FLEXIBILITY AND EFFICIENCY IN ALLOCATING BUS DRIVERS SHIFTS

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ABSTRACT: *Brisbane City Council operates the public bus system in Brisbane using approximately 550 buses. In an effort to reduce resource requirements the work allocated to a driver (his run) may involve a number of trips on different routes. Understandably this increases the complexity of the runprinting task when alterations to services are contemplated. It has been argued that by increasing the level of blocking in the runprint ie the number of runs or drivers shifts allocated to one route or set of routes, the runprint response time could be shortened. The authors have examined the weekday runprints for the largest bus depot to examine the cost effectiveness of the thesis.*

BACKGROUND

One of the greatest advantages a bus system enjoys over other public transport modes derives from its shared right of way with the private motor vehicle. The flexibility this provides can be used in either the spatial or temporal dimension.

The temporal benefit is used when the bus system is easily adapted in response to changing travel demand patterns. An express bus service can be instituted for example without worrying about conflict with other all stops vehicles. Advantage is taken of the spatial characteristic by using buses to do trips on different routes, thereby making efficient use of the varying weekday level of bus demand throughout the metropolitan area. Alternatively two or more drivers may work on one trip to optimise resource efficiency within award constraints.

However, there is some concern that in seeking efficient driver utilisation by allocating work on more than one route during a single shift, the temporal flexibility of the bus system is greatly diminished. A route linked driver shift operation, whilst efficient in use of resources, may be costly from the viewpoint of reacting quickly to new challenges. It is said this is because even a small alteration could lead to changes in many runs in such a system. At the present time the process of runprinting is the critical point in determining the response rate to changes in the Department. Over several years it has been suggested that the runprinting response time could be reduced by significantly increasing the proportion of the Runprint in which work for each run is confined to a route or set of routes. Such a Runprint is expected to lead to simpler and thus quicker response times for runprinting alterations.

This paper explores the thesis that increasing the number of runs in the Runprint which are confined to a route or set of routes will lead to a cost effective reduction in the runprinting response time for service alterations.

The terms used in this paper are defined in the Glossary.

THE EXISTING SITUATION

Blocking at Light Street Bus Depot

Brisbane City Council's Department of Transport operates three bus depots; Light Street, Carina and Toowong. Just under 200 buses are garaged at each depot. To begin the analysis the authors decided to examine the weekday runprints of the Council's Light Street Bus Depot. Light Street was chosen as this was the largest of the three depots. The weekday runprints were examined because these comprise the great bulk of the work performed and are subject to most changes. The Runprint was that operating in July, 1982.

Analysing the current degree of blocking required the formulation of a number of categories into which the different types of runs could be grouped. These categories are described below:-

(i) Fully Blocked (one route) is a run which operates on one route for the entire shift.

(ii) Fully Blocked (two routes) is a run which operates on one route only for the first portion of the shift then, after the break, on a different route for all of the second portion of the run.

(iii) Half Blocked is a run which has only a half shift (either before or after the break) operating on one route.

(iv) Not Blocked are runs which have a day's work linked between trips on different routes in both shift halves.

Waiting time runs were included in the analysis. To categorise each run, the principle of maintaining the blocked schedule/runprint integrity was used. That is, if it was clear that the runprinter had organised the work following scheduling guidelines it was considered blocked. The following principles illustrate this approach.

(i) If work was confined to one route (Enoggera/Chermside) or set of routes sharing a common linehaul for the majority of the route it was considered blocked.

(ii) If one regular trip on a different route between the Depot and point of taking up or leaving blocked work was made, the work was considered blocked (so long as the trip ended at the point the block work began or finished and there was not substantial waiting time or increased travel time involved). This practice makes efficient use of otherwise dead running.

(iii) In Brisbane buses operating local services such as school trips are called District buses. A run where district work was allocated was only considered blocked when the bus returned to the same route or route group after the District work was completed or if the district work was at the beginning or end of the half shift.

(iv) Even where a bus spent waiting time at a depot between trips on different routes the work was not considered blocked. This situation arises when much of the work is blocked and isolated trips have to be run on several routes to augment services.

The results of the analysis are presented in Table 1. Assuming two half blocks are equivalent to one blocked run, 74 percent of the weekday Light Street Runprint is blocked.

TABLE ONE

BLOCKING OF LIGHT STREET DEPOT WEEKDAY RUNPRINT

Category	Number of Runs	Percent
Fully Blocked (one route)	35	15.2
Fully Blocked (two routes)	79	34.3
Half Runs Blocked	41.5	18.0
Waiting Time runs	14	6.1
Equivalent Blocked	169.5	73.6
Not Blocked	19	8.3
Half Runs Not Blocked	41.5	18.0
Equivalent Unblocked	60.5	26.3
TOTAL	230	100

note: Runprint was current for October, 1982.

Blocking in a Typical Route

The authors were suprised at the 74 percent level of blocking revealed earlier. It was thought desirable therefore to attempt a runprint of a typical route, using standard runprinting procedures, to see if a similar level of blocking resulted.

