

Task 5 Networks and Assignment – Public and Private

Scope

This section covers the specification of the ART3 road and PT networks and assignments and their implementation. While the implementation of the model as a whole is Task 15, the networks and assignments are required prior to the implementation of other components in order to provide generalised costs for estimating the distribution/mode split models.

A new roading network for ART3 has always been intended, whereas our original proposal for PT was to make use of the APT network in conjunction with ART3 or APT zones. Following discussions with the ARC it has been agreed that new PT networks will be developed for use with both ART3 and APT, using the ART3 roading network plus some additional PT-only network where necessary. It is intended that the new PT network would draw on the APT model for various PT attributes as far as possible.

Hence it is necessary that the specification and then the development of these networks are carried out jointly where necessary.

Additionally, with the approval of the ARC, the road network is to be largely developed as part of Transit New Zealand's evaluation of the Western Ring Route (WRR) as a toll project. This will occur during the latter part of 2006 and involve Tasks 5.1 to 5.8, with the testing and calibration focussed on the WRR corridor. The ATM2 project will then complete the network development for ART3, that is, for the whole of the network.

The overall approach for the assignments will be to use the roading and PT assignment procedures within EMME/2.

For roading generalised cost equilibrium assignments will be used. These will allow for both all-vehicle assignment (single class) and multi-class assignments; the latter enabling separate assignment of vehicle-type and/or purposes which can reflect differences in time and operating cost values. It is expected that the single class assignment will be used in most applications.

The PT assignment will be of all modes and separation into PT sub-modes will occur as part of this.

The specific tasks described in the following sections are:

- Task 5.1 Network Inventory Data
- Task 5.2 Develop Road Networks (Links)
- Task 5.3 Develop Road Network Delay Modelling
- Task 5.4 Develop Peaking Factors
- Task 5.5 Develop Motorway Delay Procedures
- Task 5.6 Auto Access Functions
- Task 5.7 Design of Private Vehicle Assignment
- Task 5.8 Implementation and Testing of Private Vehicle Assignment
- Task 5.9 PT Travel Time Functions

- Task 5.10 Park-and-Ride
- Task 5.11 Design of PT Attributes and Assignment
- Task 5.12 Develop PT Networks (Links)
- Task 5.13 Coding of PT Services
- Task 5.14 Implementation and Testing of PT Network and Assignment
- Task 5.15 Networks and Assignment Report

The development of the networks and assignments has, necessarily, a close interaction with other tasks such as:

- Definition of time periods
- Zone system and model extent
- Implementation

Task 5.1 Network Inventory Data

Purpose

This task involves collation/collection of the network inventory data required to develop the base year roading and PT networks.

Inputs

- GIS database – census road centrelines, TLA boundaries, traffic zone boundaries
- District Plan hierarchy maps
- Transit NZ route data sheets (State Highway only)
- Aerial photos
- Street maps
- Sample free-speed surveys (with sample from each link-type classification)
- Inventory surveys at key junctions
- TLA data on clearways, bus lanes, HOV lanes

Processing

Assemble and collate all data sources/bases and store in a convenient form. Specifically:

- network data that varies by time period will be collated (clearways, bus lanes, tidal-flow facilities), and identified by link i-j reference (this data is held by TAs/RCAs);
- a library of the layout details for all key junctions will be developed. This should include a sketch of the layout, including lanes, lane markings, basic lane dimensions (widths, short lanes etc), phase diagrams etc. These will be sketched on template forms (then scanned into electronic format). An electronic storage system will be developed for the junction library.

Develop a robust link-type classification, identifying:

- TLA
- RCA
- Road environment (service road, local road, arterial, rural, expressway etc)
- Posted speed-limit

Using this classification allocate link-free-speeds, capacities and volume delay functions, and the generic relationship between link type/speed limit and the free-speed. Free-speeds by link-type should be based on a sample of free-speed surveys.

Outputs

- Link-type classification of all links
- RCA/TLA/DP Hierarchy classification of all links
- Generic allocations of free-speeds and capacities by link type
- Junction layout library

Task 5.2 Develop Road Networks (Links)

Scope

The network will generally include all roads down to major collector road, but with minor collector roads added where required to support the zone system. Networks will be developed to avoid multiple centroid connectors, but only to a level of refinement supported by the zone system.

New networks will be developed from the GIS centreline data rather than from any existing networks.

Additional nodes will be included on longer links at significant landmarks (such as local road intersections). This would assist in avoiding later refinement of the networks that might be required for the PT network and any associated more refined zone system implemented with APT.

Node numbering would be based on geographical clusters, broadly in line with current practice.

