

## **TITLE: THE AUCKLAND TRANSPORT MODELS PROJECT: OVERVIEW AND USE TO DATE**

Authors: John Davies (Auckland Regional Council)  
Jojo Valero ((Auckland Regional Council)  
David Young (David Young Consulting)

### **ABSTRACT**

This paper begins with an overview of the integrated system of new regional transport demand and land use models that were developed for the Auckland Regional Council in 2006-08. The project was known as the Auckland Transport Models (ATM2) project.

The models are strategic in nature, mainly used to assess the regional impacts of land use and transport policies and projects. They are presently being used in the reviews of the Auckland Regional Growth and Land Transport strategies, and in doing so a number of modifications to the transport model have been made to adapt the model to reflect changing policy requirements, to improve outputs and to improve model performance.

The second part of this paper discusses some of these modifications, primary those that address questions and issues that have arisen recently in the local planning environment. The paper will close with a sample of outputs of integrated land use transport tests.

Other detailed topics related to research undertaken as part of the ATM2 project have also been submitted to the ATRF2009 – it is not proposed to repeat those elements in this paper.

Keywords: Auckland, modelling, land use, transport, policy

### **INTRODUCTION**

The Auckland Transport Models (ATM2) Project developed an integrated system of regional transport and regional land use models for the Auckland Regional Council (ARC) over the period 2006-08. This paper describes the background to the new models, their current status and the structure of the model system, some recent modifications and closes with some sample outputs and applications.

### **HISTORY**

The ATM2 project was a major update of the previous regional modelling system that was initially developed using 1991 data. In the early 1990's land use and transport demand models were constructed and although they were linked and run interactively the two models were not fully integrated. The Auckland Regional Transport Model was referred to as ART and the Auckland Strategic Planning model as ASP. (Auckland Regional Council, 1994-96)

In 2001 the ART model was re-based using 2001 Census and other observed data and was known as ART2 (Sinclair Knight Merz, 2003). At about this time a dedicated Auckland Passenger Transport model, APT, was developed to support the ART model and provide more detailed passenger transport modelling in the region (Booz Allen Hamilton, 2001).

Over the last ten years the region has seen relatively high growth and demographic changes, as well as significant changes to the transport system. These, along with the fact that the models were based on 1991 data and there were ongoing issues with aspects of them, meant that the continued use of the ART and ASP models was questionable.

Following a scoping exercise (Sinclair Knight Merz, 2004), the ARC decided to redevelop the system entirely, based on 2006 data, which corresponded with the 5-yearly Census in New Zealand. The new modelling system is referred to as ATM2, the transport demand model as ART3 and the land use model as ASP3.2, the trailing digits corresponding to the model version numbers.

The ATM2 project was undertaken by a consultant project team lead by Sinclair Knight Merz, teamed with David Simmonds Consultancy, Beca Infrastructure, and other sub-consultants (Sinclair Knight Merz, 2007-08).

## **ATM2 OVERVIEW**

The ATM2 system is an integrated land use / transport modelling system in which data is passed between the land use and transport models as they forecast into the future. The models are aggregate models based on a common 512 spatial zoning system covering the whole of the Auckland region.

External to the ATM2 system are **economic and population models** that provide high level, regional employment and population forecasts for ASP3.2 (Auckland Regional Council, 2008). This data is derived from national statistical forecasts and regional economic future scenarios, and sets the regional totals for a number of employment sectors and demographic segments. At present only a single set of employment and population scenarios have been tested.

The **land use model** (ASP3.2) is an annual incremental model that forecasts off a base year (2006), and was built using DELTA<sup>1</sup> software (Simmonds, 1999). Future land use capacity scenarios are developed as inputs to the model and this land is developed (or taken up) in the model according to regional demands and spatial accessibilities. Accessibilities are calculated in the transport demand model and fed back into the land use model.

The **transport demand model** (ART3) uses the EMME<sup>2</sup> software platform. It is a multimodal model that estimates travel demands based on the spatial land use patterns and quantities passed over from ASP3.2. Outputs include vehicle and passenger demands and network flows, as well as accessibility levels by zone that are passed back to the land use model.

