MORGAN WESTON
Transport Analyst
TransPosition

Morgan@transposition.com.au

WHAT GOES ON INSIDE A ZONE? THE SECRETS OF INTRAZONAL MODELLING

Transport models generally work by dividing a city into traffic zones and considering travel between these zones. Travel that remains within a zone – the intrazonal travel – is generally not handled well. The quantity of intrazonal trips depends on the size of the model's zones, but can account for around 10% of all travel. These trips are even more significant for active transport modes and the problem is compounded by many current policy objectives; increased density, mixed-use development and reduced car ownership all increase intrazonal travel. This paper examines the methods and assumptions used for intrazonal modelling, including estimates of intrazonal distances from zone area or shortest intrazonal distance. As it is not reliant upon traffic zones and explicitly models all travel, TransPosition's 4S model for Brisbane and Sydney is used to examine travel zone assumptions and make recommendations for improvements, with estimated distance factors and an assessment of intrazonal traffic.

1. BACKGROUND

All transport models require some degree of abstraction – they are a simplification of reality that seeks to include the most essential elements so that they can provide useful insights into a complex problem. One of the most obvious simplifications lies in the representation of demand through the use of zones.

Traffic analysis zones (TAZ) have been used since the earliest days of traffic modelling. The earliest models ran on computers that had (by today's standards) extremely constrained memory and storage limits, allowing for only a small number of zones. As computers became more powerful, particularly as memory and storage constraints became more relaxed, the number of zones increased.

An example of this trend can be seen by considering models in Brisbane. In one of the first models used by the author, the model for Brisbane developed for the Brisbane Traffic Study (BTS) in 1986, the number of zones was limited to 266. The Brisbane Integrated Transport Forecasting and Evaluation Tool (BITFEM), developed ten years after the BTS model, had almost ten times as many zones with 2571. This was a little unwieldy with the computers of the time so the Brisbane Strategic Transport Model (BSTM) in the 2000's dropped the number back to 1551 where it remained until relatively recently with the BSTM Model Improvement Program see Pool (2014).

Zones serve two primary functions in traditional transport models – they give a simplified way of specifying and connecting population and employment to the network; and they limit the range of travel alternatives that need to be considered by the model. The second point is crucial as traditional models require a full enumeration of all travel destination alternatives. This is done through skim and demand matrices that give the time, distance, cost or number of trips that travel between every possible combination of origin and destination (or production and attraction). The number of zones determines the size of matrices; each matrix will have a number of cells equal to the square of the number of zones. This means that the algorithmic complexity of many elements of the model, and the corresponding storage space and run times, increase with the square of the number of zones.1

1 In practice, one of the most time sensitive components of modelling is the shortest path algorithm which has a complexity of $Z \cdot N \cdot \ln(N)$ where Z is the number of zones and N is the number of links. However since the centroid connectors typically account for around 20-25% of links, the complexity still increases with roughly the square of the number of zones.

Due to this impact on run time complexity, it is practical to keep the number of zones as small as is reasonable. However this runs against the desire to ensure accuracy in the representation of the transport network, particularly at the local level. The simplification associated with the use of zones means that anything that happens at a level of spatial detail similar to the zone size is mostly abstracted away. Thus travel that occurs within a zone (intrazonal travel), or travel that occurs between neighbouring zones, will generally be poorly represented. In fact, the intrazonal travel will not appear on the network at all, and much of the traffic from within the zone will be carried on another abstracted component of the transport model – the zone centroid connector.

This paper seeks to explore the impacts of the simplified assumptions associated with the use of traffic zones, and, by comparing with a model that does not use traffic zones (the TransPosition 4S model), provide advice on how assumptions can be improved to mitigate some of the problems associated with intrazonal demand.

2. TYPES OF INTRAZONAL TRAVEL

Intrazonal travel is usually concerned only with travel that occurs completely within a zone – i.e. the origin and the destination of the trip are within a single zone. These types of trips are modelled quite poorly in traditional models, and the demand is never loaded onto the transport network since all travel is considered to be between zone centroids. However there are a number of types of travel that occur within a zone that are problematic for traditional models.

1. Intrazonal trips – origin and destination are within the same zone (fig. 1 a)
2. Intrazonal stops – travel to an intermediate stop within a zone, such as a bus stop or train station (fig. 1 b)
3. Local component of trips – Connection between the internal location (origin or destination) and the wider transport network (fig. 1 c)

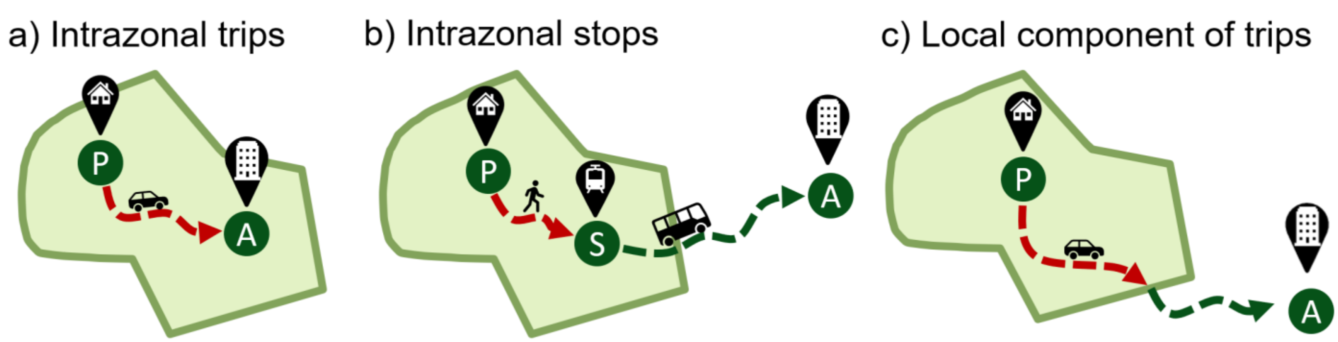

Figure 1: Types of travel that occur within a zone

The first of these is the conventional intrazonal travel, and is usually estimated only so that the number of intrazonal trips can be removed from the trip productions for a zone to give correct demand for interzonal travel. These intrazonal trips are all located on the diagonals of trip matrices, and are usually estimated using the (interzonal) destination choice models, with some mechanism for estimating intrazonal costs. These trips are considered in sec. 5.

The second type – intrazonal stops – are more difficult and are usually dealt with in the public transport network coding or the centroid connectors. Tbl. 1 below shows that traffic zones typically have areas of $3km^2$, with an approximate radius of around 1km. This is quite a distance for people to walk to public transport – Daniels and Mulley (2013) found that only 20% of rail and 10% of bus travellers in Sydney walked more than 1km to access PT. Thus the internal distribution of activities (population and employment) within a zone in relation to public transport stops is quite crucial. The only way for this to be dealt with in a traditional model is through careful coding of the centroid connectors to public transport. Some models separate centroid connectors for PT walk access from those used for other modes – this can give more flexibility to a manual correction but does not solve the basic problem. By treating all of the activity in a zone as though it is located at a single point (the zone centroid) it is impossible to correctly reflect the range of access the people in the zone have to public transport.

The final intrazonal type – the local component of trips – covers the travel from locations within the zone onto the transport network. Some of this travel does make it into the model; if the model has links representing the local collector network then the local travel can travel on these links. But much of this travel is represented by the traffic on the zone centroid connectors, which are an abstraction (even if they are built from real roads, as is the case in the BSTM).

