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Who are the Users?: A Person-Oriented View of Australian Travllers

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1. INTRODUCTION: WHO OR WHAT IS A 'USER'?

What (or who) are regarded as the "users" of transport will differ depending on the individual or organisational standpoint taken and the types of resources being addressed. Transport involves (amongst other factors) the consumption of space, time, land, lives and investment funds. Each of these have their own constituency.

Major distinctions exist between the views taken of personal movements and commodity movements: infrastructure responsibilities and vehicle operations: mobility provision and environmental and safety impacts. Clearly all these factors are involved in any transport proposal, decision or operation - but the emphasis can cause one or more of these factors to be virtually ignored due to the low perceived impact on the are of immediate concern. These relative priorities will rarely be in accord with the other parties involved.

Those concerned in the first instance with road network construction will necessarily take a primary interest in those users (organisational, individual or corporate) who consume capacity, and those who consume road structural life. Similarly, those concerned with waterside operations will be well aware of those who consume wharf space and time, and railway interests with the uses of time and space to gain capacity and track life.

Not surprisingly, these concerns are realised in a focus on the vehicles and freight operations in particular, as these are the forms in which usage affect the transport infrastructure with which those bodies are concerned.

The focus shifts when public transport services for people are the object of concern: the peaky patterns of demand to be serviced lead to a focus on the users of funds and the matching of the infrastructure for people movement capacity to service these peaks.

The latter is the first provider group to be concerned with personal travel demand levels as a primary goal: all the other areas have vehicle (and at one remove, freight) as the 'direct' users. This does indeed reflect past patterns of approach in several of these transport sectors, where the understanding of individual travel demand is of value ainly as an intermediate step for vehicle movement (and apacity) planning projection purposes.

sment and evaluation procedures reflect the bout who the 'users' are - and indeed just exactly what is it that they are using. An economic assessment of road movements will usually place a real (and usually substantial) value on any time savings that might be made, yet rarely consider the times of day at which these saving occur. The 'users' of the locations in close proximity to the movements will suffer significantly different negative impacts depending on the time of day or night that these changes occur.

Here the 'users' being taken into account are freight and personal transport vehicle operators or passengers **when moving** and the benefits are to those groups: those who are not traveling at the time suffer the side effects of the travel movements, and are sensitive to the time of day or night that the movements occur - yet the time of day that the freer or lower cost movements occur are not considered an economic factor other than for capacity provision and usage. The timing of travel (as distinct from travel time) is quickly seen to be of real importance to individuals who are often trying to combine activities and people under severe constraints on the times and places which must be coordinated. The timing of travel has therefore a real benefit to those traveling as well as appearing in the negative side of the ledger for those living along the route of the resulting movements.

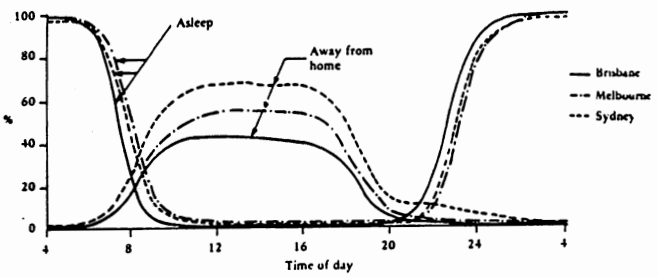

FIG 1.

PRESENCE AT HOME, AWAKE AND ASLEEP, ADJACENT TO TRAFFIC ROUTES

Fig. 1 (drawn from Brown, 1978) illustrates the potential exposure of such residents to traffic noise as a function of the time of day, and also emphasises that the periods at which people are normally asleep raises questions about the timing of a particular predicted traffic flows, rather than simply the volume.

This illustration sets the scene for a greater degree of attention to be paid in turn to the travelers themselves, who are the users in the last analysis of all transport movements, and the knowledge that we have about them is what enables us to understand and plan to try to meet their needs in the most effective manner for all parties. This underpins the point that evaluation and better user understanding and knowledge are tightly linked, and that projections of both are equally essential. This has not been a widely held view in the past.

