PROBLEMS WITH PLANNING AND MODELLING ROAD INFRASTRUCTURE IN A RAPIDLY DEVELOPING SATELLITE OF A MAJOR CITY

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ABSTRACT: *A study into the future road infrastructure requirements of a rapidly developing satellite area of Brisbane has recently been completed. The study involved both a reasoned approach to the development of a Recommended Road Network for the area, as well as a modelling approach to assist in determining priorities of development for that network. The following paper discusses the problems involved in both these study phases, and focusses on the approach to Gravity Model Calibration employed during the second phase. The paper provides some guidance to agencies contemplating future studies of a similar nature.*

INTRODUCTION

Background

Logan City is a rapidly developing Local Authority on the southern outskirts of Brisbane City, as indicated in Figure 1. It was initially gazetted as a Local Authority in June, 1978 to enable the problems of rapid development on the peripheral areas of Brisbane to be more effectively addressed. It is an area which has experienced very high population growth rates in the past (24% p.a. compound over the 1971-1976 period and 8% p.a. compound over the 1976-1981 period) and continued high population growth rates are anticipated to be a feature of the area for some time to come. The growth in employment opportunities in the area has been no less dramatic.

These growth rates have naturally posed acute problems for general infrastructure provision, including that of road space. Figure 2 shows the arterial/sub-arterial road network current in the area at the time of the study. It can be seen that there are a number of areas of existing development which lack an upper hierarchy road system to cater for through traffic. There are also other areas (e.g. the ribbon development on the northern side of the Pacific Highway) which, though served adequately now for their longer-distance and cross-highway tripping, will not be so catered for when Pacific Highway accesses are removed for safety and capacity reasons. Moreover, there are large areas still to be developed which currently lack any upper hierarchy road network.

It is clear then that adequate provision for through-traffic has not always been made in this area in the past, and that the scope for improvement of this situation in the future is great. Therefore, to complete connectivity of the existing arterial road system and to prevent any further conflict between low-capacity local roads and high volumes of traffic, a joint study by the Main Roads Department (Qld.) and Logan City Council was initiated into the future road needs of the area.

The aims of this study were to-

(a) Develop a Recommended Network and hierarchy of arterial/sub-arterial roads for the Logan City area;

(b) Develop Recommended Road Corridor Widths which could be used in conjunction with (a) to preserve corridors now for future road requirements; and

(c) Develop an affordable list of road projects, ranked in broad priority order, which would indicate priorities for development of the network defined in (a).

Approach to the Study

In recent years a distrust of transport planning models has developed. Moreover their usefulness in areas such as Logan City has been questioned. Because funds available for roadworks are commonly limited, it has been contended that roadworks requirements for up to 10 years can be adequately assessed using the judgement of a person with experience of the immediate and pending problems of the area under study.

In this study, the questions of the need for and the role of travel models were addressed and felt to be adequately answered. The approach adopted was to firstly rely on a reasoned assessment to develop the network hierarchy and corridor preservation widths. The travel models were then used to assist with the grouping of candidate road projects into broad priority order, thus determining network development priorities. Both approaches therefore found a valid role and details of each approach can be researched in more detail with reference to Main Roads Department (1982 a).

DATA COLLECTION/COLLATION PHASE OF THE STUDY

While the data requirements for the development of the future road network were fairly small, study staff were confronted with a very real problem regarding lack of Logan City travel data for the quantitative approach. An extensive data gathering exercise was therefore mounted with two broad aims:

(1) To provide reliable data on current travel to provide some assistance to the reasoned assessment of network requirements, and

(2) To provide the basis for development of travel models for the area.

Data were collected on the following:

(a) The extent and nature of the existing Arterial/Sub-Arterial Road Network

(b) Existing Traffic Flows over this Network.

(c) Demography and Land-Use.

(d) Existing Mode Choice throughout the area; and

(e) The nature of existing Travel Patterns in the area.

MODELLING A SATELLITE AREA

The approach adopted in (e) is perhaps worthy of comment.

A carefully designed roadside interview survey was carried out to determine the number of vehicle trips (by trip purpose and by origin/destination) both coming into and leaving an important cordoned sub-area in Logan City, delineated as Sector 1 (refer to Figure 1). This sub-area contained around 46% of the Logan City population. In meeting the above two aims, the survey provided information to -

(1) Further assist planners in their knowledge of how roads in the area were being used. The information thus gathered (see Main Roads Department 1982 b) provided an input to the reasoned development of the recommended network; and

(2) Enable derivation of partial trip-tables (by trip purpose) for the calibration of Gravity Models. (This is discussed in more detail further in this paper).

In relation to (2), the roadside interview method of data collection was considered to be much cheaper than a Household Interview. Large amounts of data were collected quickly and inexpensively, and though (in terms of the requirements for Gravity Model Calibration) the data were only partial with respect to zones and transport modes surveyed, no insurmountable problems arose with the handling of these data.

For full details of the Roadside Interview Survey, reference should be made to Sinclair Knight and Partners Pty. Ltd. (1981).

PLANNING ROAD INFRASTRUCTURE - DEVELOPMENT OF A ROAD NETWORK (AND CORRIDOR PRESERVATION WIDTHS)

Logan City, lying on the south-east fringe of Brisbane, has its existing road system dominated by north-south routes which are radial to the more central areas of Brisbane. In some cases these routes are inter-city highways connecting Brisbane to other centres. However as the area develops, there will be a clear need for non-radial and cross-highway routes to be established in the area, possibly in the form of a network grid. This was a consideration of overriding importance in planning for future road infrastructure for this area.

The recommended arterial and sub-arterial network was therefore developed on the following bases -

(a) that existing and already planned road reservations would need to be accommodated.

(b) that arterial roads on a broad 1-2 km grid seem appropriate for outer urbanised areas such as Logan City, when they are fully developed.

(c) that more highway overpasses and associated approaches would need to be planned to overcome the severing effect of the Pacific Highway through the centre of the area.

(d) that provision for long-term connections from the Pacific Highway through Logan City to the contiguous Local Authorities of Ipswich City and Redland Shire would need to be made.

The approach to this network development was basically a reasoned (or qualitative) one, and perhaps the most noteworthy conclusion that could be drawn from the experience was that the results obtained were found to be sound even when subjected to quantitative scrutiny. That is, the modelling process applied later in the study did not show the need for any more road network links than had been identified by reasoning during this phase of the study.

The network finally developed, and the recommended right-of-way widths to be used in conjunction with it for road corridor preservation, are documented fully in Main Roads Department (1982 a).

GRAVITY MODEL CALIBRATION

As a prelude to the application of the four stage travel demand modelling process, it was found necessary to calibrate Gravity Models.

Previous work on calibrating Gravity Models using partial matrices has been reported by Neffendorf and Wootton (1974) and Gaudry and Lämarre (1980). In these studies, partial trip tables for calibration were derived from surveys conducted along a screenline passing through the entire study area. In the study reported in this paper, however, a complete cordon was used to encompass the most important region within the study area (sector 1) and complete travel data on movements into and out of this sector were obtained by roadside interview. This sector 1 cordon was chosen to cover as much of the important area of Logan City as possible, consistent with the perceived impracticality of surveying the heavily trafficked Pacific Highway. The resultant observed trip matrix contained no information on some traffic movements, and incomplete information on others.

The Gravity Model which was calibrated using these data is contained in the U.T.P.S. computer program"AGM" and is of the form -

$$T_{ij}^{P} = K_{ij}^{P} \cdot P_i^{P} \cdot A_j^{P} \cdot f(C_{ij})^{P}$$

where $f(C_{ij})^P$ is the Travel Impedance Function Curve (or F Factor Curve) being calibrated. It is a synthetic curve which attempts to account for the reduction in trip making which is caused by difficulty of travel between zones. The cost of travel between any two zones i and j, is represented by C_{ij}; and

K_{ij}, P_i, A_j and T_{ij} are as normally defined for Gravity Models.

