Ministry of Transport

Domestic Transport Costs and Charges Study

Scoping Report

May 2020

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with associated consultants

Contents

Part A: Overview

A1. Introduction

The Domestic Transport Costs and Charges (DTCC) study aims to identify all of the costs imposed by the domestic transport system on the wider New Zealand economy and the countervailing burdens, including charges faced by transport system users. The Study is being undertaken for the Ministry of Transport by a consultant consortium headed by Ian Wallis Associates.

The Study is an important input to achieving a quality transport system for New Zealand that improves wellbeing and liveability. Its outputs will improve our understanding of the economic, environmental and social costs imposed by different transport modes - including road, rail, coastal shipping and domestic passenger aviation - and the extent to which those costs are currently offset by charges paid by transport users.

Study outputs will be consistent with the Ministry's Transport Outcomes Framework, and will contribute to a more consistent, system-wide and mode-neutral approach to transport assessment and evaluation.

Robust information on transport costs and charges is critical to establishing a sound transport policy framework. The outputs from the study will help to inform important policy development in areas such as charging and revenue management, internalising externalities, and travel demand management.

This report sets out the methodology that will be used for the DTCC study. It provides an overview of the approach to the study, a detailed description of the tasks that will be undertaken, the project deliverables, and an outline of data requirements and sources.

> It is possible that some aspects of the study methodology outlined in this report will need to be amended over time as the study progresses and more detailed (or improved) information becomes available. Any significant departures from the approach outlined in the paper will be discussed and agreed with the project working group as the need arises.

A2. Transport Outcomes Framework

The DTCC study forms part of the Ministry's wider work programme to establish a system-wide approach to improve transport assessment and evaluation. The aim is to establish consistent, clear and comprehensive approaches for assessment, evaluation and modelling across all transport modes, and to contribute to the Transport Outcomes Framework. The system-wide approach is also expected to account for outcomes traditionally not valued in cost benefit analyses and assessment models, and will help the Ministry to monitor the overall performance of the transport system against desired outcomes.

The Transport Outcomes Framework identifies five outcomes, as illustrated below. A guiding principle of the Framework is mode neutrality, which aims to ensure that:

- all modes and options are considered and evaluated to find the best system solution; and
- users and decision-makers are aware of the benefits and costs of transport choices.

The DTCC outputs will contribute to this by providing a consistent method for estimating and reporting financial and economic costs and impacts by different modes and user types.

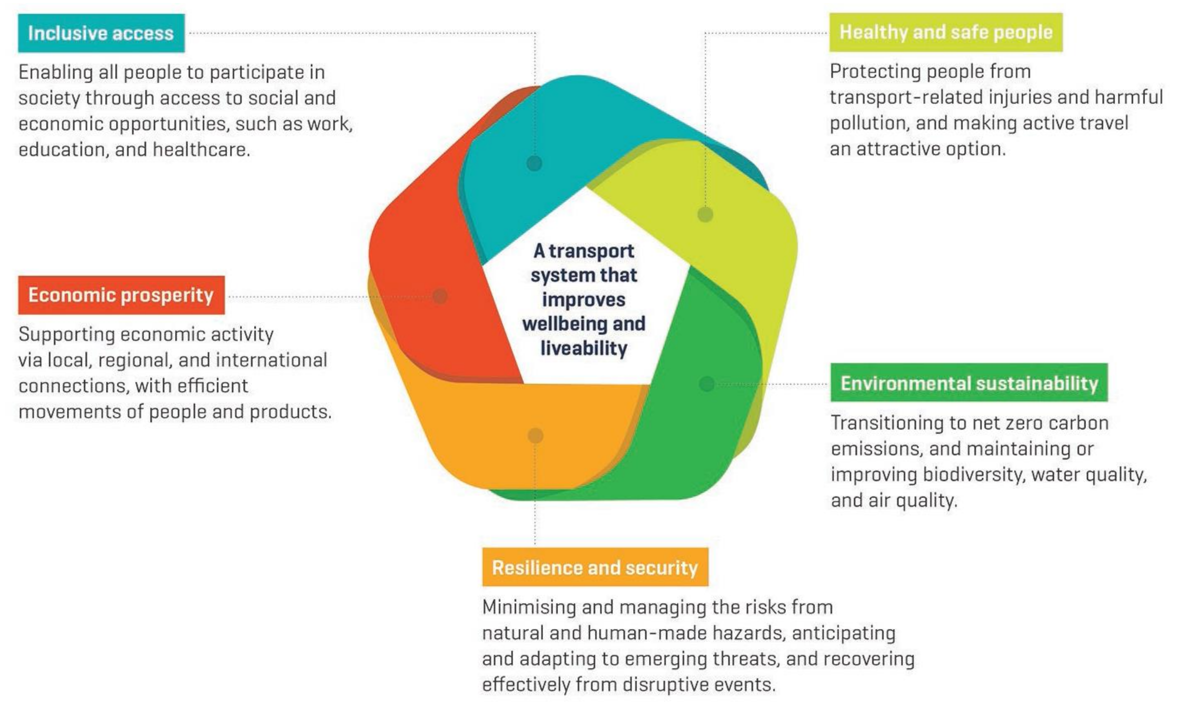

Figure A1: Transport Outcomes Framework Overview

As discussed below, the DTCC work has been divided into modal and impact topic areas, and the DTCC outputs will be structured and reported in a manner that is consistent with, and supports, the Transport Outcomes Framework. This is discussed further in Part B, section B1.

A3. Policy Applications

Note: This section incorporates input from the Ministry of Transport

Transport costs and charges data is important for a wide range of transport policy analyses. It helps inform the value for money and financial sustainability of investment, as well as the size of the negative consequences of transport uses. It also helps answer a number of key policy questions. For example:

- What are the values of existing infrastructure assets? What are the costs associated with their maintenance, operation and renewal? What are the long-term financial implications regarding to network or system expansions?
- What are the total costs of transport service provisions? What are the financial implications regarding to services expansions?
- Is the current transport system financially sustainable?
    - Are the current levels of expenditure sufficient to ensure assets can be maintained, renewed, upgraded and/or expanded? How does the level of expenditure relate to user charges?
    - What are the current levels of subsidies? Are the current levels of charges sufficient to pay for these subsidies?
    - What are the likely cost burdens to future generations?
- What are the average financial, social and full costs per passenger and tonne kilometre (for specific routes) by mode? What are the corresponding incremental/marginal and total costs?
- What are the average time costs of freight by mode?
- What are the social costs of transport emissions, noise and accidents by mode?
- Are transport policies, projects or programmes delivering value for money?
    - What is the size of the policy problems being addressed?
    - What are the potential economic, social and environmental benefits from transport policies, strategies and interventions?

The outputs of the DTCC Study are not intended to directly deliver specific answers to transport policy questions. However, the Study will contribute to the transport sector's understanding of how specific modes, and to the extent possible, specific subsets within modes (types of users, vehicle types, fuel types), impose costs on New Zealand's economy, environment, and population, and to what extent those costs are 'met' by charges paid, in some cases, for transport system use. The level of disaggregation of the Study outputs will therefore help answer a range of transport policy questions, including those set out in the Transport Evidence Base Strategy - Enduring Questions (particularly, but not solely, the Enduring Questions listed under topic 6: Transport Funding and Revenue)[1].

The Study will collect important information for determining the effectiveness and efficiency of different modes of transport. Such information is important to encourage better utilisation of the existing network and thus increase economic benefits through productivity gains and reduction in transport costs (e.g. congestion). It will also help to better understand the external costs and impacts of the transport system on society and the environment, which will help to inform policies aimed at reducing those costs and impacts.

[1] Ministry of Transport: Transport Evidence Base Strategy (December 2019)

This project will also contribute to making evidence-based policy making possible. It will help instil greater transparency into the policy making process. Possible observable outcomes include:

- Increased use of economic analyses in policy decisions when the full costs of transport use become available. When used with information on other benefits and costs of policy proposals, this information will improve our understanding of the “value for money” aspect of policy proposals;
- Consistent use of costs and charges information in policymaking if study results are clearly documented and are made available to wider audiences.

The study outputs have the potential for subsequent application in addressing a range of future policy issues related to the New Zealand transport system. When used with other tools and data, the DTCC outputs will help with:

- policy problem definition - by helping to define the significance of impacts
- multimodal investment decisions and options assessment
- development of policies to reduce externalities
- understanding the effect of economic incentives on travel behaviour
- improving the transport funding and charging system

A4. Proposed approach

A4.1 Study scope

The DTCC is the first comprehensive assessment of transport costs and charges in New Zealand since the Surface Transport Costs and Charges Study (STCC) in 2005. The STCC was a 'baseline' analysis of the costs of the NZ transport system(s) for the movement of persons and freight. It focused on the financial and economic costs of the road and rail systems, at both aggregated and segmented levels, and on how the charges levied on both users and other parties related to the costs they imposed.

However, the scope of the DTCC is considerably wider than that of STCC; in addition to road and rail, the DTCC is to cover a wider selection of transport modes/segments, including:

- domestic air passenger transport
- domestic sea freight transport
- active travel modes – walking, cycling
- other road-based transport modes not covered in STCC – ride-hailing (including taxis) and micro-mobility (scooters etc.)

Further, and complementary to this wider selection of transport modes, the consideration of economic costs will be widened in two main respects:

- a more detailed assessment of environmental costs; and
- the inclusion of the relative health cost implications of the different transport modes.

The DTCC is primarily concerned with the financial, social and environmental costs and impacts of the NZ transport system and the user charges associated with this use. It does not include an assessment of the benefits to transport users (or other parties) of their travel decisions. However, we note that the transport literature and practice does not make a clear distinction between items treated as transport user costs and items treated as economic benefits to users. This

In parallel with the DTCC, the NZ Transport Agency has recently commenced a major market research study to establish updated valuations for user benefit parameters (e.g. values of time, reliability and safety improvements), for use in the behavioural and economic evaluation of transport investment proposals.

A4.2 Organising framework and topic-based methodology

We have structured our approach to this project on our understanding of the different types of costs, charges and impact that exist across the domestic transport sector, in terms of modes, market segments, and differing levels of data availability. We have therefore structured the study into a number of topic areas (workstreams) that we propose to address. This is illustrated in Figure A2 below, which shows the organising framework for the study and summarises the topics that are dealt with in more detail in the three main parts of this report. The table also shows the relationship between the modal topics and the impact topics.

Figure A2: Organising framework for DTCC topics

PART B: GENERIC (CROSS-MODAL) TOPICS	PART C: MODAL TOPICS (Financial & economic costs and charges)		PART D: IMPACT (EXTERNALITY) TOPCS D1 Crashes	D2 Congestion	D3 Public Health	D4 Emissions	D5 Noise	D6 a Biodiversity	D6 b Biosecurity
	C1-10 Road	C1 Road infrastructure maintenance & operations							
		C2 Valuation of road infrastructure							
B1 Alignment with Transport Outcomes Framework		C3 Road expenditure & funding overview (4)							
		C4 Road vehicle ownership & use charges							
		C5 Road vehicle operating cost models							
B2. Regulation, institutionaland funding overview		C6 Long distance coaches	*	*	*	*	*	*	*
		C7 Car parking							
		C8a Walking							
		C8b Cycling							
B3 Methodological approach to costs and charges		C9 Ride hailing/taxis							
		C10 Micro-mobility							
	C11 Rail	Freight							
		Long dist passenger	*			*	*	* (3)	* (3)
		Metro							
B4 Economic costs of capital assets									
	C12 Urban PT	Bus							
		Ferry	*	*	*	*	*	*	*
		Rail (1)							
B5 Weighted average cost of capital	C14 Shipping	Coastal freight							
		Inter-island freight (2)	*			*	*	*	*
		Inter-island passenger (2)							
	C13 Aviation	Primary routes							
B6 Market segmentation		Intermediate routes	*			*	*	* (3)	* (3)
		Secondary routes							

Notes: * denotes impacts resulting from modal activity

(1) Includes inputs on 'below rail' costs from Rail (Metro) topic.

(2) Includes inputs on inter-island ferries from Rail topic.

(3) impacts expected to be minor -- comments only

(4) includes public sector expenditures and funding for urban public transport services (included with Road for convenience)

The first main part of the report (**Part B**) deals with **generic (cross-modal) topics** that are necessary to ensure a consistent approach to the treatment of financial and economic costs for the modal topics. Topics in Part B include:

- **Transport Outcomes Framework** – an outline of how the topic areas are expected to align with the Transport Outcomes Framework
- **Regulatory, institutional and funding overview** – an outline of the current arrangements applying to each of the four main modes, which provides the context for current costs and charges
- **Economic methodology issues** - the economic and financial concepts underpinning the study
- **Economic costs of capital assets** – an outline of the approach proposed to assess the economic costs of capital assets
- **Weighted average cost of capital (WACC)** – the approach to estimating WACC for the different transport modes
- **Market segmentation** - an overview of how the total transport task for each of the four main modes will be segmented for analysis purposes

Part C deals with **modal topics,** focused on the direct financial costs and charges for each mode This recognises the different cost and charges structures that exist for different transport modes in New Zealand, and the need for these to be assessed separately in the early stages of the DTCC study. The modal topics are listed below, and the methodology for each will focus primarily on the financial and socio-economic costs and charges for each mode in question.

- Roading system, including:
    - Road infrastructure maintenance and operations costs
    - Valuation of road infrastructure
    - Vehicle ownership and use charges
    - Road vehicle operating cost models (trucks, cars, motorcycles)
    - Long-distance coaches
    - Car parking
    - Walking and cycling
    - Ride-hailing and taxis
    - Micro-mobility
- Rail system, including:
    - Rail freight
    - Long distance rail passenger
- Urban public transport – buses, rail and ferries
- Domestic passenger aviation
- Coastal shipping

Note that the urban public transport topics (bus, rail and ferry) have been combined into a single topic for the purposes of analysis, given the integrated manner in which these activities are managed via regional councils (and Auckland Transport). Where appropriate, the results will be presented by mode as outlined in Figure A2.

The third set of topics (**Part D**) deals with assessment of the indirect **impacts** associated with each mode (as distinct from the direct costs and charges). These address the main types of external social, economic or environmental impacts associated with domestic transport activity. Within any one of these topic areas, impacts are typically associated with multiple modes and market segments, but the nature of these impacts can differ. The impact topics, which are detailed in **Part D**, cover:

- Social costs of transport accidents (crashes): this covers all modes using the road system, as well as accidents associated with the rail, coastal shipping and aviation sectors
- Congestion (relating principally to road traffic)
- Public health impacts
- Emissions: greenhouse gas emissions and local air quality
- Noise
- Biodiversity (freshwater and marine) and biosecurity

Note that the emissions topic includes both greenhouse gas emissions and local air quality, which are shown separately in Figure A2. To ensure a consistent approach, they will be dealt with as two sub-topics within the overall emissions topic for the purposes of analysis.

Figure A3 below shows how the topics are linked to the outcomes from the Transport Outcomes Framework. In some cases, particularly for the Healthy and Safe People and Environmental Sustainability outcomes, there is a direct relationship between topic outputs and the outcomes. For some others, the outputs from the topic areas are likely to contribute to more than one outcome. This is especially the case for the Economic Prosperity and Inclusive Access outcomes.

At this stage, the DTCC outputs are expected to provide less extensive information to inform the Resilience and Security outcome, but there is likely to be some information from topic areas (e.g. aviation security, biosecurity, and road/rail infrastructure recovery costs) that will specifically relate to this outcome. This may be an area where further work will be desirable beyond the scope of the current study.