One of the prime sources of individual travel information, constraints and behavior is the accumulation of the many household interview surveys carried out originally to provide a basis for forecasting origin-destination vehicle flows, but also even more valuable if used to find out about travel behavior of Australians. These have generally (but not excessively) concentrated on the vehicle travel movement, the locational implications, and overall household characteristics. Many useful and usable models of mode, travel and destination choice behavior have been built with various goals in view. Unfortunately, overall views of the personal (as distinct from household) travel behavior of different groups of individuals, in households of different types have been rare - particularly those which distinguish between the sexes. Some work with these goals has recently been completed at ARRB (Wigan 1987).

The work was based on the cross-sectional interview surveys from 1970 to 1981, and the results illustrated the advantages that come from a better appreciation of the personal characteristics of the travelers that determine the travel demand for which the transport system is designed. The examples discussed include the differences between the sexes in time of day and overall travel demand. The significance of taxi travel to different types of households, and the participation and activity rates in different forms of transport and as function of the age of the person. The non-motorised travel modes (walking and cycling) are also examined across the country.

Two significant outcomes were a wider appreciation of the insights available for transport planning from a person-oriented analysis and presentation approach - and another was a better appreciation of the value of graphical presentation methods to make these insights available to others. Much of the data which is needed to understand transport users may be in our hands - but has not yet explored with the appropriate imagination or delivered in a form where the form of presentation helps to communicate the insights or perspectives. We have undervalued our data sources by neglecting to explore what they have to tell us about our users. As in so many other areas of transport today, we have a great deal of data - but comparatively little information.

This under-use and consequent undervaluation has led to an alarming vulnerability of this unit record data and to the present fragility of this type of valuable resource (Wigan 1985). It is therefore not very surprising that the investment in the newer and even more helpful longitudinal and activity surveys has been low in Australia to date.The now-widespread corporate planning processes, with their emphasis on customer needs should ensure a greater desire to understand the users and therefore to make more effective use of such transport consumer specific information in the future. The integration of the longitudinal (panel survey over ti. and cross-sectional (household interview and activit, survey) methods of tracking and projecting travel demand and behavior and their determinants require both types of tools.

2. WHAT DO WE BASE OUR VIEWS UPON?

For several decade the planning and analysis of transport and roads have relied upon the initiatives of Wilbur Smith and others who propagated the large scale adoption of a transport planning survey and modelling process. The initial emphasis of this effort in the 1960's was to obtain vehicle flows on a traffic network, based on a measurement of the geographical characteristics of the demand for travel. The assignment of these demands to routes over a series of networks yielded different patterns of vehicle flows, dependent on the travel demands expected and the topological (and, later, capacity) characteristics of the roads, present and proposed.

The seminal ideas that took root from that stage in the development of transport and road planning were the following:

(1) Models of traffic flow over large (and small) networks of roads could be very useful

(2) The necessary data about the demand for vehicle trips could be obtained from large scale household surveys.

The large scale of the effort required to collect such data, calibrate a suitable model of vehicle movement demands and flows, prepare detailed forward proposals for evaluation and execute the models and analyse them had a major impact on the manner in which the resulting proposals were produced.

Constructing matrices of vehicle movement demands and the assignment and calibration of the resulting network flows took place after the major household interview surveys had been carried out and edited. The sheer size of the transport surveys used tended to dominate the project time scale. The remaining time was spent on constructing traffic flow models, design of future road and transport network patterns, and running these models on the (few) fully-worked out alternatives.

This process tended to consolidate the overall alternatives into a small number of major plans for evaluation, and to freeze these quickly - and sometimes very early in the project - so that the resulting reports generally shared the following characteristics.

(1) A small number of large scale plans were reported on

(2) Few variations were (or could be) examined

(3) The models were rarely well suited to handing a mix of large and small scale proposals at once - and very unsuitable for incremental and iterative design approaches using the model and the data as a test bed.

(4) Most projects recognised these shortfalls and tried (often unsuccessfully due to the timetable) to fit in some research to plug the gaps to some extent.

(5) The results were almost invariably presented in terms of vehicle flows rather than personal travel needs.

(6) Environmental impact analyses, when included at all, did not usually examine the effects of various changes on different locations and groups of people

(7) The survey results were a rich source of household and personal travel information, but little time or effort was available to make effective use of this.

(8) The survey and modelling team usually disbanded soon after the project reported, and the data became difficult to access and significant elements were often lost at the same time.

