North East Link EES

IAC Hearing

Evidence of William McDougall

Traffic Modelling

William McDougall

I am an independent transport planner with extensive experience in transport modelling and project appraisal

I have over 45 years of career experience in these fields, in the UK, Australasia, Asia and the Middle East, with major consultancies

In Australia since 1985 (worked in Perth, Sydney, Brisbane and Melbourne)

In Victoria since 2001 I've been closely involved in inception, planning, appraisal of many major transport initiatives, such as Melbourne Tram Plan, Melbourne Metro, Rowville and Doncaster Rail studies, West Gate Tunnel, High Speed Rail, Melbourne Airport Rail Link and the Eddington Transport Study (East West Link Needs Assessment)

Expert witness statement

My witness statement covered two main areas:

1. Strategic transport modelling (the Zenith model)
2. Performance of NEL in relation to the Transport Integration Act (TIA)

Following lodgement of expert witness statements (mine and others), the Zenith modelling was discussed at a conclave meeting with VLC on 25/26 July 2019

- Some of the issues raised in our witness reports were discussed and agreed upon, and some were left where we ‘agreed to disagree’
- Additionally, new information provided at the conclave has prompted me to investigate the strategic transport modelling further, raising new concerns which I will present today

The Zenith model is important for NEL EES

Strategic transport modelling with Zenith provides the travel and traffic projections on which the future performance of NEL is based – the estimates of how much traffic will use NEL, and consequently how much traffic relief will take place on existing roads

These projections determine the scope and size of NEL and therefore its attendant impacts on land and property, and its construction cost

They also determine the effects of NEL on travel and traffic patterns, forming the basis for statements in the EES regarding NEL's impacts on issues such as traffic noise, emissions, air quality and road safety

Accordingly it is fundamentally important that the strategic transport modelling follows industry best practice and is demonstrably robust

Detailed guidance exists in Australia (Australian Transport Assessment and Planning – ATAP) and elsewhere (notably UK Transport Appraisal Guidance (TAG)), based on years of continuous development and use of strategic transport models, which stipulates how it should be done to ensure maximum confidence in the outputs

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- Explanation of four-step modelling
- Main agreement from conclave – overestimation in present day (2016) model
- Main disagreement from conclave – ‘single loop’ modelling approach
- Issues arising from further investigations after the conclave, regarding Zenith modelling
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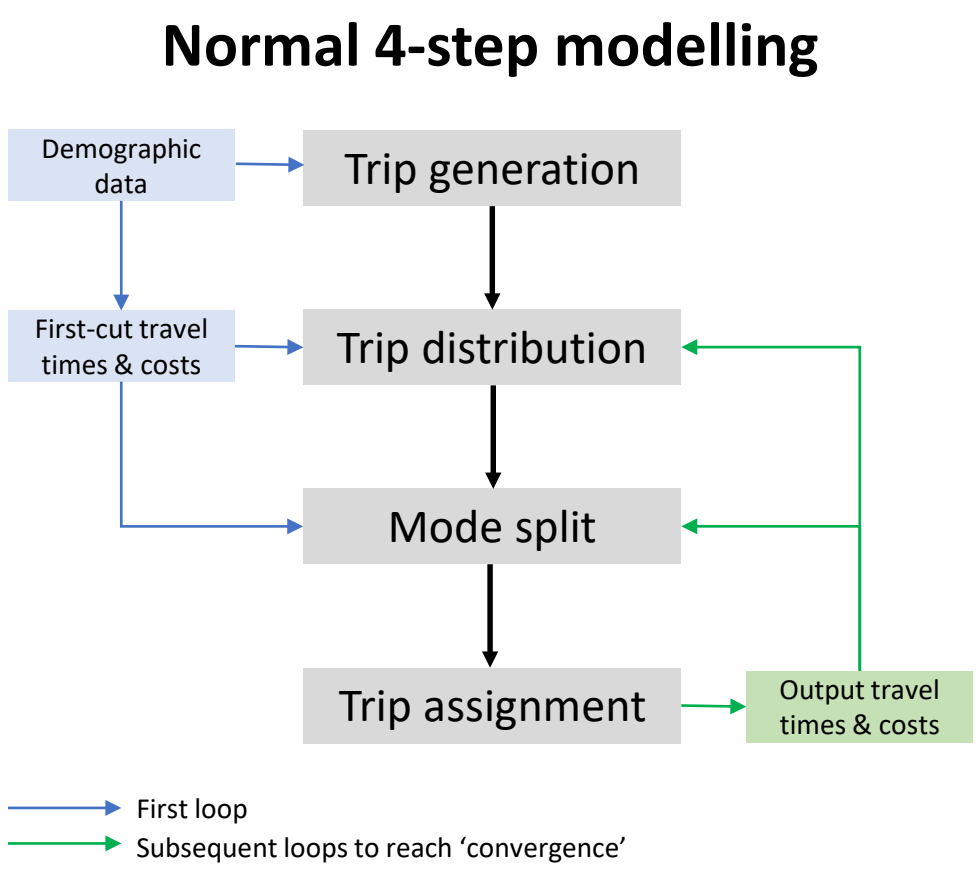
Normal four-step modelling explained



Base year:

- Calibrate for base year against travel surveys
- Loop until convergence achieved
- Validate against traffic counts and patronage surveys

