Peak Spreading Behaviour and Model Development

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1 Introduction

During the morning and evening peak travel periods, transport networks within Australasian urban regions experience congestion as travel demands approach capacity. Sydney is no exception with population of over 4 million people generating 146 million kilometres of travel every weekday, approximately 20% of which occurs during the AM peak alone. Transport systems within most metropolitan regions around Australia experience a similar rise in demand levels during peak travel periods.

Peak period traffic congestion introduces negative environmental, economic, financial and social impacts due to reduced operational efficiency of the transport system. The severity of these impacts not only depends on demand-capacity relationships but also the temporal distribution of demand across the day. Communities therefore stand to benefit from reductions in urban traffic congestion, particularly during the morning and evening peak periods when it is most widespread.

The term 'peak spreading' refers to the process of reducing the proportion of traffic demand in the most severely congested, or critical part of the peak period with corresponding increases in demand at time periods immediately before and after the critical peak. This leads to a general flattening of the travel demand profile across a broader time period. Implementation of transport policies such as temporal road pricing, flexitime work options and temporal public transport fare options encourage peak spreading behaviour and can cause a more efficient use of urban transport networks during peak travel times.

The testing of peak spreading policy strategies requires the application of appropriate transport modelling tools. Such tools need abilities in representing the trip timing decision and the peak spreading policy dimension. The modelling of peak spreading policies requires a sophisticated model with a focus on the peak period and shoulder peak times.

The research reported in this paper describes a peak-spreading modelling tool currently under development. Firstly, the paper aims to define the peak spreading phenomenon and provides an analysis of Sydney travel demand data focussing on the peak periods. A brief overview of research into peak spreading models is then provided followed by a detailed description of a modelling structure currently under development as part of this research. Important aspects of the model such as the theoretical structure, parameters and calibration datasets are described followed by future research objectives.

2 Peak spreading definitions

Morning and evening peak traffic congestion periods commonly occur in urban transport networks when travel demands are at their greatest. Morning peaks are typically more pronounced compared to the evening which can cover a longer time period due to the contribution of work and education-related travel. Shoulder peak times occur immediately before and after the peaks where travel demands build and diminish respectively.

Bolland and Ashmore (2002) define the phenomenon of peak spreading as "a dynamic process whereby the pattern of demand changes over time from one where there is heavy peaking to one where the demand spreads out over a longer period". This essentially results in a travel demand shift from a critical peak time to the peak shoulders as represented in Figure 1 for a typical AM peak travel demand profile.

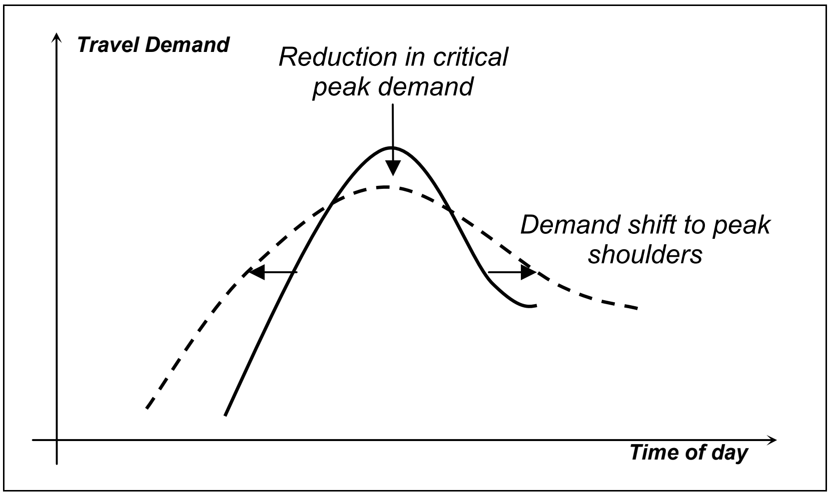

Figure 1: Representative effect of peak spreading on AM travel demand profile.

It is possible to extend the definition of peak spreading by identifying the contributing elements. This is described by Hounsell (1991) as the *active* and *passive* elements of peak spreading. Active spreading occurs as the individual travellers make a conscious decision to retime the beginning of their trip. This is done in an effort to avoid the negative impacts of the congestion during the most heavily congested time of the peak. Passive peak spreading on the other hand occurs as peak period travellers experience delays to their trip due to congested traffic conditions. These delays lengthen the individual travel time and therefore prolong the peak period to the post-peak shoulder time.

Hounsell (1991) notes that during the morning period, much of the peak period travel has an arrival time constraint (especially for work and education trip purposes). In congested conditions this will encourage travellers to depart earlier to satisfy this trip constraint, effectively promoting active peak spreading. Passive peak spreading would therefore seem less likely to occur during the AM peak. In the evening however, a departure time constraint exists for many trips so that the spreading is only likely to occur in the post PM peak shoulder. This period is likely to reflect trip re-timing and delayed travel due to congestion effects, i.e. active and passive peak spreading.

In practice, both active and passive peak spreading are likely to occur simultaneously to some degree in all peak spreading situations. Effective travel demand management strategies that seek to encourage peak spreading behaviour should focus on the decision-making process of the individual. In a modelling sense, this translates to a focus on the active peak spreading dimension.