As time progressed, the increases in computing power and the greater awareness of the need to cater for the transport users (rather than just for the vehicle flows) led to greatly improved public transport treatments, and slowly to the re-examination of the basic element: the person. It was found that the vast majority of the information in the transport surveys had been neglected by the road and transport analysts. On the other hand, other public and private sector infrastructure bodies had found the survey information (as distinct from the transport study reports and alternatives) a valuable and useful resource that lent a coherent and numerate overall view of the actual complexities of the present (rather than the abstracted and forecast future).

This trend was shared by a movement to call these major exercises 'transport surveys' rather than 'transport studies' or 'plans', although the pattern of the tasks remained largely unchanged.

The unhappiness with the large scale modelling approach was soon diverted by two trends. Econometricians introduced data-efficient models of disaggregated traveller choice behaviour to bring the person choice aspects under better consideration. These models provide a better way of extracting some of the understanding from the data collected, but also altered the demands on data requirements if attitudinal factors were to be added satisfactorily. Such approaches were soon supplemented by social geographers with extremely data-intensive small scale surveys of detailed time and activity patterns of very small numbers of households. The latter surveys altered the perspective of 'vehicle flows' as the basic unit of road transport planning and understanding to 'household constraints' and the consequent stratification of the traveling population into rather different groupings from the cars/household approach often underpinning many of the large scale models.

In both cases, a greater level of attention was paid to the actual user of the transport system. Also, in both cases, the resources offered by the large numbers of people covered in the detailed transportation surveys at the household level were not fully tapped.

The reasons were not solely technical. An initial summary of the resources there to be applied was given by Dumble (1978), but the maze of problems inherent in obtaining and reducing the many large scale surveys that had been carried out have been discussed elsewhere (Wigan 1985 1987).

A recent parallel development has been the treatment of traffic and transport management small areas using sophisticated transport planning network techniques. Wigan's (1974) RRLTAP/PANIC system was one of the first to appear with detailed user impacts of a wide variety at the small-scale level, Taylor's (1987) MuLATM one of the most widely used today - both using variants of network equilibrium techniques. The strong vehicle flow forecasting orientation of small area planning has also helped to stimulate methods of obtaining origin-destination flows of vehicles directly (Willumsen, 1981), without requiring any interviewing access to the people concerned. These have been included in Saturn, another of this class of local area transport planning based traffic investigation and management tools. The rise in importance of area management relative to major new capital road construction may therefore be contributing to a decline in the knowledge of the personal users of the system.

Any such approach that takes care to assess a reasonable range of user impacts will inevitably have to cater for the numbers of houses, residents and pedestrians adjacent to the highways - yet this types of data are still not routinely collected and incorporated in the network models used at strategic or local levels.

It is therefore appropriate to reassess the information bases and instruments currently used for understanding, monitoring, evaluating and forecasting user demands needs and impacts - and work out what is now needed to ensure better understanding, for further improvements in management and resource allocation. The 'user' is a different entity for different parties involved in transport, and it would be a reasonable goal to maintain a broader basis of common information and understanding of the people whio in the last analysis give rise to all of the realised transport demand.

3. PRIVATE VEHICLE TRAVEL

Cars have been the major focus of transport modelling for a considerable time, and goods vehicles have only recently attracted much concerted analytical attention. The need for vehicle traffic flows for capacity planning purposes has emphasised the reproduction of vehicle movements from point to point, and thus imposed a strong geographical orientation to data analysis, synthesis and model checking and calibration. It is not practical to sample heavily enough to represent both the geographical spread of movements and the detailed personal characteristics of the individuals making them. Analyses of vehicle travellers have therefore been biased towards the purpose of the travel (work, shop, education etc) rather than the age group, sex or family/household structure of the individual.

Car ownership has been a key variable for forecasting for a considerable time, and the stratification of households into different levels of car ownership has been common, and models are frequently calibrated on this basis.

The usage of public transport has been considered more and more carefully over the 1980's, as the market to which this mode of transport is directed has been examined afresh. However the data sources available, in some cases since the 1960's, have held sufficient information to permit a more considered view to have been taken far earlier. The guilty party has of course been the tendency to plan for the vehicle rather than the person, and to model the geographical aspects almost to the exclusion of all else barring car ownership levels.

