



"Designing" trip generation rates from new residential areas

Ted Collins
Wollongong City Council

Brad Collins
Student

Abstract:

It is generally acknowledged that communities go through "life cycles" which, over a period of 20 to 30 years, may result in changes in environmental, social and economic impacts. It is this variation in demand over time, particularly on local public infrastructure such as primary schools, youth and aged facilities and transport that is of concern to Planners and Engineers. The question of how much, where and when in relation to the provision of public infrastructure is a perennial problem.

This paper specifically details the use of demographic data in a computer spreadsheet model to quantify the variations in trip generation rates from residential areas over a long time period. Australian Bureau of Statistics census data together with Department of Transport's *Home Interview Survey (1991-1992)* data was used as input to derive a life cycle "demand wave" produced by a community over a time period. The model's graphical output draws attention to the need to seriously consider what is the appropriate level of local community infrastructure. Numerous planning, social, engineering and financial problems eventuate where some "rule of thumb", arbitrary or average demand level is selected as the required design capacity for the necessary local infrastructure.

The spreadsheet model generates a range of trip rates and shows how, over time, a "demand wave" is generated. It is then shown how trip rates can be influenced by planning controls to smooth demand to achieve a relatively even "demand line". The benefits of being able to, firstly evaluate a planning strategy and then finally achieve some degree of consistency in demand for local infrastructure over time, are shown to be substantial.

Contact author:

Ted Collins
Senior Traffic and Transportation Planner
Wollongong City Council
1 Poplar Avenue
UNANDERRA NSW 2526

Telephone: (02) 4227 7106
Email: tcollins@wollongong.nsw.gov.au

Fax: (02) 42269796

Introduction

The ability to travel, whether for long or short trips, is generally accepted to be a necessary part of everyday life for most people. Furthermore, one's ability to travel by certain modes appears to have strong connotations of affluence and even seems to infer some degree of social status. Travel is therefore often seen as a positive and even desirable activity. However, the product of travel, traffic, is not viewed so enthusiastically and is often considered a problem to be eliminated, or at least dealt with.

It is this dichotomy which increasingly occupies the minds of transport planners, traffic engineers and others who wrestle with the competing objectives of maximising the economic benefits of development while minimising the social and environmental impacts arising. Unfortunately, a simple 'middle-of-the-road' determination is usually inappropriate when considering the complexity and implications of real-life situations.

Accordingly, methods are required which firstly, quantify and describe the nature of the (traffic) problem before it can be dealt with in the most appropriate way in the given circumstances.

This paper examines the traffic generated from areas of residential development and shows how this varies over time to exhibit a 'life cycle' characteristic. A methodology is then suggested which demonstrates how an average trip rate for a residential area can be 'designed.'

Identifying the problem

If traffic, or more precisely too much traffic, is a problem, then two questions arise:

- When does 'too much' become a problem?
- What is the cause of the problem?

Both these questions have, over many years, been the subject of much research and practitioner debate. The first question often does not have a definitive answer, as what one person considers to be a problem may be tolerated by others. However, generally there is some consensus with documented thresholds which are used as guides. This question therefore is deliberately avoided at this point in order to focus on the cause of problems and their solutions.

Dealing with the cause of the problem is generally approached from two opposing directions. The traffic engineer sees the problem from a network capacity viewpoint and through sophisticated technology and traffic management techniques seeks to maximise (or optimise) traffic flows. Some measure of relief from the problem's most obvious symptom, congestion, is thereby achieved. However, another approach to identifying the cause of the problem is to examine the origin and reasons for the proliferation of and increase in use of the private motor car. This aspect of the problem

tends to be related to the land use and demographic characteristics of an area and accordingly is of particular interest to the traffic planner. It is this latter aspect that is the subject of this paper. While acknowledging the necessity of appropriate traffic management, understanding the source of existing problems and planning in such a way as to avoid future problems is seen as truly 'getting it right.'

While the traffic planner is mainly concerned with 'cars' a more holistic approach is seen in the recent interest in the integration of land use and transportation planning. This approach is commendable; however, the fact remains that traffic is, and is likely to be for quite some time, a problem which must be understood and addressed. In fact, if the magnitude of a future traffic problem can be quantified, the case for implementing an integrated transport solution is strengthened.

Quantifying the problem

Traffic is quantified or measured in many ways. One of the simplest is a tally of the number of vehicles passing a given point in a nominated time period. The number of vehicles is usually expressed as a rate of 'x' number of vehicles per hour or 'x' number of vehicles per day. Numerous traffic management procedures and formulae utilise rates such as these to determine capacities, timings, thresholds of acceptability or simply to monitor traffic growth.