3. ZONING SYSTEMS

According to the ATAP guidelines (Transport and Infrastructure Council (2016)), transport zones should have the following properties

1. Should contain homogeneous land use (e.g. solely residential, industrial, commercial or parking lots)
2. Special generators (airports, ports, universities, shopping centres etc) should be coded as separate zones
3. Should have reasonably homogeneous access to the modelled transport system
4. Should match (as far as possible) the standard statistical boundaries - such as the Australian Bureau of Statistics (ABS) Australian Statistical Geography Standard (ASGS).
5. Should have concordance with the resolution of the highway and public transport networks used in the model
6. Centroids should represent the centre of gravity/activity within the zone
7. Centroid connectors should represent realistic zonal access/egress routes
8. Centroid connectors should be connected at mid-block rather than at intersections

For the purposes of this paper, two traffic models have been examined – the Brisbane Strategic Transport Model (BSTM) and the Sydney Strategic Travel Model (STM). Neither of the models examined here are the latest incarnations – for Brisbane the 2012 version of the model has been used, and for Sydney the model is from 2015. We understand that both models have undergone significant revisions since the versions used for this paper, with modified zoning systems – Pool (2014) describes the shift to zones based on SA1 geography. The assessment here is illustrative only, and is not intended to be an evaluation or critique of the respective models. The older versions of the models can be used to show examples of the issues that can occur with intrazonal modelling more generally.

An examination of the zoning systems used for the Brisbane and Sydney models shows that these rules are generally followed. The last rule is sometimes difficult to achieve – the centroid connectors are often made up of real local roads, meaning that the point that they connect to the network is at an actual intersection. However since most models exclude local intersections then this might be expected.

Basic information about the two zoning systems can be found in tbl. 1. For Brisbane, the data has been broken down by traffic zone (TAZ) and SA1, since the Brisbane HTS reports trip data at the SA1 level. For each model the table also shows the area, population and the number of one-way road links and centroid connectors in the model.

Table 1: Zoning system summary

Metric	Brisbane (TAZ)	Brisbane (SA1)	Sydney (TAZ)
Zones	1,546	5,261	2,277
Population	2,283,345	2,322,778	4,550,595
Area (km^2)	4,678	9,128	6,416
Links	24,356	280,317	39,588
Connectors	5,986	5,261	5,154
CBD Zones	60	48	148
CBD Pop	25,313	25,126	31,254
CBD Area	4.81	4.88	4.30
Pop/Zone	1,477	442	1,999
Area (km^2)/Zone	3.03	1.74	2.82
Average radius	0.98	0.74	0.95
Conn/Zone	3.9	1.0	2.3
Links/Zone	15.8	53.3	17.4
CBD Pop/Zone	422	523	211
CBD Area/Zone	0.08	0.10	0.03

It can be seen that both models have similar zone sizes (around $3km^2$ per zone) and similar population per zone (although the higher density in Sydney does mean that the average persons per zone is a third higher, at 2000 persons/zone c.f. 1500 in Brisbane). The table also includes information on the SA1 system within Brisbane. The reason for this is that the household travel survey results for Brisbane (shown in the next section) are for SA1 zones rather than the traffic zones used by the model. For the Brisbane SA1 column the Links row shows the total number of one-way road links in the complete road network (with every street included).

The Brisbane network seems to have more centroid connectors on average, perhaps reflecting the fact that centroid connectors in the BSTM are designed to follow real roads. The following table shows typical zones and centroid connectors in the two models.

In the CBD areas of both cities the zoning systems are much smaller – down to individual city blocks. The high levels of employment in the CBD, and the density of travel alternatives provided by the public transport system, make this level of detail appropriate.

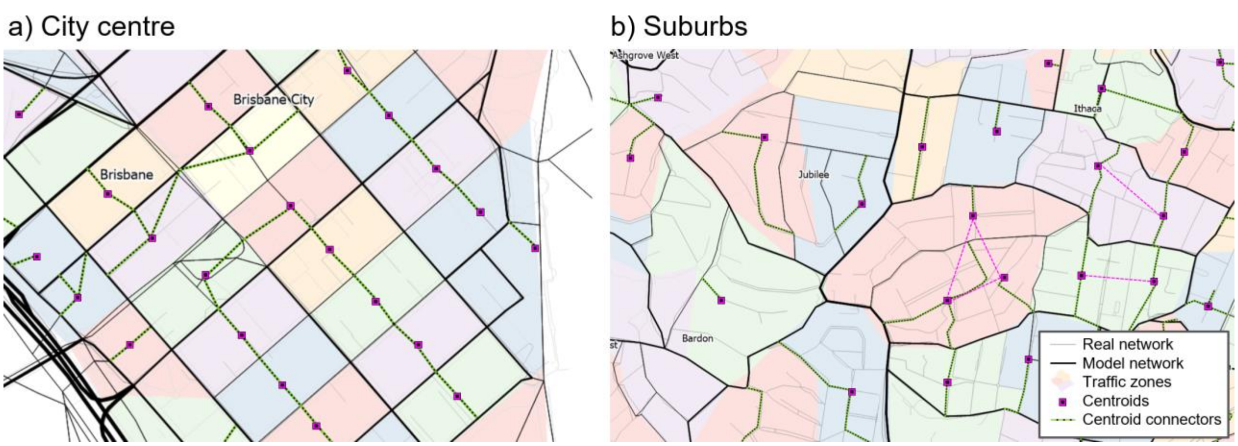

Figure 2: Typical zone sizes and centroid connectors - Brisbane

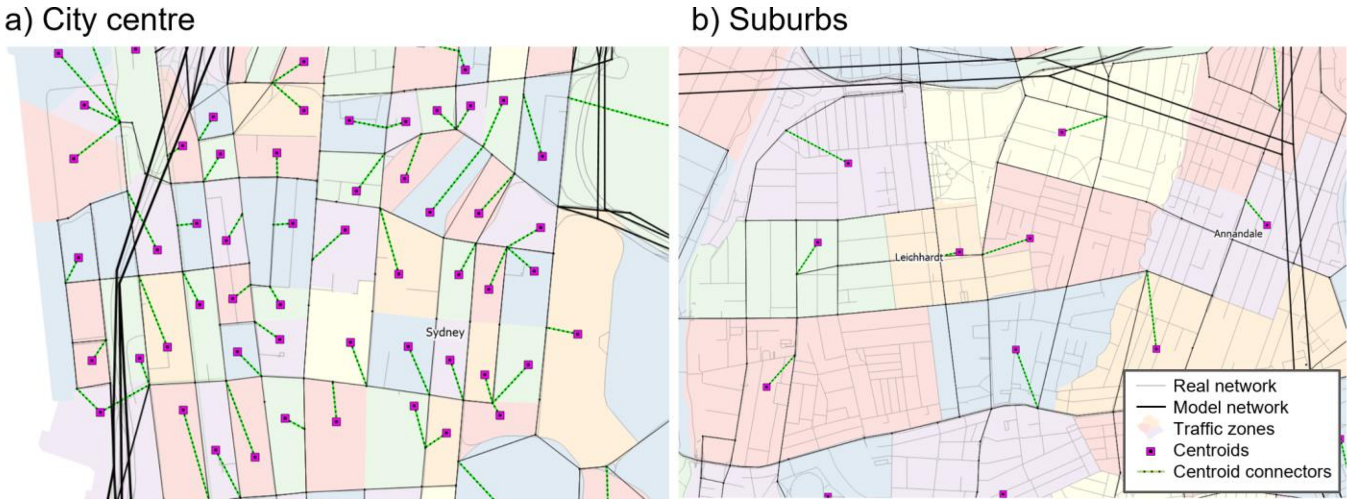

Figure 3: Typical zone sizes and centroid connectors – Sydney

4. SURVEY RESULTS FOR INTRAZONAL TRAVEL

The significance of intrazonal travel can be seen by examining the results from surveys of travel behaviour. Each capital city in Australia has a program of surveying households on their travel. These Household Travel Surveys (HTS) are used to monitor changes in travel patterns, and are one of the primary inputs into strategic transport models during development. The HTS typically provides the origin and destination for every stop within a trip, and each trip is given a weight which represents what proportion of the population is represented by that trip. The weight is used so that the HTS sample can be scaled to represent the entire population.

