Australasian Transport Research Forum 2010 Proceedings
29 September – 1 October 2010, Canberra, Australia
Publication website: http://www.patrec.org/atrf.aspx

Comparison of Trip and Tour Analysis of Sydney Household Travel Survey Data

Frank Milthorpe[1] and Andrew Daly[2]

[1] Bureau of Transport Statistics, Transport NSW, GPO Box 1620, Sydney NSW 2001

[2] RAND Europe, Westbrook Centre, Milton Road, Cambridge CB4 1YG, United Kingdom

Email for correspondence: Frank.Milthorpe@transport.nsw.gov.au

Abstract

The traditional 4-step transport model has used the origin-destination trip as the basic unit of analysis. The leading state of practice for transport models has shifted to production-attraction or tour based models with the most advanced models nowadays being activity based models. Both tour and activity based models use a tour rather than a trip as the basic unit of analysis. Whilst there are many differences in these modelling techniques, it is relatively simple to analyse household travel survey data from both a trip and tour perspective.

This paper takes travel data from the Sydney Household Travel Survey and analyses it using both a trip and a tour methodology. Comparisons are then made of the results from this analysis. Major differences include insights into non-home based travel, the proportion of journeys which involve deviations (intermediate stops) and the resulting additional kilometrage. Also, as most people start and finish the day at home, it is possible to examine the symmetry, or otherwise, for outward (away from home) and return (towards home) tour legs.

1. Introduction

The structure of the classic four stage transport model developed from practice in the 1960s Ortúzar and Willumsen (2001). The basic unit of analysis for the classic model is the origin-destination trip. Daly et al. (1983) and Algers et al. (1995), the latter paper presented in Sydney, provide details of tour based model systems developed for part of The Netherlands and for Stockholm. Ruiter and Ben-Akiva (1978) report on one of the early tour based model systems impelemeted in San Francisco. Even earlier, a workshop (organised by David Hensher) held in England in 1975 discussed approaches to tour modelling based on data from a number of European countries. Bradley and Bowman (2008) report on ten activity based model systems which have been implemented in the USA. These activity based models all used the tour as the unit of analysis. Closely related to the tour concept is the representation of demand in production-attraction (PA) form.

However, in their review of models of Australian capital cities SKM (2009) found that the Sydney Strategic Travel Model (STM) was the only Australian capital city model which was tour based (the others being trip based). Rossi et al (2009) review 12 activity-based model systems implemented from 1995 onwards. TRB (2008) contains a number of papers on tour and activity-based modelling. Clearly the trend in transport modelling is towards tour and activity-based modelling. For example, the UK Department for Transport (2010) consider that “PA based matrices are strongly recommended in demand modelling”. TRB (2010) explains that one of the deficiencies of trip based modelling is the inability to “attach demographic characteristics to non-home based travel. To estimate and implement these types of models it is necessary to have household travel survey data available in tour format.

The concept of reformatting household travel survey data is not new in Australia. For example Richardson et al (1995) discusses the distinction between unlinked trips (sometimes called stages or legs or stops) and linked trips. O'Fallon and Sullivan (2005) have a detailed review of combining trip records to form tours. In this paper and their more recent analysis O'Fallon and Sullivan (2009) they use the concept of trip chains and tours. A new trip chain commences when a person leaves from home or work, or from a location where they have remained from more 90 minutes.

2. Defining home based tours

The basic unit of travel survey data collected is normally unlinked trips (sometimes referred to as stops). To create tours, these unlinked trips need to be combined. A home based tour is a round-trip journey, a sequence of trips starting at home and ending when the person next returns home. Once the sequence of unlinked trips to form the tour has been determined, a travel purpose for the tour needs to be defined. This purpose is associated with the primary (main) destination of the tour. There are a number of methods which can be used to define the primary destination. These include:

i) the destination (stop) at which the person spent the most time

ii) the destination which is furthest away from home (most distant)

iii) the destination determined by a purpose hierarchy.

It is possible to include a combination of the above options as part of the definition and/or to resolve ties. For the analysis reported in this paper, the purpose of tours have been determined using a combination of the purpose hierarchy and stop at which the person spent the most time. The first rule is, if a tour involves a stop at work it is a work tour. The second rule (only used for tours not allocated a purpose from the first rule) is if the tour involves a stop for the purpose of work related business it is a work related business tour. The third rule (applied to the tours without a purpose) is the stop at which the person spent the most time determines the purpose of the tour. HCG and ITS (2002) outline the specifications for the tour files created for the estimation of the STM.

For work tours, it is possible to implement some additional rules which are not so easy to implement for other travel purposes. During the day some people undertake travel from their work location whereby they travel to another location before returning to their work location. Examples include attending a meeting and going shopping at lunch time. For the purposes of the analysis reported in this paper, the outward tour concludes the first time someone reaches their workplace (within the trips selected for the tour). The return (homeward) tour commences the last time someone their workplace (within the trips selected for the tour). If a worker goes home for lunch and then returns to work in the afternoon, this is two separate home based tours.

