



TN22 - WELLINGTON TRANSPORT ANALYTICAL TOOLS 2019-21 UPDATE – MODEL INPUT PARAMETERS

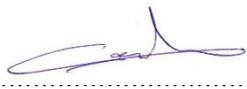
PREPARED FOR GREATER WELLINGTON REGIONAL COUNCIL

August 2022

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1	8 Aug 22	Draft	Geoffrey Cornelis	Julie Ballantyne	Scott Wilkinson	Julie Ballantyne
2	4 Oct 22	Final (draft + response to comments)	Geoffrey Cornelis	Julie Ballantyne	Scott Wilkinson	Julie Ballantyne

Greater Wellington Regional Council

TN22 - Wellington Transport Analytical Tools 2019-21 update – Model Input Parameters

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1. Introduction

This technical note is part of a series documenting the 2019-2021 update of components of the Wellington Regional Transportation Planning Analytical Tools ("Analytical Tools", "Tools"). The higher-level Analytical Tools are maintained and operated by Greater Wellington Regional Council (GWRC), who are the client for this project. This project is being primarily delivered by Stantec and Jacobs, supported by GWRC transport planners.

This technical note details the economic input parameters into the 2018 Wellington Transport Strategy Model (WTSM). These parameters are:

- Vehicle operating costs
- Values of time
- Car parking
- Public transport fares

They are used to calculate the generalised costs of travel for light and heavy vehicles and public transport, and therefore impact on the trip distribution, mode choice, and route calculation components of the model. Calculation of generalised costs themselves is included in TNXXX – Trip Distribution and Mode Choice.

2. Vehicle Operating Costs

2.1 Methodology

The vehicle operating costs (VOC) used in WTSM are based on values from the Waka Kotahi 2020 Monetised Benefits and Costs Manuals (MCBM) and include the following components:

- Base costs: fuel and oil, tyres, maintenance and repairs, and depreciation
- Costs related to stoppages, congestion and changes in speed
- Road surface condition / roughness

These costs are combined into two main categories: fuel-related costs (representing immediate costs perceived by the driver) and non-fuel-related costs (representing longer term costs of operating a vehicle). Different costs are calculated for light vehicles, light vehicles on "Business" trip purpose, and heavy vehicles. The reason for dividing vehicles in this way is based on the following assumptions:

- Most users (non-business or commercial) only perceive the immediate variable component of their operating costs, i.e. the cost of fuel
- Business and Commercial Vehicle users perceive the full operating cost, including maintenance and depreciation, but excluding GST

This is consistent with the approach recommended in the UK's Transport Analysis Guidance (WebTAG) and most models in Australasia.

Some of these cost components vary in function of the road category, gradient or speed/congestion, but they are implemented in WTSM as fixed parameters. Therefore, in order to calculate network-wide values, several assumptions had to be made regarding average speed, gradient, and other parameters.

2.1.1 Vehicle Operating Costs Calculations

Base VOCs are given in Tables A79 to A83 in the MCBM, and the breakdown of these costs by components is in Table 21 of the MCBM. These are shown in the following table, separately by vehicle class. All costs are expressed in 2015 NZ\$.

Table 2-1: Base Vehicle Operating Costs by Vehicle Type and Component (2015 NZ\$)

Class	Base Cost	% of Total			
	c/km	Fuel and Oil	Tyres	Repairs and Maintenance	Depreciation
Private Car (PC)	22.3	35.7	6.2	37.2	21
Light Commercial Vehicle (LCV)	28.1	39.6	7.2	29.4	23.8
Medium Commercial Vehicle (MCV)	53.7	38.6	4.2	44.2	13
Heavy Commercial Vehicle Cat. I (HCVI)	92.7	42	8.3	42.1	7.6
Heavy Commercial Vehicle Cat. II (HCVII)	161.7	37.3	10.4	43	9.3
Bus	67.4	46.1	6	36.9	11

Additional costs, and the assumptions made for those are as follows:

- Roughness represents the wear and tear caused by the condition of the road (Table A89 in the MCBM). Assumptions include:
 - IRI (international roughness index) = 4.5
 - road category Urban
- Congestion accounts for additional fuel use due to acceleration and deceleration in a congested environment (Table A92 in the MCBM):
 - road category: Urban Arterial and Urban Another
 - Volume to capacity 0.7
- Stoppages represents the fuel consumptions of idle vehicles due to bottleneck delays (Table A27 in the MCBM):
 - 1 stop per 10km travelled
 - 4 minutes per stop
- Speed change cycles are the costs due to vehicles having their speed interrupted by road features (Table A97 to A107 in the MCBM):
 - 1 intersection stop per kilometre
 - lower speed (from deceleration): 0kph
 - upper (original) speed: 50kph

These assumptions were chosen for consistency with the previous version of WTSM and its successive updates. The resulting additional costs are shown in the following table, per vehicle types.

Table 2-2: Additional Vehicle Operating Costs by Vehicle Type and Component (2015 NZ\$)

Class	Roughness	Congestion	Stoppages		Speed Changes	
	Costs (c/km)	Costs (c/km)	Costs (c/min)	Costs (c/km)	Costs (c/cycle)	Costs (c/km)
PC	2.7	1	1.816	0.73	1	1
LCV	2.6	1.9	2.56	1.02	1.7	1.7
MCV	7.6	3.3	3.06	1.22	5.2	5.2
HCVI	10.2	9.9	4.41	1.76	10.2	10.2
HCVII	13.6	28.1	4.41	1.76	24.3	24.3
Bus	9.1	5.8	3.245	1.30	7	7

In addition, all the costs in the tables above are expressed as resources costs. To be used to calculate generalised costs, these were converted into user costs using the factors provided in Table A17 of the MCBM and detailed below:

- Roughness: 1.125
- Stoppages: 2
- Speed change: 1.9
- All other costs: 1.2

The resulting costs in 2015 NZ\$, per vehicle type are shown in the following table.

Table 2-3: Additional Vehicles Operating Costs by Vehicle Type and Component (2015 NZ\$)

Financial Costs (c/km)		PC	LCV	MCV	HCVI	HCVII	Bus
Fuel	Base Costs: Fuel/Oil	9.54	13.35	24.87	46.72	72.38	37.29
	Congestion	1.20	2.28	3.96	11.88	33.72	6.96
	Bottleneck delay	1.45	2.05	2.45	3.53	3.53	2.60
	Speed change cycles	1.90	3.23	9.88	19.38	46.17	13.30
	Total	14.10	20.91	41.16	81.51	155.79	60.14
Repairs & Maintenance	Base Costs: Repairs & Maintenance	9.32	9.29	26.70	43.91	78.22	27.98
	Roughness	3.04	2.93	8.55	11.48	15.30	10.24
	Total	12.36	12.22	35.25	55.38	93.52	38.22
Other	Base Costs: Tyres	1.66	2.43	2.71	9.23	20.18	4.85
	Base Costs: Depreciation	5.61	8.03	8.38	8.45	18.05	8.90
	Total	7.27	10.45	11.08	17.69	38.23	13.75

These costs per vehicle types were combined into costs per 'light vehicles' and 'light vehicles for business purposes' using weighted average based on proportions from the Wellington Household Travel Survey (showing respectively ratios of 87.5% car/12.5% LCV and 60% car/40% LCV). Heavy and Medium commercial vehicles were combined into a single 'heavy commercial vehicles' category based on average proportions observed on a number of traffic counts in the region (showing a ratio of 60.5% MCV, 32.8% HCVI and 6.8% HCVII).

The GST rate of 15% was applied to costs for light vehicles for non-business purposes.

Finally, these 2015 NZ\$ costs were uplifted to 2018 \$NZ using a factor of 1.07 sourced from the 2018 Economic Evaluation Manual (which was recently replaced by the MCBM but does include update factors for costs).

The resulting vehicle operating costs for input into the model are shown in the following table.

Table 2-4: Vehicle Operating Costs (2018 NZ\$)

Class	Costs (c/km)
Light vehicles non-business (fuel only, incl. GST)	18.4
Light vehicles business – fuel (excl GST)	18.0
Light vehicles business – non-fuel (excl GST)	21.5
Light vehicles business – total (excl GST)	39.5
Light vehicles All purposes	19.7
HCV – fuel (excl GST)	66.5
HCV – non-fuel (excl GST)	62.9
HCV – total (excl GST)	129.4

The VOC value for Light vehicles all purposes (to be used in assignment of the full light vehicle demand) was obtained by applying a factor of 6.3% light vehicles trips being for business-related purpose, obtained from the HTS.

