Greater Wellington Regional Council

2013 WTSM Update

Technical Note 3: Development of Base Year Networks

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Greater Wellington Regional Council

2013 WTSM Update

Technical Note

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1. Introduction

This technical note details the update of the road network and public transport services for the 2013 update of the Wellington regional transport models (Wellington Transport Strategy Model – WTSM, and Wellington Public Transport Model – WPTM).

The current network used in the models was developed during the 2011 re-validation of WTSM and development of WPTM. This note therefore details the incremental changes made to develop the new base 2013 network, which can be grouped in three categories:

- Update to reflect actual changes to the network, e.g. changes at junction or new public transport services;
- Fixing of minor coding issues that have been identified since 2011; and
- Modifications of the network and assignment macros to include new functionalities which have been developed since 2011, to allow analysis of more detailed projects such as Bus Rapid Transit (BRT) and integrated ticketing which could not be modelled previously.

Networks used in WTSM are passed on to WPTM during a model run, so any changes made to WTSM apply to WPTM as well. There are however a few WPTM specific modifications which are also detailed in this note.

2. Update of Road Network

2.1 2011-2013 Changes to the Road Network

The Territorial Authorities in the Wellington region were consulted to obtain a list of all changes to the road networks between 2011 and 2013, from changes to intersection layouts to new sections of road. There were only a limited number of changes that occurred during this 2-year period, and most of these were too small scale to be represented or have any measurable effect in a strategic model such as WTSM.

However, the following schemes were included in the 2013 networks:

- New signal at intersection of Hanson Street / John Street (Newtown);
- New roundabout at Upland Road / Glasgow Street (Kelburn);
- New roundabout at Main Road / Willowbank Road (Tawa);
- New roundabout at Westchester Drive / Middleton Rd (Churton Park);
- New bus lanes on Courtenay Place: all day in the westbound direction, PM Peak only in the eastbound direction); and
- New bus lanes on Kent / Cambridge Tce: northbound in the AM Peak, southbound in the PM Peak.

2.2 Coding Issues from 2011 Networks

A few minor coding errors have been identified in the network developed in 2011, which were subsequently fixed by applying standard EMME network change batch files when using the model for analysis. These corrections (shown in Figure 1) are now included in the base 2013 network as a permanent addition:

- One lane was added for the section of Riddiford St between Adelaide Rd and Mein St, which was originally coded as having one lane instead of two. The exception is the southbound approach to the traffic signal at Mein St which was incorrectly coded as having three lanes, this was reduced to two lanes (the flare for left-turners is essentially modelled through the higher fixed capacity on this approach from the WTM Saturn model capacities);
- Some sections of Lambton Quay were incorrectly coded as having two lanes for general traffic. This has now been revised to one traffic lane only for the whole length of Lambton Quay.

Figure 1: Changes in Number of Lanes in WTSM Network

In addition, Goa St in Hataitai, which was not included in the 2011 network as it was considered to be only a minor local road, has been required for coding a number of future schemes in the area (e.g. Public Transport Spine Study[1], Ruahine Street duplication and BRT). It was therefore reinstated when incorporating these future schemes in the network. Again, this has now been made permanent and Goa St is now part of the base 2013 network.

3. Update of PT Network

3.1 2013 PT Services

Since 2011, public transport services coded into WTSM and WPTM are input automatically using information contained in the General Transit Feed Specification (GTFS) of the Wellington region. The GTFS contains information on all public transport itineraries and schedule data and is created from the Regional Council Public Transport Database. Transit lines for all PT modes (bus, rail, ferry and cable car) are coded into the model by converting the GTFS data into a standard EMME transit batch-in file, using a tool developed by Opus consultants and called G2E converter. More information on this process and the development of the G2E converter is provided in "TN1 – Network Preparation" from the 2011 update.

[1] The Wellington Public Transport Spine Study (2012-13), a key action from the Ngauranga to Airport Corridor Plan (2008), was undertaken to help determine a future public transport solution for Wellington City – one that is high quality, modern and meets the longer term aspirations and demands of our city and region.

For the 2013 update, GTFS data representing public transport services in the Wellington region as of March 2013 was sourced. The format of the GTFS data had slightly changed compared with 2011, meaning that the G2E tool could not be used with the new format, but it was possible to obtain the same data in the old format from the GWRC Public Transport Database.

The fact that the format had changed, as well as the fact that INRO (developers of the EMME software) had developed their own conversion tool to import GTFS data into EMME models led to an investigation into the merits of using either tool. This analysis is included in Appendix A, and the outcome was that it was recommended to keep using the G2E converter for this update. The fact that this tool was designed specifically to work with Wellington data and the Wellington network led to better results both in terms of path routing and frequency calculation.

The G2E converter was therefore run with March 2013 GTFS data and the resulting PT transit lines were imported into the WTSM network. A number of checks against both 2011 PT services and observed 2013 routing and frequencies were then undertaken.

Comparison with the 2011 network confirmed that there had been no significant changes between 2011 and 2013, both for the bus and rail networks. Checks of modelled frequencies against Metlink timetable data were undertaken for a number of locations in the AM Peak, the results of which are shown in Table 1.

