ABSTRACT
An accessibility model has been created to assist decision making at Auckland Transport (AT). The model uses a range of indicators to measure private vehicle and public transport accessibility performance and was used to inform the Auckland Integrated Transport Plan (ITP). The model complements the traditional transportation model that was unable to answer all the questions being posed by decision makers and links to the existing model to leverage an existing investment.

This technical note summarises the development of the Auckland Transport Accessibility Model (ATAM) and subsequent accessibility indicators and model outputs used to inform the ITP. The travel indicators focus on measuring accessibility to employment locations from residential and other employment locations using accessibility scores calibrated via negative logistic deterrence functions, and as a series of threshold-based accessibility measures. The accessibility of 460,000 households in base year (2012) and future year (2041) planning scenarios were calculated.

The indicators facilitate spatial and area wide comparisons to support infrastructure investment and land use planning decision-making. The Auckland ITP which this model informs is an example of collaboration between Auckland Transport and Auckland City and consultants, to help Auckland plan for and create the world’s most liveable city.
INTRODUCTION
Auckland Transport (AT) commissioned Abley Transportation Consultants (Abley) to develop an Accessibility Model of the Auckland region using outputs from the Auckland Regional Transport (ART3) model. The objective of developing the model was to present a number of indicators that show the Auckland land use and transport network performance in 2011 and 2041 under various investment and landuse scenarios.

The Auckland Transport Accessibility Model (ATAM) was developed to specifically measure accessibility to employment from households, and accessibility to employment from other employment locations, that is, to understand connectivity between the location of businesses and the degree of accessibility to other supporting services within the Auckland region.

DEVELOPMENT OF SCENARIOS
The ATAM has been developed for private vehicle and public transport modes of transport, to specifically measure accessibility by these two modes of transport in Auckland for ten scenarios as shown in Figure 1.

Figure 1: Development Scenarios
The current landuse was developed from 2006 census data and the 2041 medium and high growth scenarios are based on the Auckland draft plan. The specific number of households, population and jobs in each ART3 model zone has been sourced from Auckland Council with region wide totals presented in Table 1.

Table 1: Auckland Landuse Totals from ART3 Model

<table>
<thead>
<tr>
<th>Demographic</th>
<th>2006 Census</th>
<th>2041 Medium</th>
<th>2041 High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>459,795</td>
<td>816,030</td>
<td>912,179</td>
</tr>
<tr>
<td>Population</td>
<td>1,347,377</td>
<td>2,013,733</td>
<td>2,441,112</td>
</tr>
<tr>
<td>Jobs</td>
<td>520,251</td>
<td>816,030</td>
<td>918,051</td>
</tr>
</tbody>
</table>

The ten scenarios comprise of five roading and public transport infrastructure options. These include two levels of infrastructure funding noted in this paper as Level A and Level B. At this time of publishing the author does not have client permission to disclose the level of funding corresponding to Level A and Level B. The five scenarios modelled in the morning peak and interpeak periods of the day are:

- current (2011);
- 2041 Auckland Plan Level A funding for medium scenario
• 2041 Auckland Plan Level A funding for high scenario
• 2041 Auckland Plan Level B funding for medium scenario; and
• 2041 Auckland Plan Level B funding for high scenario.

The roading works, public transport infrastructure projects, and public transport route and timetable changes for each of the future configurations have been sourced directly from the ART3 Model. In each case the changes have been identified and added to the current network to prepare GIS-traversable private vehicle and public transport networks within the ATAM.

Comprehensive lists of the future roading and public transport infrastructure projects to be included in the Level A and B options were sourced from Auckland Council and cross-checked against the ART3 model data to ensure that there were no significant departures or omissions from the Auckland Plan. The Auckland Plan is a broad-based 30-year strategy for Auckland that supports the Mayor’s vision for Auckland to become the world's most liveable city and is available at Auckland Council (2012).

**MODEL ASSUMPTIONS**

Modelled networks were received in ArcGIS format from Auckland Council, corresponding to ART3 model runs for the 10 scenarios shown in Figure 1.

The total vehicle time (i.e. including intersection approach delay) for private vehicles on the road network was divided by the link lengths to determine the operating speeds for each of the link types specified in the ART3 data.

These were compared against the free flow speed for each link type using the guidelines from Young (2008), to calculate the percentage of free flow speed by link type, and consolidated using the roading hierarchy classification in the GIS map layers. The resultant percentage of free flow speed for each of these roading hierarchy classifications includes intersection approach delay (both geometric and stop-line components) and can be directly applied in the GIS to convert posted speed limit data to effective network operating speed.

The operating speed of links on the Public Transport network are coded as being identical for Motorway links and 15% slower than the private transport operating speeds for non-express services. This is consistent with Young (2008). Express services operate at the same speed as private transport on the equivalent link. Additional allowances have also been made for boarding and alighting that equate to 0.5-0.6 minutes per kilometres for non-express services only. This is also consistent with Young (2008).