Travel is complex, and will often consist of multiple modes and stops along the way. The HTS typically combines information in three levels. At the lowest level is the *stop* – this refers to travel from one location to another by a single mode, even if that location is not the final destination. The *trip* refers to travel from one location to another location for a given purpose, and will always contain one or more stops. A *tour* consists of a sequence of trips that start and end at the person's home. For this paper the analysis will focus on trips and stops, which are sometimes called linked and unlinked trips.

In order to understand intrazonal travel, it is useful to examine both stops and trips. As discussed in sec. 2, there are multiple types of intrazonal travel. An analysis of the intrazonal *trip* proportion will show how many people are travelling to destinations within the same zone. The HTS shows that 3.5% of all Brisbane and 12.2% of all Sydney trips are purely intrazonal. These trips will all lie on the diagonals of the demand matrix and will never be assigned to the network in a traditional model.

By looking at the proportion of *stops* that are intrazonal we can identify where people travel to an intermediate location within their zone in order to change to a different mode. The most common example of this an individual walking to a bus stop or a train station. A large component of intrazonal travel is comprised of this type of unlinked trip. tbl. 2 shows the percentage of all stops that have both there origin and destination within the same zone. These results show that intrazonal travel is significant especially for active transport, with 28% of Brisbane's active transport unlinked trips (stops) being intrazonal and 38% of all Sydney's. However further segregation of these results into smaller areas reduces the intrazonal stop proportions; this can be seen in the Brisbane results which are based on SA1 areas.

Table 2: Percentage of unlinked trips (stops) that are intrazonal across the Brisbane and Sydney network

Mode	Brisbane % intrazonal (SA1)	Sydney % intrazonal (TAZ)
Car	1.2	5.8
PT	0.4	0.6
Active	28.0	38.5
Taxi	1.9	0.8
All	6.5	15.6

The variations in the intrazonal share can be seen by calculating intrazonal proportions at the level of traffic zones, but then aggregating into a larger sector system. For Brisbane we have used SA3 and for Sydney we have used SA2 for aggregation. Within each sector, we can see the total number of unlinked trips (with the corresponding weekday weights applied) and compare this to the number of unlinked trips that originate in the sector and end within the same zone as they started.

In Inner Brisbane, 16% of all trips are intrazonal, increasing to 25% of all active transport trips. There is also a reasonably large proportion of taxi and other rideshare intrazonal trips at 6%. The area of St Lucia (near the University of Queensland) also has a very large number of intrazonal active transport trips (54%). This is likely due to the large number of students either living within walking/cycling distance of the university area or relying on public transport (which has a walking component). The university is also accessible by numerous PT services and a green bridge making active and public transport a more attractive option then it might be elsewhere.

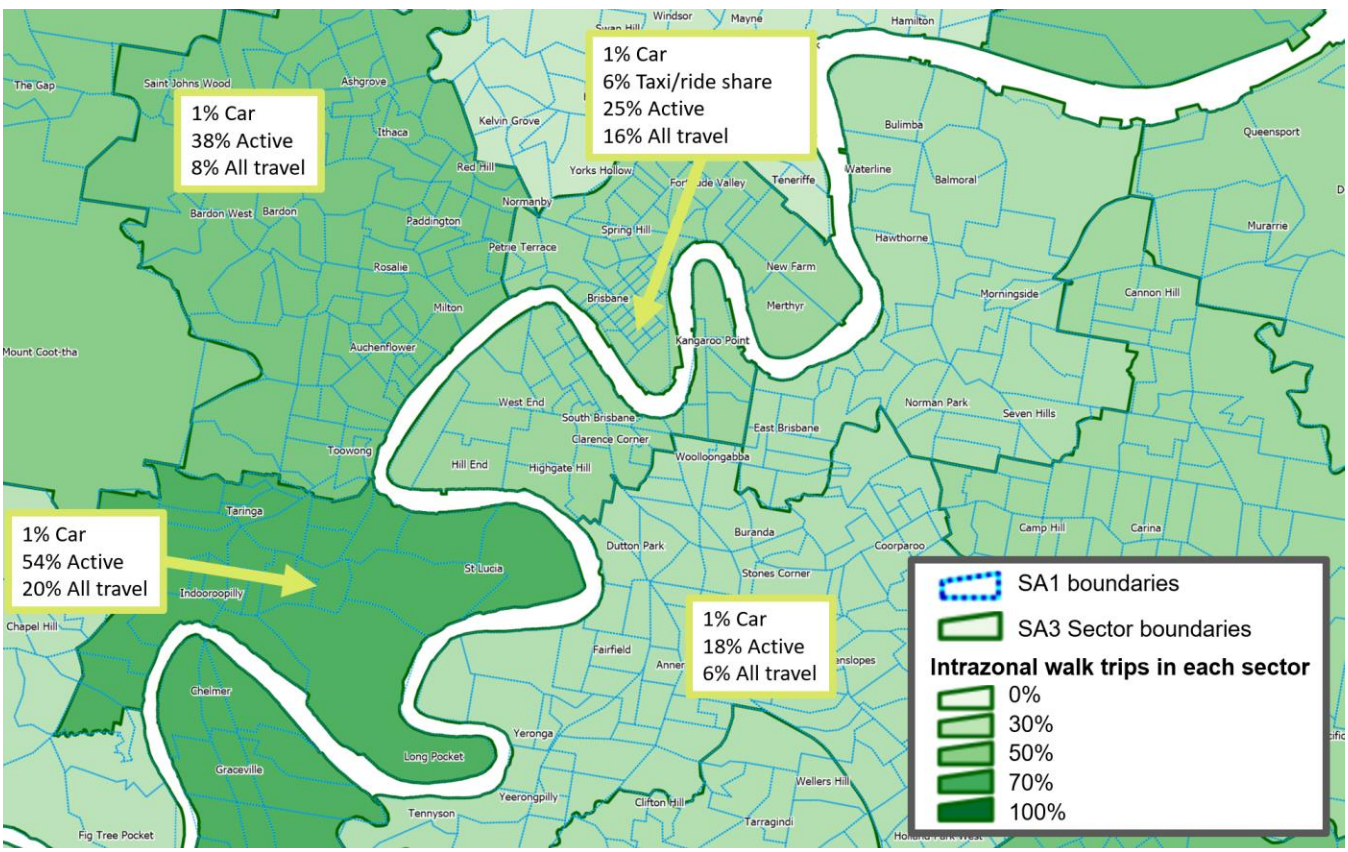

Figure 4: Brisbane's proportion of Intrazonal (SA1) stops determined by HTS

In fig. 5, we can see that the large number of zones in the Sydney centre region means quite small zones, with only 8% of all trips remaining within the zone and 10% of all active trips being intrazonal. This is in contrast to the more typical larger zones in the Annandale area, which has 26% intrazonal trips (8% of all car trips and 58% of active trips). We can see that unless the zones are very small the majority of active transport trips are intrazonal. These trips could be made up of walking to and from public transport stops or be a complete trip that remains within the zone.

