

A Proposed Methodology for Measuring Public Transport Accessibility to Employment Sites in the Auckland CBD

Research Project undertaken as part of the Masters in Engineering Studies (Transportation)

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ABSTRACT

There is currently a global focus to increase the use of alternative modes of transport, particularly the use of Public Transport (PT) with the aim of minimising the economic and environmental costs of traffic congestion. Part of this change is to improve accessibility. If the PT modal share is to be increased, the transport authorities, transport planners and other professionals need to ensure that the service is available to as many people as possible. To enable measurement and monitoring of PT, quality of service and accessibility ratings allow local authorities to define the level of service available to users at various times and locations. This information can then be used to influence decisions on land use planning, Travel Demand Management (TDM) schemes and planning regulations such as minimum or maximum parking requirements as well as being a useful tool to help predict modal share from new developments.

To date, measuring PT accessibility in New Zealand has been limited. This paper outlines a proposed methodology for assessing PT accessibility to work places in the Auckland CBD from the surrounding areas to map the CBD area according to calculated PT accessibility levels.

1.0 INTRODUCTION

An increase in awareness of the economic costs of traffic congestion and greenhouse gas emissions has resulted in a focus by transport policy makers on reducing the use of private vehicles, especially for commuter trips. This global focus is evident in New Zealand in the National and Regional strategies, all of which focus on increasing alternative modes of transport, including the use of PT.

Part of this change is an increasing focus on accessibility including a more specific aim of increasing accessibility to PT. If the PT modal share is to be increased, transport planners and other professionals need to ensure the service is useful and easily available to as many people as possible. To enable measurement and monitoring, PT quality of service and accessibility ratings have been developed that allow local authorities to define the level of service available to users at various times and locations. In turn these objective ratings can then be used to influence decisions on land use planning, TDM schemes and planning regulations such as minimum or maximum parking requirements. In addition they can also be used as a useful tool to help predict modal share from new developments.

To date, specific focus on measuring PT accessibility in New Zealand has been limited. However, for the following reasons it is considered that the need for this data is increasing, particularly in larger urban areas such as Auckland.

- ◆ The Auckland Regional Growth Strategy (Auckland Regional Council, 1999) is focussed on increasing the density of development around major transport corridors resulting in a change in land use patterns that will impact on PT use and traffic generation.
- ◆ The Regional Parking Strategy (Auckland Regional Council, 2009) suggests linking parking supply rules with PT accessibility. If this is to be considered, appropriate methodologies for measuring accessibility have to be in place.
- ◆ The Integrated Transport Assessment (ITA) Guidelines (Auckland Regional Transport Authority, 2007) include, as well as many other aspects, assessments of modal splits and the suitability of the proposed land use within the context of the wider transport network. To enable these assessments to be made, the impact of accessibility to PT on modal split needs to be clear.
- ◆ Travel Demand Management Plans have already become compulsory for larger developments in Auckland and measuring their success is likely to be a major area of research in the coming years.

The aims of the research are therefore:

1. To propose a suitable methodology for measuring public transport accessibility to employment destinations in Auckland.
2. To test the methodology by applying it to the Auckland CBD and produce a PT accessibility map of the Auckland CBD area.
3. To investigate ways in which this information can be used in developing policy aimed at increasing the PT modal share and reducing congestion during peak times.

2.0 LITERATURE REVIEW

2.1 Defining PT Accessibility

One of the key challenges with completing work in this area is how to define PT accessibility. Various disciplines define accessibility in different ways though in transport planning the term accessibility is generally defined as *'the potential of opportunities for interaction'* (Hansen, 1959) or *'people's ability to reach goods, services and activities'* (Litman, 2008).

Murray et al (1998) distinguishes between the terms 'access' and 'accessibility'. Access is the opportunity for systematic use based on the proximity to the service and its cost. Accessibility is the suitability of the PT network to get individuals from their system entry point to their system exit location in a reasonable amount of time. Thus the term accessibility encompasses the operational functioning of a system for travel through a network as opposed to just the ease of access. Austroads (1999) also distinguishes between access and accessibility in this way.

When considering definitions particular to Transit (or PT) accessibility Litman (2008) defines this term as *'the quality of transit serving a particular location and the ease with which people can access that service'*. Hillman and Pool (1997) make a distinction between network and local PT accessibility. Local accessibility is seen as the accessibility of a particular residential area or other location to public transport (ie 'access'). Network accessibility is used to describe the accessibility of locations to specific destinations by using public transport (ie 'accessibility').