3 Trip timing and travel behaviour in Sydney

The Sydney Household Travel Survey (SHTS) is a face to face interview survey conducted at households within Sydney and has collected personal travel data on a continuous basis since 1996. It provides a vast database on the respondents' personal, household and trip-making characteristics. An analysis of the SHTS database and associated socio-demographic summaries (Australian Bureau of Statistics, 2002) provides an illustration of the most current travel patterns and trip-making behaviour for residents of the Sydney metropolitan region. In particular it is possible to depict peak period travel movements and factors attributing to peak period traffic congestion.

3.1 Daily travel and trip purpose

With a total metropolitan population of approximately 4.1 million in 2002, Sydney produces an average of 15.5 million weekday person-trips. Figure 2 displays the demand profile for trip departures across an entire day. Trip purpose disaggregation is grouped into home-based (HB) and non-home based (NHB) type trips.

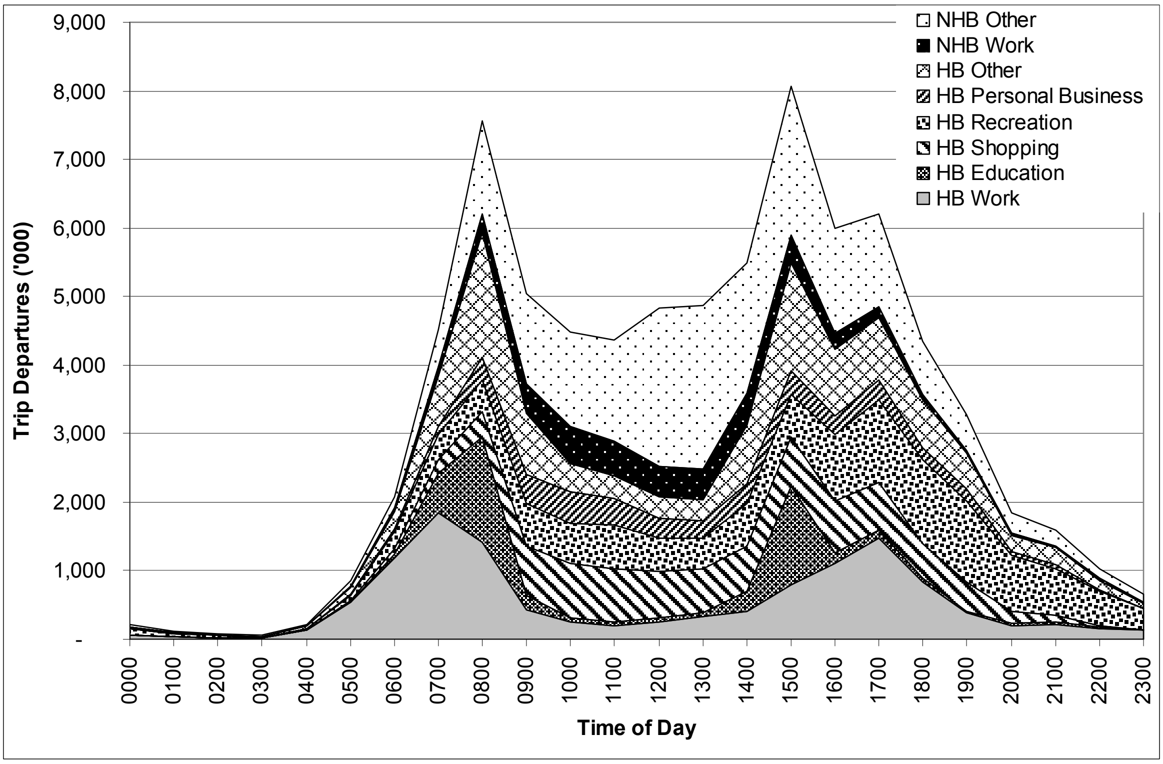

Figure 2: Sydney trip departure time profile.

From Figure 2 it can be observed that the NHB *other* trip category is most common throughout the day and especially during the inter-peak period. This category includes all work-based trips and has a significant contribution from the NHB *serve passenger* trip purpose. The next most common trip type is the HB work category which makes a significant contribution to peak period departures with more than 50% of trip departures between 4.00am and 7.00am generated by people travelling to and from work. Home based education contributes significantly to the AM peak during the 8.00am to 9.00am period and again in the PM during the 3.00pm to 4.00pm period. Home based recreation trip departures generate most trips from 6.00pm, extending throughout the evening.

The AM peak departure period, including the peak shoulders, is captured within the 6.00am to 9.00am departure time period where the PM peak departure period is longer in duration with the peak period captured between 2.00pm and 6.00pm. It may also be noted that the HB work critical peak "spike" is timed earlier within the AM peak period when compared to the PM peak. This combined with the longer duration of the HB work PM peak suggests greater flexibility in departure times leading into the PM peak.

3.2 Modes used during the day

When considering strategic transport policy options, a useful classification of travel mode are the private, public and non-motorised groups. Figure 3 illustrates the proportion of total travel demand utilised by these and other modes.