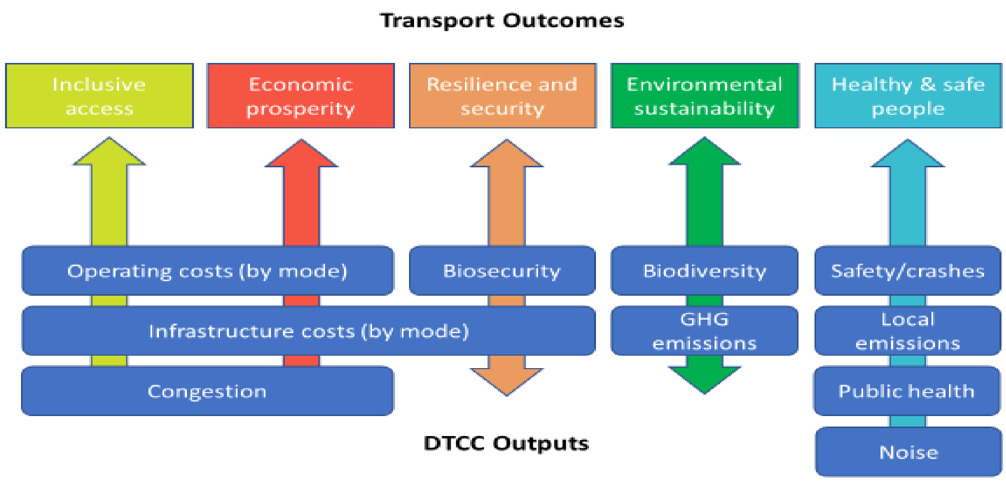

Figure A3: DTCC outputs and TOF outcomes

A5. Study deliverables

Figure A4 below summarises the key deliverables from the DTCC study.

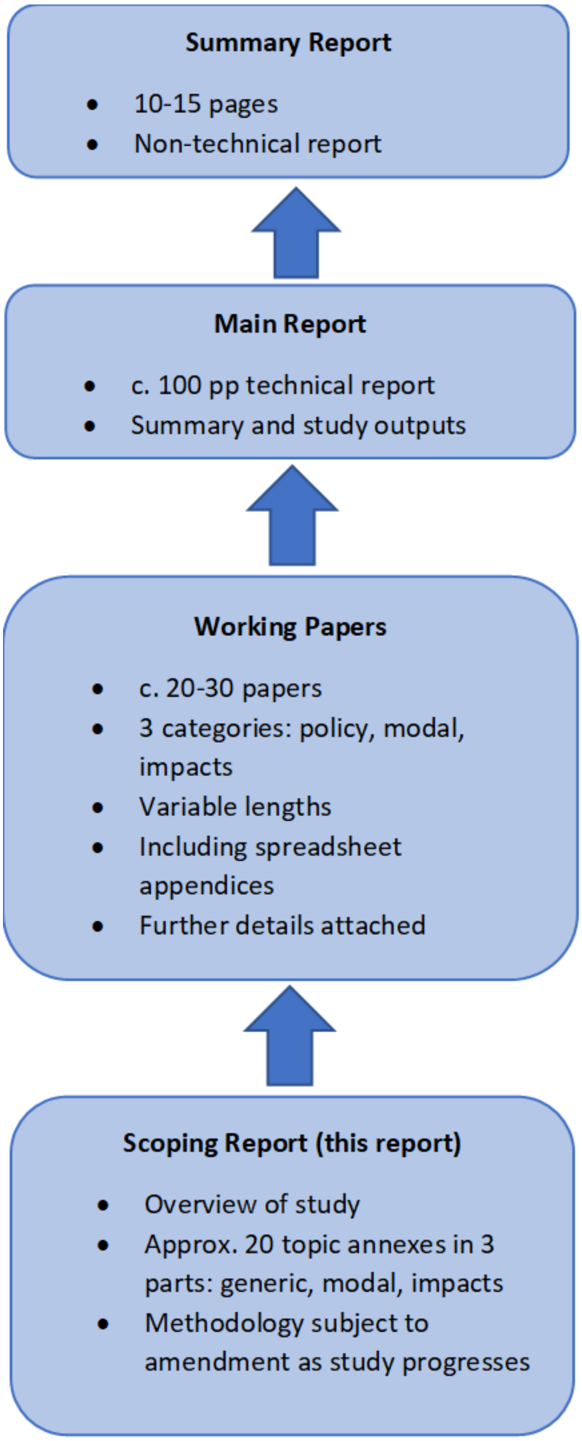

Figure A4: DTCC Proposed deliverables

A core part of the work outlined will be the preparation of a series of **working papers** documenting the investigations and outputs for each topic area. These will be completed progressively over the period May to September 2020, with the timetable allowing opportunities for staged feedback from the Ministry and key stakeholders. Parts B, C and D of this report provide detail of the approach to the development of each of these working papers.

The working papers will follow a consistent structure and format, including the following contents:

- Cover
- Contents page
- Executive summary
- Author/ affiliation
- Draft number/date
- Introduction/scope/purpose
- Relation to other working papers
- Market segmentation (as appropriate)
- Data sources, assumptions and methodology
- Key results – total / average costs
  - overall / by segment
- Key results – marginal costs (as appropriate)
  - overall/by segment
- Key results -- user and other charges
- Conclusions
- References
- Future updating and analysis guidance
- Detailed data / spreadsheet etc (including links)

A working paper template will be prepared to provide more guidance for authors to follow, with more detail on the contents set out above. This will be prepared once the study is underway, as the availability of data becomes clearer and initial results begin to emerge. The focus of the template will be on ensuring consistency in the presentation of study outputs, while retaining a degree of flexibility to recognise the inevitable variations in the complexity and quality of data that will be available across different topic areas.

Following completion of the working papers, the outputs will be drawn together in the **main report:** this will include an overview of the work undertaken, explain how each element fits together, and summarise the key outputs. It will be prepared initially as a draft version, for stakeholder review, followed by a final version. A **summary report** will also be prepared, giving a briefer and non-technical summary of the study's scope and findings

Part B: Generic (Cross-Modal) Issues

B1. Alignment with the Transport Outcomes Framework

B1.1 Introduction

In developing the scope and methodology for the DTCC study, attention was paid to the outcomes, themes and indicators for the NZ transport system, which are set out in the Transport Outcomes Framework (TOF).

The TOF documentation is in two parts[2]:

- the government's ***vision*** for the NZ transport system, focused on ***five outcome areas*** (as illustrated in section A2 of this report); and
- the ***guiding principle*** of ***mode neutrality,*** which is to underlie the approach to achieving the vision.

This section discusses the guiding principle of mode neutrality first, as the DTCC outputs are likely to influence pricing, which is a critical factor in pursuing mode neutrality. It then summarises the themes and indicators from the TOF and comments on the extent to which, and how (where relevant), those themes and indicators will be addressed through our proposed DTCC impact evaluation framework and methodology

B1.2 Mode neutrality

The TOF paper notes that mode neutrality should be a guiding principle for the Government's involvement in the transport system if the TOF desired outcomes are to be achieved. It comments that mode neutrality involves two important aspects, summarised as follows:

(1). Ensuring that all modes and options are considered and evaluated to find the best system solution.

The TOF paper notes a tendency towards bias in assessing transport policy options on account of the greater role of governments in planning and regulation in the roading sector relative to its involvement in the rail sector and particularly in the coastal shipping sector. It proposes that greater attention should be given in future to the following travel modes, when considering transport regulation and investment:

- ***Public transport and active travel modes***. Relevant to TOF, it notes that these modes would improve inclusive access, support healthy and safe people, reduce carbon emissions and make urban environments more liveable overall. They would also support economic prosperity by helping to mitigate road congestion and to encourage use of local facilities, including development around transport hubs.
- ***Rail and coastal shipping freight travel modes***. Greater use of these modes would contribute to overall transport system safety, increasing transport system resilience and to reducing greenhouse gas emissions. These modes would also support economic prosperity by improving connectivity and by helping to mitigate road congestion.

(2). Making users and decision-makers more aware of the benefits and costs of transport options, so as to incentivise more robust decision-making and smarter travel choices.

The TOF paper notes the important role of prices in terms of: (i) influencing consumers and businesses as to their travel choices; and (ii) influencing signals to transport suppliers about how much they should invest to provide goods and services. It also notes that prices should (ideally)

[2] Ministry of Transport. A framework for shaping our transport system: Transport outcomes and mode neutrality. June 2018

include any costs imposed on society resulting from transport choices, including externalities such as greenhouse gas emissions, air pollution and local community cohesiveness.

The paper comments that prices in the aviation, maritime and rail sectors are set by the suppliers of the services based on their customers' willingness-to-pay towards the costs of providing the services. Price signals in the roads sector are less clear, on account of: (i) a large degree of averaging across all road users; (ii) the 'PAYGO' financing system, which tends to result in road users not paying for the full costs of capital investments; and (iii) prices do not (in general)make any allowances for non-financial costs associated with road system use (e.g. greenhouse gas emissions).

The paper concludes by stating that:

- *"This means that roads may seem cheaper than they actually are, leading users to choose road transport over alternatives such as rail or coastal shipping (for freight) or public transport (for passengers)."*
- *"Better awareness of the full costs and benefits of alternative transport modes could lead to smarter travel choices, better use of existing infrastructure, and increased productivity."*

B1.3 Outcomes for the transport system

The government's vision for the NZ transport system is ***"to improve people's well-being, and the liveability of places***". It aims to do this by contributing to five key outcomes, as set out in section A2 of this report. The TOF document also notes that: *"All of these outcomes are inter-related, and need to be met as a whole to improve inter-generational wellbeing and the quality of life in New Zealand's cities, towns and provinces."*

The five outcomes specified in the TOF for the transport system are supported by a set of transport indicators (grouped into themes) to track the performance of the transport system as a whole against each outcome. These outcomes, themes and indicators are detailed in the left-hand side of Table B1.1 (following). The centre/right-hand side of the table sets out the main impacts which we anticipate assessing within DTCC. The matrix cells in the table indicate which of the DTCC impact measures are likely to be of most relevance to each of the TOF outcomes, themes and indicators[3].

The main conclusions we draw from our assessment in table B1.1 include the following:

- Some of the DTCC impact measures are relevant to multiple TOF themes and indicators.
- Only a few of the TOF themes and indicators appear not to have any relevant DTCC impact measures. Particularly notable in this regard are:
    - The TOF outcome 'Resilience and security' (and its three related themes), which appear to have limited coverage by DTCC impacts.
    - To a lesser extent, relatively few DTCC impact measures are relevant to the TOF 'Inclusive access' outcome, particularly in terms of poor access for people without primary use of a private vehicle.
    - Two of the TOF indicators are being addressed primarily outside the transport sector. These are indicator 1.3 (transport sector work injuries) and indicator 2.2 (passenger arrivals /departures NZ).
    - While travel time reliability is an important impact to be included in the DTCC assessment, being relevant to multiple TOF themes and indicators, in practice the extent and quality of data available on this measure (as compared with typical or average travel times) appears to be rather limited.

[3] Not all outputs from the DTCC will match one-to -ne to Table B1.1. In some cases, a collection of information is needed to inform the achievement of an outcome, and in other cases such information will need to be supplemented by a modelling tool to evaluate the impacts

B1.4. Implications for DTCC evaluation framework

Given the centrality of TOF to the transport portfolio's policy development and assessment function, it is clearly important (to the extent realistic) for the DTCC impacts to be related to the TOF objectives, themes and indicators. However, it should be noted that the current indicator package is still under development and does not provide complete coverage of all relevant outcomes or themes.

DTCC's inputs and particularly its analyses of measures of financial costs, socio-economic costs and any changes in user charges may highlight opportunities for enhancement to existing TOF indicators and for the introduction of new indicators.

Given the importance that the NZ transport sector places on the TOF outcomes, in further developing DTCC's methodology and data collection /analysis approach, we will give priority (to the extent possible) to assessing those impacts of the existing transport system that can provide useful contributions to the TOF system framework and indicators.

Table B1.1: Transport Outcomes Framework: outcomes, themes, indicators and DTCC impacts mapping

Outcome/focus	Theme	Indicator	Transport system financial costs (infra, op, mtce, user fees & charges)	User taxes & charges					User costs	Social/ environmental costs / externalities						
				Fuel taxes (FED, ETS)	Road User Charges	Fares (PT etc)	Freight rates	Other user levies & charges	Travel time/ reliability costs	Crashes	Public health	GHG emissions	Local emissions	Noise	Biodiversity	Biosecurity
1. Healthy and safe people (*Protecting people from transport-related injuries and harmful pollution, and making active travel an attractive option*)	**Public safety** (*Ensuring that people arrive safely at their destinations)*	1.1 Transport-related deaths 1.2 Transport-related serious injuries						*		*						
	Workplace safety (*Ensuring that people who work in the transport sector are protected from work-related injuries)*	1.3 Transport sector work injuries	***Note 1***					*		*						
	Active travel *(Improving physical and mental health through physically active travel)*	1.4 Time spent travelling by active modes	?			?			*	*	*	*	*	*	*	
	Air and noise pollution (*Protecting people from exposure to harmful pollution from the transport system)*	1.5 Harmful emissions from fuel combustion									*	*	*	*	*	
		1.6 Exposure to elevated concentrations of air pollution from the transport system									*		*		*	
		1.7 Exposure to elevated levels of noise from the transport system									*			*		
2. Economic prosperity (*Supporting economic activity via local, regional and international connections, with efficient movements of people and products)*	**Contribution to the economy** *(Contributing to economic development through transport and freight sector activities)*	2.1 Contribution of transport and freight movements to NZ GDP	*		*		*		*	*		*	*	*	*	
	Movement of people (*Supporting economic activity through local, regional and international travel connections)*	2.2 Passengers arriving/departing NZ	***Note 2***	*				*	*	*		?	*			
		2.3 Travel time reliability on priority tourist routes							*							
	Movements of freight *(Supporting economic activity through local, regional and international freight connections)*	2.4 Freight imports and exports			*		*			*		*	*	*		
		2.5 Freight carried domestically (local and regional)			*		*		*	*		*	*	*		
		2.6 Travel time reliability for freight transportation							*							
		2.7 Load efficiency	*		*		*									
		2.8 Freight productivity /utilisation	*		*		*		*	*		*	*	*		

		2.9 Farm expenditure on freight	*		*		*									
3. Inclusive access *(Enabling all people to participate in society through access to social and economic opportunities, such as work, education and healthcare)*	**Access** *(Providing viable transport options for people to access work, education and healthcare, and to participate in society)*	3.1 Household spending on transport (% of income)	*	*		*										
		3.2 Population with access to frequent public transport services	*								*	*	*			
		3.3 Access to jobs	*	*		*			*							
	Barriers to access *(Reducing barriers for people to access social and economic opportunities and essential services)*	3.4 Rural households without access to a motor vehicle		*												
	Perceptions (*Improving public transport and active travel modes, so that they are perceived as good options)*	3.5 People unable to make a beneficial transport journey	*	*												
		3.6 Unmet need for GP services due to lack of transport	*	*												
		3.7 Perception of public transport		*		*			*		*	*	*			
		3.8 Perceived safety of walking and cycling								*			*			
4. Resilience Security *(Minimising and managing the risks from natural and human made hazards, anticipating and adopting to emerging threats, and recovering effectively from disruptive events)*	**Security** (*Ensuring that transport users are protected from security risks)*	4.1 Security incidents									*					*
		4.3 Perceived personal safety while using the transport system									*					
	Risk assessment (*Ensuring that the transport sector has the capability and options to respond to disruptive events)*	4.4 Operator risk profile						*		*						
		4.5 Response capability	*													
		4.6 Availability of viable alternative routes	*													
		4.7 Preparation for loss of traditional transport options	*													
		4.8 Susceptibility to coastal inundation with sea level rise							*							
	Responding to disruptions	4.9 Outages on routes with no viable alternative							*							
5.Environmental sustainability *(Transitioning to net zero carbon emissions and maintaining or improving biodiversity, water quality and air quality)*	**Water quality** (*Protecting NZ's marine environment)*	5.1 Marine oil spills in NZ waters						*					*			
	Air quality/climate change *(Supporting NZ's transition to net zero carbon emissions)*	5.2 Greenhouse gases emitted from the NZ transport system		*	*							*				
		5.3 Vehicle fleet compositions		*	*							*				
		5.4 Mode share of short trips				*						*	*			

***Notes**: (1) This theme and indicator are to be addressed separately, through ACC.*

(2) This theme and indicator are to be addressed separately, through Customs.

