Multiple Outcomes Assessment Tool

Using What We Have to Estimate What We Might Get

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Te Kāwanatanga o Aotearoa
New Zealand Government

Problem

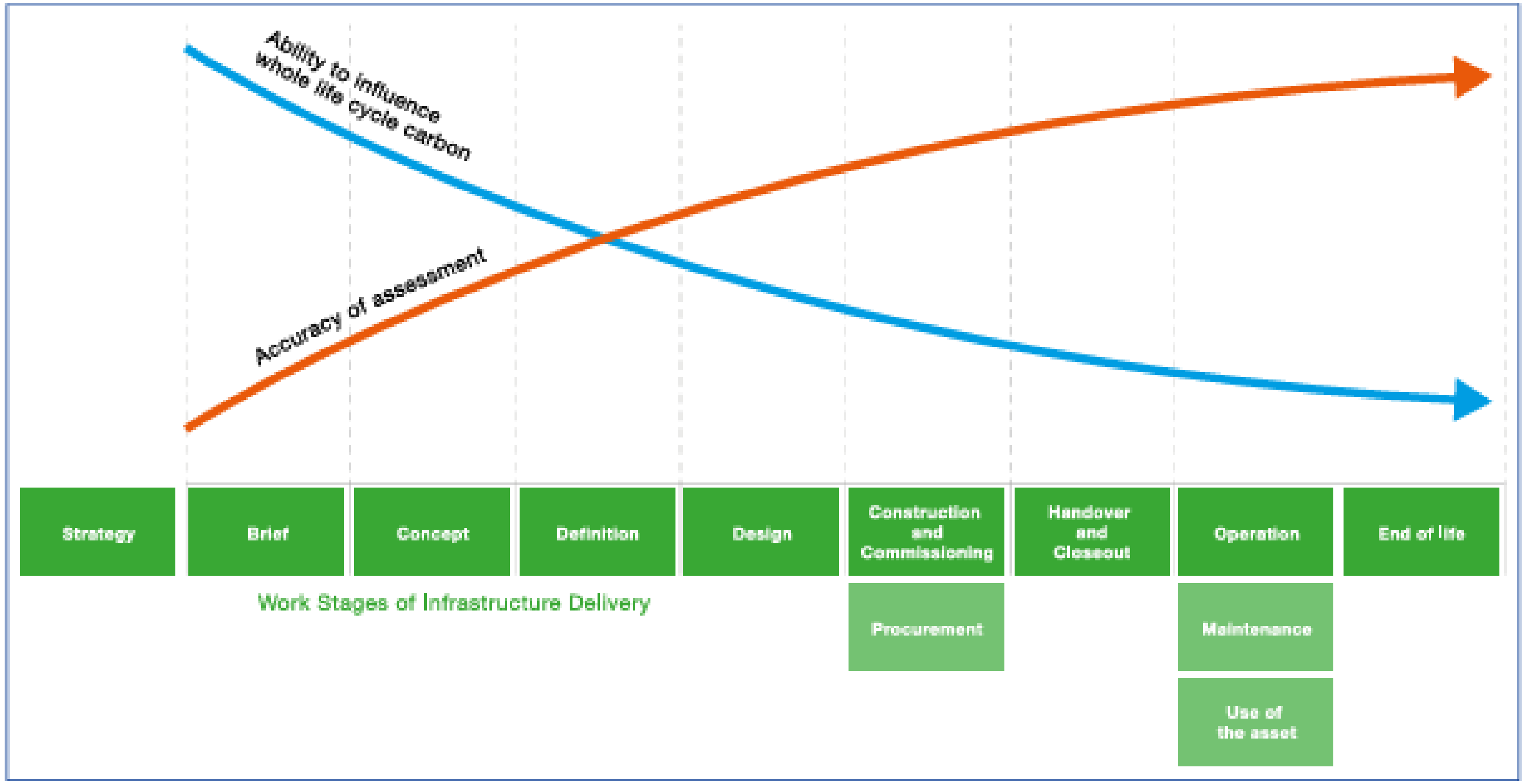
Limited ability to provide a comprehensive view of the impacts of programmes of investment in the transport system, to inform early decision-making

Questions:

- What will we get from our investments? – usually from governance level
    - Ministry of Transport
    - Responsible ministers
    - Central government politicians
    - Other interested parties
- What if we invest in a different mix of activities?
- What may this deliver and how does it align to current government priorities?

MOAT

Potential to influence outcomes – example from carbon management



*Source: PAS 2080:2016 Carbon management in infrastructure

MOAT

Constraints of Existing Analyses

- Activities at different stages of development
- Development and delivery span NLTP periods (and GPS priorities)
  - Analysis presented in terms of different priority settings
  - Subset of outcomes/ Benefits/ measures used
- Detailed analysis skewed towards obtaining funding
- Very little (if any) presentation of possible adverse impacts

MOAT

Important considerations

- Use of the Land Transport Benefits Framework
- Based on quantified impacts
- Agnostic to current priorities
- Does not ascribe value to impacts – that is applied exogenously
- Provides some understanding of potential trade-offs within and across outcomes (e.g. those that are complementary or mutually exclusive)
- A common dataset is used for all impacts assessed
- Adopts a highest common factor approach to data (and analysis) use:
  - Wind back to lowest precision
  - Keep it conspicuously crude

MOAT

Transport Outcomes Framework

- Developed by Ministry of Transport
- Aligns to the 4 pillars of the Treasury’s Living Standards Framework
- Focuses on 5 key outcomes (used for all govt departments)
- Informs the Land Transport Benefits Framework

Land Transport Benefits Framework

- Links transport investment measures and benefits to the 5 key outcomes
- Over 60 measures (mix of quantitative and qualitative) are used to cover a wide range of investments

Land Transport Benefits Framework Strategic Benefits

A set of 14 Benefit Measures chosen to represent a wide coverage of benefit types

Transport outcomes framework Benefit cluster	Benefit	Measure
Healthy and safe people	1.1 Impact on social cost of deaths and serious injuries	1.1.1 Collective risk (crash density)
		1.1.3 Deaths and serious injuries
		1.1.4 Personal risk (crash rate)
	1.2 Impact on a safe system	1.2.1 Road assessment rating – roads
Resilience and security	4.1 Impact on system vulnerabilities and redundancies	4.1.1 Availability of a viable alternative to high-risk and high-impact route
		4.1.2 Level of service and risk
Economic prosperity	5.1 Impact on system reliability	5.1.2 Travel time reliability – motor vehicles
	5.1 Impact on system reliability	5.1.3 Travel time delay
	5.2 Impact on network productivity and utilisation	5.2.2 Freight – mode share value
	5.2 Impact on network productivity and utilisation	5.2.3 Freight – mode share weight
Environmental sustainability	8.1 Impact on greenhouse gas emissions	8.1.1 CO_2 emissions
		8.1.3 Vehicle kilometres travelled (light vehicles)
Inclusive access	10.1 Impact on user experience of the transport system	10.2.1 People – mode share
	10.2 Impact on mode choice	10.3.1 Access to key social destinations (all modes)

Current Development

Outcome Cluster	Benefit Measure	Developer
Healthy and safe people	• Change in DSI • Tonnes of NO_x, PM	Abley Aurecon
Environmental sustainability	• Tonnes CO_2eq	Aurecon
Resilience and Security	• Change in NRAT score	Aurecon
Economic Prosperity	• Change in travel time and travel delay	Infometrics
Inclusive Access	• Change in mode split • Change in accessibility	NZTA – to be developed

MOAT

General Requirements

1. Independent of policy settings
2. Dealing with IMPACTS, not Benefits
3. Account for impacts over time
4. Include projects at various stages of development, including investigation, pre-implementation and implementation
5. Include both continuous programmes and improvement projects

General Approach

1. Use existing data
2. Exclude any valuation or prioritisation
3. Include impacts in all TOF outcomes
4. Use a consistent high-level viewpoint i.e. don’t use detailed analysis on individual projects (even if it exists)
5. Assume all activities in a programme will progress to complete implementation

Existing Data

Investment Activities

- Data held and managed in Transport Investment Online (TIO)
- Every activity submitted for consideration in a Regional Land Transport Plan
- Limited information at early stages of development
- Type of activity proposed (Activity Class (AC) and Work Category (WC))
- Indicative timing and cashflow
- Outcome(s) sought

Specific Impacts

- Detailed appraisal of activities in a late stage of development – skewed to funding application
- Large(ish) body of evidence from local and international research.
- Variable level of detail for different outcomes
- Use of upper and lower ranges to reflect level of uncertainty

Determining Confidence

- It is NOT accuracy, which is not able to be determined (in most cases)
- Adapted the Grade system developed for assessing medical research
- Assesses relevance, consistency, currency of the EVIDENCE used to derive specific outcomes
- Weighted by predicted cost to give composite view of confidence in the output
- Points to types of investment where evidence may be less reliable.

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abley

Multiple Outcomes Assessment Tool (MOAT)

Healthy and Safe People

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Overview

- MOAT estimates impacts of a programme of investments (e.g., NLTP) on:
  - Emissions
  - VKT
  - Resilience
  - **Safety** ← our focus
- This tool estimates impact on Health and Safe People outcomes:
  - **Change in deaths and serious injuries** (DSI), relative to counterfactual where programmed activities do not occur
  - Does not estimate absolute number of DSI
  - Programme-level estimates, not suitable for activity-level analysis

Prior work – Aurecon MVP

- Safety outcomes estimated as a function of:
  - Estimated treatment length, average DSI change and regional baseline DSI rates
- Limitations
  - Road to Zero activity class (AC) only – limited to low cost / low risk and road improvement work categories (WC), assumed to represent linear safety interventions
  - No activity-level data on urban/rural location

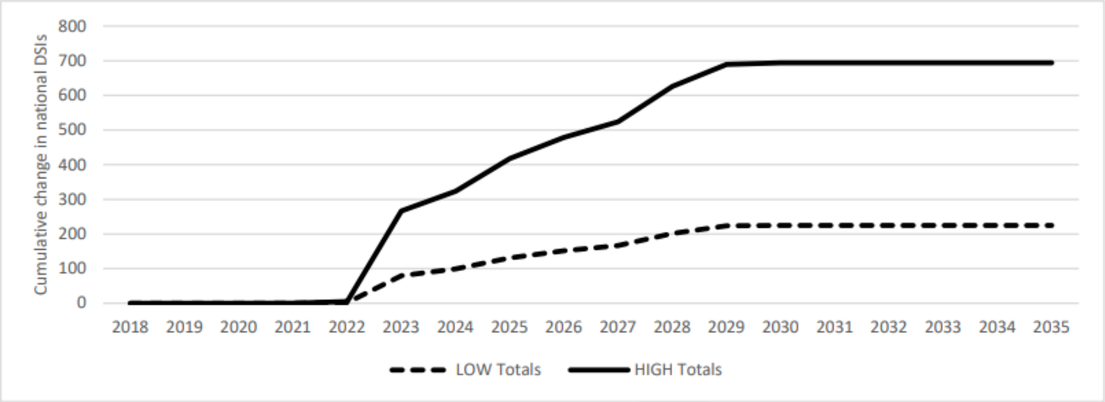


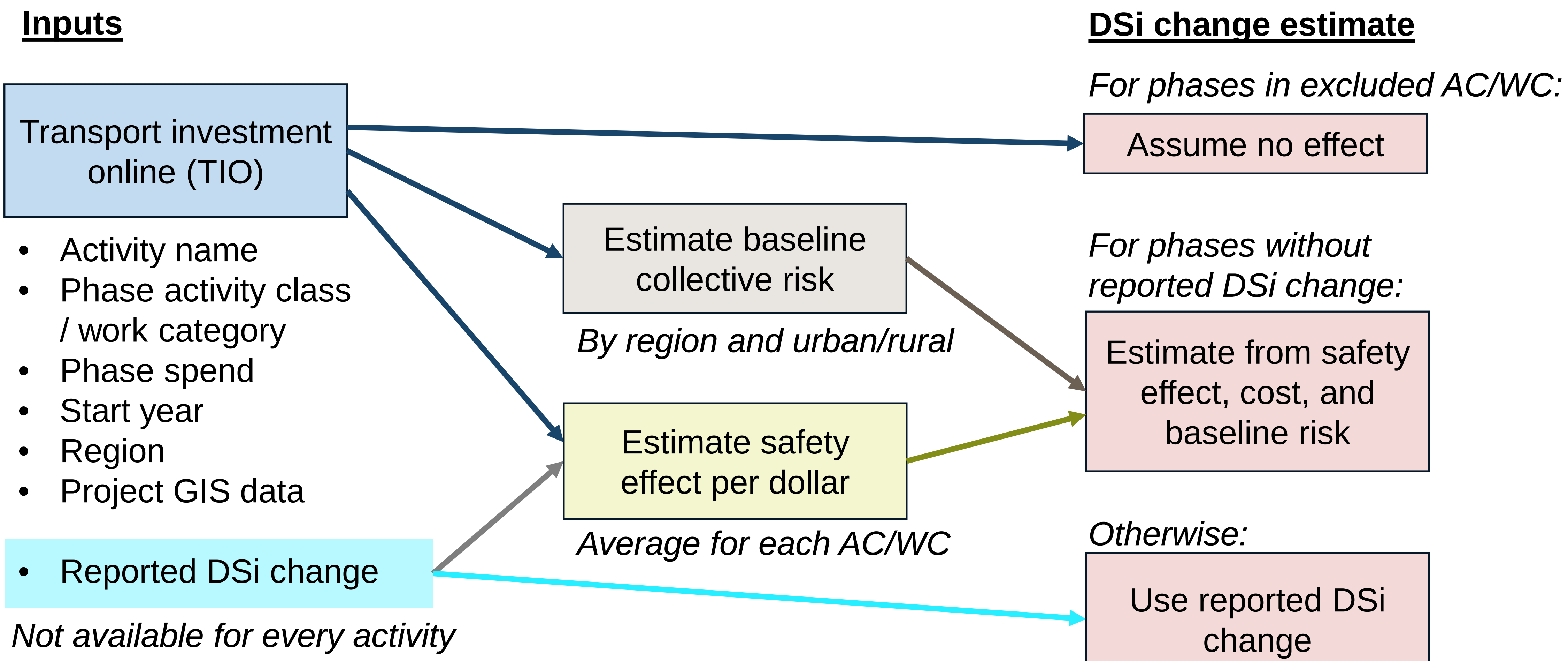
Figure 8: National DSI change estimates 2018- 2035 – Road to Zero Programme