The superscript "P" throughout the above definition is used to denote that the observed trip matrix is partial.

The method used to achieve calibration was to input a trial F Factor curve and to adjust this curve iteratively until a good match was achieved between the trip length distributions of P_i^P. A_j^P. $f(C_{ij})^P$ and T_{ij}^P. Early problems were experienced with this method in that the model produced synthetic trips between all sectors of the study area. Some of these sector-sector interactions had to be eliminated however, since the partial observed trip matrix contained no information on this travel These problems were overcome by applying the following additional constraints on the modelling process -

(a) Cells of the travel impedance matrix for which no observed travel data existed were assigned very high impedance values.

(b) All cells of the observed trip table for which little data were available were set to zero, and

(c) The K Factors for all zonal interactions other than from or to Sector 1 were set very low.

The final F factor curves developed for each of the four trip purposes (HBW - Home based work, HBO - Home base' other, NHB - Non home based and CVEH - commercial vehicle) are shown in Figures 3 and 4. It is interesting to note that the three private vehicle trip curves have peaks in their lower ranges. This is unusual in that F factor curves would normally be expected to continuously decrease from low values of travel impedance to high.

This inconsistency in the F factor curve was attributed to the small number of trips of a short duration actually surveyed in the study. Unfortunately there were also no intrazonal trips recorded in the survey which further added to the problem.

It was therefore thought reasonable to simply extrapolate the curves as shown in Figures 3 and 4. These extrapolated F factor curves were then accepted as the calibrated F factor curves for each trip purpose

MODELLING ROAD INFRASTRUCTURE

The Process Employed

The modelling process applied in the study was a conventional four stage travel demand one, and details of the exact process employed are documented in M.R.D. (1982 a). Once the Gravity Model Travel Impedance Function Curves had been calibrated by the method described above, the modelling process was applied to achieve Base Year Calibration (see Table 1 for accuracy achieved) and thereafter to investigate various road network development options for the 1986 and 1991 planning horizons. The process of achieving the most desirable network for each planning horizon was an iterative one, involving selection/elimination of candidate road projects until the most tolerable network overload situation was obtained for that planning horizon.

At any given iteration, network development could be described by making reference to both the Base Year Road Network and a list of arterial/sub-arterial road improvement projects. These projects were ranked in broad priority order, and were chosen so that an approximate balance between funds needed and funds available would result. This list was referred to as a Schedule of Recommended Works, and its aim was to guide the drafting of future Works Programs for roads in the area.

The final Schedule of Recommended Works developed entailed a number of changed network development priorities from that contained in an initial first-cut Schedule which had been drafted using a reasoned approach. In this way, the modelling approach justified itself in a quite tangible way.

Problems Encountered in the Modelling Process

In this study, Logan City was modelled at a level of fine detail while Brisbane City and its environs were modelled at a much more aggregated level. This was necessary so that the important interactions with Brisbane City could be modelled and so that modelling of this wider area did not involve unnecessary computing expense. However, because of this disparity in zone size, a number of peculiar problems arose with Base Year Calibration.

It was found that the larger Brisbane zones were interacting too much with Logan City zones, resulting in high and unrealistic flows in a general north-south direction. This arose because, with such large Brisbane City zones to the north, the number of trips coming out of these zones was too high. With such a size of zone, the number of intrazonal trips needed to be much higher than normal since areas within these zones would be interacting highly between themselves.

It was further found that the proportion of intrazonal trips within these zones could not be increased to the required levels by artificial reduction of their intrazonal impedances. This was because of the finite value ascribed to the F Factor at even zero intra-zonal impedance Therefore, to overcome the problem, non-unity values of Kij (refer to the Gravity Model formulation) had to be derived for these zones.

CONCLUSIONS

(a) Rapidly developing satellite areas of major cities would appear to be prone to road traffic problems induced by the lack of development and continuity of their upper hierarchy road system. It seems essential that road planning for such areas be undertaken early so that preservation of future road corridors can be undertaken either before or preferably in conjunction with land development.

(b) Planning for a future arterial/sub-arterial road network can be successfully accomplished by means of a reasoned (i.e. non-quantitative) approach. In the study undertaken, the network developed was found to be sound, even when subjected to quantitative analysis.

(c) On the other hand, modelling of the proposed future network has a valid and useful role in the determination of priorities for development of that network In the study undertaken, a conventional four stage travel demand modelling process was implemented and a number of network development priorities were changed as a result.

(d) Costs of data collection for the modelling approach can be minimised by undertaking a carefully designed and relatively inexpensive roadside interview survey. The data derived in this way can be used to construct <u>partial</u> trip tables from which Gravity Models can be reliably calibrated. The paper has given an account of how this was achieved in the study, being based on earlier work by Neffendorf and Wootton (1974). Means of adapting the process using UTPS programs have been shown to be workable.

(e) Modelling a satellite area as part of a wider conurbation presents some difficult (though not insurmountable) problems if the wider area needs to be modelled coarsely for reasons of economy.

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TABLE 1

BASE YEAR MODEL CALIBRATION
FINAL 1981 SCREENLINE CHECKS

Screenline	Link Nos	Assignment	Traffic Count	
Brisbane R.	247-248	43565	51142	
	273-274	222097	196094	
	Total	265662	247236	+ 7.5%
Western Screenline	237-238	21000	17770	
	125-239	7800	9135	
	165-234	2800	3446	
	185-234	2100	5410	
	Total	33700	35761	- 5.8%
Mt. Lindesay Highway	231-232	13700	13600	+ 0.74%
Beenleigh	196-197	2900	4500	
	205-206	35200	33408	
	Total	38100	37908	+ 0.51%
Pacific Highway North	102-256	41600	43370	
	100-262	16400	14970	
	100-264	0	510	
	Total	58000	58850	- 1.4%
Ipswich Road	244-245	34900	33874	+ 3.0%
Sector 1 N/E	125-239	7800	9135	
	124-237	2600	3430	
	106-121	28900	27144	
	119-120	12200	12900	
	Total	51500	52609	- 2.1%
Sector 1 S/W	155-156	10100	9896	
	175-176	1200	1291	
	172-180	12000	15775	
	169-185	550	1800	
	165-234	2800	3456	
	Total	26650	32218	- 17.2%
Grand Total (Both above sectors)		78150	84827	- 7.8%
Adjusted* Grand Total (Both above sectors)		84724	84676	0%

*Included in this total are 6574 intra-sector 1 two way trips. These would not appear in the computer assignment, but were picked up at the roadside interview survey sites.