Location	Timetable 2013	WTSM 2013	% Diff
Thorndon Quay at Motorway (Handy Rentals)	75	78	4%
Murphy Street - Wellington Girls	42	44	5%
Willis Street - Abel Smith Street	24	24	0%
Taranaki Street (near 274)	31	30	-3%
Cambridge Terrace at Basin Reserve	56	56	0%
Elizabeth Street at Kent Terrace	65	66	2%
Oriental Parade at Freyberg Pool (opposite)	12	14	17%
Hutt Hospital - High Street	21	20	-5%
Guthrie Street at Trafalgar Street (near 6)	18	18	0%
Victoria Street at Weltec, Block F	14	18	29%
Porirua Library - Norrie Street (opposite)	24	22	-8%
Kapiti Road at Moana Road (near 36)	17	16	-6%

Table 1: Comparison of PT Service Supply (No. of Services for 2hr Period) – AM Peak

The observed and modelled frequencies are generally a very good match, with most locations being within 10% and only Oriental Parade and Victoria Street showing larger differences. It must however be noted that observed and modelled values show slightly different measures, observed values counting the numbers of actual services stopping at a location during the AM Peak period, whereas modelled services are based on the proportion of each journey within the AM Peak for services for which the whole journey does not occur fully during the modelled period. Analysis undertaken during the 2011 update showed that this explain some of the difference between observed and modelled values.

3.2 PT Services Consolidation

During the 2011 initial built of the PT network based on GTFS, it was found that many bus services had a number of variants with only a few stops differing from each other. To simplify the network and subsequent analysis of assignment output, it was decided that these minor route variants would be combined as a single service route. This consolidation was undertaken manually, based on judgment of which variants were similar enough to be aggregated together. The same exercise was carried out for the 2013 services, which led to a reduction of 35 variants, or about 13% or all bus services. It should be noted that this consolidation has no effect on the actual public transport patronage modelled, who consider total headways in the model assignment and not individual services.

The resulting public transport services included in the 2013 base networks are shown in Appendix C.

4. Implementation of Additional Model Functionalities

This section details project-related modifications that were made incrementally to WTSM and WPTM to allow analysis of schemes which could not be modelled in the version of the models delivered in 2011, and which have now been included in the base 2013 networks and associated procedures. These projects included Bus Rapid Transit (BRT) that was part of the Public Transport Spine Study, as well as integrated ticketing for public transport.

4.1 Public Transport Fare Calculation (WTSM)

4.1.1 Functionality

Prior to the modelling for the Public Transport Spine Study (PTSS), the fare matrix calculation was not a part of a standard WTSM model run. A process was set-up during the 2011 model update to accurately calculate the fare matrix based on current Metlink services and fare structure (i.e. fare zones and boundaries, and cost per boarding and per additional zone boundary crossed), as described in “TN15 – Input Parameters” from the 2011 update. But this process was only a one-off, carried out once during the update to recalculate the fare matrix but not included in the course of a model run. As a result, any future year model runs were still based on the 2011 Metlink services and fares, making it impossible to model changes caused by a potential increase in forced transfers, or measures such as integrated ticketing.

During the PTSS however, the re-calculation of fares was integrated to be part of all model runs, which was necessary to take into account the impact on generalised costs of additional boardings between bus and BRT, as well as integrated ticketing. This more dynamic approach ensures that the fare matrix is always an accurate representation of the PT services in place and allows for changes to the fare structure. For this reason, it has now been incorporated into the 2013 base version of the model.

This functionality is run before a PT assignment and has a negligible impact on model run time. It must be noted that this fare matrix is used in the generalised cost calculation for mode choice and trips distribution, and not in the PT assignment which uses a different representation of fare for inclusion in generalised costs (using a fare proxy of 10min per boarding).

4.1.2 Implementation in WTSM

The PT fare calculation is carried out in a new macro called PTfarecalc.mac, which is called in the PT assignment macro (runasspt13.mac) before the actual assignment, for both the morning and interpeak periods.

The macro uses the following approach:

- 1 – A unit matrix (i.e. all origin-destination cells have one trip) is created and assigned to the PT network, using the same parameters as a true PT assignment;
- 2 – Networks are skimmed to obtain the number of zone boundaries crossed and boardings for each origin-destination (O-D) pair;
- 3 – An initial boarding is added, to reflect the current Metlink fare system where boarding a vehicle is considered equivalent to travelling a fare zone;
- 4 – The Metlink rule for trips within the Wellington Territorial Authority is applied, for which trips within zones 1 to 3 are capped to 3 stages. This only applies to journeys with only one boarding (>1.5 boarding in average) to exclude multi-legs journeys;
- 5 – The resulting fare is calculated, based on the number of fare boundaries crossed (including the initial boarding) and additional boardings; and
- 6 – Factors are applied to decrease the fare in order to replicate the mix of ticket types used (including various type of concessions), depending on the number of zones travelled and based on Metlink data.

Using this approach when forecasting, integrated ticketing can be implemented at stage 5 by essentially setting the cost per additional boarding to zero.