The traffic planner attempts to relate traffic flow rates to the traffic generation attributes of land use. In doing so it has been observed that particular land use activities 'cause' more, or less traffic than others. For planning purposes, it is important to be able to predict the additional traffic to be generated by a new land use activity or mix of activities in order to ascertain the traffic impacts of that land use.

Traffic flow rates (trip generation rates) are therefore used to describe the additional traffic generated, either on a daily basis or for a peak hour.

Numerous studies have been undertaken with the most common reference being the Roads and Traffic Authority (RTA) publication "Guide to Traffic Generating Developments" (1993). Through extensive surveying of the appropriate samples of various land uses, traffic generation rates have been derived. It is the traffic generation rate for residential dwellings as documented in section 3.3.1 of the RTA "Guide" that is of particular interest and is examined in this paper.

The traffic generated by a proposed residential area is often simply determined by rule-of-thumb methods such as multiplying the number of residential dwellings by ten to produce a daily flow rate. (The 'peak hour' generation rate is typically the daily rate divided by ten). The RTA Guide recommends a rate of nine vehicle trips per dwelling per day but cautions the reader by stating this value is typical of areas where 'public transport accessibility is limited'. Exactly what is 'limited' and what should be allowed for either below or above 'limited' public transport provision, is not clear.

A more complex method utilised by some land use/traffic computer modelling software generates traffic using 'category models.' In this case the traffic generated by a residential dwelling is a function of demographic characteristics such as cars per household and employees per household. A category model attempts to provide a trip rate by cross-classifying the casual household socioeconomic characteristics that influence trip generation. The trip rates are calibrated to surveys, typically household interview surveys and use average values derived from reasonably large areas. The accuracy of this method overall is quite good; however, at a local level, validation surveys sometimes highlight the occurrence of particular local factors which influence trip rates.

Almost every traffic engineer has at some time placed a pneumatic traffic counter across a road leading to a residential area of a known number of dwellings. By simply dividing the number of dwellings into the average daily traffic flow, a trip rate of vehicles per day per dwelling can be calculated. However, these daily trip rates can vary greatly from place to place with little explanation. Local knowledge may assist in guessing why a rate from one area is higher or lower than another; however, without a detailed analysis of each household make-up in the surveyed area, an explanation for a particular trip rate can only be surmised.

A study by Preston (1995) involved a number of surveys to determine a correlation between measured trip rates (pneumatic traffic counter readings) and household demographic data (average rates of car ownership and employees per household). Once again however, a number of variables possibly influencing household trip rates was considered to be reflected in the survey results.

The traffic planner's task of estimating trip rates is not made a lot clearer by all of this data and research. For a major subdivision or land release area, the question arises 'what trip rate is appropriate for the future housing?' Given the number of variables and uncertainties, is the rule-of-thumb ten trips per household per day good enough? Developer contributions required under Section 94 of the New South Wales 'Environmental Planning & Assessment Act' may be sufficient incentive for the proponent to adopt the RTA Guide's nine vehicle trips per day rate or even argue a case for something less. Who is to say what is right? The traffic management treatment necessary as the result of additional traffic generated from say, a 1,000 lot residential subdivision, may differ significantly if the traffic generated was estimated to be 20% less than that determined at the ten per household rate. This difference of only two vehicle trips per day per household becomes significant when a 3,000 or 5,000 lot residential subdivision is being considered. The 6,000 or 10,000 trips per day difference, particularly when compounded with traffic from existing adjacent areas or existing through traffic, may have significant environmental, cost and infrastructure provision implications.

Now the question can be asked: "Why is there such variation in trip rates from residential areas?" As shown above, there are many demographic factors which influence residential trip rates; however, one factor which may account for a significant component of the variability is a phenomenon known as 'life cycles.'

Life cycles

It is a fact that many 'things' have a finite life span. Furthermore, groups of 'things' or communities may also exhibit similar characteristics to the individuals and also experience a finite life. By observation, the characteristics displayed by both individuals and communities change over their lifetime. When the lifetime of a 'thing' reaches its allocated duration and is replaced, certain characteristics previously exhibited may be repeated and so the cyclic aspect of the 'life cycle' phenomenon is manifested.

Examination of the demographic characteristics of a residential population can show evidence of life cycles. These cycles may either be very pronounced, as seen in a relatively homogenous community, or else be blurred in a community exhibiting a range of socio-economic characteristics.