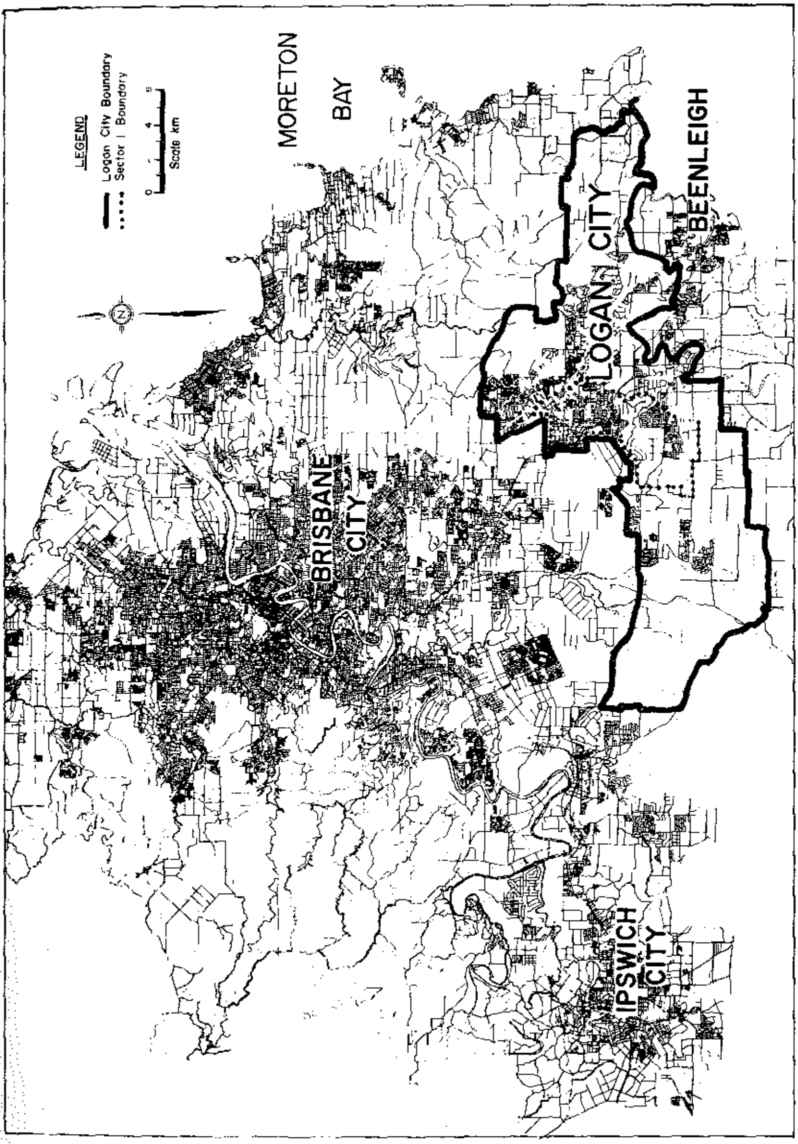

FIGURE I - LOGAN CITY LOCALITY PLAN

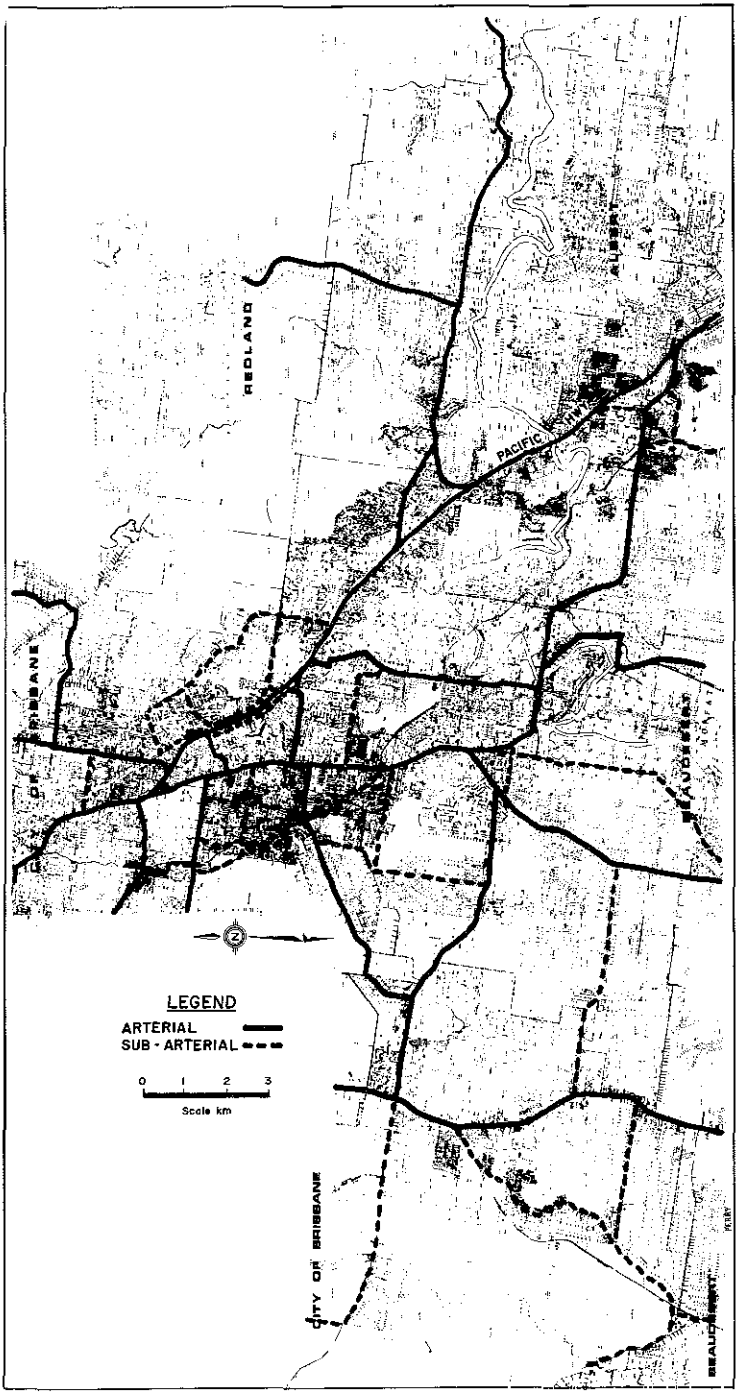

FIGURE 2 - THE AGREED 1981 ARTERIAL AND SUB ARTERIAL ROAD NETWORK

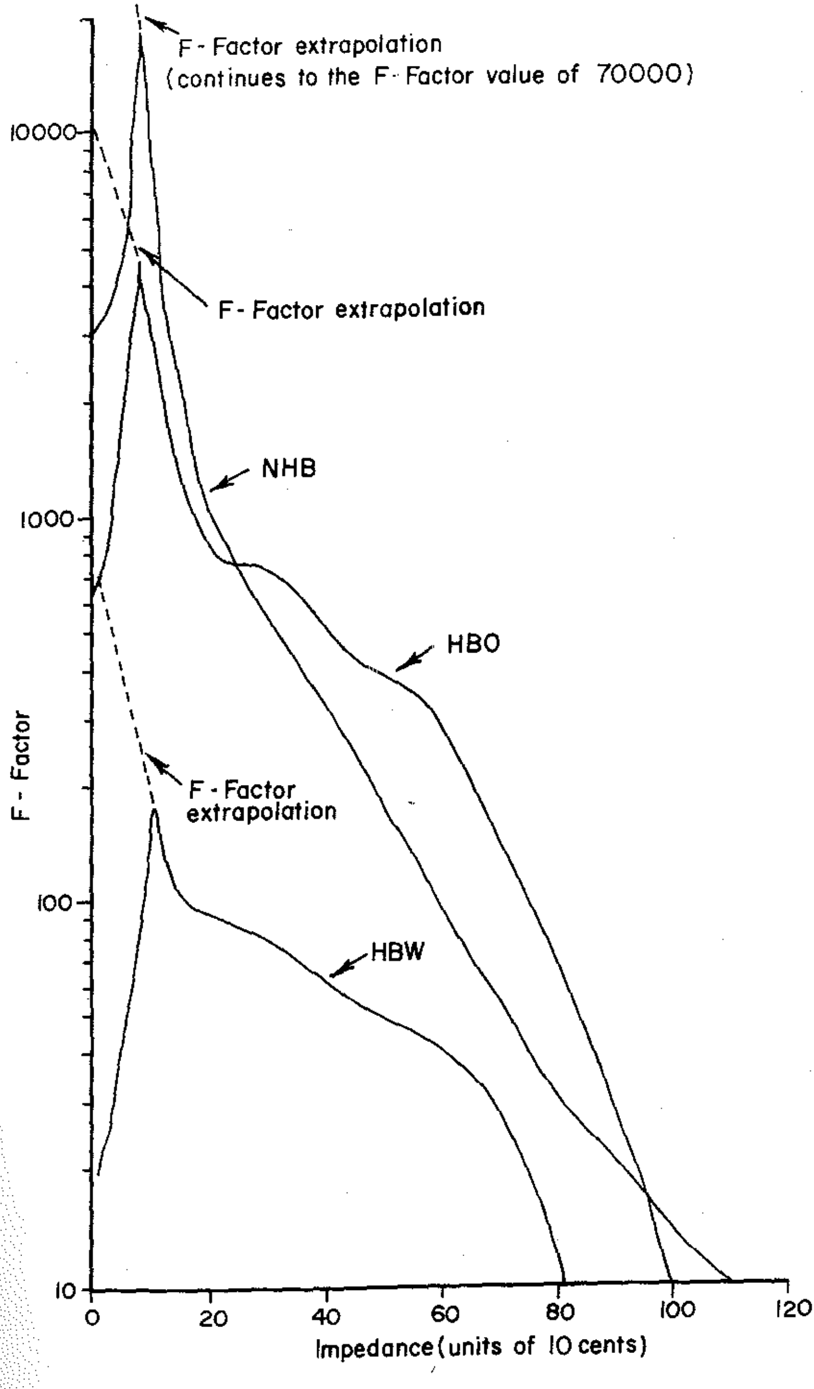

FIGURE 3 - PRIVATE VEHICLE F FACTOR CURVES

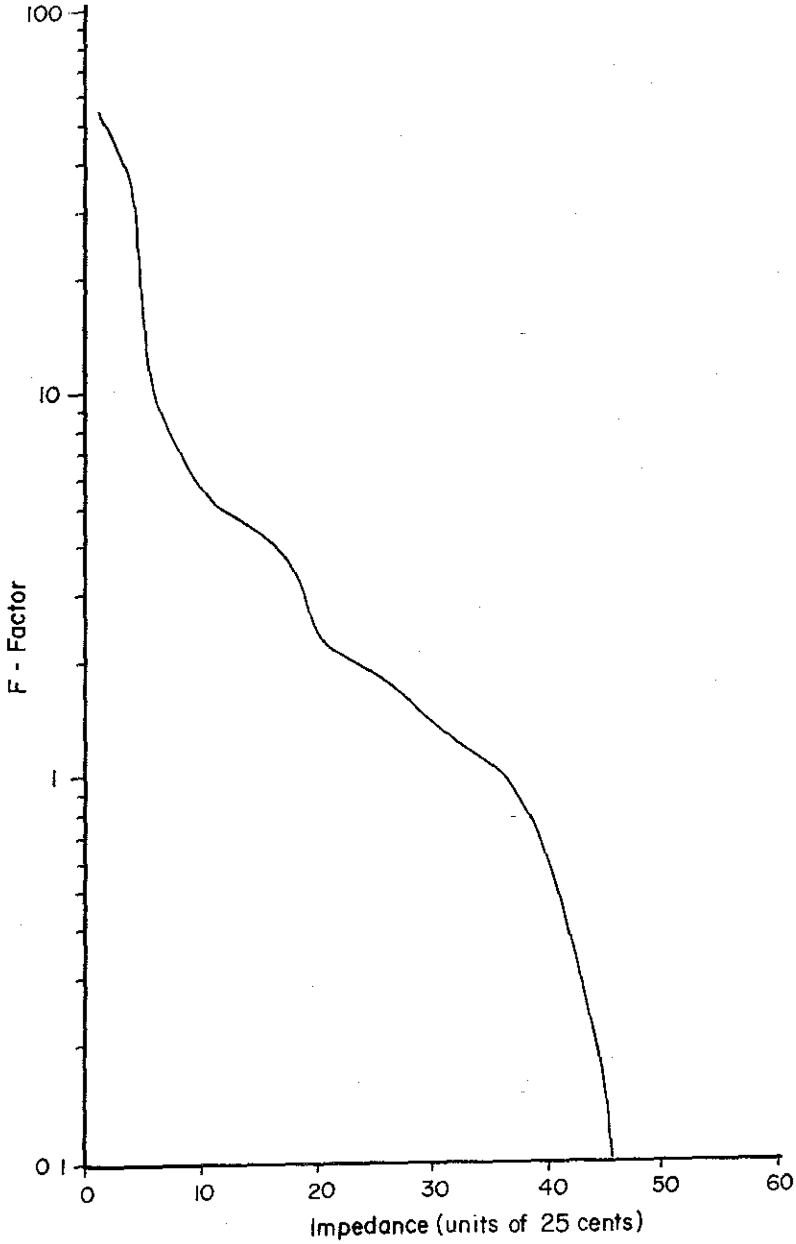

FIGURE 4 - COMMERCIAL VEHICLE F FACTOR CURVE

MELBOURNE'S ZONE FARE SYSTEM

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ABSTRACT: *In October 1981, a major change was made to the fare structures and ticketing practices on Melbourne's public transport system. 'Travel Cards' were introduced, valid for travel on all Government and privately operated public transport services in the metropolitan area.*

The paper describes the new fare system in Melbourne and the research undertaken to assess the effects of the new system on travel patterns, ticket sales and fare revenue. The research concentrated on establishing 'before' and 'after' profiles of the transport systems' usage, comparing the profiles, and thus attempting to assess the extent and causes of changes. Profiles were developed from data supplied by the transport operators, supplemented by surveys.

The research highlighted the difficulties in identifying changes in travel patterns associated with fare structure changes and the complexities of monitoring passenger statistics under a multi-mode ticket system.

Now 40%
use travel cards
initially daily, then weekly
now there is a 2-station railway ticket

INTRODUCTION

On 4 October 1981 a major step towards integrating Melbourne's public transport fares systems occurred with the introduction of "Travel Cards". For the first time it was possible to purchase a ticket which was valid for travel on all Government and privately operated public transport services in the Melbourne Metropolitan area.

The introduction of "Travel Cards" was part of a Government policy for an integrated and co-ordinated public transport system, with common tickets for travel on all modes. Behind the policy was an assumption that a simplified multi-mode ticket scheme would benefit travellers and operators, and, hopefully, induce greater use of public transport.

Any major change in the fare structure has effects on travel patterns, but measuring the changes and then attributing changes to their causal factors is extremely difficult. Sound data and complex analyses are essential.