Inputs

- GIS inventory data
- Additional inventory data
- Revised zone system
- Current networks for ART2 and project models
- Road network already developed for ART3 (in ARC GIS)
- Link-type classification

Processing

- Identify node locations and links from GIS centrelines and export co-ordinates and link numbers
- Import skeleton networks into EMME/2
- Load centrelines as background and identify visual anomalies in network shape
- Define modes
- Allocate lanes, modes and link types
- Develop zone connectors
- Identify and code period-specific coding (clearways, tidal lanes etc)
- Run EMME/2 link validation macro to identify errors (including review of link lengths against calculated distance)
- Assign a unit matrix and identify empty links and un-attached zones

Notes:

- NZTM grid reference used for co-ordinates
- Include walk-links on 1-way streets and in Auckland CBD
- The AM peak networks to be the reference networks, with period-specific amendments added for other periods
- Reference network master copies to be stored in a spreadsheet, and imported to EMME/2

Outputs

- Base road networks stored in both spreadsheet and EMME/2 format
- Node numbering protocols

Task 5.3 Develop Road Network Delay Modelling

Scope

The modelling of road speeds and delays will be similar to WTSM, with link speed-flow relationships and approach-based intersection delays. Intersection delays will be calculated as a function of opposing flow (where the zone system is refined enough). Where the zone/network detail is not refined enough to support interactive calculations of capacities based on opposing flows (such as inner CBD areas), fixed capacities will be used.

Key components will be as follows:

- Akcelik volume-delay functions on all links
- Link parameters (capacity, free speed etc) allocated globally based on defined link type
- Akcelik volume-delay functions for turn delays
- Turn capacities based on simplified ASRaTM¹-type procedures
- Special procedures for modelling over-capacity conditions on the motorway (see Task 5.5 below)

Of these 5 components, the first 4 are essentially updates to or developments of the procedures presently used in either or both of the Auckland and Wellington city models. The fifth is a new development.

Issues considered during development of these functions will include:

- Consistency with requirements of equilibrium assignment
- Minimisation of assignment run-times
- Avoidance of 'hard' delay functions, which could increase model sensitivity and instability
- Development of delay functions which reasonably reflect the key locations and extent of delays, but also reflect the strategic-demand nature of the models (i.e. models that reflect the hierarchical structure of models in Auckland)
- Development of simplified coding systems which reflect the strategic nature of the model

The procedures intended for junction modelling have been implemented elsewhere along with procedures for achieving satisfactory convergence. Convergence and stability will be achieved in assignment through damping procedures.

Inputs

- WTSM delay functions
- ASRaTM delay macros¹⁷
- HCM and AUSTROADS capacity guides
- aaSIDRA software manual
- Akcelik volume-delay papers

Processing

- Code Akcelik volume-delay functions for links

¹ These are the EMME/2 macros developed for modelling turn capacities and delays for the Auckland sub-regional models. They compute capacities based on opposing flows, as simplification of which was adopted at major intersections in WTSM.

- Allocate generic link parameters based on link type (with parameters based on reference guidelines and other calibrated models using these functions)
- Develop simplified junction coding procedures (similar to WTSM)
- Code junctions
- Develop assignment procedures, including warm-start and feed-back loops for intersection capacities
- Test delay functions using sub-area demands in isolated areas and ‘validate’ capacity and delay predictions with other models (e.g. aaSIDRA or local project models)
- Test procedures to optimise convergence and run-time
- Document road network coding procedures