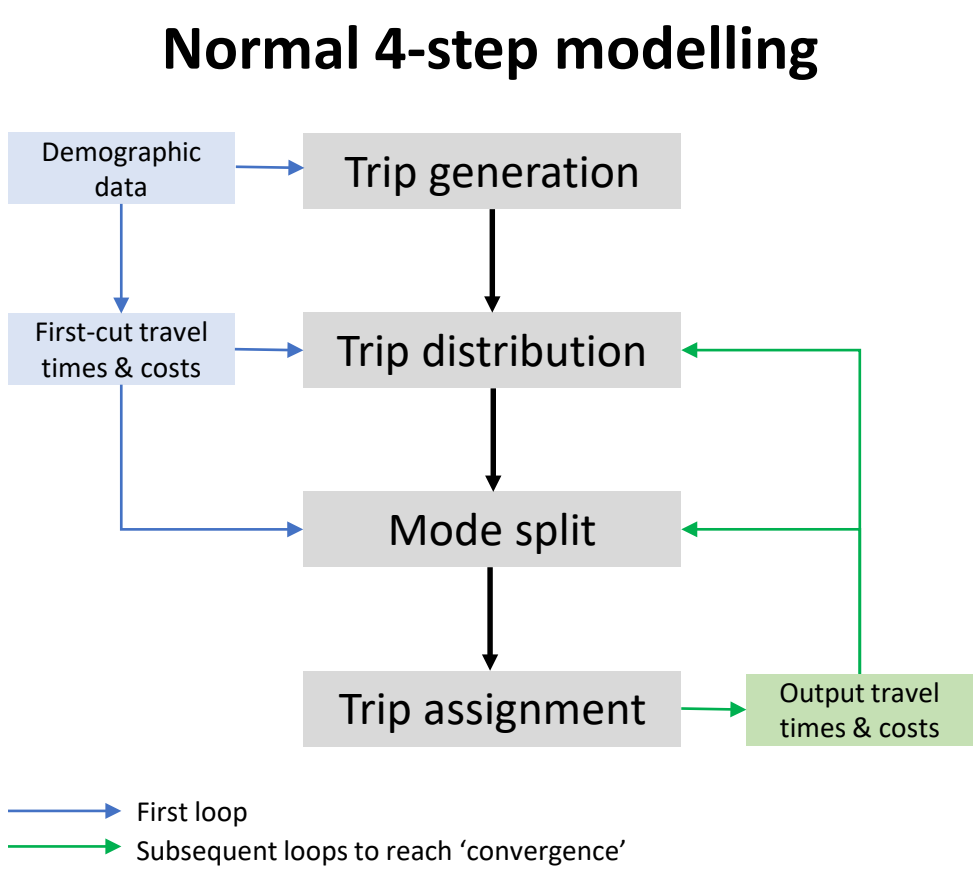
Future years:

- Modelled by inserting future estimates of demographics and network changes
- Loop until convergence achieved

VLC employs a significantly different method for future year forecasting with the Zenith model ('single loop')

- I shall explain these differences shortly

Normal four-step modelling explained



Guidance stipulates that model performance is demonstrated by documenting the results of calibration, validation and convergence (in base and future years) to establish 'fitness for purpose'

When modelling future years, the four model steps should be followed exactly as in the base year, with input changes to represent the future

- As well as demographic and network changes, adjustments are often made to other items (e.g. fuel prices, public transport fares) to reflect future trends
- In Victoria, TfV specifies a future year Reference Case which stipulates what should and shouldn't be changed in the model, to ensure that future projections are as consistent as possible between different projects and different models (reflecting Govt policy and projections)

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Importance of model validation

Transport model validation against observed, present day conditions (usually represented primarily by surveys of traffic volumes, travel times and public transport passenger loadings) is vital to ensure that the mathematical model replicates them with sufficient accuracy

The model can then be used with maximum confidence when inputting future demographic and transport network details, to predict future travel demand and traffic volumes

ATAP explains it thus (my highlighting): *'The validation process should use data separate to that used in the model calibration.*

Calibration and estimation data are critical for establishing the parameters and equations used in the transport modelling system.

Validation data are critical to testing the overall validity of the model against a set of criteria.' (ATAP module T1, section 5.3)

Agreed - present day traffic overestimation

We agreed that, compared to surveys, the Zenith model of 2016 overestimates:

1. Car traffic by about 10% in peaks (but daily flows are more balanced)
2. Truck traffic by about 20% (daily flows)
3. Road travel times systematically, and not enough routes were surveyed

Veitch cited early/late peaks in the NEL study area as a possible explanation for 1), and Willumsen said there are day-to-day variations in any case

However it is normal to post-process the actual traffic counts (e.g. by using seasonal and day-of-week adjustment factors) to provide estimates of annual average term-time weekday traffic, thus corresponding with the figures that the Zenith model produces, for comparison therewith

It should also be possible to extract the actual traffic peaks in the area for comparison with the modelled ones, but this has not been done

Neither the Veitch nor Willumsen explanations satisfy me that the base year model is sufficiently calibrated to reflect existing conditions

We all agreed that more could have been done (and I think it should be done) to refine the model in the NEL area of influence, before using it to produce traffic projections into the future