Approach for updated tool

- Include all safety-relevant activities
  - AC/WC including maintenance, new roads, road safety promotion, network asset management, walking and cycling etc.
- Improve collective risk DSI / baseline
  - Use activity GIS and other information to estimate urban / rural for more precise baseline
- Incorporate activity-level safety effect estimates from Transport Investment Online (TIO)
  - Some activities report expected DSi change in TIO (or in business case)
  - Use this information to estimate average safety effects across a wide range of AC/WC

Project_ID	Project_Name	Measure	Primary_Benefit	Baseline	Forecast	Unit_of_measure
162011	Road Safety Promotion 2024-27	1.1.3. Deaths and serious injuries	Primary	15.0	10.0	Average annual number of deaths and serious injuries

Methodology overview



Methodology – Collective risk baseline

- Determine activity urban / rural, based on:
  - TIO geospatial data, where available
  - Otherwise assume based on: organisation name, activity class, activity name, regional / state highway network length
- Calculate ***adjusted collective risk*** by region, urban/rural, local road / state highway
  - Adjusted collective risk: combines observed risk (crash data) and predicted risk (from Infrastructure Risk Rating) based on traffic volume and crash history.
  - Recognises that historic crash data is a poor predictor of future crash risk on low volume roads.

	Urban Local Roads	Urban State Highways	Rural Local Roads	Rural State Highways
Auckland	0.38	0.70	0.19	1.17
Bay of Plenty	0.22	0.67	0.09	0.42
Canterbury	0.21	0.48	0.04	0.27
Gisborne	0.18	0.64	0.03	0.23
Hawkes Bay	0.22	0.50	0.05	0.33
Manawatu/Wh	0.18	0.60	0.04	0.37
Marlborough	0.16	0.44	0.06	0.26
Nelson	0.29	0.44	0.06	0.42
Northland	0.17	0.71	0.07	0.37
Otago	0.14	0.45	0.03	0.24
Southland	0.11	0.44	0.02	0.18
Taranaki	0.15	0.64	0.04	0.40
Tasman	0.13	0.44	0.06	0.27
Waikato	0.19	0.53	0.08	0.45
Wellington	0.29	0.79	0.07	0.45
West Coast	0.05	0.44	0.02	0.15

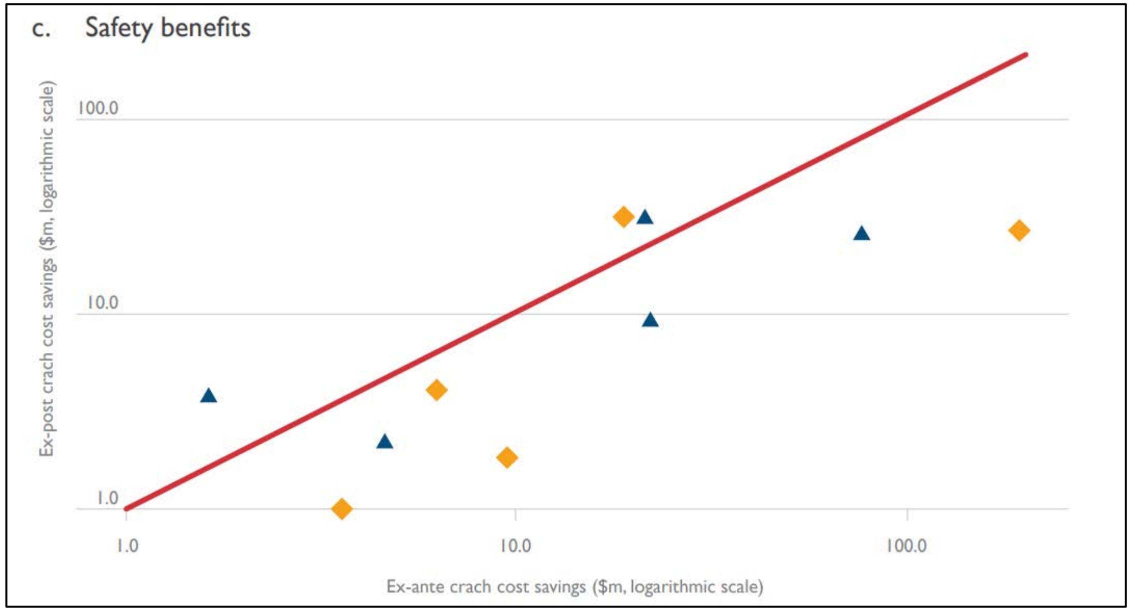
Methodology – DSi reduction estimate

- Exclude phases with AC/WC assumed to have insignificant or ambiguous safety impact – e.g., Debt funding, investment mgmt., PT infrastructure/services, property purchase, etc.
- Where available, use TIO-reported DSi change
- Otherwise, estimate DSi change from average *safety effect*
  - Take average of TIO-reported DSi reductions for other activities in same AC/WC (as of 2025 snapshot)
  - Scale by phase spend and collective risk baseline
    - Assumes: larger spend or baseline risk → larger DSi reduction

Methodology – Adjustments and low/high values

- For activities with TIO-reported DSi change
  - International evidence indicates safety benefits are often overstated
  - Assume low estimate of DSi change is 40% smaller than reported
- For phases with DSi change estimated from safety effect
  - Low/high range comes from confidence interval of average safety effect
  - Adjust based on whether safety is reported as a primary or secondary benefit.

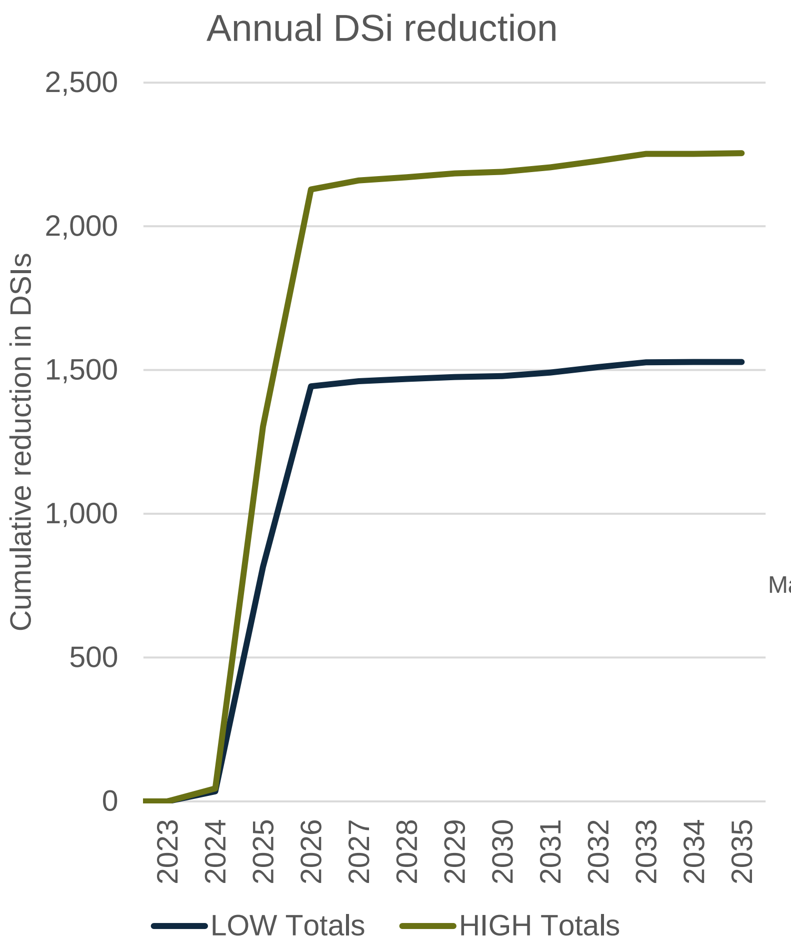
Ex-ante vs ex-post safety benefits for a sample of Australian projects

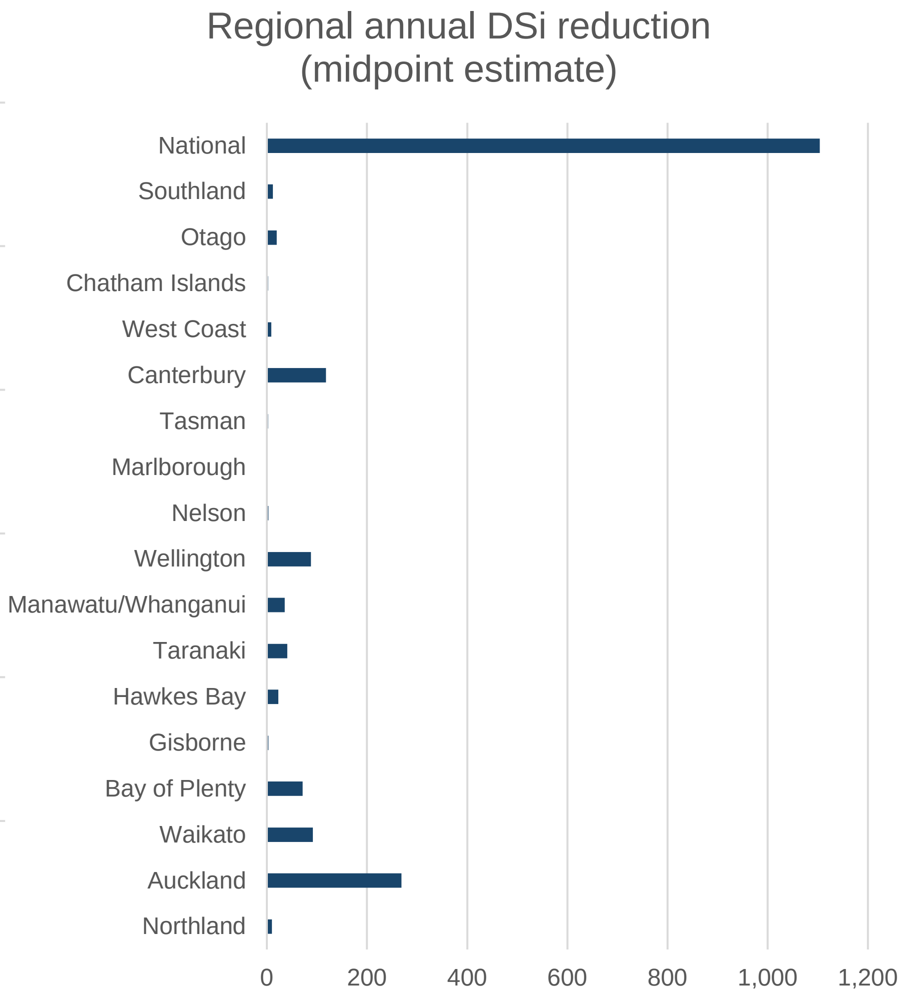


Source: BITRE (2018)

Results – March 2025 NLTP snapshot

Program elements
Safety Cameras
New State Highways (RONS)
Local Road Safety Improvements
State Highway Improvements
Speed Management
Maintenance and Safety Preservation
Other Projects