Outputs

- Coded road networks
- Road network coding procedures

Task 5.4 Develop Peaking Factors

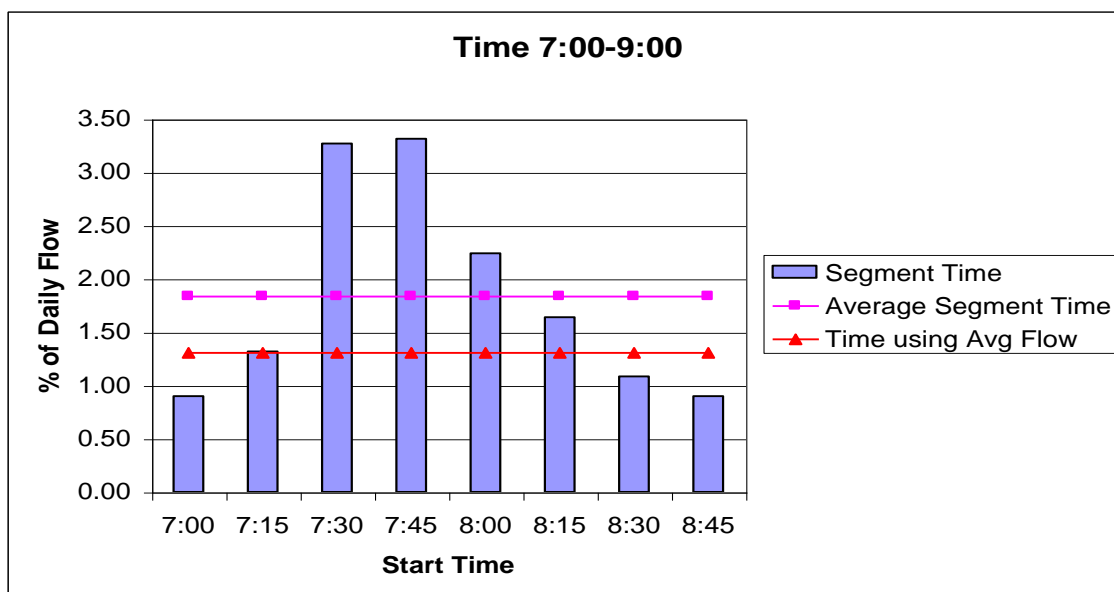
Scope

The Akcelik time-dependant delay functions assume that the flow rates within the period are constant, with no peaking and no initial queueing. The time periods for ART3 will be determined as part of the preliminary studies, however it is unlikely that the delays throughout the peak periods will be constant. In this situation, due to the non-linear shape of the functions, the use of an average flow rate for the modelled period will not replicate the average of the delays throughout the period.

Hence the volume delay functions can include adjustments, called peaking factors, so that they do predict the average delay for the period. This is shown in principle in Figure 1 for the period 7-9am divided into 15 minute segments, where the time from using the average flow is less than the average segment time.

While this is not usual in strategic models this was implemented in WTSM and a further development is to link with the time-of-day choice model and modify these factors as congestion changes in the future.

■ Figure 1 Average Times and Peaking Factors



Inputs

Modelled time periods

Count data

Processing

- Using the count data prepared under Task 1.8.1 compute peaking factors for the modelled peak periods, including investigating locational and road type differences, where the factors are defined as:

$$\frac{\text{average rate of flow for intervals which exceed the period average}}{\text{average period flow rate}}$$

- 2) Develop the methodology for implementing the factors in the delay functions, such as their inclusion in link or intersection delay, and whether the factors are applied to volumes or capacities.
- 3) Implement peaking factors
- 4) Consider methods of modifying these profiles in future years to reflect changes in time of travel (refer to Task 12, particularly 12.1 and 12.2 on time period factors and macro time period choice)²

Outputs

Peaking factors by location, time of day etc implemented in delay functions

Note

² This would be an innovatory approach in NZ city models, and will rely on cross-sectional and historic data providing evidence of the relationship between the profiles and the general level of congestion.

Task 5.5 Develop Motorway Delay Procedures

Scope

Motorway delay functions will be modelled using the same general Akcelik curves used on the local network. However, experience on other models shows that the standard speed-flow methods do not adequately reflect the significant congestion and blocking-back queuing experienced on the motorways in Auckland. Motorway-specific procedures will be developed to address the following key limitations of the standard volume-delay functions:

- Reduced capacity due to flow-breakdown and blocking-back
- Unequal Lane Utilisation
- Ramp Signalling

We recognise that with the introduction of new procedures there is always associated risk; mitigating this will be a key criterion in the design of the procedures. The intention is to use simple procedures with progressive impact (rather than sudden on/off queue procedures). The convergence and stability will be achieved through damping procedures applied both with each assignment process (refer to Tasks 5.7 and 5.8) and between iterations of the demand model.

Flow-Breakdown and Queue Capacity:

The standard functions, which reflect over-capacity delays when volume-capacity ratios exceed 100%, have been found to under-estimate the observed delays (for example, a number of locations on the motorway which have significant delays and queues due to flow-breakdown and blocking-back queues, actually have volume-capacity ratios well below 100%). This is fundamentally because the theoretical link capacities do not reflect flow break-down conditions or blocking back queues.