B2. Regulatory, Institutional and Funding Overview

Work is currently in progress to provide an outline of the current NZ regulatory, institutional and funding arrangements applying to each of the four main 'modes' being assessed in the study, ie:

- Roads - covering all road user categories.
- Rail - covering both freight and passenger movements.
- Air - covering domestic passenger aviation (excluding tourism and charter flights, private flying etc).
- Sea - covering domestic sea freight movements (including those transported by international carriers).

The following Table B2.1 provides a 'first pass' overview of the current arrangements, in abbreviated form, for the four main 'modes'.

The more detailed work (anticipated to be 2-4 pages for each main mode) will start with the Rail mode, as a pilot in terms of scope, format etc[4]. The scope proposed for this pilot covers the following topics:

- Organisations involved -- status (public v private, central v local govt, etc) and roles.
- Relevant legislation and regulations/rules (v brief).
- Planning and funding arrangements and processes.
- Service requirements (to the extent these may be subject to regulation).
- Charges on operators (e.g. safety regulation etc) and on end users (e.g. FED, RUC, PT fares etc).
- Contestability and competition aspects (contestability in theory, extent of real and threatened competition in practice).
- Sector supply, demand and cost statistics – overview/summary.

In addition, brief descriptions of the current regulatory, institutional and funding position will be provided for other significant modes, including motorcycles, cycles and e-bikes, and e- scooters.

Once the detailed work is completed, we propose that this will be included as a section in the relevant modal working papers for each mode. As an alternative (or possibly additional), the regulatory etc provisions for the various modes could be brought together into a single working paper (so facilitating the task to 'compare and contrast' across the modes).

[4] Note that the work for the rail mode will focus on the new regulatory and funding system shortly to be introduced: it will not cover the previous system or attempt comparisons between the old and new systems.

Table B2.1: Organisational, market structure and potential competition by transport mode – summary

Assets	Functions	Roads Freight	Roads Persons -Cars etc	Roads Persons -Coaches	Roads Persons -Local buses	Rail Freight	Rail Persons -LD	Rail Persons -Metro	Air Persons -LD	Shipping Freight -LD
Regulation etc		CG	CG	CG	CG/RC .	CG	CG	CG/RC	CG	CG
Infrastructure:	Provision	)	)	)	)	)	)	)	3 largest LG/pvt;	Port coys -
	Maintenance	) CG/LG	) CG/LG	) CG/LG	) CG/LG	) KR	) KR	) KR	others largely LG	mostly RC/LG,
	Operation	)	)	)	)	)	)	)		some pvt
	Market structure	Monopoly - CG/LG	Monopoly - CG/LG	Monopoly - CG/LG	Monopoly - CG/LG	Monopoly (but road option)	Monopoly (but road option)	Modal monopoly	Regional monopoly	Regional monopoly
Vehicles &	Provision	)	)	)	)	)	)	)	)	)
Services:	Maintenance	) Pvt Op	)H'holds	) Pvt Op	) Bus ops	) KR	) KR	) RC	) Airlines-pvt	) Pvt Op
	Operation	)'- hauliers	)	) -coach cos	)	)	)	)	)	)-shipping coys
	Market structure	Open entry	Open entry	Open entry	Periodic contestability (route contracts)	Single rail op (modal monopoly)	Single rail op (modal monopoly)	Single rail op (periodic contestability)	Open entry (but min competition)	Open entry/ contestable.
	Alternative modes	Rail, ship	Coach, train, plane	Train, plane, car	Car, train (some), active	Truck, ship	Coach, car, plane	Car, bus (some)	Car, coach, train	Truck, train
End users		Distn, I-E	Persons	Persons	Persons	Distn, I-E	Persons	Persons	Persons	Distn, I-E

Key:
CG = central government
RG = regional government
LG = local government
KR = KiwiRail Group
I-E = Import/export

B3. Proposed approach to costs and charges assessment

B3.1 Introduction

The purpose of this study is to assemble data to support future policy analyses – it is not to undertake policy analysis. We need data on costs and on prices paid in a level of detail and disaggregation that enables their use for policy analysis. We do need to have some form of policy framework to identify the sort of analyses that may be undertaken.

B3.2 Outline of approach

A working paper will be prepared to provide a consistent framework for the assessment of the costs and charges that are included in the study. This will include:

- **Costs:** Three types of costs are typically used in transport economic policy analysis. These are ***average operating costs, social marginal costs*** and ***operator marginal costs***. Social marginal costs are short run costs. Operator marginal costs can be classified as short run or long run.

- **Prices (charges):** We also distinguish between average and marginal prices. Prices may be expressed as a per passenger or tonne and per passenger-km or tonne-km price.

- **Application by mode:** The working paper will summarise the relevant social marginal cost and operator marginal cost components by infrastructure type and mode, distinguishing where appropriate between user costs and externality costs.

B4. Economic Costs of Capital Assets

B4.1 Introduction

This section outlines the proposed methodology for assessing the annual costs of capital assets in economic terms: this methodology is to be applied to each of the four main modes being covered in DTCC (ie roads, rail, domestic passenger aviation and domestic sea freight).

In broad terms, the methodology involves the following steps (for each mode):

(A) Estimation of the value of the current asset base, calculated on a depreciated replacement cost (DRC) or optimised depreciated replacement cost (ODRC) basis as appropriate.

(B) Estimation of the annual depreciation of this asset base (in real terms), starting from the expected economic depreciation resulting from age and use, adjusted (upwards or downwards) to reflect any significant betterment or impairment in the asset condition over the year.

(C) Derivation of an appropriate "weighted average cost of capital" (WACC) relevant to each mode, having regard to its mix of assets and the mode's risk profile.

(D). Calculation of the annual economic costs of the assets as the sum: (A) * (C) + (B).

This paper focuses on the methodology for items (A), (B) and (D). Item (C), the estimation of an appropriate WACC, is covered in the separate section B5 – 'Weighted Average Cost of Capital.'

B4.2 Asset valuation concepts and potential applications

The approach/methodology outlined in this section applies to situations in which total (fully allocated) costs or average costs are appropriate, e.g. for cost recovery analyses comparing total costs of a mode/market segment with the government charges imposed on users of this mode/segment. This approach/methodology is not appropriate for situations where marginal costing is the more appropriate concept to apply (e.g. for congestion pricing).

As outlined in this section, a number of different concepts may be applied in valuing assets, depending principally on the purposes of the valuation.

The following asset valuation concepts are relevant here:

- ***Depreciated Historical Cost (DHC)*** is the original purchase or construction cost (including later improvements) less an allowance for depreciation based on an assumed economic life.
- ***Depreciated Replacement Cost (DRC)*** values the asset at its current replacement cost less an allowance for depreciation based on an assumed economic life, and differs from historical cost when costs have changed over time (e.g. as a result of cost inflation)..
- ***Optimised Depreciated Replacement Cost (ODRC)*** values assets at the cost of replacing the functions performed by a currently optimal configuration of assets (rather than replacement of all the current assets). This excludes redundant or obsolete assets, and is relevant where technological or economic changes shift demand for services.
- ***Opportunity Cost*** is the value of an asset in its most productive alternative use, and is a measure of the cost to the economy (or a company) of continuing to use the asset for its current purpose. Only recoverable assets that can be salvaged or used elsewhere have an opportunity cost, and the value in alternative use is net of the cost of converting it from its current use. Opportunity cost is a valuation principle implicit in all the replacement cost approaches, as it is used to value the resource inputs in defining replacement cost.
- ***Deprival Value*** is the loss that the current asset user would suffer if the asset were no longer available: it combines elements of the concept of replacement cost and that of the value of revenue streams generated by the asset.

As noted above the valuation used for infrastructure assets needs to reflect the use to which the figures are to be put. DRC is a measure of the current value of assets that previous governments and users have put into the transport system – calculated at current dollar values. It is a number the government should be aware of. But it is not the value of the current assets either to its owner (e.g. in the case of the railway) or the government.

ODRC is arguably a better measure of the value of the assets for an ongoing business, as it excludes obsolete and non-productive assets. We make the further distinction between depreciating assets – ie assets that eventually need to be replaced such as vehicles, track, pavements – and non-depreciating assets such as tunnels, land and earthworks. To keep the business going, revenue will need to be sufficient to replace the depreciating assets.

If the network is contracting, the assumption of an ongoing business no longer holds. Dis-investment decisions need to be made on the value of the network assets in their best alternative use, ie their opportunity cost.

The way that asset valuation concepts might be used is demonstrated by the following tests:

- Does the benefit to users exceed the value of the assets in their best alternative use (less the cost of recovery)? If not, the assets should be sold. The test of this condition is that prices cover the opportunity cost of capital.
- Does the benefit to users exceed the cost of maintaining the business as a going concern? If not, re-investment in those assets may not be justified. The test of this condition is that prices cover the ODRC of depreciating assets (ie those assets that wear out over tine and need replacement).
- Does the benefit to users justify expansion of the business? Investment decisions will have to be taken on a case-by-case basis, but one would expect expansion to be justifiable if prices cover ODRC on all assets.

The New Zealand Commerce Commission observes that: *"Opportunity cost is the correct economic concept for the valuation of assets. . . when what is to be determined is the cost to society of using an asset"* but notes that *". . . does not work very well when what is being considered is investment in new specialised assets. It is for this reason that regulators like the Commerce Commission permit regulated entities to earn a return on the value of a specialised asset greater than its opportunity cost – typically . . . its optimised depreciated replacement value (ODRC)".*

B4.3 Proposed approach to asset valuation in practice

Our assessment of asset valuations will start from the current (published) valuations of assets for each of the main transport 'modes' of interest. Our first step would be to identify the valuation principles and practices applied for each mode (and separately for state highways and local roads), and to clarify any substantial differences between the various practices.

The following approach is proposed for estimating the values of the assets currently used in the NZ (domestic) transport sector:

- The optimised depreciated replacement cost (ODRC) methodology is proposed as the basic approach to infrastructure valuation for study purposes. (Methods such as NPV are inappropriate in this case as they suffer from the 'circularity' problem.)
- Depreciation will, as a default position, be calculated on a straight-line basis in real terms over the expected life of the assets. We note that this will in general result in higher asset values than if a geometric depreciation approach (ie a constant %pa function) were adopted, for a given specified asset life and residual value [5].

[5] For 'mobile' assets for which there is a market (eg rail rolling stock), there is significant evidence indicating that a geometric formulation would better reflect market values. This point is to be considered further.

- For guidance, we will separate the DRC for items that depreciate and those that relate to non-recoverable ('sunk') items. The former includes track, signalling and telecommunications equipment (for rail), while the latter includes formation, tunnels and bridges (both road and rail).
- For land (which is non-depreciating but recoverable), valuation is more problematic: we propose valuation based on the value of adjacent land. However, we note that roads and other transport infrastructure can confer value on adjacent sites in urban areas: this valuation approach is likely to overstate the realisable value of transport land in practice in almost all situations, as both road and rail land holdings are likely to have high recovery costs that may well render the recoverable value near zero. As appropriate, we will seek expert advice on this issue from professional land valuers, including those in the transport agencies directly involved.
- Issues re optimisation and estimation of replacement costs ('greenfields' vs 'brownfields') may warrant more detailed consideration subsequently.
- In the study context, there may be a strong case for expecting a return on infrastructure assets that have a significant opportunity cost in alternative use (ie 'recoverable' assets); but the case for expecting a return on 'sunk' (non-recoverable) assets having no significant value in alternative use is much more arguable. These cases will be explored further as part of the study.

We note that the above proposals are generally consistent with those adopted by the NZ Commerce Commission in its determinations on the valuation of infrastructure assets for network industries (e.g. electricity lines and telecommunication sectors).

B5. Weighted Average Cost of Capital

B5.1 Introduction/Overview

The weighted average cost of capital (WACC) is the rate that a company expects to pay on average to all its security holders to finance its assets. The WACC is commonly referred to as the firm's cost of capital. A firm will typically raise some money from shareholders and some from banks and other financial institutions. The WACC will reflect the industry structure as well as the risk perceived by investors and lenders.

The cost of capital is an important component in estimating the economic costs of the domestic transport system. Most transport modes are capital intensive and the cost of the capital used needs to be reflected in the cost estimates.

The WACC will differ between modes and between operators. The questions for the DTCC study are whether the differences are significant (ie they might potentially compromise the Ministry's principle of mode neutrality) and whether they reflect real differences (e.g. risk), and in particular, whether state ownership has an effect on the availability and cost of capital. A related question is, when we are estimating capital charges, whether we should use an industry-specific WACC or a standard rate (e.g. the Government's social discount rate).

We believe it is important to estimate the WACC for transport asset owners and operators and in particular to identify the differences that do exist. If these are large, we will look further into the reasons for this and their impacts on investment decisions. We will discuss our findings with MoT and agree on the approach to take for further analyses at the modal level.

This section covers the methodology we propose to use for estimating the WACC for the different transport modes in New Zealand. The main transport modes covered are air, coastal shipping, rail and road.

Because the cost of capital for the four transport modes cannot be observed directly, it is necessary to use a model and derive data from market studies of comparable companies to estimate the cost of capital.

B5.2 General framework

The most common method used in New Zealand to estimate the WACC is some variant of the Capital Asset Pricing Model (CAPM).[6]

The CAPM has both methodological and practical limitations[7] but has the advantages of being widely used, is mathematically precise, and is relatively straight-forward to implement. Results from the model must however be tempered by a pragmatic view of investor behaviour and acknowledge that a relatively wide range of values can be supported.

[6] Sharpe, William F. (1964). "Capital asset prices: A theory of market equilibrium under conditions of risk". *Journal of Finance.* Lintner, John (1965). "The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets". *Review of Economics and Statistics*. **47** (1): 13–37.

[7] At the methodological level, the CAPM assumes that investors are only concerned with the impact of systematic risk factors on the required rate of return, as opposed to the total risk of the investment. Systematic risk relates to factors that affect all investments to some degree and which cannot be eliminated by holding a diversified portfolio of investments. The practical limitations of the CAPM relate to difficulties in obtaining accurate estimates of several of the key parameters to the model. In particular, because the asset beta and the post-tax market risk parameters cannot be directly observed but must be inferred from market studies.

The version of the CAPM formula usually applied in the New Zealand market is often referred to as the Brennan-Lally model[8] which provides an estimate of the expected return on equity after corporate taxes, but before personal taxes. The Brennan-Lally model adopts the standard CAPM model to account for New Zealand's dividend imputation scheme. The Brennan-Lally model is the version of the CAPM used by the Commerce Commission to derive allowable rates of return for the regulated electricity, gas and telco lines businesses and disclosure rates of returns for the three major airports in NZ.

B5.3 Estimation of the WACC

The post-tax weighted average cost of capital (WACC) will be calculated using the following formula:

$$WACC = (D/V)k_d(1-t_c) + (E/V)k_e \qquad (1)$$

where WACC = the weighted average cost of capital

D/V = the ratio of debt to asset value (at market values)

k_d = the required return on debt capital

t_c = the marginal corporate tax rate

E/V = the ratio of equity to asset value (at market values)

k_e = the required return on equity capital.

