Modelling an Optimal Speed Limit

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VIASTRADA

TRANSPORT PLANNING AND DESIGN

Presentation outline

- Modelling the effects of speed
  - Case 1: Optimum speeds on state hwys
- Case 2: Nelson/Tasman Speed Mgmt
  - Methodology
  - Estimating changes in Speeds and DSIs
  - Results
  - Some Caveats and Challenges
- Takeaway Conclusions

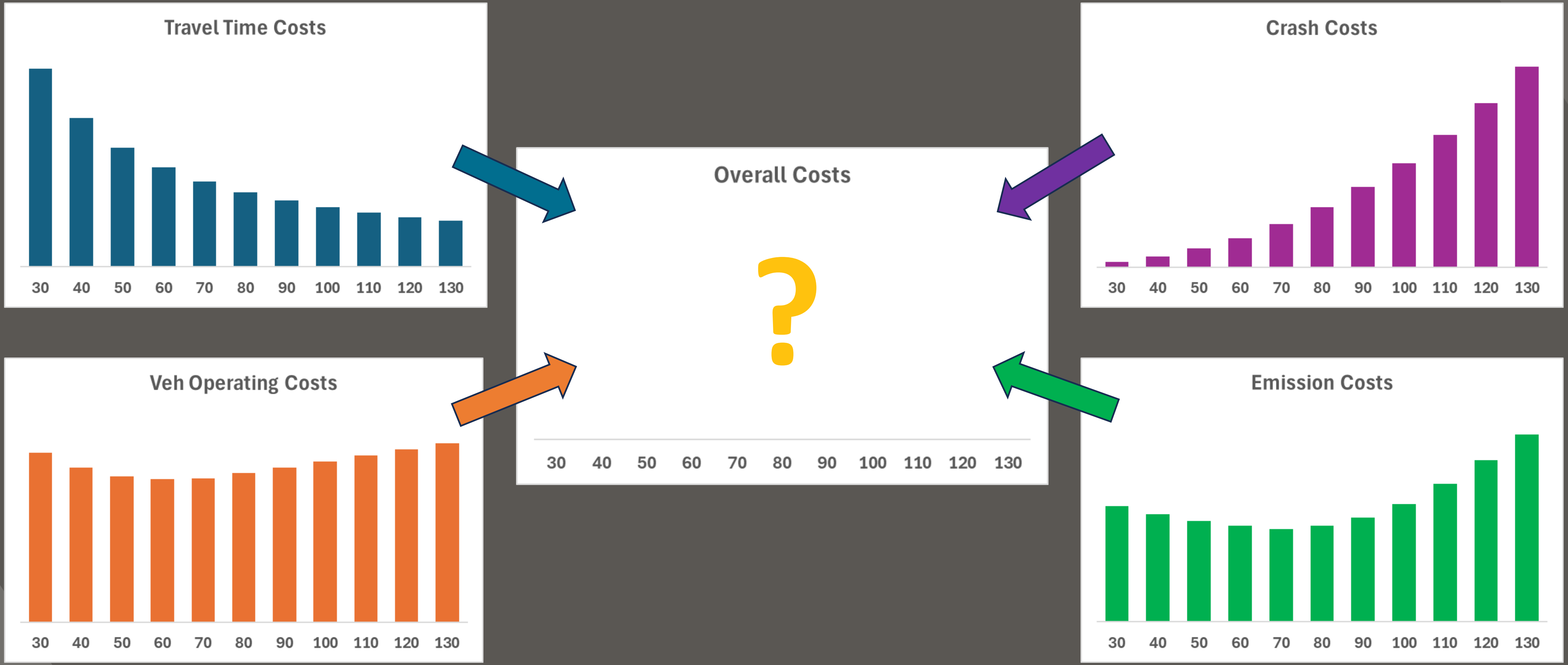
tasman district council
Te Kaunihera o te tai o Aorere

You might recognise these guys...

"Transport is a critical enabler for ***economic growth and productivity****... the new higher speed will help ensure people and freight can get to where they need to go, quickly and safely,"*

"...the coalition Government is all about making it easier for people and freight to get from A to B as quickly and efficiently as possible, which will help drive ***economic growth and improved productivity****."*