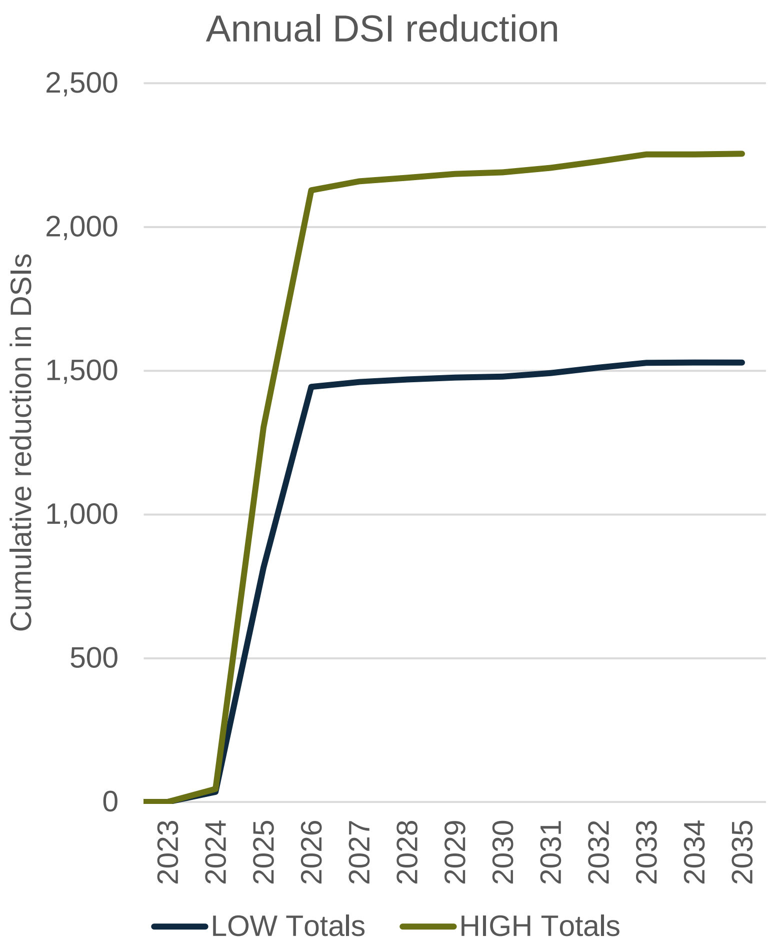


Limitations

- Reliance on TIO reporting
  - TIO safety benefits used as a pragmatic estimate of safety benefits for disparate activity types, but data quality is uncertain
  - TIO reporting is a biased sample – activities unlikely to report negative safety outcomes
- Cost scaling assumption: Higher spend → greater DSI change
  - May not be appropriate for some activity types
- Assumption of independent DSi changes
  - Activities will have combined impacts on safety where they overlap – e.g., national-level activities will reduce baseline risk for local/regional interventions
  - TIO does not define the do minimum assumed when evaluating activities – may be some double-counting

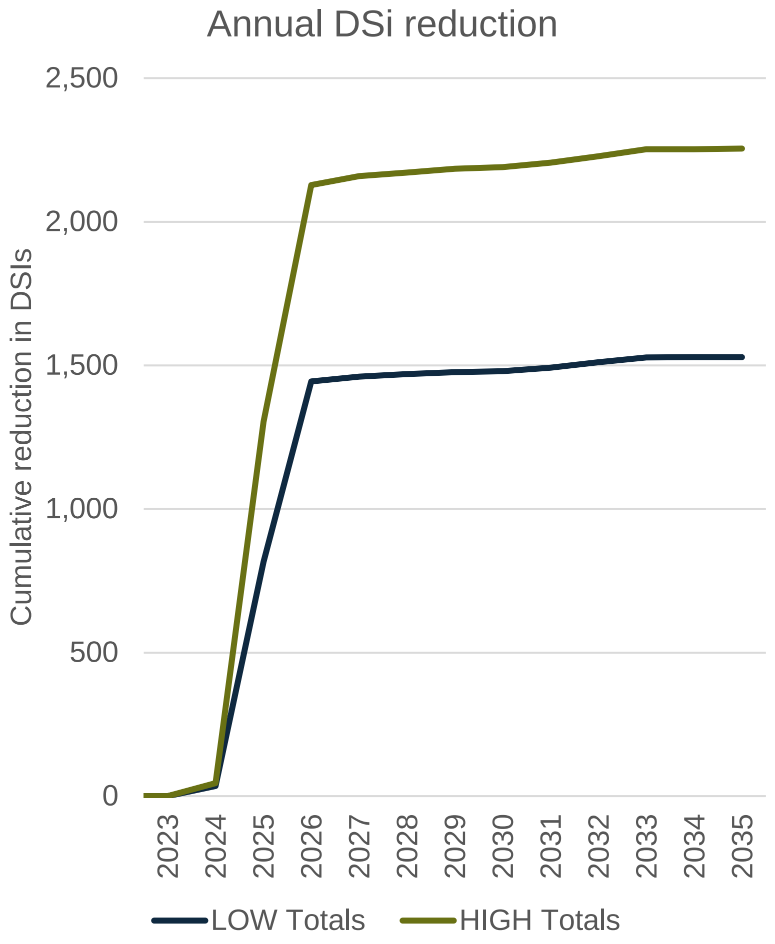
Potential improvements

- Validate and improve safety estimates
  - Use bespoke safety estimates for broad, low-cost activities such as speed management or safety promotion
  - Cost scaling assumption may not be appropriate for these activities
- Estimate absolute injury trends
  - Apply DSI reduction estimates to baseline DSI trend predictions, including effect of anticipated VKT (including due to NLTP changes)
- Adjust for potential double-counting
  - One option: apply DSI change from national/regional projects before estimating local project effects



Key takeaways

- Modelled range of expected reductions (for provided TIO snapshot – not finalised NLTP):
  - 1500-2300 reduction in annual DSI
- Evidence strength
  - Higher confidence in estimates for large projects with published business cases, e.g. RONS
  - Lower confidence for lower-spend national programmes – speed management, safety promotion
- Uncertainties
  - Bias in TIO reporting, particularly for projects with negative safety impacts



Economic Property

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Travel Time and Travel Time Delay in NZTA's MOAT model

A model to estimate changes in travel time and travel time delay for motor vehicles, resulting from new roads (WC 323) for state highways (AC 13) and local roads (AC 12), for an entire NLTP.

Presentation to
Transport Conference
March, 2026

Adolf Stroombergen
Infometrics

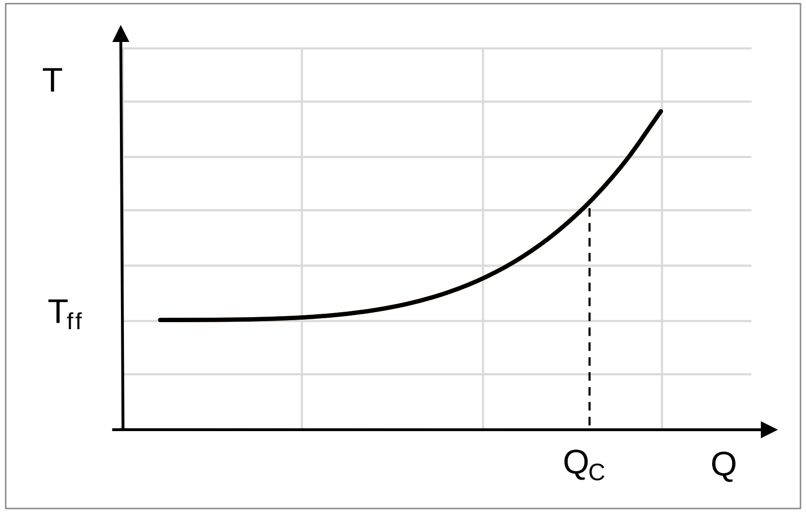
Infometrics

Travel Time and Travel Time Delay in the MOAT model

The model for travel time and travel time delay uses the function developed by the US Bureau of Public Roads:

$$TT = TT_{ff}\left[1 + \alpha\left(\frac{Q}{Q_C}\right)^{\beta}\right]$$

TT is travel time
TT_{ff} is travel time with free flowing traffic
Q is the average amount of traffic (number of vehicles per hour per lane)
Q_C is the capacity amount of traffic (number of vehicles per hour per lane). $Q<Q_C$
α and β are parameters which differ by type of road



Spreadsheet Version of TD/TTD Model

Travel time tool: proof of concept

Enter user-defined values in cells shaded orange. Ouput is in cells shaded green.
All projects are normalised to be 1km in length and based on hourly traffic flows.
Select LA/region, road type, traffic flow, flow-capacity ratio and budget.
Full model will automatically run for multiple locations, road types, and congestion.
Model solves the equation to the right for TT.

$$TT = TT_{ff}\left[1 + \alpha\left(\frac{Q}{Q_C}\right)^{\beta}\right]$$

	Do Minimum (1000 vehicles/hr over 1 km)		
	Local authority or region	Auckland	
	Region	Auckland	
	$/Lkm new road cost	2,169,000	(from MOAT)
	Total NLTP investment $m	20000	$m
	Regional or LA share	36.70%	
Lkm	Distance (default)	1.0	km
	Base VKT/hr on selected road(s) at congested time:	1,900	vehicle/hr over 1km
Q/Qc	Ratio of actual flow to capacity	0.96	
	Is this for bus travel time (yes/no)?	no	
	Road type	H100	Use drop-down menu for best fit. Refer to box on right
	Speed limit	100	km/hr
TT_{ff}	Free flow travel time	0.0100	hours per vehicle
	or equivalently	0.600	minutes per vehicle
α	Alpha	0.21	
β	Beta	8.60	
TT	Travel time	0.690	minutes per vehicle
TTD	Travel time delay	0.090	minutes per vehicle
	Implied speed	87.0	km/hr

	Type	Speed	Signals (No./km)
H100	Highway - single lane	100	
M110	Motorway - multilane	110	
M100	Motorway - multilane	100	
M80	Motorway - multilane	80	
A80L	Signalised arterial	80	0.33
A80M	Signalised arterial	80	1.0
A80H	Signalised arterial	80	2.5
A70L	Signalised arterial	70	0.5
A70M	Signalised arterial	70	1.0
A70H	Signalised arterial	70	2.0
A50L	Signalised arterial	50	4.0
A50M	Signalised arterial	50	5.0
A50H	Signalised arterial	50	6.0

	Intervention		
ΔLkm	Change in lane capacity, km	1.00	(use 1 for a doubling, etc)
Qc	New capacity	3958	
ε	Elasticity, VKT v Lkm	0.50	(from MOAT)
ΔQ	Change in Q (VKT)	950	(using MOAT approach)
Q/Qc	Ratio of flow to capacity	0.720	
	Total vehicles/hour	2850	
TT	Implied travel time	0.608	minutes per vehicle
TTD	Travel time delay v free flow	0.008	minutes per vehicle
ΔTT	Change in travel time	-0.082	minutes per vehicle
ΔTTD	Change in travel time delay v Do Min	-0.082	minutes per vehicle (must be same as ΔTT)

Scale for annual and cumulative effects		
No. hours per day affected	12	
No. days per year affected	350	
Total change in TT and TTD per year	-16,359	hours/yr
For how many years	40	years
Discount rate	2.0%	%pa
Undiscounted total	-654,340	hours over time
Present value	-456,445	hours over time

	Scale for investment budget		
ΔLkm	Implied No. new projects of 1 Lkm	3,384	
	Total change in TT and TTD per year	-55,362,742	hours/yr
	Undiscounted total	-2,214,509,674	hours over time
	Present value	-1,544,763,822	hours over time

Used to test proof of concept:

- Applies to only one new road in one location at a time.
- Normalised to new roads 1km in length.
- And no. vehicles per hour.
- Scales up the results by 12 (for congested hours during the day) and by 350 days per year. Both values may be altered by the user.
- Can allow for induced demand.

Spreadsheet to GAUSS to R

R Version of TD/TTD Model

```
# define input variables -----------------------------------------------------

# Below are budget in $m, hrs/day congestion, days/year congestion
budget_millions <- 20000
congestion_hours_per_day <- 12
congestion_days_per_year <- 350

#correlation between congestion and induced demand elasticity
rho <- 0.0

monte_carlo_iterations <- 1000L


# define file paths --------------------------------------------------------

path_moat <- "MOATLA80.csv"
#Cols are local road %, state highway %, mapping from TAs to regions,
#cost per new lane km, traffic flow per hour, region v LA
#The first 2 cols can also be obtained using the TIO.R file instead.

path_bpr <- "BPR.csv"
# cols are speed, alpha, beta, share, road type

path_mstats <- "MStats.csv"
path_region_labels <- "MRegionsLAs.csv"


# define functions -------------------------------------------------------------

weighted_select <- function(weight_vector, proportion) {
  which.min(proportion > weight_vector)
}



AND MORE
```

Minimum Viable Product

- Applies to entire NLTP.
- Can input data manually or automatically from a TIO file.
- Spatially disaggregated by region and local authority.
- Uses Monte Carlo simulation to provide error margins.

See the Guidance paper.


Incorporating Travel Time and Travel Time Delay into the MOAT Model:

Model Guidance

for New Zealand Transport Agency

6 June 2025

Infometrics
Economics put simply

How does the TT/TTD model work?