Estimates of the WACC from equation (1) require estimates of the required returns on each of the component sources of capital (equity and debt). Each component is discussed in turn below.

B5.4 Cost of equity

The model is written as:

$$k_e = r_f(1-t_i) + \beta_e(PTMRP) \qquad (2)$$

where r_f = the risk-free rate of interest

t_i =investors' average marginal tax rate on interest income[9]

β_e =the equity beta of the investment

PTMRP = the Post-Tax Market Risk Premium

Implementation of the model described in equation (2) requires estimates for four input parameters: the riskless rate, the marginal tax rate on interest income, the PTMRP, and the asset beta of the company or sector.

B5.5 Cost of debt

Estimating the cost of debt is relatively straight-forward. The standard approach simply adds a premium to the risk-free rate to reflect the default risk and illiquidity associated with any debt issued by the subject firm.

B5.6 Assumed proportions of debt and equity

The adopted gearing level typically assumes that there is a target capital structure for the firm, and that this target capital structure will hold for every year covered by the forecast free cash flows. Although the capital structure will obviously vary through time as debt is retired and new issues of both debt and equity are made, the assumption of a constant capital structure is not actually very

[8] Lally (1992).

[9] We assume that the effective tax rate on capital gains is zero.

important in the New Zealand context because the WACC estimate derived from equation (1) is largely invariant to the assumed level of debt.[10] This is a direct result of the assumption of tax neutrality that is built into equation (2).

B5.7 Sources of data

We propose using the Commerce Commission's latest estimates for the risk-free rate, the marginal tax rate on interest income and the PTMRP. The Commerce Commission's estimates are publicly available, are independent and have been widely reviewed and tested in the industry,

Our estimates of the asset betas, debt premia and capital structures for the four transport modes will be based on comparable company (compco) estimates from a range of data sources including:

- Reuters
- Bloomberg
- PWC's Cost of Capital report
- Broker report

The key parameter will be the asset beta. It will be necessary to assess separate asset betas for each of the four transport modes given the different technologies, competitive dynamics and risk profiles of the four modes.

Given the limited number of compcos for the NZ transport modes listed on the NZX, it is likely we will need to undertake research on international compcos. It will be important when assessing the international compcos that only companies with risk profiles that are comparable to the NZ companies are included in the reference set.

In undertaking our study we will consult with the major industry participants (including airlines, coastal shippers, Commerce Commission, KiwiRail and NZTA) as to the estimates and data sources they have.

[10] As a greater proportion of the cheaper source of funds is added to the capital structure, the required return on equity derived from the CAPM model increases to reflect the increase in financial risk. Under the assumption of tax neutrality, the cost advantage of more debt is almost exactly offset by the increase in the cost of equity.

B6. Market Segmentation

The two tables following provide an overview of how the total transport task for each of the four main 'modes' being covered in DTCC is to be segmented for analysis purposes:

- Table B6.1 provides a top-level segmentation by mode between person travel and freight travel, and between short distance/urban movements and longer distance movements.
- Table B6.2 provides a somewhat more detailed segmentation (not directly linked to table B6.1) for each of the four main modes and includes urban public transport (as a fifth 'mode'):
  - For the road 'mode' (A), the required segmentation will be relatively complex, with differences in the appropriate level and structure of segmentation depending on the particular aspects being analysed. Further details will be provided in the Roads working paper.
  - For the rail mode (B), the sea mode (C) and the domestic air mode (D), the basis for segmentation is less complex, with relevant details being shown in the table.
  - For the urban PT 'mode' (E), segmentation will be both by region (centre) and by mode. Rail mode will be assessed for both AKL and WLG: ferry mode only for AKL (the ferry services in WLG and CHC cater for only a very small proportion of their regional PT markets): bus mode will be assessed for the three largest centres in patronage terms (AKL, WLG, CHC), a selection of the medium size centres (covering Otago, Waikato, Bay of Plenty), and a selection of the smaller centres (about 12 centres each with patronage of less than 1.0 million boardings pa).

Table B6.1: NZ domestic travel market -- top-level segmentation

Infrastructure	Mode/vehicle type	Person travel		Freight travel	
		Short dist/ urban	Long dist	Short dist/ urban	Long dist
Roads	Car	* (1)	* (1)		
	Truck/van			*	*
	Bus & coach	* (2)	* (3)		
	Cycle	* (4)			
	Walk	*			
Rail	Freight train				*
	Pass train - long dist		*		
	Pass train - metro	*			
Air	Passenger		* (5)		
	Freight				* (6)
Sea	Passenger	* (7)			
	Freight				*
Notes:					
(1). To include taxis, car share etc					
(2). Covers scheduled services only					
(3). Covers scheduled bus/coach and tour/charter services					
(4). To include e-bikes, micro-mobility modes (scooters etc)					
(5). Covers scheduled services only					
(6). Air freight outside scope of DTCC.					
(7). Principally urban area ferry services (AKL, WLG, CHC)					

Table B6.2: DTCC Market Segmentation				Notes
A: Road system				
	A1 - Vehicle types:		*A2 - Area types (2):*	* The four road system categories (A1-A4) are essentially independent, so segmentation matrix in principle contains (8+8)*2*4*2 data cells for unit costs etc. In practice, different sub-matrices will be required for different analyses, so data requirements will be considerably reduced. More details of sub- matrices required to be provided in Methodology (Roads) report.
	Person tpt (8):		Metro/urban	
	Car -maybe sub-divided (eg standard car, SUV etc)		Rural/other	
	Light van		*A3 - Road types (4):*	
	Bus (public service)		E-way/M-way	* A1: This detailed vehicle type breakdown is primarily required (especially for freight) for VOC model development and road damage costs analyses.
	Coach (tour/charter etc)		SH other	
	M/cycle		Other-sealed	* A4: This time period breakdown is likely to be required only for analyses of congestion cost externalities.
	Cycle		Other - unsealed	
	Pedestrian			
	Other vehs		*A4 - Time periods (2):*	
			W/day pk periods	
	Freight tpt(8):		Other periods	
	Light van			
	MCV			
	3-4 axle rigid			
	8 axle T+T - GVM 44 t			
	8 axle T+T HPMV - GVM 48t			
	9 axle 50MAX T+T - gen fgt			
	9 axle 50MAX T+T- logging			
	9 axle T+T HPMV - GVM 53t			
B: Rail system				
	Freight (rail)	Domestic		I-I fgt costs for rail traffic included with relevant commodity
		IMEX		
		Bulk		
		Forestry		
	Freight (ferry CV)	I-I (KRG)		Road transport on ferries ("CVs"). Subsequently to be reported along with Bluebridge ferry service (see Section C below)
	Person	Long dist	Service	Split by 3 main routes: AKL-WLG, CHC - PIC, CHC -Greymouth.
		I-I (KRG)		Inter-islander passengers, cars. Subsequently to be reported along with Bluebridge ferry service (see section C below)
		Metro	Region	By region, - AKL, WLG (transfer info to section E)
C: Sea (domestic freight)				
	Containers -intl ships			Accounts for c 80% of NZ coastal container task.
	Containers -domestic ships			Accounts for c 20% of NZ coastal container task.
	Bulk - regular services			Distribution of petroleum products ex Marsden Point (Coastal Oil Logistics) and cement ex Northland (Golden Bay Cement) and imported (Holcim).
	Bulk - irregular (tramp) services			Coastal Bulk Shipping (MV Anatoki) operates ex Whangarei, transporting wheat, dolomite, cement, fertiliser etc.
	Bluebridge ferry		Freight	Cost allocation assumptions fgt v pax v cars -consistent with I-I ferries (Section B)
			Passenger (incl cars)	
D: Air (domestic commercial passenger)				
	Operator	Air NZ	Primary routes	Split of routes to be defined (depends on aircraft type, service frequency, patronage levels). The three route categories may be reduced to two, based on the results of analyses undertaken.
			Intermediate routes	
			Secondary routes	
		Other	Primary routes	As for Air NZ. 'Other' may focus on Jetstar, omit smaller airlines.
			Intermediate routes	
			Secondary routes	
E: Urban public transport				Principal data source will be Regional Councils. Some of this info will be derived in other sections (principally Rail) and consolidated here.
	AKL	Bus		
		Train		Some 'below rail' (infrastructure) data transferred from metro rail (Section B)
		Ferry		Desirable to include (largest ferry operation in NZ, by an order of magnitude).
	WLG	Bus		
		Train		Some 'below rail' (infrastructure) data transferred from metro rail (Section B)
		Ferry		Probably not warrant covering WLG ferry (very minor)
	CHC	Bus		Desirable to include (3rd largest urban bus operation in NZ).
		Ferry		Probably not warrant covering CHC ferry (very minor)
	Medium centres	Bus		Selection from Otago, Waikato/Hamilton, BoP/Tauranga (1-5m pax pa)
	Smaller centres	Bus		Selection from smaller centres, having regard to location and size (c12 centres, up to 1.0 million boardings pa).

Part C: Modal Topics

C1. Road infrastructure maintenance and operations

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C1.1 Introduction

This part of the study will look at the costs associated with the use of the road network by different vehicle types. These costs would cover the ongoing maintenance and operation of the road network. We will consider the costs imposed on the road asset for different heavy vehicle types, especially the heaviest goods vehicles and logging trucks which have their own particular characteristics and impose different levels of cost on the network. These and a range of other vehicle types would be covered for this work. These would include:

- Motorcycle
- Car
- LCV
- MCV
- Standard 8 axle truck and trailer operating at up to a GVM of 44 tonnes
- 8 axle truck and trailer operating as an HPMV with a GVM of 48 tonnes
- 9 axle 50MAX operating at up to 50 tonnes
- 9 axle 50 MAX operating as a logging truck (travelling full in the laden direction and returning empty with the trailer loaded onto the truck in the reverse direction). By loading the trailer onto the truck, the vehicle wear increases compared to an empty vehicle but the road user charges are reduced.
- Standard 8 axle truck and trailer/articulated unit operating as an HPMV with a GVW of 53 tonnes
- 2 axle bus
- 3 axle bus

In addition, we would also consider the position for the generic vehicle types of HCV1 and HCV2.

C1.2 Road Cost Allocation Model

The charges faced by motorists whether through petrol tax or road user charges are based on the MoT road cost allocation model (RCAM). We will look to the RCAM for guidance on which costs should be taken into consideration in different circumstances. The RCAM has been revised over the last 10-15 years and there has also been discussion about its appropriateness for particular types of traffic.

The RCAM by its name essentially allocates the total cost of road maintenance to different vehicle types. It is thus an average cost concept. For the purposes of the DTCC, information is required on marginal costs, the change in the costs resulting from a unit increase in use by road type. For this it is necessary to consider the extent to which the allocated costs derived from RCAM would be able to meet this requirement, both in general and for different road types and conditions. Allowance needs to be made for elements for which the costs are effectively fixed or variable. For the agency cost, road maintenance will be considered from a steady state perspective, without enhancement or degradation of the network.

For the vehicle types set out above, estimates will be made of their typical loadings. These will then be translated into Equivalent Standard Axles (ESAs) per vehicle. This and the vehicle type would then be input into RCAM to determine the costs imposed on the road network from these vehicles. This would give the average cost and the marginal cost for the "typical" aggregated road type.

Further work would then be undertaken to give estimates of the road wear potential and associated costs for a range of different road types, as follows:

- Motorway
- Other Urban SH

- Other Rural SH
- Urban Local
- Rural Local Sealed
- Rural Local Unsealed.

C1.3 Social Marginal Cost

Passage by heavy vehicles causes road wear that results in deterioration of the road profile as measured by the international roughness index (IRI). This in turn causes an increase in the operating costs of all vehicles using the road. The practice in New Zealand is to undertake regular maintenance so that the road remains in good condition. Nevertheless, there is a short run cost which is the cost to all users consequent upon travel by the marginal vehicle in the absence of mitigating action by the road authority. We will call this the social marginal cost (SMC) to distinguish it from the agency cost of undertaking remedial maintenance.

We will calculate the SMC for representative road and vehicle types. We will use the pavement management program dTIMS to estimate the change in the IRI due to the passage of heavy vehicles. To assess the damage factors, the ESAs and PCEs for each of the vehicle types to be considered will be calculated. This will be based on available data about the usage of these vehicles, including possibly WIM data, and a review of the literature. Where data is not readily available or a range of numbers is all that is found, engineering judgement and experience will be applied to produce reasonable values, with some commentary on the possible range of values that could be used. Once we have calculated the change in IRI, we will use tables and equations provided in NZ Transport Agency's Economic Evaluation Manual (EEM) to calculate the change in vehicle operating costs and then multiply by the AADT to get the SMC.

C1.4 Proposed approach for Average and Agency Marginal Cost

Three major elements are associated with this work, as follows:

1) Determining the damage factors associated with different vehicle types - expressed in terms of Equivalent Standard Axles (ESAs) and Passenger Car Equivalents (PCEs); and
2) Assessing the costs imposed on different road types; and
3) Apportioning these costs to different types of vehicles.

w**1) Our approach to assessing the damage factors associated with different vehicle types** was described in section C1.2 It should be noted that currently there is little financial incentive for heavy transport operators to load vehicles in such a way as to minimise road consumption, so there is a large range of ESA values, even for the same axle number and spacings with the same total vehicle gross weight.

2) To assess the variable costs for the different road types, we would seek to extract information from available data sources such as RCAM supplemented by NZTA funding data or other available sources. Initial checks suggest that there may be limits on the level of disaggregation of cost data available from RCAM in terms of the 6 road types chosen for this study. If other sources have similar limitations, assumptions drawing on professional judgement will need to be made to adjust the splits to achieve the best possible approximation of the split of costs. As far as possible we would base our analysis on the RCAM output but supplemented by other data sources to allow a more comprehensive assessment to be undertaken.

In the event that the RCAM process proved infeasible or if it becomes necessary to provide supplementary evidence to provide greater detail, an alternative methodology would be to estimate the variable costs of maintaining a generic km of each type of road based on research, personal knowledge and experience, and data available. This will assume a traffic volume and ESA for which each type of road has been designed, based on a review of traffic data.

For either approach, the main categories of work on roads required to overcome the variable effects of traffic, for both sealed and unsealed roads, include:

a) Pavement Maintenance
b) Pavement Surfacing
c) Pavement Rehabilitation
d) Traffic Services (markings and RRPMs – these will not apply to unsealed roads).

It will be assumed that most other costs are relatively fixed and unaffected by additional use of the road.

It is not proposed to consider bridge maintenance, repair, upgrade and replacement costs as part of these variable costs, as assigning these costs between different vehicle types is too complex within the scope of this study. An argument can be made that the bulk of any upgrade or replacement work is required to carry heavy traffic but eventually bridges deteriorate to such a degree that they need to be upgraded or replaced anyway, just to safely carry lighter traffic, especially if they are very narrow. Upgrades carried out to allow overweight, 50 Max or HPMV vehicles to cross bridges are not needed immediately to allow Class 1 vehicles and lighter to use the bridge so potentially should only have this work costed against the heaviest vehicles.

It is also not proposed to consider as part of this task the variable additional cost that congestion imposes on some parts of the networks. This will be addressed separately (see paper D2).

3) To apportion costs to different vehicle types, the variable costs will be split between those which are pavement structure/ axle weight related (a and c above), as measured in terms of ESAs, and those that are dependent on other factors, primarily surface/ tyre damage related (b and d above), as measured in terms of Passenger Car Equivalent (PCE). As far as possible we would aim to develop an approach which is based on RCAM or consistent with the RCAM approach.

The costs calculated under item 2) above will be split into a cost per ESA or PCE based on the number of ESAs or PCEs expected to run across a road prior to it needing a specific maintenance or renewal treatment.