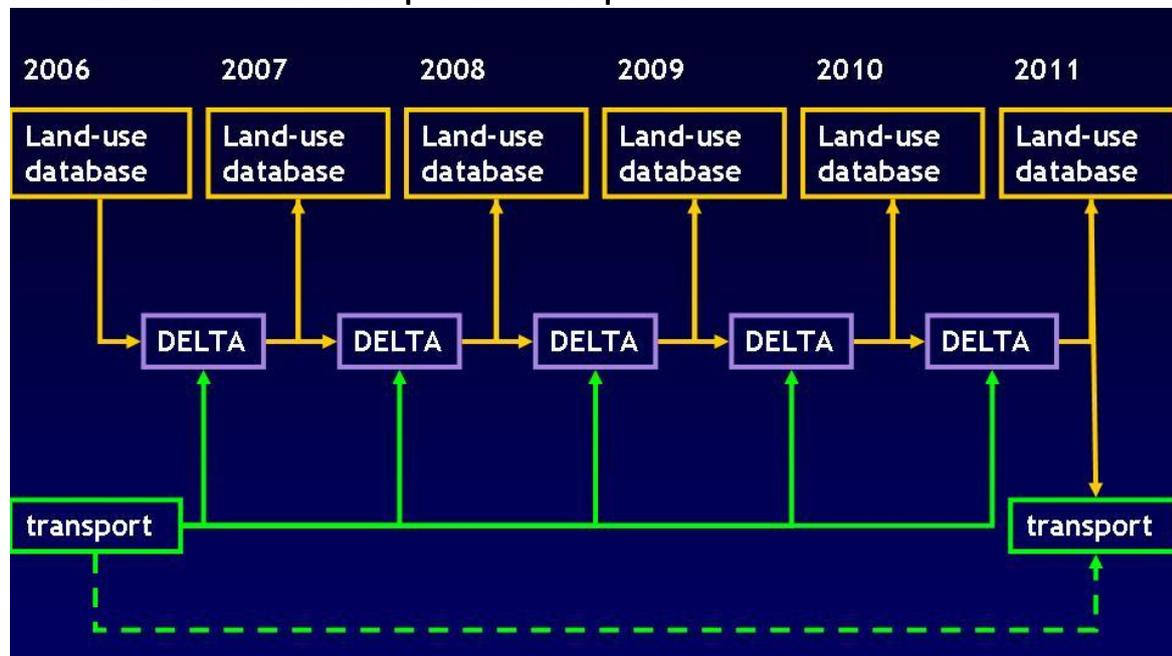
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<sup>1</sup> Trademark, David Simmonds Consultancy Ltd

<sup>2</sup> Trademark, INRO Consultants Inc

Currently forecasting occurs from the base year (2006) to year 2051. The land use model increments land use changes on an annual basis (that is, is run sequentially in every forecast year) with the transport model run in every fifth year, and transport accessibility updates are provided to the land use model every fifth year, as depicted in Figure 1.

**FIGURE 1: Land use and Transport Model Sequence**



Large amounts of data are output, which is generally post-processed into an aggregated level for evaluation and reporting.

### 2006 DATA AND MODEL BUILD

A major component of the ATM2 project was the collection of base year 2006 data, comprising 2006 Census data and a series of surveys.

The Census data for the land use model was a set of bespoke cross-tabulations used to extract data by a number of significant variables such as person type, household type, car ownership and demographic data. This and trend data related to land use and floor area take up were used to calibrate the land use model.

The transport model was calibrated on Census and survey data. The surveys included household travel surveys (household, person, vehicle and weekday trip data), passenger transport intercept surveys, commercial vehicle (medium and heavy) surveys, traffic counts, travel time surveys, parking surveys, amongst others.

The data collection took up the first year of the project, model calibration the second year and a further six months for validation, modification and refinement as well as model hand-over, ARC staff training and reporting.

Generally the surveys progressed well but there were a number of issues that affected data collection and quality. The household interview survey was a self-completion survey and probably the biggest problem related to the completion of the trip records, fairly typical of such surveys. About 1.4% of households were sampled. Retrospectively it was discovered that there was some under-reporting of car trips during the non-peak periods, which was rectified in the demand modelling<sup>3</sup> (Sinclair Knight Merz, *ibid*). On board passenger transport intercept surveys generally progressed well although survey logistics were problematic. If such surveys are completed in future, it is likely that use would be made of spatial tracking systems to improve spatial and temporal data quality. Other surveys generally progressed favourably even though there was some time slippage.

Within the Auckland context, “new” surveys that were conducted included a survey of medium and heavy commercial vehicles and a cycle travel diary survey. The household travel survey included Saturday travel data, aimed at building a weekend travel model, but this has not been used to date.

## **NEW MODEL COMPONENTS**

The paragraphs below provide a general overview of the new elements of the models. Other papers presented at the ARTF2009 describe specific components in detail<sup>4</sup>.