Modelling the effects of speed

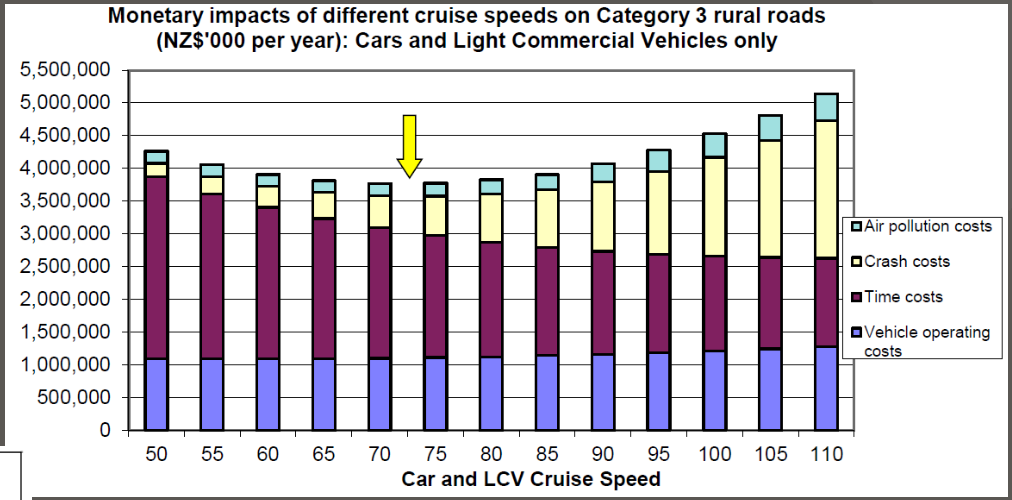


NB: Not all to same scale

Cameron, M. H. (2024). *Optimum speeds on New Zealand rural state highways: an update. Proceedings of the 2024 Australasian Road Safety Conference, Hobart*

Optimum speed limits on NZ State Hwys

- Work by Max Cameron in 2012 for NZTA
  - Later revised for 2021 new MBCM values
- Speeds are especially limited for ***trucks***
  - 90 km/h limit and extra veh operating costs



	Cruise speeds on straight sections of rural highway (km/h) 2012		Optimum cruise speeds (km/h) 2012		Optimum cruise speeds (km/h) 2021	
Road Category	Cars & light commercial vehicles (LCV)	Heavy commercial vehicles (HCV I)	Light vehicles (Cars & LCVs)	Heavy vehicles (MCVs & HCVs)	Light vehicles (Cars & LCVs)	Heavy vehicles (MCVs & HCVs)
1. Motorways/Expressways (divided four-lane) roads	99.1	92.5	105	80	95-100	80
2. High Volume National Strategic roads	93.9	87.7	85	70	75	70
3. Straight National & Regional Strategic roads	95.8	89.5	80	70	70-75	65-70
4. Winding National & Regional Strategic roads	83.6	78.4	75	65	65-70	60-65
5. Straight Regional Connectors & Distributors	95.7	89.4	80	70	70	65
6. Winding Regional Connectors & Distributors	79.7	74.9	65	55	60	55

Key findings:

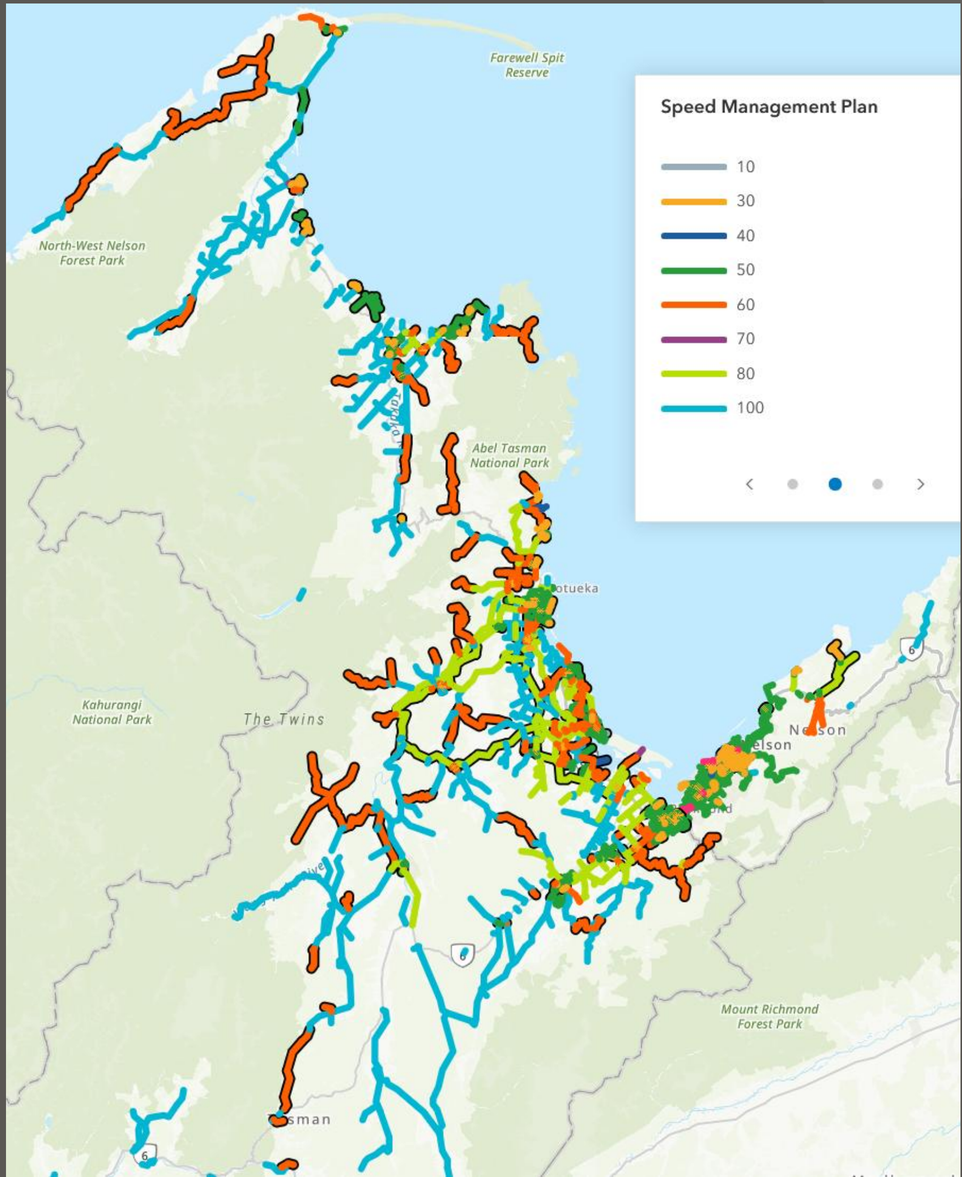
- *Undivided rural SHs are best at speeds **<80 km/h***
- *Even 4-lane motorways barely warrant exceeding **100 km/h***