Life cycles can be observed by examining Australian Bureau of Statistics (ABS) census data. Large communities tend not to show life cycles and because of their social diversity may only show general trends such as an ageing of the population or a gradual increase in car ownership. Smaller communities or parts of communities with more uniform socio-economic characteristics are, on the other hand, seen to display more distinct life cycle patterns.

The smallest geographic unit for which census data is available is the 'collection district' (CD). The data from these areas is therefore useful for the purposes of examining life cycle patterns.

One of the most pronounced life cycle patterns seen in the census data at CD level for a community is from the ABS 'Basic Community Profile' Table 03 (AGE BY SEX) which gives the age distribution for the population of that area.

Analysis of the census data is assisted by graphing the data, an example of which is shown in Figure 1

Determining life cycles

A suitable residential area was sought in order to directly examine the long-term cyclic nature of traffic generated. Certain requirements were deemed necessary for that area so that the survey data obtained would reflect any changes over time in that area. To fulfil the necessary requirements a geographic area should have:

- (i) an area which is wholly residential
- (ii) a consistent number of dwellings over, say 25 to 35 years
- (iii) at least 100 dwellings
- (iv) only one access road to avoid the possibility of through traffic
- (v) reasonably uniform socio-economic characteristics, and
- (vi) periodic traffic counts on the single access road over a 25 to 35 year period.

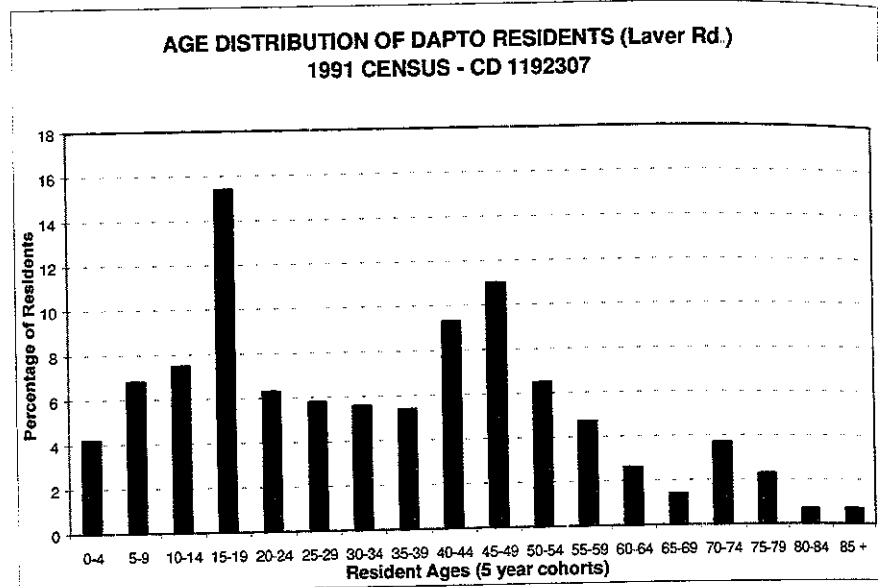


Figure 1 Age Distribution of Dapto Residents (source: Australian Bureau of Statistics)

An area which does not comply with all of the above criteria must be discarded. Surveys such as this, conducted at one location at regular intervals over a number of years, are referred to as 'longitudinal surveys.' Although the traffic counts recorded at such a location may show (significant) variations over time and even some cyclic pattern, there would inevitably have been numerous non-cyclic factors which would have influenced the trip generation rate at any particular time. In many instances it would be difficult to identify, let alone quantify, the extent of 'cause and effect' attributable to these factors. Therefore the difficulty in relating traffic generation rates to demographic characteristics renders traffic counts somewhat less than useful for the purpose of this research. (The factors influencing trip rates may include national economic climate, fuel prices, vehicle affordability/car ownership, public transport availability/ accessibility, number of licensed drivers, etc). The final requirement listed in the previous paragraph as (vi) was particularly difficult to satisfy, as typically, most traffic counts undertaken regularly over an extended period at one location are inevitably situated on a main road having a significant proportion of non-local through traffic.

Accordingly, after quite some investigation, the conclusion was reached that the necessary requirements listed as (i) to (vi) above, may well render such a study area, for all intents and practical purposes, as being non-existent. For these reasons the search for a suitable area was abandoned and another approach to 'solving' the problem sought.