Bardon - Stafford route 144 was chosen for the simple reason that a man-hour graph was available. It is one of Brisbane's typical old "tramline" routes served by a twelve minute daytime off-peak frequency[1]. The route has two suburban termini and is linked through the City and Fortitude Valley.

Figure 1 shows the man hour graph and Figure 2 the men in service graph for Bardon - Stafford route 144. The man graph shows a relatively high off-peak usage of 9 drivers while 16 are required for the evening peak. The authors found at least 70 percent of work could be blocked. Thirty percent of work had spare time available and would need to be combined with other routes or be available for district trips to make up time.

This small analysis demonstrates why the level of blocking in the Light Street runprint is so high, even though runprinters seek to save resources by using drivers to cover small periods of work on different shifts. Much of the work can be efficiently blocked. Only a minority needs to be linked.

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1 Since writing the paper Bardon-Stafford route has been eased to a fifteen minute clockface frequency in the daytime off-peak.

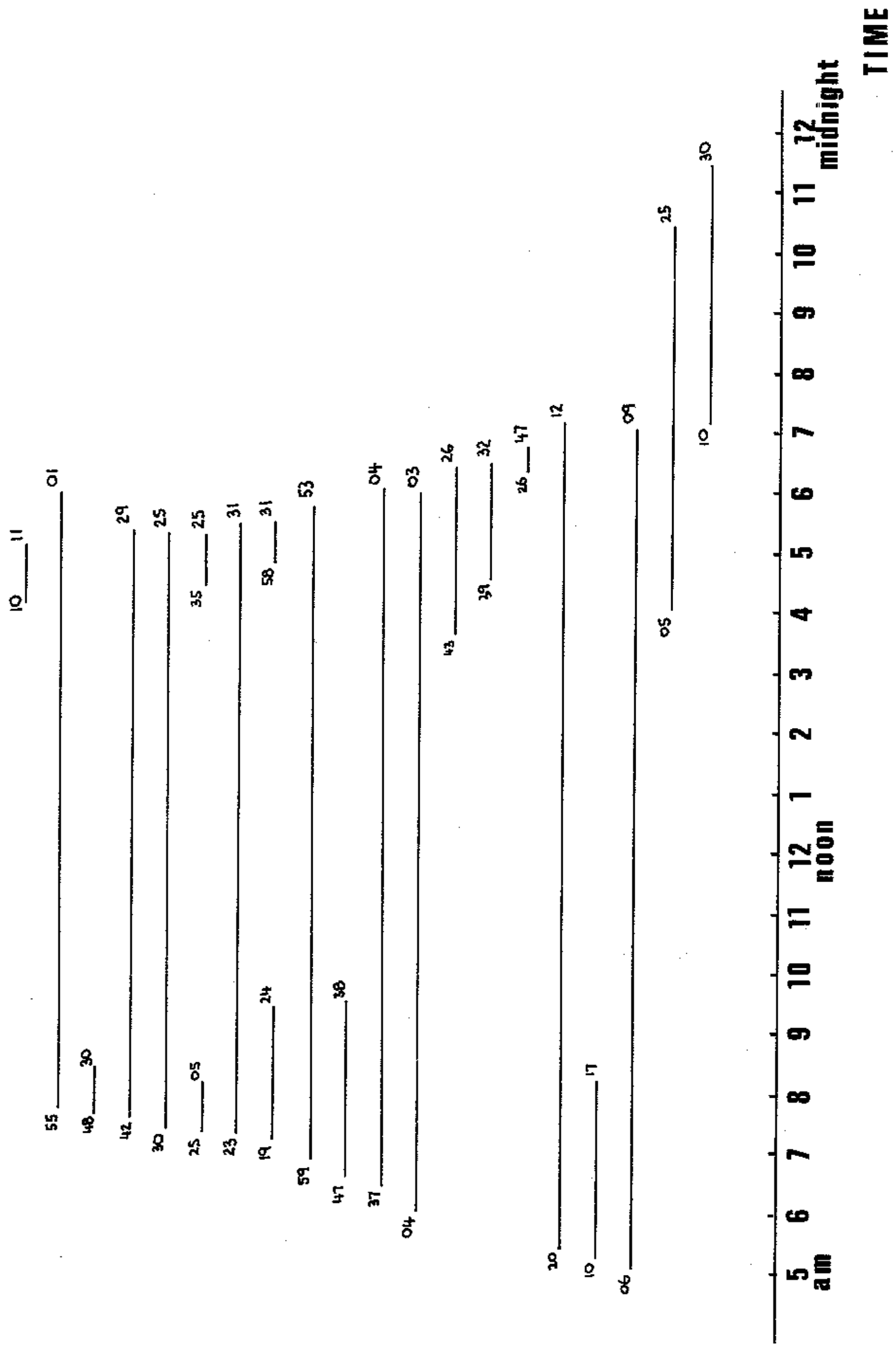
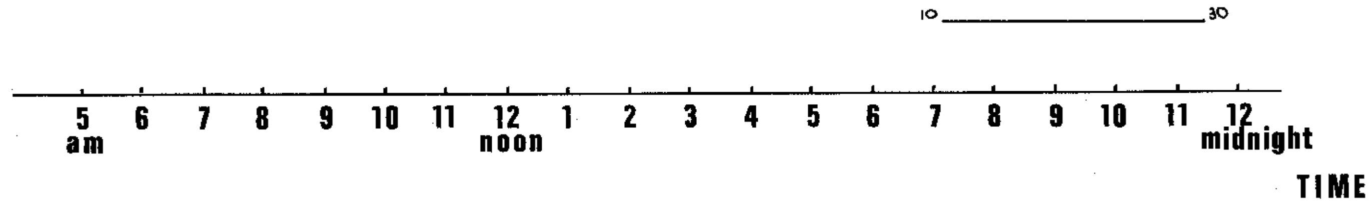