It is recognised that there is little scope for significant change to the modelling of motorway delays and bottlenecks within the EMME/2 software and within the strategic context of the models. However, it is considered that some attempt to better reflect flow-breakdown capacities is required in the ART3 model. The actual details of the method will be developed as part of the study; however the guiding principles for their development will be as follows:

- The procedures must be automated and predictive (i.e. they must be able to reasonably identify where similar conditions could apply on future networks)
- Convergence and stability must be retained within reasonable run times
- The procedures should be simple to code and their impact easy to identify
- The procedures should be able to broadly reflect changes in capacity allocation by ramp signalling

The basic approach proposed is as follows:

- Undertake a preliminary or 'warm-start' assignment (broadly representing pre-peak shoulder period)
- Identify motorway links at or over the theoretical capacity
- Identify unsatisfied demand on each link (i.e. the excess demand over capacity)
- Propagate back upstream the un-satisfied demand, being representative of queuing
- Reduce capacities on links with this identified 'queuing'
- Continue assignment using the reduced capacities

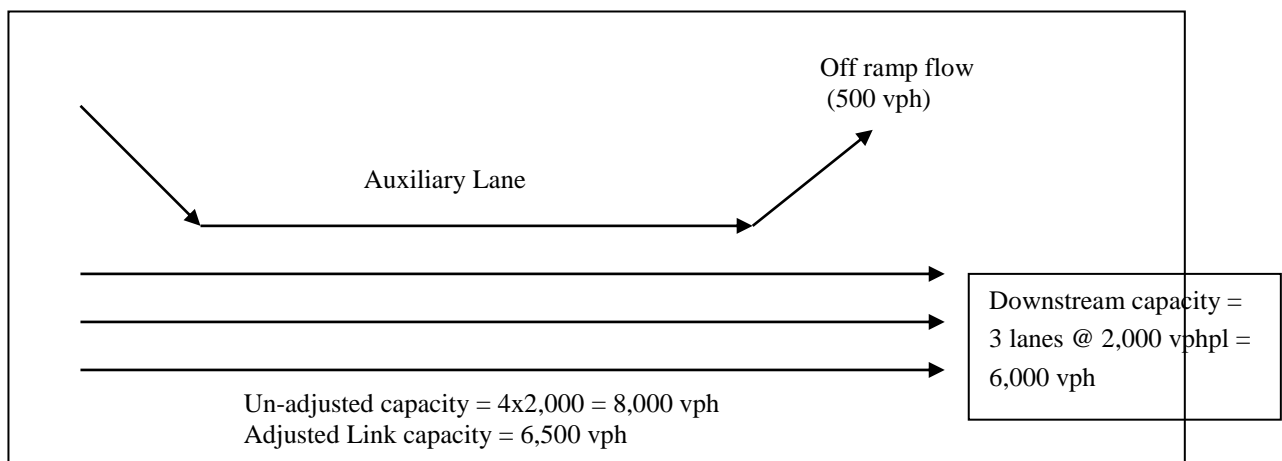
These procedures would be run within the EMME/2 assignment process, with capacities updated during interruptions to the assignment (as will be done for intersection capacities).

The procedures would be developed within a 'test-bed' corridor model to avoid the complications of re-routing, before being implemented across all motorway links. Bounds would be placed on the procedures to avoid extreme capacity reductions.

Lane Utilisation:

Simple procedures will be developed where non-equal lane utilisation reduces the theoretical link capacity. This is especially apparent on sections of motorway with auxiliary lanes present, where the low utilisation of the auxiliary lanes is not reflected in the EMME/2 models (which assume equal utilisation across all lanes). Simple procedures will be applied where the number of mainline lanes reduces to reflect this unequal utilisation. In essence, a proportion of the auxiliary lane capacity will be added to the downstream (through) capacity. The proportion will be based on the volume of off-ramp traffic. Implementation of such procedures is feasible using the EMME/2 network calculation module.

For example, in the Figure shown below, the capacity of the section with the auxiliary lane would be calculated as the downstream capacity, plus the volume of off ramp traffic.



Ramp Signalling:

Detailed representation of ramp signalling is not feasible using this type of software or within this type of strategic demand model. However, two broad effects of ramp signalling will be considered during network development, namely the re-allocation/re-prioritisation of capacity between ramps and mainlines and additional delays on the ramps.

Within the capacity reduction procedures outlined above are assumptions on the allocation of capacity between ramps and mainline at bottleneck locations. The current (forced-flow) allocations can be determined from observations at existing bottlenecks. The potential effect of ramp signals can then be considered by coding revised allocations. The broad approach could be as follows:

- Identify current allocations of ramp and mainline capacity at existing bottlenecks
- Develop simple relationship between the capacity and site conditions (for example it is known that short, narrow merges such as at Symonds Street have lower ramp allocations than ramps)

with longer, less acute merges). This would be developed into a simple coding system (e.g. 'good', standard' or 'poor' on-ramp merges);

- In future networks, the potential effects of ramp signalling could be reflected by altering the merge coding (e.g. reducing the ramp allocation to a fixed, lower proportion);
- Additional delay functions could then be used on ramps where ramp signals are activated (these would be treated similar to normal intersection delays)

Inputs

- Standard delay functions
- Observed ramp and mainline count and speed data

Processing

- Develop procedures within test-bed corridor model (spreadsheet)
- Once confirmed, implement within corridor EMME/2 model of the same area as the spreadsheet model
- Once confirmed, roll-out across all motorway links

Outputs

- EMME/2 calculation macros and associated assignment procedures for automatically reducing motorway capacities where flow-breakdown
- Documented coding procedures.