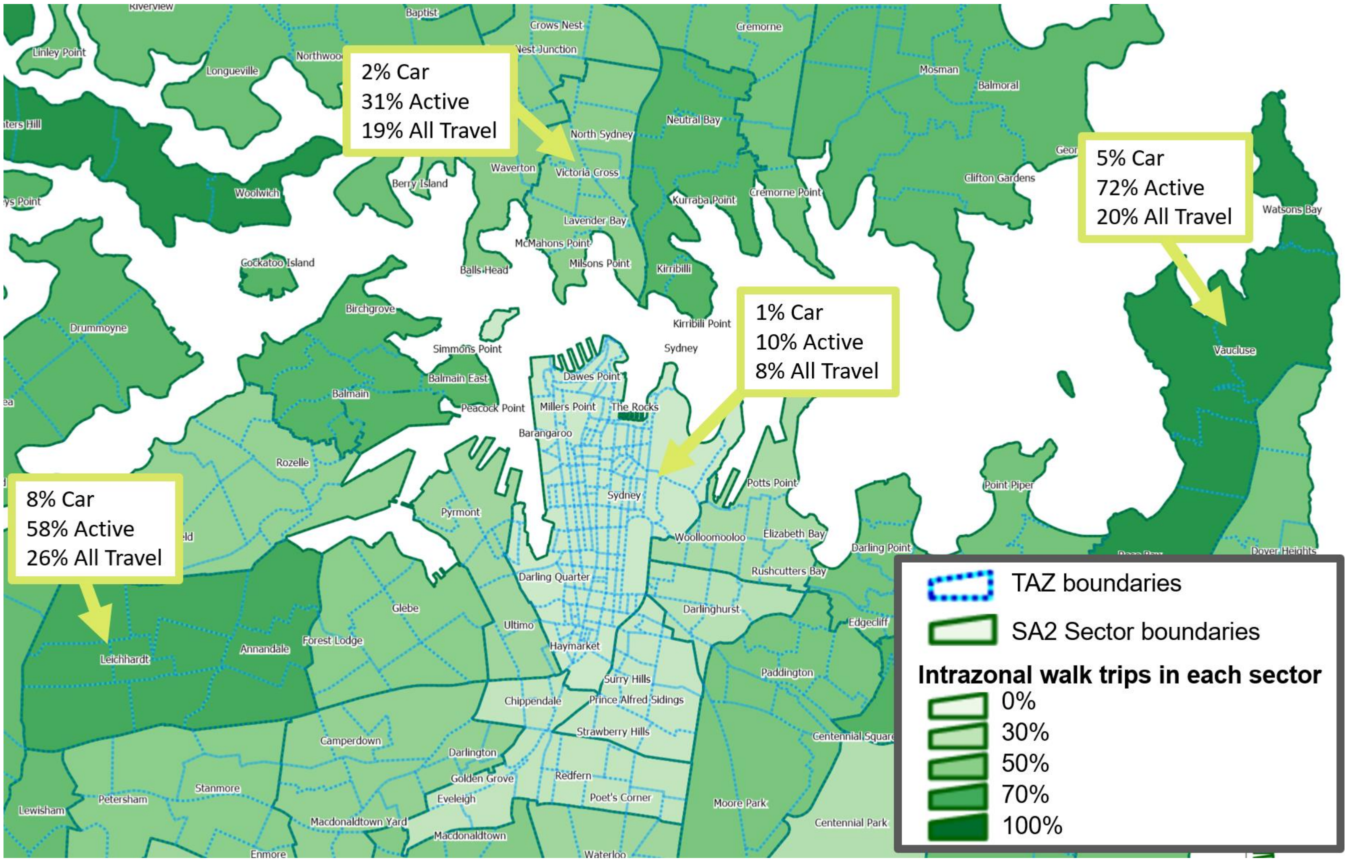

Figure 5: Sydney's proportion of Intrazonal (TAZ) stops determined by HTS

These results indicate that, depending on zone size, intrazonal travel can be reasonably significant, particularly for active transport or for the walking component of public transport trips. This means that it is important to model it as well as possible – the next section considers different approaches for doing this within a conventional model.

5. ESTIMATING INTRAZONAL TRAVEL WITH THE FOUR-STEP MODEL

The traditional four-step model assumes that travel demand by mode is a function of travel times (or costs) by mode between an origin zone and a destination zone. The actual structure of this model can vary, but most commonly includes hierarchical-logit-based mode choice and either a trip distribution model or a destination choice model, again often based on logit models. Regardless of the structure, the basic approach is the same – the network is "skimmed" to produce matrices of travel time/cost/distance and these are used to apportion demand between destinations and modes.

The structure of these models is such that short distances are generally more attractive than longer distances - the classic "gravity" model assumed that the attractiveness of a location varied with the inverse square of the travel distance. This can cause problems because the shortest travel destination that can be reached from a zone is within the zone itself. This is intrazonal travel, where both the origin and the destination are within the same zone.

As discussed previously, ATAP guidelines suggest that traffic zones should include only homogeneous land uses, thus precluding many opportunities for intrazonal travel. If a zone includes only residential areas OR employment areas then no-one could remain within a zone for commuting travel – all home-based-work demand would be interzonal. However, this goal is very difficult to achieve – our cities generally contain some degree of mixed-use, often even within the same building. Furthermore, local shops, schools and recreational facilities are intermixed with residential areas – separating all of these into separate zones would be infeasible. Finally there is some demand that is inherently localised within a homogeneous land use - for example workplace-to-workplace travel (such as interoffice meetings) and household-to-household travel (such as social visits).

Thus it is usually necessary to have some method for predicting intrazonal demand. The simplest approach is to prepare some assessment of intrazonal travel time/cost/distance and then feed those numbers into the same model structure used for interzonal demand.

5.1.Techniques for estimating intrazonal travel times

There are two basic approaches for preparing estimates of intrazonal time/cost/distance.

- Network-based approaches
- Zonal attribute approaches

Usually one or the other approach is used, but it is possible to use a combined approach (see Kordi, Kaiser, and Fotheringham (2012) for an example).

5.1.1. Network-based estimates of intrazonal travel times

The network-based approach is based on the assumption that there is a relationship between the time to travel within a zone and the time it takes to travel to neighbouring zones. The simplest assumption is that the intrazonal time is simply a factor of the shortest interzonal time.

Thus

$$t_{ii} = k \min_j (t_{ij}) \quad \text{for } i, j \in Z.$$

The factor k can vary, but a value of 0.5 is typical.

More complex approaches can also be used. An adjacency matrix between zones can be used to find all adjacent zones, and then an average of all adjacent travel times taken instead of the simple minimum.

If $\boldsymbol{A}_i$ is the set of zones adjacent to i, with n_i being the number of zones in this set, then the average travel time is

$$t_{ii} = k \frac{\sum_j t_{ij}}{n_i} \quad \text{for } j \in \boldsymbol{A}_i.$$

5.1.2. Zonal attribute estimates of intrazonal travel times

An alternative approach is to base the intrazonal travel time only on variables that describe the zone itself. The simplest version of this approach is to assume some function of the area of the zone, but more complex models can be developed that include measures of population, employment or other zonal attributes (see Kordi, Kaiser, and Fotheringham (2012)).

If the zonal area is to be included then it is usually transformed into a distance measure. If we assume that each zone is circular, then

$$A = \pi r^2 \quad \text{so} \quad r = \sqrt{\frac{A}{\pi}}.$$

Batty (1976) suggested that if the zone is assumed to have uniform population density then the intrazonal cost can be estimated by

$$c_{ii} = \frac{r_i}{\sqrt{2}} = 0.707 r_i.$$

From some analysis of the potential minimum and maximum travel in a zone, Fotheringham suggests that intrazonal trip length can be estimated by

$$d = 0.846 \cdot r,$$

where r is the distance between the zone centroid and the destination within the zone.