4.2 Bus Rapid Transit Modelling (WTSM and WPTM)

A number of modifications were made to WTSM and WPTM to allow modelling the BRT schemes resulting from the PTSS carried out in 2013. These modifications are not meant to implement BRT services in the network by themselves, but they make the models compatible with potential inclusion of a BRT scheme. As a result they have been included in the 2013 base version of both models.

The main modifications involve the creation of new modes, link and nodes attributes used by BRT, new PT assignment parameters for BRT, amended generalised cost calculation to model dedicated interchanges (WTSM only) and the modification of fare calculation at nodes (WPTM only).

4.2.1 BRT Travel Time and Dwell Time

WTSM and WPTM use similar travel time functions for PT lines, and a new function was included for services circulating on a dedicated BRT corridor. This function applies to all services running on a BRT corridor, including buses, and uses a new attribute *@rtsp* representing estimated average speed on a link for bus rapid transit, including potential junction delay. This means that speed on BRT corridors is hard-coded and not calculated by the model. An estimation of minimum delay at junctions calculated by WTSM was determined to be too coarse, and this approach was deemed preferable to ensure realistic speeds would be used.

Regarding dwelling times, values of 0.30min and 0.18min respectively within and outside the CBD have been specified for BRT.

Finally an in-vehicle time factor of 0.95 for WTSM and 0.94 for WPTM was implemented for BRT services.

These values are consistent with those calculated for the PTSS.

4.2.2 Interchanges

The modelling of interchanges is currently limited in EMME, with no differentiation between initial and transfer boardings. This was not considered a major issue with the current network as there are relatively few transfers taking place (both inter and intramodal). But with some Wellington City Bus Review (WCBR) services and most of all BRT services requiring more transfers at dedicated interchanges, as well as to better model integrated ticketing during the assignment stage, it was important that the inconvenience and cost of transferring (as well as their mitigation) were accurately represented in the model for forecast years.

The methodology adopted for the PTSS to address this issue is detailed in "PTSS TN2 – Coding of Interchange for PTSS Short List" included in Appendix B of this report. As a summary, it is based on the use of additional nodes at dedicated interchanges used exclusively by transferring passengers, and for which the transfer penalty can potentially be reduced, and/or the fare component waived. These nodes are identified by using a new node attribute called *"@intch"*.

Some adjustments were necessary in the generalised cost calculation in WTSM, so that the modelling of interchanges in the assignment does not impact on generalised costs for PT. These adjustments are detailed in Appendix B as well.

In WPTM, the flagfall component of the fare calculation had to be changed from being line specific only to being a combination of line and node specific. This way, the node flagfall (i.e. boarding) component can be waived at interchanges.

Regarding boarding time penalty in WPTM, these can be varied by specifying the type of facilities. When forecasting, improved interchanges can then be added to the list of designed, dedicated interchanges which will therefore have a reduced boarding penalty.

4.2.3 Implementation in WTSM

Modifications were made to the following macros:

- **Netinput.mac:** New extra attributes @rtsp (link attribute) and @intch (node attribute) were created and set to 0 for the base 2013 year. They will then offer the possibility to implement rapid transit when creating networks for future years;
- **Runasspt11.mac**: A new travel time function was set up for BRT based on @rtsp attribute. A new dwelling time values dwt was added for BRT services (0.30min in CBD, 0.18 outside CBD). A new in-vehicle time value (@msc) of 0.95 was added for BRT. PT generalised costs calculations run after the assignment were modified to include the fact that no fare is paid at interchanges in the assignment (See Appendix B for more detail).

4.2.4 Implementation in WPTM

Modifications were made to the following macros and parameter files:

- **Wtsm2wptm.mac:** A new node attribute @bdpfn was created, which is used to store node flagfall fare information;
- **AssignParamsFares.prn:** A new value was added for the node specific flagfall fare, which now contains the main flagfall cost. Line specific flagfall fare was set to 0 for all modes, except modes that incur an additional cost (i.e. Flyer services);
- **AssignsParamsFactors.prn:** An in-vehicle time factor of 0.94 was added for BRT; and
- **Assignment macros (WA_skim1.mac, CA_skim1.mac and railAss_noSkim2.mac):** The reading of the fare parameter file (assignParamsFares.prn) was updated to include the new node flagfall fare, which is stored in register r60. All nodes in the network were then assigned the value of r60, except interchanges (with @intch=1) for which the fare is set to 0 if integrated ticketing is assumed (not occurring in base 2013 network). The cost calculation and assignment scripts were also updated to combine both node specific and line specific flagfall fares.

Appendix A

General Transit Feed Specification Conversion to EMME Transit Lines

A.1 Introduction

This note compares the two tools available for converting Metlink transit lines from General Transit Feed Specification (GTFS) to the standard EMME format used in the Wellington Transport Strategy Model (WTSM):

- **The 'GTFS to EMME' Converter (G2E):** This is a stand-alone program based on the C# programming language, which was developed by Opus during the 2011 WTSM update, and has been tailored specifically for this project and the Wellington network. As a result the G2E contains a list of all bus stops in the region and their corresponding node in the model network and matches them together to convert the GTFS files into the EMME compatible transit lines in a text file format. These can then be batched into the network manually;
- **The 'Transit Import' Modeller Tool:** This tool has been developed by INRO and is used through the EMME Modeller interface. It reads the GTFS files and directly converts the transit lines and imports them into the active scenario network. The main difference compared with G2E is that this is a standard Modeller tool to be used with any network, and as such is does not have a bus stop to node equivalence list but rather uses GIS coordinates to match stops to neighbouring nodes.