This paper describes the new fare system introduced in Melbourne in October 1981, and the research undertaken to assess the effects of the new system. The paper notes the difficulties in identifying changes in travel patterns associated with fare structure changes and the complexities of monitoring passenger statistics under a multi-mode ticket system.

MELBOURNE'S FARE SYSTEM PRIOR TO TRAVEL CARD

Melbourne's railway, tramway and bus systems have historically developed under separate controlling authorities. As a consequence fare structures and methods of collecting fare revenue evolved in ways which were more suited to the requirements of each mode and its controlling authority than to any requirement for compatibility and consistency with each other.

Pricing policies and fare levels have been determined by Government. However, there were significant differences between the modes in features such as fares for journeys of similar lengths, availability of periodical tickets and the extent of concessions offered.

Despite differences in the actual fare levels on each transport mode, each authority (VicRail for trains, Melbourne and Metropolitan Tramways Board (MMTB) for trams and Government buses, and the Transport Regulation Board (TRB) for private buses) adopted a fare structure based on a "flag fall" component and a distance based component. The distance component was based on a tapering rate which meant that longer journeys were priced at a lower rate per kilometre than shorter journeys. The fare scales meant that travellers using more than one mode or vehicle to complete a journey were required to pay higher fares than travellers who could complete journeys without transfer.

Some small-scale experiments with multi-mode tickets have been undertaken in Melbourne in recent years. Most of the experiments have been with combined train-bus or train-tram tickets for specified routes only. Very few tickets of these types were sold, mainly because the combined ticket usually provided little, if any, discount on the price of separate tickets for the same journey. The reluctance to set a combined fare which provided a significant discount was no doubt due to concern by each operator to maintain its own revenue.