Polzin et al (2002) state that to obtain accurate measures of PT accessibility, we need to take into account temporal elements as well as geographical or spatial elements. These include the time span of the service and frequency. Another distinction is made between availability and quality of PT to help measure accessibility. Availability refers to the number of services and ease of access whereas quality is a measure of the service provided once it has been accessed.

For the purposes of this paper ‘accessibility’ encompasses local, network, spatial and temporal elements.

2.2 Measuring PT Accessibility

The original idea of measuring accessibility is generally attributed to Hansen (1959). In his paper, ‘How Accessibility Shapes Land Use’, Hansen (1959) describes a link between residential land use patterns and accessibility to commercial industrial and residential locations and suggests a method for determining accessibility patterns. Austroads (1999) describes a number of accessibility indicators that have been developed since Hansen (1959). The discussion below focusses on those developed specifically for PT.

In the US, at a very basic level, the theory of how accessibility can inform travel patterns can be seen with the studies on Transit Orientated Developments (TODs) or Smart Growth developments which focus on providing mixed use relatively dense developments with good PT access (Litman, 2008). Studies have shown that these kinds of developments can reduce private car use and ownership and increase walking, cycling and PT use. These findings have been used to develop methodologies for adjusting predicted trip generation rates in TODs.

With the growth in use of Geographical Information Systems (GIS), a large number of studies have been completed where the proximity of PT stations to various sites has been mapped. This data is then used to compare PT usage of residents and employees at the site compared with other sites further away from PT (Hsiao et al 1997, Cervero 1994 and Dill 2003). Traditionally, most models have used the GIS Buffer method to determine the proportion of population or workers that are within a certain distance (typically 400m) from PT services. More recently this method has been developed to include more accurate network analysis such as the network ratio method (which assumes that a population is evenly distributed along streets, and measures pedestrian travel distance along the street network) or the Distance Decay method (which takes into account the fact that the number of people using PT is likely to decrease as the distance increases).

A separate but related body of research suggests that proximity to PT alone does not encourage PT use (eg Loutzenheiser, 1997). This research focusses on the impact of other features of pedestrian routes. These other factors include lateral separation between pedestrians and motor vehicles, motor vehicle lane volume, effect of motor vehicle speed, roadway crossing inconvenience, environmental amenities and footpath surface conditions (Philips and Guttenplan, 2003). Other examples are Scholosberg and Brown (2004) who included an intersection density rating and identified freeways and major arterial roads as pedestrian un-friendly and therefore removed them from the walking network they prepared for Portland, Oregon.

In terms of network accessibility models, Hillman and Pool (1997) describe various ways that accessibility can be measured. One example is a standard ‘gravity model’ where the accessibility of one zone is calculated by the number of activities in other zones and the travel

impedance between zones. This can be used to measure the general accessibility of particular sites through a PT network.

Although these methods are well documented for their use in measuring spatial accessibility to PT, more recently models have been developed which have included time accessibility. Time accessibility can be incorporated into measurements by including the frequency of the service and travel times to particular locations. A common approach when incorporating time accessibility is the use of isochrones to map travel time by various transport modes. The accessibility of a facility is calculated as the number of people within a selected isochrone from the facility (Hillman and Pool 1997).

The majority of the research described above has focussed on accessibility to PT at the origin end of the trip and therefore residential developments. Examples of studies looking at the destination end include Modarres (2003) and Gent and Symonds (2004), both of which focus on determining the level of population accessible within a defined travel time distance from the destination.

As well as individual studies, a number of PT accessibility indices have been adopted by various local authorities in the US, UK and Australia. In the US, measurement methodologies have been developed that include assessments of PT quality as well as availability. Multi-modal Levels of Service (LOS) for PT has been developed based on similar ratings used for road capacity LOS in the widely used Highway Capacity Manual. The Transportation Research Board (TRB) released a Transit Capacity and Quality of Service Manual in 1999 (subsequently updated by Kittleston in 2003). This contained multi modal LOS indicators developed for all transport modes including specific ratings for PT with the aim of generalising the measures for easy calculation and understanding (Kittleston and Associates, 2003). These LOS ratings are used readily in the US by transport planning professionals. Many of these indices go further than assessing accessibility and include various other factors. These factors are wide and varied and include availability, frequency, travel speed, reliability, cost, boarding speed, safety and security, price and affordability, integration, comfort, accessibility, baggage capacity, universal design (ie for mobility or sight impaired users, etc), user information, courtesy and responsiveness, attractiveness and marketing (Victoria Transport Institute, 2008).