Comparison of both tools and their potential use will inform the decision to keep the WTSM/WPTM networks as current or to simplify them by joining nearby opposite bus stop together.

A.2 Tools Operation

Both tools operate similarly and have a number of equivalent parameters that can be adjusted:

- Days (weekdays or weekend) to include, start and end times;
- Vehicle types to include;
- Travel time function for each mode; and
- A service variant tolerance / stop tolerance which is used to combine services with only slightly different itineraries or stopping patterns.

In addition to these, the INRO tool has a number of additional parameters for matching of stops and nodes (bearing tolerance, link buffer, etc) which are not needed in the G2E given that it uses direct equivalence of stops and nodes. It also provides two different ways of calculating services headway, either based on the number of departures at the first stop of a route, or based on the proportion of each trip within the specified period. G2E only uses the second headway calculation as it was found during the 2011 model update that it provides the more accurate results (See "TN1 – Network Preparation" by Opus produced during the 2011 model update).

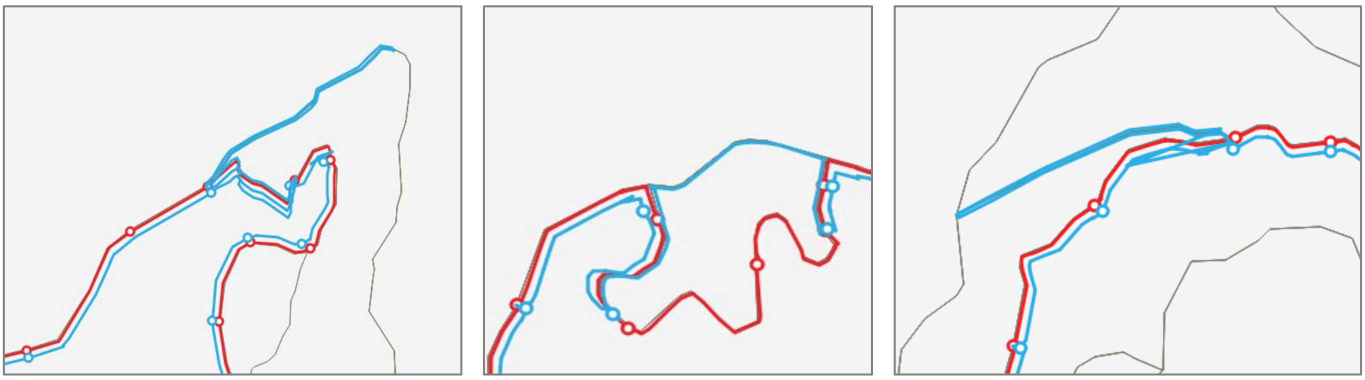
A.3 Comparison of Stop Allocation and Path Calculation

The following plots show examples of stop allocation and path calculation from both G2E (in red) and the INRO tool (in blue).

Intensive testing of the G2E tool during the model update has shown that the tool is virtually always accurate when allocating stops, and the path calculation is carried out through batching in the PT lines file onto the network which usually gives correct results as well. The resulting routes are always realistic even though some minor rerouting can happen which is usually sorted by banning some links to buses.

Comparison with the INRO tool shows that in most cases the stop allocation is correct as well, with only one minor difference (highlighted in green) in the examples above.

However there are occurrences where the path calculation becomes much more erratic, as shown in the screenshots below.



A quick overview of the transit lines converted through the INRO tool seems to indicate that for most services more than 90% of a route is correct but these type of anomalies do occur on at least a few sections.

No detailed attempt was made to improve the results by adjusting the tolerance parameters but a few tests showed that they do impact on the results, although sometimes adjusting these fixed some routing issues but created new ones for services which were correct previously.

A.4 Comparison of Headway Calculation

The following table replicates 2011 analysis undertaken in the WPTM validation technical note (TN19), which aimed to show that the number of modelled services passing through a number of locations was a good match to observed values based on Metlink timetable (AM peak hour 0700 to 0900). The same analysis was carried out with the 2013 GTF, converted both with G2E and with the INRO tool. For the latter, both the normal headway calculation method and the alternative (based on the proportion of each trip within the specified period) are shown.