In general terms the cost could be assumed to be

$$c_i i = kr = k\sqrt{\frac{A}{\pi}}.$$

6. INTRAZONAL TRAVEL IN THE 4S MODEL

The Segmented Stochastic Slice Simulation (4S) model is a new approach developed by TransPosition over the last 8 years that seeks to overcome many of the limitations of strategic transport models. A full discussion of the theory behind the model is beyond the scope of this paper, but more details can be found in Davidson (2011) and Davidson (2017). In brief, the model includes a generalised utility model to assess the full range of travel alternatives as a simultaneous choice (as opposed to traditional four-step models that consider travel as a series of sequential choices). The model allows for variability in all aspects of travel behaviour, with each element of the utility function given as a flexibly-specified random variable. Monte Carlo simulation is used to find the outcome of the full range of travel choices, with the method of successive averages (MSA) used to incorporate the impacts of traffic and public transport congestion.

The 4S model is a useful basis for comparison of intrazonal travel because it does not use traffic zones at all. Instead, all travel within the 4S model is from node to node on the complete network (fig. 6). This is done by distributing all population, employment and other activities to nodes in the network, and allowing every node to produce and attract trips. The model uses agent based simulation, but considers a probabilistic “cloud” of agents located across the network. Each step of the model considers travel from all production nodes to their optimal attraction node. Because the model does not require full enumeration of all destination alternatives, there is no need to simplify these alternatives through the use of zones.

It is still possible to produce demand matrices by traffic zone from the 4S model – these are done by simply recording the travel done from the nodes that are within each zone. In fact the model can output results for multiple zonings at the same time, since the zoning system is simply a reporting detail rather than a key element of the model. The model does also use areas to describe some components of land use/demographics, but there is no need for a single consistent system. Instead the data can be included in the model in whatever form is suitable – for population this might be SA1, for employment it might be SA2, and for schools and hospitals the building footprints might be used (or a single coordinate).

The efficiency associated with the “agent cloud” approach in the 4S model means that it is not necessary to simplify the representation of the road network. Instead all road links (including residential streets), all public transport routes, and all off-road walking and cycling links can be included in the model. Fig. 6 shows a typical comparison between the network used in traditional models and that used by the 4S model.

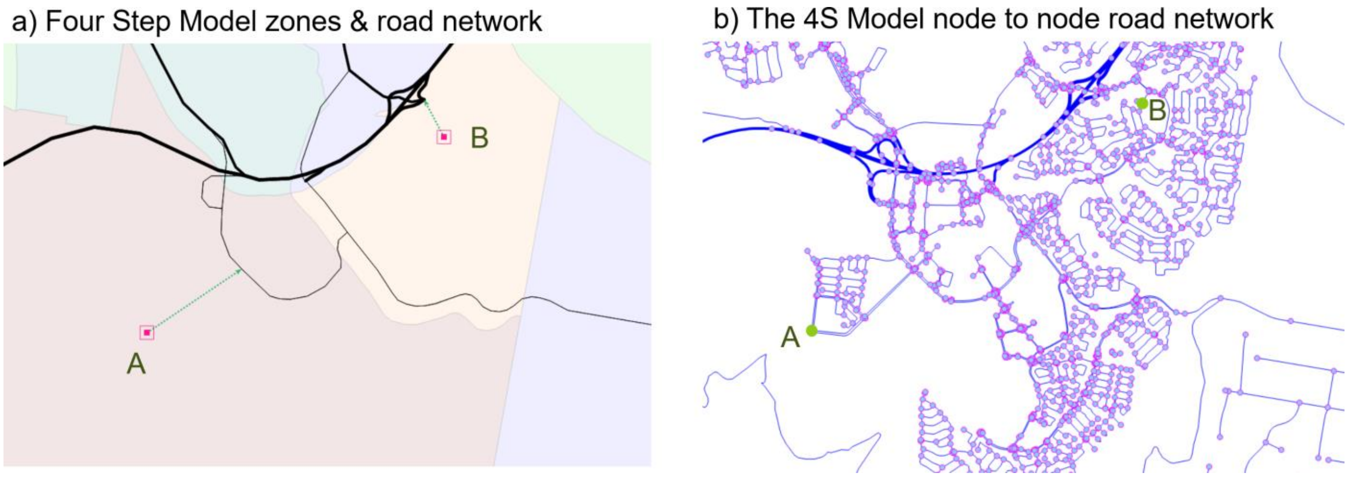

Figure 6: Model networks and zones comparison

TransPosition has developed versions of the model in a number of cities, including Brisbane, Sydney, Melbourne, Auckland, Sunshine Coast, Gold Coast and Toowoomba. Wider scale models have also been developed, including a single model of the whole of Australia and the whole of New Zealand. Test models have also been developed for the whole of the United Kingdom, and the US states of California and Colorado. The model has been used for projects ranging from the development of the Business Case for the Toowoomba Second Range Crossing, to due diligence traffic forecasts of toll roads in Brisbane, Sydney and Melbourne and examining the likely impacts of connected and autonomous vehicles.

Since the model addresses all elements of demand, it can be used to examine what happens within the zone itself. Since the previous analysis focused on Brisbane and Sydney we have used the 4S model for these cities. For the purposes of this paper, four particular outputs were produced:

1. Trip matrices by travel mode using the zoning system used by the four-step model
2. Distance and cost matrices taken from the simulation results, aggregated to the zoning system
3. Traffic volumes associated with intrazonal trips
4. Traffic volumes associated with trips that are produced or attracted within a zone, but only up to the border of the zone

For the purposes of testing the methods for calculating intrazonal distances/costs only the second result is needed. Discussion of the intrazonal trip and volume numbers will be addressed in sec. 8.

7. COMPARISON OF INTRAZONAL DISTANCE ESTIMATES

Note that the comparisons included here have been based only on the structure of the zoning system and the basic topology of the network. We have tried to exclude the effects of congestion (for the most part) by focusing on travel distances rather than times. For local demand, congestion effects tend to be less important than network structure and local intersection delays. As discussed below, the 4S model does consider both congestion and intersection delays in its assessment, but this should not unduly influence the calculation of trip distances.

For the purposes of this paper, we have sought to analyse results from TransPosition's 4S model, and compare these with the assumptions used in typical Four Step models. We do not have access to the most up-to-date models from each city, but have included relatively recent models from Brisbane – the Brisbane Strategic Transport Model (BSTM) – from 2014, and Sydney – the Sydney Traffic Model (STM) – from 2017.

Comparisons were conducted between the three methods of estimating intrazonal distances, that is the two network-based estimates (Minimum length and Average length) and the zonal attribute estimate (Radius). An estimate of intrazonal distance was made for each travel zone using the three traditional methods, which were compared to the average 4S model intrazonal distance. As the 4S model creates paths between nodes, a travel zone must contain at least 2 nodes that are connected in order for there to be a possibility of an intrazonal stop or trip. Further, the more nodes there are in a travel zone, the more likely there is to be an intrazonal trip. The greater number of trips, the more accurate the 4S model estimate will be. For this reason, we have included only travel zones with 20 or more nodes, excluding around 150 zones (<10%) in the Sydney region.

For each approach in each city we calculated the optimum factor for estimating the intrazonal distance. The factors were different for Brisbane and Sydney – the results are shown in tbl. 3.