In addition to the TRB manual (Kittleston, 2003), individual authors have developed various indices that consider a mix of the different components. Examples include Rood's (1997) Local Index of Transit Availability (LITA), Ryus et al's (Transit Level of Service Indicator, Galindez and Mireles-Cordov's (1999) Mobility Index and Polzin et al's (2002) Transit Service Accessibility Index. It is noted that the more recent indices tend to be more comprehensive in the factors they include which some argue may make them more accurate. However, the more comprehensive the measurement, the more complex the result, making them difficult to interpret as well as more expensive to determine (Victoria Transport Institute, 2008).

One of the most recent developments and now seemingly one of the most widely used, has been the use of Public Transport Accessibility Levels (PTALs). The methodology was developed by the London Borough of Hammersmith and Fullham in 1992 (Transport for London, 2003) and has since been adopted by Transport for London. The PTAL measurement is relatively simple compared to some of the newer American indices discussed above. The measure reflects walking time from a point of interest to the PT access points, the reliability of the service nodes available, the number of services available within the

catchment and the average waiting time. PTALs have been mapped across whole areas or used to assess individual developments. They are used by planning authorities to rate PT availability and as a major consideration when determining permitted land use and parking requirements throughout the UK. Further developments have included PTALs for different time periods, using alternative parameters for different development purposes and how PTALS can be used alongside other measurements of accessibility and assessments of capacity (Transport For London, 2003).

PTALs have been used in Australia as part of measurements to assess PT accessibility in New South Wales and Queensland and in NZ PTALs have been modelled for Christchurch City Council (Abley, 2008).

Whilst PTALS seem to be the most widely used measurement, a number of professionals in the UK have stated that the tool is too simplistic as it does not take into account where the service is going or how long it takes to get there. It is also principally an origin based measurement and so assumes the development is at the origin end of the trip rather than the destination.

A number of useful examples have come from the UK where various professionals have proposed alternatives to the industry accepted PTAL methodology. One of these examples was Gent and Symonds (2004) who use travel planning software 'Accession' to determine accessibility of a site in terms of a catchment and travel time. They calculate the proportion of the population within a 60 minute travel time of a site and compare the results with the PTAL methodology. They conclude that their proposed Public Transport Relative Accessibility percentage (PTRAP) produces a more realistic accessibility measurement.

3.0 METHODOLOGY

3.1 Defining PT Accessibility

The first stage of this research project is to define the term PT Accessibility and to select a suitable methodology for measuring accessibility to employment sites in the NZ context. Having reviewed the various definitions covered in the above literature review, it was decided for the purposes of this research, PT accessibility can be defined as:

'The potential for employees to travel to a place of work using public transport'.

3.2 Selecting a Measurement Methodology

The next stage of the research was to identify a measurement methodology to enable the 'potential for employees to travel to a place of work using public transport' to be assessed. It is considered the methodology used should be simple, repeatable and use readily available data.

Table 1 below summarises the elements of accessibility considered necessary to develop this methodology. The elements were chosen based on the aim of the research, which elements were considered most important to commuter travellers and available data. These elements are taken from the various definitions discussed in the literature review including local, network, spatial, temporal, availability and quality.

Table 1: Accessibility Elements Required

Measurement Required	Element of Accessibility
Ease of access to the PT network.	Local and spatial
Time the service is available and frequency of the service.	Temporal and availability
Travel time to the work site using PT.	Temporal
Where the service is coming from.	Spatial and network

3.3 Proposed Methodology

After reviewing the available literature, it was determined that the methodology developed would be loosely based on that proposed by Gent and Symonds (2004) as an alternative to PTALs. However, use would be made only of the travel planning information currently available in the Auckland region. In addition, it would also consider a local element (eg walking distance) of the distance to the PT terminal from the site using the GIS network methodology (eg Zhao et al, 2007).