	Timetable 2011	G2E 2011	Timetable 2013	G2E 2013		INRO 2013		INRO 2013 (Alt Headway)	
Thorndon Quay at Motorway (Handy Rentals)	*75*	*77*	75	78	4%	94	25%	84	12%
Murphy Street - Wellington Girls	*46*	*46*	42	44	5%	78	86%	66	57%
Willis Street - Abel Smith Street	*24*	*24*	24	24	0%	28	17%	24	0%
Taranaki Street (near 274)	*30*	*30*	31	30	-3%	42	35%	38	23%
Cambridge Terrace at Basin Reserve	*57*	*57*	56	56	0%	98	75%	86	54%
Elizabeth Street at Kent Terrace	*62*	*63*	65	66	2%	92	42%	82	26%
Oriental Parade at Freyberg Pool (opposite)	*13*	*13*	12	14	17%	20	67%	18	50%
Hutt Hospital - High Street	*24*	*25*	21	20	-5%	30	43%	26	24%
Guthrie Street at Trafalgar Street (near 6)	*17*	*17*	18	18	0%	24	33%	20	11%
Victoria Street at Weltec, Block F	*20*	*19*	14	18	29%	32	129%	28	100%
Porirua Library - Norrie Street (opposite)	*22*	*22*	24	22	-8%	32	33%	26	8%
Kapiti Road at Moana Road (near 36)	*18*	*17*	17	16	-6%	24	41%	22	29%

Again, the G2E converter was extensively tested during the 2011 update and as a result compares favourably in general. The INRO tool is largely overestimating headways with the default headway calculation. Using the alternative headway calculation improves results but they are still too high.

A.5 Future Use

In terms of future use, the main issue with the G2E is that it is based on a GTFS format which has already been superseded. This is not a problem for the 2013 model update as the transit lines as of March 2013 have been obtained in the old format but this might not be available later on. However GWRC have obtained the source code for the G2E, which would allow for updating the tool to the current format or any future format, ensuring that it is still usable in the future.

Regarding the INRO tool, it works with the latest GTFS format and it can be assumed that it will be updated in the future by INRO should this format change again.

A.6 Recommendations

Based on the above tests, it is recommended to keep using the G2E converter for this model update. Although the 'Transit Import' tool from INRO can no doubt be very valuable for other models as it allows converting directly the transit lines and manually adjusting the path errors, instead of coding everything from scratch. The fact that the G2E converter was designed to work specifically with the Wellington network (which includes all bus stops) led to better results both in terms of path routing and frequency calculation.

Regarding the impact of the choice of tool on the decision to keep the network as is or simplify it, even if opposite bus stops were joined together it would still be a better option to use the G2E, potentially with an additional automated procedure to replace removed bus stops in the transit lines.

Appendix B

Coding of Interchanges in WTSM - WPTM

B.1 Introduction

This note details a proposed approach to improve the representation in WTSM and WPTM of transfers between public transport services for the Public Transport Spine Study (PTSS) short list modelling.

Currently within the Wellington region relatively few transfer trips take place (both inter and intra modal) and therefore the issue of accurately modelling transfers is not of paramount importance.

However, the PTSS LRT and BRT schemes are partly based upon the principle of terminating some bus services at locations such as Kilbirnie and Newtown and forcing their passengers to transfer onto LRT / BRT. In addition, as part of the Wellington City Bus Review (WCBR) it is proposed to create a system of feeder bus services that will connect with core bus services at a series of pre-determined 'interchanges' where a minority of passengers will have to transfer. Finally, and partly in relation to the WCBR, it is also proposed that an integrated ticketing system is implemented in the region, facilitating easier and cheaper transfers between services.

As a consequence of these schemes, it is important that the perceived inconvenience and additional monetary cost of transferring between services (as well as their mitigation, e.g. through upgraded interchanges and integrated ticketing) is accurately modelled in order for the PTSS assessment to capture the impact of the potential increase in transfer on public transport demand.

B.2 Current Coding in WTSM and WPTM

The EMME transport planning software used to develop WTSM and WPTM does not distinguish between first boarding and subsequent transfer boardings, as well as transfer between same modes or different modes. As a result, there is currently a simplification in the way transfer penalties are coded. This also impacts on fare calculation, as it is not currently possible to apply different fares for initial or subsequent boardings in the PT assignment. Both models follow a different approach to deal with this limitation, which is detailed below:

B2.1 WTSM

B2.1.1 Assignment

Boarding penalties in WTSM are applied through a node attribute (@board). The boarding penalty components breakdown is detailed in the following table.

@board Component	Value for bus (min)	Value for rail (min)
Boarding time	3	3
Transfer Penalty	10 by default 5 for high quality interchange	7.5 by default 2.5 for high quality interchange
Fare	10 (proxy for average fare)	10 (proxy for average fare)
Total	**23 by default**	**20.5 by default**

Table A1: Boarding Penalty Components in WTSM

In the WTSM assignment phase, every boarding, including the initial boarding, incurs a transfer penalty in addition to the actual boarding time. While this intuitively appears incorrect, it does not affect significantly the assignment as it does not greatly impact on the selection of the strategy or PT mode, all services including the same extra penalty. This transfer penalty is currently 10min by default for bus stops, and can be decreased for improved facilities or dedicated interchanges.

While it can be expected that this extra penalty might lead to too many trips assigned to walk-only, the WTSM 2001 documentation (TN14_2 Base Public Transport Network) shows that this only occurs for a negligible number of O-Ds.

The boarding penalty also includes an extra 10min proxy for fare cost, representing the average fare and applied to all stops and stations in the transit network.

B2.1.2 Generalised Costs Calculation

The total boarding penalty for each O-D is then skimmed after the assignment and the resulting matrix is fed into the PT generalised costs calculation, after removal of the transfer penalty for the initial boarding and the fare proxy component.