While a longitudinal survey involves the repeated collection of data over time, another type; 'the cross section survey', samples data across a geographic area. However, once again the problem arose of eliminating many of the same factors identified and noted above as being detrimental to the use of longitudinal surveys in this research. Notwithstanding the difficulties described, when examining census collection district (CD) data for a number of areas, significant differences in patterns between areas were seen (Lee 1997). For example, census data enabled the determination of percentage of residents in five year age cohorts which, when plotted on spreadsheet graphs, provide a visual appreciation of the characteristics of each area (see Figure 1).

Traffic generation – demographic correlation

Although a long-term life cycle pattern can be seen to be emerging from the census data, this data in itself does not provide a direct (if at all) indication of a resultant trip generation rate from a residential area. As mentioned earlier, 'category models' attempt to provide a trip rate but appear not to truly reflect a correlation between residential trip generation rates and physical planning control variables such as lot size/housing type and the related household/family type.

The latter demographic characteristic was thought to be particularly relevant as an indicator or factor responsible for some variation in residential trip generation rates. Surveys of households in new residential areas, together with census data, have shown that some demographic characteristics vary according to the age of that residential area (Lee 1997). Accordingly, sources of data were sought which would provide a link between residential household/family type and trip rates. The NSW Department of Transport's, Transport Data Centre (IDC) database containing the "1991-92 Home Interview Survey" (HIS) data was then considered a potential source of trip rates which could be useful to this research. As detailed in following sections, data from this source was used to provide the link between a residential area's demographic characteristics and residential household trip rates.

The life cycle 'wave' characteristic

Firstly however, before making use of the data available, it is useful to examine the properties of a life cycle 'wave'.

The characteristics of a life cycle within a community arise from alternating growth and decay of certain demographic variables such as number of children of an age group, or cars per household. A peak value is reached, then over time decreases to a minimum value before repeating the cycle. It is a significant fact that the values and characteristics observed may not necessarily be the same or even similar for the second or subsequent cycles.

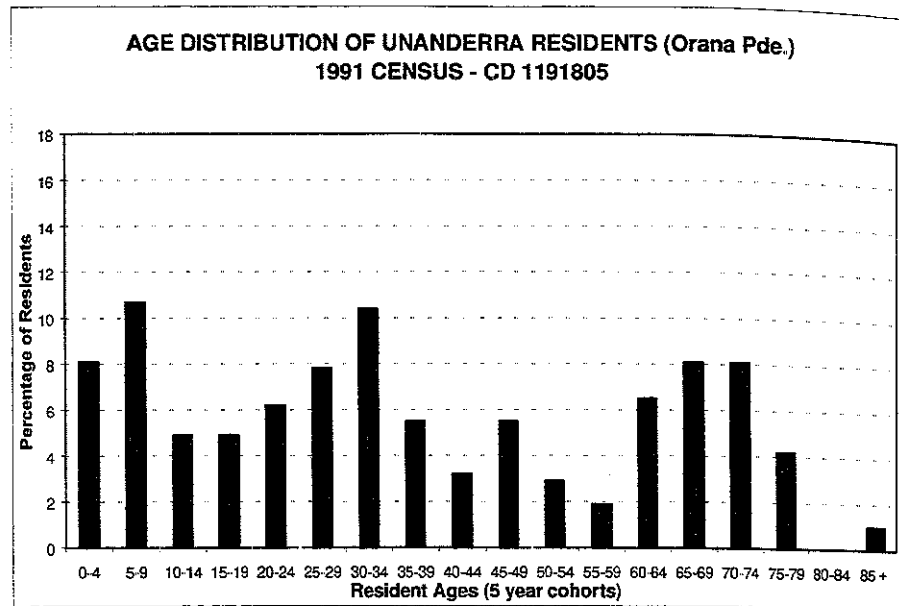


Figure 2 Age distribution of residents (source: Australian Bureau of Statistics)

Notwithstanding this, any life cycle can be described by certain geometric properties common to any wave pattern. A wave, by definition, has crests and troughs. When population demographics are graphed, the results are often seen to display wave-like characteristics with sometimes very distinct crests and troughs. For example, when graphing a residential area's age distribution (say in 5 year cohorts) a wave pattern (albeit irregular) is seen. The wavelength is seen to be the elapsed time in years between successive person (family) generations. From a limited sample of CD data this time period (wavelength) was found to be approximately 30 years.

Figure 2 shows a graphical presentation of ABS census data of age distribution for an established residential area (CD 1191805) in a working class suburb of Unanderra, some 10 kilometres south-west of Wollongong. This area was originally public housing and was developed around 1953. The graphed data shows three crests representing three generations of residents with peak values some 30 years apart.