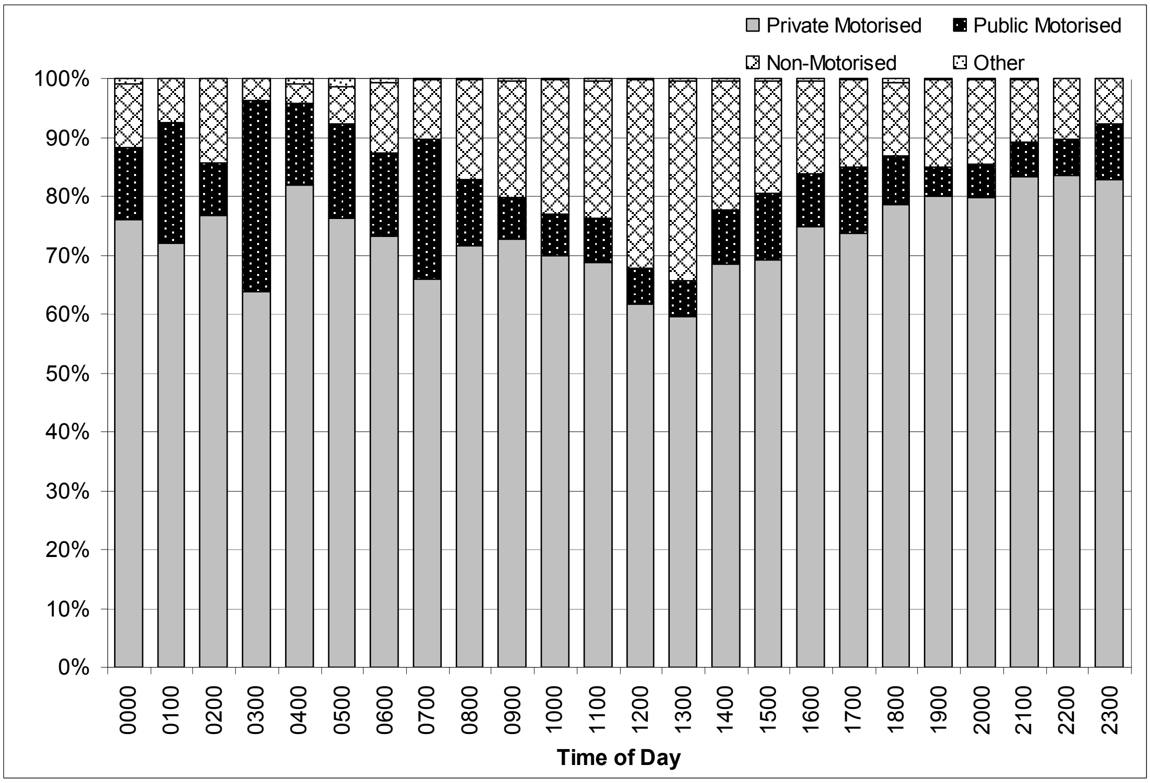

Figure 3: Daily modal proportion profile.

As expected, Figure 3 clearly shows that travel by the private motorised mode is by far the most common mode choice especially during the AM and PM peak demand periods. Walking and bicycling also have a good share of trips during daylight hours, especially during the general lunch period around midday when over 30% of trips are by walking and bicycle.

Departures in the early morning from 1.00am to 3.00am show a significant use of public transport relative to other modes. This is due to the relatively large number of trips using the taxi mode, which is included in the public motorised mode classification. Another time that public transport has a relatively large transport share, with approximately 24% of all departing trips, is at 7.00am which is during the morning peak for HB work trips. The proportion of public transport usage reduces to 11% from 8.00am when HB education trips are at a peak. This phenomenon implies that there are more trips made to work by public transport than trips made for education purposes.

It may be observed from the 2001 Social Atlas of Sydney (Australian Bureau of Statistics, 2002) that in general, private transport modes are popular for the travel to work trip in areas of Sydney with higher incomes. It s also notable that persons who travel to work by public transport are in close proximity to rail routes and major roads which would provide easy access to public transport services. This is noted as “Sydney’s highest population densities were found in the inner city and in areas along rail lines” (Australian Bureau of Statistics, 2002)

3.3 Strategic travel movements

Trips made by private motor vehicle mode are a major contributor to traffic congestion. On an average weekday, an average trip maker will travel for 32 minutes and a distance of 35 kilometres. The major travel movements around the metropolitan area extend in all directions from the CBD with longer distances travelled to the North, West and the South as the coastline bounds long trips to the East. Trips originating in outer regions dominate the private vehicle usage with areas such as Hornsby, Penrith, Paramatta and Sutherland generating much private vehicle travel. Areas where the private vehicle use is less dominant include districts within the inner west and to the east of the CBD such as Burwood and Randwick.

The ABS social atlas (Australian Bureau of Statistics, 2002) displays that areas with high private vehicle use generally have larger household sizes and not surprisingly, higher household vehicle ownership. Population density also appears to have a relationship with vehicle ownership as densely populated areas have fewer vehicles per household.

3.4 Regular start and finish work times

The home-based work trip purpose is a significant contributor to peak period traffic congestion. The timing of departures to and from work is dependant on regular starting and finishing work times for employers and employees. Workers interviewed in the SHTS reported this information and it is displayed graphically in Figure 4.