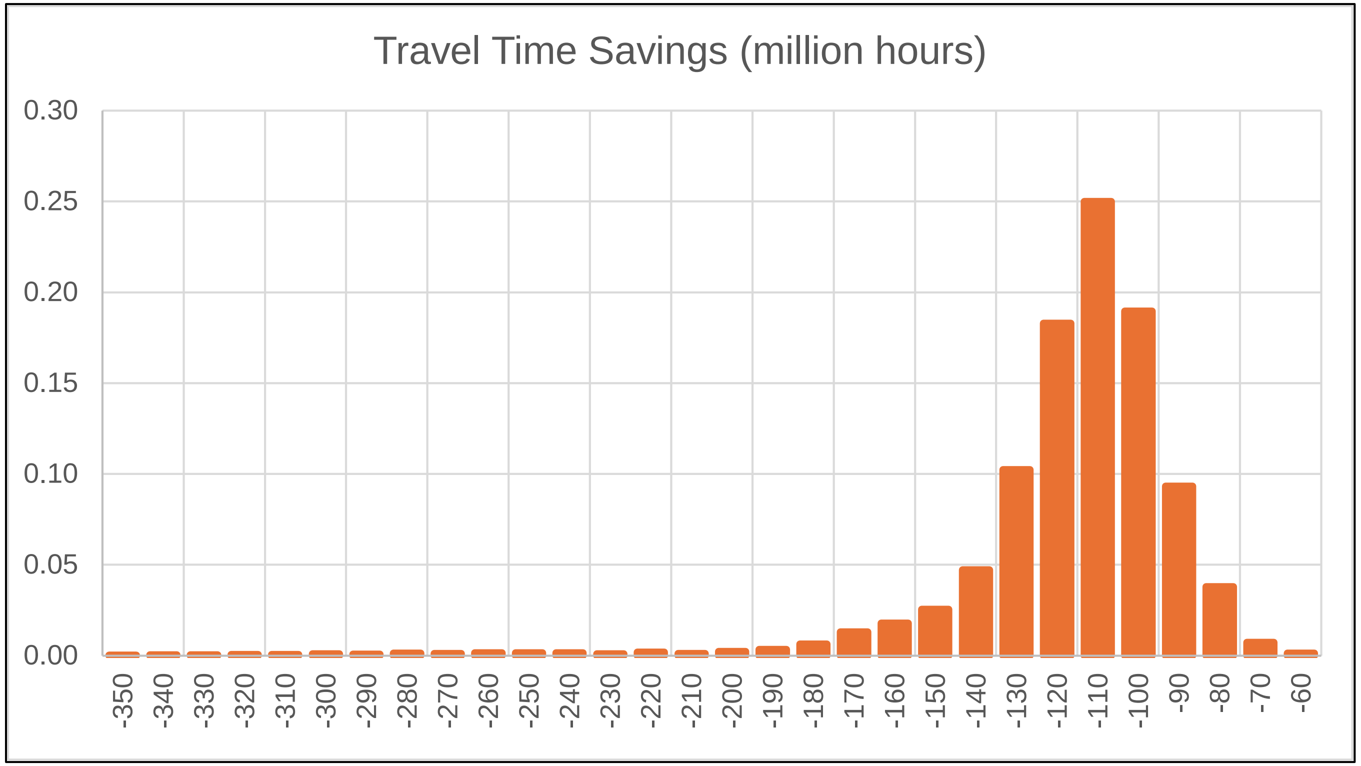
In each iteration the model calculates the changes TT and TTD for each of the 80 locations, weighted by the exogenous (NLTP) budget shares and the implied number of 'projects' (of 1 Lane km) that can be combined.

Within each iteration the following occurs:

- The type of road for each location is drawn from the distributions derived from the NLTP (state highway & local road, plus additional BPR detail).
- The congestion ratio Q/Qc is drawn from a triangular distribution with mode 0.95 and bounds of 0.90 and 0.99.
- The elasticity of VKT with respect to changes in Lkm is drawn from a triangular distribution with mode 0.60 and bounds of 0.10 and 0.90.
- Covariance between congestion and induced traffic may be set by the user.
- Traffic flows per hour by location are drawn from triangular distributions with means derived from NZTA data and bounds of ±20%.

To accommodate uncertainty the model then repeats the whole process multiple times. The default is 10,000, but that may be changed by the user.

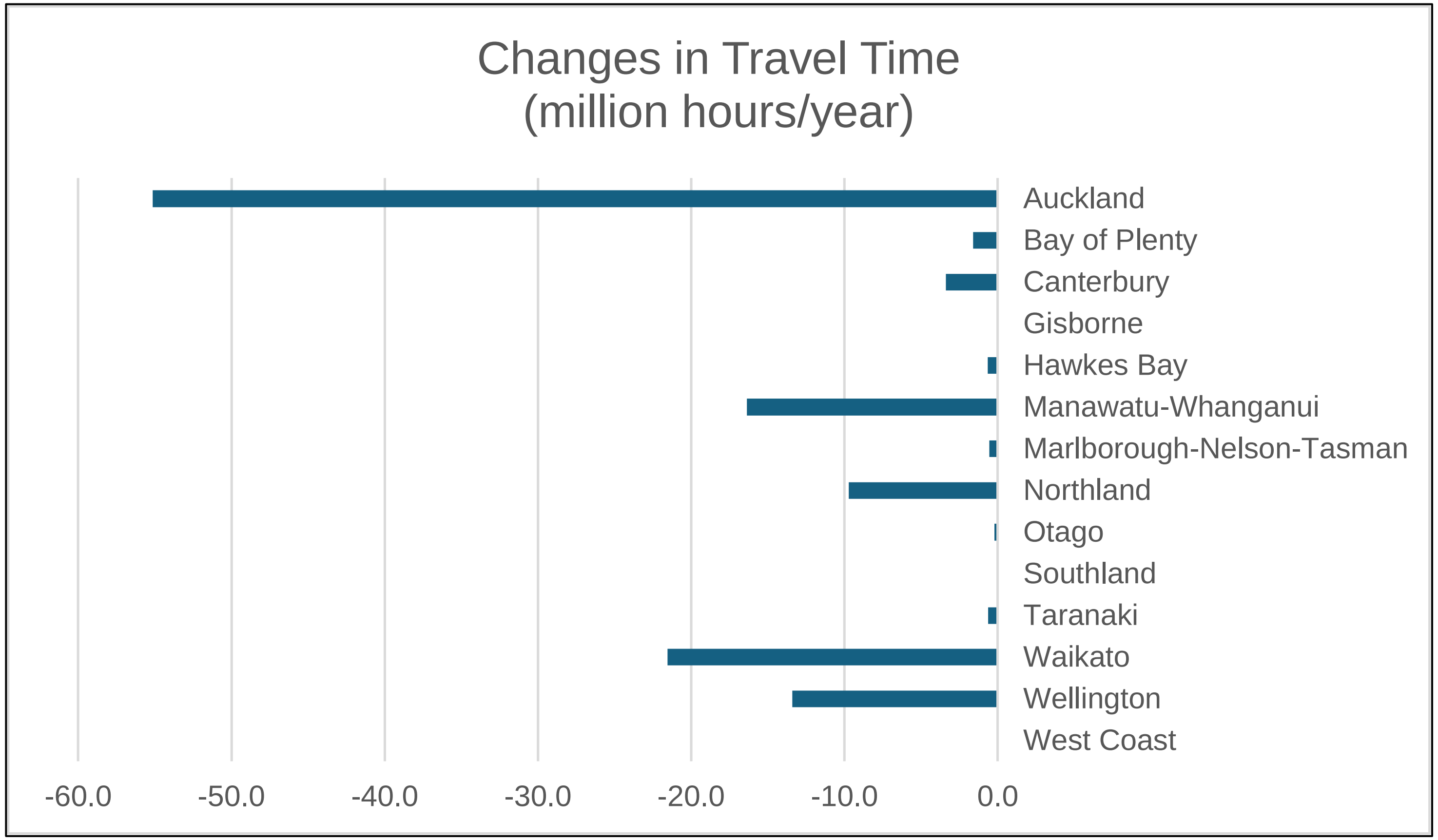
Change in annual travel time (NLTP)



Distribution allows us to derive travel time savings:

- Mean: -123 million hours
- 5th percentile: -165 million hours
- 95th percentile: -91 million hours

Change in annual travel time (NLTP)



Note: Change in travel time is equal to change in travel time delay.

Challenges in model development

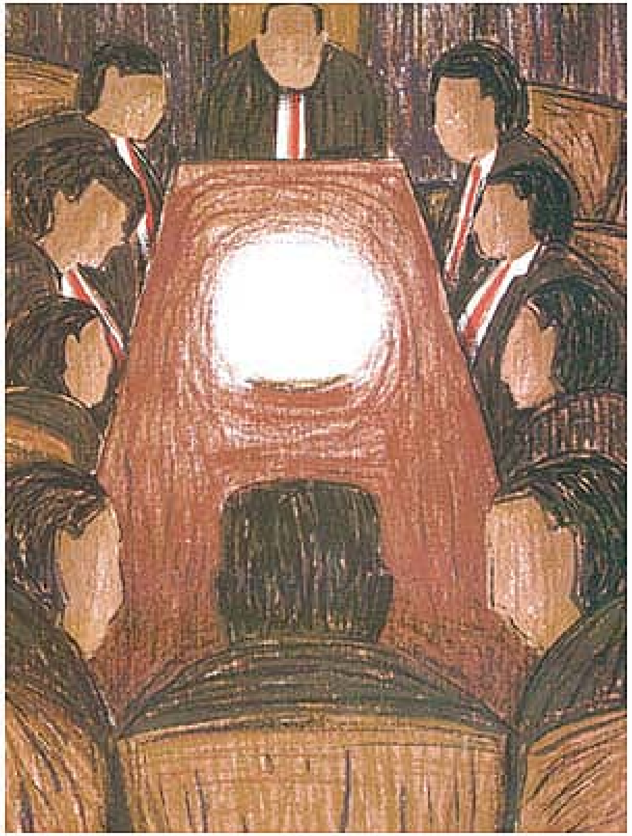
- Many data sources to reconcile:
  - TIO
  - Regional data
  - SHTV-2016-2020-all-regions
  - PS Roads Lane km
  - NLTP
  - Various NZTA research reports
- Only two road types in the NLTP – state highways and local roads – not sufficiently disaggregated for the 9 types in the TD/TTD model.
- Spatial allocation (by region or LA) of the 9 road types.
- Hourly traffic flow at each location for the hours for which a road is congested.
- Conversion from GAUSS to R (the former is more efficient).
- Model would benefit from (ongoing) calibration.

Cautions

- All models are abstractions of reality. The TD/TTD model is intended to provide broad estimates of changes in travel time for large packages of new roads, such as in the NLTP.
- Applying the model to individual projects is unwise as the error margins would be considerably wider.
- The BPR function does not reallocate traffic between routes in highly congested situations. It should not be used if Q/Q_C >100%.
- Alternatives to the BPR function may be worth investigating.

Possible extensions

- Incorporating road improvements (WC 324).
- Allow for mode shift from other WC classes if significant enough to affect travel time for motor vehicles.
- Explicitly allow for changes in VKT over time when projecting TT/TTD to future years. Compare errors in forecasts of TT/TTD and VKT.



Summary

- The TD/TTD model is based on a simple relationship between vehicle speed, the amount of traffic and lane capacity.
- For analytical purposes it disaggregates large NLTP programmes of investment in new roads into smaller components, but applying the model to individual projects is unwise as the error margins at such fine levels are too wide.
- Monte Carlo analysis plays a very useful role in understanding uncertainty.
- The model would benefit from ongoing calibration of its parameters as its application increases.

Lessons

- Because the various data sources were not developed with MOAT in mind, reconciling data from different sources was time-consuming. That will hopefully be ameliorated as use of the tool increases.
- Developing a workable model (such as for TT/TTD) is one thing. Integrating that into the protocols and software used in MOAT was quite another challenge.