The general form of the transport model (ART3) has some similarity to the previous model (ART2) in that both are essentially four-step demand models covering trip generation, trip distribution, mode split and assignment. ART3 does have many features and characteristics that are very different and improved over ART2. This is not unexpected given that over time the requirements of transport demand models have increased and become more complex, and that it was recognised that ART2 had a number of inherent weaknesses and issues. As expected the aim was to build a model that dealt with these issues and was aligned as far as practicable with best international practice. The requirements of integrating with the land use model also had to be considered.

Some of the main differences and improvements are outlined below.

### Study Area

The previous model covered the main urbanised areas of the region, but not the rural areas nor the more peripheral towns. ART3 covers the whole of the Auckland region plus two small towns to the south: Tuakau and Pokeno.

### Zone System

The zone system of the previous ART2 model was fairly coarse, giving rise to a lack of required sensitivity in some areas and situations and also making disaggregation of traffic demands to more detailed project models problematic. ART3 has a much finer zone system – 512 zones compared with 203 – which was designed in part around the requirements of the Regional Growth Strategy at the time.

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<sup>3</sup> A separate paper on Household Travel Survey under-reporting is to be presented at this conference

<sup>4</sup> Time of day modelling, Land use model application

### Modelled Periods

The previous ART2 model generated trips for the morning and interpeak 2-hour periods directly and the afternoon peak for vehicles was a combination these. This limited the transport assessments and the updated ART3 model now generates 24-hour trips, which are then split into time periods. Assignments are based on these time period demands but only morning, interpeak and afternoon peak period vehicle and passenger transport (PT) assignments are run in the ART3 model. Composite travel costs based on the assignments are passed to the DELTA land use model.

### Networks and Assignments

New roading and PT networks, compatible with the zone system, were created for ART3. They have a greater level of detail than in ART2 with, for example, the roading networks having much more detailed intersection modelling and specific representation of the effects of queuing on the motorway network. The PT networks include improved multi-modal access to park-and-ride sites, representation of fares, and boarding and transfer attributes.

### Car Ownership

The ART3 car ownership includes both cross-sectional and temporal models, whereas ART2 in forecasting required judgement and past trends to set the regional levels.

### Trip Ends

The main variables in trip rates are person and household characteristics (productions) and employment, households and educational rolls (attractions). Locational effects have been included in the models where identified, such as those related to more highly intensified centres or corridors.

### DMS and ToD

Trip distribution and mode split (DMS) in ART2 were carried out sequentially and in that order, and the mode choice model combined all purposes, presumably because it was based solely on 1991 HTS data which included few public transport trips.

The ART3 trip distribution, modal split and time of day (ToD) modelling includes simultaneous and sequential processes, depending on the trip purposes being modelled. This is a major advancement on the previous model. The collection of PT intercept data has enhanced the PT trip sample and subsequently improved the PT model component of ART3.

In ART2 the period models were separate throughout and there was some representation of peak spreading in the AM peak model. In ART3 the ToD model is based on the concept of trip tours where the outbound and return tours are allocated to specific times of the day and travel decisions are based on the costs of tours rather than individual trips.

### CV Model

The ART3 commercial vehicle (CV) model includes medium and heavy commercial vehicles and is based around a 2006 matrix created from a synthetic prior matrix and matrix estimation using screenline count data. In forecasting this matrix is factored according to land use and economic growth.

The ART2 CV model included light delivery vehicles, couriers, etc, which proved problematic for any assessment of freight movements. It was recognised that the model was less robust than other components of the ART model, largely due to the uncertainty in the commercial vehicle survey data collected in 1992.

Table 1 summarises the main differences between ART2 and ART3.

**TABLE 1: ART2 compared to ART3 (2006)**

Item	ART2	ART3
Study area	Main urban areas of the region	Entire region plus Pokeno and Tuakau
Zones	202	512
Persons per zone	5,100	1,600 (>=15yrs)
Employment per zone	2,400	880
Modelled periods	AM and IP full model, PM vehicle assignment only	Demands covering 24-hour period; AM, IP, and PM assigned
Trip ends (trip generation)	By period (AM and IP)	24-hour
Active modes	By period (AM, IP)	24-hour productions
Trip distribution and modal split	Separate steps in set order	Simultaneous and separate, according to statistical calibration
ToD model	Period models with vehicle peak spreading module in AM peak	Allocation of periods according to trip tours and their costs
Auto assignment	Equilibrium by period	Equilibrium by period
PT assignment	AM and IP periods; assigned by captive/ choice segments	AM, IP and PM periods; assigned by purpose segments
Run time	2 hours	7 hours (with tolling)