C1.5 Steps required

The steps required to undertake this task would therefore involve:

- Identify the road wear characteristics for the range of typical vehicles (as outlined below)
- Estimate the change in IRI due to an additional vehicle of each type
- Use EEM to calculate the change in vehicle operating costs
- Review the results obtained from RCAM for these vehicle types
- Develop approaches to disaggregating the results by road type
- Review this approach against alternatives developed elsewhere
- Finalise the estimates of average, social and agency marginal costs by vehicle and road type, and convert these into estimates per net tonne-km (by applying average load factors for different vehicle types)

These results would then be available to be used alongside the outputs from other workstreams to estimate the total costs of operation for a range of vehicle types and road configurations. The proposed breakdown of road types and vehicles is set out in Table C1.1, but this may be amended to reflect either new opportunities or limits in the data available. In addition, not all road/vehicle combinations are likely to occur in practice so a number of the matrix cells would not be completed

The results will be provided in a matrix along the lines of the following:

Table C1.1

Vehicle and road type combinations

	Possible vehicle type									
Road type	Car	LCV	MCV	Standard 8 axle Truck & Trailer/ Artic 44 tonnes	Standard 8 axle Truck & Trailer/ Artic HPMV 48 tonnes	50 MAX	50 MAX as logging truck	Standard 8 axle Truck & Trailer/ Artic HPMV 53 tonnes	Bus 2 axle	Bus 3 axle
Motorway										
Other Urban SH										
Other Rural SH										
Urban Local										
Rural Local Sealed										
Rural Local Unsealed										

It should be noted that once the costs this per ESA and PCE are calculated for each road type, the variable costs of any vehicle type or loading configuration of a vehicle type can be calculated by multiplying its ESA and PCE values by the unit costs for that road. This could then be used for a wider range of options and loading configurations.

C2. Valuation of road infrastructure

Principal author: Richard Paling, Richard Paling Consulting

C2.1 Introduction

The valuation of the road infrastructure in New Zealand is an important element in determining the total costs of the road system and the extent to which the revenues from users match these costs. (In the STCC study the possible capital return from the investment in the road system was estimated to account for over two-thirds of the provider costs associated with the road system.)

While there are alternative approaches to valuing road infrastructure. we would propose to use simple Depreciated Replacement Cost for this analysis. This probably provides the most robust method of assessment and avoids the complexities involved with the Optimised Depreciated Replacement Costs.

Road assets can be classified into three types, reflecting their opportunity costs and the extent to which the asset depreciates:

- recoverable and depreciated. These assets would need to be periodically replaced and would have an opportunity cost in alternative uses;
- recoverable but not depreciated (land); and
- sunk costs; These would include assets like bridges and tunnels and road formations which have a long life.

The extent and value of the State Highway network is updated regularly by NZTA. Replacement values and current depreciated values for the local road network can be derived from data typically included in the TLAs annual reports. Recent estimates of the current values of these networks give a value of about $30bn for the State Highway network and $50bn for the local road network. We propose to investigate and document the basis on which the current valuations for both the state highways and the local roads (which may not be consistent across all local authorities) have been made.

In allocating these asset values to the categories defined above, one issue is whether an infrastructure asset is considered to have an alternative use or whether the asset has no significant value in alternative use: we would review the data available to help determine this split. Alternative valuation approaches and their implications would be reviewed and the costs associated with each determined for roads in different ownership. It may turn out to be appropriate to provide a range of valuations for the road system, related to plausible variations in the assumptions made.

Because of the way in which the data is available it may not be possible to split the valuation of the network down beyond the basic split between State Highways and local roads for the categorisation by segment. We would investigate the extent to which additional material would be available on the geographical distribution of the costs, particularly for local roads. We would also investigate and comment on the significance of any differences in the approach used for the valuation of local roads and State Highways.

C2.2 Approach to be undertaken

The key steps to be undertaken can be summarised as follows:

- Assembly of information on updated valuations of the state highway and local road networks.
- Review of documentation and discussions with the roading authorities as to the basis for their valuations (both original and current depreciated values)
- Review and discussion on the split of valuations between the three asset types noted above.

- Derivation and summary of current ODRC values of the SH and LR networks, broken down by area/ road type where possible.

C3. Transport expenditure and funding overview

Principal author: Richard Paling, Richard Paling Consulting

C3.1 Introduction

This element will look at the flows of funds to and from the main agencies involved in the provision of roading and urban public transport services in New Zealand. The majority of the funds involved are derived from direct user charges. Lesser amounts are obtained through rates levied by regional and local authorities. Our analyses will focus on the figures for financial year 2018/19, on the assumption that these will all be available, (The equivalent information for rail, coastal shipping and domestic aviation is provided within the appropriate modal papers.)

C3.2 Sources of revenues

The main sources of transport funds include:

- Fuel duties
- Road user charges
- Motor vehicle licensing and registration
- Regional fuel tax
- Road tolls
- Public transport fare revenues
- Government funding for the SuperGold card scheme
- Government funding for fire services
- Motor vehicle insurance charge fire levy
- Local authority (transport) rates
- Regional council rates
- Police fines

The extent to which other sources of revenue are generated for transport purposes and which enter public sector finances would be investigated. These could potentially include for example the fare revenues from public transport users which now typically accrue to regional councils. The exact procedures for these would be identified.

C3.3 Funding uses

The current structure of payments would be reviewed and categorised under four main headings (further subdivided between roading and public transport where appropriate):-

- Transport capital
- Transport recurrent
- Other transport - non-recurrent (mainly payments to ACC)
- Non-transport - various levies and fines

C3.4 Outputs

As well as producing a report showing tables of revenues and expenditures, the results would be summarised in a flowchart, showing the linkages between the various forms of revenues and expenditures. In developing this we would investigate whether this is best kept as a single chart or whether splitting this into separate charts for different types of transport would be appropriate.

C3.5 Linkages with other workstreams

This work would link with the "Road vehicle ownership and use charges" task (following), which would provide further details of charges on road users.

C4. Road vehicle ownership and use charges

Principal author: Richard Paling, Richard Paling Consulting

C4.1 Introduction

There are a number of charges levied on road users relating in part to vehicle ownership and in part relating to the use of the vehicle. These are supplemented by roading rates raised by the TLAs to fund local road construction and maintenance. The main charges are:-

- Vehicle licensing and registration
- ACC levies
- Driver licensing fees
- Fuel duties
- Regional fuel taxes
- Road tolls
- WoF/CoF fees
- Fire insurance levies
- Transport infringement charges
- Roading rates - while these are not strictly a charge on vehicle ownership or use, they contribute to the total revenues raised to fund the transport system.

Two complementary approaches will be taken, the first a bottom-up approach based on disaggregated data and the second looking at aggregated data to assess the overall position for the sector. The results from the two approaches will be compared and any significant differences reconciled.

The work will incorporate changes in the structure of taxation in recent years. These include the introduction of the Auckland Regional Fuel Tax and the implementation of a number of tolled routes. There have also been changes to the structure of road user charges including the introduction of HPMVs (high productivity motor vehicles) with increased road user charges to allow for the effects of the increased weight of vehicles. There have also been changes in the regime for charging for vehicle licensing and registration with a reduction in the annual registration payments.

C4.2 Approach to the work

The ”bottom-up” approach to the assessment of the vehicle ownership and use charges aims to assess revenues by vehicle type, whereas the “top down” approach looks at the total revenues received by the relevant authorities. For this work we would aim to extend the bottom up approach, as far as possible allocating charges not directly attributable to particular vehicle types using appropriate measures of vehicle ownership or use. This would allow the revenues generated by different vehicle types to be compared with the costs imposed by these on the road network.

The vehicle types for which we would aim to allocate revenues would comprise:

- Car
- Truck (by type)
- Bus
- LGV
- Motorcycle
- Other

We would also investigate whether the data available would allow further disaggregation by vehicle type, particularly by different categories of heavy vehicle. We would also aim to separate identify the revenues raised by the Auckland regional fuel tax.

The specific steps required in this task would comprise:-

- Review scope of charges on road vehicles.
- Identify bottom-up and top-down estimates of vehicle ownership charges by vehicle type
- Identify as far as possible the basis for allocating charge revenues to particular vehicle types (where this is not immediately available from the information collected).

C4.3 Outputs

This aspect of the study will be documented in a working paper.

The aggregated figures would be reconciled with those derived from task C3.

The figures for unit charge rates (per vehicle etc) would also be reconciled with the relevant charge figures included in our vehicle operating cost models (refer task C5 following).

C4.4 Key agencies

It is anticipated that the key sources of data would be provided by the following public agencies:

- MoT
- NZ Transport Agency
- ACC
- Regional and local councils
- Police
- Ministry of Justice Traffic enforcement unit.

C5. Road vehicle operating cost models

Principal author: Richard Paling, Richard Paling Consulting

C5.1 Introduction

This section summarises the approach that will be taken to determining the vehicle operating costs for the main categories of road users: private vehicles (cars), commercial vehicles (trucks and vans), and motorcycles. Operating costs for other road- based modes (including bus, taxis and ride-share, cycling and micro-mobility) are dealt with separately under their particular modal topics.

While broad operating cost relations are set out in the EEM, for the vehicle operating cost models developed for this study, we are proposing a more fine-grained approach. This would look at a range of different vehicle types for both cars and freight vehicles in more detail than would be possible using the EEM material. We would however compare the results we obtain from our more detailed models with those derived from the EEM approaches.

One element of the operating cost models is the valuation of the time of the occupants of these vehicles. For road freight vehicles this would be based on the wage of the driver. For private cars the costs of the time of the occupants have been excluded but these could be added in separately if required. For this we would make use of the values of time as set out in the EEM.

C5.2 Car operating cost model

C5.2.1 Introduction

Private cars play a dominant role in the movement of people both in cities and in rural areas, and even in major cities like Auckland they are used for over 70 per cent of commuting journeys and 45 per cent of journeys to education. Understanding the structure of the costs of vehicle ownership and operation therefore plays an important role in determining the total costs for personal travel.

C5.2.2 Proposed approach

The assessment of car operating costs would consider a broad range of vehicle types. A review would be made of the types of vehicles entering and within the vehicle fleet and typical vehicles would be identified which represented the main components of the fleet. While the types of vehicles are yet to be identified, it is anticipated that these would include a standard car, an SUV type vehicle, and possibly a people carrier: separate operating cost models would be derived for these, as well as combining these into an overall model for cars as a whole.

In line with emerging trends we would also investigate the costs of hybrid and fully electric vehicles although it is recognised that the patterns and types of electric vehicles are changing.

To develop the costs, we would aim to draw on the vehicle operating cost models developed by the AA and would discuss with this organisation the most appropriate specific vehicle types to assess.

C5.2.3 Cost structure

We anticipate identifying the costs in three categories, ie those that this vary by distance, those which can be regarded as a fixed amount (per year) and those which vary with the time the vehicle is in operation. Then, as required, we could readily derive average costs per vehicle km as a function of average operating speeds and vehicle utilisation.

The use of the models would allow costs to be estimated for a range of traffic conditions and journey types including urban journeys in peak and other periods on different road types, and longer distance interurban and rural movements.

The costs developed would primarily be in terms of the financial costs to the user (expressed including or excluding GST, as appropriate). With appropriate adjustments to remove any taxation components, these would provide the economic costs of car operation from the national perspective (but without covering externality costs such as for congestion and GHG emissions - which will be addressed in other work streams).

C5.2.4 Outputs

The outputs of this component of the study would be documented in the working paper. The relationships derived in this could then be applied to estimate the costs facing users based on the different conditions for trips in different areas or at different times

C5.3 Truck cost model

C5.3.1 Introduction

Information on the costs of operation for a range of trucks and truck types forms an important element of understanding the costs faced by those moving freight and in association with the models being developed for other freight modes allows the comparative costs of different modal options to be identified.

C5.3.2 Understanding the cost structure

new operating cost models developed in recent years particularly by National Road Carriers (which are also used by the Road Transport Forum). These allow the costs to be developed for a range of vehicle types and operating conditions including the use of vehicles as HPMVs either as standard 50MAX vehicles which are permitted to use any part of the road transport network except where they are excluded and other vehicles operating under an HPMV mass permit which are restricted to particular routes.

The range of vehicles proposed for this exercise comprises:-

- Light Van
- Medium Goods vehicle
- 3-4 axle rigid vehicle
- 8 axle T+T - GVM of 44 t
- 8 axle T+T HPMV - GVM 48 t
- 9 axle 50MAX T+T general freight
- 9 axle 50MAX T+T used for logging
- 9 axle T+T HPMV - GVM of 53 t

The models developed would aim to break the costs of operation into three main categories:-

- Fixed costs (ie annual charge per vehicle, covering truck capital, operating overheads etc);
- Distance related costs ('direct operating costs', including fuel, RUC, vehicle repairs and maintenance, tyre costs etc); and
- Time related costs per hour costs (principally driver wages and direct on- costs).

This would allow the costs for different movement types and different vehicle utilisations to be estimated on a per veh-km basis and potentially on a per net tonne km basis (using average payload data by truck type, from WIM or other sources).

The approach would be developed to provide two sub-models, the first reflecting the full financial costs of operation of trucks and the second adjusting these to remove a range of taxes and levies in order to provide the basis for the assessment of the economic costs of truck operation. These economic costs could then be combined with estimates of the external costs (covered in other topic areas) associated with truck movements including environmental impacts, road wear costs and accidents and congestion to give estimates of the full social costs of truck operation.

C5.3.3 Applying the model in practice

While the model developed above would provide the basic building blocks to estimate truck costs, the results of this would need to be combined with real world experience for these to provide the results required for the DTCC study. In particular this would need to take into account the annual utilisation of vehicles and also the typical payload carried. Information on typical payloads is available from the WIM data collected by the NZ Transport Agency and from the recent research project "Valuation of freight time and reliability" and the results from this would be reviewed with freight industry stakeholders. Information on typical vehicle usage and trip patterns for particular movements such as urban delivery by different vehicle types would be sought from a range of industry stakeholders.

C5.3.4 Outputs

The output of this component of the study would be documented in a working paper.

C5.4 Motorcycle operating costs

C5.4.1 Introduction

Although not a major transport mode and indeed this is no longer considered as separate mode in the Census journey to work or journey to education questions, the costs, impacts and charges associated with motorcycle use are distinct from other modes. For this reason, we have identified them as a separate user group and sub-mode in this study.

C5.4.2 Operating Cost Estimates

The assessment of motorcycle operating costs would follow a similar approach to that set out for private vehicles in section C3 above. A review would be made of the types of vehicles in the vehicle fleet and typical vehicles would be identified which represented the main components of the fleet. We expect to segment motor scooters from motorcycles, and a further engine capacity-related segmentation may be appropriate.

To estimate the costs we would develop an operating cost model with a structure similar to that used by the AA for private vehicles (we note that the AA vehicle operating cost model does not include estimates for motorcycles). We would analyse the data on the registrations of motorcycles and discuss the key model inputs with motorcycle user groups, including advice on the most appropriate specific vehicle types to assess.

In common with our approach to private vehicle costs, we would aim to identify the costs in three categories, the operating costs that vary by distance, those which can be regarded as a fixed amount (per year) and those which vary with the time the vehicle is in operation. The use of the models would allow costs to be estimated for a range of traffic conditions and journey types including urban journeys in peak and other periods on different road types, and longer distance interurban and rural movements.

The costs developed would primarily be in financial terms representing the cost to the user, but with appropriate adjustment they would also form the basis of the assessment of the full social costs of car operation bringing together the results from other workstreams covering congestion and environmental costs.

C5.4.3 Outputs

The outputs of this component of the study would be documented in a working paper generally similar to that for private cars.

C5.5 Presentation of the results

Together with assumptions about typical operating conditions by different road types, for the vehicle operating models we would aim to present the results for the range of vehicle and road types set out in Table C5.4.1. Two sets of costs will be provided: the financial costs to the road user (per vehicle km); and the economic costs excluding any taxation components (per vehicle km).