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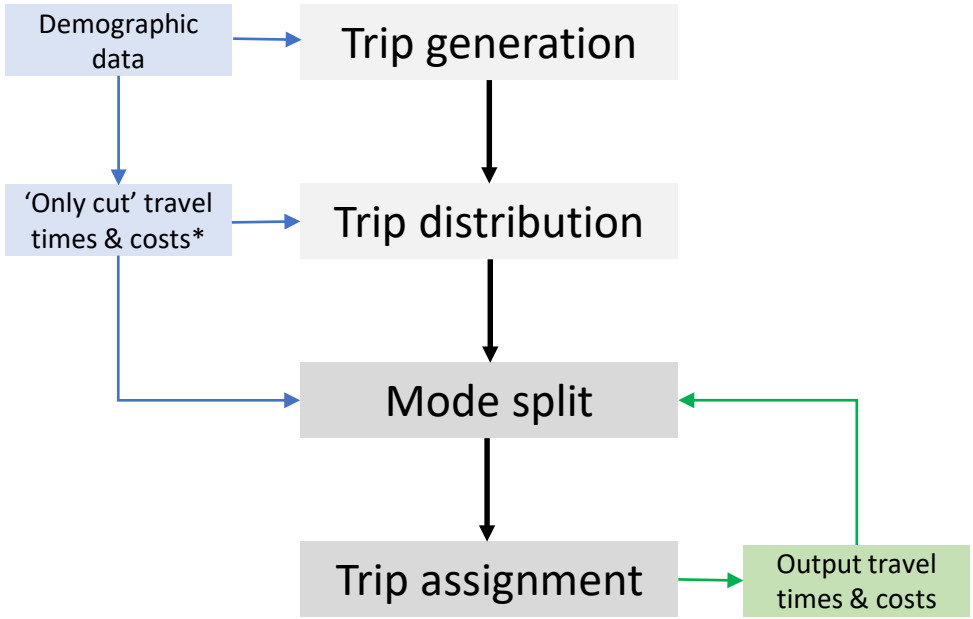
‘Single loop’ method

VLC ‘single loop’



* VLC uses base year travel demand on future year network in the ‘only cut’ of trip distribution

VLC’s ‘single loop’ method (for future year modelling) excludes trip distribution in second and subsequent loops

- The effect of doing so assumes that trip distribution is not affected by refinements to travel times and costs (TT&C) in looping
- This is a distortion of reality because people make decisions about where to work, educate, shop in part based on TT&C and not just based on a choice of mode
- This is why TT&C are input into the distribution step of the model in the first place

Another distortion is introduced by VLC; they use present day travel demand with future year networks in their ‘only cut’ of trip distribution

Justification for the ‘single loop’ method is unconvincing and inconsistent with established practice

Disagreed - ‘Single loop’ method validity

Notwithstanding that VLC has used the ‘single loop’ method for a long time and on a number of projects, the inner workings have not been documented in detail until recently

In my opinion the ‘single loop’ method artificially distorts a critical step of the modelling process (trip distribution) and has consequent impacts on a variety of model outputs without any logical justification

It is not appropriate to use base year travel demand with network costs/times (as the single loop method does) because it will result in unjustifiably longer trips with the consequence that the model overestimates future growth in vehicle-km travelled

The correct way to do this is to use future year travel demands (growthed up from the base year) with future year network costs and times to more realistically represent travel patterns associated with anticipated population growth and land use change

VLC relies on the fact that the ‘single loop’ method produces more growth in future years (longer trips and increased trip-km per capita) as a justification for its use. This is the distortion that is of concern to me

Disagreed - ‘Single loop’ method validity

VLC makes conflicting and illogical statements about growth in trip distances

> *VLC Transport Modelling summary report page 18 (Tech Report A pdf page 1119):*
>
> ‘The primary rationale for the *dampened single distribution approach*… is that it has historically produced more realistic forecasts of future travel demands. In particular, it was found that the *undampened loop through distribution* method forecasts that the distance travelled per capita will reduce over time, whereas in reality it has tended to increase overtime due to, among others, the steady expansion of the urban area. The *dampened single distribution* approach produces forecasts that are more consistent with observed trends.’

For the last 15 years, trip-km per capita in Melbourne has been going down, not increasing. I contend (see my witness report) that this may, in part, be due to densification of Melbourne’s land use, which is now proceeding faster than its geographical spreading, and is projected to continue in that direction

VLC has used the ‘single loop’ technique for the last 20 years, thus they have been historically projecting travel distance growth while in reality it has been going down

Disagreed - ‘Single loop’ method validity

In relation to the ‘single loop’ method:

- It appears that the objective is to achieve a model result as quickly as possible by not cycling through the distribution step
- There is no evidence given that the demand model converges adequately in future years
- Indeed, future year demand model convergence cannot be calculated, because the distribution step (the most difficult – and important – step to converge mathematically) is omitted from looping

The results of the ‘single loop’ method must therefore be treated with extreme caution, with a risk that there is significant over- or under-estimation of future traffic volumes, and changes thereto due to a project like NEL

By definition, the ‘single loop’ method cannot be said to be ‘fit for purpose’ for travel forecasting under established modelling guidance, because it does not follow that guidance and its performance cannot be measured in convergence terms (which I will discuss next)