Case Study: Nelson/Tasman Speed Mgmt

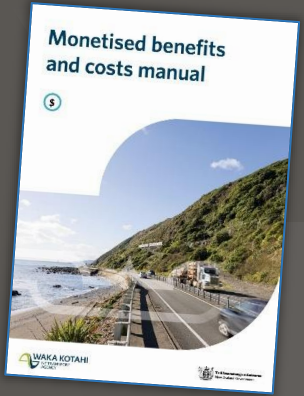
- ViaStrada commissioned by Tasman DC to provide an economic assessment on the Nelson/Tasman Speed Management Plan
  - Including a comparison of the costs and benefits between four different urban and rural options

URBAN ROADS	OPTION A	OPTION B	OPTION C	SAAS OPTION D
Outside schools (within 100m of boundary)	30	30	30	30
School neighbourhoods	50	30	40	30
Selected town centres and tourist areas	50	30	40	30
Local urban streets	50	50	40	30
Urban connector streets with separated cycle facilities	50	50	50	50

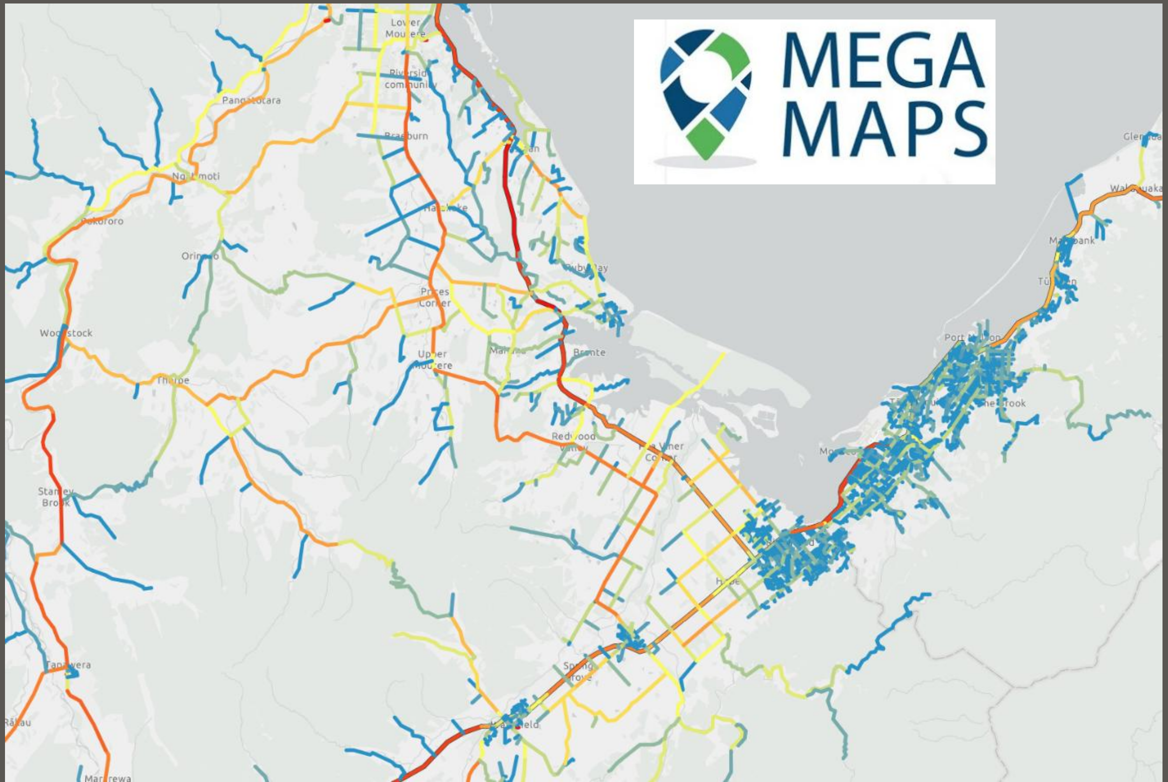
RURAL ROADS	OPTION 1	OPTION 2	OPTION 3	SAAS OPTION 4
Outside schools	30-60	30-60	30-60	30-60
Rural residential areas	100	50-60	50-60	50
Unsealed rural roads (winding or narrow)	100	60	80	60
Unsealed rural roads	100	100	80	60
High risk roads and adjacent roads	100	80	80	60-80
Sealed rural roads (winding or narrow)	100	100	80	60
All other sealed rural roads	100	100	80	80