The land use model runs on DELTA software, developed by David Simmonds, which is an acronym for the five main sub-models that represent **D**evelopment, **E**mployment, **L**ocation, **T**ransition and **A**rea-quality. Some characteristics of the Auckland DELTA model are (David Simmonds Consultancy, 2008):

- Integrated with transport model, passing and calling transport data every fifth forecast year:
- Forecasts annual incremental change in the population and employment data for the 512 zones in the modelled area;
- High level of segmentation (136 household types, 4 person types, 17 employment types, 22 non-household activities)
- Use of floor space by five activities (households, retail, office, industrial, warehouse)
- Six other activities are modelled but they do not use floor space
- Scenario development requires the estimation of floor space permitted development over the forecast period
- Extensive and detailed output data is produced (by 512 zones over the 2006-51 forecast period).

## ART3 MODEL VALIDATION

There are modelling uncertainties or inaccuracies associated with every step in the modelling process, from the Statistics NZ Census data that was used in model estimation to traffic counts used to validate the model. Each step will have a different accuracy level and thus a specific model result will have a margin of error associated with it. The model validation process (Sinclair Knight Merz, *ibid*) ensures models are reasonable and that margins of error are minimised and kept within accepted bounds applicable to the type of modelling. Large scale regional models have higher margins of error compared to small-scale detailed models because it is not practical to measure or observe all the model elements to levels that ensure small margins of error. At the end of the modelling process the overall model is validated against observed vehicle and passenger flows, producing an overall indication of the model's applicability in representing the base year (2006). The distribution-mode split models, a critical and complex part of the process, validate well at an aggregated 20-sector level, reflecting statistically significant model coefficients and good correlation between observed data and modelled results. Errors vary between 0% for larger scale trip components to 45% for small trip components.

Overall, the base year traffic flow validation across screen lines in the region in each of the three peak periods modelled (morning, interpeak and afternoon) is between -1% and +3%. The variation in errors between individual screen lines and by direction of flow is larger, between -20% and +40% with about 85% varying by less than 10%. The  $R^2$  goodness of fit values exceed 0.98 in the three assigned periods (a value of 1.0 indicates perfect fit), which indicate a good fit between observed and modelled results. When assessing individual link flows about 65% are within 10% of observed flows and the goodness of fit declines to 0.88, which is acceptable. Observed and modelled travel times differ by less than 20% on about 80% of the routes surveyed.

The overall passenger transport observed versus modelled flow differences across the periods are between 2% and 6%, with the errors increasing similarly to those for vehicle trips as the level of assessment detail increases.

The interpretation of regional or higher level results can be made with greater confidence than that for individual parts of the system, for example regional total traffic demand compared to the number of passengers boarding at a specific bus stop. This is expected for regional scale transport demand models.

The US Federal Highway Agency FHWA (Barton-Aschman, et al, 1997) targets likely observed versus modelled errors in regional models, including freeway flows at +/-7% to flows on collector roads at +/- 25%. Screenline goodness of fit should not be less than 0.88. These tests are exceeded in the ART3 model.

The Project Evaluation Manual (Transfund, 1997) was referred to but it does not provide suitable guidelines for regional scale model validation. ART3 screenline validation was compared with the GEH values recommended for (more detailed) project models and was found to be satisfactory (90% of screenlines have a GEH value of <12).

## **MODEL APPLICATION**

This section outlines the use of the model and some of the general issues that have arisen since delivery in July 2008.

While the ATM2 modelling system was tested in forecasting prior to delivery, in the initial runs undertaken by the ARC a number of convergence issues in both models arose which required re-setting of some parameters.

A full forecast model run to 2051 takes between 5 and 7 days to run: with ASP3.2 taking about an hour for five years of forecasting (between the transport model runs) and ART3 about seven hours per modelled year. There were numerous adjustments to the way scenarios were developed but these have been streamlined using macro processes or developing customised applications to develop and format data.

The initial model applications revolved around the testing of growth scenarios to 2051 as part of the Regional Growth Strategy. The forecast population growth is from 1.4M to 2.3M between 2006 and 2051. Five different growth scenarios were constructed and tested. The process was repeated as the learning curve progressed and different issues surfaced. This process, all in all took about five months to complete although the last scenario was completed in a relatively quick two week period (excluding post-modelling evaluation). We still consider this to be an initial run of the ATM2 process as a number of significant inputs and assumptions have not been tested.