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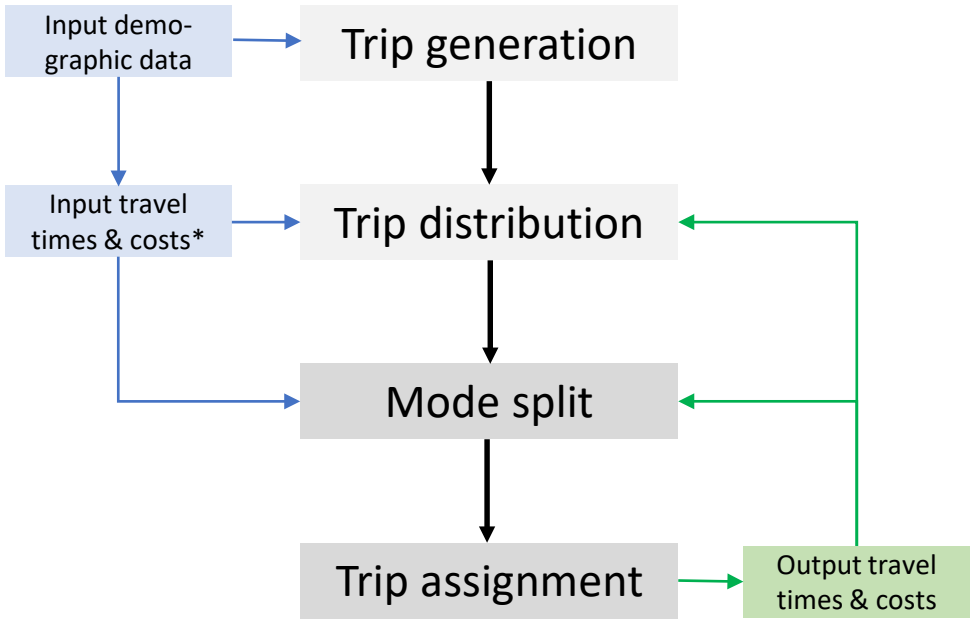
‘Single loop’ and ‘loop through’ comparison

VLC ‘loop through’



* VLC uses base year travel demand on future year network, in first loop

In conclave at my request, VLC provided results for a ‘loop through’ run of the Zenith model (carried out during the modelling for NEL Business Case)

Mr Veitch told me in conclave that in using the ‘loop through’ method, base year travel demand from the base year was combined with the future year travel times and costs at the beginning of the first loop through (i.e. just like in the ‘single loop’ method)

This approach is not consistent with correct methodology and is likely to add a further level of distortion in the comparison between the two methods, exacerbating concerns about the reliability of the model outputs

‘Single loop’ and ‘loop through’ comparison

Melbourne GCCSA 2036 average weekday		2036 No Project				Change due to Project			
		Single loop	Loop through	Difference		Single loop	Loop through	Difference	
Person trips	Car	19,014,195	18,975,960	-38,235	*(-0.2%)*	12,890	13,362	472	*(3.7%)*
	PT	3,275,055	3,214,894	-60,161	*(-1.8%)*	-2,763	-4,532	-1,769	*(64%)*
	Walk	3,105,359	3,199,795	94,435	*(3%)*	-8,948	-7,815	1,133	*(-12.7%)*
	Cycle	421,860	425,302	3,442	*(0.8%)*	-1,187	-988	199	*(-16.8%)*
	Total	25,816,470	25,815,951	-518	*(0%)*	-7	28	35	*(-471.8%)*
Vehicle trips	Car	14,129,277	14,099,274	-30,004	*(-0.2%)*	9,190	10,161	971	*(10.6%)*
	Light CV	605,091	605,091	0	*(0%)*	0	0	0	*(0%)*
	Heavy CV	381,394	381,394	0	*(0%)*	0	0	0	*(0%)*
	Total	15,115,762	15,085,759	-30,004	*(-0.2%)*	9,190	10,161	971	*(10.6%)*
Vehicle km	Car	200,111,151	192,548,178	-7,562,972	*(-3.8%)*	1,330,302	1,068,499	-261,802	*(-19.7%)*
	Light CV	7,380,544	6,769,431	-611,113	*(-8.3%)*	34,431	37,166	2,735	*(7.9%)*
	Heavy CV	12,650,896	12,016,401	-634,495	*(-5%)*	-36,112	-12,085	24,027	*(-66.5%)*
	Total	220,142,591	211,334,010	-8,808,580	*(-4%)*	1,328,620	1,093,580	-235,040	*(-17.7%)*
Vehicle hours	Car	4,618,232	4,189,115	-429,117	*(-9.3%)*	860	-4,203	-5,063	*(-588.8%)*
	Light CV	177,383	155,052	-22,331	*(-12.6%)*	-960	-723	237	*(-24.6%)*
	Heavy CV	232,849	210,434	-22,415	*(-9.6%)*	-3,647	-2,941	706	*(-19.4%)*
	Total	5,028,464	4,554,601	-473,864	*(-9.4%)*	-3,747	-7,868	-4,120	*(110%)*
Population		7,482,153	7,482,153						
Employment		3,816,690	3,816,690						
Per capita	Person trips	3.45	3.45	0.00	*(0%)*				
	Vehicle trips	2.02	2.02	0.00	*(-0.2%)*				
	Vehicle-km	29.42	28.25	-1.18	*(-4%)*				
	Vehicle-hrs	0.67	0.61	-0.06	*(-9.4%)*				

Results from the ‘loop through’ method (already tabled as Document 125)

Big changes in NEL impacts, especially on change in vehicle-km (20% less), vehicle-hours (double), loss of PT trips (up 64%)

Counterintuitive to me, in many ways

Also not what I’d call ‘correct’ anyway

- Like the ‘single loop’, it still uses base year demands in the first run of distribution step
- Fixed number of loops and iterations with no indication of convergence
- The large changes apparent could be because of oscillations between model loops (to be explained)

This is what caused me to look into the model convergence issue more closely

Demand model convergence

Demand model convergence is a **fundamental requirement** of robust four-step modelling.