Task 5.6 Auto Access Functions

Auto access functions will be coded with representative link lengths to the zone centroid. Fixed speeds will generally be used on auto access functions with no capacity constraints (e.g. fixed speeds of 40 km/hr).

On zones with multiple auto connectors, functions will be considered which attempt to spread trips between the connectors, rather than reducing to shortest-path access.

Task 5.7 Design of Private Vehicle Assignment

Inputs

Outputs from preceding network tasks and others, such as related to model segments.

Overall ART3 implementation design

Processing

The basic assignment methodology is fixed within EMME/2, but the design will include and consider:

- Assignment segmentation into user classes for multi-user assignment, including possible future segmentations, and coding
- Representation of fixed costs, that is distance-based costs, in generalised cost assignment
- Global and user-class specific routeing parameters
- Link-specific routeing parameters to account for environmental factors not included in basic generalised cost function (such as strategic signage, comfort, road hierarchy etc)
- Representation of road-pricing or tolls (most probably through additional fixed-costs on specific links, which also allows differential tolling by market segment when using mode-specific links)
- Network 'priming' ('warm starting') (refer Task 5.3)
- Peaking factors (refer Task 5.4)
- Feed-back and update loops, especially in respect of intersection modelling (refer Task 5.3)
- Ease of extraction of data required in other modules (e.g. skimmed matrices of generalised cost components for use in distribution/mode split)
- Convergence
- Running times
- Interface between roading and PT (especially ability to extract link speed data for assessing bus speeds)
- Ease of secondary analysis (select-link, sub-area traversals, emission-analysis (cold-start assessments))

Outputs

Note on design of private vehicle assignment

Task 5.8 Implementation and Testing of Private Vehicle Assignment

Purpose

This task implements the design and individual components developed previously. Additionally, as noted in the overall scope for this section, the road network and assignment are to be developed initially as part of Transit's WRR tolling project, and then completed as part of the ATM2 project.

Inputs

Road networks including coding for link types, lanes, and link and junction delay parameters and functions

Procedures etc developed in previous tasks

Matrices from HTS (plus 2006 ART2 matrices for the Transit WRR component)

Note on design of assignment.

Processing

Generally this task implements the design from Task 5.7 and the individual procedures developed in previous tasks. Matrices from the HTS are to be used along with a unitary matrix as required.

This includes:

- Development of EMME/2 macros
- Setting up of input files and parameters

Testing and checking of the assignments and networks will include:

- Checks on convergence, with varying assignment iterations and EMME/2 convergence criteria, and different junction feedback procedures;
- Checks on maximum delays across the network;
- Comparison of modelled and observed journey times (see Model Validation task);
- Checks on routing patterns via select-link analysis;
- Tuning of routing parameters;
- Checks on sensitivity to minor changes in delay parameters; and
- Test of response to increased traffic demands.

From these tests any identified errors will be corrected along with tuning and adjustment to both the networks and the assignment procedures as required. Note that final testing in conjunction with the other sub-models is carried out as part of the full model testing and validation.

Outputs

Note on tests

Implemented and tested networks and assignment procedures.

Ideally these will be used to provide costs for the distribution/mode choice estimations, but the timing may be such that interim versions of these are used.

Task 5.9 PT Travel Time Functions

Purpose

The purpose of this task is to develop travel time functions for bus, rail and ferry.

Inputs

Bus and private vehicle travel time databases

Existing travel time functions: ART2, APT, WTSM

Ferry and rail timetables

Processing

Set up database for analysis of bus and private vehicle times by:

- extracting times from private vehicle travel time database on bus route sections and
- processing the bus and private vehicle data into suitable compatible formats

Calibrate relationships between car and bus times time for different contexts (urban, rural, arterial, motorway, mixed with traffic, bus lanes) and time periods. This should be, in the first instance, based on relating bus running times with car times with bus stopped times a separate component, that is functions of the form:

$$\text{Bus time/km} = x * \text{car time/km} + y$$

Where:

- x is likely to only vary by road type, and
- y, which reflects the frequency of stops and the number of boardings and alightings, can vary by context and period.