The actual fare information used in the generalised cost calculation is contained in a fare matrix, which was revised during the 2011 update of WTSM. This calculation was based directly on the current Metlink fare zone system, and uses skims of the number of boardings and fare zone crossings for each O-D. The fare from zone to zone was then calculated for both AM and Inter peak periods based on the number of fare zone boundary crossings and service boardings.

The fare matrix calculation was a “one-off” undertaken for the 2011 model update and it is not currently recalculated during a model run, i.e. the current fare matrix would not reflect any changes in the number of zone crossing or service boardings caused by changes to the public transport network.

B2.2 WPTM

In a WPTM assignment, transfer penalties are not explicitly coded, the only penalty being therefore any additional boarding time caused by transfer between services. Boarding penalties are coded as a combination of line and node boarding penalties, equating to between 3 and 6 minutes of generalised cost.

The current fare system in WPTM represents the cost of each journey in terms of a boarding fare component (flagfall fare) for each leg of a PT trip and an additional fare component for each zone boundary that is crossed. Table A2 shows the average fare table used in the transport model. Whilst in reality the zonal component of fare does not increase in a strictly linear fashion (i.e. according to Metlink, the Adult cash fare increases by $1.00 when going from a 2 to 3 zone fare but by $1.50 when going from a 3 to 4 zone fare), a linear approximation of the relationship was made for modelling purposes as EMME cannot easily model non-linear fare relationships.

Mode	Flagfall Fare ($)	Zone Boundary Component ($)
Rail	$1.90	$0.70
Bus	$1.90	$0.70

Table B2: AM Peak Average PT Fares – WPTM

B.3 Proposed Modelling Approach

B3.1 Interchange Network Coding

As mentioned before, the main issue with modelling perceived time penalties and different boarding fares caused by transfer between services is the inability of EMME to distinguish between initial boarding and transfer boarding, making it impossible to have different parameters for different categories of boardings. This section details a proposed approach, valid for both WTSM and WPTM as they share the same network, to get around this limitation through the addition in the network of virtual “transfer nodes” at some key locations. These additional nodes can be a representation of dedicated interchanges, but can also be used to model regular PT stops where a high level of transfer is projected to occur under certain schemes. The following figure shows a representation of the proposed coding.

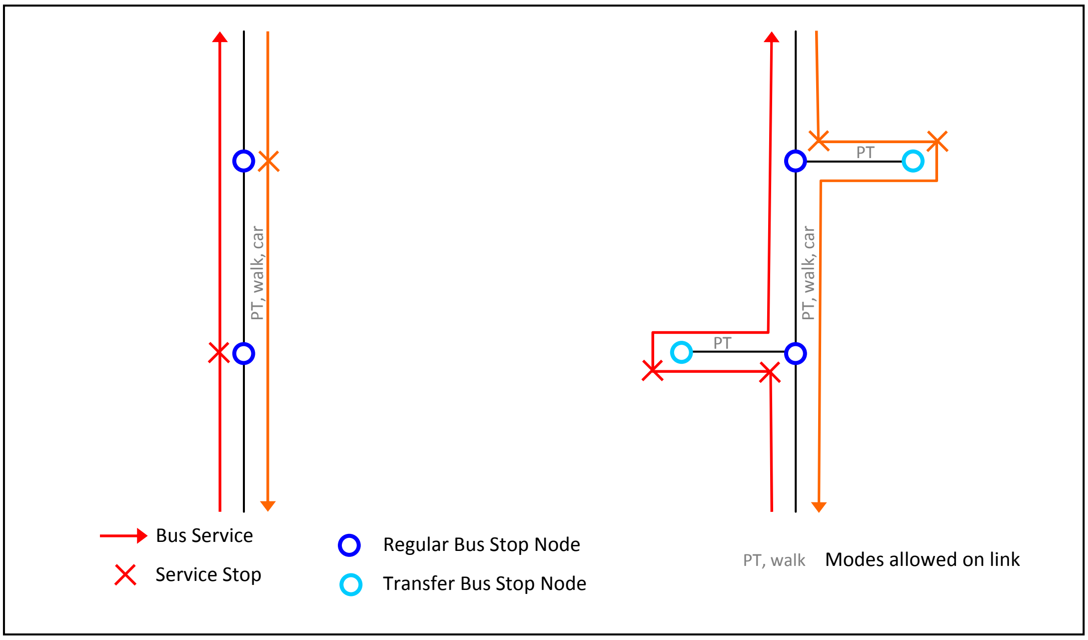


Figure B1: Proposed Interchange Coding

Selected bus (or other modes such as BRT and LRT) stops will be recoded as per the figure above, which will allow for different boarding penalty and fare parameters to apply at the "regular" node and at the "transfer" node. These different parameters could for example be no fare cost at the transfer node to account for integrated ticketing, or reduced transfer penalty for high quality interchanges (the proposed parameter changes are detailed in the following sections).

Only interchanging passengers can board at these transfer nodes. No initial boarders can access the transfer node as the links attached to the node are transit only (i.e. no walking allowed). Similarly, nobody can alight at the transfer node and walk to the road network for the same reasons. Transferring passengers will naturally use the interchange node as it will be more attractive due to reduced fare or transfer penalty.