FIGURE.1.

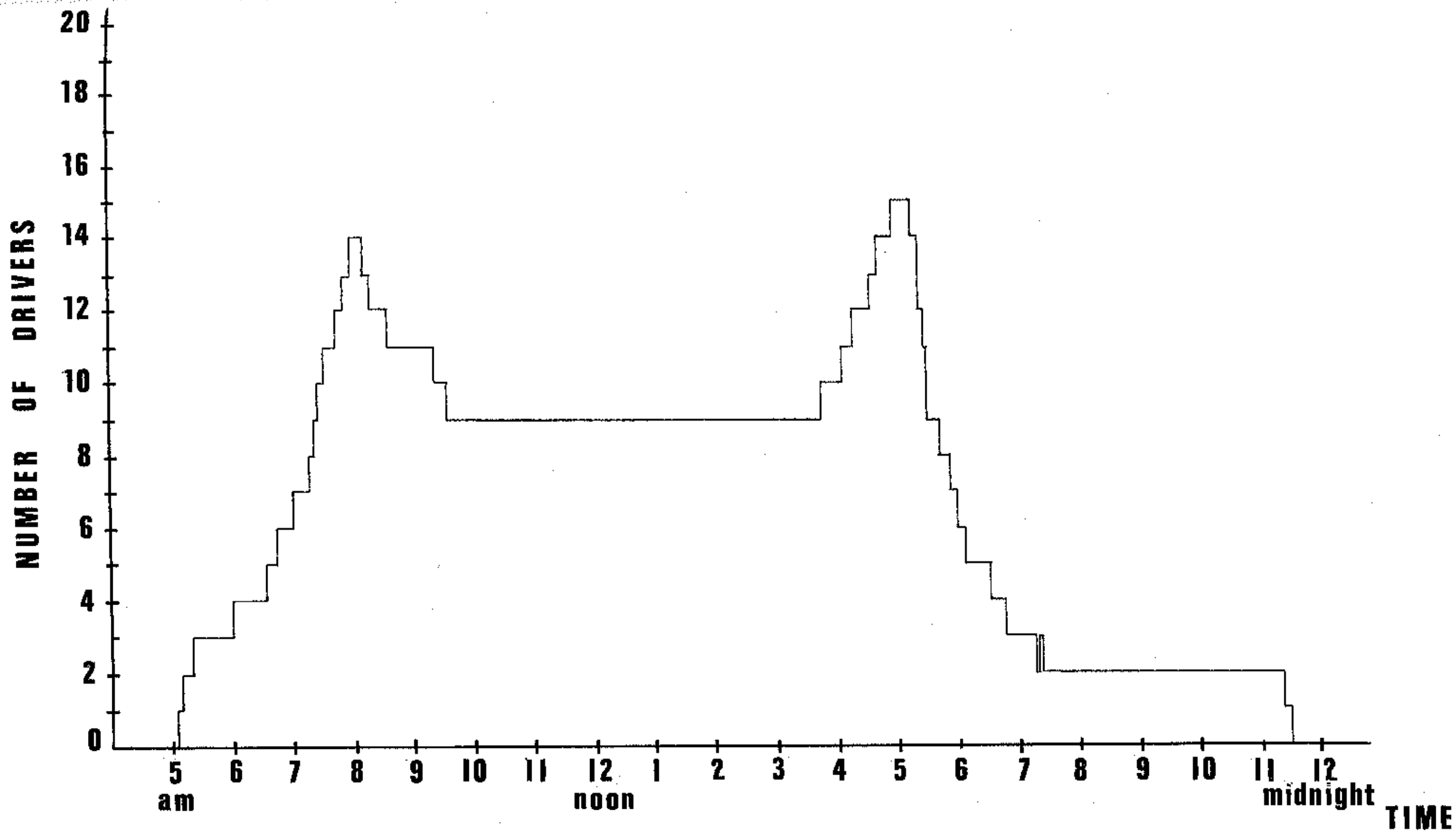
MAN HOUR GRAPH



MAN HOUR GRAPH

BARDON - STAFFORD

FIGURE .2.