Check the compatibility and consistency of these results with timetabled times to generally confirm their applicability, and compare with functions from ART2, APT and WTSM.

For rail and ferry:

- in the base year develop functions based on timetable travel times between stations and terminals;
- for changes to the networks, external information on changed travel times would be required for implementation in the model

Outputs

Travel time functions for bus, rail and ferry

Note

Task 5.10 Park-and-Ride

Scope

Park-and-ride in Auckland affects rail and ferry services currently and, in future, the North Shore Busway. Car access to public transport also includes kiss-and-ride. There are a number of different aspects to be considered:

- car access by park-and-ride or kiss-and-ride are equally important in demand modelling;
- informal park-and-ride may occur at all stations; the provision of a car park at a station may have little effect on usage unless informal parking was previously constrained or distant from the station or there were previously car security considerations;
- generally, major park-and-ride sites are created in situations where the station achieves a relatively high level of service (the busway park-and-ride stations are the main example in Auckland, rather than the railway);
- we expect generally rail/busway park-and-ride to occur for the outer stations/stops where potential car users can access the journey time benefits of a high quality longer distance rail/coach service;
- for ferries the position is quite different, with for example the Devonport ferry enabling car users to avoid the harbour bridge congestion and make the last short leg of their journey by ferry, the larger part of the journey being by car.

For a strategic model, the key issue is to establish how the provision of park-and-ride options influences mode shares. In Auckland the potential mode share of the North Shore Busway is an example. Forecasts are sensitive to (i) the catchment area of a park-and-ride station, which is in principle larger than other stations and (ii) how the choice between the park-and-ride station and the local station is represented.

The output from the preliminary analysis on park-and-ride will enable us to confirm many of these preconceptions and to explore some of the modelling issues.

At this time the intention is for a similar level of representation as in ART2 and WTSM:

- park-and-ride stations would be identified and linked to a wider station catchment by connectors which represent multi-modal access, including park-and-ride and kiss-and-ride; hence the use of park-and-ride will be determined as part of the PT assignment;
- these connectors would have journey times allocated to them based on the access distance and the mix of access modes likely to be used (for a given distance band); thus short distance access would be by active modes and longer distance access would increasingly use the mechanised modes, predominantly car (as park-and-ride or kiss-and-ride); it should be possible to infer from this process the implied parking demand (but this is not something we have attempted before and will need to be investigated during the model development); it should also be possible to allow for parking charges, but again this will need to be investigated;
- catchment areas for current stations would be determined from the survey (and this should also include the busway 'stations') and rules would be developed for defining the catchments of new sites;

- for ferry, we need to consider including ferry services in both the public transport and road networks, the latter to provide a more sensible way of representing park-and-ride.

While there are more complex options than this, including hierarchical logit choice methods and EMME/2 matrix convolution techniques as used in the APT, the information available within a strategic model is not seen to merit this level of detail. The method proposed can be readily validated and tuned on the survey data (the PTIS) and is transparent in application.

Inputs

Note on park-and-ride analysis of HTS and PTIS data

Information on park-and-ride sites showing layouts etc

Processing

Using the preliminary studies analysis, the steps include:

- Confirmation that the above approach is appropriate
- Identification of existing park-and-ride sites and their catchments, and comparison with those presently in APT
- Assessment of car access distances and journey distances to determine any constraints to be applied, and comparison with APT procedures
- Assessment of relevancy of parking costs

Using information on the layout of park-and-ride sites, make an assessment of average transfer times for each.

Outputs

Note setting out:

- the final approach to park-and-ride in ART3;
- the sites to be included in the 2006 network and definition of catchments in terms of ART3 zones;
- other parameters such as minimum car access and journey distances, transfer time, parking costs, and any others arising from the analysis.

Task 5.11 Design of PT Attributes and Assignment

Inputs

Information from other tasks, such as related to model segments, network development, etc

Current attributes and procedures in ART, APT, and WTSM

Processing

1) Modes and vehicle types:

- Define mode and vehicle type codes and descriptions and default speeds.
- Design how vehicle capacities (seated and standing) and operating costs (per km and per hour) will be implemented; that is as part of the service coding or as external inputs as required.
- For on-street modes define the auto equivalent of each vehicle type.

2) Buslanes:

- In the current ART model the travel times on buslanes are reduced from the standard by a specified percentage on links identified as having buslanes, whereas in APT the travel times on buslanes are based on specified speeds.
- The tasks are to:
 - Define travel time functions (see Task 5.9).
 - Define how buslanes will be identified in the network.