Table C5.4 .1   Vehicle operating cost functions – by vehicle and road type combinations figures in $/veh km)

Vehicle type	Urban expressway	Other metro	Other urban	High quality rural	Other rural sealed	Other rural unsealed
Motorcycle						
Standard car						
SUV						
People carrier						
Light Van						
Medium Goods vehicle						
3-4 axle rigid vehicle						
8 axle T+T - GVM of 44 t						
8 axle T+T HPMV - GVM 48t						
9 axle 50MAX T+T general freight						
9 axle 50MAX T+T used for logging						
9 axle T+T HPMV - GVM of 53 t						

For the urban components, assessments would be made of the typical costs for peak and other periods

As well as giving general parameters for estimating truck costs for different vehicle types, the results could also be applied in case studies which would allow the costs of transport by different modes or by different vehicle types to be compared both on the basis of financial costs and of the full social costs of operation. This could either use standard assumptions about vehicle use or payloads or more specific assumptions where available. Again, as far as possible we would aim to validate the results obtained from this modelling against real world experience.

C6. Long Distance Coaches

Principal author: David Lupton, David Lupton & Associates

C6.1 Scope and methodology summary

Table C6.1: Scope and methodology	
Topic	Long distance coaches. (Scheduled)
Key outputs	Typical peak season and off-peak costs, fares and revenues per km.
Key inputs	Vehicle capital and operating costs. Annual km per vehicle, Average passengers per service, Proportion of buses held for maintenance /spare. Typical fares for main routes.
Data sources - specification	Operator annual accounts, published fares
Data sources - organisation	We propose to find one or more long distance operators who are willing to share data, but this can be cross-checked or substituted by published data on vehicle costs and data from urban operators
Data issues (known or anticipated)	Assumptions on utilisation have a considerable impact and will be the focus of discussions with operators
Proposed analyses	Long distance bus operating costs will first be divided into costs per vehicle, per kilometer and per hour. Typical high and low season utilisation rates will then be used to calculate an average cost per passenger-kilometer for trunk routes and for regional routes by these periods. These will be compared with published high and low season fares.
Dependencies on other topics - inputs	Cost information will be compared to that for urban buses (with allowance for differences in operating speeds, vehicle capital costs and effective lives etc). Road user costs and charges will be taken from the Road Vehicle Operating Cost Models (paper C5).
Dependencies to other topics - outputs	None
Risks, uncertainties	Cooperation from long distance operators may not be forthcoming or limited
Other comments and issues	The concept of marginal cost is difficult to interpret for scheduled services. It is probably better to include a discussion of the issues rather than present numbers that are almost certain to be misunderstood. Much of the analysis also applies to tour and charter services. We will cover these discursively.

C6.2 Supporting notes

The costs for operating a long-distance coach can be relatively easily identified. They are normally divided into three main categories: bus kilometre costs, primarily fuel and road user charges; bus hour costs, primarily wages; and per vehicle costs, primarily capital charges and vehicle license fees. Vehicle maintenance costs are often divided between all three cost drivers depending on the maintenance regime of the operator (ideally using regression analysis, but often arbitrarily). To these need to be added passenger servicing (reservations, ticket office and terminals), marketing and management costs. Vehicle operating costs vary with vehicle size, age and quality but are otherwise, to a large extent, common across all operators. Passenger handling and overhead costs are very operation-specific but will generally vary with the size of the operation. While depot and terminal costs can be operator-specific, they are generally a small proportion of total costs.

Of these costs, only road user charges and vehicle licence fees are direct government charges. These will be investigated under the road infrastructure cost section and the implications of the results will be subsequently incorporated here. Tax and other charges that form a component of other costs (e.g. fuel) will be identified.

As well as estimating the average cost, we will calculate short and long run marginal costs, Timetabled operations pose a conceptual problem for any comparison of economic costs against the fare paid. At the extreme, the marginal cost of an extra passenger on a midweek off-season service is near zero while an extra passenger at peak times necessitates an entire additional bus. For this reason, it is common to use an increment of (say 5%) in passengers but the right answer actually depends on the question posed. We suggest that some appropriate questions to ask an operator would be - what would your criteria be (i.e. what costs would you need to cover) for running additional services in the low season; in the high season (maybe purchasing additional buses)?

Long distance bus fares are generally distance-based with relatively little taper, reflecting the ability of the operator to adjust the total capacity offered to demand over sub-sections of a route. However, for longer distances the fares are believed to be constrained by competition from discounted air fares. We will compare costs and fares on a per passenger-kilometre basis, but will also look at the fare structure to see whether this logically divides into per passenger and per kilometre components.

We will seek the cooperation of one or more of the InterCity franchise operators and/or other smaller operators to provide management accounting data from which unit vehicle operating costs can be derived together with a questionnaire to ascertain passenger handling and overhead costs and on fare policy. Data collected in this way will be supplemented (or in the worst case replaced by) data derived from industry publications, from urban bus operators and suppliers to the industry. There is extensive international literature on bus and coach operating costs, much of which can be converted to New Zealand conditions by changing the assumed vehicle prices, fuel price and wage rates. This will be compared with data we already hold for the NZ urban bus sector.

C7. Car parking

Principal author: Stuart Donovan, Veitch Lister Consulting

C7.1 Introduction

Along with rights-of-way and vehicles, parking is a key part of the transport system required to support the use of private vehicles. Evidence suggests the price of parking exerts a major influence over people's decision to travel by car. Notwithstanding its central role, there exists limited prior research—at least in the New Zealand context—on the costs and charges of parking. For this reason, the DTCC study presents a somewhat unique opportunity to address an important gap in our understanding of parking costs and charges, which is likely to usefully inform policy.

To estimate the costs and charges of parking, we need to overcome several complications. First, the supply of parking is made-up of both public and private providers, which face distinct incentives that lead to different costs and charges. Second, the supply of private parking is, in many places, not set by market forces but rather land use policies, which cause the cost of parking to be bundled into the costs of goods and services, such as housing, and passed onto all users. Hence, people who travel by non-car modes are likely to be cross-subsidising parking for those who drive. Third, the actual charges that are paid by users can vary significantly depending on trip-type, for example shopping vis-à-vis commuting, and unobserved characteristics, such as whether someone receives employer provided parking. This gives rise to large variation in the incidence of parking costs. Finally, compared to rights-of-way and vehicles, there has historically been a lack of consistent and comprehensive data on the nature of parking supply and demand.

Our parking methodology seeks to overcome these complications and, in the process, help to answer the following three focus questions:

1. What is the economic cost of parking (per day) and how do these costs vary by location?
2. What financial charges are attached to parking and how do these charges vary by trip-type, time of day, and location?
3. How is the burden of parking charges split between commuters and employers?

In some respects, the DTCC study represents one of the first serious attempts to answer these questions in the New Zealand context. Moreover, some of our work relies heavily on data supplied by local government and even private organisations. For this reason, our methodology is not overly prescriptive but rather designed to adapt to the information that is forthcoming.

C7.2 Key features of our scope and methodology

C7.2.1 What is the economic cost of parking (per day) and how do these costs vary by location? To answer this question, we will distinguish between several typologies of parking, specifically (1) on-street parking and (2) off-street parking. The latter may be further split into (2A) surface parking and (2B) structured parking. We assume the costs of providing each parking typology varies by location.

Formally, let c_{ij} denote the cost of typology i in location j. The average cost of parking in each location, which we denote by $\bar{c}_j$, can be calculated using the following formula:

$$\bar{c}_j = \frac{\sum_i c_{ij} s_{ij}}{\sum_i s_{ij}} \quad \forall\, j$$

Estimating $\bar{c}_j$ requires two pieces of information: the average cost of each parking typology in each location, c_{ij}, and the supply of each parking typology in each location. For c_{ij}, we propose to draw on parking input costs presented in Nunns (2017), specifically Table 3, which considers the costs of inputs for land, construction, and operations. As part of the DTCC study, we will (1) update the figures in Nunns (2017) to 2019 dollar values and (2) extend the data to include on-street parking, as per Table C6.1 below (NB: These are preliminary values and subject to confirmation and change).

Table C7.1: Preliminary parking costs

Input	Typology	Annual costs per car-park (by user characteristic)		
		Low density	***Medium density***	***High density***
Land [$ p.a.]	*On-street*	$112	$640	$1,440
	At-grade	$400	$2,200	$4,800
	Structure	$64	$448	$1,493
Cons. [$ p.a.]	*On-street*	$55	$61	$67
	At-grade	$195	$210	$224
	Structure	$1,893	$2,038	$2,184
OPEX [$ p.a.]	*On-street*	$227	$325	$422
	At-grade	$455	$650	$845
	Structure	$910	$1,300	$1,690
Totals [$ p.a.]	*On-street*	$394	$1,026	$1,930
	At-grade	$1,050	$3,060	$5,869
	Structure	$2,866	$3,786	$5,366

To gather information on the supply of each parking typology in urban locations, s_{ij}, we will request information from local government in New Zealand, with a focus on those urban areas where the composition of supply is likely to be most heavily skewed towards structured parking.

Using our data on costs and supply, denoted by c_{ij} and s_{ij}, respectively, we can calculate the average cost of parking, $\bar{c}_j$ in each location. To finish, we will develop a simple quantitative model that links $\bar{c}_j$ to readily observed spatial outcomes, such as density and mode share, which will enable us to expand our sample to all areas in New Zealand. In doing so, we expect the average cost of parking $\bar{c}_j$ will be relatively flat in most locations, although rise relatively sharply in major urban centres as the cost of land increases and the composition of supply shifts to structured parking.

In more rural locations, where data on parking supply is less readily available, we propose estimating the supply of parking by dividing the number of registered private vehicles by the average utilisation of car-parks. For example, if there are 150,000 registered vehicles in rural parts of Auckland, and the average car-park utilisation is assumed to be 25%, then this implies a total of 150,000 / 0.25 = 600,000 car-parks. In these areas, we suggest (1) surface parking is predominant and (2) operating costs can be ignored. Using the costs in Table C7.1, we can impute costs of $701 p.a., which comprise annualised costs of land ($640 p.a.) plus construction costs ($61 p.a.). Multiplying the total number of car-parks (600,000) with the estimated annual cost ($701 p.a.) yields total annual parking costs (capital and operating) of $420.6 million p.a. We will define the precise spatial extent of our analysis of parking costs once we have (1) collated data on parking supply and (2) confirmed the geographic segmentation adopted in other parts of the DTCC study.

C7.2.2 What financial charges are attached to parking and how do these charges vary by trip-type, time of day, and location? Second, we will consider the question of financial charges. The charges paid by users vary due to myriad factors, such as differences in trip-purpose and personal circumstances, such as employer-provided free parking.

To estimate user charges, we propose drawing on several sources of data. Our primary source of data will be responses to HTS questions about parking payment, specifically responses to fields *trwpark*, *trparkfee*, and *trwhopaid.* We will investigate whether meaningful differences exist between trip-types, such as shopping vis-à-vis commuting. To ensure a decent sample to these questions in smaller locations, we propose analysing HTS data over several years. At this stage, we expect to use the HTS to answer the following questions:

- The type of parking used (*trwpark*)
- The proportion of trips for which a parking fee was paid (*trparkfee*)

We will liaise closely with the MoT HTS team to interpret answers to these questions. We understand—although wish to confirm—whether the HTS records the parking fee, or charge, itself. If not then we will need to impute parking charges from other sources of data, such as:

- *Parking data from Councils that currently charge for on-street and/or off-street parking, including residential parking permit schemes.* We will use this data to gain insight into priced parking in different parts of New Zealand. We are interested in revenue charged per user / hour, duration of stay, and the split between on and off-street parking.
- *Commercial parking operators, from which we will collect data on posted parking charges.* Given the commercial sensitivity of this data it is likely we will have to estimate average charges paid at commercial parking facilities based on assumptions on the average duration of stay, which can be sourced from the HTS and/or council parking data.
- *Ancillary research,* such as Colliers Global Survey of Parking Costs and documents associated with recent government proposals to apply fringe benefit tax to city centre parking.

We will use these secondary sources to expand and corroborate our analysis of the HTS data. We note the annual cost of residential parking permit schemes should be counted as a charge, even if users are unlikely to record it as such when answering the HTS.

We expect our analysis of the HTS to show average parking charges are effectively zero outside larger urban centres, reflecting both lower input costs and an over-supply of parking due to the application of minimum parking requirements (MPRs). In these locations, parking costs are usually bundled into the costs of development. This creates a challenge for our analysis because it may be that users are charged *indirectly* for parking via the prices of the goods and services they consume, such as housing. For this reason, our estimates of parking charges seem likely to under-estimate the parking charges paid by users and the gap between economic costs and financial charges cannot be interpreted as an indication of the actual subsidy. At the same time, people who do not travel by car will also be contributing to meeting parking costs, such that these people are cross-subsiding those that do. We propose to investigate this issue by analysing information on how mode share varies by location. While we are unlikely to address this gap via the DTCC study, we suggest the issue of indirect charging warrants attention and will consider evidence from other jurisdictions that may transfer to the New Zealand context.

C7.2.3 How is the burden of parking charges split between commuters and employers? Finally, the incidence of parking fees and charges—and how this incidence varies over space—is relevant to policies to reduce congestion by, for example, encouraging employers to unbundle parking costs. Examples of such policies might include efforts to remove minimum parking requirements and/or apply fringe benefit tax to employer-provided commuter parking.

For this reason, we will seek to understand how the burden, or incidence, of parking charges is split between commuters and employers. To collect information on this issue, we can draw on information in the HTS, specifically responses to *trwhopaid,* which whether the parking fee is paid by user, employer, or someone else.

Again, we will seek to corroborate the HTS using secondary sources of information. This will involve consulting with a range of organisations to understand whether they hold information on the extent to which employers provide parking in central city locations. Such information may be held by:

- Local government, which may have undertaken parking intercept surveys;
- Central government, given earlier proposals to apply FBT to employee parking;
- The Automobile Association, Business associations, and employer organisations; and
- Major parking providers, both public and private.

Obviously, uncertainty exists over whether these organisations (1) currently hold relevant information and (2) are willing or able to share information for the purposes of this study. For this reason, we suggest this aspect of our methodology will need to be relatively flexible and adaptive; if information is not readily forthcoming, then we may need to draw a line under this task and move on, which acknowledging the need for and benefits of further research.

C7.3 Key inputs, data sources, and risks

Table C7.2 summarises key inputs, data sources, and risks to the methodology and scope of our analysis.

Table C7.2: Summary of key inputs, data sources and risk for car-parking

Inputs	Sources	Risks and Mitigation
Land values	DTCC study	To investigate the best sources of land value data for actual/potential car park sites, particularly in CBD areas.
Operating costs	Nunns (2017) Local Councils	Operating cost data used in Nunns (2017) will be compared to data supplied by Local Councils.
Const. costs	Nunns (2017) Local Councils	We propose to compare construction costs in Nunns (2017) to data from Local Councils on the replacement value of their parking facilities. To mitigate this issue, we propose testing low / medium / high scenarios.
Supply	Local Councils, private parking owners and operators	There is a risk that Local Councils supply inadequate and/or inconsistent data. To mitigate this issue, we propose first working with major urban areas, such as Auckland, to refine our analysis and requests.
Charges	HTS (MoT) Local Councils Colliers (2010) & (2011) Parking operators Major employers	Small HTS samples may be mitigated by modelling or extrapolating results from larger centres. Council data may not be representative of whole market, although can be compared to HTS. Colliers parking surveys in 2010 and 2011 considered the charges for long-stay and lease parking in Auckland and Wellington, providing a useful—albeit dated—external reference point. Current charges for all its publicly available parking can be obtained by inspection of parking tariffs for council and privately owned/operated parking sites.