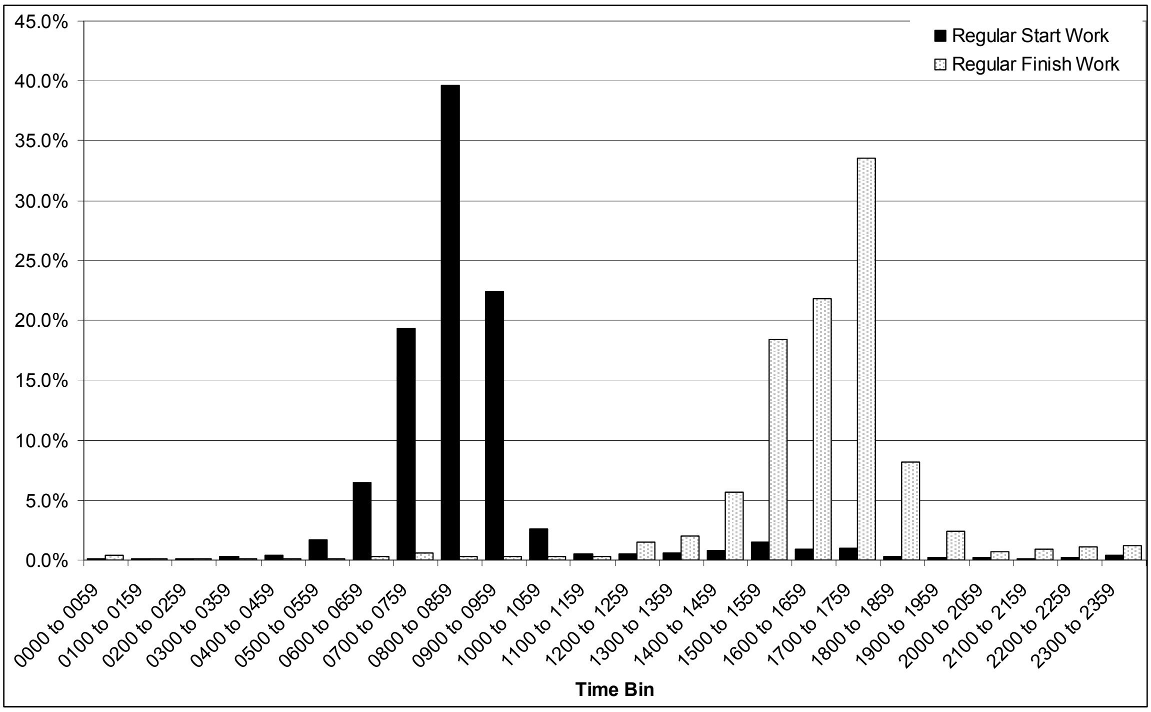

Figure 4: Reported regular start and finish work times.

The majority of workers begin work in the morning peak between 7.00am and 9.59am and finish in the evening between 3.00pm and 5.59pm, relating well to the HB work trip purpose departures in Figure 2 previously. There are few inter-peak start or finish work times however there is a slight presence of start work times around 3.00pm, most probably reflecting the presence of shift-type work. Flexitime for the 8.00am to 8.59am start work peak in particular would assist in the introduction of peak spreading within the AM peak. A similar opportunity would exist for the PM peak around the 6.00pm to 6.59pm finish work time period.

3.5 Trip timing constraints for workers

For persons within the Sydney metropolitan area with employment, the daily work schedule plays an important role in departure time choice for the work trip. Respondents to the SHTS were asked to best describe their work schedule at their main place of employment. Figure 5 illustrates the responses gained from the survey.

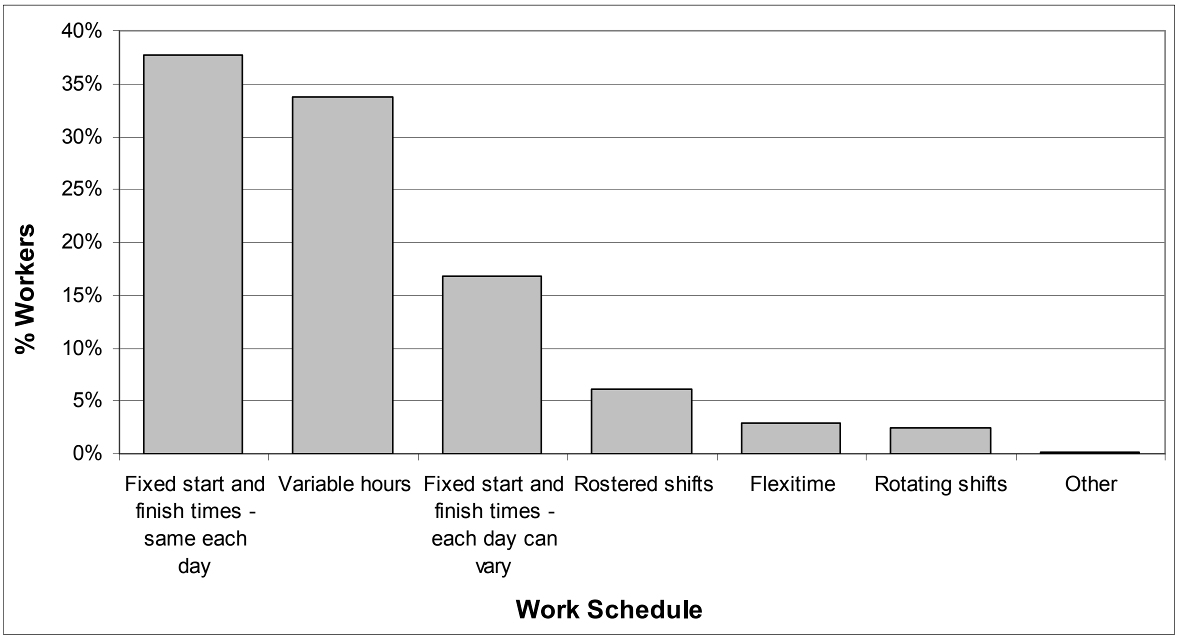

Figure 5: Work schedules of Sydney workers.