2.2 Values of Time

The values of time in WTSM are also based on values from the MCBM for different modes and trip purposes, and by applying proportions for these trip modes and purposes from the 2018 Wellington Household Travel Survey.

The behavioural values of time given by the MCBM (MCBM Table 13) are shown in the table below.

Table 2-5: Values of Time Per Mode and Purpose (NZ\$2002)

Vehicle Occupant	Work Travel Purpose	Commuting To / From Work	Other Non-Work Travel Purposes
Car (& motorcycle) driver	23.85	7.80	6.90
Car (& motorcycle) passenger	21.70	5.85	5.20
Light commercial driver	23.45	7.80	6.90
Light commercial passenger	21.70	5.85	5.20
Medium/heavy commercial driver	20.10	7.80	6.90
Medium/heavy commercial passenger	20.10	5.85	5.20
Seated bus and train passenger	21.70	4.70	3.05
Standing bus and train passenger	21.70	6.60	4.25
Pedestrian and cyclists	21.70	6.60	4.25

These costs are expressed in 2002 NZ\$ and were uplifted to 2018 using a factor of 1.5 sourced from the 2018 Economic Evaluation Manual.

Finally these resources costs were converted to user costs for non-work travel purposes using a factor 1.15 (from MCBM Table A17).

Table 2-6: Values of Time Per WTSM Mode and Purpose (NZ\$2018)

Purpose	Car Driver	Car Passenger	PT	Active	HCV
Home-Based Work	13.46	10.09	8.11	11.39	
Business	35.78	32.55	32.55	32.55	30.15
Other	11.90	8.97	5.26	7.33	

For each trip purposes except HCV, modal proportions from the Household Travel Survey were applied, leading to the values of time for all modes and each purpose in the following table.

Table 2-7: Values of Time, All Modes, Per Purpose (NZ\$2018)

	Person Travel VoT (\$/hr)	HCV VoT (\$/hr)
Home-based work	11.95	
Business	34.98	30.15
Other	9.96	
All purposes	11.63	

2.3 Parking

Car parking supply and charges were reported in Technical Note 7 (TN7: Parking).

At the time the parking analysis was undertaken only the 2001 Household Travel Survey was available. HTS data is used to allocate the parking supply (e.g.: free on-street, time restricted, employer provided, etc) to trip purposes and to calculate the average duration of stay for parked vehicles, which in turn is used to calculate daily parking charges.

This section replicates key metrics from TN7 and includes updated analysis using the 2018 HTS.

Parking supply and charges are calculated for five sectors in the Wellington CBD, which are illustrated in Figure 2-1. The sector grouping was developed so that the different types of parking were available in each sector. The model will be set up with a flexible re-definable sector system which will enable parking charges to be added for other locations when required. At present, the model will have a sixth sector which represents the rest of the modelled area.