ART3 is being used as a stand-alone model to assist in the development of the Regional Land Transport Strategy 2010. This process uses a fixed land use scenario, derived from one of the growth strategy tests, and alternative network and travel demand management scenarios are being tested.

## **CHANGING REQUIREMENTS**

The ATM2 project was scoped out in 2005 to co-ordinate data collection with the 2006 Census. Since then there have been a number of changes and factors that needed to be accommodated. Political change, manifesting as Government Policy Statements (Transport) and the New Zealand Transport Strategy (NZTS) were the principle drivers for model changes. These included the setting of active mode (walk and cycle) targets and passenger transport use targets for the region that needed to be measured using the model.

From the land use side there was an increased need to assess the effect of centres, corridors and the roles of typical and higher density residential developments. ASP3.2 was modified to accommodate these needs and in-house scenario building was enhanced and linked to GIS to more accurately assign development to the model zones.

Recently there have been requests for the modelling of projects located on the periphery of the modelled area. As these areas were modelled at a lower level of accuracy and exclude some demand effects, this posed a problem.

In response to these requirements some modifications and refinements have been implemented in the ART3 during the course of its use over the past year. Some of these are outlined in the next section.

## **MODEL MODIFICATIONS AND REFINEMENTS**

There have been a number of specific issues and strategic planning requests that have driven changes or modifications to the model. These are generally minor in terms of the structural or mathematical build of the models but they sometimes have a reasonably significant effect on outcomes. These are briefly summarised below.

### Travel Demand Management

Travel demand management in terms of travel plans (workplace, school-based, community-based) is an important component of regional policy. The effects of such initiatives have been estimated outside the model and defined as percentage reductions in trips by car, and corresponding shifts to active mode and PT trips. The changes vary over time and can vary spatially. Procedures for asserting these trip changes, which vary by trip purpose, have been implemented in the model.

### Active Modes

Active mode (walking and cycling) trip productions are estimated as part of the trip ends models. Two refinements have been made to the active mode models during the use of the model.

During estimation, statistically different active mode trip rates were found between Auckland CBD, the inner city and other areas. As part of forecasting such areas are now extended to vary over time and between land use scenarios as other areas become similar to those identified in estimation.

Secondly, active mode trips in specified zones can vary as the relativities between zonal demographics change. For example, active mode productions for home to work trips (HBW) in large employment areas can increase as the ratio of population to employment increases. Some such areas were identified in the base year, and in forecasting other areas are included over time according to the land use scenario being modelled.

### Under-Reporting Factors

To rectify the effects of under-reporting in the household travel survey, which formed the basis of the roading side of the model estimation, under-reporting factors are applied to the light vehicle matrices. The factors were originally applied only in the modelled periods where assignments were carried out and for which counts existed.

The original factors have now been extended to include all modelled periods, that is, the school peak (3-4pm) and the off-peak (6pm to 7am), and are now also applied to active mode productions.

### ASP3.2

The initial land use model runs had convergence issues that sometimes resulted in the model looping. This required some adjustment of coefficients to improve model stability

and convergence and updating of some pre-2006 zonal data. The development of permitted floor space data over the 2006-51 modelled period became quite complex as actual data formats sourced across the region often differed from the model input formats. GIS-based data and methods were used to assist in building the future development scenarios.

Residential development is a critical part of land use scenario testing and it was decided that splitting housing into typical and higher density types would be beneficial. The allocation of different dwelling types to different areas, for example higher density housing in centres, would assist planners in evaluating the model's location response to different scenarios. This enhancement was implemented in the ASP3.2 model.