C7.4 Key organisations and individuals to assist with data provision

Table **C7.3** lists Councils we propose to contact to source parking data. We prioritise these Councils because:

- In some way, they charge for public parking;
- Our experience leads us to believe that they have decent parking inventories; and

- They have removed, or at least reduced, minimum parking requirements, such that the supply of and demand for parking is likely to be closer to the level demanded by the market.

In the first instance, we will prioritise contacting the larger urban councils, notably Auckland, Wellington, and Christchurch. Once we understand the data that is available from these councils, then we will look to contact smaller urban councils in Hamilton, Tauranga, and Dunedin.

Table C7.3: Councils to Contact for Parking Data

Organisation
Auckland Council / Auckland Transport
Hamilton City Council
Tauranga City Council
Wellington City Council
Christchurch City Council
Dunedin City Council

Some councils may be unable or unwilling to supply parking data for the purposes of this study. Should data not be forthcoming from the councils listed above, then we can consider approaching other councils to expand our sample. We do not list contact details for commercial parking operators or major employer groups. Rather we will in each city leverage our contacts with local councils to identify the most appropriate contacts in their respective jurisdictions. We expect that information from these sources is not essential to our analysis, rather it is merely intended to provide an external reference point to which we can compare and corroborate results of from other analyses.

C7.5 Main outputs

Main output: We will present average parking costs in different locations in terms of $ per annum (and their daily/hourly equivalents). Costs can be converted into various units of demand, such as per vehicle, per trip, or per vehicle-kilometre travelled, as needed to be compared to results from other DTCC workstreams. Charges will be presented as an average but also broken down by trip-trip, where relevant. And for commuters, we will also present an estimate of the percentage of the parking charges that are paid by users vis-à-vis employers in each location.

Due to the scalable nature of off-street parking facilities, we do not in general see value in distinguishing between average and marginal parking costs. We will, however, consider marginal costs in major urban centres, which is likely to be defined by more expensive off-street, structured parking facilities. We expect the marginal cost of parking in rural areas to be negligible, given low utilisation and the ready availability of land.

Table C7.4 summarises the main outputs for average parking charges. Average parking charges borne by users will be calculated for each relevant geography.

Table C7.4: Average parking charges table for each relevant geography in the DTCC

Geography	Costs		Notes
	Average (A_j)	Marginal (M_j)	
Centre	$A_j = \frac{\sum_i c_{ij} s_{ij}}{\sum_i s_{ij}}$	Defined by marginal cost of structured parking	Calibrate for major urban centres.

Urban / Suburban	May adopt the centre or rural approaches.	Consider whether costs at margin differ from average	Decision to use the centre / rural model defined by evidence.
Rural	$A_j = Land_j + Construction_j$	Defined by average cost of surface parking.	May be negligible in some places due to low land costs.

C7.6 Risks and uncertainties

In general, the availability of data poses a major risk to our analysis. We are heavily reliant on the HTS and the cooperation of relevant central and local government organisations. Uncertainty exists over the speed, detail, and extent with which this data will be provided, which may necessitate additional liaison, analysis, and methodological adaptations. We propose to overcome this issue by (1) working most closely with selective councils with which we have established relationships, such as Auckland Council and Auckland Transport; and then (2) progressively expanding our sample of local councils where necessary to address identified limitations in our analysis and modelling. In general, our work on parking seeks to provide some evidential foundations to inform policy and research. In doing so, we remain mindful of the relatively limited research in this area and the somewhat messy governance compared to other aspects of the transport system. For this reason, we feel there is a need to actively manage stakeholder expectations in relation to parking.

C8. Walking & Cycling

Principal author: Stuart Donovan, Veitch Lister Consulting

C8.1 Key features of our scope and methodology

Walking and cycling, often considered together as active transport, are important but often overlooked modes of passenger travel. We define these modes relatively broadly to include (1) walking, including using mobility aids, such as canes and wheelchairs for those who need assistance and (2) cycling, including e-bikes and tricycles. We note that cycling (in all its forms) has shown strong increases in usage (in both absolute and proportionate terms) as a result of the current Covid-19 pandemic and the various 'lock-down' restrictions associated with it: it remains to be seen whether this increased usage will persist over the longer term.

Walking and cycling will be treated separately. Where allowed by data, our methodology will also seek to estimate the costs of e-bikes separately from conventional bicycles. The primary reason for this is that the capital and operating costs of e-bikes, as well as their resulting levels of use, tend to be higher than for conventional bicycles. At the same time, e-bikes are a new and rapidly growing mode that appears to be expanding the market for active travel, in a similar way to the micro-mobility technologies that we discuss in more detail in a separate paper.

To estimate costs and charges for walking and cycling, our methodology proposes to cover:

- *Infrastructure costs*, including capital charges for land;
- *External costs*, such as crashes and health system benefits; and
- *Operating costs*, including bicycle purchase and maintenance.

External costs of walking and cycling, such as crashes and health benefits, are being considered separately by ViaStrada and the University of Otago, respectively. As such, we focus on infrastructure and operating costs.

We propose to quantity infrastructure costs associated with walking and cycling infrastructure by drawing on several relatively detailed spatial data sets, namely:

- Open Street maps data and other sources on the extent of road, cycle, and pedestrian networks;
- Cadastral information on the footprint of the road network held by Local Government;
- Information on land values relevant to road networks, to be developed together with Richard Paling Consulting (refer topic area C2) this; and
- Construction cost estimates, such as the cost of laying concrete.

We will use OSM data to estimate the physical length of the road transport network.[11] The footpath network is proposed to be allocated solely to walking and dedicated bike paths will be allocated to cycling. Shared paths present a challenge: while OSM provides functionality to tag, or code, shared paths, we are unsure of the extent to which this functionality is used. And we are also unsure of the degree to which data on shared paths is systematically recorded by Councils. If reasonable data on shared paths is available in OSM or from Councils, then we propose to assign the network to walking and cycling based on estimated volumes.[12] The physical area of the pedestrian and cycle network will then be estimated using data on the average width of paths. The area of each network is a key

[11] https://wiki.openstreetmap.org/wiki/Downloading data

[12] Outside of cycle lanes and an allowance for shared paths, we do not propose any of the remaining road and footpath network is allocated to cycling, as the proportion of cycling demand and impact would be minimal compared to its dominant use by vehicles and pedestrians. The use of the road network by cyclists also seems unlikely to place additional capital or maintenance cost on the network where no specific provision for cyclists has been marked.

determinant of capital costs for land, combined with average costs of road system land developed by Richard Paling, and construction, combined with average costs of laying footpaths. In terms of capital depreciation and infrastructure maintenance, we propose to engage with Richard Paling, the MoT, NZTA, and Local Councils to quantify (1) relevant rates of capital depreciation and (2) costs of maintaining walking and cycling facilities. We expect to find limited data on the latter, which may necessitate simplifying assumptions.

Operating costs of walking will be taken as zero even though walkers will eventually wear out their shoes and those with mobility aids will require maintenance, as these costs are neither substantial nor readily quantified. Operating costs for cycling will include bicycle purchase and maintenance costs. The HES collected by Statistics New Zealand contains useful information on annual household expenditure on bicycles. We propose to use a rapid review of existing data and studies, such as the HES, to estimate bicycle purchase and maintenance costs. For example, a detailed—albeit anecdotal—case study reports average costs of 4 cents/km over a ten-year period.[13] The cost model for conventional bicycles can then be adapted to e-bikes, which have higher capital and operating costs as well as greater annual usage. We will estimate costs of e-bikes drawing on published information and own professional expertise—possibly complemented with information sourced from credible organisations.

Finally, we propose to normalise our costs using the average distance and trips walked and cycled per annum, using the HTS as the best source of demand data for walking and cycling, including for e-bikes. The demand for walking and cycling seems unlikely to affect infrastructure depreciation and result in congestion, such that marginal costs are limited to increased operating costs and environmental externalities.[14]

C8.2 Key inputs, data sources and risks

The HTS will be our primary source of data on cycle usage, including e-bikes (refer Table C8.1). We propose to use the HTS to calculate kilometres and trips cycled. Census JTW data offers a large sample, albeit for only one trip purpose, so will be used for comparison purposes if there are concerns with HTS data quality or sample sizes.

Table C8.1: Summary of key inputs, data sources and risk for walking / cycling

Input	Source	Risks and Mitigation
Extent of physical infrastructure	Open Street Map + DTCC	Our analysis of the OSM data will need to be compared to other DTCC modal analysis to ensure consistent allocation methodology. If required, will compare OSM with available council data on walk and cycle infrastructure.
Construction costs	MoT/Councils + Richard Paling Consulting	Construction cost estimates can vary over time and space. We will use a simple and transparent approach that can be easily validated and/or updated.
Allocation of shared paths	HTS councils	Inconsistent data may be hard to generalize. Results for some councils could be used as a benchmark for others.
Land values	DTCC study	Average land values, e.g. for a region, may understate costs in city centres, creating the need for adjustments.
Bicycle purchase and maintenance	HES (Statistics NZ) and literature	HES estimates of bicycle purchase costs drawn from small samples. To develop a robust estimate, we will compare these numbers in relation to numbers reported in the wider literature.

[13] https://can.org.nz/article/bicycle-running-costs

[14] Although walkers and cyclists can experience low levels of congestion costs, their relatively high space-efficiency; short trip length; and flexibility to adjust behaviour in response to crowding and disruptions, suggests these costs would be both minimal and very difficult to accurately quantify

Demand data	HTS (MoT) and Census (Statistics NZ)	Reliant on one source for demand with potentially small sample sizes. May complement and/or validate with census JTW data.

C8.3 Main outputs

Table C8.2: Walking and cycling cost table

Cost type	Cost item	Costs		Notes
		Average	Total	
Infrastructure	Asset maintenance and depreciation			May vary between walking and cycling
	Land cost and economic return			Reflecting the physical footprint of network
Operating	Bicycle purchase*			Available from HES
	Bicycle maintenance*			Sourced from external literature
E-bike	Purchase, maintenance and energy			Sourced from external literature and industry contacts

* Only applies to cycling

Most of these cost items do not seem likely to vary with geography nor time of study except for land cost. Our primary focus would be on urban (including CBD) situations. A decision on the need for separate geographic breakdown to centre, urban/suburban and rural will be made dependent on the extent of data availability and materiality of any difference.

C8.4 Additional comments

Needs for related information and/or liaison with other team members: Some input and output assumptions, e.g. land values, construction costs and externality costs will need to be consistent with other consultants.

Areas of uncertainty: Extent of physical infrastructure and allocation across walking and cycling will require reasonable supply and demand data from various sources. Uncertainty exists over the accuracy and consistency of this data across regions. We propose to overcome this issue by reviewing available data and making assumptions that extend its applicability where needed.

C9. Ride-hailing

Principal author: Stuart Donovan, Veitch Lister Consulting

C9.1 Overview

Ride-hailing and taxi services incur costs substantially higher than those of private vehicles, including:

- **Service Provider fees.** The costs of building and maintaining a customer base, customer service, electronic payment fees, insurance and contracting are anywhere from 15-30% of the cost of the ride, charged to the driver as a 'technology licencing' fee (if ride-hailing) or 'service fees' if a taxi. These additional costs are passed on to users in the form of higher charges.
- **Licensing costs**. Drivers are required to maintain specific licences (P-Endorsement) and maintain their vehicles in a higher state of fitness (Certificate of Fitness vs. Warrant of Fitness for standard private vehicles).
- **Labour costs for drivers**. User charges will include labour costs of driver. While there is currently no independently collected time-series data on earnings for ride-hailing or taxi drivers, we can make assumptions on the relative cost of labour per hour.
- **Vehicle operating costs**. The vehicles used to provide ride-hailing and taxi services may differ from the general passenger fleet. In general, we expect vehicles will be more modern, of higher quality, and more fuel efficient, considering the large number of kilometres travelled and higher average occupancy, and be subject to a higher level of usage than a standard vehicle, so increasing depreciation.
- **"Dead" running**. Due to the need for re-positioning between rides, ride-hailing vehicles typically travel 30-60% further than private vehicles for the same trip. While financial costs of dead running will be reflected in user charges, congestion externalities will not.

We plan to utilise a taxi cost model obtained from industry participants (NZTF) and/or the Ministry of Transport for both taxi and ride-hailing businesses. Drawing on information sourced from research and industry participants, we will produce an average per-km charge rate for consumers for both kinds of services.

In estimating costs for ride-hailing and taxi operators, the heterogeneity in service providers (ie ride-hailing vs. traditional taxi industry) results in differences in associated cost structures. For example, user charges may vary significantly between operators depending on the quality of service or whether the driver is contracting to a ride-hailing service (Uber, Ola, etc) and therefore paying a per-trip 'technology service fee' or is contracting to a taxi company with a fixed 'licensing fee' per day or month.

In terms of demand, there is little public data on ride-hailing or taxi demand, however use is tracked in the HTS, which captures the combined demand. We also intend to survey the NZTF and largest operators, then factor up the available data in proportion to the total fleet of small passenger service licenced vehicles relative to the operators surveyed.

Table C9.1: Key data sources and risks, such as availability and confidentiality

Data	Source	Risks and Mitigation
Operating costs	Industry participants, Stanford	Commercially sensitive information, mitigated by sourcing general industry statistics from independent consultants.
Dead heading statistics	*Fehr & Peers (2018)*	Uses Uber and Lyft data in 6 metropolitan areas in the US to show impact on VMT due to deadheading. Differences to NZ are assumed to be negligible.
Demand for ride-hailing and taxi services	HTS and Census (Statistics NZ)	Reliant on one source for demand with potentially small sample sizes for some segments. May seek to complement and/or validate with census JTW data.

C9.2 Key organisations to assist with data provision

- New Zealand Taxi Federation
- Uber New Zealand
- Zoomy

C9.3 Additional comments

Needs for related information and/or liaison with other team members. Some input and output assumptions, e.g. costs of private vehicle ownership, will need to be consistent with other consultants.

***Areas of uncertainty**:* Total mode share of ride-hailing and taxi is currently unknown and will need to be proxied via the HTS. The amount of 'deadheading' is variable based on urban density / form, e.g. urban vs suburban, for which there is no robust local data available, though we will obtain what is possible from the industry participants and compare that to analysis from offshore.

C10. Micro-mobility

Principal author: Stuart Donovan, Veitch Lister Consulting

C10.1 Key features of our scope and methodology

Micro-mobility (MM) technologies have only recently emerged on the NZ scene, with demand growing rapidly from near zero over the last two years. Much of the initial demand was as part of a sharing service offered only in limited areas and constrained by permits. More recently, privately owned e-scooters are emerging in greater numbers and are more dispersed, although demand remains primarily in limited urban areas.

While MM is currently dominated by e-scooters, the field will continue to evolve. For the purpose of costs, MM will be considered as conforming to the SAE Micro-mobility definitions of being lightweight (WT1-2 - up to 45kg), narrow (<WD2 or <1.2m), low-speed (SP1-2 category - up to 32kmh) electric-assisted (E) lightweight vehicles that are most suitable for physical infrastructure allocated to bicycles and pedestrians. For the purpose of charges, micro-mobility will be considered as a shared fleet of for-hire vehicles.

To estimate user charges for MM, we need to cover:

- Infrastructure costs, including capital charges for land used to park devices (using a similar process to the walking/cycling analysis and assuming a proxy for shared use).
- Externalities, such as crashes, health system impacts, and emissions, and
- Operating costs.

Externality costs for crashes, health system impacts, and emissions will be estimated drawing on the work of ViaStrada, University of Otago, and Emission Impossible in other study topic areas. As such we do not discuss them further here.