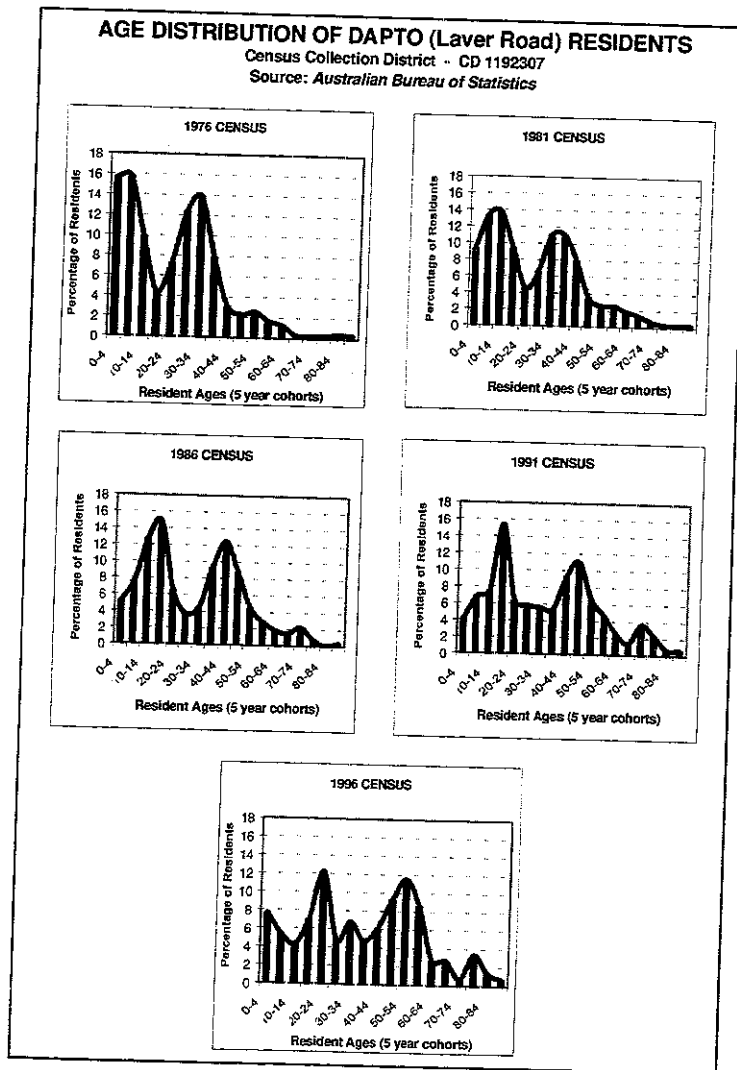


Figure 3 Age distribution of residents

Furthermore, this wave pattern will shift over time. If the census data for, say, age distribution is again examined over a number of census periods, the wave can be seen to move as the population ages. This phenomenon is thought to be more evident in suburban residential areas where "traditional" family units are found. Figure 3 illustrates the wave dynamics over a 20 year period for another established residential area (CD 1192307) in Dapto, some 15 kilometres south of Wollongong. This area was a privately developed residential subdivision with housing constructed and occupied circa 1964.

Household type trip rates

The major advantage of the IDC trip rates over 'ground surveys' is that specified household types can be 'isolated out' and their trip rates only can be recorded. This in effect satisfies the majority of the criteria identified (in a previous part of this paper) with the only exception being the lack of an historic time dimension.

The historic aspect is overcome by using the IDC trip rates associated with different household types based on the assumption that each type represents a different point on the cycle or time scale on the wave graph.

Trip rates for six household types were provided by the IDC for a number of geographic areas in the Wollongong and Shellharbour Local Government Areas (LGAs). The data used is derived from some 500 questionnaire responses as being representative of about 64,000 households. The combined Wollongong and Shellharbour LGA residential population is 228,300 persons (ABS 1991 Census data).

The DOI's 'Home Interview Survey' data set contains trip rates for nine different 'Household Types'. Each type defines the household occupant's family make up and/or social relationship, together with data on children (if any) by age grouping.

One key hypothesis of this research is that 'different household types exhibit different daily trip rates'. Also, it was thought that households with children of driving age (16+ years) would have higher trip rates (more cars per household) than households with children younger than 16 years. Therefore household types were selected which included (a) no children; (b) only children 0 to 14 years, and (c) only children 15+ years.