In August 1980, VicRail and MMTB introduced METROCARDS which were valid for travel on trains, trams and MMTB buses. These tickets allowed the purchaser unlimited travel on the day of issue within defined zones. Three zones were defined - a "Central" zone comprising the Central Business District and immediate surroundings, a "Suburban" zone which included all MMTB services and rail lines up to 25 kilometres from Melbourne, and an "Outer" zone which included all Metropolitan routes.

METROCARDS were a significant development towards multi-mode ticketing, but had two features which limited their share of the market to about 1 per cent of public transport trips : private buses were excluded, and the ticket prices were generally higher than the total price of separate tickets (except for people making an unusually high number of trips in the day).

Despite the limitations of METROCARDS and their relatively low market share, experience with these tickets highlighted the importance of pricing and gave Government operators experience with multi-mode ticketing which proved valuable in developing Travel Cards.

THE PRINCIPLES BEHIND TRAVEL CARDS

Simplification and integration of the ticketing systems has been the policy of both State Government and Opposition parties for some years. The rationale for the policy has not been detailed but appears to be based on four main premises:

i) public transport should be, or at least appear to be, a co-ordinated system without anomalies between modes;

ii) travellers who are required to change vehicles during a journey should not face a fare penalty;

iii) a simpler fare system could result in cost savings; and

iv) a simpler fare system would be more attractive to users and provide public transport with a new image.

There was no real attempt to quantify potential cost savings when developing Travel Cards. It was recognised that significant cost savings could only be realised if there were to be a radical change in the number of tickets sold, the issuing collection and validation procedures, and in operating practices. Changes of such magnitude were not envisaged at the time.

From the marketing viewpoint it was hoped that the fare changes, particularly the removal of fare penalties against multi-mode travel, would induce increased usage (both by existing travellers and by attraction of new travellers). This hope was based on an analysis of Melbourne's urban development since the War and the concomitant changes in travel patterns. Increasingly, desired combinations of origins and destinations are not linked by a single public transport route, and a potential public transport user is faced with a change of mode to complete the journey. The prospect of transfer is frequently discouraging enough for a potential public transport user, without the further deterrent of a fare penalty.

THE TRAVEL CARD SYSTEM

The major features of the change implemented in October 1981, were:

i) A zonal system was introduced, with three principal zones and a central sub-zone covering the whole metropolitan area (Figure 1).

ii) Daily and (later) weekly Travel Cards were introduced: these allow the holder unlimited travel for their validity period on all public transport services within the zone of validity. The services covered are VicRail suburban services, MMTB bus and tram services and metropolitan private bus services.

iii) VicRail changed to a zonal basis for most suburban ticketing, and also replaced periodical tickets (3 monthly, 6 monthly, yearly) by date-to-date tickets, valid for between 10 and 52 weeks. On average VicRail fares increased by about 13 per cent.

iv) MMTB fares were increased by an average of about 15 per cent.

v) Later (January 1982) private bus section fares were also increased by an average of about 15 per cent.

In essence, the previous section-based fare structure was retained on MMTB and private bus services, while VicRail converted to a simpler zone fare system. Average fares on all modes were increased. The new Travel Card system, permitting unlimited travel on all modes, was designed to overlay these individual mode fare systems.

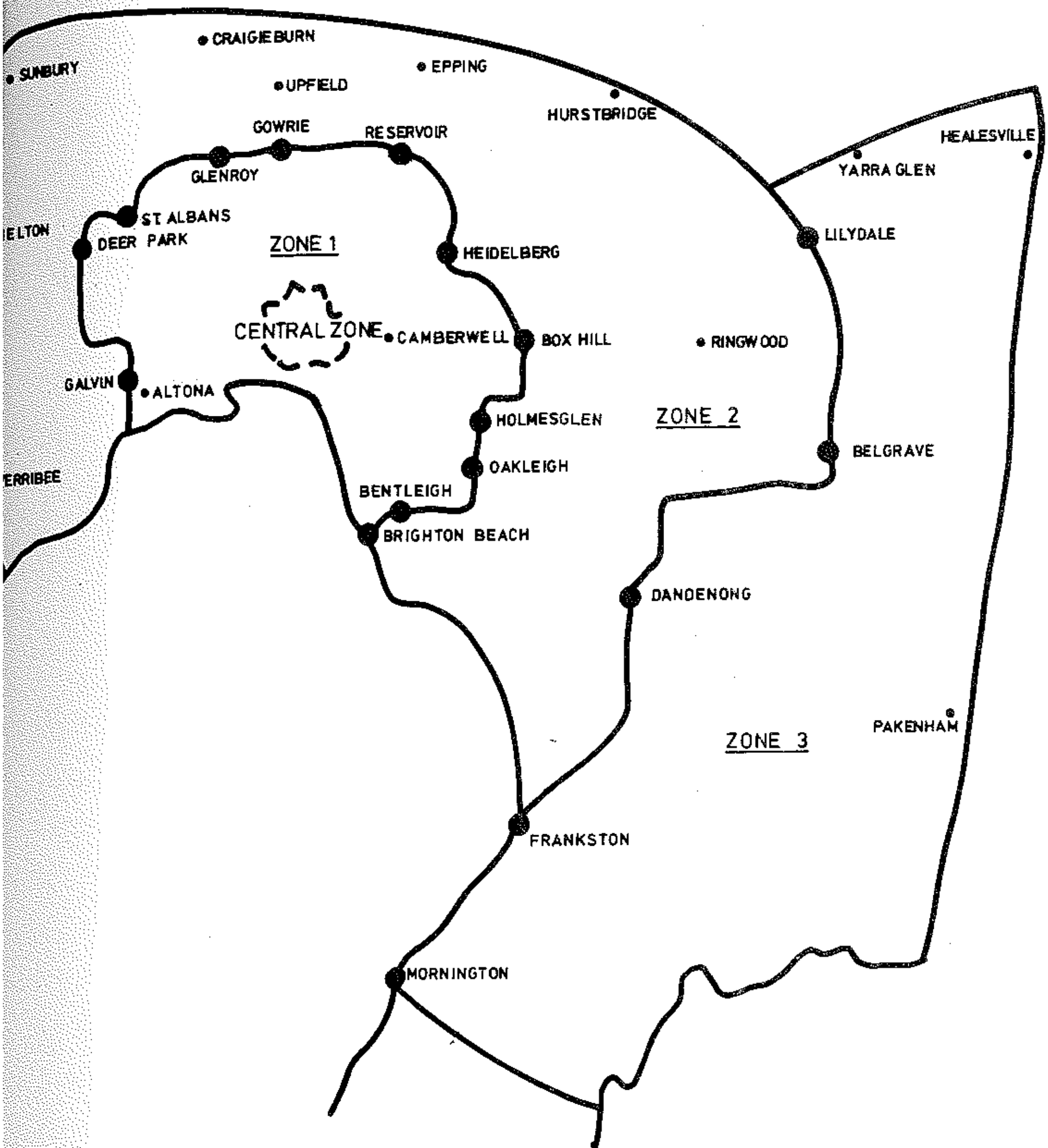

Fig. 1 - FARE ZONES

While the average fare increases for single mode trips were 15 per cent for MMTB tickets and 13 per cent for VicRail, the actual fare changes ranged from a decrease of 9 per cent up to an increase of 133 per cent. (Such a wide range of changes is an inevitable result of changing VicRail's fare structure to a coarse zonal system.) The vast majority of changes were in the range of 9 per cent to 33 per cent increases.

The prices of Travel Cards were set such that multi-mode (or multi-vehicle) journeys generaly decreased in price. In particular, Travel Card prices were set lower than the price of two single rail fares for the same zone(s). Travel Cards, therefore, also effectively replaced the standard rail return ticket.