Australian Transport Assessment & Planning guidance (ATAP Module T1, pp31 & 45) says:

- "It is necessary to assess the stability of the trip assignment process referred to in Section 3 before the results of the assignment process are used to influence decisions or for input to economic appraisal, or both."
- "Where the variable demand (VTM) model is used to forecast responses to scheme related cost changes, there is a need to ensure satisfactory convergence of the demand-supply iteration in addition to the network model convergence… particularly when estimating user benefits"

UK Transport Appraisal Guidance (TAG Unit M2 page 45 para 6.3.1) says that:

- "It is of crucial importance to demonstrate that the whole model system converges to a satisfactory degree, in order to have confidence that the model results are as free from error and 'noise' as possible."
- It is bold and shaded, which means: "Throughout the advice there are a number of important recommendations shown highlighted and in bold: if these actions are not followed, analysts will need to provide rigorous justification for the course of action taken."

Both ATAP and TAG require the use of a demand-supply error metric (%GAP), which should be less than 0.1% between the last two loops, to demonstrate satisfactory convergence

A model which does not converge satisfactorily in both base and future modelled years, cannot be said to be 'fit for purpose' for project appraisal

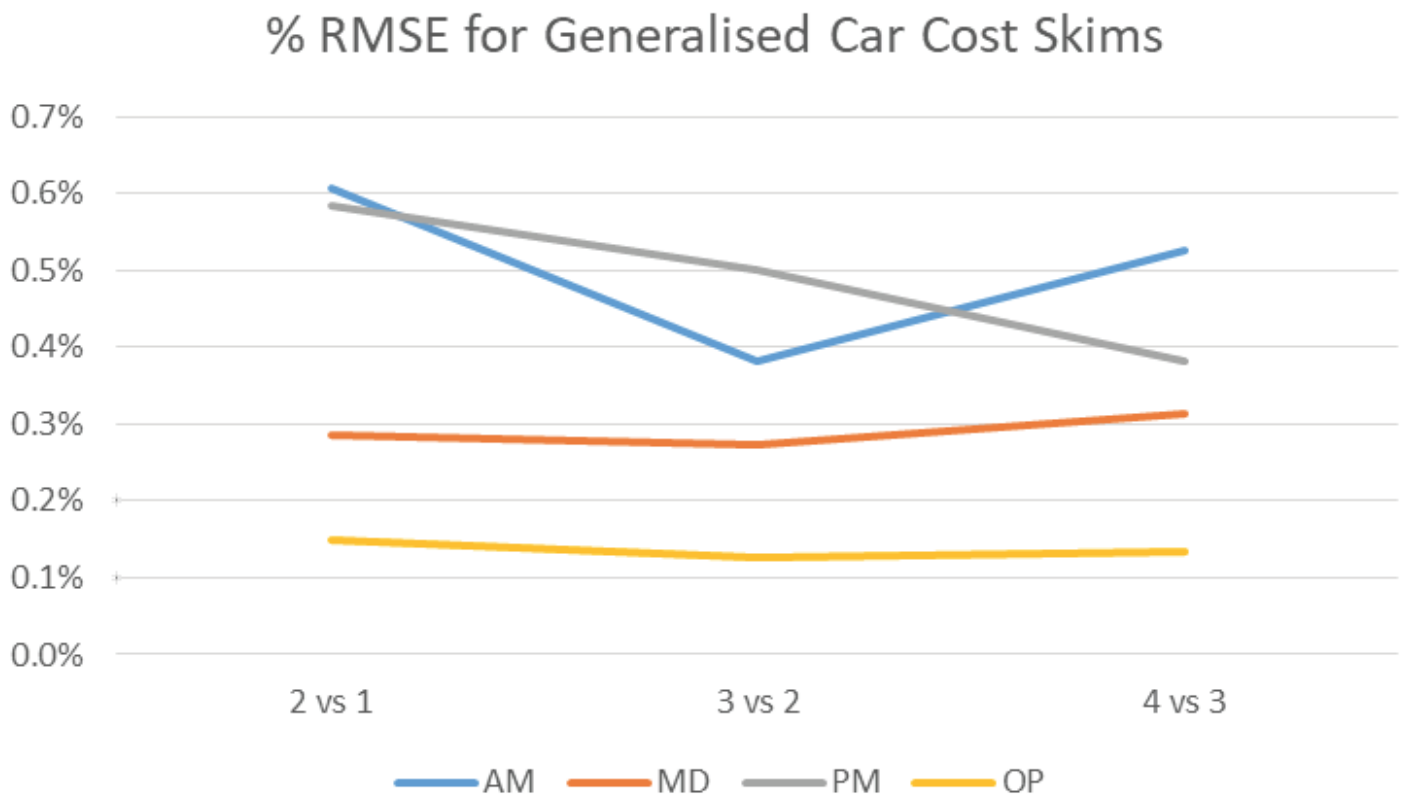
Does the Zenith base year model converge?