The home based tour concept is similar to the trip production and trip attraction (i.e. PA) representation undertaken in a many trip generation and trip distribution models. The home based tour concept also matches that used the Australian Bureau of Statistics (ABS) in providing Journey to Work (JTW) data from the Census of Population of Housing. For the JTW data there is a home (origin) and work location (destination). The chief difference would be that the PA approach focusses on the outbound and return legs of the tour, while the tour approach attempts to capture the whole sequence of trips; in most cases, tours comprise just two trips and there is no difference.

3. Analysis of Sydney household travel survey data

Household travel surveys have been undertaken in Sydney for many years. These include one-off surveys in 1971, 1981 and 1991. These surveys generally comprised approximately 10,000 responding households with travel for all members (or for some surveys those aged five year of age and older) were surveyed (TSG 1993). Since 1997 the Transport Data Centre (TDC) has conducted the continuous Household Travel Survey (HTS). Each financial year approximately 5,000 households are approached with a fully responding household response rate of over 60%.

The scope of HTS data reported in this paper is summarised in Table 1. HTS households in Sydney Statistical Division (SD) interviewed during the 2004/05, 2005/06, 2006/07, 2007/08 and 2008/09 waves on non-public holiday weekdays have been retained. The median survey date of these households is 31st December 2006. The data has been weighted to 2006 Estimated Resident Population (ERP), adjusted to reflect the population living in private dwellings, which is the scope of the HTS. This is comparable to approach reported in TDC (2009) where three waves of data are combined for that analysis. Five waves of data have used for the analysis reported in this paper to provide more robust analysis of travel. Table 2 summaries some of the key aspects of the person weight variable used to expand the survey data to the population data.

Table 1: Scope of HTS data analysed

Characteristic	Details
Home Location	Sydney Statistical Division
Survey Waves	2004/05, 2005/06, 2006/07, 2007/08, 2008/09
Median Survey Day	31 December 2006
Survey Days	Mondays to Fridays (non public holidays)
Population Control Total	2006 Estimated Resident Population (adjusted to reflect population in private dwellings)

Table 2: Summary of person weighting

Characteristic	Number/Value
Persons Surveyed	23,573
Weighted Number of People	4,217,882
Mean Weight	178.9
Standard Deviation Person Weight	73.4
Inter Quartile Range	79.5

3.1. Exploratory analysis

Preliminary analysis of the HTS data was undertaken using three different methods of travel linkage; unlinked trip, linked trip and tour level. The (unlinked) trips are the individual stages of travel, i.e. the movement between individual stops recorded in the travel survey. Linked trips are individual trips combined when the purpose of the activity at the destination stop is change mode. Home based tours are derived as outlined in Section 2. For tour analysis the

standard practice is to report full tours where a full tour comprises an outward journey leg and return journey leg. For this paper, as comparisons are being made with unlinked and linked trips, the unit of reporting for tours is a single tour journey leg, either an outward journey leg or a return journey leg. With this approach to reporting of travel which involves a single unlinked trip to a destination and then a single unlinked trip home will be reported as two unlinked trips, two linked trips and two tours.

The travel analysis results are summarised in Table 3. Firstly, all travel from the HTS is reported for all three methodologies. Secondly, the scope of travel was restricted to having both an origin and destination within Sydney SD, i.e. removal of "externals". The removal of externals was undertaken independently for each of the three methods. Consider the example of a linked trip which comprised two unlinked trips where the first trip is an internal-internal trip (e.g. to the airport) and the second trip is internal-external. For the trips analysis, the first trip will be retained whilst for the linked trip it will be excluded. The exclusion is based on the origin and destination of the particular linkage method. A consequence of this exclusion definition is there are minor differences between the different methods. From Table 3, as expected it can be seen that there are many more (unlinked) trips than there are linked trips. Also as expected there are fewer tours than linked trips. It can be seen that approximately 1% of records are excluded as externals using each of the three methods.

Table 3: Initial investigation of alternative methods of travel analysis

Number	Trips	Linked Trips	Tours
Full Scope			
Unweighted	108,792	89,877	61,618
Weighted	19,705,037	16,264,591	11,091,060
Internal Only			
Unweighted	107,608	88,784	61,000
Weighted	19,482,809	16,059,780	10,974,523
Travel Excluded			
Unweighted	1,184	1,093	618
Weighted	222,229	204,810	116,537
Travel Excluded			
Unweighted	1.09%	1.22%	1.00%
Weighted	1.13%	1.26%	1.05%

Table 3 shows that there is a considerable difference in the number of units of travel for each of the three methods. Table 4 shows the (weighted) amount of travel by priority mode for each of the three methods. The Table also shows the mode shares calculated using two approaches. Firstly, considering all modes and secondly excluding walk journeys from the calculation. As the priority mode concept is used, the apparent usage of the minor modes is suppressed. This can be seen in Table 4 where walk is the main mode for nearly 30% of the trips and less than 15% of the tours. It can be seen from the third block of Table 4 (where walk is excluded from the calculation) that the mode shares are reasonably similar for all three methods.