MEN IN SERVICE GRAPH

BARDON - STAFFORD

Summary

The examination of the Light Street weekday Runprint has shown that the level of blocking is 74 percent. A cursory examination of the Carina Depot runprint revealed a similar level of blocking. It is also expected a similar level of blocking would occur at Toowong Depot, as the same scheduling/runprinting staff perform work in all three depots. It follows that if blocking leads to a reduction in the runprinting response times, at least some of these benefits should already be being realised.

The level of blocking can only increase from 70 plus percent to 100 percent. The next section examines whether there are any theoretical constraints to this sort of increase.

THE THEORY OF THE LEVEL OF BLOCKING

Theoretical Limits to Blocking Runprints

There are differences in the passenger demand/environment characteristics of an urban area by time of day which affect provision of public transport.

In peak periods, the demand for bus travel increases. This demand is also highly directional. More buses are required to supply capacity in the peak direction only. Express and Rocket services are operated mainly in peak periods. The extra passenger demand increases the average number of boardings and alightings per trip and consequently the bus travel times in the direction of peak travel. This is exacerbated by the environment of the road system where private vehicle demand leads to traffic congestion. Running times of trips vary throughout the peak on each route. The ratio of peak/off-peak running times can reach 1.5:1. During and after the morning peak and generally prior to the afternoon commuter peak there is a considerable demand for bus travel by mostly students on regular and district bus trips.

During off-peak periods, passenger demand is generally more constant, less directional and traffic congestion is not such a problem. Running times on all routes are reasonably constant.

These different operating environments mean that the Department generally supplies buses according to demand in peak periods and for District services, but operates policy headways in the off peak.

It can therefore be seen that more buses operate during peak periods on trips with varying travel times. It follows that although vehicle work can reasonably be blocked in the off peak and at nights, the variable travel times and increased number of regular and district trips make complete blocking infeasible during peak periods. Blocking of all work would require more buses and drivers to be used during peak periods. Studies[1&2] in other Australian capital cities have demonstrated that it is peak period resources which contribute most significantly to the cost of operating a large public bus system.

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1 "Adelaide Bus Costing Study" report by R. Travers Morgan Pty. Ltd. for the Director General of Transport, South Australia, March, 1980.

2 "Melbourne Public Transport Study" report by Pak-Poy and Kneebone Pty. Ltd. for the Ministry of Transport, Victoria, 1980.

The Blocking Argument

From experience the authors expected to find a relationship between the extent of blocking of the Runprint and the resources used of the form shown in Figure 3. This postulates that a minimum resource point MR exists such that changing the level of blocking would result in an increase in resources.

However, it has been stated that increasing the level of blocking, even though it may result in an increase in resources, may be cost-effective as beneficial changes can be introduced more rapidly. If this is so the real system optimal point for blocking the Runprint O' would occur when the marginal rate of return for reducing the runprint response time, equalled the marginal cost of the extra resources required by increasing the level of blocking in the runprint.

This argument for temporal flexibility can therefore be represented graphically. Assume a project produces a positive uniform benefit over time. Under the present system the project can be implemented at time A in Figure 4. A uniform increasing benefit occurs the earlier the scheme can be implemented. This is represented by line BA. The intesection of the abscissa by the ordinate represents that point where runprinting commenced. If increasing the level of blocking (and thus the use of resources and expenditure) is a cost effective means of increasing the runprinting throughput this can be represented by the cost curve CA. If it is not cost-effective a curve such as C'A is expected.

Thus in seeking to clarify the relationship between the two curves there are two aspects to examine.