Zenith base year model uses 5 (or is it 4?) model loops

%RMSE of car travel cost given, without any commentary on what it means for model quality

%RMSE is not the preferred metric for model convergence (should use %GAP)

Convergence is not evident, especially in AM peak and PM peak



Source: VLC Appendix Figure B.28 (page B-45)

Demand model convergence

Methods to achieve demand model convergence have been available for many years

A 2007 paper by Rogerson and Carnovale (tabled*) tested the convergence of MITM with a 'naïve' looping method and a 'convergent feedback' method

- Naïve looping produced large variations (oscillations) between adjacent model loops, resulting in very different outputs (e.g. major road traffic flows varied by +/-100% or more)
- A 'convergent feedback' method (as developed by Prof David Boyce et al in 1994) enabled model convergence to acceptable limits and shows extreme stability between final loops of the model

Ortuzar and Willumsen describe these methods in 'Modelling Transport' (4th Ed, 2011)

- Regarding naïve looping, they say *'there is no guarantee of convergence to a unique solution that would make it possible to compare strategies or projects'*
- They describe Prof Boyce's work as 'exemplary' and present it and a number of other ways to achieve model convergence, stating that *'The main reason to use models is to provide advice on transport decisions and this requires comparing alternative ways of intervening in the transport system. Consistency in the use of models to estimate the performance of these interventions is then of capital importance as we wish to compare 'like with like'. Casting the transport modelling into a general equilibrium framework seems a prerequisite for ensuring this consistency.'*

Demand model convergence is vital

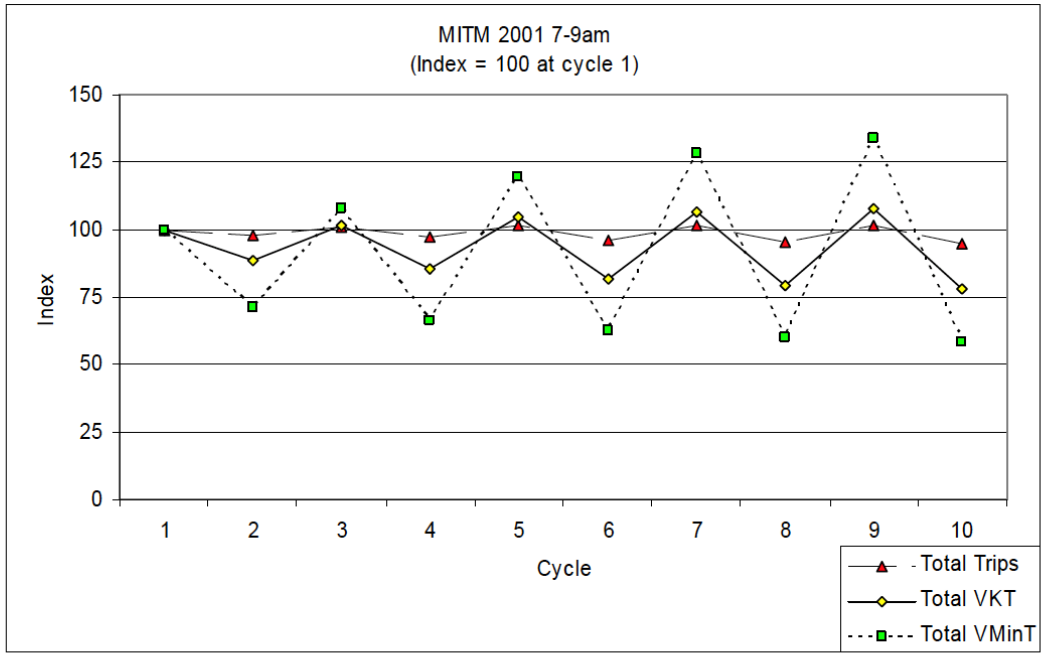


Figure 1 Naïve feedback. MITM 2001 (7-9am). Results indexed to the value of the first cycle