Note the DOI household types grouping adopts a child age cut off point at 14/15 years. A description of each household type selected is given in Table 1

Table 1 Household types (source: Department of Transport)

DEPT OF TRANSPORT 'HOME INTERVIEW SURVEY' HOUSEHOLD TYPES		
Types	Description	Comment
1 and 2	Person living alone, and Married couple only	No children
4 and 7	Married couple living only with unmarried children 0 - 14, and One person living only with unmarried children 0 - 14	Young children
3 and 6	Married couple living only with unmarried children 15+, and One person living only with unmarried children 15+	Older children (drivers?)

A life cycle model

As previously discussed in this paper, a wave has two key dimensions:

- Wavelength (measured along the 'x' axis), and
- Amplitude (measured along the 'y' axis)

Therefore, to properly define a life cycle wave, specific values must be determined for each of the above key dimensions. Furthermore, a range of 'y' values must be specified for corresponding 'x' values to produce a wave pattern

From the ABS Census age distribution data, a wavelength of 30 years is adopted which equates to a typical cyclic pattern of approximately 30 years. This 30 year cycle can be used to represent an 'x' axis value (on the horizontal axis and graduated in years) for the wavelength when plotted on a graph

As the purpose of this research is to examine residential traffic generation values (ie, household trip rates over a lengthy time period), it is appropriate that the 'y' axis represent the derived traffic generation rates. Therefore, for a specified study area, data is required which gives trip rates that can be related to a particular residential household occupant type, which in turn is reflected by a particular demographic wave pattern (eg, one of the five shown in Figure 3). The NSW Department of Transport, IDC Home Interview Survey (HIS) data is able to provide trip rates for various household types. The TDC data, including household types and trip rates for the various residential areas are shown in Table 2. These rates therefore give the required 'y' axis values (vertical axis) for a graphical representation of a cyclic pattern or wave form.

Table 2 Trip rates by household type (source: Department of Transport)

TRIP RATES BY HOUSEHOLD TYPE (veh/hh/day)			
	Household Types ¹		
Locality	Types 1 and 2	Types 4 and 7	Types 3 and 6
Wollongong south west	5.67	17.34	10.28
Wollongong remainder	4.10	12.72	8.91
Wollongong Total LGA	4.43	14.31	9.39
Shellharbour Total LGA	4.91	10.30	9.83
Wollongong & Shellharbour	4.52	13.27	9.50

1. For details of selected household types, see Table 1

The data presented in Table 2 for the combined Wollongong and Shellharbour LGAs is now taken and assigned to a five-yearly time scale which, with corresponding trip rates, is shown in Table 3 and graphically in Figure 4. By observation, significant variation is seen in the trip rates with the minimum (4.52) some 50% less than the RTA's value of 9 trips/hh/day and the maximum (13.27) being some 47% greater than the RTA value.

Clearly these values, when multiplied by the number of residential dwellings in a proposed residential development represent a large range. Furthermore, it is suggested that, depending on the type of occupants in the study area, the traffic volumes emanating from that area will, over time, either increase dramatically or conversely decrease just as dramatically.

Table 3 Trip rates by household type by years
(source: Department of Transport)

TRIP RATES BY HOUSEHOLD TYPE BY YEARS ¹		
Years ¹	hh Type	Trip Rate (veh/hh/day)
0	1 + 2	4.52 ²
5	---	8.90 ³
10	4 + 7	13.27 ²
15	---	11.39 ³
20	3 + 6	9.50 ²
25	---	7.00 ³
30	1 + 2	4.52 ²

¹ Years denotes time elapsed since dwelling first occupied.