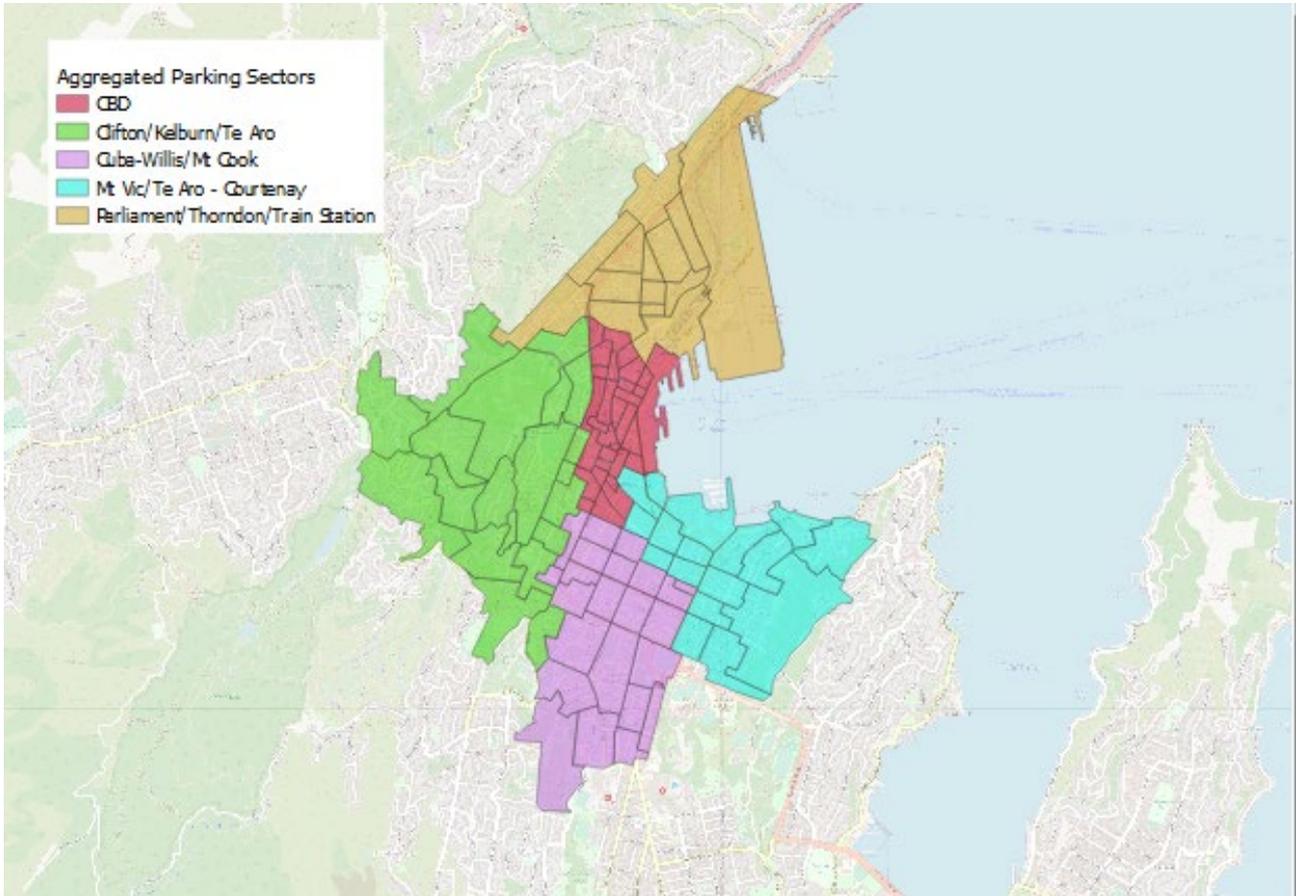


Figure 2-1: Parking Sectors in WTSM

Parking supply and charges are calculated for three aggregated trip purposes. The relationship between the trip purposes in the model and those used to calculate parking metrics is documented in Table 2-8 below.

Table 2-8: Trip Purposes for Parking Charges

WTSM Trip Purposes	Aggregated Trip Purposes for Parking
Home-based work (HBW)	Commuting (HBW)
Home-based education (HBED)	Rest
Home-based shopping (HBSH)	
Home-based other (HBO)	
Non-home based (NHB)	
Business (BSN)	Business (EB)

The following tables have data from the 2018 HTS. In all cases, the data represents daily vehicle trips with a destination in the CBD, excluding vehicles that did not park (i.e. drop off) and excluding vehicles that parked at residential destinations (houses).

To allocate data for the "Rest" aggregated trip purpose to the four trip purposes in the model, the proportion of daily parked vehicle trips from the 2018 HTS was used (see Table 2-9).

Table 2-9: Proportion of “Rest” of the Trip Purposes, 2018 HTS

Proportion in 2018 HTS				Total
HBED	HBSH	HBO	NHBO	
4.8%	9.9%	20.4%	65.0%	100.0%

From the 2018 HTS, the proportion of daily parked vehicle trips by aggregated trip purpose and by the type of parking facility was calculated (see Table 2-10).