Nelson/Tasman Speed Mgmt Plan
Methodology



- Assessment undertaken using standard NZTA *MBCM* parameters
  - Likely benefits & dis-benefits related to lowered travel speeds on some roads
- Used NZTA **MegaMaps** data for each road section of the network
  - Estimated likely ***changes*** in speeds from ***existing*** recorded mean speeds



Mean Operating Speeds

Operating Speeds

Operating Speed

- > 95
- 90 - 94
- 85 - 89
- 80 - 84
- 75 - 79
- 70 - 74
- 65 - 69
- 60 - 64
- 55 - 59
- 50 - 54
- 45 - 49
- 40 - 44
- 35 - 39
- 30 - 34
- <30

Nelson/Tasman Speed Mgmt Plan
Methodology

Plan Options – New Speeds

URBAN ROADS	OPTION A	OPTION B	OPTION C	SAAS OPTION D
Outside schools (within 100m of boundary)	30	30	30	30
School neighbourhoods	50	30	40	30
Selected town centres and tourist areas	50	30	40	30
Local urban streets	50	50	40	30
Urban connector streets with separated cycle facilities	50	50	50	50

RURAL ROADS	OPTION 1	OPTION 2	OPTION 3	SAAS OPTION 4
Outside schools	30-60	30-60	30-60	30-60
Rural residential areas	100	50-60	50-60	50
Unsealed rural roads (winding or narrow)	100	60	80	60
Unsealed rural roads	100	100	80	60
High risk roads and adjacent roads	100	80	80	60-80
Sealed rural roads (winding or narrow)	100	100	80	60
All other sealed rural roads	100	100	80	80

Est. **Cost** of each Option $$$

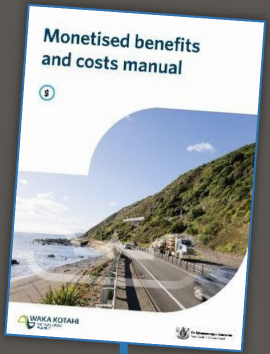
Benefit/Cost Ratio of each Option

Est. **Benefit** of each Option $$$

MEGA MAPS

- Road section
- Road length
- Traffic volume
- Posted speed
- Mean speed
- DSI crashes

Estimated change in mean speeds



For each Option:

- Expected reductions in **crash casualties**
- Expected impacts on **travel times**
- Expected changes in **veh operating costs**
- Expected changes in **vehicle emissions**

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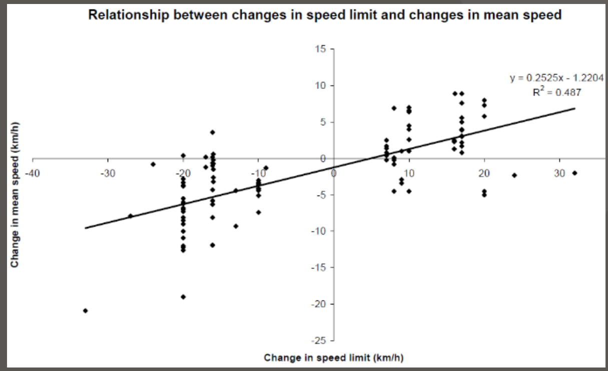
Estimating changes in Mean Speeds

Estimated change in mean speeds



- Previous research by Elvik *et al* (2004) shows

*For each **10 km/h** of speed limit decrease, an associated **~2.5 km/h** decrease is observed in mean operating speeds*