Source: Rogerson & Carnovale, 2007

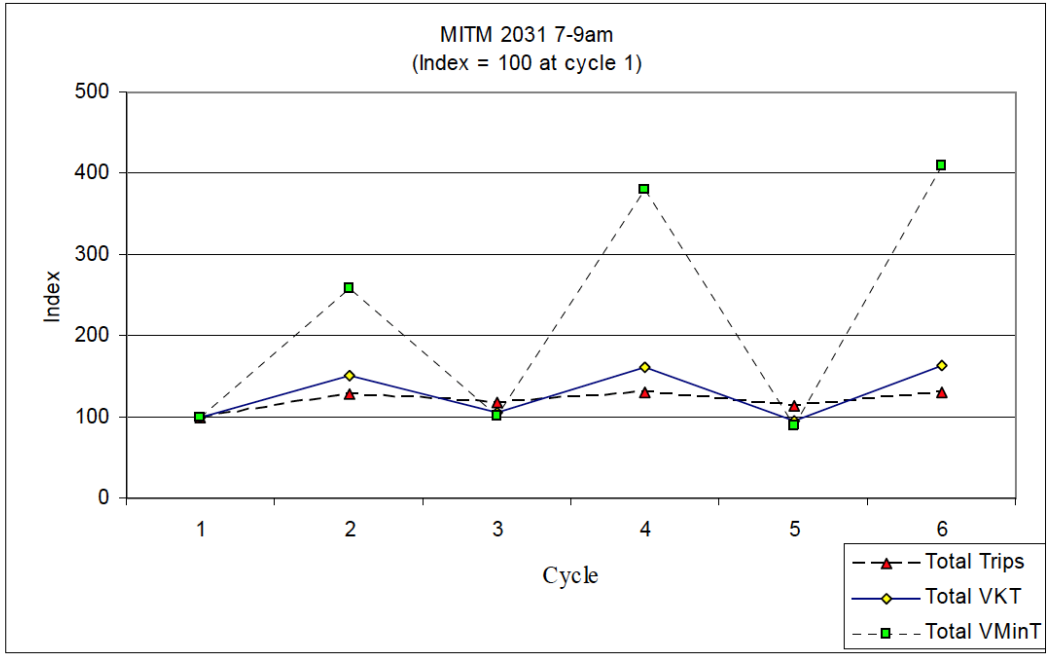


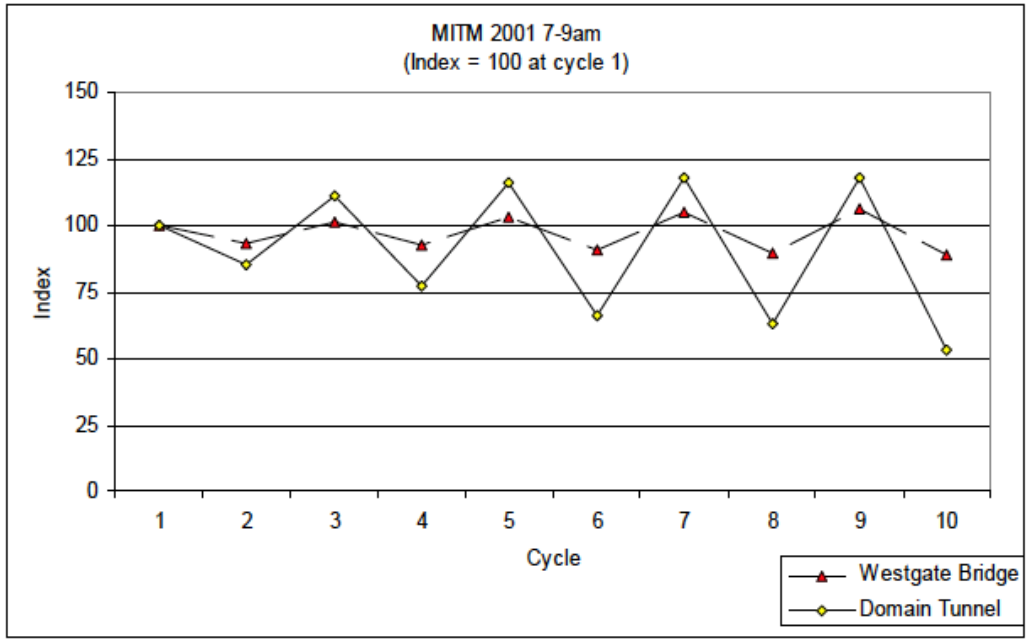
Figure 2 Naïve feedback. MITM 2031 (7-9am). Results indexed to the value of the first cycle

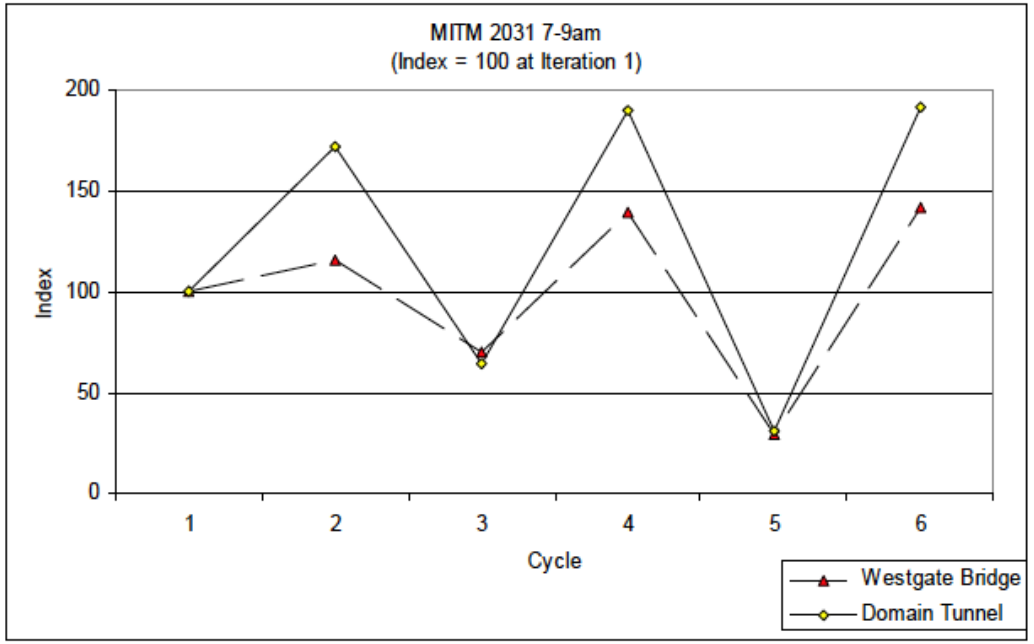
Demand model convergence is vital

Without it:

- Modelled traffic volumes can vary enormously between loops, especially in future years (oscillation)
- Picking the right number of loops is arbitrary (but paradoxically also very important)

Source: Rogerson & Carnovale, 2007





Naïve feedback MITM results for Westgate Bridge and CityLink Domain Tunnel in 2001 (top) and 2031 (bottom).