Table 2-10: Trip Purpose Proportion by Parking Type, 2018 HTS

Parking Type	Proportion in 2018 HTS			Total
	Commuting	Business	Rest	
Public Unmetered On-Street	24%	3%	73%	100%
Public Metered On-Street	10%	5%	85%	100%
Public Off-Street	23%	11%	66%	100%
Work/Employer's Carpark	59%	4%	37%	100%

The average duration of stay for vehicles parked in the CBD by aggregated trip purpose was calculated from the 2018 HTS and is shown below. The HTS shows that commuters park for just under 5 hours on average, however it will be assumed in the model that commuters pay a daily parking charge. This is because many facilities offer deals for longer duration stays or early bird discounts. If the five-hour average duration is used, the parking charge for commuting will be much higher which is not considered realistic.

Table 2-11: Average Duration of Stay, Weekdays, Private Vehicles Parked in Wider-CBD, 2018 HTS

Metric	Commuting	Business	Rest
Daily Parked Vehicle Trips, 2018 HTS	16,721	7,910	56,092
Average Duration of Stay (decimal hours)	4.87	1.20	1.20
Average Duration of Stay Applied (decimal hours)	Day	1.20	1.20

The parking supply by sector and trip purpose is shown in Table 2-12. This has been updated based on 2018 HTS. The number of spaces in each sector is the same as reported in TN7, however, the allocation to trip purpose has been updated using the 2018 HTS. Average parking charges per day are shown in Table 2-13. These are rounded to the nearest dollar to reflect the approximate calculation and are technically 2020 dollar values as historic charges were not available when this work was undertaken. This small difference is not expected to have a substantive impact.

Table 2-12: 2018 Parking Supply by Sector and Trip Purpose by 5 Sectors

Suburb	Sector	HBW	EB	HBED	HBSH	HBO	NHBO
CBD	1	6342	1006	366	761	1570	5013
Clifton/Kelburn/Te Aro	2	229	122	74	153	316	1009
Cuba-Willis/Mt Cook	3	1647	362	151	314	648	2068
Mt Vic/Te Aro - Courtenay	4	1420	314	152	316	652	2083
Parliament/Thorndon/Train Station	5	1209	257	111	231	476	1520

Table 2-13: 2018 Average Parking Charge by Sector and Trip Purpose (2020\$) by 5 Sectors

Suburb	Sector	HBW	EB	HBED	HBSH	HBO	NHBO
CBD	1	13	9	7	7	7	7
Clifton/Kelburn/Te Aro	2	22	9	8	8	8	8
Cuba-Willis/Mt Cook	3	8	4	4	4	4	4
Mt Vic/Te Aro - Courtenay	4	10	4	4	4	4	4
Parliament/Thorndon/Train Station	5	11	6	5	5	5	5

The home-based work parking price for Clifton/Kelburn/Te Aro stands out as high compared to other sectors. This is because there is no employer-provided parking in this sector.

2.4 Public Transport Fares

2.4.1 Methodology for Rail and Bus

Public transport fares are based on the 2018 Metlink fare structure, which includes 14 fare zones centred around the Wellington CBD and a number of fare products for adults and children (including cash, the 'Snapper' stored value card and various passes and concessions). While some of the fare products and their related discounts vary between rail and buses, the zones themselves and base fares by zones travelled are identical for both modes.

The 2018 public transport fares are shown in the following table for the main fare products.