Once the personal characteristics of the people become the prime matter for attention, then the patterns of involvement can be seen more clearly. The trend for the 'young driver' age group to also be crucially important public transport users is matched by the strong tendencies of women to use buses while men use trains as their preferred public transport mode, once they have committed to us public transport.

It is ironic that some of the highest mobility rates by private cars are to be found in exactly the same age groups that provide the highest public transport participation rates!

There are interesting differences between the types of people who use trains, trams and buses - and there is a pronounced difference in choice between the sexes.

The times of day that people choose to travel also show up distinctive differences, and the tendency of men and women to travel at very different times in the morning and evening peaks has implications for road safety analysis as well. The information shown in Wigan (1987) is but a small part of the analyses held at the ARRB, and the results in Fig. 5 provide the flavour of these patterns. Women tend to comprise the (sharp) peak at the end of the morning peak hour, and the early peak in the evening. The patterns of usage of trains and car passenger with a member of the family driving show the smallest differences between men and women, while trains, buses and other public modes tend to follow the overall patterns for car passenger travel illustrated at the top of Fig. 5.

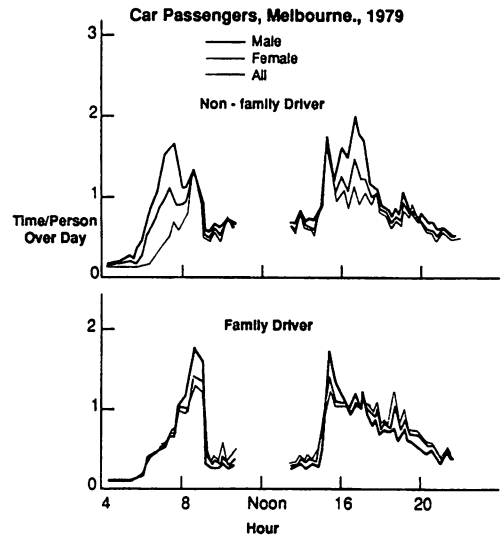

FIG. 5

PEAK HOUR CAR PASSENGER TRAVEL TIME USAGE BY MEN AND WOMEN IN MELBOURNE 1978-9

As public transport service levels have a strong influence on their usage, the time of day patronage differences and the difference in time of travel preference by men and women also have a supply-driven aspect.

5. VULNERABLE ROAD USERS

The road is used by many different types of transport, and people take up different roles at different times of day. The same person may be a pedestrian, a car passenger, a train user and a tram passenger at different times on the same day. A 'non-traveller' may indeed simply be one who does not count the short walking trips outside the home as 'travel'.

Amongst the 'normal' modes of transport, bicycle, motorcycle users and pedestrians are almost uniformly assumed to be 'safety problems', and most public and political treatment of these three minority modes starts from this premise. Bicycle riding has been efficiently promoted as a 'recreational' mode, and so has attracted a rather different group of user protagonists, many of them concerned more with 'encouragement of bicycle use' that with the mobility, access and safety aspects of this pleasant transport mode in a full transport context. the close association of bicycles with younger adolescents and school children is correct as far as it goes, but further biases and confuses the image of the users of this travel mode.

Taxi users are treated ambiguously, as quasi-public transport at one time and as semi-private transport at another: this derives from the two quite different roles that taxis play, and the drastic difference between the types of people and purposes of travel that these two categories of user represent.

In terms of the travel time spent on road, taxis are vanishingly small contributors to total time consumption on road, yet bicycles appear as fairly significant users of road space and time, equally in trams and buses in Melbourne at their peak, and with very similar results for most other Australian cities other than Sydney. Consequently, bicycles are considerably more important users of road space than is generally perceived

Motorcycles share the small consumption of time and road space with taxis, and attract a great deal of attention due to the prevelance of young driver usage and consequential high levels of accident involvement. While bicycles and motorcycles both share this 'safety problem' perception, bicycles are actually substantial consumers of road space and time.

To place the overall travel demand patterns in context, walking times are comparable with car driver exposure - and yet walking trips are known to be very substantially under-reported. Pedestrian, motorcycle and bicycle injuries are all of special concern, but these road users also present very different profiles of usage of road space and time. In a large number of cases the same individuals are both pedestrians and car drivers on a given day, and the easy identification of a travel mode with a 'user' is perhaps too facile for sensible consideration of user needs, behaviour and demands.