The prices of Travel Cards and other tickets are shown in Appendix I.

RESEARCH INTO THE FARE CHANGE

In August 1981, shortly before the fare change, the Ministry of Transport, Victoria, supported by the other transport authorities concerned, decided to commission a study concerned with the usage of and revenue from metropolitan public transport services before and after the change.

The principal objectives of this study may be summarised as follows:

i) To determine the pattern of ticket sales, patronage and revenue on metropolitan public transport services subsequent to the October 1981 fare change.

ii) To compare this pattern with the corresponding pattern prior to October 1981, and to assess the extent of the changes and thus the effects the new fare system had on ticket sales, patronage and revenue.

iii) To set up a system for the permanent monitoring of ticket sales, patronage and revenue on all metropolitan public transport services, on a regular and consistent basis.

Ove Arup Transportation Planning and R Travers Morgan Pty Ltd were jointly commissioned to carry out this study. The study was supervised by a Steering Committee of representatives from the Ministry of Transport, the Public Transport Authorities and the private bus industry. Staff from the transport authorities also worked closely with the consultants. The study findings have been reported in full to the Steering Committee (Ove Arup Transportation Planning and R Travers Morgan Pty Ltd).

The study approach was based on establishing "before" and "after" profiles of transport system usage, comparing these profiles, and thus assessing the extent and causes of the patronage changes. The profiles were to be developed where possible from data available from the operators, supplemented by results from surveys undertaken for the Study by the Study Team and the authorities involved.

It was anticipated that most of the basic information on ticket sales, patronage and revenue could be derived from data collected by the authorities, except for multi-mode travel, where surveys would be necessary. In particular, surveys would be required to obain important information on the use of Travel Cards and on patterns of multi-mode travel.

For the "before" profile, the data available from the operators were supplemented by an on-vehicle survey of travellers in September/October 1981. The survey was designed essentially to derive estimates of the number of journeys involving transfer between modes and vehicles.

For the "after" profile, a further on-vehicle interview survey was undertaken in March/April 1982. This survey provided the basic "after" data on transfer travel, together with detailed information on the trip patterns of Travel Card users.

The basic "after" profile related to ticket sales, patronage and revenue patterns for the first six months after the fare change (October 1981 - March 1982). This period was effectively fixed by the study's time constraints. To minimise seasonality problems in comparisons, the basic "before" profile was related to the corresponding period 12 months earlier (i.e. October 1980 - March 1981).

Not unexpectedly, difficulties arose in establishing accurate passenger profiles, particularly for the "before" situation. The major difficulties related to VicRail: deficiencies in its system of monitoring ticket sales data were compounded with the problems arising from seasonal effects and incomplete information on the usage patterns of periodical tickets.

Further complications occurred during the study period: free Sunday travel was provided during December 1981 and January 1982, private bus fares were increased in January 1982, and weekly Travel Cards were introduced in February 1982.

It had always been anticipated that the development of compatible "before" and "after" profiles would be difficult, and the comparison of such profiles and the causal explanation of any differences would be more difficult. The above complications only served to increase the problems involved.

THE SITUATION AFTER THE FARE CHANGE

For the basic analysis period after the fare change, Table 1 summarises total metropolitan ridership on each mode, sub-divided between Travel Card users and other ticket holders. These figures are based primarily on ticket sales in the period: they thus exclude rides on tickets sold in earlier periods (periodicals), free rides by employees and ticketless rides. Table 2 shows the comparable data on revenue collected.

On average over the first 26 weeks of the new fare system, Travel Cards accounted for some 28 per cent of both total ridership and total revenue in metropolitan public transport services. The following paragraphs describe the Travel Card market in more detail.

THE USAGE OF TRAVEL CARDS

Travel Card Sales, Ridership and Revenue

A total of 33.8 million rides were made on Travel Cards in the 26 week period (Table 1). 50% of these were on MMTB services (tram and bus), 34% on VicRail and 16% on private buses. However, the revenue from Travel Cards was distributed very differently: 52% was collected by VicRail, 31% by MMTB and 17% by private bus. Table 3 compares Travel Card revenue collection, ridership and passenger kilometres travelled for each mode. These data are of relevance to any revenue - sharing arrangements among the authorities involved.

The proportion of riders on each mode using Travel Cards was 32% on VicRail, 29% tram, 20% MMTB bus and 21% private bus.

On average over the 26 weeks, 75% of Travel Card rides were on Adult Daily Cards, 20% on Concession Daily Cards and 5% on Weekly Cards. However, weekly Travel Cards were only introduced in February 1982 (at the price of 5 daily Travel Cards) and thereafter accounted for considerably more than 5% of the total Travel Card market.

TABLE 1: METROPOLITAN RIDERSHIP SUMMARY

26 Weeks after Fare Change (4/10/81 - 3/4/82)

Mode	Total Ridership (million)(1)		
	Travel Cards	Other Tickets	Total
Train	11.64	24.63	36.27
Tram	14.40	35.76	50.16
MMTB Bus	2.43	6.97	9.40
Private Bus	5.35	20.48	25.83
Total	33.82	87.84	121.66

Notes:

(1) Figures include adjustment for free Sunday travel scheme. Ridership based on ticket sales data and study Travel Card survey. 'Rides' as defined by authorities: for VicRail, 1 ride counted on each access to the system; for other modes, 1 ride counted on each vehicle boarding.

TABLE 2: METROPOLITAN REVENUE SUMMARY

26 Weeks after Fare Change (4/10/81 - 3/4/82)

Mode	Total Passenger Revenue Collected ($ million)(1)		
	Travel Cards	Other Tickets	Total
Train	9.41	19.16	28.57
Tram	4.08	14.12	18.20
MMTB Bus	1.59	3.15	4.74
Private Bus	3.00	9.30	12.30
Total	18.08	45.73	63.81

Notes:

(1) Figures include adjustment for free Sunday travel scheme. Revenues as collected, prior to any revenue sharing scheme. Also exclude any Government reimbursements.

TABLE 3: TRAVELCARD DATA SUMMARY (First 26 Weeks)

Mode	% of total by Mode		
	Revenue	Boardings	Passenger Kilometres
Train	52.0	34.4	55.8
Tram	22.6	42.6	29.1
MMTB Bus	8.8	7.2	7.2
Private Bus	16.6	15.8	7.9
Total	100.0	100.0	100.0

TABLE 4: AVERAGE DAILY RIDES PER TRAVELCARD - BY PURCHASE MODE AND USAGE MODE(1)

Purchase Mode	Usage Mode(2)				
	Train(3)	Tram	MMTB Bus	Private Bus	All
Train	1.95(0.03)	1.02(0.08)	0.12(0.03)	0.23(0.04)	3.32(0.09)
Tram	0.34(0.05)	3.16(0.11)	0.11(0.03)	0.17(0.04)	3.78(0.11)
MMTB Bus	0.57(0.12)	1.23(0.17)	1.68(0.12)	0.45(0.12)	3.93(0.20)
Private Bus	1.06(0.09)	0.84(0.12)	0.21(0.06)	2.11(0.10)	4.22(0.15)

Notes:

(1) Based on survey in March/April 1982. For Weekly Travel Cards, average weekday rides are included (weekly rides per card estimated at 5.21 x average weekday rides). Note that the figures are average survey figures and are only relevant to the mix of Travel Card types on issue at the time of the survey.

(2) Figures in brackets represent 95% confidence intervals (+ or -) for average values, based on analysis of variability of survey findings.

(3) For train travel, one ride is counted on each access to the system (on average one ride is equivalent to 1.14 train boardings).

Travel Card Usage Rates

Table 4 shows the average number of rides on each mode (for all Travel Card types combined) by mode of purchase. For example, on average 4.22 rides were made on Travel Cards issued on private buses: 2.11 of these were by private bus, 1.06 by train and the remainder by MMTB tram and bus. Travel Cards issued by private bus involved more rides than average, while those issued by VicRail involved fewer than average. The average daily rides per Travel Card for all modes was 3.75.