In some cases, it may be likely that some transfer will occur between services that do not follow the same route but stop at nearby locations. This can be dealt with by adding a walk link between the relevant transfer nodes, to allow passengers alighting from one service to board other services nearby without accessing the road network. The following figure shows two example of this coding, with the link in red being PT only and the link in orange being walk only.

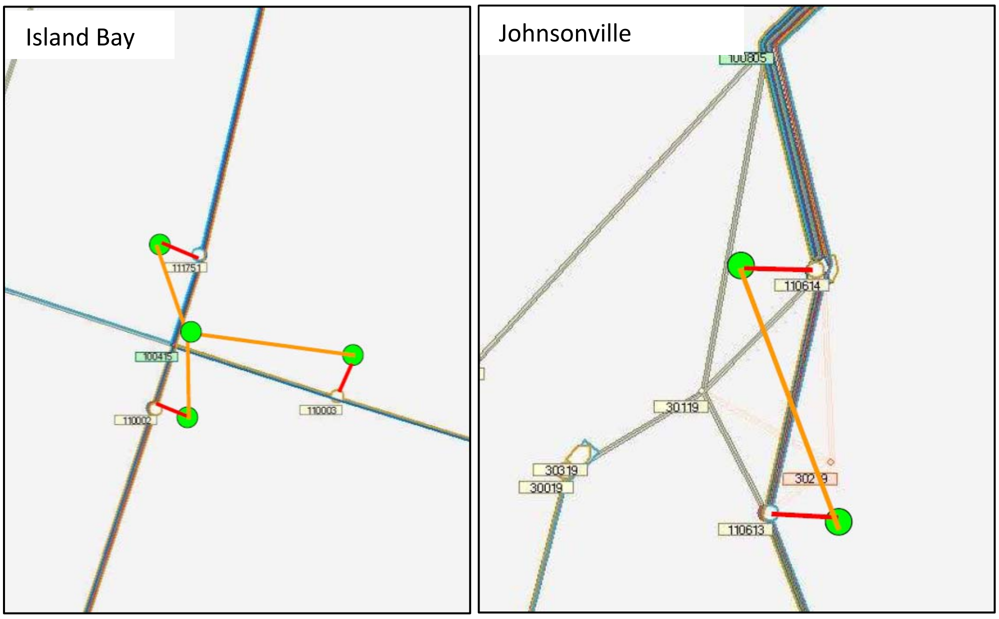


Figure B2: Proposed Interchange Coding

B3.2 Transfer Parameters in WTSM Assignment

B3.2.1 Transfer Penalties

Using the interchange coding detailed above in WTSM, a different transfer penalty could be applied for passengers transferring at a designated interchange. At present, the default transfer penalty is 10 minutes, but the WTSM original documentation recommends values of 8 minutes for purpose built interchanges and 5 minutes for high quality interchanges. Other suitable values could also be sourced from international guidelines or examples.

B3.2.2 Fares

The boarding penalty in WTSM includes a 10min fare proxy component, representing the average fare and is applied to all stops in the transit network. If integrated ticketing was implemented, this component should be reduced for the second leg of a PT journey since the boarding fare would be removed for transferring passengers. The proportion of this 10min penalty that should be removed to account for boarding fare removal can be calculated from fare analysis carried out for the WPTM development (see “TN1 – Network Preparation” by Opus produced during the 2011 model update).

However, it can be argued that the fare for any subsequent service being used should be set to zero, since having a fare paid for every boarding (even reduced fare) would still make a journey involving two legs less attractive than a single leg trip. Since this fare component is really a proxy, the fare paid for both single leg and multiple leg trips should be the same with integrated ticketing. More analysis might be needed to determine the impact of this change and the sensitivity of the model to this parameter.

B3.3 Transfer Parameters in WPTM Assignment

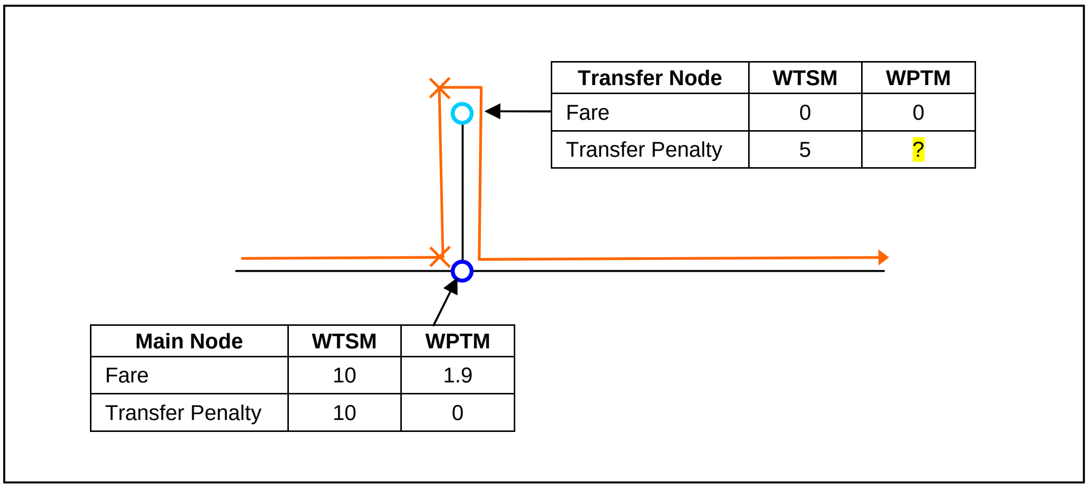
B3.3.1 Transfer Penalties

None.