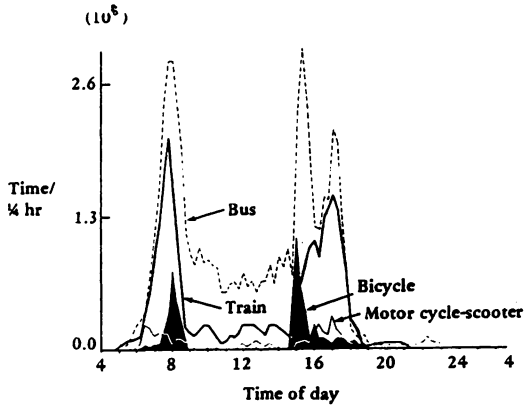

FIG. 6
TRAVEL TIME EXPOSURE PROFILES FOR SEVERAL MODES: BRSIBANE 1978

These two modes underline the different views of mobility that become attached to the users of particular modes, and suggest that a more consistent treatment of what are essentially exactly the same invididual users, seen in varying model lights, be taken.

6. SOME REGULARITIES IN BEHAVIOUR

The analysis by mode of transport uses up most of the statistical information available, and the analysis of the various activities to which people are travelling can only be examined in a summary manner when the spatial dimension is ignored and all the data is applied to investigate the characteristics of the users themselves.

A number of regularities emerge. The likelihood that someone is going to travel on a particular mode (or make a trip for a particular purpose) on a given day may be termed the participation rate, and is expressed innterms of the fraction of the population concerned: once that person is known to be using a particular mode (or making a journey for a particular purpose), the number of one-way trips that will be made by that person is termed the activity rate and is expressed in terms of the number of trips/day. Such activity rates prove to be remarkably stable over different age groups, or lifecyle stages - the variation appears to arise mainly from the participation rates. This shift ones view to a marketing stance whan examining 'user requirements'.

There are differences between cities, sexes, and age groups in participation rates and the differences in survey methods alone might explain some of these differences. However, if the participation rates are expressed in terms of the numbers of people reporting at least one trip of some kind (even if was only a walking trip) on the day, than the differences to be seen in Fig. 7 between Melbourne and Sydney disappear (Fig. 8).

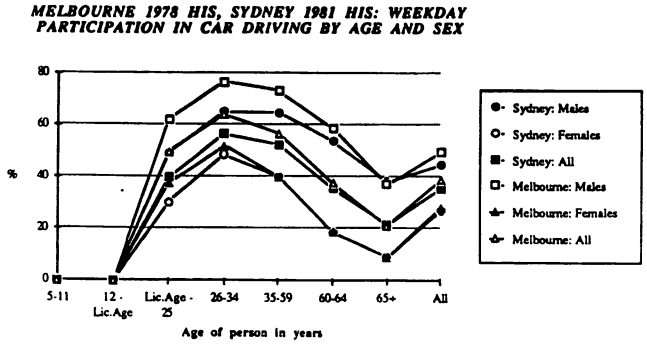

FIG. 7

PARTICIPATION RATES IN CAR DRIVING IN MELBOURNE AND SYDNEY BY AGE AND SEX

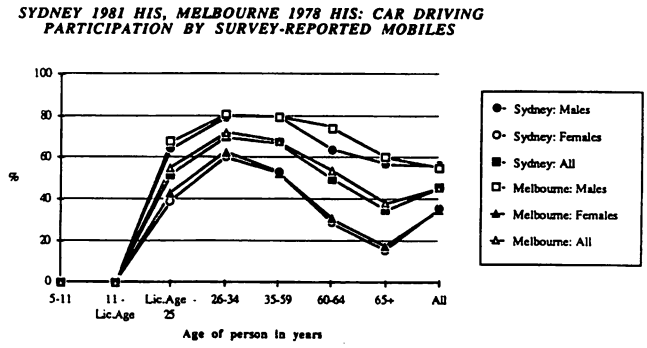

FIG. 8
PARTICIPATION RATES OF MOBILE PEOPLE IN CAR DRIVING IN MELBOURNE AND SYDNEY BY AGE AND SEX

The overall approach illustrated by these examples was applied to a range of Australian cities (Wigan, 1987), and gave quite a different view of the transport system, complementary to the road and transport network analyses so familiar to us all, as a result of asking questions about the people rather than the locations and the capacity of the transport links.