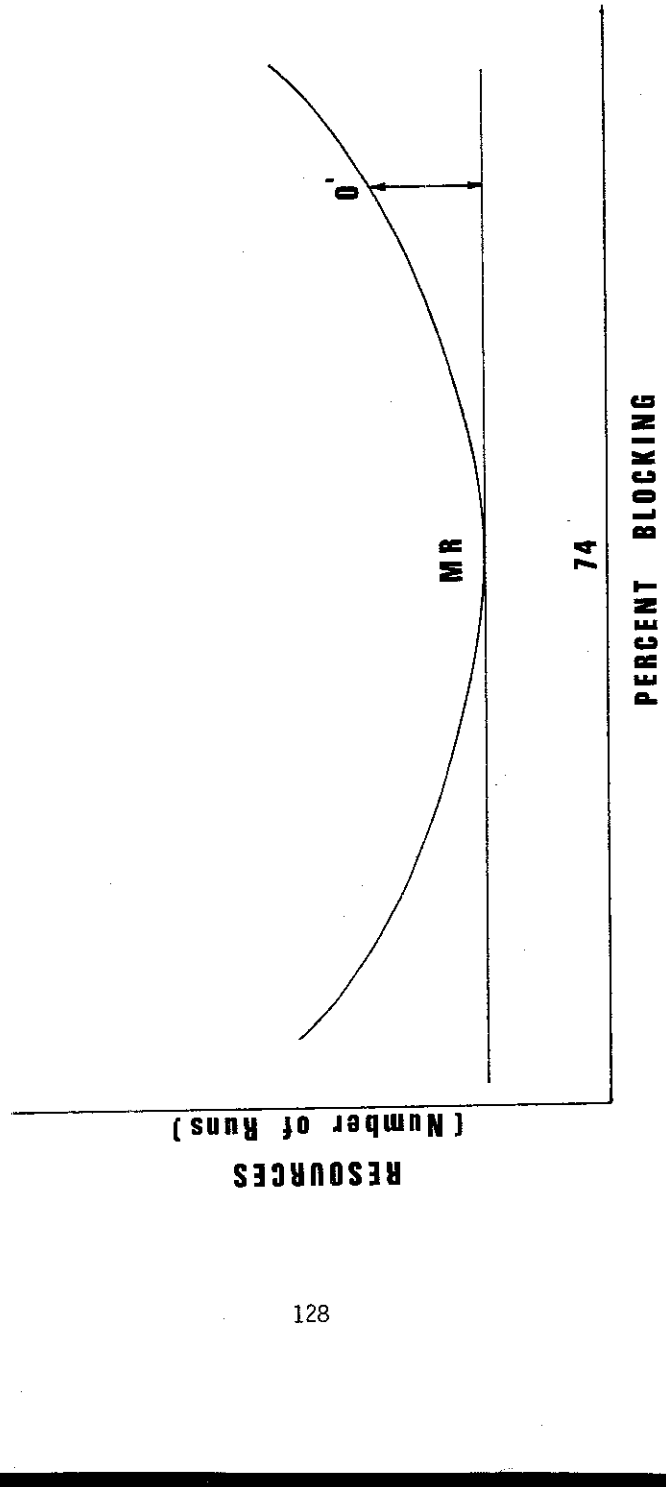
(i) the relationship between the level of blocking of the Runprint and resource use.

(ii) the thesis that increasing the level of blocking will lead to simpler and thus quicker Runprint alterations.

COST EFFECTS OF CHANGING THE LEVEL OF BLOCKING

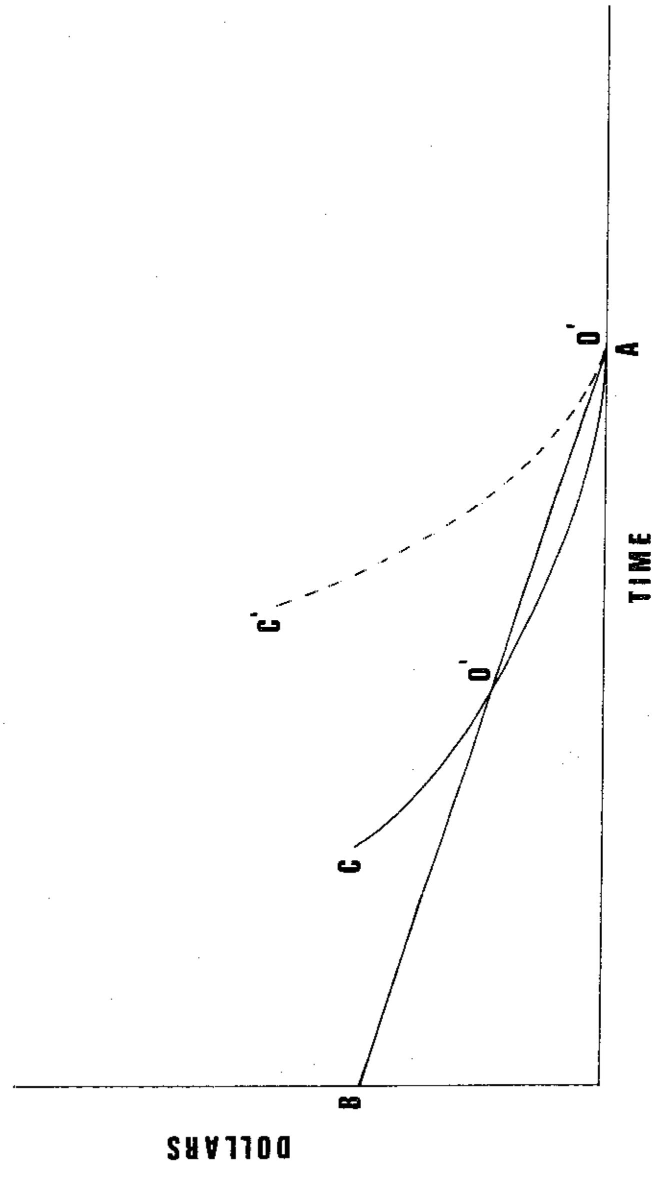
In order to determine the relationship between the level of blocking and change in resource use it was decided to use the Light Street Depot weekday runprint examined earlier. This makes the assumption that the bus operation implicit in the runprint provides a suitable base to assess fairly the effect of changing the level of blocking. The authors believe this to be so. Initially work that was not blocked was altered so that it met the blocking criteria. Where this led to a "hole" in the Runprint extra resources were provided. This procedure was reversed when a reduction in the level of blocking was sought. Each change was plotted and the sum of the alterations resulted in the graph of Figure 5.