## OUTPUTS

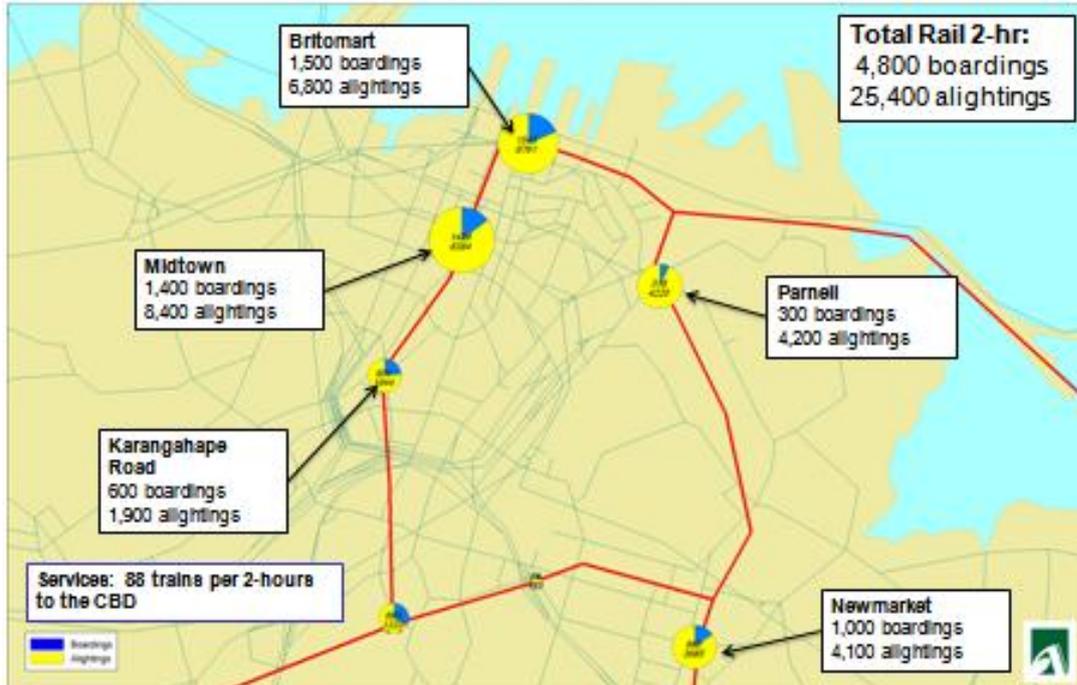
The ATM2 system produces vast amounts of data, including both land use and transport data, split over 512 zones, by year from 2006 to 2051 and segmented into numerous land use and travel demand segments. An ongoing task is developing ways of reporting model results in a simple and easily presentable form that is nonetheless useful enough to assist evaluation! Most of the model results are relatively standard and can be provided in tabular and graphical forms, post-processed using spreadsheets. GIS-based mapping is also used to produce spatial maps of results at a zonal level. Most results tend to get aggregated to provide district-level or regional indicators. Outputs are available at a zone level, either at points in time or continuously over the 2006-51 modelled period. Sample outputs are shown in Figures 2 to 5 below.

**FIGURE 2: Passenger Transport Flows (ART3 model)**



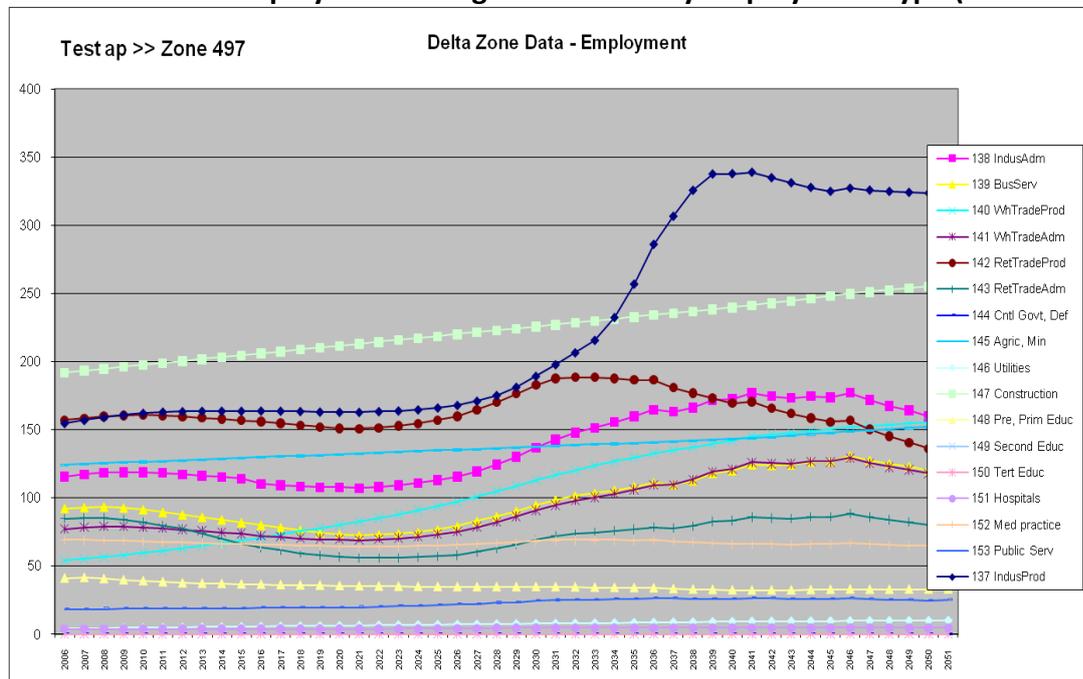
Figure 2 spatially shows the morning peak passenger transport flows on the PT network, predominantly radial to the Auckland CBD (located in the middle of the figure).