7. WHAT ARE THE "RIGHT" QUESTIONS FOR USERS?

The very first question to ask when taking a people-centered view of travel is: did this person travel on the survey day anyway? The second is: if so, how much?

Questions that reflect the spatial and capacity needs of road and transport planners are of the form:

Where did you come from?
Where are you going?
What is the purpose of this trip?

These items tend to be well used, to produce forecast traffic flows over networks.

Questions that reflect the timing of such trips :

When did you start this trip?
When did you finish this trip?

These provide estimates of total travel time, and the timings of the trips themselves. These items tend to be collapsed into a rough test of overall average journey speed, and the timing information used only at the aggregate level for peaking factor usage in the network flow forecasts.

Once the personal characteristics of the people are added these standard spatial analysis questions, user (as distinct form vehicle flow) information begins to emerge:

Which sex are you?
How old are you?
How many other people were with you on this trip?

Adding this information to the timing of trips provides a very different view of the usage of the transport system - but one that does not directly provide traffic flow capacity assistance.

The household information that it requested is used mainly for calibration of expansion factors for the transport models, but the questions asked have much more to offer:

How many cars/motorcycles/bicycles etc. do you have access to?
Is this journey linked to the needs of another person in the house?
If you could not have gone to this particular shop, where would you have gone?

These are some of the many questions that have been asked in transport surveys, have even been used for special analyses and modelling investigations, but have somehow missed the mainstream of the information that becomes created and bruited abroad when a transport survey is completed.

However, once these questions begin to be asked of the data (wherein at least partial answers lie), then a real sense of unease arises: how can the detailed cross-section of activities on a single day tell one much about the behaviour and choices of these people over time? While the information for the survey day can (and will) tell you the overall activity patterns as a whole , it is necessary to know if a particular individual on a bus used buses every day - or only once a year, if the user profiles are to be explored or understood better.

This leads one to questions (which are now beginning to appear) such as:

When was the last time you used this mode, made this trip, or undertook this activity?
How often do you go there/make this type of trip/use this type of vehicle?

This type of question tells us much more about the participation in the various forms and timings and locations of travel, but still does not give us any assurance that the behavious will remain the same over time: in fact it simply fires a concern that the variability of travel behaviour from day to day that then emerges requires much more informed interpretation (at the individual level) than we have been accustomed to do in the past. It even makes the expense of family and household activity and constraint surveys begin to seem economic and feasible.

The next step along this path is to ask how stable are the household characteristics themselves? Category analyses and other methods rely on car ownership and other factors remaing good descriptors of the household and its trip making. Already the line of questioning outlined above has led us to person trip rates (rather than hosehold), and both are clearly now needed for sensible projectiuons. This is the point to introduce longitudional survey methods, which can ask how:

Major lifecycle changes affect vehicle ownership
Does a persons' behaviour follow his/her family lifecycle or his/her age group?
What is the effect of new public transport services?
How long does it take for a fresh transport service change or constraint take to affect travel or locational behaviour?
If public transport is in place in a new subdivision when the people are moving in, does this have a long term effect on the economics, viability and usage of public transport and the ownership of vhicles?

These questions are all close to the transport needs of users, relate directly to planning and public policy for service provision and evaluation.

8. BUILDING ON A FIRMER FOUNDATION

The regularities of greatest solidity are those of population aging: a given age group will move steadily up the age scale, losing members at an increasing rate, giving rise to children more in some age ranges than others, and with differing transport usage at each stage: car purchase, etc are all influenced by age. This cohort approach is one of the best ways of matching the need to monitor changes, and is a natural analysis framework for longitudinal analysis and discussion. It is also ideal for projections of the future users and their demands: a robust and effective means of marshalling the considerable amounts of information that we already have (in a less than organised and coordinated form) about travellers of different types, ages and sexes.

The comparative stability of trip activity rates strongly suggests that participation determinants (rather than usage levels) would give a greater return for the research effort applied. This means a more user-centered approach.