FIGURE .3.

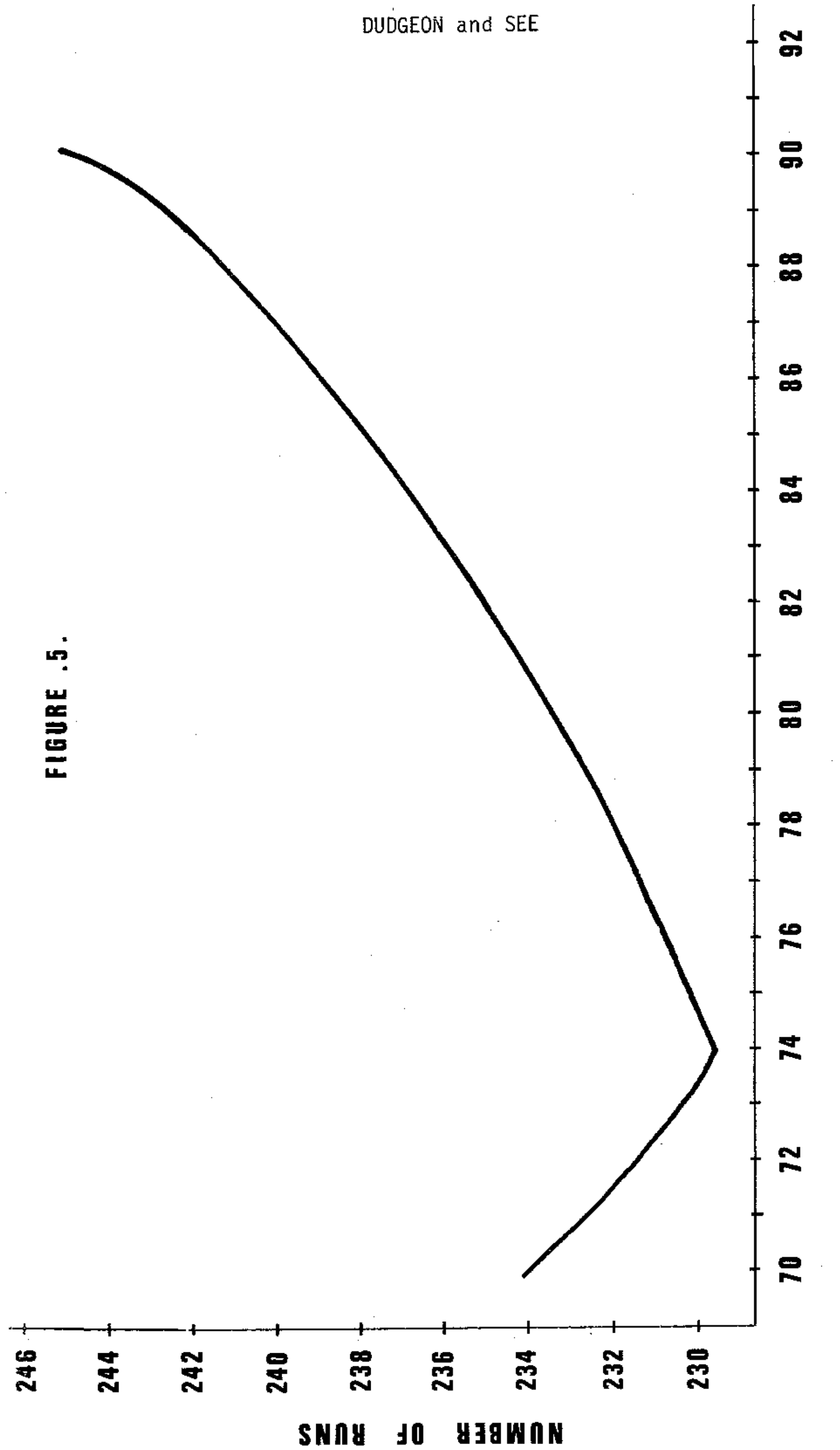


RESOURCES vs PERCENT BLOCKING

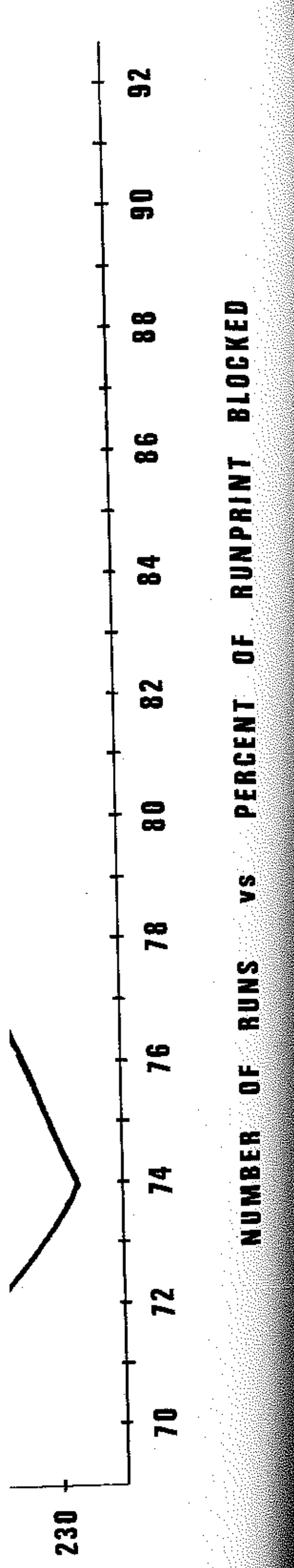
FIGURE 4.



DEFINING THE SYSTEM'S OPTIMAL BLOCKING POINT



NUMBER OF RUNS vs PERCENT OF RUNPRINT BLOCKED



It can be seen that the expectations of the authors were satisfied. A change in the level of blocking from the present point very soon causes an increase in the use of resources, in this case runs. (While not all runs have the same cost the changes produced runs with a much higher incidence of waiting time which increased costs). That changes led to an increase in resources should not be entirely unexpected as public transport systems in Australia have been operating in a deficit situation for some years. Consequently there has been an increasing emphasis on the runprinters to produce the most efficient runprint to operate the Traffic Plan.

It also appears that changing the level of blocking leads to an exponentially increasing use of resources. This also is expected from an understanding of the bus operating environment described earlier. Increasing the level of blocking of the Light Street weekday runprint from 74 to 90 percent is achieved at the cost of 15 runs. This is an increase of 6.5 percent in existing bus drivers. Using current average weekly wages this represents an increase of $400,000 per annum, including on costs. Unfortunately, because most of the unblocked work was during peak periods, the increase in runs would also be associated with an increase in bus demand, bus kilometres and maintenance. While no detailed record of this increase was calculated the authors believe the extra costs would approximately equal the increase in driver costs. It is estimated therefore that increasing the level of blocking of the three weekday runprints to 90 percent would cost at least $2 million per annum for the Council bus system.

There would obviously have to be a great reduction in the runprint response time for this to be a cost effective strategy.

FACTORS AFFECTING RUNPRINT RESPONSE TIME

To assess whether changing the level of blocking in the runprint will lead to simpler and thus quicker runprint response times two things are necessary. There must be an understanding of the runprinting process and the types of possible changes.

The Runprinting Process

Essentially the runprinting process is divided into two components

(i) strategy time,
(ii) administrative time.