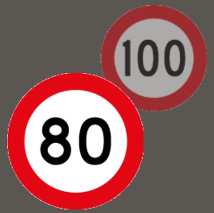
- Similar findings have been observed in various studies in NZ

Elvik, R., P. Christensen, A. H. Amundsen (2004). Speed and road accidents. An evaluation of the Power Model. Report 740/2004. Inst. of Transport Economics, Oslo

- However, greater speed changes *might* be observed

➔ **low**, **mid** and **high** estimates of speed change were used

	Change to mean operating speed per 10km/h posted speed limit reduction
Low estimate	**-2.0** km/h
Mid estimate	**-3.0** km/h
High estimate	**-5.0** km/h



-4 km/h

-6 km/h

-10 km/h

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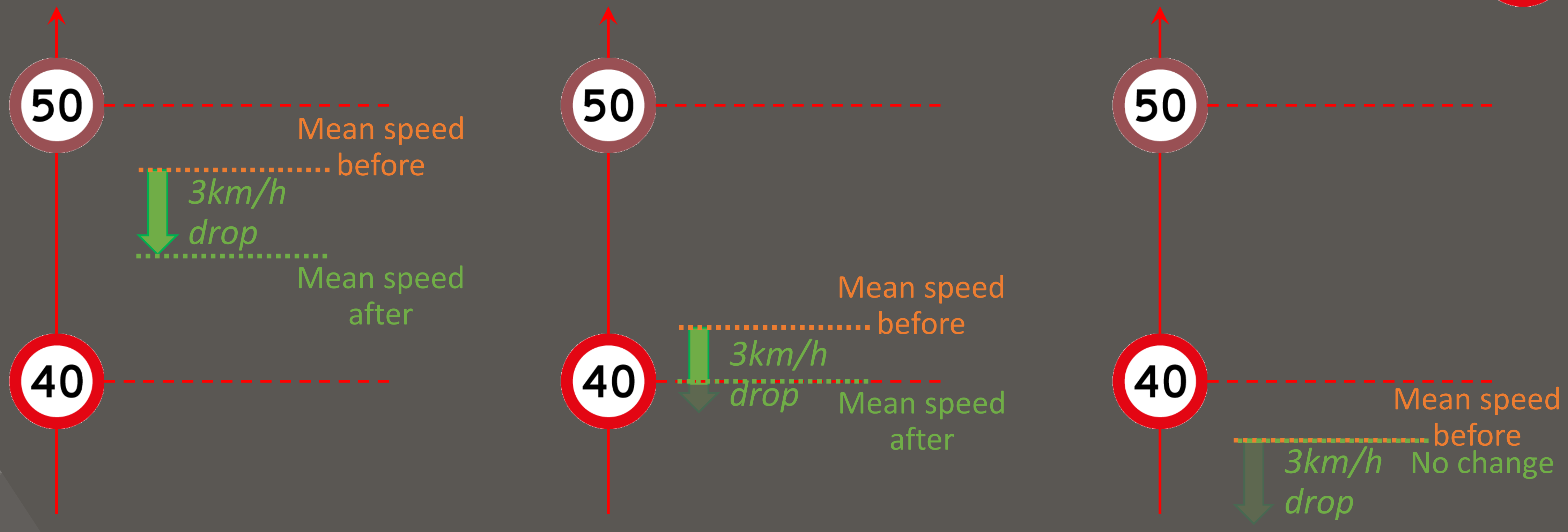
Estimating changes in Mean Speeds

- The final new mean speed also depends on the ***posted*** speed limit

e.g. assuming a **3 km/h** mean speed drop per 10 km/h limit drop:



Mean speed well above new limit *Mean speed just above new limit* *Mean speed below new limit*

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Estimating changes in Deaths/Serious Inj's

Two different theoretical approaches were tested in this analysis:

- Nilsson's (2004) power model

$$Estimated\ DSIs\ After = Estimated\ DSIs\ Before \times \left(\frac{Speed\ After}{Speed\ Before}\right)^{exponent}$$

Nilsson, G. (2004). Traffic safety dimensions and the Power Model to describe the effect of speed on safety. Bulletin 221. Lund Inst. of Technology, Dept of Technology & Society, Sweden

- Elvik's (2013/19) exponential model

$$Estimated\ DSIs\ After = Estimated\ DSIs\ Before \times e^{(Speed\ After - Speed\ Before) \times exponent}$$

Elvik, R., Vadeby, A., Hels, T., van Schagen, I. (2019). Updated estimates of the relationship between speed and road safety at the aggregate and individual levels. Accident Analysis & Prevention, 123

Each uses somewhat different exponents:

	Injury severity	Land Use Type	Exponent
Nilsson (2004) power model	-	Urban	**3.50**
	-	Rural	**2.00**
Elvik (2013/19) exponential model	*Fatal*	-	***0.08***
	Serious	-	***0.06***

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Estimating changes in Deaths/Serious Inj's

Calculated DSI reductions using theoretical methods seemed *less* than expected, based on empirical evidence observed elsewhere in NZ

➔ a separate analysis was carried out applying some ***assumed*** DSI reductions for *all* road segments where speed limits were being reduced

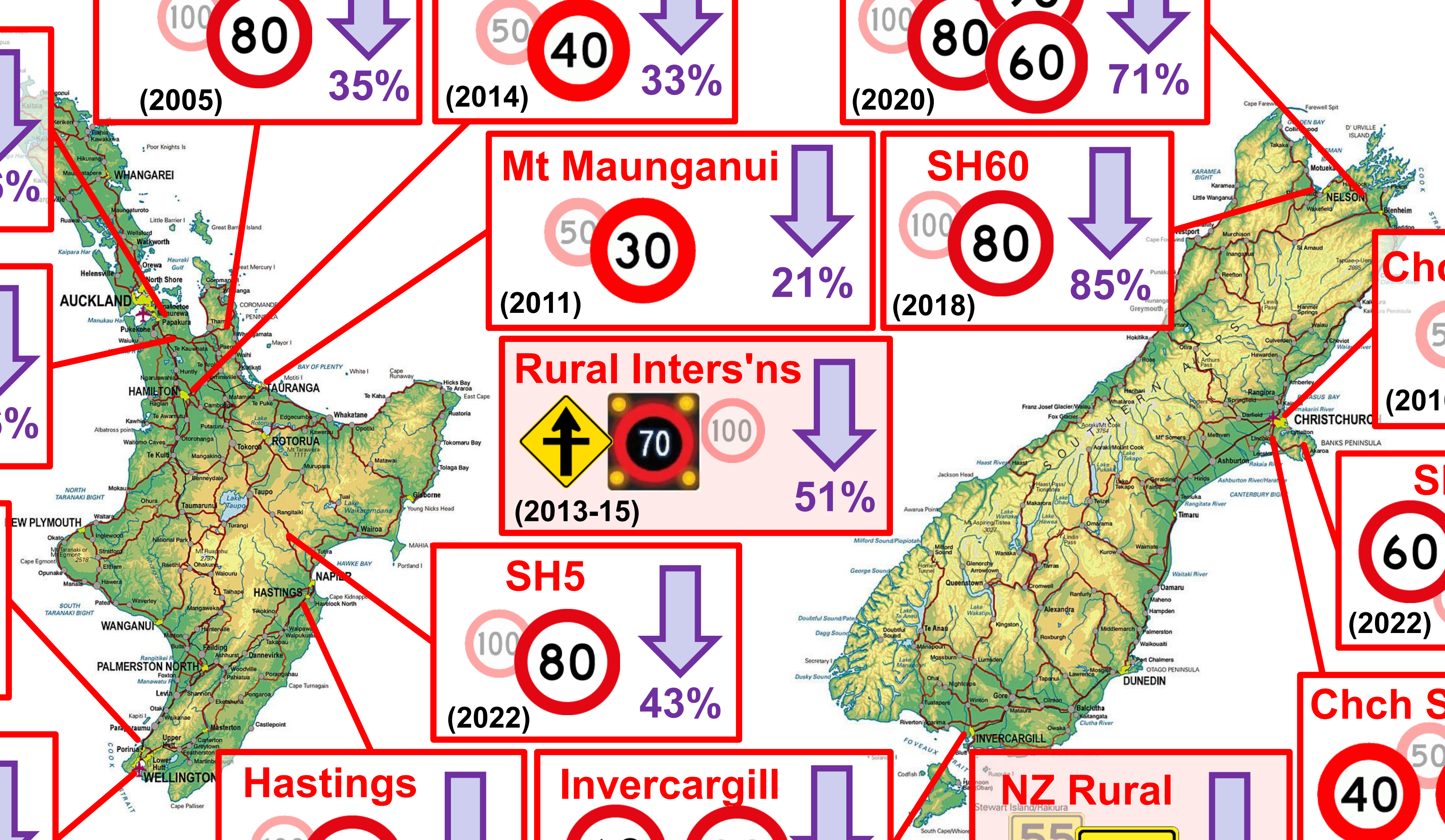
- Reductions were based on several case studies from around NZ
  - *Conservative* estimates applied to the **low/mid/high** scenarios:

	Urban Areas	Rural Areas
Low estimate	-15%	-20%
Mid estimate	-20%	-25%
High estimate	-25%	-30%

Speed vs Safety: If you want to see the evidence…

Drop in Injuries or DSIs

(up to 5 years before & after, compared with similar unchanged control site)