**FIGURE 3: Rail Passenger Boardings and Alightings (ART3 model)**



In Figure 3, the locations of forecast boarding and alighting rail passengers are shown by means of scaled pie charts at possible stations in the Auckland CBD.

**FIGURE 4: Zonal Employment Changes over Time by Employment Type (ASP3.2 model)**



The chart in Figure 4 plots the employment changes in zone 497 from 2006 to 2051. Each line charts a different type of employment, ranging from industrial production jobs to public service jobs. The dark blue line (Industrial Production employment) exhibits rapid growth in the third quarter as development land is released, indicating that the zone is accessible and

attractive. In the fourth quarter a slight decline is evident, probably due to increased rents, reduced accessibility and competition from other zones.

**FIGURE 5: Accessibility Changes over Time by District (ASP3.2 model)**

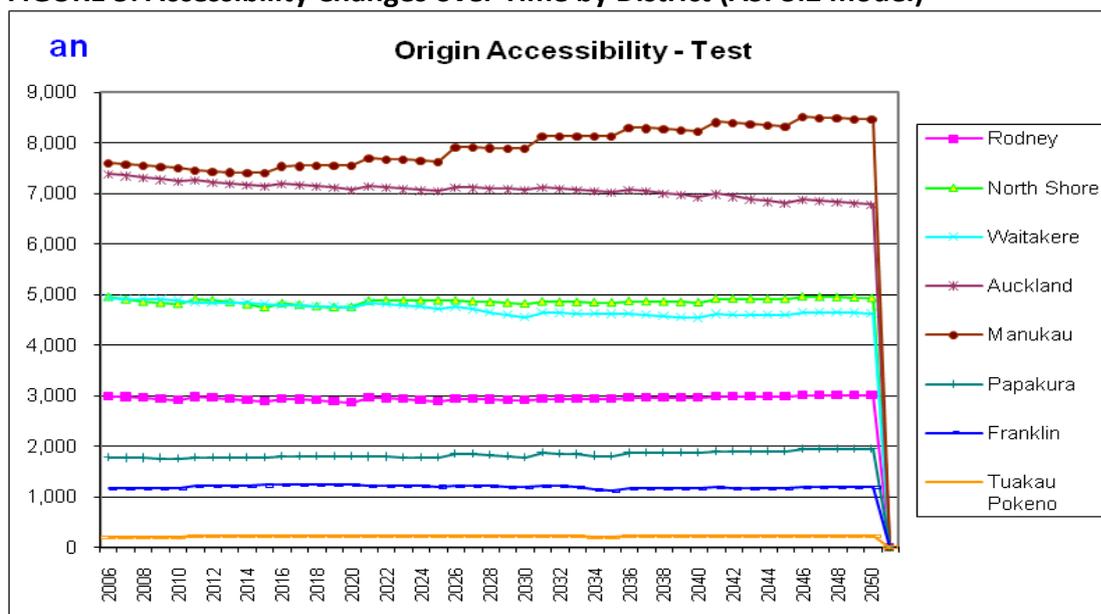


Figure 5 shows how the aggregated accessibility for each district in the region changes over the 2006 to 2051 modelled period (higher value = higher cost = less accessible). The origin accessibility measures the accessibility from a zone to other activities and can be used as an indication of access to jobs, for example. The “kinks” in the lines at every fifth year coincide with year the transport model is run, reflecting the relatively large change in accessibility when the transport costs are updated due to changed land use. Accessibility (and travel costs) generally worsen due to demographic growth over each five year period but can be offset by greater access to activities nearby, network improvements and changing trip patterns. This tends to reflect in the in-between four years as travel costs are static but access to more / closer activities improves, thus slightly improving accessibility.

## REGIONAL TRANSPORT SCENARIO TESTS

The ART3 model is being used to develop the region’s land transport strategy, in line with achieving Government transport targets (Ministry of Transport, 2008). A number of scenarios are being assessed, which include significant changes to a number of system components. An sample of test inputs and outputs has been provided in Table 2 as an indication of how the model responds.