During strategy time the modified work is allocated into runs or blocks which can be reincorporated into the runprint. This is the time required to think through the process. The new runs or blocks are constrained by the need to satisfy the current drivers award. Administrative time is that used for the writing of roughs, typing, checking, gaining approval and production of supervisory material.

The authors were advised by Mr Robinson, Acting/Senior Timetable Officer (A/STTO) that of time allocated for runprinting, approximately 10 to 40 percent is strategy time. The other 60 to 90 percent is administrative time. Before commenting on the possible improvement in runprint response time of a blocked system compared with the present system it is necessary to consider the types of scheduling/runprinting changes.

Types of Scheduling/Runprinting Changes

There are two categories of changes, those internal to or external to the block of work or run. Both types of changes can be made necessary be either an alteration in timetabling/scheduling, or it may be caused by a runprinting problem such as insufficient running time.

Before comparing the runprint response time of a blocked or the existing linked runprinting system two further aspects should be noted. Firstly, if any change can be accomplished by using excess layover time, the response time is independent of the system type. The administrative changes would be the same whether a blocked system or the present linked system is used. Such a change was recently implemented in Brisbane when route 37 was extended a kilometre to the nearby Toowong shopping centre. Secondly, if the change affected only the daytime off-peak, the same comment would apply. This is because the daytime off-peak of the existing system is already virtually blocked for efficiency reasons that were outlined earlier.

Consider changes external to a block (e.g. provision of an extra trip). As long as the award constraints on the time available between sign on/sign off and meal breaks are not broken, there is again no difference between the existing and blocked systems. The number of runs affected are the same. The recent provision of an extra McDowall trip is an example. If the above award constraints are broken, a blocked system is generally better. This is because in such a system extra resources will generally be required, a quick but expensive solution. In the existing system a cheap solution would be sought by reworking a number of runs, but this would take significantly more strategy time.