In practical modelling using tours, it is possible to represent the use of more than one mode for a tour leg, e.g. bus and train or car and train (park and ride). This representation mitigates the apparent increase in mode share for the train in particular but also for the bus.

Table 4: Amount of travel and shares for three methods

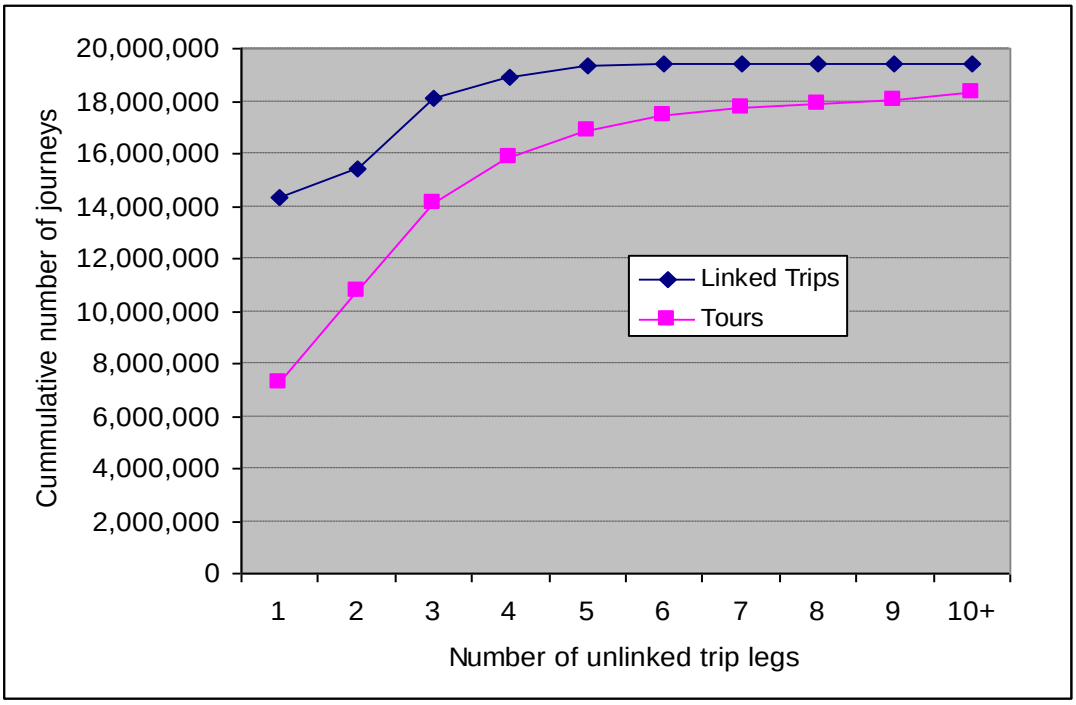
Mode	Trips	Linked Trips	Tours
Number			
Vehicle Driver	8,165,000	8,005,000	5,543,000
Vehicle Passenger	3,507,000	3,303,000	2,402,000
Train	779,000	721,000	682,000
Bus	890,000	660,000	600,000
Walk	5,773,000	3,074,000	1,546,000
Other	369,000	297,000	203,000
Total	**19,483,000**	**16,060,000**	**10,975,000**
Mode Shares			
Vehicle Driver	41.9%	49.8%	50.5%
Vehicle Passenger	18.0%	20.6%	21.9%
Train	4.0%	4.5%	6.2%
Bus	4.6%	4.1%	5.5%
Walk	29.6%	19.1%	14.1%
Other	1.9%	1.8%	1.8%
Total	100.0%	100.0%	100.0%
Mode shares (excl walk)			
Vehicle Driver	59.6%	61.6%	58.8%
Vehicle Passenger	25.6%	25.4%	25.5%
Train	5.7%	5.6%	7.2%
Bus	6.5%	5.1%	6.4%
Other	2.7%	2.3%	2.1%
Total	100.0%	100.0%	100.0%

3.2. Investigation of the linking

From Table 4 it can be seen that there are fewer tours than linked trips. This is expected as the tours will combine some intermediate stop (activities) in contrast to the linked trips where the only activities/stops which are combined are the change mode stops. The linked trips combine only public transport journeys (which can include car access/egress). For each linked trip and tour the number of individual unlinked trips that were combined has been calculated. These have been shown as a cumulative graph in Figure 1. 74% of linked trips involve a single unlinked trip, whilst only 40% of tours involve a single unlinked trip. If there was no public transport usage the number of trips and linked trips would be almost identical. It is possible that some people would have change mode trips associated with vehicle and/or

taxi journeys. Examples include walk to/from taxi and vehicle passengers switching to be vehicle drivers. Most of the difference from the possible 100% and the observed 74% of linked trips involving a single unlinked trip arises from change mode trips (including walk) associated with using public transport.