**TABLE 2: Indicative ART3 Scenario Test Data**

Item	2006	2041 Test
Population (ART3)	1.35M	2.06M
Employment (ART3)	520,000	866,000
Education Roll (ART3)	347,000	392,000
Fuel price (2006\$/litre)	\$1.55	\$3.71
Road network changes	-	+9% lane kms
PT network changes	-	+170% service kms
Travel Demand Management	Low	Moderate
Daily person trips	4.6M	6.5M
Daily person trips in cars (share)	4,010,000 (87.3%)	4,980,000 (76.4%)
Daily person trips in PT (share)	145,000 (3.2%)	545,000 (8.4%)
Daily Active trips (share)	438,000 (9.5%)	997,000 (15.3%)
AM Peak Period Network Statistics		
Vehicle kilometres	5,094,000	6,547,000
Vehicle minutes	7,432,000	9,407,000
Vehicle trips	489,000	675,000
Av trip length (km)	10.4	9.7
Av trip time (min)	15.2	13.9
Av trip speed (kph)	41.1	41.7

The authors stress that this model run was carried out purely to test the model parameters and does not represent ARC policy.

Significant levels of travel demand management are required to attain the Government's transport targets. Measures include increased work from home, workplace, school and community travel plans. This reduces travel and shifts car trips to other modes. Similarly road investment is relatively low and passenger transport services have been increased. Resulting trip lengths have declined as a result and 2006 travel speeds across the network have largely been retained in this test scenario.

## CURRENT STATUS AND FUTURE WORK

The ATM2 model system has been quite rigorously tested over the last few months. Initial tests revealed a number of issues relating to the development of the future land use scenarios and how they are represented in the land use and transport models. Fully integrated forecast models runs will be continued once these issues are resolved and tested and once other modifications are completed. ART3 is being used extensively in the development of the Regional Land Transport Strategy for Auckland.

Current and future model improvements cover both the land use (ASP) and transport (ART) models and are briefly described below.

### ART3 Modifications

- Core versus external modelled area: initially the modelled area was split into a fully modelled core area and an external partially modelled area. The partially modelled area is generally the periphery of the region that was not covered in the 2006 home interview surveys. There are number of regional transport projects in the periphery that are

impacted by the partially modelled external area so it decided to fully model the entire area. This work has been completed.

- Variable trip rates: modelled trip generation rates are constant but consideration needs to be given to varying the rates over the long time frame in the forecasting. This is a future research-based task.
- Freight lanes: the development of a dedicated freight lane model is being considered.
- SOV / HOV split: car trips are presently not split by the number of occupants but doing this is desirable for testing issues such as single versus high occupancy lanes.
- Airport modal split: the trips generated by airport flight passengers are modelled but only as vehicle trips. It is preferable to split these into auto and passenger transport modes to improve the assessment of airport public transport schemes.
- Construct a Saturday assignment model (using the household interview data collected in 2006).
- Split Active trips (walk and cycle combined) into separate walk and cycle modes.

### ASP3.2 Modifications

At present the DELTA input data is being reviewed to include construction and demolition of floor space over the period 2006 to 2008. At the same time model inputs and parameters will be checked and amended if necessary.

### **ACKNOWLEDGEMENT**

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### **REFERENCES**

- Auckland Regional Council, Technical Working Papers on the Auckland Transport Models (ATM) Project, 1994-96
- Sinclair Knight Merz Ltd, *2001 ART Model Validation Report*, Auckland Regional Council, 2003
- Booz Allen Hamilton Ltd, Auckland Passenger Transport Plan Reports (various), Auckland Regional Council, 2001
- Sinclair Knight Merz Ltd, *ART3 Scoping Report*, 2004
- Sinclair Knight Merz Ltd, *Auckland Transport Models Project (ATM2)*, Project reports (various), 2007-08
- Auckland Regional Council, Economic and Social Policy Team, *Economic Futures for the Auckland Region, Part 2: Scenarios for economic development*, April 2009
- Simmonds D C, *The design of the DELTA land-use modelling package*, Environment and Planning B: Planning and Design, pp665-684, 1999.
- David Simmonds Consultancy, *ASP3.2 Application Report*, Auckland Regional Council, October 2008
- Barton-Aschman Associates, Inc. and Cambridge Systematics, Inc., *Model Validation and Reasonableness Checking Manual 7.0 Assignment Procedures*, Travel Model Improvement Program, U.S. Department of Transportation. February 1997
- Ministry of Transport, *The New Zealand Transport Strategy 2008*, Government of New Zealand, 2008
- Transfund New Zealand, *Project Evaluation Manual*, 1997

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