Figure 5 shows that the majority of workers have fixed start and finish times each working day, closely followed by the variable hour schedule. Combined, these account for approximately 71% of all work schedules. Flexitime accounts for only 3% of reported work routines, however this type of work schedule is important consideration for peak spreading policies which aim to shift the departure time for work-related journeys.

4 Peak spreading modelling approaches

The traditional four stage model as detailed by Ortuzar and Willumsen (1994) is a widely used and accepted standard for the forecasting of travel on strategic transport networks. It accommodates an individual's decision-making behaviour in relation to trip generation, distribution, travel mode and route choice but often does not adequately account for the trip timing decision. This can lead to a severe deficiency of the modelling process, especially when considering peak spreading policy testing and report findings of the UK Standing Advisory Committee on Trunk Road Assessment, who report that peak spreading "is an important behavioural reaction to changes in road capacity, second only to changes in route" (SACTRA, 1994).

Cambridge Systematics (1997) identify methods for including the trip timing decision within the four-stage model with the level of data required and limitations of each. The most widely used approach is to represent the trip timing decision by simply factoring daily trip matrices to estimate peak and off-peak demand, a technique with limited policy-testing capabilities. The study also identifies several "innovative approaches" with limited use in travel demand management policy analysis.

Other models developed in recent years combine the departure timing decision with other decision making behaviour represented in the traditional four stage model. Examples of this are reported in (Bhat, 1997) where a combined mode and departure time choice is represented and Matsui and Fujita, (1995) who describe a model for the representation of route and departure time choice.

In relation to the more specific peak spreading analysis problem, the UK DTLR (1996) summarise a range successful approaches for incorporating the effects of peak spreading into urban traffic models. The application of these methods depends upon the available data and resources for performing the task as each has its own level of complexity and usefulness. The identified approaches are summarised in the following table.

Table 1: Approaches for incorporating peak spreading into urban traffic models.

1	A simple estimation of peak hour to peak period ratios and subsequent adjustment of traffic demand profiles to reflect peak spreading.
2	The utilisation of historic peak period and peak hour traffic growth trends to achieve a demand profile adjustment.
3	Development of a traffic network 'peakiness factor' as a simple function of average traffic speed and a calibrated coefficient using data from a range of sources.
4	Development of peak hour to peak period ratio based on a functional relationship that includes a volume to capacity ratio measurement from the network.
5	Models that estimate the proportion of travellers that choose to shift departure times, based on utility functions built from stated preference survey information.
6	Multi-period equilibrium models aimed at modelling traffic flows in a range of time periods simultaneously whilst maintaining relative travel costs between limitations, once they exceed a pre-determined cost roof. Calibrated penalties representing drivers' reluctance to shift between time periods are introduced.
7	Incremental logit models of departure time choice that often use a logit modelling procedure where changes in travelling cost between time periods is used to govern the demand spread.

The incremental logit modelling approach described in the previous is an example of a discrete choice modelling procedure for which a range of modelling methods are available. Some examples of other types of discrete choice methods are the multinomial, nested logit and mixed or kernel logit structures, which are examined in more detail at a later stage in this paper.

Another approach to modelling trip timing is a continuous time choice model. This technique allocates trips to particular time periods (similar to discrete choice models), however these operate in continuous time where only select times exist as opposed to defined time intervals. This technique has been applied to practical model structures including HADES, (UK DfT, 2000), METROPOLIS, (De Palma and Marchal, 2002) and in the modelling of urban shopping trip departure timing, (Bhat and Steed, 2002).

When considering the evaluation of transportation control measures, it is important to note that not all of the described methods have the ability to accurately forecast future peak spreading behaviour, especially when considering the influence of policy strategies. Some of the methods are very simplistic and do not allow for policy measure assessment. As Bhat (1998) expresses, even in some of the more advanced approaches such as the continuous time method, accommodating "time-varying travel level-of-service measures is not straightforward in a continuous time model". Bhat continues this argument to iterate that discrete representation (as opposed to continuous) "better evaluate the effect of policy measures". In addition, De Jong et al (2003) note that the continuous time modelling approach adopted in HADES, "works best for small changes (5-10 min) in departure time whereas the discrete choice approach is more suited for longer periods". Longer time periods of around 30 minutes to an hour are better suited to strategic network policy implementation.

5 Modelling peak spreading in Sydney

The Sydney peak spreading model routine requires an accurate representation of the travellers' discrete trip timing choice and also needs to represent the influence of a range of peak spreading policy options. Work trips made by the private vehicle (ie. car) shall be the focus for model calibrations due to the significant impact of this purpose and mode on peak period traffic congestion.

Other car trips shall also be targeted within the modelling framework although the degree of disaggregation for these trip purposes will be revealed with further research and model calibration results. Separate calibration shall exist for both the AM and PM peak periods due to the differing nature of the trips made during these periods. The proposed model structure is defined in the following sections of this paper.

5.1 Departure time periods

Critical AM and PM peak departure time periods are identified in the existing strategic transport model for the Sydney metropolitan region; the Sydney Strategic Transport Model (STM), and exist as the following time periods identified in Table 2. This table also shows the proportion of total and work trips within each of these time periods:

Table 2: Trip departures during the day.