Figure 1: Cumulative number of trips legs



The slightly lower number of unlinked trip legs incorporated into tours can be seen in Figure 1 by observing the cumulative number of journeys for ten plus unlinked trips tours compared with linked trips. There are two situations which can result in trips not being incorporated into a home based tour. The first and most common instance is work based sub-tours are excluded. This is travel where someone is at their work location; they then travel to one or more destinations before returning to work. Examples of this type of travel include attending a meeting and going shopping at lunch time. The second situation is where someone does not start or finish the survey day (defined as starting and finishing at 4 a.m.) at home or at work. The number of unweighted trips and the reason for their exclusion is summarised in Table 5. The information reported in Table 5 is based on the full scope of trips (i.e. any external travel has been retained). This eliminates the differences that would otherwise arise in the situations where an individual trip may be to an external destination, whilst the destination of the tour is an internal location.

Table 5: Trips included / excluded as part of tour linking

Trip linkage type	Number	Percentage
Part of home based tour (included)	102,745	94.4%
At work sub-tour (excluded)	5,153	4.7%
Not part of tour (excluded)	894	0.8%
Total	**108,792**	**100.0%**

From Table 5 it can be seen that nearly 5% of trips are excluded. On first inspection this would tend to suggest that a considerable amount of travel has been lost in the creation of the home based tour records. It is possible to create separate work based tour records to incorporate this travel. These records have been created by TDC but are not analysed further in this paper. Table 6 shows the number of unweighted trip records included and excluded in the creation of home based tour records. In Table 6 mode shares for the included / excluded records have also been calculated. From Table 6 it can be seen that over 60% of the at-work sub-tour excluded trips are walk trips. This suggests that the loss of kilometrage from the excluded trip records is relatively low.

Table 6: Trip linkage to tour: Number and mode shares

Mode	Tour	At work sub-tour (excluded)	Not part of tour
Number			
Vehicle Driver	42,696	1,459	303
Vehicle Passenger	20,788	187	166
Train	4,231	44	37
Bus	4,853	75	27
Walk	28,248	3,237	305
Other	899	151	56
Total	**102,745**	**5,153**	**894**
Mode Shares			
Vehicle Driver	41.6%	28.3%	33.9%
Vehicle Passenger	20.2%	3.6%	18.6%
Train	4.1%	0.9%	4.1%
Bus	4.7%	1.5%	3.0%
Walk	27.5%	62.8%	34.1%
Other	1.9%	2.9%	6.3%
Total	100.0%	100.0%	100.0%

Table is based on all (unweighted) trips including external destinations.

3.3. Implications for kilometrage

From Table 4 it can be seen that there are fewer tours than linked trips. When the reporting of travel is undertaken on a trip basis, short and long distance trips have equal weighing. A better measure of the usage of the transport system is to report travel on a distance basis. Table 7 shows the kilometrage for each of the three methods of combining the trip records by the priority mode. The distances were obtained using GIS-calculated centroid to centroid distances for the road network for all three methods. This approach ensured consistency in the basis of the distance calculation. This is not the optimal approach as a stop which does not involve any deviation from the direct route, for example to buy petrol at a service station on the direct route will be calculated as travelling to the origin to the centroid of the service station zone and then from the service station zone centroid to the final destination. Ideally distances would be calculated on a point to point basis for all three methodologies. It is not

easy to calculate the erroneous loss of kilometrage as a result of the centroid based calculation methodology.

Table 7: Kilometres by mode for the three methods of travel linkage

Mode	Trips	Linked Trips	Tours
Distance (kms)			
Vehicle Driver	75,622,000	74,707,000	60,172,000
Vehicle Passenger	25,083,000	23,746,000	18,340,000
Train	14,650,000	15,673,000	15,199,000
Bus	5,678,000	5,028,000	4,765,000
Walk	5,687,000	3,131,000	1,989,000
Other	2,390,000	2,072,000	1,539,000
Total	**129,109,000**	**124,357,000**	**102,003,000**
Usage of system			
Vehicle Driver	58.6%	60.1%	59.0%
Vehicle Passenger	19.4%	19.1%	18.0%
Train	11.3%	12.6%	14.9%
Bus	4.4%	4.0%	4.7%
Walk	4.4%	2.5%	2.0%
Other	1.9%	1.7%	1.5%
Total	100.0%	100.0%	100.0%
Loss of kms			
Vehicle Driver		-1.2%	-20.4%
Vehicle Passenger		-5.3%	-26.9%
Train		7.0%	3.7%
Bus		-11.4%	-16.1%
Walk		-44.9%	-65.0%
Other		-13.3%	-35.6%
Total		**-3.7%**	**-21.0%**

The loss of kilometres travelled is relative to Trips.

All distances are calculated using centroid to centroid GIS road network calculation.