The proposed methodology will calculate a new value entitled the total Potentially Accessible Working Population (PAWP) for each PT service point in the Auckland CBD. While this value has not been taken directly from any of the papers discussed in the Literature Review it uses a number of similar elements. This value will then be used to map the CBD area according to PT accessibility.

3.4 Data Assumptions and Limitations

To enable the PAWPs to be calculated for the PT service points within the Auckland CBD, a large amount of data was collected from different sources. The PT service point location, service routes and travel time data for Auckland was obtained from the Auckland Regional Transport Authority (ARTA) Integrated Public Transport Information System (IPTIS) database which then had to be checked and reformatted to allow for easy data analysis. The meshblock and working population data was obtained from Statistics New Zealand and a basemap of the Auckland CBD showing kerb lines and road centrelines was obtained from Auckland City Council.

ARCGIS and Microsoft Access were used to analyse the data received from the various sources and a code was prepared using Visual Basic Applications (VBA) which allowed the PAWP values for each service point in the CBD to be calculated automatically.

For the purposes of the research, a PT service point is defined as a bus stop, train station or ferry terminal. The working population is defined as the usually resident population (as defined in the NZ Census, Statistics NZ) between the ages of 15 and 64.

A member of the working population will be considered accessible from the destination PT service point if the total travel time to the service point is 50 minutes or less. The total travel time will include an assumed maximum walk and wait time of 20 minutes at the origin end plus a 30 minute period of 'in transit' travel time.

The 50 minute period has been used to allow for an additional 10 minutes of walking time at the destination end which will ensure a maximum travel time of 60 minutes. This is the value used in the Gent and Symonds (2004) research and is considered a reasonable maximum time for a PT commute in New Zealand.

The total PAWP value for each service point is calculated by identifying all of the services that arrive at the destination PT service point between the hours of 7.00am and 9.00am (the morning peak). Each service is then analysed to determine the origin PT service points accessed within the previous 30 minutes travel time. The location of each origin PT service point is matched to a NZ Census meshblock and the working population (WP) for the meshblock is identified. The PAWP for the route is then calculated by adding all of the WPs for the meshblocks accessed along the route and multiplying that by the frequency of the service during the morning peak. The PAWP for each route is then added together to identify the total PAWP value for the destination PT service point.

The working populations of PT service points located within the CBD area will be excluded from the PAWP value as although residents live in the CBD, the CBD is considered as a destination only.

It is important to note that the WPs of some meshblocks will be double counted. For example, where two or more PT service points are located within the same meshblock, the working populations will be counted twice or more (as the case may be). In addition the inclusion of the product of the WP and the frequency of the service represents the fact that the population have more opportunities to access PT. Lastly, the PAWP value does not take into account the capacity of the service vehicle accessing the PT service point. For these reasons, the PAWP figure is not meant to be used as an estimate of the actual number of people able to use public transport but as a measure of the 'potential' or opportunity for people to access a site via PT. Although, the final PAWP value is meaningless on its own, the purpose is to provide a comparison with other PAWP values as an input to making policy and decisions related to PT, land use and other development aspects.

The authors are aware that there are limitations to this methodology and additional work will be required to ensure the robustness of the results. This work could include:

1. Further refining the proposed methodology by considering variables such as the supply of park and rides at the trip origin and/or including a weighting for choice for available routes or for different PT modes etc.
2. Considering a detailed walkability audit of the CBD area and including this in the GIS network analysis and the final PAWP figures.
3. Comparing the results to other recognised methodologies such as PTALs.

4.0 THE STUDY AREA

The Auckland City CBD has been selected as a trial area to map levels of accessibility via PT. The CBD will be defined as the area included in the Auckland City District Plan – Central Area. This area was selected for the following reasons:

- ◆ It has the highest concentration of employment opportunities in the Auckland region with approximately 73,000 people entering the CBD every day for work (Auckland Regional Council, 2005).
- ◆ The density of development within the CBD area is set to increase significantly in future years so there is scope to incorporate PT accessibility measurements in planning decisions.

- ◆ Most vehicle trips made into the Auckland CBD during the peak hours are for work with a high proportion being single occupancy. Therefore information that can be used to help reduce the incidence of commuter vehicle trips will help to reduce traffic congestion during the critical peak periods.
- ◆ It is an easily defined geographical area.
- ◆ Support and information was readily available from the Auckland City Council Central Area staff.