Resilience and Security

Liz Root and Ernest Zheng

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aurecon
Bringing ideas to life

Te Kāwanatanga o Aotearoa
New Zealand Government

Two resilience ‘tools’

Proof of concept

1. NRAT resilience risk reduction	Provides regional insights on resilience benefits ie potential risk reduction from resilience building on transport network	Uses three data sources: 1. NRAT 2. NLTP extracts from TIO 3. TIO project location data
2. Alternative route	Provides an understanding of the proportion of high risk, high impact routes with viable alternatives	Uses three data sources: 1. NRAT 2. NLTP extracts from TIO 3. NZ Detour tool

NRAT – National Resilience Assessment Tool

TIO – Transport Investment Online

Methodology – Data

Resilience Risk Reduction

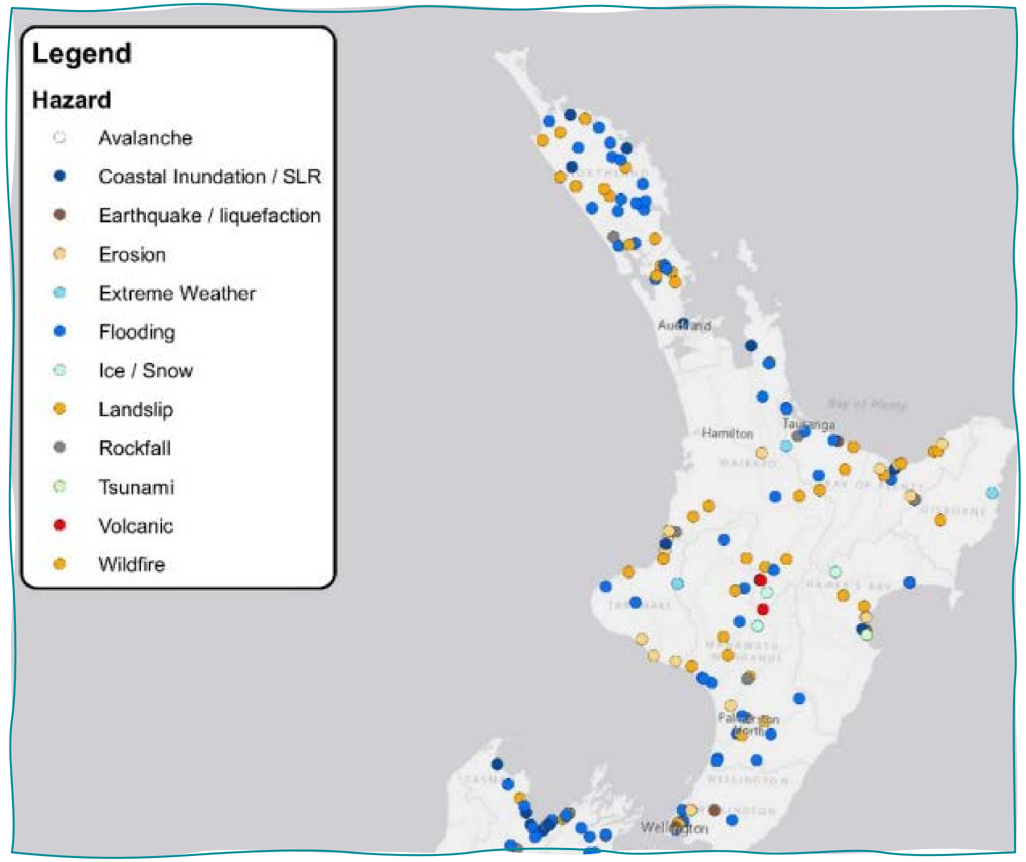
Uses three data sources:

1. NRAT
2. NLTP extracts from TIO
3. TIO project location data

Several different data points from each source:

1. **NRAT:** residual risk score, all elements of NNDRS, region data, types of risk, estimated cost to mitigate, and coordinates.
2. **NLTP:** Portfolio level extract of projects and related information
3. **TIO project location:** project locations [project id, geo_string]

Data sources



NRAT

Table 2: National Network Disruption Risk Score inputs and weightings matrix

Fibonacci Weighting	Consequence criteria						Likelihood
	Scale of Outage	Duration of Outage	ONRC[15]	Lifeline Criticality	Detour Length if Closed[16]	AADT	
1				Low	Short (<30mins extra time)	<1000	
2	Partial closure	<12 hours	Primary/ secondary collector			1001-5000	Rare (>1 in 50yr)
3		12-48 hours		Medium	Moderate (30-90 mins extra time)	5001-10,000	Unlikely (1 in 30 yr)
5		48 hrs to 7 days					
8	Full closure	7 days to 1 month	Regional/ arterial			10,001-20,000	Possible (1 in 10yr)
13		1-3 months		High	Long (>90mins extra time)	20,001-40,000	Likely (1 in 5yr)
21		3-6 months	National (including High Volume)		None	>40,000	Almost certain (<1 in 2yr)
34		>6 months					

NNDRS

Methodology – Logic

Resilience Risk Reduction

How much is potential risk reduced through investment:

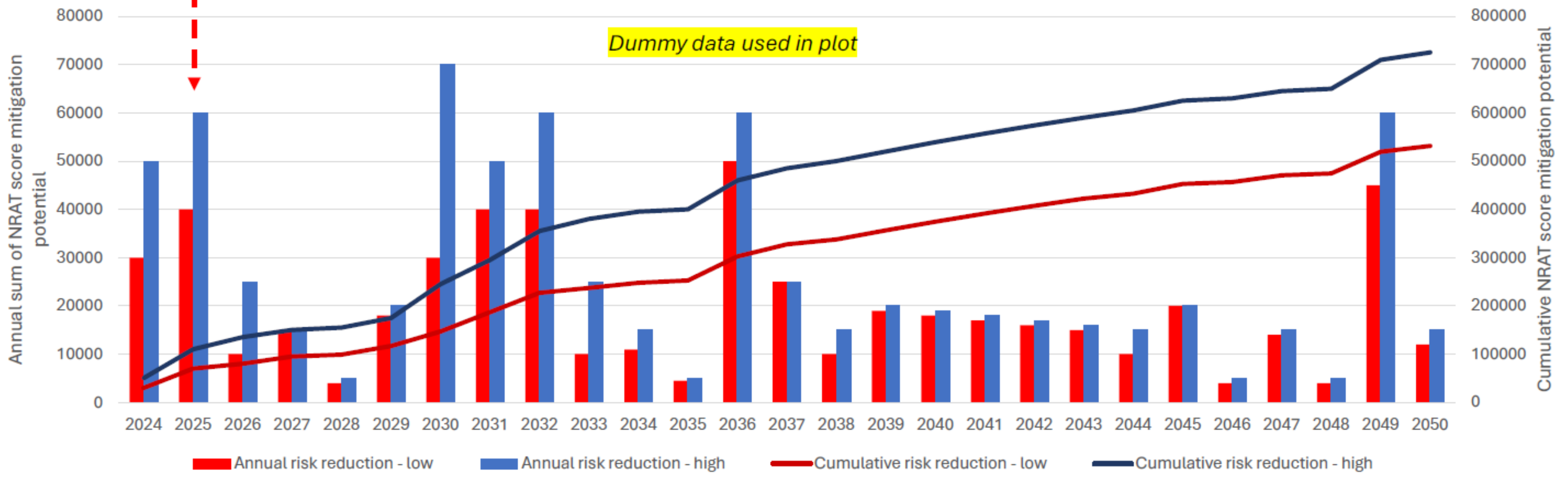
- Assumes: if a TIO project and NRAT risk location overlap, the individual risk likelihood is reduced
- When TIO data extracts are run through the tool, the output produces:
  1. a quantitative count on the amount of risk reduced,
  2. what types of hazards are potentially being addressed, eg hydrological, geological, flooding, and
  3. the potential cost to mitigate and the remaining risk and remaining cost.

Output mock-up

Resilience Risk Reduction

Local government region	Activity name	Total Expected Implementation Cost	Start year	End year	NRAT score (pre-intervention)	Residual NRAT score – high estimate (post-intervention)	Residual NRAT score – low estimate (post-intervention)
Wellington	Programme A	$1.03B	2012	2025	684	310	395

Summed NNDRS score feeds directly into the dashboard. Year of risk mitigation is assumed to be realised at the end year



Methodology – Data

Alternative Routes

Uses three data sources:

1. NRAT
2. NLTP extracts from TIO
3. NZ Detour tool

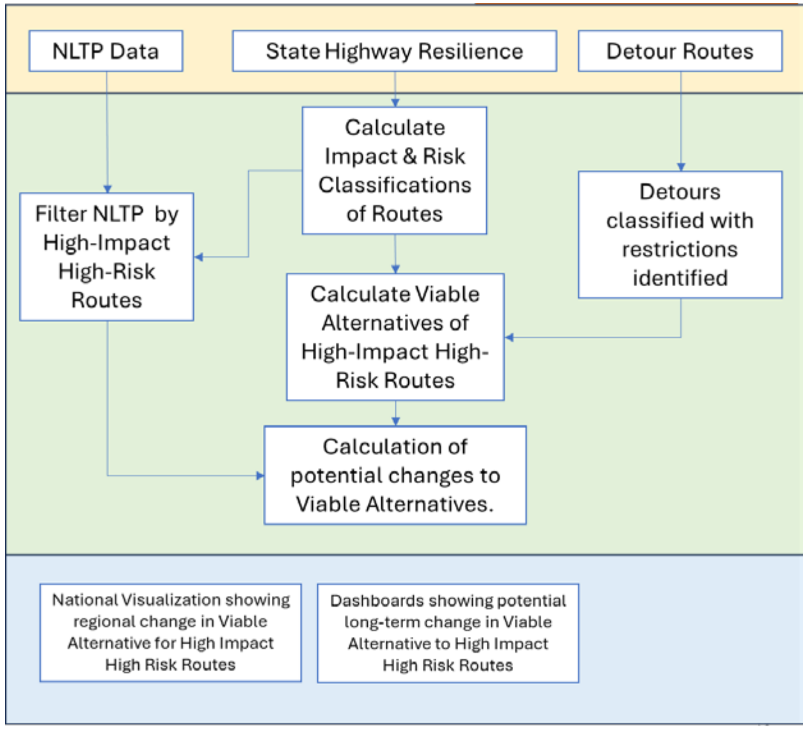
Several different data points from each source:

1. **NRAT:** residual risk score, region data, types of risk
2. **TIO data:** project locations and portfolio level extract of projects and related information
3. **NZ Detour Tool:** routes, detours and restrictions such as weight, length and one way flow restrictions

Methodology – Logic

Alternative Routes

- Screening for “High-impact” and “High-risk” State Highway routes* + current restrictions of alternative routes not yet classified as viable to create baseline
- **Intent** to produce ‘measure of potential improvement’ from investment on the estimate of Viable Alternatives Potential of High-Impact High-Risk Routes via:
  - increasing the amount of viable alternatives
  - reducing the Risk or Impact of Routes



* where impact relates to ONRC and risk relates to ONRC and disruption

ONRC – One network road classification

Uncertainty / Limitations

Resilience module

Quality of data in impacts quality of data out

- ‘Invalid projects’ excluded from scores i.e. projects where any of the required data points are missing
- Highly dependent on data sources that are live, with different users, but being used at ‘point in time’
- Assumptions may not always be true

Maturing the tool

Resilience module

Further develop the resilience workstream, including a specific module for major projects

Increase tool accuracy using spatial data where possible

Expand resilience assessments to include benefits from improving alternative routes

Pilot natural language processing of text fields to better categorise and analyse projects (initially for CO_2 emissions).

Environmental Sustainability

Liz Root and Ernest Zheng

NZ TRANSPORT AGENCY WAKA KOTAHI

aurecon Bringing ideas to life

Te Kāwanatanga o Aotearoa
New Zealand Government

GHG / Carbon assessment

Detailed Design

1. **Embodied carbon**
2. **Enabled / abated carbon**

Provides GHG 'quantification' at a high level

Uses two data sources:

1. NLTP extracts from TIO
2. existing research commissioned by NZTA

GHG – Greenhouse gases

TIO – Transport Investment Online

Methodology – Data

GHG

Uses two data sources:

1. NLTP extracts from TIO
2. existing research commissioned by NZTA

Several different data points from each source:

1. **TIO:** AC and WC codes, region, timing, phase type and expected cost.
2. **Existing research:** VEPM, Carbon Emission Baseline Recommendations for New Zealand Infrastructure Projects (NZ Transport Agency, AECOM, 2023) et al

AC – Activity Class

WC – Work Category

VEPM – Vehicle Emissions Prediction Model

Methodology

Building the GHG module

1. compiled existing transport research into an **evidence base**

2. refined the evidence base for **ΔVKT** of light & heavy fleet

3. built logic for **high & low emissions** outcomes based on the ΔVKT figures

4. deployed the MOAT logic in PowerBI and linked it to Waka Kotahi databases & forecasts

Methodology – calculations

GHG (carbon)

$$\text{Annual embodied carbon} = \frac{\text{(construction emissions intensity * project cost)}}{\text{years of construction}}$$

Annual enabled/abated carbon = AC/WC-dependent change to VKT per unit (unit/$) * project cost ($) * region/evidence-specific translator * vehicle emissions intensity

High and low estimates

MOAT tool

- MOAT produces high and low estimates of emissions associated with transport investment portfolios over the medium and long-term.
- This indicates how the results could vary depending on the policies implemented alongside the infrastructure, and reflecting the inherent uncertainty in the model.