From Table 7 it can be seen that the percentage usage of the transport system by each of the modes for the three different methods of travel linkage is reasonably similar. The loss of kilometrage varies dramatically by mode. Train for both linked trips and tours has additional kilometrage. This is because a number of train journeys involve bus and/or car access/egress which has been “consumed” as part of the priority mode concept. From Table 4 the loss of the number of train linked trips and tours is relatively modest, decreasing from 772,000 to 715,000 and 682,000 respectively. Meanwhile for bus there is 11% and 16% loss of kilometrage for linked trips and tours respectively. Vehicle driver has a modest loss of

kilometrage for linked trips and a 20% loss for tours. The main loss of vehicle driver travel for linked trips is for access/egress to public transport journeys, whilst for car tours the major source of the loss is kilometrage is a result of the car being used for multiple leg journeys. When tour based modelling is implemented in transport modelling in addition to modelling direct tours, secondary and even tertiary destinations (intermediate stops) can be implemented. Access modes can also be modelled.

3.4. Travel Purpose

One of the common methods of reporting travel is by the purpose of the journey. For single destination journeys this is straightforward. If someone travels from home to work this is a home based work trip. Now consider a trip chain where someone travels from home to a school to drop off a child and then continues onto work. Using a linked trip methodology this will be recorded as a home based serve passenger trip and a non-home based work trip. Table 8 reports the total travel by purpose for linked trips and tours.

Table 8: Purpose of travel by linking method

Purpose	Linked Trips	Tours	Difference
Home based Work	1,951,000	2,590,000	639,000
Home based Business	615,000	680,000	65,000
Home based Education	981,000	1,180,000	199,000
Home based Shopping	1,695,000	1,488,000	-207,000
Home based Serve Passenger	2,421,000	1,706,000	-715,000
Home based Other	3,332,000	3,330,000	-2,000
Total Home based	**10,996,000**	**10,975,000**	**-21,000**
Work based Any Purpose	1,977,000		
Other Non-home based	3,087,000		
Total Non Home based	**5,064,000**		
Overall Total	**16,060,000**	**10,975,000**	**-5,085,000**

From Table 8 it can be seen (as expected) that the total amount of home based travel is the same for both methodologies (the minor differences arise from the exclusion of externals). However, there are considerable differences between the purposes. With the linked trip approach there is just under 2.0 million home based work trips per day, whilst the tour approach yields 2.6 million home based work trips per day. Which is the correct number? There isn't a single correct number, which is potentially very confusing to users of data who don't always understand the subtleties of definitions. There are also important implications for travel models as they will generally use one of these definitions to represent the basic unit of travel. Also from Table 8 it can be seen that the tour definition yields more home based work, business and education journeys, whilst there is a significant decrease in the number of home based shopping and serve passenger journeys. There is only a minor change in the number of home based other journeys.

4. Detailed tour analysis

The previous section has compared trip, linked trip and tour based analysis on a comparable basis. This section illustrates some of the analysis that can be readily undertaken using the tour definition.

4.1. Outward and return tour legs

Most tours are “full” tours, that is they include an outward leg and a return leg. Table 9 shows the number of full tour, outward only and return only tour legs by tour purpose.

Table 9: Number of tour legs by tour purpose

Purpose	Full	Outward only	Return Only	Total
Home based Work	2,530,000	28,000	29,000	2,590,000
Home based Business	672,000	5,000	3,000	680,000
Home based Education	1,180,000	0	0	1,180,000
Home based Shopping	1,488,000	0	0	1,488,000
Home based Serve Passenger	1,706,00	0	0	1,706,000
Home based Other	3,249,000	48,000	33,000	3,330,000
Total Home based	**10,827,000**	**82,000**	**66,000**	**10,975,000**

It can be seen from Table 9 that education, shopping and serve passenger tours all have full tours. Within the HTS context the day commences at 4am. A consequence of this definition is night-shift workers on duty commence their travel day at work. Assuming that they return home this will be a return only tour leg. If they then work another night shift, they will have an outward only work tour journey later in the day. It can be seen from Table 9 that the number of outward and return only tour leg are reasonably symmetrical. Table 10 shows the percentage of full tour journey legs as a percentage of all tour legs. As expected all the percentages are close to 100%, indicating that most people start and the finish the day at home.

Table 10: Percentage of full tour journey legs by tour purpose

Purpose	Percentage
Home based Work	97.8%
Home based Business	98.7%
Home based Education	100.0%
Home based Shopping	100.0%
Home based Serve Passenger	100.0%
Home based Other	97.6%
Total Home based	**98.7%**

4.2. Symmetry of modes for outward and return tour legs

Using full tours it is possible to investigate whether the same main mode is used for the outward leg and the return legs. Table 11 shows the main mode used for the outward and return tour legs for the work travel. Nearly 99% of the people who drive to work also drive home from work. This is not surprising as in almost all situations the vehicle needs to get back home somehow. At the other extreme, approximately 72% of people who are vehicle passengers for their outward journey are also passengers for the return journey. Their alternative modes for the return journey are reasonably equally split between vehicle driver, train, bus and walk. Perhaps more surprisingly, only 75% people who use bus to get to work also use bus to return home. Overall over 92% of people use the same mode for travel in both directions. There is another 0.8% of people who switch between vehicle driver and vehicle passenger or vice-versa on the outward and return legs.