Travel Card Distances

Table 5 gives equivalent figures on the distance travelled on each mode, by Travel Card mode of purchase. It is apparent that on average Travel Cards issued by VicRail are used for a considerably greater distance than those issued by the other authorities, although fewer separate rides are involved. These averages hide considerable distance variations between Travel Card types: for instance, Zone 1/2/3 Travel Cards were used for over 70 kms of travel on average.

Trends in Travel Card Market Share

Figure 2 illustrates trends in Travel Card market share for the first 26 week period, expressed in terms of revenue collected. Travel card revenue is shown as a proportion of total revenue for each of the four modes and for metropolitan public transport as a whole. On the introduction of Weekly Travel Card, revenue from Daily Travel Card sales is separately identified.

For all modes there was a general upwards trend over the 26 week period in Travel Card revenue relative to revenue from other tickets. This upward trend appeared to be continuing at the end of the period analysed, although the addition of Weekly Travel Cards complicated the picture. Weekly Travel Cards, which are not sold on private bus, appear to have resulted in a gain in revenue for VicRail at the expense of the private buses.

Over the 26 week period as a whole, 28% of revenue collected related to Travel Cards. However, by the end of this period (March 1982), Travel Card revenue had increased to 35% of total system revenue. Later data suggests this proportion continued to increase after March 1982.

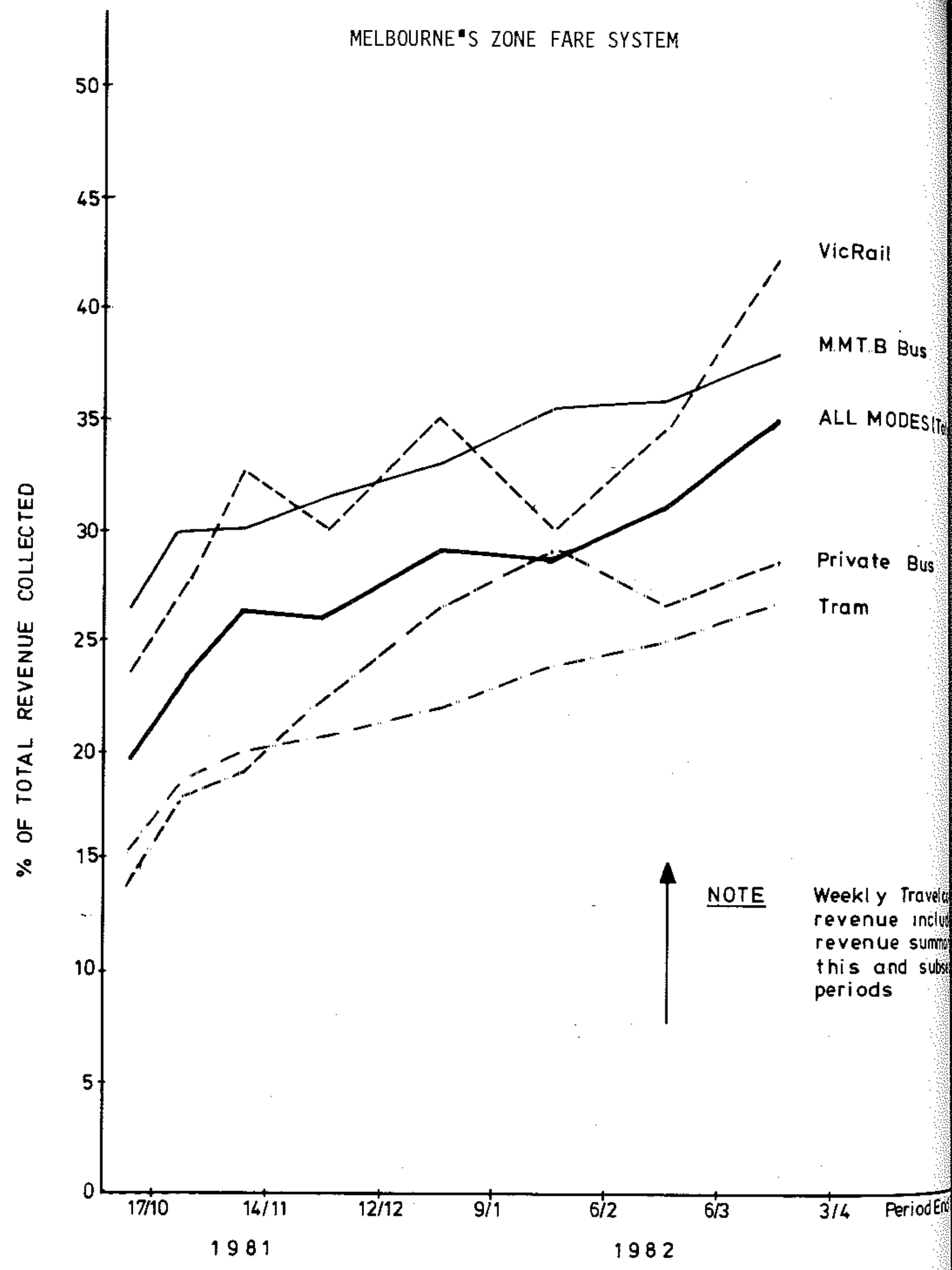

Fig. 2 - TRENDS IN REVENUE COLLECTED FROM TRAVELCARD SALES

COMPARISON BETWEEN THE "BEFORE" AND "AFTER" PERIODS

Comparisons were undertaken, on as consistent a basis as possible, between the patronage and revenue in the 26 week period after the fares change with the corresponding period 12 months earlier. These are summarised in Table 6.

Overall, system ridership increased by about 2% and revenue by 11 - 12%. The ridership increase was particularly pronounced - over 5% - on private bus services.

The ridership comparisons are subject to some uncertainty, particularly in the case of VicRail, for the following reasons:

i) possible slight under-estimation (from study surveys) of the number of trips by Travel Card holders;

ii) inadequate VicRail data on suburban patronage and revenue for the "before" period (1980/81); and

iii) some apparent discrepancy for VicRail between the trends indicated by ticket sales data and those from direct ridership counts.

EFFECTS OF THE FARE CHANGE

There are great difficulties in attempting to attribute the causes of the patronage and revenue changes between the fare change and other factors present over the 18 month period examined, e.g. underlying "time" trends, service changes. The study was not designed primarily to make such an attribution and no conclusive attribution has proved possible. However, the following comments are relevant.

The study found no convincing evidence that the marginal increase in ridership since the fare change could be attributed to the change itself, and in particular to the popularity of the Travel Card system. There is considerable evidence from Melbourne and other Australian cities of some modest patronage increases on urban public transport over the last 2-3 years, e.g.:

i) from 1979/80 to 1980/81 MMTB tram patronage increased 1.6% and bus patronage increased 5.6% (Annual Report figures);

ii) VicRail passenger counts indicate a significant upward trend in ridership since early 1981; and

iii) Australia-wide, urban bus and tram ridership increased at a rate of some 3 per cent p.a. from 1979/80 to 1981/82 and urban rail ridership also increased appreciably.

TABLE 5: AVERAGE DAILY DISTANCE PER TRAVELCARD- BY PURCHASE MODE AND USAGE MODE(1)

Purchase Mode	Distance (kms) by Usage Mode				
	Train	Tram	MMTB Bus	Private Bus	Total
Train	36.4	4.6	0.9	1.1	43.0
Tram	4.6	21.9	0.8	0.9	28.2
MMTB Bus	8.3	5.4	16.5	1.8	32.0
Private Bus	16.0	4.7	1.5	9.9	32.1

Note:
(1) See Table 4, Note (1).