The walk speeds for public transport access are 1.3 metres/second (4.68 kph) taken from the NZTA approved accessibility guidelines documented in Abley and Halden (2013). To simplify the analysis it was assumed that all passengers walk to their bus stops and ‘park-and-ride’ and ‘kiss-and-ride’ trips are not considered.

The wait times and time ‘penalty’ for public transport users who transfer services have been adopted directly from the ART3 model assumptions. Specifically, the wait time is 3 minutes plus 22% of the service headway up to a maximum of 10 minutes. Given the large number of improved headways in the 2041 public transport network and investment in real time passenger information systems, rapid transit and bus priority measures, a range of maximum wait time values were tested. The project and client team agreed that a value of 8 minutes was the most appropriate representation of wait times in the operation of the public transport network. These parameters were calibrated from survey data collected as part of the development of the ART3 model and specified in Young (2008).
The access and wait time assumptions for bus users also apply to rail and ferry users. Rail travel times include a 1.3 minute dwell time per stop, and the service operating speeds are also taken directly from those modelled in ART3 as specified in Young (2008).

**CALCULATING ACCESSIBILITY SCORES**

The assumptions and parameters documented above feed into a path-building process which is applied within the ATAM to calculate a morning peak (for Household to Employment) and interpeak (for Business to Business) travel time between each census meshblock-to-meshblock pairing in the Auckland Region.

The output of this process was a matrix of travel times for trips from each origin meshblock to each destination meshblock for both private vehicle and public transport modes. The public transport travel time makes allowance for walking time to and from the bus stops or rail/ferry termini as well as waiting time at the boarding bus stop or rail/ferry terminus.

There are approximately 9720 meshblocks in the study area, such that 94.5 million meshblock-to-meshblock path builds are required for each model run. For each meshblock, an accessibility score is then compiled by applying a decay curve. There are two curves, one for Private Vehicles (PV) and one for Public Transport (PT), which have been calibrated directly from the Ministry of Transport’s National Household Travel Survey results. The calibrated curves defined by the methodology published in Abley and Halden (2013) used in the ATAM are shown in Figure 2.

![Decay Curves - Auckland Transport Accessibility Model](image)

*Figure 2: Private Vehicle and Public Transport Accessibility Decay Curves*

The score is weighted by multiplying them by the number of jobs in each destination meshblock, and then adding up for each origin location. For the household to employment analysis the household meshblock was assigned the score, and for business to business analysis the origin business meshblock was assigned the accessibility score.

**CALCULATING THRESHOLD INDICATORS**

Threshold-based indicators are also available within the ATAM. Threshold indicators provide values for the number or percentage of a population that can access a destination type within a specified threshold such as time, distance or economic cost. Specifically, the number of jobs and the percentage of all jobs that can be reached by private vehicle or public transport within x minutes was a fundamental indicator used to inform the Auckland ITP. Analysis focused on how many jobs can be reached in 15 minute increments from 15 minutes through to 60 minutes.
MODEL OUTPUTS
The results of the model were presented as a series of maps. These show current, future and changes in accessibility outcomes using both accessibility scores and threshold indicators for the ten scenarios specified in Figure 1.

The example map in Figure 3 displays the percentage shift in the number of jobs accessible within 30 minutes by private vehicle out to 2041 under a high growth development scenario. Many parts of the City (lighter shaded areas) have decreased accessibility outcomes in the future as congestion increases on the roading network (consistent with ART3 Model), whereas other parts (darker shaded areas) experience improved accessibility over the next 30 years. The improvement areas correspond to major proposed infrastructure investments including the Penlink, Auckland Manukau Eastern Transport Initiative (AMETI) and Waterview Connection. These projects produce positive accessibility outcomes for significant parts of the City.

\(^1\) Quantum of change is not disclosed due to confidentiality
Graphs illustrating the change in accessibility results between scenarios were also presented to Auckland Transport. In Figure 4 the percentage of all jobs in Auckland that can be reached within 15, 30, 45 and 60 minutes by private vehicle for the average household is displayed. The results are shown in 15 minute increments to measure the reach to employment destinations up to 60 minutes.

The graph in Figure 4 shows the percentage of jobs the average household can reach within 15, 30, 45 and 60 minutes now and in 30 years. The reach of the average household generally decreases due to increased congestion levels, however Level B infrastructure funding (which is significantly higher than Level A funding) improves accessibility outcomes for the typical Aucklander.
CONCLUSIONS
This technical note summarises the development of the Auckland Transport Accessibility Model (ATAM), to measure accessibility outcomes to support infrastructure investment and landuse planning across the Auckland Region. The ATAM takes inputs from the existing ART3 Transportation Model and outputs a range of indicators to quantify and spatially represent both household-to-employment and business-to-business accessibility now and in the future.

Accessibility modelling supports strategic planning by considering the reach of people and businesses across transportation networks. Models provide a tool that Local and Regional Authorities can call upon to inform long-term infrastructure investment and strategic development decision-making.

ACKNOWLEDGMENTS
We acknowledge Auckland Transport and Auckland Council for their pro-active approach to planning for the future and their support in this project.

REFERENCES