Table 3: Optimal factors used to estimate intrazonal distances

Method	Brisbane Factor	Sydney Factor
Distance to closest zone	0.58	0.49
Avg distance to adjacent zones	0.31	0.27
Hypothetical circular radius	1.17	1.25

Fig. 7 and fig. 9 show the ratio between the estimates and 4S model average (i.e. estimate/4S average), a ratio of 1 represents a one to one mapping which is shown in green, a ratio less then 1 represents an underestimate and is shown in purple and a ratio greater the one is shown in orange and represents an overestimate. From these figures we can see that all methods overestimate the large outer zones, and the network-based estimates both underestimate the distance in the small central zones. For the comparisons made in fig. 8 and fig. 10 we have excluded extremely large zones (where radius is greater the 3.5km). For both Brisbane and Sydney, the Radius method gives the best estimates of intrazonal distances, as in both cities it has the largest R squared value.

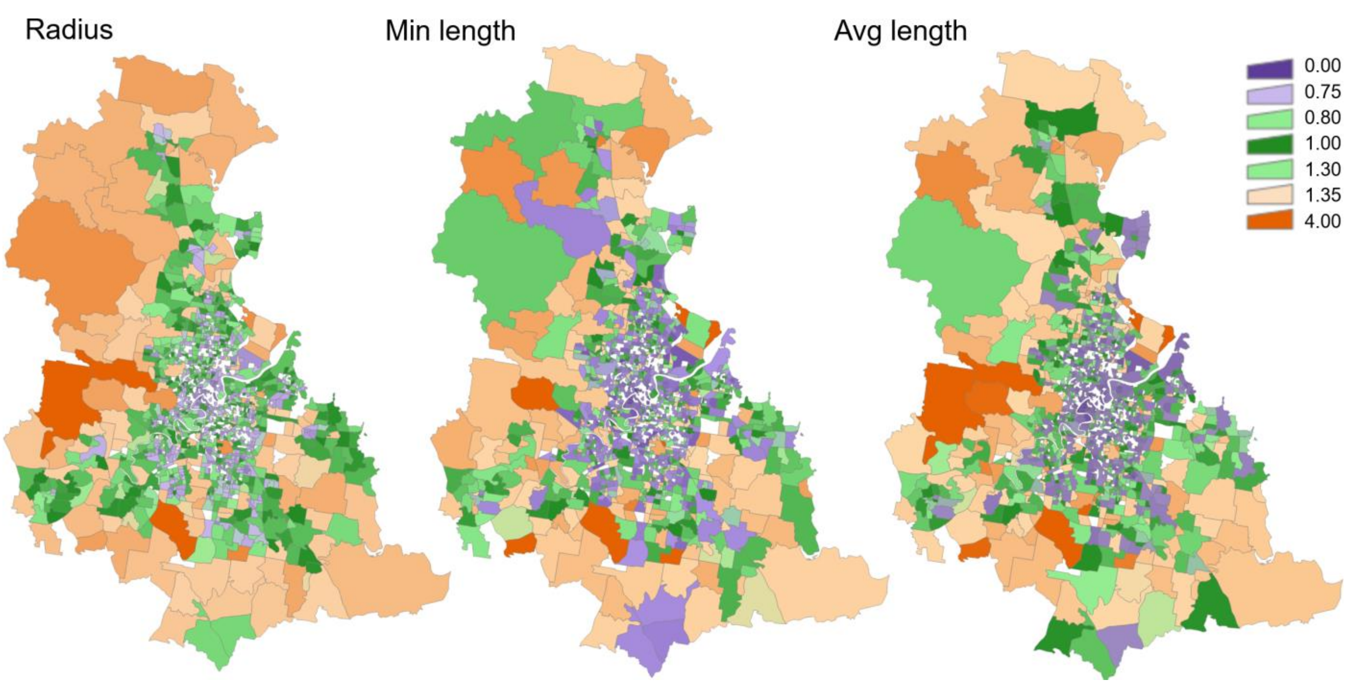

Figure 7: The ratio of the estimated distances to 4S model distance in Brisbane

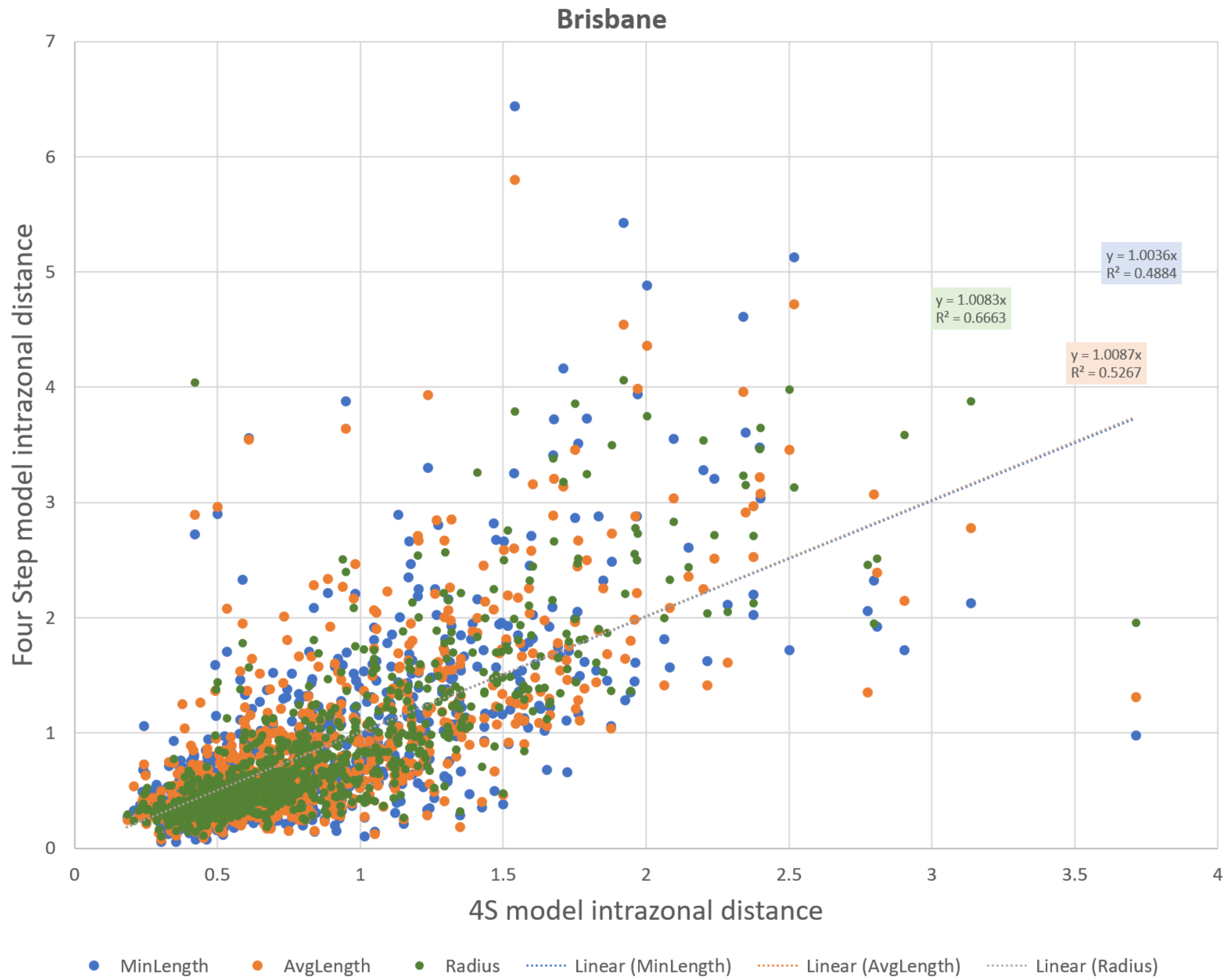

Figure 8: Plot of 4S model Intrazonal distance verse the estimates in Brisbane

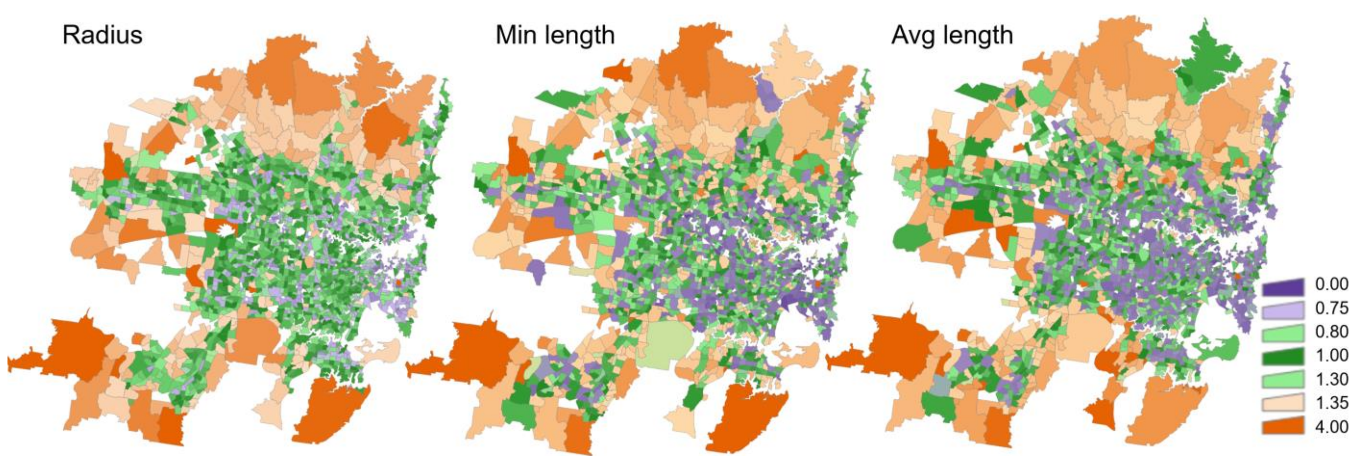

Figure 9: The ratio of the estimated distances to 4S model distance in Sydney

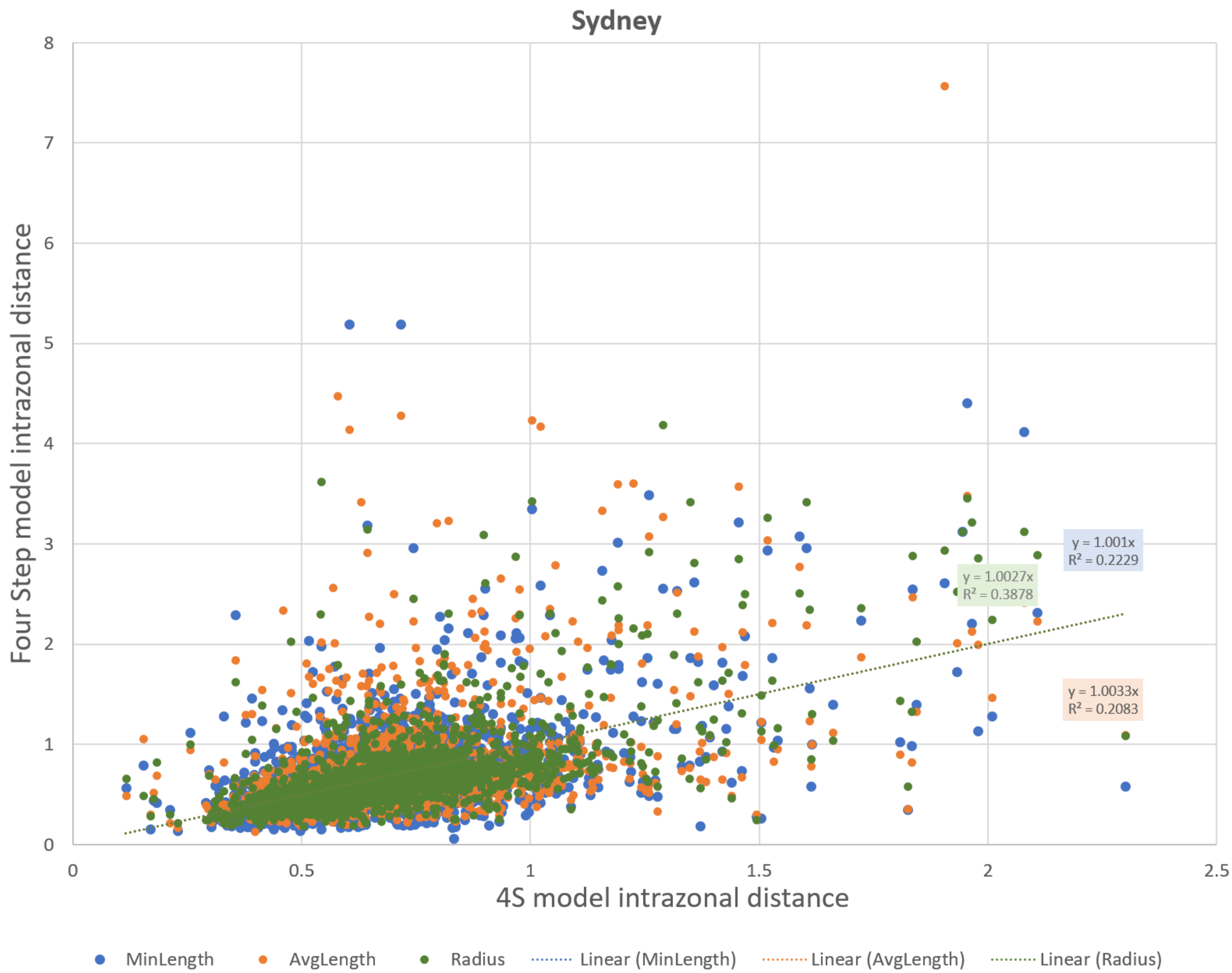

Figure 10: Plot of 4S model Intrazonal distance verse the estimates in Sydney

8. EXAMINING INTRAZONAL VOLUMES