VLC's statements about modelling quality

VLC points to their past performance in predicting the traffic volumes on certain toll roads as an indicator of the reliability of their modelling approach

These past results are not fully documented and apart from some tables contained in the EES docs there has been no explanation of the specific way in which the figures have been arrived at

Willumsen seems not to have undertaken a detailed review of these past examples

They were done in other cities using other Zenith models

All of them were done a relatively short time before the opening of those toll roads, so their accuracy cannot be extended to suggest accuracy over a 20-year modelling horizon

Base year validation of traffic flows on the Melbourne toll roads (Citylink and Eastlink) is redacted, so we have no way of knowing how well the base year model replicates them

Other remaining modelling issues

Increased value of travel time for car drivers in Zenith future years (1.55% pa)

- Not in accordance with TfV Reference Case
- 36% increase (2016-2036) will increase drivers' willingness to pay tolls
- It will also alter other aspects of the traffic assignment
- EES 2036 peak direction traffic flows on NEL are over 2,000 vehicles/lane/hour
- What would they be if VTT was not changed (sensitivity test)?

Modelling public transport without capacity constraint

- Clearly unrealistic (public transport has finite carrying capacity and is very crowded at peak times)
- May be why Zenith includes large access 'penalties' in the model to prevent over-use of (unconstrained) PT in the model, as raised by Dunn and Willumsen and discussed in conclave
- Is likely to overstate the forecast patronage of the Doncaster busway component of NEL
- Is also likely to understate the mode shift from public transport to car with NEL

Other remaining modelling questions

TfV ‘Reference Case’ (VLC Appendix C1 in EES Tech report A):

- Says no change to the value of travel time in future years (already mentioned)
- Extends tram route 48 to Doncaster, but NEL model only takes it to the Doncaster Park & Ride
- Were these (and any other) changes authorised by TfV beforehand?

I haven’t done a full audit of project inclusions/exclusions and other differences between Zenith and TfV Reference Case, but I suggest it should be done

Why is all this important for the EES?

‘Single loop’ method produces longer trips than land use changes suggest

- Longer car trips may be more ‘attracted’ to NEL than shorter ones

Model precision (convergence/stability) is unknown at present

- Might be materially affecting the model’s representation of NEL and its effects

Willingness to pay tolls might be overstated in 2036, attracting more traffic to NEL

- Less traffic using NEL will mean less traffic relief on existing roads

Public transport modelling not capacity-constrained

- But may be compensated for by large transfer penalties?
- Might change mode shift due to NEL (and Doncaster Busway component)

My impression is that most of these issues combine to inflate demand for NEL

- The extent of this is uncertain

There are so many distortions and inaccuracies in the modelling that it cannot be said to be ‘fit for purpose’ for predicting future forecasts and the effects of NEL

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Transport Integration Act and NEL

Several key impacts of NEL (in context of the TIA) are distorted or omitted, including:

- Travel time effects are distorted (limited to the extent of the project, thus ignoring project-induced changes on the surrounding roads)
- No mention is made of the finding that in 2036, NEL daily produces 13,000 more car trips, 1.7 million more car-km and 3,000 fewer public transport trips
- No mention is made of the effect on walking and cycling trips (modelled, but not reported)
- No mention is made of the effect on commercial vehicle trips (not modelled)

These effects, based on Zenith modelling, could be very different if the modelling was improved along the lines already discussed

Many effects are unquantified and do not reference where in the EES more detail can be found, requiring extensive cross-checking

Transport Integration Act and NEL

Some objectives of the TIA are not supported by NEL:

- *promoting forms of transport and the use of forms of energy and transport technologies which have the least impact on the natural environment:* NEL will increase car and truck use, leading to increases in energy use and carbon emissions
- *reducing the need for private motor vehicle transport and the extent of travel*: NEL leads to increased car use and reliance, creates longer car trips and reduces public transport patronage (despite adding the Doncaster Busway)

The EES does not mention these consequences of NEL

My recommendations to the IAC

Planning – at the very least:

- Look more closely at low(er)-cost solutions for traffic bottlenecks – include in ‘no-project’ case if significant improvements can be made for relatively little investment relative to NEL
- Consider the consequences of an optimistic view of NEL that is suggested by the transport modelling inaccuracies

Transport modelling:

- Accept that the Zenith modelling as it stands is not ‘fit for purpose’
- Request full results of a sophisticated (i.e. not naïve), ‘normal’ 4-step modelling process for review, including %GAP values and key model outputs to gauge convergence between loops and model stability, in base and future modelled years
- If demand model convergence/stability cannot be achieved to within acceptable limits, other steps should be considered to improve confidence in the transport modelling
- Resolve all differences between Zenith model and TfV ‘Reference Case’
- Incorporate public transport crowding in the modelling
- Take the opportunity to update future year modelling to include latest population and employment forecasts (VIF 2019) and future transport network changes (e.g. suburban rail loop)

I would welcome the opportunity to provide further assistance on these matters