3) Bus priority:

- This will consider how the reduced delay due to bus priority measures such as signal pre-emption and queue-jumping lanes at signals will be incorporated into ART3, including directly in the travel time functions.
- In ART this is presently represented globally as a percentage reduction travel time on all arterial roads. APT currently does not include the effect of these measures.

4) PT access and egress:

- This is concerned with the basis for PT access times from and to zones, their representation and then implementation in the network and will incorporate the outcomes from Task 5.10 on park-and-ride access.
- PT access (i.e. walk) along roads will be considered, particularly in light of decisions on how intrazonal and short trips are treated in the model. Currently in ART walking is allowed within the CBD to enable connectivity between services and zones without the need to provide specific walk links. In APT, on the other hand, all road links have walk mode available; this avoids the need to create specific connectivity, but also can enable PT trips to walk between zones without boarding PT.
- Our approach will be to allow walking on all roads and supplement this by centroid connectors for zones with longer access distances, where public transport or car would be used (for very long access distances, refer to park-and-ride discussion). For the latter, centroid connector times would be based on distance assuming speeds relating to the expected distribution of access modes.

- The design tasks will include definition of the access mode and associated coding (mode code, link type) and the implementation of the time function.
- 5) Boarding, waiting and transfers:
- This is concerned with the design of boarding, waiting and transfer times and any associated penalties and factors.
 - APT and WTSM both have a time of 3 minutes for boarding itself, which we would expect to use for ART3.
 - For wait times we would review the functions in APT and WTSM, which are 0.22 and 0.25 of the headway respectively. (as noted in Task 2.11 the weight of wait times will be 2.0)
 - All models have a boarding penalty which is included in the generalised costs for second and subsequent boardings to represent the undesirability of transferring between PT services and modes. In APT and WTSM this penalty varies with the quality of transfer facility and level of service integration as follows:
 - 10 minutes for standard interchanges,
 - 8 minutes for purpose-built interchanges, and
 - 5 minutes for high quality and/or planned interchanges.
 We would expect to continue with these for ART3.
 - It is standard in the EMME/2 assignment for the transfer penalty to be included in the initial boarding as well as subsequent transfer boardings and then the initial penalty removed prior to the generalised costs.
 - The way in which these are implemented in ART3 will be designed.
- 6) Fares and integrated fares and ticketing
- The bus and rail fare structures in Auckland are, in general terms, made up of a series of fare stage boundaries, with the minimum fare paid for a trip which does not cross a boundary.
 - While fares will part of the ART3 PT generalised costs, it is less clear to what extent fares affect routeing and hence how they might be represented in the PT assignment. This will need to be considered in light of the current fare structures.
 - The result of this will, in turn, affect the way in which fares would be implemented, whether in matrix form or in the network or both. If it were deemed that fares did not affect routeing greatly, then they do not need to be represented in assignment. If it were necessary to implement fares in the network, the fare stage boundaries would need to be set up. This is possible with radial services, but becomes very problematic with other routeings such as cross-town and circular routes, and more so when adding different types of routes in the future.
 - The fares in generalised costs can be in matrix form to reflect the fare structure and there is the possibility of these varying by both trip purpose and time period. This can account for the prevalence of each purpose paying different ticket types (full, weekly and monthly passes, discounted fares, etc), such as student discounts for HBE trips. Within a purpose the average fare from the survey data will be implemented.

- In the current ART model fare boundaries are implemented in the network as well as a minimum boarding fare applied to the boarding penalty. This was originally developed at a time when the vast majority of services were radial to/from the Auckland CBD. In APT both bus and rail have an initial boarding fare, following which bus fares are based on distance and rail has fare stage boundaries. Both are both implemented as part of the travel time functions, that is, via the network.
 - Integrated fares are modelled in APT with a different fare structure; all modes have an initial boarding fare and then a distance-based fare. This is calculated as a matrix and hence integrated fares are modelled at a matrix level rather than on the network. In ART integrated fares are represented by removing the second and any subsequent boarding fare.
 - Integrated ticketing is represented in APT by a specified reduction in boarding time.
 - The design for ART3 will consider the above.
- 7) In-vehicle-time mode specific factors:
- As part of tuning the base year network to achieve better routing factors may be applied to the in-vehicle time of a mode or sub-mode ASCs used. When a new mode is introduced or an existing mode improved an adjustment to these factors may be required to reflect the mode-specific qualities (such as comfort or convenience, or improvements in supporting infrastructure).
 - The design will consider how these factors are incorporated.
- 8) Assignment procedures, using the above and parameters for generalised cost, and including park-and-ride, the separation into PT sub-modes and the saving of result matrices.