Since it does not use traffic zones, the 4S model allows the intrazonal demand to be assigned to the network; this is aided by the fact that the model generally includes every road in the network. This ensures that the internal network within each zone is well represented, allowing the internal movements to be accurately modelled. However as discussed in sec. 2, fully intrazonal trips are not the only element of travel that is distorted by the use of traffic zones in models. The path that traffic takes as it moves out from activities within the zone onto the wider network is also affected. This is the traffic that is considered to travel on centroid connectors, from the centroid of the zone to the first node in the modelled network.

To consider the impact of this type of travel, a new output was specified in the 4S model. This takes the demand from each production and attraction, and follows it to the edge of the zone. This is not an exact analogy to the use of centroid connectors, since they will often connect to roads that are within the zone itself. However, as shown in fig. 2 and fig. 3, many zones have minimal internal links.

The volumes associated with the local component of trips as well as the pure intrazonal demand is shown in figure (a) of fig. 11 and fig. 12. Here, the thickness of the link represents the intrazonal volume and the shading (grey-blue) represents the percentage of volume on the link which is intrazonal. Figure (b) shows, for trips that occur entirely within a single zone, the volume along that link which is intrazonal and the percentage of total travel on a link that is intrazonal. Comparing figures (a) and (b) we can see that the local component of trips (travel taken from the origin to the edge of the origin zone or from the edge of the destination zone to the destination) is by far the largest contributor to volumes in the local network.