Akld Rural — 100 → 60 / 80 (2020) — 26%

SH2 K'hake — 100 → 80 (2005) — 35%

Hamilton — 50 → 40 (2014) — 33%

SH6 — 100 → 90 / 80 / 60 (2020) — 71%

Mt Maunganui — 50 → 30 (2011) — 21%

SH60 — 100 → 80 (2018) — 85%

Maramarua SH2 — 100 → 90 (2011) — 36%

Rural Inters'ns — 100 → 70 (2013-15) — 51%

Chch CBD — 50 → 30 (2016) — 46%

SH58 — 100 → 80 (2005) — 48%

SH5 — 100 → 80 (2022) — 43%

SH75 — 100 → 60 / 80 (2022) — 20%

Wellington — 50 → 40 / 30 (2010-16) — 38%

Hastings — 100 → 80 (2014) — 36%

Invercargill — 100 → 60 / 80 (2022) — 66%

NZ Rural — 55 MPH → 50 MPH (1973) — 26%

Chch Suburbs — 50 → 40 / 30 (2018-19) — 59%

c/ ViaStrada Dec 2024

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After all that... some Results!

- First the **Urban** speed management Options:

Total Combined Benefits	Option A	Option B	Option C	Option D
LOW Range scenario	-$1,100,432	-$3,176,504	-$674,464	-$6,616,291
MID Range scenario	-$1,527,987	-$4,610,919	-$1,158,544	-$9,803,853
HIGH Range scenario	-$2,321,460	-$7,357,613	-$2,480,006	-$15,583,985
Sign Installation Costs	**$1,100,000**	**$1,100,000**	**$1,500,000**	**$1,100,000**
Benefit/Cost Ratios				
LOW Range scenario	**-1.00**	**-2.89**	**-0.45**	**-6.01**
MID Range scenario	**-1.39**	**-4.19**	**-0.77**	**-8.91**
HIGH Range scenario	**-2.11**	**-6.69**	**-1.65**	**-14.17**

- Unfortunately, ***none*** of the options stack up economically
  - Although note the caveats discussed later...

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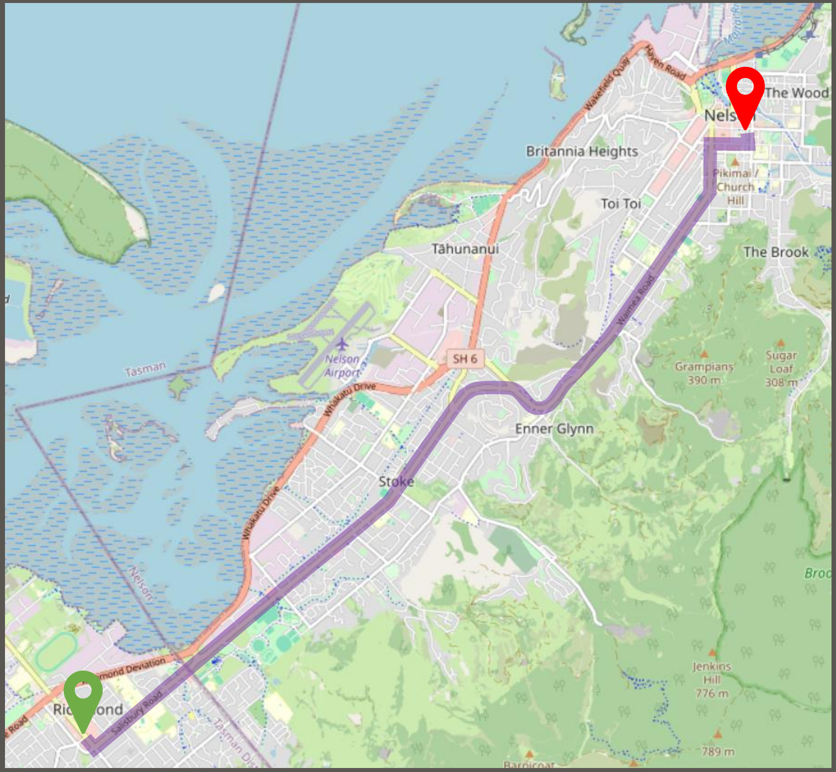
Do they really make a big difference?