Outputs

Note on PT attributes and assignment

Task 5.12 Develop PT Networks (Links)

Scope

The PT networks will build on the roading networks developed under Task 5.2. Bus mode will be added to the roading networks and additional PT-only links added – both more minor roads required for PT modelling (particularly for APT) plus any busway links. The ferry and rail networks can be imported from APT reviewed and updated, and then combined with the completed roading and bus network.

Inputs

Roading networks (Task 5.2)

Network already developed for ART3 by ARC (in ARC GIS)

Latest APT rail and ferry network (link) coding

Rail and ferry timetables showing routes

Park-and-ride sites, catchments, etc (Task 5.10)

Mode codes, walk access (Task 5.11)

Processing

- 1) Review roading network: centroid connectors for PT, additional nodes, and links, and modify accordingly
- 2) Develop and insert network for bus-only links (e.g. Northern busway)
- 3) Adapt APT rail and ferry network to fit with ART3, including:
 - Modify node numbering to fit with ART3 system,
 - Check that all existing ferry routes are included, add as required,
 - Check rail stations, modify as required,
 - Check the alignment against GIS layers.
- 4) Develop and insert network required for park-and-ride (refer Task 5.10)
- 5) Review and modify as required connectivity, particularly walk linkages, between zones and PT services and between PT modes
- 6) Add mode codes to links

Outputs

Base networks for ART3 for roading and PT stored in both spreadsheet and EMME/2 format.

Task 5.13 Coding of PT Services

Purpose

In this task the 2006 PT services for the AM, IP and PM periods will be coded onto the base year networks consistent with the travel time functions and the design of other attributes.

Inputs

ART3 networks from Task 5.10

Latest APT coded services (understood to be 2005 for AM peak)

ARTA PT databases

ARC PT services in GIS

Ferry and rail timetables

PT attributes from Task 5.11 (e.g. travel time functions, vehicle types)

Processing

- 1) Accumulate, as necessary, individual services into routes for each time period and their headways.
- 2) Design conventions for naming and descriptions of routes
- 3) Code services onto the ART3 time period networks in EMME/2, including:
 - for each route: route name, route description, headway, default vehicle speed, and if required, seated and standing capacity, and operating costs;
 - the timetable travel time may also be coded into a user data item;
 - for rail and ferry, code the speed on each segment (this will be pre-determined so that the total time on the line is consistent with the timetabled time, refer Task 5.9)
 - for each node, where applicable: type of activity, dwell (stop) time, layover time, transit time function on link following the node; rail and ferry should have zero dwell times.
- 4) Check and verify each route:
 - View plots of each, checking routeing.
 - View transit line summary reports.

Outputs

Base PT services coded onto base networks in EMME/2 and as text files

Note

Task 5.14 Implementation and Testing of PT Network and Assignment

Purpose

This task implements the design and individual components developed previously. Note that there is significant overlap between this task and Task 8.2, in which costs are obtained for calibration.

Inputs

PT networks with coded services (Task 5.11)

Travel time functions

Park-and-ride design

Matrices from HTS

Note on PT attributes and assignment.

Processing

Generally this task implements the previous design decisions and incorporates the functions and coded services. The park-and-ride component will be coded here as will any additional network connectivity identified as part of the network and assignment testing.

The implementation will include:

- Coding of park-and-ride
- Coding for network attributes defined in Task 5.10 (e.g. transfers, fares, boarding)
- Development of EMME/2 macros
- Setting up of input files and parameters

The testing of the PT networks and assignments is aimed at identifying deficiencies in the network (such as missing connectivity) and to test and adjust the routeing. The testing will include:

- Assignment of unit matrices and checking of zonal connectivity;
- Assignment of observed matrices and checking of routeing patterns, transfers and trip length, tuning of the networks, routeing parameters and assignment procedures;
- Visual comparison of generalised costs against PT accessibility to check their reasonableness;
- Checking of generalised cost components for selected zone pairs: access and egress times, walk times, wait, and in-vehicle time, boarding, transfer penalties;

From these tests any identified errors will be corrected along with tuning and adjustments to both the networks and the assignment procedures as required. Note that final testing in conjunction with the other sub-models is carried out as part of the full model testing and validation (Task 16).

Outputs

Note on tests

Implemented and tested networks, which will be used to provide costs for the distribution/mode choice estimations.

Task 5.15 Networks and Assignment Report

Write the Networks and Assignment report