Peak	Time Period	Duration	% All Trips	% Work Trips
AM	Pre-peak Shoulder	600-0659	3%	10%
	Critical Peak	***0700-0859***	***16%***	***26%***
	Post-peak Shoulder	0900-0959	6%	3%
	Inter Peak	1000-1359	24%	8%
PM	Pre-peak Shoulder	1400-1459	7%	3%
	Critical Peak	***1500-1759***	***26%***	***27%***
	Post-peak Shoulder	1800-1859	6%	7%
	Off Peak	1900-0559	13%	15%

Table 2 shows the largest proportion of total trip departures during the day occur during the critical peak periods, which are 2-hours and 3-hours in length for the AM and PM peaks respectively. These periods also have the largest proportion of departures when calculated as trips per hour. Peak departure time periods in the previous table shall be adopted for the trip timing model with the total peak periods including both shoulder times and the critical peak. It is important to include the shoulder peak times as they are crucial in the calculation of the degree of peak spreading as demonstrated at a later stage in this report.

5.2 Fixed and flexible type trips

Identification of private vehicle trips with the potential for a flexible departure time is important as these trips represent possible active peak spreaders. These journeys may be re-timed to avoid unacceptable peak congestion conditions and it is these trips that are the target for peak spreading policies.

The allocation of trips to either a fixed or flexible trip option shall occur for all trips within the AM and PM trip matrices. Separate calibrations of a discrete choice models are required for AM and PM peaks as well as for the work and other trip purposes. The discrete choice model will identify trips within the AM and PM peak period trip matrix as either a flexible or fixed type in preparation for the advanced peak spreading policy modelling stage. The binary discrete choice between the fixed and flexible trip options is possible with the application of a simple multinomial logit model (MNL), where the probability of an individual selecting an alternative is based on random utility maximisation. It is expected that the resulting model structure shall include variables such as the following within the utility function for the choice options:

- Individual occupation,
- Household structure,
- Household or personal income,
- Usual start and/or finish work times.

5.3 Departure timing choice

Following on from the identification of flexible and fixed departure time components, both the AM and PM private vehicle trip matrices are subject to discrete choice modelling for the allocation to departure time periods. Separate calibrations are necessary for each of the peak periods and for the work and other trip purposes. The discrete choice applies both to the identified fixed and flexible trips.

Peak period departure times are classified as peak shoulders and critical peak periods, shown in Table 3. To refine the critical peak departure time choice, these are disaggregated to half-hour durations. It is expected that this half hour duration option is both meaningful to the trip maker and a suitable disaggregation for strategic planning purposes. The discrete choice model will allocate trips to one of the following identified time periods for the AM and PM model calibrations.

Table 3: Peak period timing and identifiers.

Period Classification	Period Duration
Pre-peak shoulder	0600 to 0659
Critical peak	0700 to 0729
	0730 to 0759
	0800 to 0829
	0830 to 0859
Post-peak shoulder	0900 to 0959
Pre-peak shoulder	1400 to 1459
Critical peak	1500 to 1529
	1530 to 1559
	1600 to 1629
	1630 to 1659
	1700 to 1729
	1730 to 1759
Post-peak shoulder	1800 to 1859

As half-hour durations for the critical peak disaggregation, adjacent departure time options may appear to be similar to the decision maker. If so, this possibility can introduce a violation of the Independent and Identically Distributed IID assumption applied to the MNL. This can lead to a correlation between options during modelling which may introduce errors. Louviere, Hensher and Swait, (2000) state that this assumption implies "the variances associated with the component of the random utility expression describing each alternative (capturing all of the unobserved influences on choice) are identical and that these unobserved influences are not correlated between all pairs of alternatives". In application to a discrete departure time choice problem, De Jong et al (2003) note that "one of the disadvantages of using discrete choice theory is that time periods are likely to be correlated". This is especially so when the defined modelling time periods are short, when the decision maker will intuitively view them as quite similar options.

It is possible to advance from the basic MNL choice model and overcome some of the restriction imposed by the IID assumption with respect to the departure time choice. Model structures such as the nested logit (NL) and mixed logit (ML) approaches relax the IID assumption and account for a degree of correlation between alternatives.

Walker (2002) notes that "the mixed logit model is a straightforward concept: it is a discrete choice model in which the disturbances (of the utilities) consist of both a probit-like portion and an IID extreme value portion i.e. a MNL disturbance." This opens the model up to flexibility in the treatment of variance and covariance in the random component that represents the "unobservable" component of the utility.

Mixed logit modelling structures are becoming increasingly popular in application to the discrete choice problem, especially within the past 5 years with transport applications including route choice, mode and time of day choice. In practice, Bhat (1997) demonstrates that when establishing a set of two dimensional choice models for mode and departure time choice including a MNL and a ML model structure, comparison of the results indicated that a ML model formulation outperformed a MNL model in terms of data fit. The following equation may be used to represent the ML model as a MNL model with random coefficients α drawn from a cumulative distribution function *G(α;θ)* (McFadden and Train, 2000):

$$P_C(i|\mathbf{x},\theta) = \int \frac{e^{x_i\alpha}}{\sum_{j\in C} e^{x_j\alpha}} \cdot G(\mathrm{d}\alpha;\theta)$$

In the previous equation, P_C represents the probability of choosing option *i* from choice set *C* ={1,…,*J*}, *x* represents the observable attributes of alternative I and of the decision maker, *θ* represents parameters of the mixing distribution *G* and *α* represents the random parameters.

Elements that may be expected to influence the discrete choice, and hence deserve consideration for inclusion within utility functions are listed in the following. These will be refined during model development:

- Traveller/household incomes or car availability,
- Individuals age,
- Occupation,
- Journey time,
- Car ownership – private or company,
- Journey tolls,
- Before/after work commitments,
- Household structure,
- Flexitime availability.