9. MONITORING AND ITS IMPLICATIONS FOR TRANSPORT ANALYSIS

The fine-grained tracking of total vehicle flows over particularly our urban road networks is now simply a matter of tapping the massive stream of vehicle detector information the flows from traffic control systems. This does not however tell us anything about the users of the transport system, as these data systems can only tell us about vehicle flows (and not even occupancy, as they are

currently set up). The time of day, day of week, monthly, diurnal and perennial fluctuations and trends that can be drawn from traffic flow data are valuable and helpful - and more strategic thinking and development should be devoted to making these tasks more effective, useful and informative - but the changes in the times of day of total flows will always disguise changes in composition of the drivers and passengers , and the reasons why they are travelling at all.

The concentration on work and peak hour travel has long been coincident, but as afternoon peaks spread out and the importance of non-work travel continues to rise (see Gordon et al.1988) for the similar trends in the USA), then the purpose of the travel that provides the peak hour capacity problems begins to be a matter of real and pragmatic concern. To affect this, we must understand the people and their travel demands and activity needs a lot better - or face the long suspended economic sword of congestion pricing to allow the price mechanism to do the capacity allocation task that queuing, congestion (and privileged private parking spaces) has been doing in a less than visible or effective manner for decades.

Traffic analysis and planning must therefore pay more attention to the users, the people, and the determinants of demand. This is a price that must be paid for the success of traffic management in stretching the capacity that we already have, and now that this is largely done, the two major routes left to follow are to:

(1) Build more capacity, and

(2) Manage demand or respond to users with more understanding of the characteristics of the many different types and roles of users of the system.

10. WHAT SHOULD WE DO NOW?

The information systems that we currently have are not very good at monitoring how the users of the system are behaving, or likely to behave. This is because the survey methods have concentrated on large scale cross-sectional assessment of the spatial patterns of demand for movement from one place to another, and have been carried out at widely spaced intervals. The orthogonal approach of tracking the behaviour, choices and responses of different types of people over time at more frequent intervals is now more relevant to the overall tuning and adjustment of the transport system to changes, as these questions now have answers that have substantial impacts on different groups of users, and on the level of performance of the system as a whole.

A move to add such longitudinal monitoring and understanding is only possible now that the basic road and transport infrastructure has been largely created, and the interactions between the various parts of the system have therefore begun to outweigh the necessity for massive investments in new capacity to meet overwhelming demand.

This does not mean that assessments and planning for new construction are unnecessary. On the contrary, as a result of the tight traffic management policies now applied, any such new construction has every likelihood of being highly effectively utilised, and to service new areas of population growth new construction both in that area and to and from it are necessary.

The difference is that the links between such supply and the demand represented by the users and their own tastes, pockets and needs, must become a lot closer. It will be hard to make any serious assessment of new methods of cost recovery and road space charging without taking full advantage of the activity, social and behavioural methods now available to examine the demand side of such proposals - the analyses, and field experience in the Hong Kong trials demonstrated this quite well (Wigan 1988).

This brings better land use, pollution and employment forecasting squarely into the centre of the transport planning and service level debate. To understand just how much (or little) needs to be integrated into transport and roads provision requires a considerably better understanding of both users and the changes in their behaviour over time than we have today.

11. REFERENCES

Brown, A.L. (1978). Noise levels along nineteen roadways in Brisbane, Sydney and Melbourne. Internal Report AIR 206-5. Australian Road Research Board.

Dumble, P.L.D. (1978). New uses for old travel data. Internal Report AIR 289-9. Australian Road Research Board, Vermont, Victoria.

Gordon, P., Kumar, A. and Richardson, H. (1989). Beyond the journey to work. Trans. Res. 22A(6), pp. 419-426.

Taylor, M.A.P. (1987). MULATM Version 2.0. Department of Civil Engineering, Monash University, Clayton, Victoria.

Wigan, M.R. (1974). Traffic restraint as a transport planning policy: 1. A framework for analysis. Environment and Planning A (6), pp. 565-601.

_____ (1985). Secondary uses of transport survey data. In Ampt, E., Richardson, A. and Brog, W. New survey methods in transport. VNU Science Press, Utrecht, Netherlands. pp. 131-148.

_____ (1987). Australian personal travel characteristics. Special Report SR38 Australian Road Research Board, Vermont, Victoria.

_____ (1988). Dynamic and activity based approaches to travel: the Oxford TSU Conference in July 1988. Aust. Road Res. 18 (4), pp. 253-263.

Willumsen, H. (1981). Simplified transport models based on traffic counts. Transportation 10. pp. 257-278.