From Table 11 a somewhat surprising result is difference in usage of modes for between the outward and return legs. As discussed above the vehicle driver numbers are almost identical for both directions of travel, 798,900 compared with 798,200. Vehicle passenger has a net increase of 10,000 people for the return leg as does other (which includes taxi). Meanwhile these increases are from people who used public transport to travel to work with 10,600 less rail travellers and 9,300 less bus travellers for the return leg. These results do not take into consideration whether these mode changes are because people are undertaking additional activities on their way home.

Table 11: Main mode used for outward and return work tours

	Return tour leg main mode						
	Vehicle Driver	**Vehicle Pass.**	**Train**	**Bus**	**Walk**	**Other**	**Total**
Outward							
Veh Driver	788,500	5,700	900	900	300	1,800	798.200
Veh Pass.	4,100	53,500	5,200	5,800	4,200	900	73,800
Train	1,900	9,400	179,000	3,400	1,800	5,200	200,600
Bus	2,600	8,600	3,000	73,800	3,700	6,700	98,400
Walk	1,200	5,900	500	2,700	60,100	2,400	72,800
Other	600	1,000	1,400	2,500	500	16,400	22,500
Total	**798,900**	**84,100**	**190,000**	**89,100**	**70,700**	**33,500**	**1,266,300**

4.3. Access and egress modes

Whilst Table 11 reports only on the main mode used for a journey, it is also possible to analyse the access and egress modes used. Table 12 shows the access mode used for outward rail work tours. Of the 200,600 outward journeys, just under 50% have walk access, 40% have car access (either as park ‘n’ ride or kiss ‘n’ ride) and 10% have bus access.

Table 12: Mode used to access rail for outward work tours

Access Mode	Number	Percentage
Walk	94,600	47.2%
Park ‘n’ Ride	47,700	23.8%
Kiss ‘n’ Ride	36,000	17.9%
Bus	19,700	9.8%
Other	2,500	1.3%
Total	**200,600**	**100.0%**

Whilst Table 12 shows the access mode to rail, Table 13 shows the egress mode from rail. Not surprisingly walk is the dominant egress mode at over 92%. There is a further 6% of rail users with bus egress.

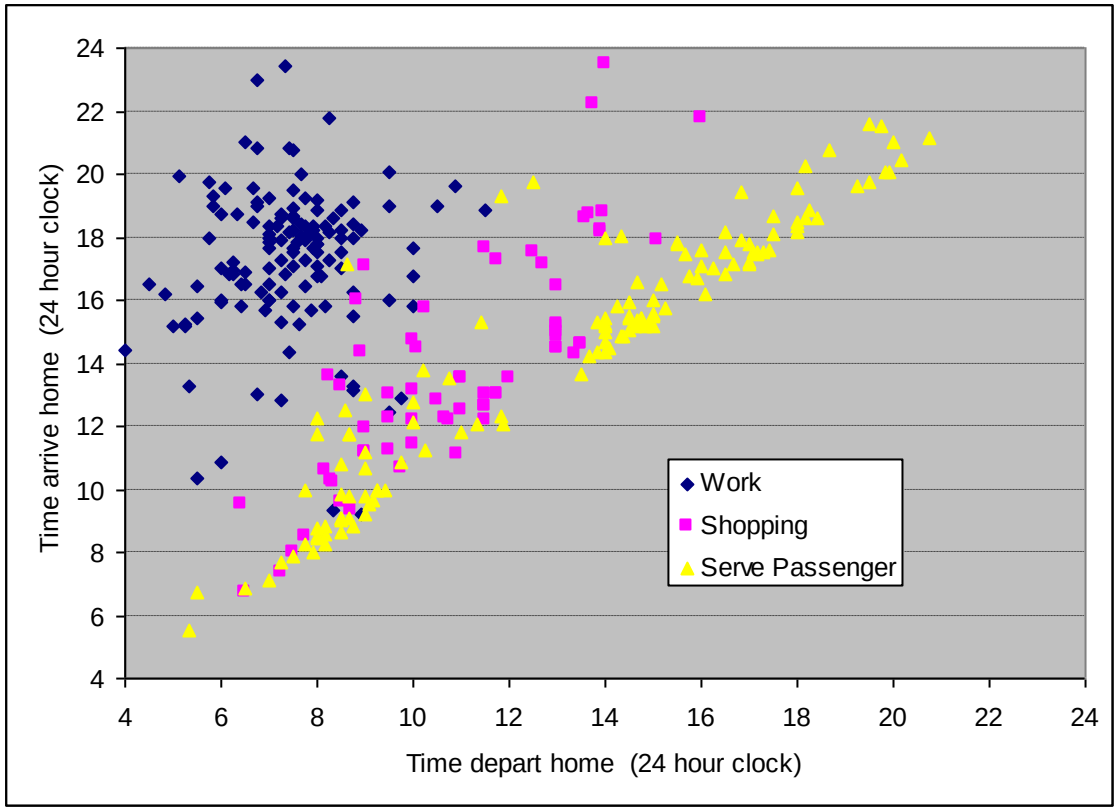
Table 13: Mode used to egress rail for outward work tours