Output example

Local government region	Number of Projects	Total Cost ($)	Projected GHG Emissions [tCO2e] - Best case	Avg. Grade Best case	Projected GHG Emissions [tCO2e] - Worst case	Avg. Grade Worst case
Auckland	753	$51.1B	15.5M	2.65	25.7M	2.65
Waikato	856	$9.47B	2.44M	2.62	4.07M	2.62
Wellington	549	$8.72B	1.57M	2.60	2.65M	2.60
Northland	389	$4.46B	1.12M	2.74	1.77M	2.74
Bay of Plenty	443	$5.24B	590K	2.64	1.07M	2.64
Canterbury	632	$4.65B	397K	2.67	1.03M	2.67
Taranaki	218	$797M	151K	2.60	240K	2.60
Manawatu/Wanganui	440	$2.04B	96.3K	2.61	196K	2.61
Hawkes Bay	255	$676M	65.8K	2.69	148K	2.69
West Coast	207	$301M	21.8K	2.88	26.5K	2.88
Nelson	107	$258M	18.5K	2.73	51.2K	2.73
Tasman	120	$165M	11.8K	2.93	12.7K	2.93
National	55	$1.61B	9.23K	2.59	22.6K	2.59
Gisborne	147	$414M	6.20K	2.78	29.4K	2.78
Southland	152	$357M	4.32K	2.90	6.19K	2.90
Marlborough	108	$296M	-28.3K	2.66	29.6K	2.66
Otago	468	$1.65B	-59.1K	2.63	198K	2.63
Total	5899	$92.2B	21.9M	2.65	37.3M	2.65

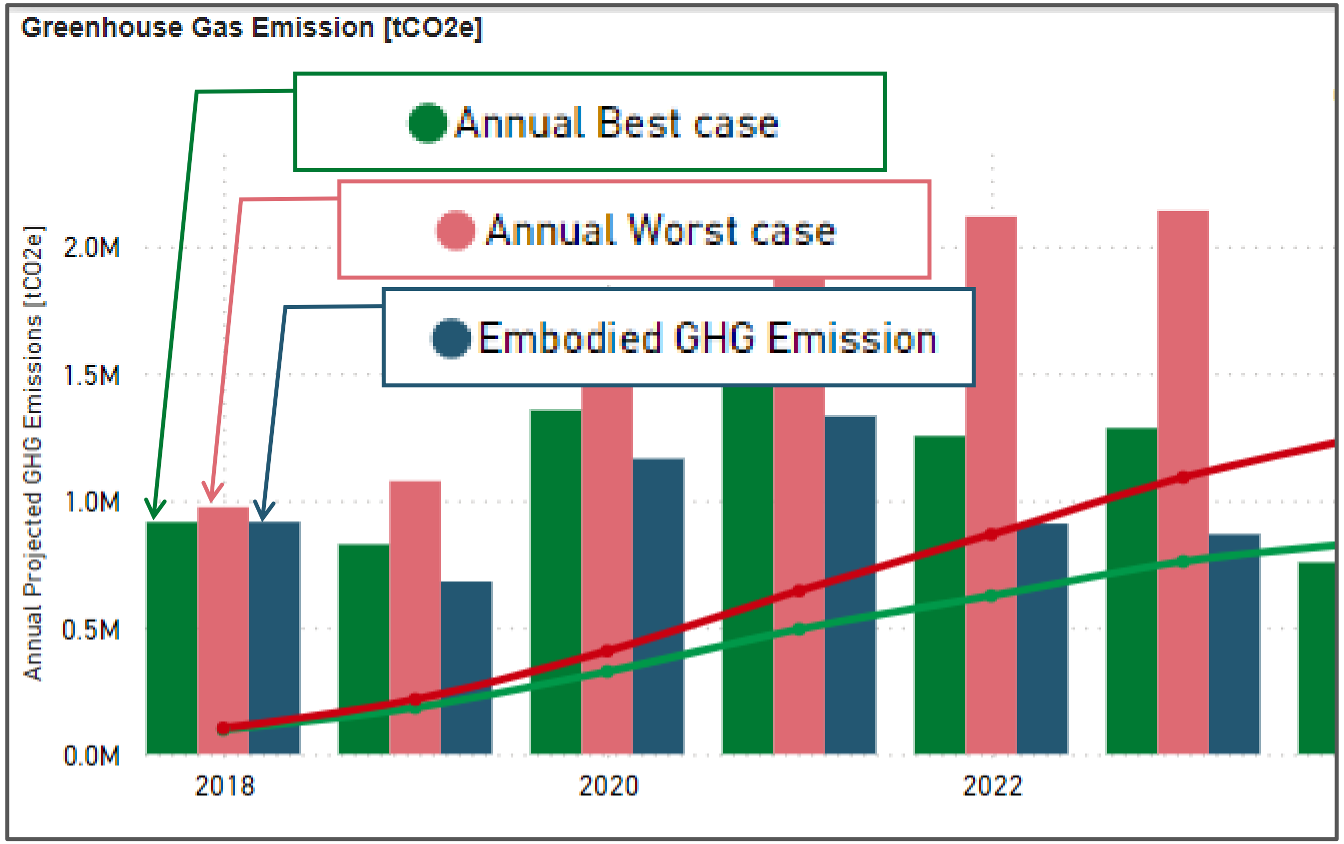
Output example

Zoom in

Total Projected GHG Emissions [tCO2e]

Best Case	Worst Case
▲ 21.93M	▲ 37.30M

Number of Projects	Total Cost ($)
5899	$92.2B



Methodology – Uncertainty / Limitations

GHG

Quality of data in impacts quality of data out

- Many projects in the NLTP pre-business case or design phase, with consequently limited data in the TIO system.
- The evidence base underpinning the tool logic is not exhaustive.
- Does not currently quantify carbon-related opex investment benefits.
- Potential influence of current / future policy decisions not accounted for.
- The tool is comparative, not predictive – not intended for portfolio or project monitoring.
- Time period to 2050

Maturing the tool

GHG

Regression factor - factor to represent uncertainty in the estimates.

Generalised cost gap factor – factor to represent the differing value for spend (ΔVKT/$) in each region based on existing infrastructure.

Currently placeholders in tool with default factors of 1, awaiting further investigation

Expand / update evidence base*
*subject to availability

Identify a suitable mean average for maintenance activities (currently allocated the same per-dollar average as major construction projects)

In summary

Key takeaways

- Not exact science
- Provides insights by outcome themes
- Insights are more valuable when contextualised
- Opportunities for refinement

Model integration and usage scenarios

Overview

Our team have developed four separate models built across different programming languages, relying on multiple file types and large datasets. This complexity increases operational effort and limits efficiency.

To streamline delivery, we need a single integrated platform that can run all models, centralise and reuse data, and significantly reduce maintenance overhead.

What we are facing?

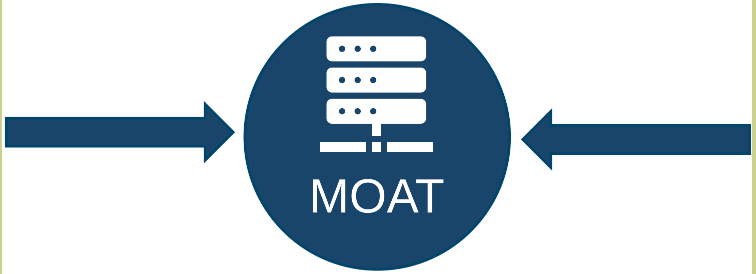
Data

- Scenario input
- Death and serious injury data
- Strategic benefits

- Project location
- Network map

- Transport Investment data

- Natural hazards and risk
- Model data



Modelling language

Python script

R script

SQL script

What do we need?

- A centralised, collaborative workspace for all models and teams
- A platform that is easy to maintain and operate, reducing manual effort
- Scalable infrastructure that grows as data and model demands increase
- Seamless connectivity to visualisation tools for reporting and insights

How we did it?


MS Azure storage
Input Data
Databricks
MOAT workspace
• Healthy and Safe People
• Resilience and Security
• Economic Prosperity
• Environmental Sustainability
MS Azure Database
Model output
Power BI Dashboard
MS Azure storage
Output Data for archive
in CSV format

How to create scenario ?

Scenario	
Description	
Creator	
Date	
ScenarioID	

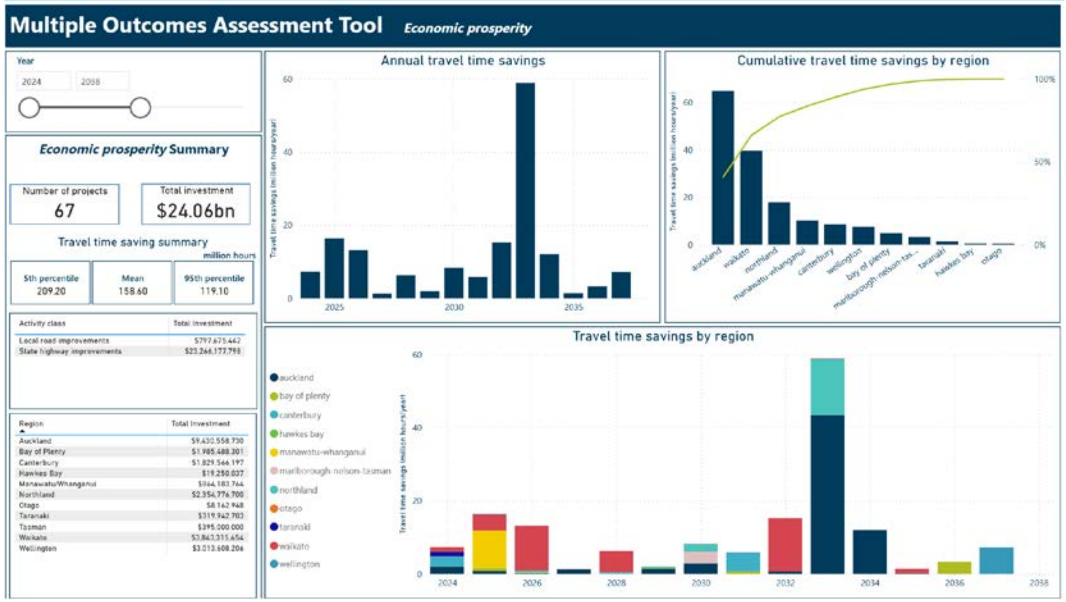
Must have fields	Better to have fields
Organisation name	Strategic context
Activity name	Activity description
Funding category	Primary Benefit
Activity type	Project location in GIS format
Duration	
Project cost	

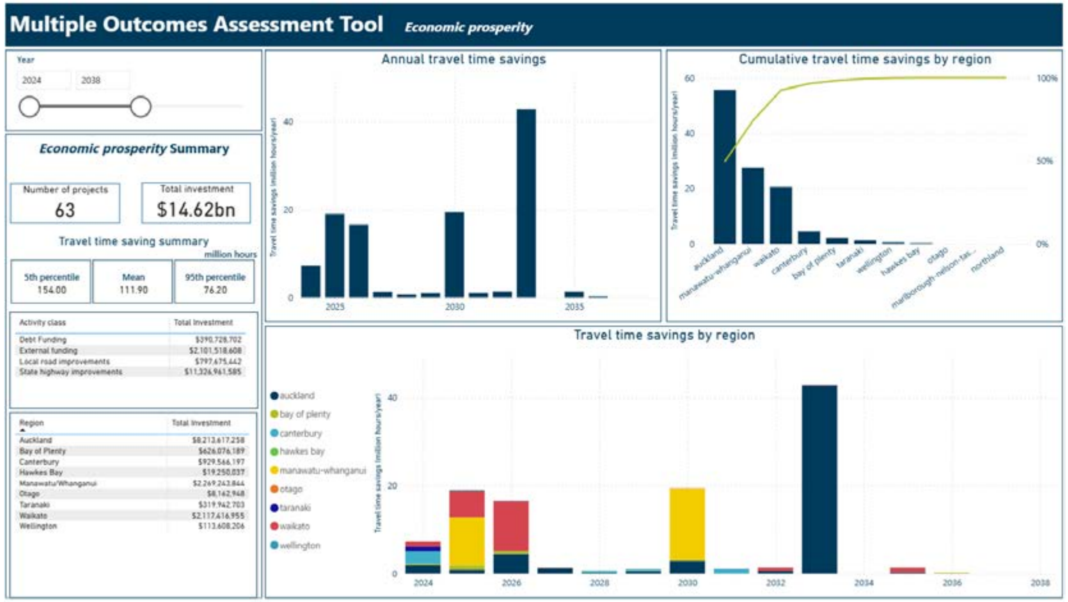
Activity_id	Phase_id	Region	Local_government_regio	Org_name	Activity_nam	Strategic_context	AC_code	AC_name	WC_code	WC_name	Phase_type	Status	Start_year	End_year	Duration_years	Activity_description	Primary_Benefi	Total_Implementation_Cost	Total_cost
65716	162199	Southern	Canterbury	Timaru Distri	Timaru Port Sou	New railway overbridge an	12	Local road imprc	323	New roads	Construction	Draft	2024	2025	2			4620000	4000000
71580	173208	Waikato/I	Bay of Plenty	NZTA (BOP)	TEL Tauranga Ea	Approximately 23km of new	13	State highway in	323	New roads	Construction	Funding Approv	2010	2025	16			545000000	393351675