It is important to note that not only must the calibration data provide a sufficient source for model estimation but that the model requires input data to operate a practical application of the model. This will also strongly influence parameter selection. Choice options for this stage of the model therefore appear as depicted in Figure 6.

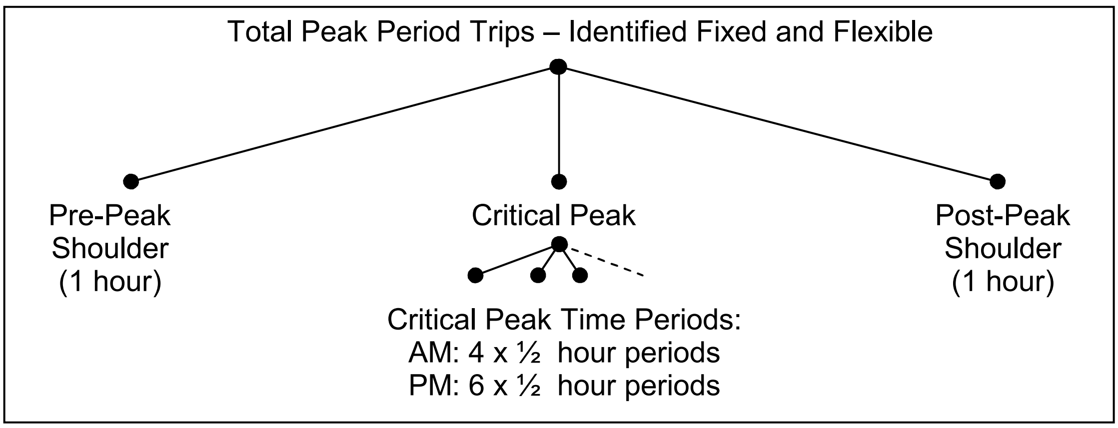

Figure 6: Choice options for Stage 2 modelling.

The result of the trip departure time choice model are a series of trip matrices representing flexible and fixed trip options within each peak time period listed in Table 3. As the levels of traffic congestion vary between each time period so to travel times will vary. Departure time period allocation will therefore demonstrate sensitivity to travel time variations within the time periods.

5.4 Peak spreading policy modelling

This modelling stage applies to the flexible trips within each time period as it targets active peak spreading behaviour. Flexible trip-makers have the option of changing their departure period or to remain with the same departure time. Changes to departure times may cause a redistribution of the flexible trips to new time periods. Policy strategies shall be represented within the model are:

- Temporal road pricing – a direct financial charge to the traveller incurred during the journey,
- Travel time change – more general policy parameter representing policy strategies that introduce a change in the journey travel time,
- Departure time change – degrees of departure time changes for earlier and later than usual departure timing.

The choice options for the traveller are therefore to depart at an earlier time, depart at the same time or to depart at a later time. The degree of departure time change is dependant on the time change parameter within the model. The following figure illustrates the structure of this choice model.

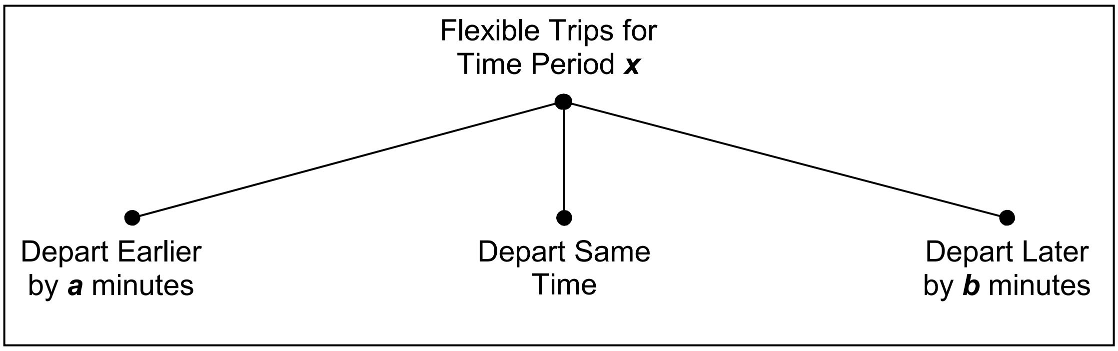

Figure 7: Choice options for Stage 3 modelling.

The SHTS database does not provide stated preference response data, therefore it is necessary to develop a calibration database collected from additional surveys. Calibration data will require surveys to be conducted to observe individuals decision making behaviour (stated preferences) in relation to the policy options as well as record individual attributes (revealed preferences). These surveys will be directed at the private vehicle travel for trip purposes defined in the previous modelling development stages for both AM and PM peak travel.

6 Stated preference surveys

Stated preference (SP) methods invoke choice responses from the individual, evoked by hypothetical propositions with controlled relationships between attributes. Saleh and Farrell (2005) discuss an investigation on the impacts of variable congestion charging on departure time choice involving a SP survey. Reported results of this investigation have proven useful in establishing a basis for the survey adopted as part of this research. The purpose of the proposed stated preference survey in this research is to gather response data from individuals relating changes in departure time choice, sufficient to calibrate the peak spreading policy evaluation model. Revealed preference (RP) information also assists in developing the calibration database and information that will be collected from survey respondents will include the following general RP data:

- Household and work locations,
- Income,
- Age,
- Occupation,
- Privately owned or company car,
- Household structure – workers, dependants, children etc.
- Flexitime options at work,
- Usual start and finish work times,
- Trip travel time,
- Before and after work commitments,
- Tolls incurred as part of the journey,
- Car parking pricing and location.