Egress Mode	Number	Percentage
Walk	184,900	92.2%
Park ‘n’ Ride	200	0.1%
Kiss ‘n’ Ride	1,200	0.6%
Bus	11,600	5.8%
Other	2,700	1.3%
Total	**200,600**	**100.0%**

4.4. Tour time profile analysis

With the tour concept it is easy to combine and outward and return legs as shown previously with the main mode analysis. It is also possible to look at the departure (from home) and arrival (back at home). Figure 2 shows the time that a tour departs home and the time that the person returns home. In Figure 2, the horizontal x-axis is the time that a person left home (in hours). On the vertical y-axis is the time that a person returned home (in hours). Results are shown for a 10% sample of tours from the 2006/07 wave of the HTS. Very short duration tours (including the time spent at the various activity(ies)) will be on the implicit diagonal line from the lower left hand corner of Figure 2 to the upper right hand corner of Figure 2. The further a point is located away from this diagonal line, the longer the person was away from home. Travel for three tour purposes are shown in Figure 2; work, shopping and serve passenger. From Figure 2 it can be seen that work tours (shown in blue) are mostly departing home between 6am and 9am, with people returning home between 4pm and 8pm. At the other extreme, the serve passenger tours (shown in yellow) are generally of short duration at most times of the day except from 10am to 2pm. The shopping tours (shown in rose) are of moderation duration distributed reasonably uniformly throughout the day.

Figure 2: Departure and return to home for selected tours



4.5. Simple and complex tours

As discussed previously if there is a single activity whilst a person is away from home, the linked trip and tour analysis will yield the same results. However in many situations people combine more than one activity whilst they are away from home. If a tour leg involves no intermediate activities it is classified as a simple tour. If the tour leg involves at least one intermediate activity it is classified as a complex tour leg. Table 14 shows the classification of tour legs (simple or complex) by purpose. From Table 14 it can be seen that 85% of serve passenger journeys were simple tours. At the other extreme only 61% of business tours were simple tours.

Table 14: Tour leg classification by tour purpose

Purpose	Simple	Complex	Total	% Simple
Home based Work	1,945,000	645,000	2,590,000	75%
Home based Business	414,000	267,000	680,000	61%
Home based Education	947,000	233,000	1,180,000	80%
Home based Shopping	1,116,000	372,000	1,488,000	75%
Home based Serve Passenger	1,453,00	254,000	1,706,000	85%
Home based Other	2,565000	765,000	3,330,000	77%
Total Home based	**8,440,000**	**2,535,000**	**10,975,000**	**77%**

With the tour approach it is also possible to examine the symmetry between the outward and return tour legs. If someone has a complex outward tour leg, do they also have a complex return leg? This can be analysed by considering just full tours. Table 15 shows the cross-tabulation between the outward and return journey tour leg. From Table 15 it can be seen that there are more simple (outward) / complex (return) tours than there are complex (outward) / simple (return) tours. For the work purpose, 60% of full tours involve simple tour legs in both directions, whilst only 10% are complex in both directions. Nearly 20% of work tours are simple on the journey to work and complex on the return journey home. Meanwhile nearly 10% of work tours are complex on the way to work and simple on the return journey. This indicates that people are doing more activities on their way home from work than they are on their journeys to work. For shopping, the reverse applies with more complex behaviour occurring on the homeward bound journey. Business and education purposes follow similar trends as work, whist serve passenger and other purposes have reasonably symmetrical behaviour. The serve passenger travel purpose has the highest percentage of simple tours whilst business has the highest percentage of complex tours.

Table 15: Tour leg classification by tour purpose

Purpose	Simple / Simple	Simple / Complex	Complex / Simple	Complex / Complex	Total
Home based Work	60.0%	19.7%	10.2%	10.1%	100.0%
Home based Business	41.8%	22.4%	15.2%	20.6%	100.0%
Home based Education	67.1%	19.6%	6.7%	6.6%	100.0%
Home based Shopping	58.3%	13.8%	19.7%	8.3%	100.0%
Home based Serve Pass.	74.8%	11.1%	9.7%	4.4%	100.0%
Home based Other	63.8%	14.7%	13.0%	8.5%	100.0%
Total Home based	**62.9%**	**16.2%**	**12.2%**	**8.7%**	**100.0%**

The outward leg is shown first. Simple/complex means simple outward and complex return tour.