Scenario Data

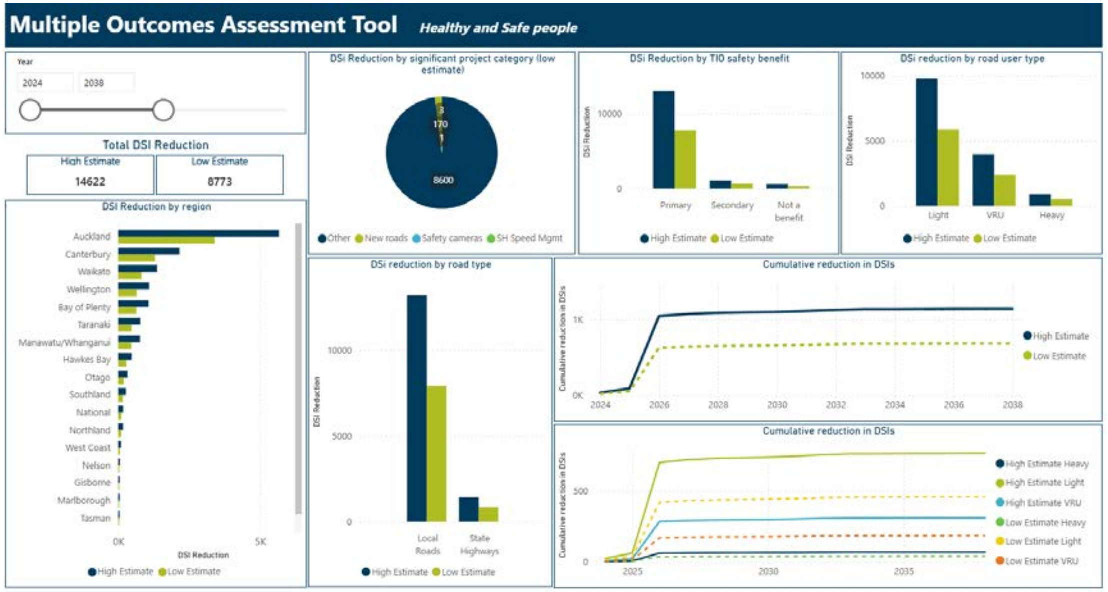
MS Azure storage
Input Data

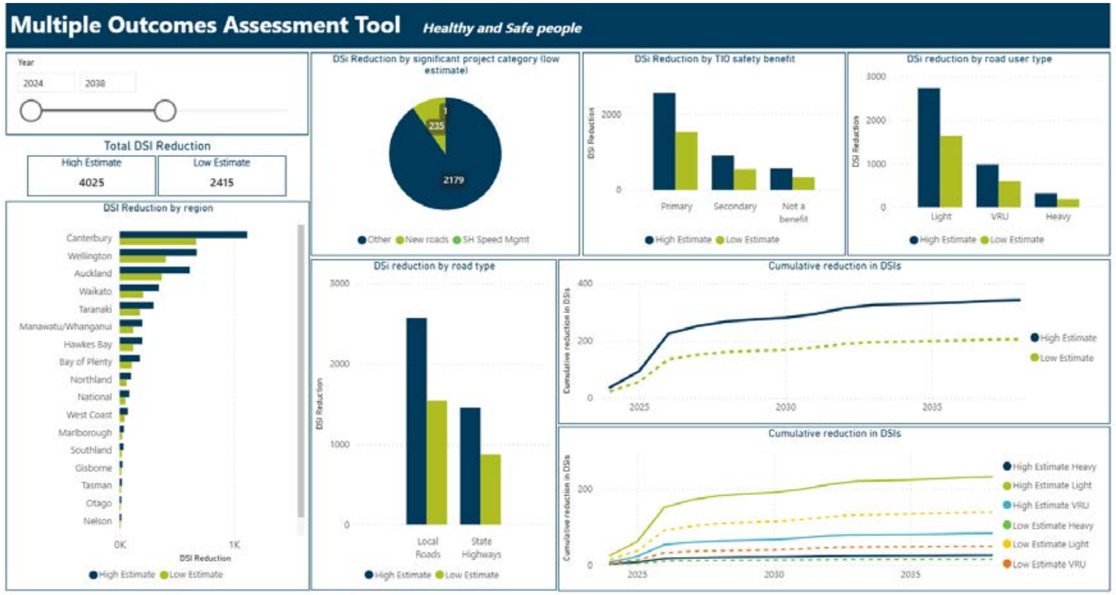
Model Outcome



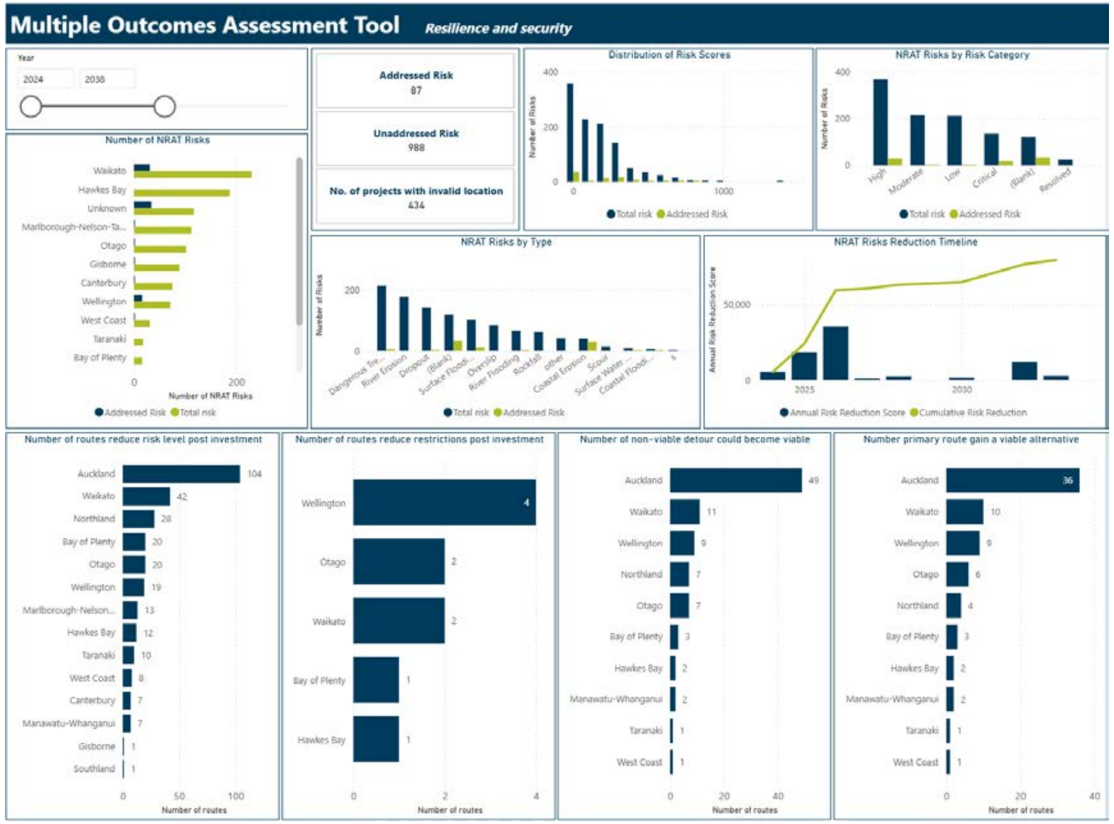


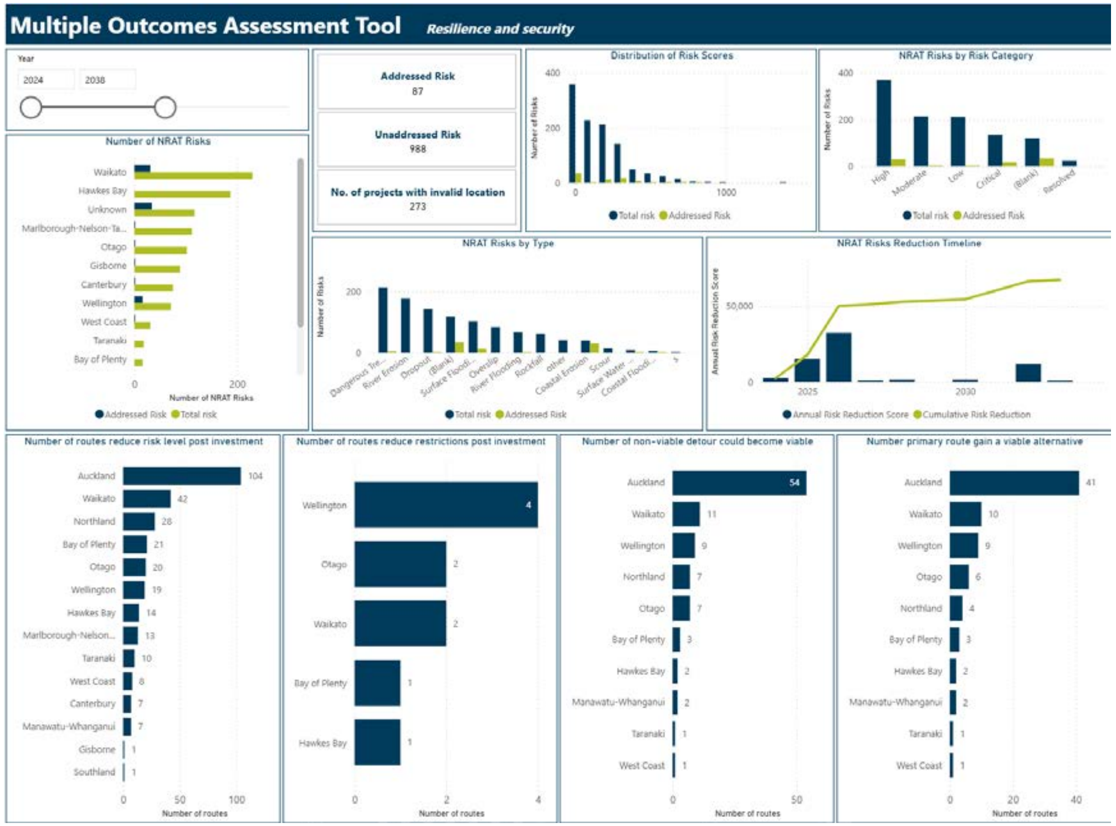
Model Outcome



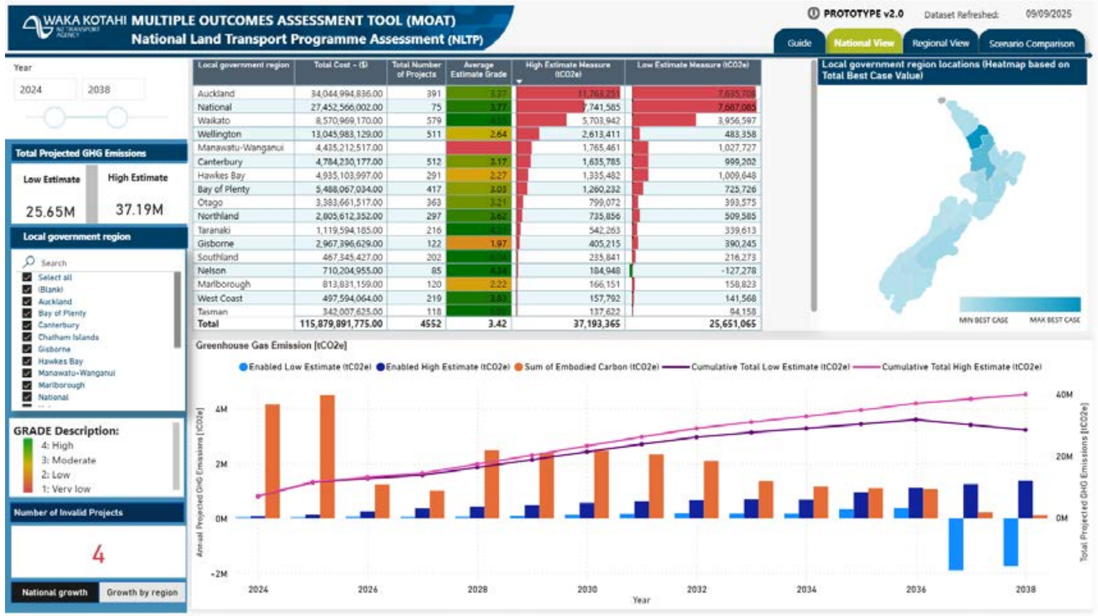


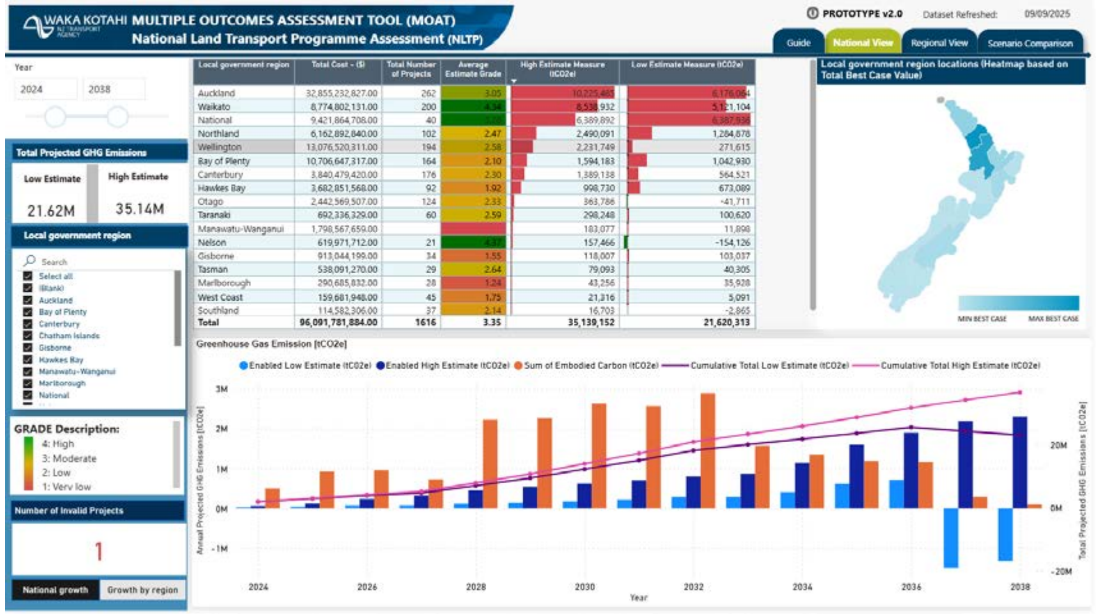
Model Outcome





Model Outcome





MOAT – Inclusive Access

LTBF Measures

2 Strategic measures

- 10.2.1 People – mode share
- 10.3.1 Access to key social destinations (all modes)