Alterations internal to a block are more common. For major alterations the blocked system will again normally demonstrate a time advantage and cost disadvantage over a linked system. For minor changes such as a late running bus problem or the provision of one extra trip a linked system will generally have a quicker and cheaper solution. A disturbance of this nature would be difficult to amend in a system of blocked work especially if layover was insufficient and if buses were not moved from route to route. The change would involve many runs and thus much strategy and run writing times. For a change of this nature linking of work between routes is a distinct advantage. It can result in fewer runs being changed as the work does not have to be reblocked. It can also mean the difference between requiring an extra bus and run or just an extra amount of overtime. Recent work in providing a bus to Algester departing the City at 9.10pm on weekdays illustrates this point.

Perhaps some changes don't fit neatly into the categories above. However, it is not immediately obvious that a blocked system leads to great reductions in the runprint response time. The reasons are twofold.

(i) It is not always appreciated that often it is the award that constrains the allocation of work to shifts rather than the complexity of changing linking trips between routes.

(ii) Secondly, the strategy time is the area where the difference in runprinting response between a blocked or more linked system is sometimes most apparent, but this is a relatively minor part of the runprinting process.

For most of the changes identified above the change in the administrative time between a blocked or more linked system would be virtually negligible.

Savings in Runprint Response Time

The runprinting process is the source of current delays, in project implementation. Any increase in runprinting throughput could be analogous to increasing the rate of implementation of new projects. Given the results of the various types of runprinting changes outlined above, the authors postulate that an average decrease of more than twenty percent in the strategy response time by increasing the level of blocking from more than seventy to ninety percent of the Light Street weekday runprint is likely. Table 2 shows the possible improvement in runprint throughput for the A/STTO's upper and lower estimates of strategy time as a proportion of runprint time. For completeness the overall improvement if there was a fifty percent reduction in strategy time is given.

TABLE TWO

PERCENTAGE IMPROVEMENTS IN RUNPRINT THROUGHPUT

	Lower Improvement	Upper Improvement
20% Reduction in Strategy Time	2	8
50% Reduction in Strategy Time	5	20

In the circumstances it is felt that a reduction in the runprint response time by about five percent is possible, if the level of blocking increased from approximately seventy to ninety percent. As the runprint process forms about thirty percent of the implementation phase for major alterations, the decrease in lead time for major alterations would be negligible.

The cost of increasing the level of blocking from 70 to 90 percent was estimated to be at least $2 million per annum. The Departments budget is approximately $44 million, in 1982/83. It is estimated that annual savings of approximately $1 million will result from a reduction in the frequency of service of some routes and the rationalisation of others this year. If more project savings could be achieved by a reduction in runprint response time a five percent improvement would save an extra $50,000 per annum. This would be achieved at a cost of $2 million per annum. So the value of the savings it may be possible to achieve by increasing the level of blocking are at a cost an order of magnitude higher.

It is immediately obvious therefore that the curve C'A and line BA in Figure 4 more closely represents the real situation. It follows that the real system optimal point O' for blocking the Runprint is synonymous with point MR of figure 3, the minimum resource point.

RESULTS AND CONCLUSIONS

This paper has examined the present level of blocking of the Light Street Depot weekday Runprint (and by inference those for the Department). The level of blocking is approximately 70 percent. The principles used to make this assessment are outlined.

There are theoretical and feasible limits to achieving a completely blocked print due to the differences between peak and off-peak operations. Peak operations have more augmented regular and express services, longer travel times, directional travel time differences and district bus operations. All these mitigate against completely blocking the runprints.

The runprinting process involves strategy time and administrative time. Strategy time, which increasing the level of blocking in the runprint <u>should</u> decrease, is only a minor percentage of the runprinting process and varies from approximately 40 to 10 percent.

Increasing the level of blocking in the Runprints from seventy to ninety percent would cost the Councils Department of Transport approximately $2 million extra per annum in resources. This may possibly increase the implementation of new projects by about five percent per annum resulting in savings an order of magnitude lower.

It is concluded that a strategy of increasing the level of blocking to produce an increase in project throughput is not feasible.

what about decreasing the amount of blocking?

GLOSSARY OF TERMS

The following definitions are used in this report.

Timetabling

Is the act of developing times at which buses should operate from a defined point or points of a bus route or routes.

Scheduling

Is the act of allocating buses to a series of times forming the timetable.

Runprinting

Is the act of allocating drivers to buses which have been scheduled to a timetable.

Block/Blocking

Is generally the activity of a bus from depot departure until it returns to arrive depot. The intent of the thesis is to restrict such bus allocations (and hence drivers) to one route or set of routes only. This more narrow terminology is used in this report.

The Runprint

The collection of runs for a days work at a Depot.

Waiting Time

Time in which the driver is on paid duty but has not been allocated any productive work.

Traffic Plan

All the bus trips in a day.

Dead Running

Work when the bus is out of service, normally either between route termini or to/from depot.

Cost recovery on Brisbane's 'Govt.' buses 40 : 24 : 36
↑ Fares ↑ State ↑ BCC