It has been decided that the research study would focus on the accessibility to work places and therefore would consider the CBD as a destination only. Therefore the resultant map produced would show PT accessibility for in-coming employees and not include residents living in the CBD.

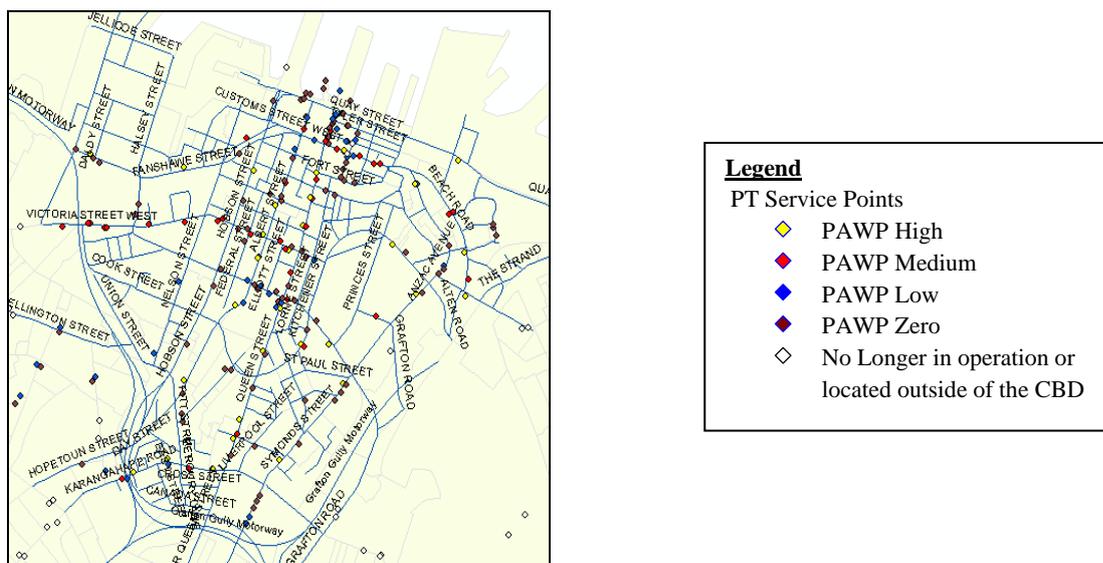
5.0 RESULTS

5.1 Calculating PAWPs for the Auckland CBD

The PAWP values were grouped into High, Medium, Low and Zero (for the cases where no services arrive between 7-9am or where all services have a travel time in excess of 30 mins). The final results were then mapped using ARCGIS. Figure 1 shows the results for the destination PT service points in the Auckland CBD area. It is noted that these results represent the first stage of the research only and further work is required before final conclusions can be made.

However currently the results indicate that those PT service points classed as having High PAWP values are well dispersed throughout the CBD area, as opposed to being concentrated around the Britomart Transport centre as one might have anticipated. However one can see from the map that generally some areas of the CBD have more access to PT service points with higher PAWP values than others.

Figure 1: Map of Results



5.2 Future Work

It is considered the information above can be used when considering an individual development at a known location. Catchment areas showing a 5 minute and 10 minute walking distance around the site can be mapped and the accessibility of PT service points within the catchment areas analysed from the information above to assess the ease of reaching the site via public transport. However, the aim of the research study is to produce a map showing different accessibility ratings across the entire CBD area. At the time of writing, this work is ongoing and the next stages are described below:

1. Dividing the CBD area into a grid and calculating proximity to PT service points from the various grid squares using GIS network analysis.
2. Determining a final formula for comparing the different grid squares in terms of PT accessibility which incorporates the calculated PAWP figures as well as proximity to the PT service points and mapping the results.
3. Investigating the potential for using this methodology in policy development aimed at increasing the PT modal share and reducing congestion during peak times.

6. SUMMARY AND CONCLUSIONS

The paper has proposed a methodology for measuring public transport accessibility to employment destinations. It has described how this methodology could be used and has undertaken a test case example based on the Auckland CBD area. The results indicate that the methodology is practical and easy to use and the results achieved can help to understand the potential of employees to travel to their place of work via PT.

The authors consider this methodology for measuring public transport accessibility to employment destinations is promising and is an important area of research which has many potential uses in transport planning policy.

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