² Average Trip Rate for Wollongong and Shellharbour LGA's Combined

³ Interpolated value

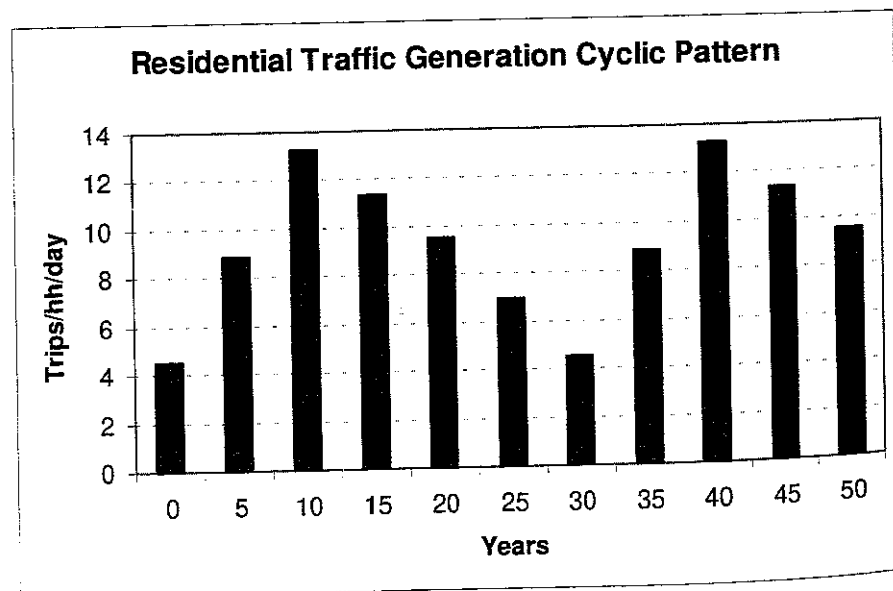


Figure 4 Residential traffic generation cyclic pattern

Synthesising trip rates

A computer spreadsheet model has been developed into which trip rates for various household types are input at five yearly time periods. The output, when graphed (Figure 4,) somewhat replicates the wave forms displayed by the demographic age cohort graphs shown in Figures 1 and 2.

The spreadsheet has been further developed in such a way as to 'mix' the household types in various proportions so that at any particular time, a number of trip rates are contributing to the production of an 'average' (synthesised) trip rate. This average trip rate is therefore the mean of a number of different rates, each generated by a different type of household occupant and each being at a different stage in its own life cycle. Accordingly, the resultant combined output is the sum of four asynchronous 'demand waves' which produce, over time, a relatively even 'infrastructure demand' line.

It is suggested that in a large and established residential area with a social and demographic mix of residents, this in fact, is what occurs. Consequently, it is considered a reasonable proposition that the intentional and planned mixing of household types (particularly in large new residential developments) can achieve an 'average' trip rate from day one. This development scenario would have the benefits of a planned 'average' calculated trip rate, thereby avoiding peak demand and the ensuing below-average demand cyclic patterns.

The spreadsheet model also has a facility to 'dial up' a desired proportional split of household types. A particular type is selected and its proportional contribution to the development of an area can be increased or decreased simply at the click of a 'button'. At the same time the results (changes to the average trip rates) can be evaluated by observing changes to the wave form seen on an on-screen line graph plot.

This model then becomes a 'tool' for the transport planner and others to undertake 'what if' and 'sensitivity analysis' evaluations of the impact of various development scenarios. By this means an average trip rate can be 'designed' into a new area giving it a relatively stable long term trip rate. Figure 5 shows a typical computer screen layout with the before (upper) and after (lower) trip generation wave forms.

The mix of households consists of the four types shown in Table 3 which, with their corresponding proportions, are

- (i) 'First home buyers' (15%)
- (ii) 'Households with children aged 0 - 14' (35%)
- (iii) 'Households with children aged 15+' (35%)
- (iv) 'Couples and singles, aged persons' (15%)

This proportional mix of household types and corresponding trip rates represents only one of a virtually infinite number of residential mix scenarios and therefore is presented in this paper only to illustrate the methodology developed