Table 2-14: 2018 Metlink Public Transport Fares

Fare Zone crossing	Adults				Children			
	Train & Bus		Train Only		Train & Bus		Train Only	
	Cash	10-trip & Snapper	Off-peak 10-trip	Monthly	Cash	10-trip & Snapper	School Term Ticket	Monthly
Boarding	\$2.50	\$1.71			\$1.50	\$0.86		
1	\$2.50	\$1.71	\$1.28	\$51.30	\$1.50	\$0.86	\$25.80	\$95.00
2	\$4.00	\$2.81	\$2.11	\$84.30	\$2.00	\$1.41	\$42.30	\$119.30
3	\$5.00	\$3.74	\$2.81	\$112.20	\$2.50	\$1.87	\$56.10	\$142.50
4	\$5.50	\$4.20	\$3.15	\$126.00	\$3.00	\$2.10	\$63.00	\$174.80
5	\$6.50	\$5.13	\$3.85	\$153.90	\$3.50	\$2.57	\$77.10	\$206.30
6	\$8.50	\$6.52	\$4.89	\$195.63	\$4.50	\$3.26	\$97.80	\$237.80
7	\$9.50	\$7.40	\$5.55	\$222.00	\$5.00	\$3.70	\$111.00	\$273.00
8	\$10.50	\$8.27	\$6.20	\$248.10	\$5.50	\$4.14	\$124.20	\$306.00
9	\$12.00	\$9.33	\$7.00	\$279.90	\$6.00	\$4.67	\$140.10	\$336.80
10	\$13.00	\$10.26	\$7.70	\$307.80	\$6.50	\$5.13	\$153.90	\$373.50
11	\$15.00	\$11.74	\$8.81	\$352.20	\$7.50	\$5.87	\$176.10	\$431.30
12	\$16.00	\$12.62	\$9.47	\$378.60	\$8.00	\$6.31	\$189.30	\$461.30
13	\$17.50	\$13.92	\$10.44	\$417.60	\$9.00	\$6.96	\$208.80	\$506.30
14	\$19.00	\$14.83	\$11.12	\$444.90	\$9.50	\$7.42	\$222.60	\$540.00

From this the average fare per zone travelled was calculated for each fare product, weighted using the number of fare zones travelled from electronic ticketing machine (ETM) and rail ticketing data, separately per passenger type (adult or child), mode (bus or rail) and time period. For monthly pass, an average of 40 trips were assumed.

The resulting average fares are shown in the following table. Boarding costs are constant, while the slight differences in average number of zones travelled per time periods lead to small variations in average cost per zone.

Table 2-15: Average Fare Per Boarding and Zone Travelled

	Adults				Children			
	Train & Bus		Train Only		Train & Bus		Train Only	
	Cash	10-trip & Snapper	Off-peak 10-trip	Monthly	Cash	10-trip / Stored Value Card	School Term Ticket	Monthly
AM								
Boarding	\$2.50	\$1.71	\$1.28	\$1.28	\$1.50	\$0.86	\$95.00	\$0.65
Per zone	\$1.11	\$0.92	\$0.63	\$0.63	\$0.52	\$0.49	\$31.89	\$0.34
IP								
Boarding	\$2.50	\$1.71	\$1.28	\$1.28	\$1.50	\$0.86	\$95.00	\$0.65
Per zone	\$1.19	\$0.95	\$0.62	\$0.63	\$0.52	\$0.49	\$29.67	\$0.34
PM								
Boarding	\$2.50	\$1.71	\$1.28	\$1.28	\$1.50	\$0.86	\$95.00	\$0.65
Per zone	\$1.12	\$0.92	\$0.63	\$0.63	\$0.52	\$0.49	\$29.71	\$0.34
ON								
Boarding	\$2.50	\$1.71	\$1.28	\$1.28	\$1.50	\$0.86	\$95.00	\$0.65
Per zone	\$1.19	\$0.96	\$1.42	\$1.42	\$0.51	\$0.49	\$29.67	\$0.34

For the Inter peak, a 25% discount was applied to payment by Snapper card and 10-trip tickets. In reality, this discount was introduced in July 2018, i.e. later than the March 2018 period that the WTSM is representative of. While the model is intended to represent March 2018 demand, both the public transport network and electronic data used for validation are from 2019, post network changes and introduction of the Inter peak fare discount. It was therefore decided to apply this discount for consistency.

These fares then need to be aggregated as the generalised costs feeding into the WTSM mode choice and trip distribution models are applied to the full public transport demand, and not split by fare product, mode or passenger type. This was done by first calculating the average of these fares, weighted by demand, per fare product.

The proportions of passenger per product type, for both adults and children, bus and train, and separately by time period is shown in the following table.

Table 2-16: Proportion of Fare Products Per Mode and Passenger Type

Period	Bus			Train			
	Cash	Snapper / 10 trip	Free	Cash	10 Trips	Free	Monthly
Adults							
AM	6%	94%	0%	13%	41%	0%	46%
IP	10%	66%	25%	27%	19%	26%	28%
PM	9%	91%	0%	13%	41%	0%	46%
ON	10%	86%	5%	27%	19%	26%	28%
Children							
AM	6%	94%	0%	18%	43%	0%	39%
IP	13%	87%	0%	16%	41%	0%	44%
PM	9%	91%	0%	18%	43%	0%	39%
ON	10%	90%	0%	16%	41%	0%	44%

Finally, ratio of bus vs rail and adult vs children patronage were calculated from ticketing data and applied to get a single boarding and fare zone cost, for each time period.