5. Conclusions

Whilst the linked trip has been the basic unit of analysis for the classic four stage model, the trend in transport models is towards tour and activity based models. These newer models use the tour as the fundamental unit of analysis. Whilst Sydney is the only capital city in Australia with a tour based model, the concept of tour based modelling has been standard practice in a number of cities in Europe and the USA for many years. To create models based on tours, it is necessary to reformat travel survey data into the tour format. This is a relatively easy task to undertake. Unlike the fundamental decision whether the transport model will be linked trip or tour based, the decision to reformat travel survey data in the tour format is much easier. It is possible to reformat household data using both the linked trip and tour methodologies. We recommend that the holders of travel survey data do this as it provides opportunities to undertake additional analysis which would otherwise not be possible with only linked trip data.

Tour based household travel data allows an analyst to examine the symmetry of travel on journeys away from home compared with journeys returning home. Our analysis has shown that there are considerable differences in this symmetry between modes. It would be possible to extend our analysis to consider travel purposes. Our analysis has also shown

that the travel purposes have different duration and time of day profiles. This type of analysis is important if differential time of day pricing is to be investigated. The tour concept also enables much easier categorisation of simple and complex (multiple activities) travel that people undertake. Tour based analysis helps to highlight the complexity of the travel which individuals undertake. A challenge for transport modellers is to determine how much of this complexity they will incorporate in their transport models.

References

Algers, S., Daly, A., Kjellman, P. and Widlert, S. (1995) *Stockholm model system (SIMS): Application*. Paper presented to the 7th World Conference of Transportation Research, Sydney.

Bradley, M and Bowman, J (2008) *Design Features of Activity-Based Microsimulation Models for U.S. Metropolitan Planning Organizations* in Innovations in Travel Demand Modeling Volume 2: Papers , Conference Proceedings 42, TRB, Washington. Available at: onlinepubs.trb.org/onlinepubs/conf/CP42v2.pdf

Daly, A.J., van der Valk, J. and van Zwam, H.H.P. (1983) *Application of Disaggregate Models for a Regional Transport Study in the Netherlands*, presented to *World Conference on Transport Research*, Hamburg.

Hague Consulting Group and Institute of Transport Studies (2002) Report 0032-1 Sydney Strategic Travel Model Stage: Model Input Data (Part1) available at www.transport.nsw.gov.au/sites/default/file/tdc/documents/TR-2002-01-STM-Stage-2-Model-Input-Data-Part-1.pdf

Ortúzar, J. and Willumsen L. (2001) *Modelling Transport*, (Chichester, West Sussex: John Wiley & Sons)

O'Fallon, C. and Sullivan, C. (2005) *Trip chains and tours: definitional issues associated with household travel surveys*, Australasian Transport Research Forum. Available at: www.patrec.org/web_docs/atrf/papers/2005/O%27Fallon%20&%20Sullivan%20(2005).pdf

O'Fallon, C. and Sullivan, C. (2009) *New Zealanders' travel patterns: trends in trip chaining and tours*, 32nd Australasian Transport Research Forum. Available at: www.patrec.org/web_docs/atrf/papers/2009/1759_paper94-OFallon.pdf

SKM (2009) *Critical Review of Transport Modelling Tools, National Transport Modelling Work Group*, March. Available at: www.bitre.gov.au/info.aspx?ResourceId=734&NodeId=132

Richardson, A., Ampt, E., and Meyburg, A (1995) *Survey Methods for Transport Planning*, (Parkville, Eucalyptus Press)

Rossi, T., Winkler, B., Ryan, T., Faussett, K., Yali, L., Wittl, D., and Zied, M. (2009) *Deciding on Moving to Activity-Based Models (or Not)*, TRB 2009 Annual Meeting CD-ROM

Ruiter, E. R., and Ben-Akiva, M. E. (1978) Disaggregate travel demand models for the San Francisco Bay Area, Transportation Research Record, 673 121-128.

Transport Data Centre 2009, *2007 Household Travel Survey Report, 2009 Release* available from www.transport.nsw.gov.au/sites/default/file/tdc/documents/hts-report-2007.pdf

Transport Study Group (1993) *1991-92 Sydney Region Travel Surveys Home Interview Survey Methodology and Data Dictionary* Report 93/8, TSG. Available at www.transport.nsw.gov.au/sites/default/file/tdc/documents/TR1993_08-1991-92-Sydney-Region-Travel-Surveys.pdf

TRB (2010), NCHRP Synthesis 406 *Advanced Practices in Travel Forecasting*, Washington, D.C. Available at www.trb.org/Main/Blurbs/Advanced_Practices_in_Travel_Forecasting_163651.aspx

TRB (2008) *Innovations in Travel Demand Modeling Volume 2: Papers* , Conference Proceedings 42, TRB, Washington. Available at: onlinepubs.trb.org/onlinepubs/conf/CP42v2.pdf

UK Department for Transport (2010) WebTAG Unit 3.10.2d, *Variable Demand Modelling – The Scope of the Model*, www.dft.gov.uk/webtag/documents/expert/pdf/unit3.10.2d.pdf.