In Brisbane, the area around the University of Queensland is shown, and in Sydney we show a suburban area around Wetherill Park. In the Sydney suburban area, we can see that many links have intrazonal traffic that is almost 100% of the total traffic on the link. These are the links that operate most purely like centroid connectors. There are other links that carry significant intrazonal demand, but have other types of travel as well. These are the links that should be included in the simplified model network.

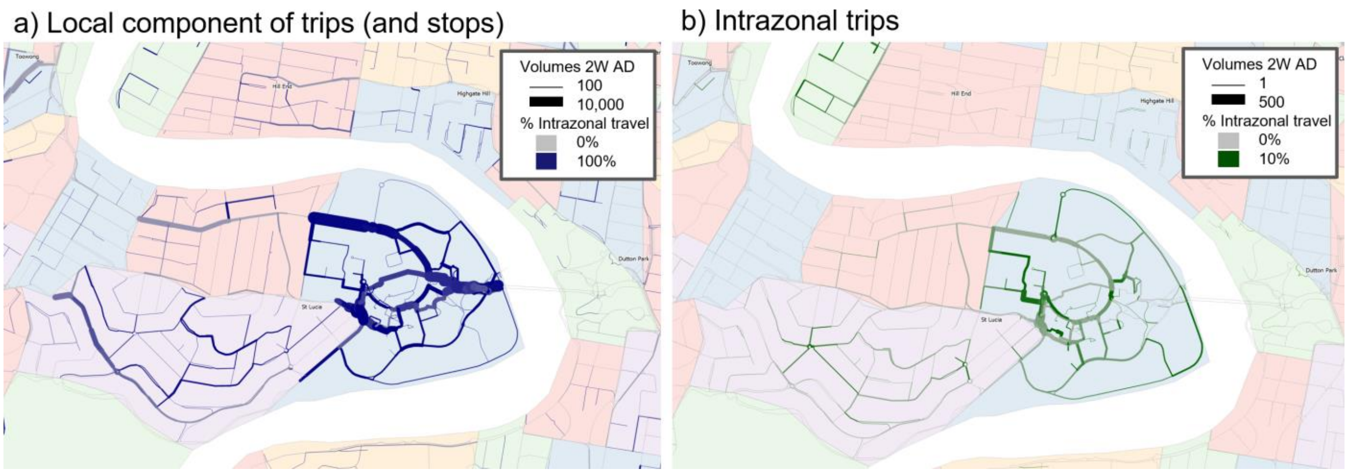

Figure 11: Brisbane's 4S model intrazonal volumes

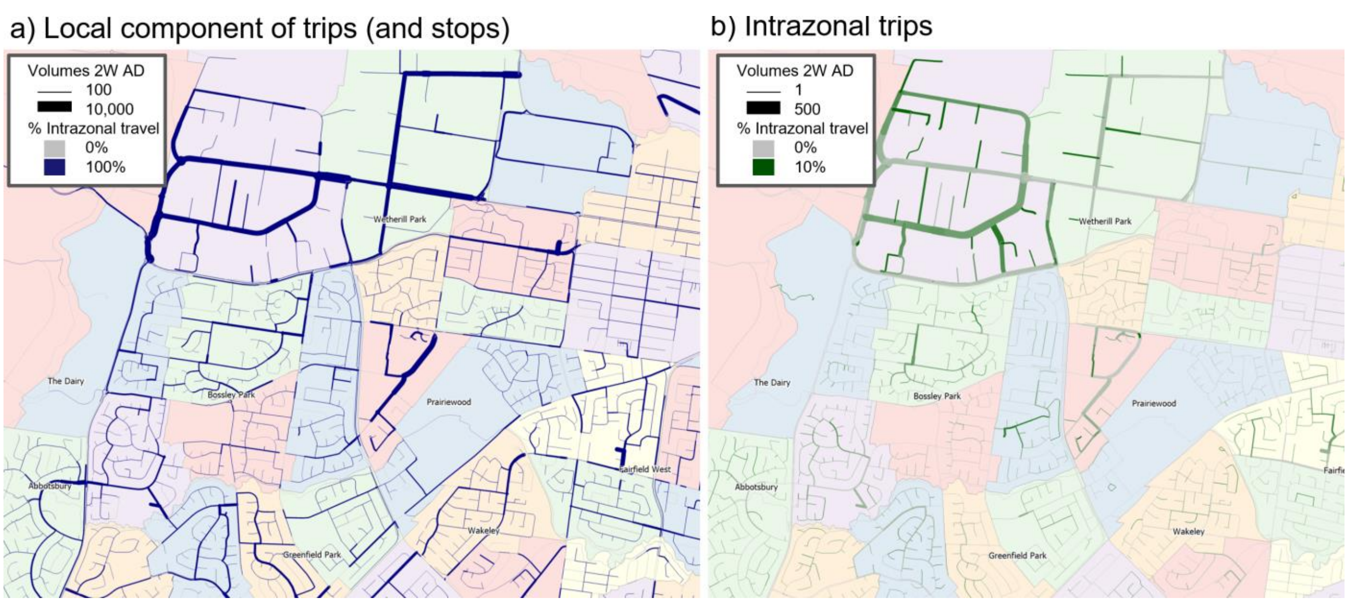

Figure 12: Sydney's 4S model intrazonal volumes

9. CONCLUSION

Historically, transport models were focused on modelling car travel, usually on arterial roads and above. When this was the case, intrazonal travel could usually be ignored - trips within a zone are short, with high active transport proportions and travel on local roads. However this is increasingly not the case - increased density, mixed-use development and reduced car ownership all lead to increased intrazonal travel. Moreover, many policy issues are now concerned with supporting active transport, where these local issues are critical. Finally, public transport demand always has an active transport component, requiring local connectivity and network permeability.

The household travel survey analysis shows that intrazonal demand is a significant proportion of total demand across all modes, but is largest for active transport modes. Not surprisingly the proportions depend on the size of the zoning system – larger zones will have a higher intrazonal proportion. However model run time considerations mean that the number of zones cannot increase without limit, and even a large number of zones will still have a portion of intrazonal demand.

The typical approach to calculating the number of intrazonal trips is by estimating the intrazonal time/distance/cost. The effect of this was tested and no alternative worked perfectly well – the R^2 values ranged from 0.2 to 0.4 in Sydney and 0.5 to 0.66 in Brisbane. Unfortunately no single set of factors worked for both cities, but in both cases the radius method worked best. This is somewhat surprising since it is the simplest approach and takes no account of the road network. However an examination of the types of problems that can occur with both the shortest interzonal distance and the average adjacent interzonal distance does shed some light on the issue. The network paths between zones can often be unrealistically short, due to the details of centroid connector locations or asymmetries within the zone. In other cases the network paths may be unrealistically long for similar reasons. Averaging out across all adjacent zones can sometimes help, but in other cases there may be poor connections between some adjacent zones, artificially increasing the average. The area-based method is less susceptible to these problems, and give more reasonable estimates in many cases.

The 4S model, which does not use zones and allows for node-to-node travel with fully detailed networks, was used to test the assumptions typically made in traditional models. These include the calculation of intrazonal distance from the zonal area, and the estimate of intrazonal travel time from a factor of the shortest inter-zonal skim. This demonstrates the strength of the new approach for testing localised issues. It also opens up the possibility of using more detailed models such as this to refine the assumptions used in more traditional models. The outputs of the 4S model can be used to refine the assumptions regarding intrazonal travel, and also to test the appropriateness of centroid connector location and the selection of internal links to include within the models.

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