The resulting fares are shown in the following table.

Table 2-17: 2018 WTSM Public Transport Fares for Bus and Rail

	AM	IP	PM	ON
Boarding	\$1.53	\$1.10	\$1.61	\$1.54
Zone	\$0.79	\$0.58	\$0.83	\$0.87

2.4.2 Methodology for the Airport Flyer, Ferry and Cable Car

The Airport Flyer bus service links the Wellington Airport to Wellington CBD and Queensgate in Lower Hutt. It is not part of the Metlink network and uses a different fare system. Fares for this service were compared with Metlink for trips between the Airport and both the Wellington CBD and Queensgate. The difference in cost will be added to regular bus fares for users on this service in the assignment, amounting to an extra \$8.4 between the Airport and Wellington, and \$13.5 between the Airport and Queensgate.

For the East by West ferries linking the Wellington CBD to Days Bay in Eastbourne and Seatoun, fares were based on a 10-trip pass 2018 cost, leading to a single trip fare of \$8.7.

Finally, fares for the cable car were based on the 2018 charge of \$3.50 adult one-way fare. While a number of discounts are available, this simple assumption was deemed appropriate in the absence of more detailed information as this service is not part of the Metlink network and services a relatively small number of passengers, many of them being tourists.

2.4.3 Intermodal Fares and Integrated Ticketing

For the bus network and payment with the Snapper Card, additional boardings in 2018 were free for transfers within 30 minutes. This however did not and currently does not apply for transfers between modes, e.g. between bus and rail, or for transfers between rail services.

It is likely that full integrated ticketing including intermodal will be introduced in the near future and the model needs to have the capability to reflect this for forecasting. Fares were therefore implemented in a way that enables both the current free transfers for bus only, and any future and changes in transfers for rail and intermodal. More details can be found in the Technical Note describing the PT Assignment.



Appendices

Appendix A Client Comment and Consultant Response

No.	Comment By	Comment	Response
1	Peer reviewer	My main comment relates to the assumption that business and CV users perceive the full operating costs, including maintenance and depreciation. Depending on how the calibration/validation goes, and if there are challenges, this issue (of the perception of VOCs) could be revisited.	<p>After a review of practices in NZ, Australia and the UK, there is a general agreement that businesses perceive the full resource costs of operating a vehicle, including maintenance.</p> <p>Depreciation is not always mentioned but it is a very small component in any case. This is the approach recommended in webTAG and used in most models in Australia. We can still revisit during the calibration if needed but this is a good starting point.</p>
2	Peer reviewer	I'm interested in Table 2-6 giving different values of time by mode, with these then being averaged across all modes. Does this then adversely influence the mode shift calculations, e assuming a similar cost for all modes, when different costs have been found to be applicable?	<p>Practices on this topic issue were also reviewed with the general approach in the UK and Australia being to apply the same VoT for all modes, with recurring comments than having a separate VoT might lead to inconsistent results in the mode choice and may make less sense overall at an individual decision making level, since because someone change mode should not mean their value of time changes. WebTAG provides an explanation why applying different VoT per mode makes sense for an economic evaluation purpose, but it does not state that this applies to modelling. Interestingly the MBCM recommends applying the same VoT to all modes for economics so a different approach than WebTAG.</p>
3	Andrew Ford, GWRC	Perhaps more of an issue for forecasting, but given that many people can now do something productive whilst using PT (checking e-mails, reviewing documents), the setting of future PT values of time will be of interest. This is consistent with Ian's comment around Table 2.6 - having an average VOT means that if a future change in VoT is greater for one mode than another, this will not be captured in WTSM.	<p>It is worth noting that VoT values are usually used to convert time into \$. As the model uses generalised minutes, we are using them the other way around, to convert \$ into time. In the model the time component itself would not change even if people have a more productive use of their time (emails in the bus, etc), only the monetary components converted to time would change.</p> <p>A better way to account for these aspects would therefore be through in-vehicle time perception factors</p>

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