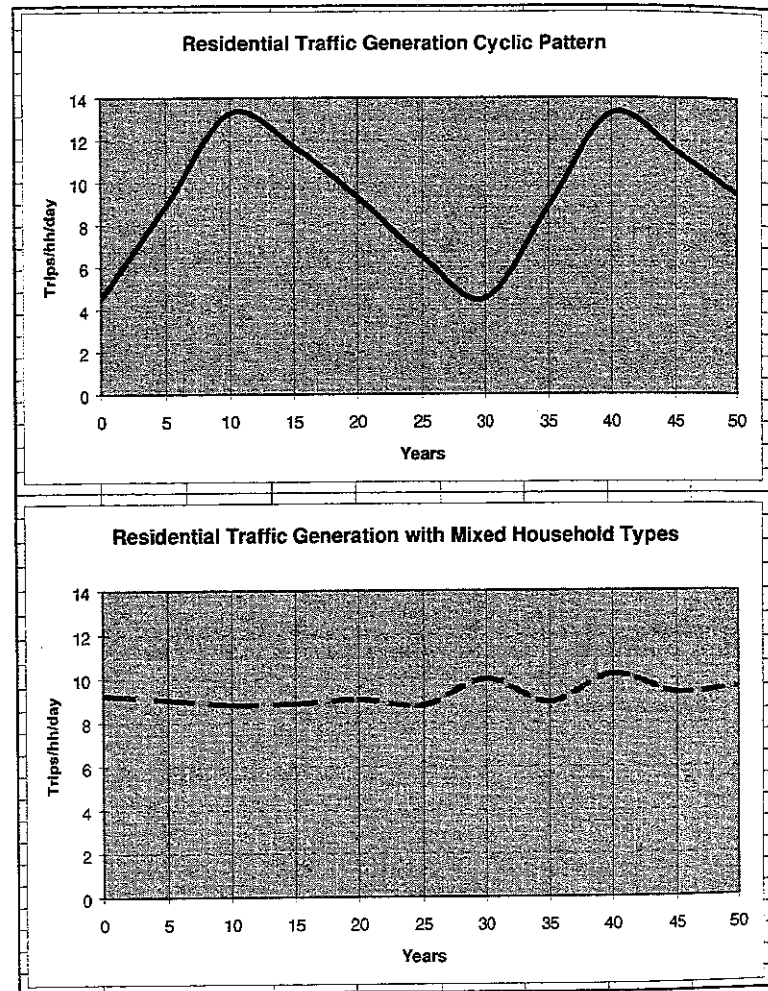


Figure 5 Residential traffic generation: cyclic pattern (top) and mixed household types pattern (lower)

Application of the model

The ability to mix and design trip generation rates in reality presents significant challenges. Firstly, the household types as provided by the NSW Department of Transport must be related to some form of development for which there are planning controls. Without this link the exercise becomes essentially academic. Therefore it is suggested that the household type descriptions be matched to planning and development industry market segment customer types such as 'first home buyers', 'second home buyers' and 'retirees'.

Secondly, a mechanism must be found and applied which allows a planning authority some control over the selection, location and proportion of future resident household types. Numerous planning measures are available, even within the existing legislative frameworks under which various authorities operate, which could enable a 'mixing of resident types' such that a planned outcome is achieved.

A range of planning controls and development options which may be selectively used to influence, attract or limit certain residential household occupant types include;

- small lot size with zero side boundary offset (integrated housing or terraces)
- local Environmental Plan and Development Control Plans (to facilitate appropriate mixed use development)
- medium size lots for large detached dwellings
- medium sized lots designated for dual occupancy, and
- large lots close to facilities designated medium density for unit development.

The application of the principles and methodology described in this paper is being pursued by Wollongong City Council in the planning of the West Dapto urban land release area (Collins 1998). The majority of West Dapto is currently rural land but was placed on the Illawarra 'Urban Development Program' in the mid-eighties (DUAP 1997). West Dapto is situated some 15 kilometres south of Wollongong. This area has been assessed as having 1,380 ha of urban capable land with the potential for over 20,000 new households. This development is typical of many other such areas in the Greater Sydney Metropolitan Area fringes.

Conclusion

The benefits of planning a 'mixed households design' community are expected to be considerable. It is understood that many existing recently-developed residential areas of predominantly homogeneous age and demographics experience many social problems. Poor levels of public transport lead to either isolation or high levels of car dependence which, in the latter case give rise to high levels of traffic and associated environmental problems.

Furthermore, it is also understood that large areas of homogeneous residential development lead to aberrations in behaviour of certain groups. Personal movement is also a behavioural phenomenon and therefore the same types of areas also generate aberrations in trip rates either above or below the average 10 (or 9) trips per day. Therefore, the benefits to be achieved by a 'mixed community' include not only a more even demand on local public infrastructure, but may also contribute to a number of social benefits such as greater community cohesion, family stability and possibly reduced crime rates.

No doubt there is still a place for the use of 'rule of thumb' rates such as the 10 trips per household per day, but at some point in every major land development project a proper determination of the environmental impacts should be made. To pin one's hopes on the benefits of some notion of an improved public transport service to achieve some reduced level of trip generation can hardly be justified as planning, let alone '**getting it right**'. Further research is needed to determine optimum proportions and effective planning controls, together with economic and social evaluation of a range of inputs and consequential outcomes.

Planning by definition is about doing something now to get it right 'down the road', so to speak. This spreadsheet planning tool provides a means of testing various planning and development scenarios so as to give some degree of certainty that the traffic generated from a proposed residential development will not exhibit significant upward or downward movement in trip generation rates over time.

Rather than adopting the sometimes more traditional 'leave it to later for someone else to fix' approach, the planner now has a tool available to assist in '**getting it right ... the first time!**'

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