Considerations

- TIO contains data for subset of activities
- Data (where supplied) based on known details of proposed investment

MOAT – Inclusive Access

Plan A

Use tools developed for other outcomes within MOAT

- Travel time delay and reliability – from Economic Prosperity module
- Modal shifts – from environmental sustainability module

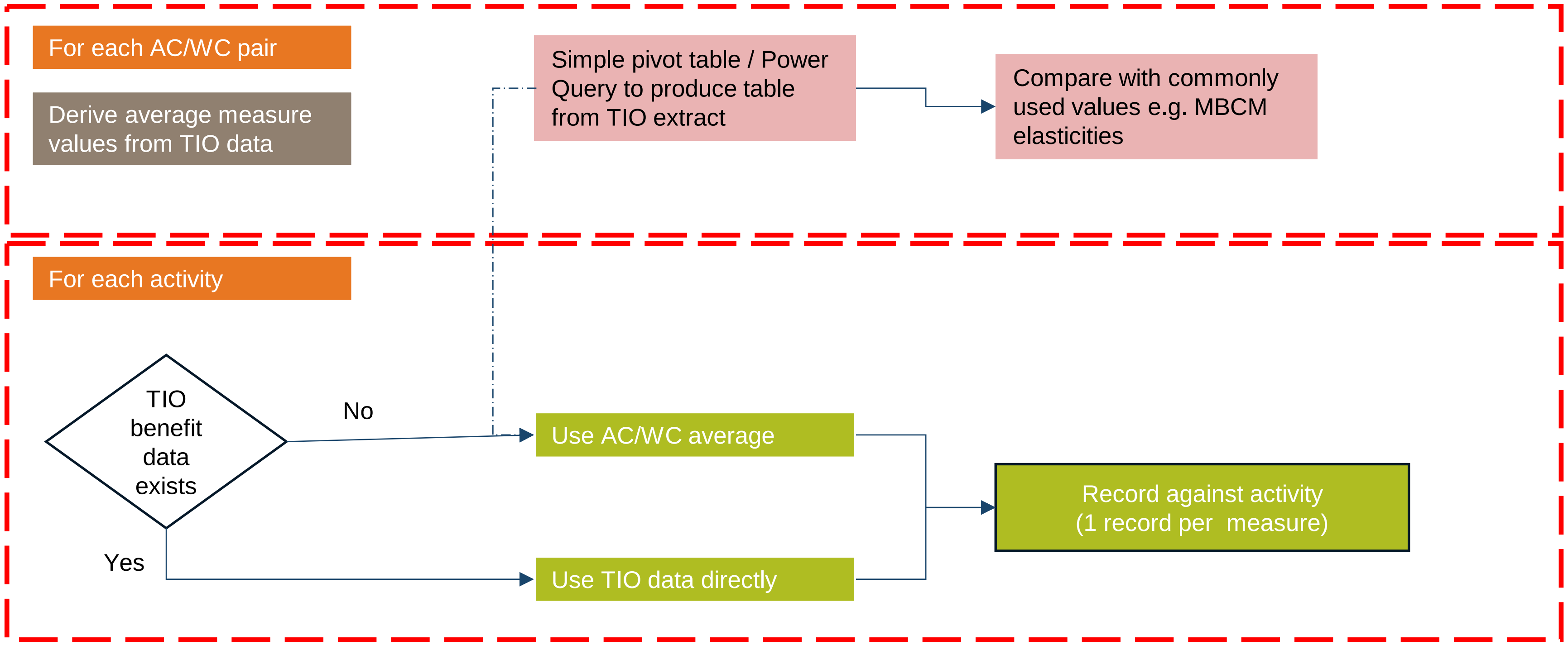
And tools being developed outside of MOAT

- Mode Choice Models
- Accessibility Toolkit

But we’re not there yet, so go to Plan B – leverage what we DO have

Inclusive Access - Roadmap

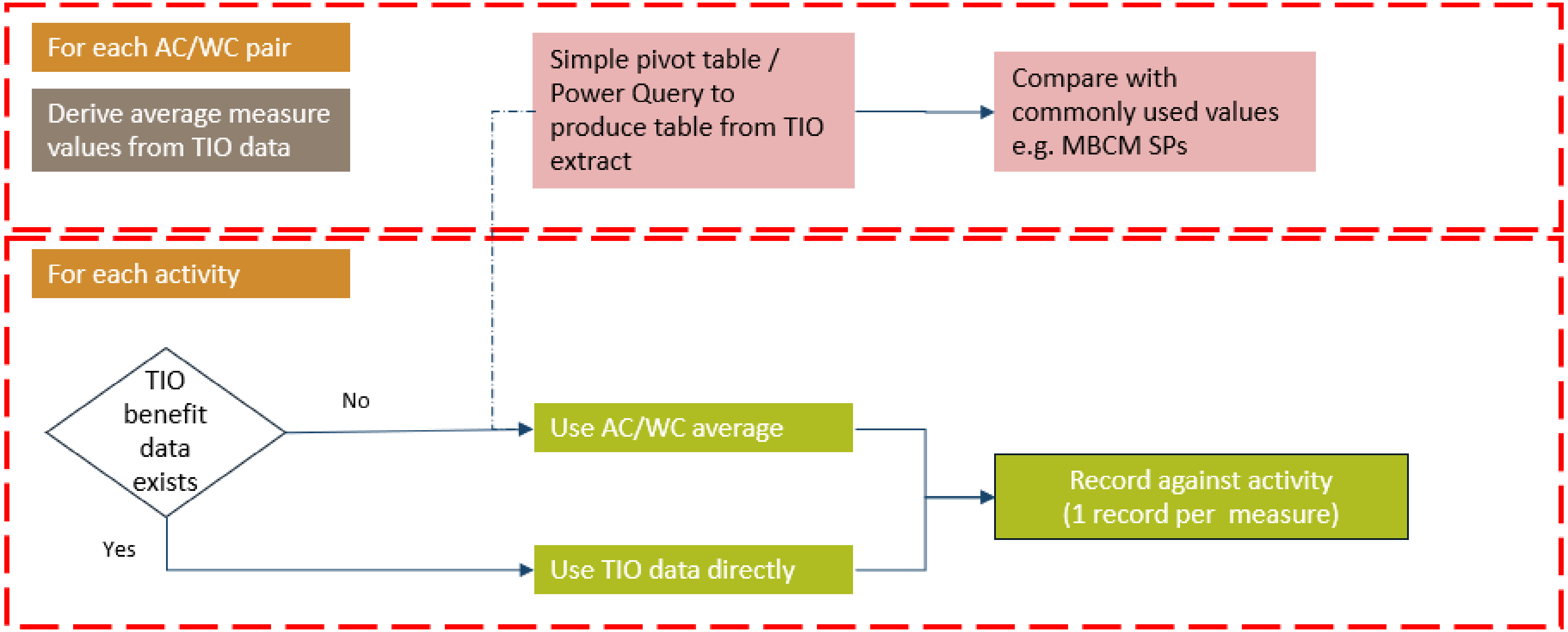
Process Steps – PT Improvements



Data:
PT patronage
Mode share
PT Accessibility

Inclusive Access - Roadmap

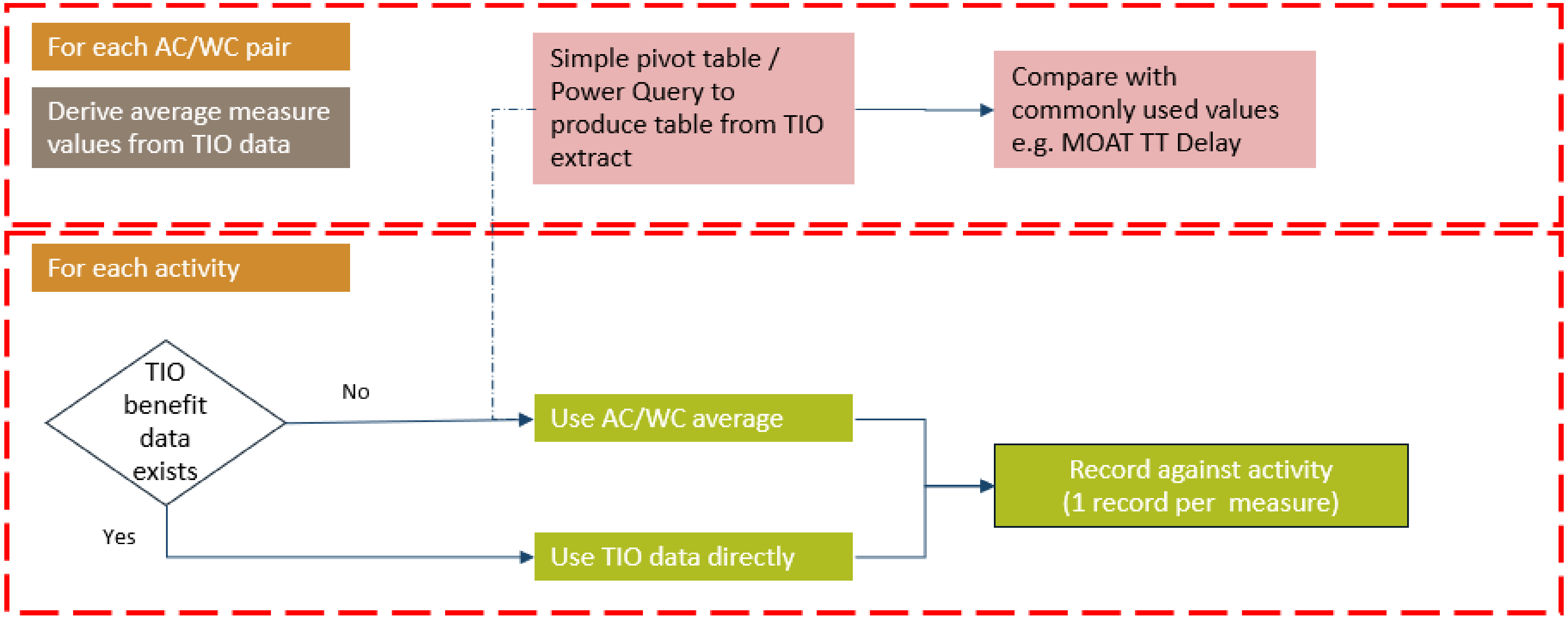
Process Steps – Walking and Cycling improvements



Data:
Predicted new cyclists/pedestrians
Mode share change
Active Mode accessibility

Inclusive Access - Roadmap

Process Steps – Road Improvements



Data:
Travel time changes
PV Mode share
PV Accessibility

Scenarios

Much of the forward planning for transport investment is subject to high levels of uncertainty.

- We don’t know what we don’t know
- Even if we can identify some things that we don’t know – much of those we can’t know
- Many of our base assumptions are on shifting sands

These factors suggest an approach of wide-spread use of scenarios is appropriate.

Scenarios developed must:

- include varying critical assumptions as well as alternative investment programmes
- be wide ranging, and sufficiently different to inform a view of alternatives

Where to from here?

- Harmonise the approach – consistency of detail level, termnology, output visualisation
- Expand individual measures to full coverage of activities (AC/WC pairings)
- Expand to include Strategic Measures in the LTBF
- Include background assumptions in scenario development process
- Firm up on role in Decision Support functions
- Seek feedback from stakeholders and practitioners
- Develop guidance for stakeholders and users

Feedback

We welcome your thoughts

- Models at NZTA: Models@nzta.govt.nz

Thank you

Patai?