TABLE 6: BEFORE AND AFTER COMPARISON SUMMARY

Mode	Change from Before to After Period(1)	
	Ridership	Revenue Collected
Train	0 to + 2%	+ 10% to + 13%
MMTB (Tram & Bus)	+ 1% to + 2%	+ 7% to + 8%
Private Bus	+ 5% to + 6%	+ 20% to + 21%
Total	+1½% to + 2½%	+ 11% to + 12%

Note:
(1) Before period 6 months October 1980 - March 1981.
After period 26 weeks 4 Oct 1981 - 3 April 1982.

The reasons for these increases are not fully clear, nor is it yet clear whether they represent the start of a longer term upward trend. The increases are probably partly related to service quality and possibly partly to the impact of increased fuel prices. The evidence suggests that Melbourne has been sharing in these national trends, irrespective of the introduction of the new fares system. There is no conclusive evidence that the new system has increased Melbourne's total system patronage to a higher level than it would otherwise have been. It seems likely that it has had a number of quite complex effects on particular travellers and particular journey types, but these effects are largely masked when considering the aggregate statistics.

PASSENGER MONITORING

As noted earlier, one of the study's principal objectives was to set up a system for the permanent monitoring of metropolitan public transport patronage on all modes, on a regular and consistent basis. Hitherto, patronage had been monitored by each of the individual authorities, but with a lack of consistency among authorities on such aspects as accounting period (eg. four-weekly or monthly). The need for a consistent system was increased by the introduction of Travel Cards, involving purchase of tickets from one authority for use on the services of another authority, with consequent need for revenue - sharing arrangements.

A regular monitoring system for all modes was developed and introduced to coincide with the introduction of the new fare system. Its principal characteristics are:

i) it covers all four metropolitan modes (suburban rail, MMTB tram, MMTB bus and private bus);

ii) it adopts a common 4-weekly basis (13 periods per year) for monitoring;

iii) for each mode, data on tickets sold and revenue collected are prepared by the authorities on a common basis, and collated by the Ministry of Transport;

iv) each period's data is presented along with data for the preceding period and the year-to-date.

This system represents a considerable improvement over the previous records available. However, at time of writing, it is still incomplete in that certain ticket types, accounting for a few percent of total revenue, are not yet included (e.g. MMTB scholar concession tickets).

The present system is confined to ticket sales and revenue data and makes no attempt to estimate passenger rides (boardings) on each mode. Such ridership statistics are of considerable importance to the authorities. They may be calculated from ticket sales data by application of trip rates by mode for each ticket type, derived from surveys such as those carried out in this study: the ridership estimates will of course be only as accurate as the trip rates used. It is at present expected that the monitoring system will be computerised, and that estimated trip rates will be input so that ridership data may readily be derived for each mode on a 4-weekly basis.

COMMENTS ON SURVEY AND ANALYSIS TECHNIQUES

Survey Planning and Design

One major purpose of the study was to establish and then compare profiles of patronage on each mode in the "before" and "after" situations. A second purpose was to investigate the use of Travel Cards in some detail, as an input to revenue-sharing arrangements and to the further development of fares policy.

In a "traditional" situation where each passenger purchases a ticket on boarding each vehicle, passenger rides may be deduced directly from ticket sales. With the increased sophistication of the fare system, and particularly with the introduction of Travel Cards, calculation of ridership from ticket sales has become more difficult: special surveys are needed to derive trip rates for multiple-use tickets. A high level of accuracy is needed in such surveys, particularly when "before" and "after" comparisons are required (involving small differences between large numbers).

The study approach was to establish Travel Card trip rates by an extensive interview survey of a random sample of passengers on vehicles, asking each interviewee about all journeys made (or to be made) on the day in question on the ticket held. Statistical methods were used to estimate the sample sizes required to enable trip rates (and consequent passenger rides) to be calculated with a specified level of accuracy: the 95% confidence intervals on trip rates are included in Table 4. In survey design and analysis, particular attention had to be paid to:

i) achieving a random sample (by area, route and time period) of public transport passengers;

ii) avoiding under-enumeration of the number of rides on each ticket (due to respondents' imperfect recall);

iii) avoiding or correcting for potential bias towards passengers making longer rides or more rides per ticket (by suitable factoring of results).

Other survey and analysis procedures developed in the study highlighted the need to investigate and allow for systematic variations (between different weekdays, different periods of the year) and random variations in ticket sales, patronage and revenue data. Survey methods adopted and lessons learnt are being written up in a separate paper (Singleton and Wisdom, 1983).

"Before" and "After" Comparisons

It was desirable that the study should provide as much information as possible, from comparison of "before" and "after" profiles, on the effects of the new fare system. Among other aspects, it was important to establish whether aggregate ridership on each mode had increased or decreased, and by how much - using the ridership estimates derived from ticket sales and study surveys.

While changes in aggregate ridership were successfully established (Table 6), these were generally small and various analyses confirmed their sensitivity to changes in trip rates, survey bias, etc. The ridership estimates excluded two classes of traveller, which are also excluded from the operators' usual statistics:- employees travelling on free passes, and ticketless riders (fare evaders). The level of ticketless riding may be such that changes in it resulting from a changed fare system (or from changes in the level of enforcement) could significantly affect the assessment of Table 6.

As noted earlier, it is extremely difficult to attribute the patronage changes to the change in fare system and other causes. The survey methods adopted were deliberately chosen to focus on the aggregate patronage position, rather than to investigate in detail the causes of any changes. To gain detailed understanding of responses to the fare change (e.g. Travel Card holders making extra short trips instead of walking), different types of survey would be necessary. In-depth interviews would probably be most appropriate to provide this understanding, in a qualitative manner: on-vehicle interviews or diary surveys are unlikely to be appropriate.

The Need for Updating

The authorities' regular ticket sales data, together with the Travel Card trip rates derived in the study, now form the basis of ridership figures for Melbourne's public transport system. Evidence from the study indicates that Travel Card usage levels and patterns have taken many months to stabilise (Figure 2), as compared with some 3 months typically after a simple change in fare levels.

Given the fundamental importance for monitoring of the trip rates, regular updating of the Travel Card surveys appears desirable. This would probably be appropriate at yearly intervals, particularly if there are annual fare changes which would be expected to affect Travel Card usage patterns.

CONCLUSIONS ON THE FARE SYSTEM

As noted earlier, it is difficult to determine the effects of the new fare system with confidence. It appears that the system has had no substantial net impact on aggregate public transport ridership. To draw more detailed conclusions on the effects of the new system would require surveys of a different type to those undertaken in this study. However, several general comments may be made.

Table 6 indicates that the private bus mode appears to have experienced a ridership increase of some 5%, by comparison with a downward trend in previous years. This is probably partly the result of Travel Card inducing an increased use of private buses for access to the line haul (generally rail) mode.

One of the major reasons for introducing the Travel Card system was to eliminate the price penalty paid by people whose trips involved a vehicle or mode transfer (about 23% of all trips). However only just over 50% of transfer rides are now made by Travel Card users, as Travel Card purchase is not economical for many transfer trips. Thus nearly half of all transfer travellers continue to pay the "flag-fall" penalty.

The shortcomings of the October 1981 system in this regard were apparently recognised by Government in its introduction of the Neighbourhood Public Transport System in the Caulfield - Moorabbin - Sandringham area in November 1982. This allows unlimited travel (bus, tram and train) for 2 hours in the defined area for 60¢ (50¢ outside peak periods). Similar systems are under discussion for other areas of Melbourne.

Weekly Travel Cards were introduced in February 1982, in response to a perceived demand. However they have not been available for purchase on vehicles, but only at railway stations and MMTB bus and tram depots. As a result over 95% of such tickets have been purchased from VicRail outlets and over half the trips on these tickets are made by train. Easier availability of Weekly Travel Cards would seem a further step towards an improved fare and ticketing system for Melbourne.

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