- Collectively the total increases in urban travel times add up to a reasonably large figure for most options
  - BUT the ***relative*** increases in travel times overall were ***negligible***

e.g. Consider a trip from TDC offices (Richmond) to NCC offices (Nelson):

(ignoring intersection effects)

	Option A	Option B	Option C	Option D
Current travel time (secs)	957.6	957.6	957.6	957.6
Additional travel time (secs)	**3.6 s**	**18.6 s**	**9.1 s**	**19.1 s**
Percentage change	***0.4%***	***1.9%***	***0.9%***	***2.0%***



For three of the urban options, the relative changes across the whole network were ***<1.0%***

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Intangible benefits of Urban speed mgmt

- Likely to be other benefits from speed management that are more difficult to accurately quantify, including:
  - Shifts to **active travel modes** from lower speeds (safety/health benefits)
  - Reduction in **air pollution** from reduced travel (health/environmental benefits)
  - Reduction in **noise exposure** from lower speeds (health benefits)
  - Reduction in **social severance** from less/slower traffic (social benefits)

Glazener A, Sanchez K, Ramani T, et al. Fourteen pathways between urban transportation and health: A conceptual model and literature review. Jnl Transportation Health, 2021

- Recent research in Europe has highlighted several of these benefits from cities with **30 km/h limits**

Yannis, G.; Michelaraki, E. (2024). Review of City-Wide 30km/h Speed Limit Benefits in Europe. Sustainability 2024, 16

- Separate modelling work on Auckland streets around schools also found good BCRs for **permanent 30 km/h zones**

Flow Transportation (2022). High Level Economic Assessment of Strategic Approaches. Memo to Auckland Transport, Dec 2022

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Some more Results…

- Now the **Rural** speed management Options:

Total Combined Benefits	Option 1	Option 2	Option 3	Option 4
LOW Range scenario	-$211,286	$5,051,512	$6,779,590	$6,301,167
MID Range scenario	-$402,509	$6,181,486	$8,372,910	$7,495,998
HIGH Range scenario	-$856,982	$7,253,330	$9,917,814	$9,922,022
Sign Installation Costs	**$500,000**	**$1,000,000**	**$1,100,000**	**$1,200,000**
Benefit/Cost Ratio				
LOW Range scenario	**-0.42**	**5.05**	**6.16**	**5.25**
MID Range scenario	**-0.81**	**6.18**	**7.61**	**6.25**
HIGH Range scenario	**-1.71**	**7.25**	**9.02**	**8.27**

- A ***much*** better outcome! *(for 3 out of 4 at least)*
  - Notable that Option 1 (worst BCR) largely mirrors ***current*** plans under the new Speed Rule to reverse many lowered rural speed limits ***back*** to 100 km/h…

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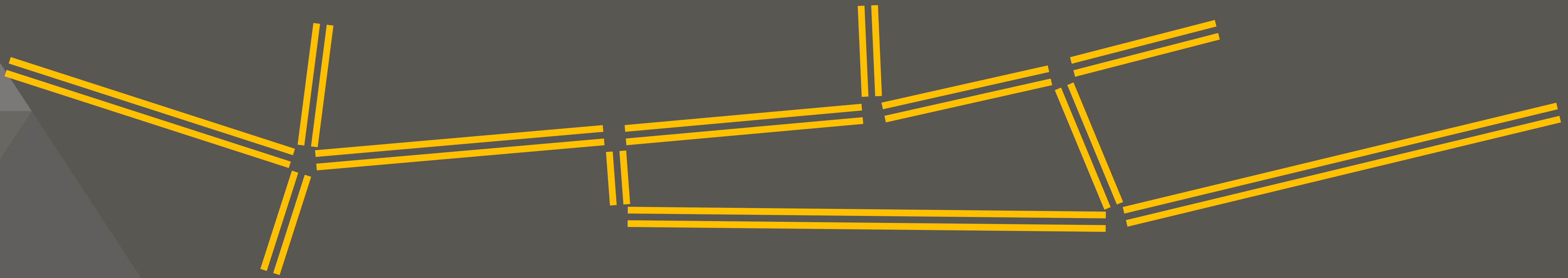
Some Challenges with the Methodology

Some limitations to the simple assessment method used in this study

- Can't capture all of the potential vagaries of each scenario, e.g.
  - Differences in speeds during peak vs off-peak times due to relative congestion
  - Delays involved in traversing each intersection (due to geometry or intersection control) - generally not expected to change greatly with speed limit changes
  - Speed changes between one road segment and the next, and the subsequent effects on acceleration, deceleration, and speed-change cycle operating costs
  - The effects of gradients on speeds and VOCs/emissions



Modelling Optimal Speed Limits
Some takeaway Conclusions

Often a simplistic “**travel time** costs vs **safety** benefits” tension when it comes to comparing different posted speed limits

- Overlooks the relative ***scale*** of each impact
- Overlooks ***other*** tangible/intangible benefits from lower speeds

For **rural** roads:

- Far more economically optimal to introduce speed limits **<100 km/h**

For **urban** areas:

- Benefits are ***less clear*** with a simplistic link-by-link assessment
- More sophisticated traffic modelling would give a more valid result
- Also investigate/quantify other intangible benefits from lower speeds

Higher speeds = Economically optimal or efficient? Yeah, nah…

Ngā mihi | Thank you!

Patai | Questions?

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