B3.3.2 Fares

Similarly to WTSM, the fare will be reduced at interchange nodes to account for integrated ticketing. In WPTM however, this reduction in fare can be much more accurate due to fares being calculated during the assignment. In this case, the flagfall component of the fare will be removed for transferring passengers, with passengers on the second leg of their trips paying only for fare zone boundary crossings.

The following figure presents an example of parameters for the proposed interchange coding, for both WTSM and WPTM.



Transfer Node	WTSM	WPTM
Fare	0	0
Transfer Penalty	5	?

Main Node	WTSM	WPTM
Fare	10	1.9
Transfer Penalty	10	0

Figure B3: Transfer Node Parameters

B3.4 Changes in WTSM Generalised Costs Calculation

Due to the way PT generalised costs are calculated in WTSM, some adjustments have to be made so that the modelling of interchanges in the assignment doesn't impact on the generalised cost calculations.

Generalised costs (expressed in minutes) are a function of walking time, waiting time, in-vehicle time, boarding penalty, fare and value of time, with the equation being as follows:

GC = [In-veh time] + 2[Waiting time] + 2*[Walking time] + [Boarding penalty] + [Fare]/[VoT]*

The fare for each O-D is derived from a fare matrix, however the boarding penalty also includes the 10min fare component used during the assignment, to approximate the actual cost of boarding a service. There is therefore an element of double-counting of the fare which is dealt with in the base WTSM by subtracting 10min per boarding from the total boarding penalty skimmed after the assignment.

Additionally, due to the inability of EMME to differentiate initial and transfer boardings, every boarding in the assignment currently incurs a transfer penalty. This penalty needs to be removed for the first boarding before the generalised costs are calculated, and as an approximation WTSM calculates the average transfer penalty per boarding for a given O-D, and then subtracts it from the total boarding penalty. The equations used to include these two adjustments are as follows:

Boarding penalty = *[Skimmed boarding penalty] – [Initial transfer penalty] – [No. of boardings] * 10*

and

Initial transfer penalty = *([Skimmed boarding penalty] – [No. of boardings * 10])/ [No. of boardings] – 3*[2]

For the new interchange / integrated ticketing modelling, these equations need to be adjusted to account for the fact that a reduced fare is being paid at interchanges in the assignment. This can be done by subtracting the number of boardings at interchange (skimmed using a new attribute during assignment) from the total number of boardings. The resulting equations are as follows:

Boarding penalty = *[Skimmed boarding penalty] – [Initial transfer penalty] – ([No. of boardings] – [No of boardings at interchange])* 10 – [No. of boardings at interchange] * reduced fare*

and

Initial transfer penalty = *([Skimmed boarding penalty] – ([No. of boardings] – [No of boardings at interchange])* 10 – [No. of boardings at interchange] * reduced fare)/ [No. of boardings] – 3*

Note: the fact that in WTSM the transfer penalty that gets removed from the initial boarding is based on the average transfer penalty for an O-D, and not the actual value for this first boarding is an approximation, and as a result impacts slightly on the resulting costs and demand. This issue doesn't invalidate the approach but it might be worthwhile carrying out more investigation to estimate the impact of this approximation on results.

B3.5 Fare Calculation in WTSM

As mentioned in Section B2.1.1, the fare matrix calculation is not currently part of a WTSM model run and the current matrix is therefore based on the existing Metlink services and fare structure.

In order to replicate the changes in fares caused by modifications to PT services (such as additional boardings) or integrated ticketing, and their potential impact on generalised

[2] These 3 minutes represents the actual boarding time

costs and therefore trip distribution and mode choice, it is necessary to recalculate this fare matrix with the new services and fare system in place.

Since the process set up during the WTSM 2011 model update to recalculate the fare matrix can be easily rerun with any new PT network or fare structure, it is proposed to include this calculation as part of all WTSM model runs. This more dynamic approach would ensure that the fare matrix used in generalised cost calculation would always be an accurate representation of the PT services in place and the fare system used.

As an example for integrated ticketing, the current $2 charge (undiscounted) for boarding a service in the Metlink system could be applied to the first boarding only and waived for any subsequent boarding.

B3.6 Rail to Bus Transfer

Similarly to passengers transferring between buses, passengers transferring between rail and bus also currently pay a boarding fare for both legs of their trip. Although bus-rail transfers are not deemed to be of significant importance for the Public Transport Spine Study for most rail stations in the region, transfers occurring at Wellington station (over 1,000 transfers in the AM peak) must be accurately represented as it can have a significant impact on potential transfer to new modes introduced as part of the PTSS.

The proposed approach for Wellington station would be similar to the coding for bus to bus transfer and would include a new walk link connecting directly the transfer node for the rail station to the ones for the bus station, allowing passengers to transfer directly from one mode to the other.