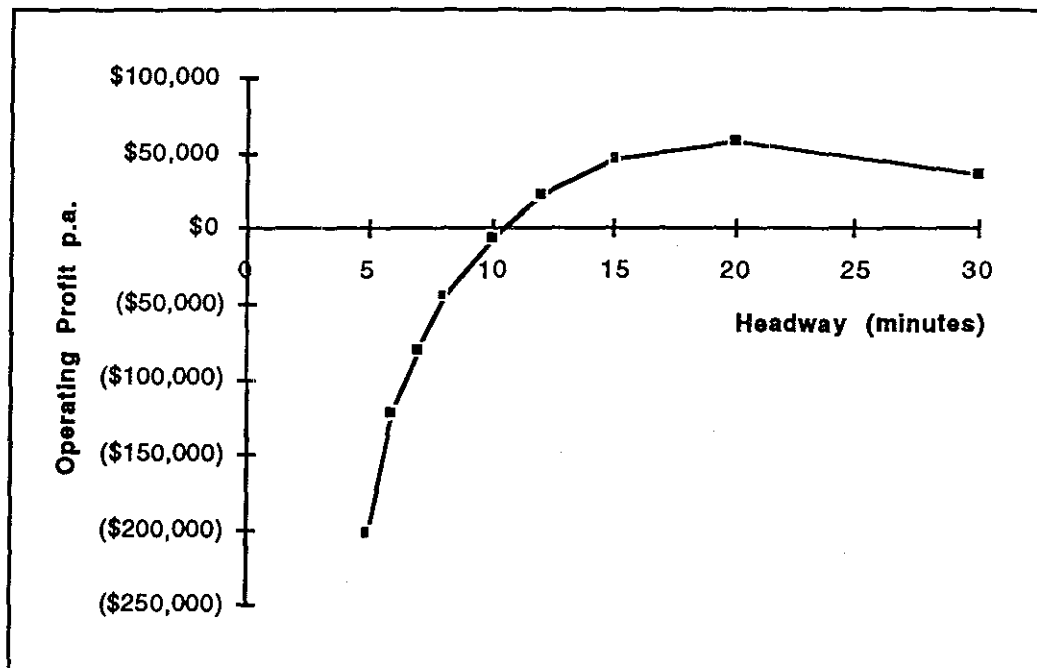


Figure 18 The Effect of Headway on Annual Operating Profit

Here, then, is a classic trade-off between the economic, environmental and social costs of operating a public transport system. It appears that the service can be operated more profitably by offering a lower level of service (in terms of reduced frequencies).

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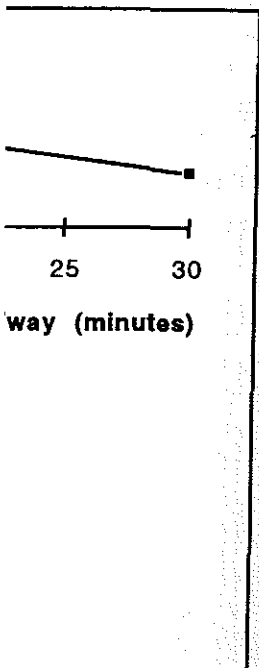
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However, the story does not end here! Perhaps the passengers would have been willing to pay more for the better service, and that by increasing the fares for the higher frequency service, the service could have been restored to profitability. Or maybe, the reduction in load factor could have been corrected by using smaller vehicles at the higher frequencies, thereby saving on operating costs for these smaller vehicles (as well as charging a higher fare to raise the revenue levels). Also, if smaller vehicles had been used, then perhaps the walking distance could have been reduced by "taking the vehicles to the people"; but then this may have increased the in-vehicle time. Clearly, there are almost endless combinations of input parameters which could and should be tested before arriving at a final decision. TRC BusModel can be used to test these combinations to help the designer obtain a better feeling for the trade-offs involved.

5. CONCLUSION

Designers and operators of public transport systems are continually faced with trade-offs as they attempt to design services which meet the social and environmental objectives of the community at a reasonable economic cost. These trade-offs may occur at the highest policy levels when global decisions are required about the future of public transport systems, or at the level of the design of individual routes which comprise the system. This paper has attempted to outline the nature of these trade-offs by reference to three "models"; the architect's triangle model, a conceptual model of public transport operations, and a pedagogical spreadsheet model which operationalises the conceptual model. The latter model is then used to highlight some specific trade-offs which need to be made in route design, when considering stop spacing, frequencies and fares.

The major advantage of the TRC BusModel spreadsheet is that it ties together the various aspects of public transport route and system design within a relatively simple framework. The operational performance of the system, which is of interest to the operator and is essential to rational costing of the service, is linked to the levels of service offered to the passengers. Changes in one area can then be traded off against consequential changes in the other.

For example, is it worth improving the level of service to the passenger if it means that the cost of providing the service is also going to increase? The answer to this question depends on whether the operator has the freedom to alter fares in response to changes in level of service. If operators do not have the flexibility to increase, or decrease, fares in order to defray costs or increase patronage, then a vital connection in the model has been severed. This will mean that operators will lose the incentive to improve levels of service, since they know that this will increase their costs, but they also know that they cannot increase their fares to cover these costs. Unless the increase in patronage is sufficient to cover the increase in costs, the end result is that operators will lose money by trying to improve the service. Thus service levels will remain stagnant, or worse still they will decline as operators try to find ways to save costs (and hence reduce levels of service) within a constant fare scenario. Only by seeing that levels of service and fares are inextricably linked, can we move public transport into an upward spiral of improving levels of service and increasing levels of customer satisfaction.

To quote a well-know television commercial for Scotch Whisky, "What would you prefer - the Scotch you can afford, or the Scotch you want to drink?"

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