Stated preference responses on the other hand are for the evaluation of temporal road pricing, general travel time savings and departure time change as suggested in the previous section of this paper. Survey options for these items are discussed in the following sections of this report.

6.1 Temporal road pricing

Temporal road pricing is included within the stated preference survey to discover the influence of different time-based tolling strategies on the departure time decision. Initially it is necessary to establish a meaningful toll structure for the respondents. Although this will not necessarily be a final toll structure for the final peak spreading policy option, it will assist in providing an accurate response if the toll is similar to what they may experience currently within the network.

At present, there are a total of 6 toll roads operational throughout the Sydney metropolitan region. The following table summarises the toll road locations, maximum toll amount and toll road length.

Table 4: Summary of current tollways in Sydney.

Location	Type	Max Toll (private car)	Max Length (approx km)
Sydney Harbour Bridge	Bridge	$3.00	1.6
Sydney Harbour Tunnel	Tunnel	$3.00	2.1
M1 Eastern Distributor	Tollway	$4.50	5.6
M2 Hills Motorway	Tollway	$3.80	23
		$2.20	15
M4 Western Motorway	Tollway	$2.20	45.5
M5 South Western Motorway	Tollway	$3.30	31
M7 Westlink	Tollway	$6.01	39.5
Cross-City Tunnel	Tunnel	$3.50	2
		$1.60	1.1

From Table 4 it is possible to establish that the average maximum toll on these links is $3.67 with an average maximum travel distance of 26.6 km. It is therefore reasonable to assume that for a temporal road pricing policy the average toll to be paid would be a rounded average tollways figure of $3.50.

To gather information on a range of toll prices within the SP survey other toll options are required. A total of 3 toll options will provide a sufficient value range. Toll options to be included within the survey are therefore $2.00, $3.50 and $5.00. Increments of 50 cents are applied for ease of interpretation for the respondent

6.2 General travel time saving

In addition to the toll road pricing policy analysis the model will allow for the testing of peak period travel time savings for the traveller. In practice this may be achieved through a range of policy scenarios but for the strategic modelling of departure time choice such policies may be represented as a simple travel time saving for the individual. Respondents may also relate more easily to a direct travel time saving for their journey as represented in the survey.

Travel times across Sydney vary greatly depending upon origin and destination location as well as the time of day, route chosen and mode of travel. Average travel times for all travel modes across the day are as follows:

- All modes, work trip purpose = 32 minutes,
- All modes, other trip purposes = 21 minutes,
- Private vehicle mode, work trip purpose = 24 minutes,
- Private vehicle mode, other trip purposes = 20 minutes.

As with the road pricing preference options, the travel time saving element of the survey requires a range of options to establish an effective response database. For this survey, the preferred 3 travel time change options are 10%, 20% and 30% travel time saving. To best relate a percentage travel time saving to the respondent, the survey should express this in actual minutes saved on their travel time response in the revealed preference component of the survey.

6.3 Departure time change

Again we wish to make this simple for the respondent to interpret and relate to their regular travel decision making behaviour. Three levels of departure time change provide a range of options for the respondent to select from. These three travel time change options are 5 minutes, 20 minutes and 30 minutes change to either the *depart at an earlier time* or *depart at a later time* choices within the survey. The *depart at the same time* option will of course have no associated departure time change.

6.4 Other policy modelling opportunities

Other peak spreading policies for possible consideration as part of the modelling framework include strategies such as workplace flexitime incentives and temporal car park pricing initiatives. These and other initiatives can be represented by equivalent changes in travel time saving to the traveller and incorporated in the peak spreading policy modelling. This can be achieved through the application of the travel time saving parameter with a conversion utilising a correct value of travel time figure. Indeed, this is the purpose of including such a parameter within the model.

7 Conclusions and further research

An analysis of travel demands within the Sydney metropolitan region identify peak demand periods, heavily influenced by the work trip purpose and private vehicle travel. Regular start and finish work times contribute to this phenomenon and working constraints define travel time flexibility for such trips.

This paper defines the phenomenon of peak spreading including the active and passive dimensions and summarises important research into the incorporation of peak spreading into urban traffic models. The departure timing and peak spreading policy model described in this paper is currently under development. It is based on discrete choice modelling theory and involves the application of a mixed logit model. Calibration operations shall utilise the SHTS database and offer calibrations for AM and PM peak periods. In addition, proposed stated preference surveys shall offer sufficient data for the peak spreading policy model development.

Research beyond the stages of development detailed in this paper include the completion of the stated preference surveys and calibration of the discrete choice models. This can be achieved for both the Sydney metropolitan region and for the Adelaide region using the 1999 Metropolitan Adelaide Household Travel Survey dataset and similar stated preference surveys. Comparisons between the two model calibrations may then be made. The models may then be incorporated within larger strategic modelling frameworks such as the STM and the Metropolitan Adelaide Strategic Transport Evaluation Model (MASTEM).

Beyond the completed model development, it will be possible to develop a range of peak spreading policy scenarios for testing and comparison with the use of the peak spreading modelling components. The development of support modules including a possible economic benefit and cost module or an environmental impact module for scenario comparison will add to modelling capabilities.

8 References

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