In terms of infrastructure, we propose to estimate capital costs using a similar methodology to that for walking and cycling. Estimates of the number of MM devices currently in circulation and their distribution will be combined with estimates of footpath construction costs and land costs. We note the latter will depend on some broad-based assumptions, particularly about the allocation of space and costs for shared paths.

In terms of operating costs, most of the data on MM devices is commercially sensitive. Access to this information is therefore limited and will have to be proxied. Moreover, costs and charges are also likely to evolve rapidly as business models and technology mature, so they come with greater temporal uncertainty than more established transport technologies. We plan, with assistance from local experts, to formulate a model for the cost of provision of services, based on the latest data. Further, we propose extrapolating these costs to a 'near-term future state' where impending operational efficiencies have been realised (battery swapping, distributed charging stations, more robust vehicles etc.), delivering lower costs of provision to customers. As with taxis and ride-hailing services, user charges will be taken as a rough proxy for long-run financial costs.

Estimates will be provided on a per trip and per day basis using average time/distances for trips taken on these shared services. There is limited public data available from councils within New Zealand regarding shared MM demand. Demand arising from private use of MM is unknown but can potentially be proxied in recent waves of the HTS by the 'other' category. We will pull HTS data of modal shares and pkm for each for scooters, with breakdowns by type of area (metro, urban, rural), by period of the day (peak v off-peak), by trip length, by age/gender, by journey purpose and HTS demand data with industry data where possible to formulate demand. We will also adopt relevant findings from the NZTA TAR 18/12 research paper, which seeks to forecast demand for MM via modal shift modelling, as well as expected impacts on infrastructure.

We assume MM do not cause congestion. As such, the difference between average and marginal costs will mainly reflect internal economies of scale / density rather than the effects of externalities.

Table C10.1: Key data sources and risks, such as availability and confidentiality

Data	Source	Risks and Mitigation
Construction costs for infrastructure	MoT/Councils/NZTA + Richard Paling Consulting	Will compare available construction cost estimates per square metre to propose an average for the major infrastructure types/materials, as per Walking and cycling section.
E-scooter purchase and maintenance	Industry insight	Access to the data is the critical constraint, will utilize trusted industry figures to maximise access.
MM operating costs	Industry, Micromobility Industries	Will review available data to build a defensible estimate
Industry usage reports	MM Industry	Access to the data is the critical constraint, will utilize trusted industry figures to maximise access.
Demand for services	HTS, NZTA TAR 18/12, Auckland Council Mobility Specification data	HTS will be supplemented with industry, NZTA forecast data and existing council data as only recent waves are likely to capture any MM data and there would be little capability for disaggregation.

C10.2 Key organisations and individual with contact details

- Micro-mobility Industries
- Lime
- Flamingo

C10.3 Main outputs

Table C10.2: Micro-mobility cost table

Cost type	Cost item	Costs		Notes
		Average	Total	
Infrastructure	Asset depreciation and maintenance			Similar basis to walking and cycling
	Land cost and economic return			Similar basis to walking and cycling
Operating	Purchase and maintenance			Industry data
	Re-charging and distribution			Electricity rates and industry data
	System administration			Industry data
User charges	Flag fall and per minute fee			Estimated industry average

C10.4 Additional comments

Needs for related information and/or liaison with other team members: Some input and output assumptions, e.g. crash costs with ViaStrada and other service providers. The NZTA TAR 18/12 report is currently quantifying the expected impact on mode shift of these new vehicles.

Areas of uncertainty: While the demand for privately owned micro-mobility can be proxied via the HTS, the fact this is a lagging indicator may prove problematic given the rate of industry growth. We suggest there may be value in sensitivity testing of results in alternative medium-run demand scenarios.

C11. Rail

Principal author: Murray King, Murray King and Francis Small Consultancy Ltd

C11.1 Coverage

- Main market segments: rail freight, long distance rail pax, metro pax (below rail) costs, KiwiRail (KR) ferries[15].
- The remainder of this section outlines our proposed scope of methodology within nine topic areas.

C11.2 Approach to Rail Cost Allocation - Overview

- Currently, rail costs and charges are based on a rail cost allocation approach
- The KR rail system caters for three main market segments, i.e. rail freight, long-distance rail passengers, metropolitan (Auckland, Wellington) rail passengers.
- Except in the metro areas, rail freight is the primary market segment (e.g. on the basis of train km, gross tonne km (gtkm)), while the long-distance rail passenger segment is relatively small. In the metro area, rail freight dominates on some line sections, with metro passenger trains on other sections, with long-distance rail passengers again playing a relatively small role.
- The 'above rail' costs may be allocated relatively easily to one or other of these market segments. The allocation of 'below rail' costs across the market segment is more debatable - our proposed approach is as follows:
  1. Long-distance rail passenger services. In all cases we treat these as the marginal (incremental/avoidable) traffic, i.e. we allocate to them their incremental costs above the costs of the 'base' market segments (principally rail freight).
  2. Metropolitan areas (principally freight services and metro rail passenger services). Currently the 'below rail' costs in the metro areas are primarily the responsibility of KR: they are allocated between the parties in a 'neutral' way, in proportion of their relevant gross tonne km (GTK) operated in these areas. The proportion of these costs allocated to the two regional authorities covered (AT, GW) then becomes part of their regional transport budget and programme, along with all the above rail costs for the metropolitan services (plus all the bus and ferry service costs). All these metro PT costs will then be analysed consistently across the three modes, within the Urban PT topic area (C12).
- Given these established arrangements, we propose to adopt the current gtkm and train-km based allocation of below rail costs between KR and AT/GW. If required, supplementary analyses could also be undertaken treating one or other of the two market segments (i.e. freight, metro passenger) as the 'prime user', the other as the incremental/avoidable user.
- These cost allocation aspects are principally relevant to topics 6, 7 and 8 covered below. The KR ferry (inter-island) business is covered under topic 9.

C11.3 Rail Marginal Cost Calculation

- We identify two types of marginal cost -social marginal costs and operator marginal costs

[15] Refer topic 9 for details. KR ferries are analysed here for convenience (but co-ordinated with analyses for Bluebridge ferries (which are included in Coastal Shipping annex C14). For final reporting purposes, the KR ferry and Bluebridge ferry assessments will be brought together in a combined set of tables and commentary.

- Social marginal costs are the costs to users and non-users consequent upon travel by an additional passenger or consignment without adjustment to the service provided. For a timetabled service this could be increased crowding or, if the service is at capacity, an existing passenger or consignment is displaced. We will use as a proxy the revenue per seat-km or tonne-km of capacity which approximates the probability of being displaced times the value to the marginal passenger (equal to the fare).
- For infrastructure, the equivalent measure is the delay to other trains at the margin.
- The operator marginal cost is the cost of increasing capacity offered by one step (e.g. increase train size or run more trains) divided by the additional seat or freight-km that would provide. Rail capacity can only be increased in steps, however what the next step is will depend on the circumstances. Hence we will determine the costs by cost-driver at a disaggregated level so that the appropriate costs can be applied in particular cases.

C11.4 Topic 1: Sources of information

Scope/coverage	• Set out the major sources of information on rail costs • Segmentation • International practice review (Dick Bullock)
Key outputs (incl sample tables)	• List of sources with commentary; data and text • Proposed segmentation • Summary and analysis of key international practices on estimation of infrastructure variable costs.
Key inputs	• Research, internet and consultant's own resources
Data sources – specification	• Detail the data to be used, mainly ex KR • Cost, revenues, passenger km, ntkm, gtkm
Data sources – organisation	• KiwiRail
Data issues	• Confidentiality
Proposed analyses (summary or example)	• na
Dependencies on other topics – inputs	• na
Dependencies to other topics – outputs	• All other topics – top of the chain
Risks, uncertainties	• Refusal to supply data; or confidentiality requirements that are severely constraining
Other comments, issues	• To include brief literature review of European practice on infrastructure costs, along with description of US and Australian practice.

C11.5 Topic 2: Regulation and oversight

Scope/coverage	• Discussion and analysis of the principal legislation and regulations, and supervisory bodies.
Key outputs (incl sample tables)	• Analysis of relevant laws, bodies involved, and their roles: NZTA (safety) NZTA (rail investment), Treasury (ownership), Ministry of Transport (policy) • Summary table and text
Key inputs	• Discussion with relevant KR executives
Data sources – specification	• Legislation • Discussions with regulators
Data sources –organisation	• Multiple sources, especially related to deliberations or changes in rail regulatory and funding policy over last 2 years
Data issues	• None
Proposed analyses (summary or example)	• Identification of compliance requirements specific to a railway (principally a safety issue).
Dependencies on other topics – inputs	• None
Dependencies to other topics – outputs	• None
Risks, uncertainties	• Difficulty in teasing out the additional safety requirements that are borne by rail (primarily relative to road transport mode)
Other comments, issues	• None

C11.6 Topic 3: Investment

Scope/coverage	• Capital requirements for above rail and below rail assets

Key outputs (incl sample tables)	• Capital requirements for steady state; excluding current "catch up", for:
	  ○ above rail: freight: locomotives, wagons, handling equipment, yards and terminals, premises
	  ○ long distance pax: locomotives, carriages, terminals
	  ○ below rail: track, civil, structures, signalling, traction, buildings, yards, other
	• Separate information for freight, KR ferry and the infrastructure elements of 2 metro pax businesses
	• Identification of steady state asset lives, and current age of equipment
	• Identification of variability/ use relatedness of these costs, drawing (for infrastructure) on work done in the context of the current Rail Review (subject to any confidentiality constraints).
	• Identification of recoverable and depreciated, recoverable and not depreciated, sunk costs
	• Valuation of assets: assessment of DRC and ODRC for key asset classes
	• Consider implications of revaluation by government of below rail assets (as "public benefit entity" status)
	• Track User Charges – level and rationale
	• Costs, net of TUC
	• Analysis by density of traffic (3 density bands)
	• Tables to cover use-related costs, track valuation and capital charges, summary of investment costs.

Key inputs	• KR Asset Management Plan and working papers • 2019 below rail capital expenditure classification, produced by KR • Plans for above rail assets replacement • KR product/line costing model • Ntkm and gtkm data
Data sources – specification	• As for key inputs
Data sources –organisation	• KiwiRail Corporate Finance
Data issues	• Confidentiality
Proposed analyses (summary or example)	• Refer outputs
Dependencies on other topics – inputs	• None
Dependencies to other topics – outputs	• The below rail info will be needed as input to the long distance pax and metro analyses
Risks, uncertainties	• KR unwilling to supply data, or devote time to its supply.
Other comments, issues	• Some of the data will be embargoed until the GPS or Budget • Consideration to be given as to whether infrastructure insurance should be included (NZTA does not insure).

C11.7 Topic 4: Funding sources

Scope/coverage	• Funding of rail activities from public sources –NLTF, Crown, PGF, local authorities • Assumes new arrangements as per Land Transport (Rail) Legislation Bill
Key outputs (incl sample tables)	• Description of the sources of public funding for investment, below rail and above rail. Quantification of funding. Excludes description of metro funding arrangements for above rail assets (to be covered in Urban PT paper C12) • Description of any sources of public funding for operating costs, and quantification of funding. • Identification of changes brought about following the Land Transport (Rail) Legislation Bill (when passed) including the Track User Charge, and partial integration into the NLTF funding arrangements. • Table of funds by source 2019 and 2020
Key inputs	• 2020 GPS, 2019 and 2020 Government Budgets, Rail Plan, Land Transport (Rail) Legislation Bill, 2020 Rail Network Investment Programme • NZTA documentation • KiwiRail working papers; MoT working papers if available.
Data sources – specification	• Not a data issue per se
Data sources –organisation	• Not a data issue per se
Data issues	• None
Proposed analyses (summary or example)	• 'Wiring' diagram of new process
Dependencies on other topics – inputs	• None
Dependencies to other topics – outputs	• Investment and operating costs analyses
Risks, uncertainties	• Availability of background papers
Other comments, issues	• Will have to await the Govt budget, 2020 GPS, and passing of the rail legislation before completion.

C11.8 Topic 5: Safety

Scope/coverage	• Safety legislation, safety system, accidents, Worksafe • Level of compliance, impact on costs, comparison with competing modes • Focus will be on the 'like-for-like' comparability of safety/accident statistics between rail and alternative modes (principally road)
Key outputs (incl sample tables)	• Description of safety activities • Assessment of the absolute and relative (to road) compliance costs, including expression per ntkm • Analysis of rail accidents by type and attribution (to rail, road, trespassing) eg level crossings (10-year series if available) • Possible tables (by train type: freight, metro, passenger, and total) – example below (for up to last 3 years). See outline table below.
Key inputs	• KR detailed accident data • MoT summary of detailed accident data • Worksafe, ACC data • Coroners' records (possibly).
Data sources – specification	***KR:*** • Site, nature, equipment involved, consequences of each fatal accident (for 2019 FY) • Site, nature, equipment, consequences of each injury accident • More generic list of non-injury incidents. • Classification into train type (eg freight, metro) ***MoT:*** • Published data on rail accidents and road accidents ***Worksafe:*** • Data on rail accidents reported/investigated/prosecuted. • Ditto for road accidents (to be covered in Paper D1) ***ACC:*** • Data on rail accidents; and equivalent for road accidents
Data sources – organisation	• Kiwrail – GGM Zero Harm • Worksafe and ACC
Data issues	• Attribution (eg to rail/motorist/trespasser) will be challenging • Creation of compliance costs data
Proposed analyses (summary or example)	• Assessment of responsibility for a level crossing accident; or for a trespasser death, or a suicide • Assessment of influence of train density/population/metro operation • Assessment of liability and compliance costs for rail compared with road • Identification of costs specific to being a railway; or where the costs fall differentially relative to road.
Dependencies on other topics – inputs	• None
Dependencies to other topics – outputs	• To be undertaken in close consultation with road crash topic area (paper D1) so as to ensure consistency of accident statistics between road and rail modes
	• None
Other comments, issues	• None

Rail accidents -- summary table (illustrative)								
Year (FY)	**Type**	**Fatal #**	**Fatalities**	**Injury #**	**Injuries**	**Non-injury #**	**Attribution to rail**	
							Fatalities	**Injuries**
2019	Level Crossing							
	Pedestrian							
	Staff							
	Passenger							
2018	etc							

C11.9 Topic 6: Freight operating costs

Scope/coverage	• Costs of operating infrastructure and freight trains, and related activities
Key outputs (incl sample tables)	• All segmented by freight business unit: Domestic, Import-export containers, logs, other bulk • Derive basic operational parameters: ntkm, gtkm, tonnes, commodity, average haul • Operating costs for above and below rail, expressed per ntkm (freight) • Excluding long distance pax and metros (see topic areas 7, 8) • Analysis of variability/ relationship to use of these costs, above and below rail • Revenue, incl per ntkm • Net costs/surplus • Tables to cover cost categories, cost allocation assumptions, infrastructure costs, rolling stock replacement and track replacement costs; marginal and average cost summaries. • Note: KR has models for above rail analysis: the models' structure and outputs will be reviewed and, where appropriate, incorporated in the study modelling work. • Contributing data to other workstreams – emissions, noise -add diesel/electric split to t, ntkm, gtkm - train movement data
Key inputs	• Staff, fuel, maintenance and other key operating costs • Net tonne kilometre data • KR above rail costing model (subject to review of methodology and assumptions)
Data sources – specification	• As per key inputs
Data sources – organisation	• As for investment costs
Data issues	• None
Proposed analyses (summary or example)	• Costs (from model) for business units • Revenue by business units, also by major commodity segments if available • Revenue per ntkm, train km, and wagon km • Variable/ average cost analysis • Total KR (fully allocated) cost and average cost, by major commodity segment, compared with revenues earned • Short run marginal costs (SRMC) corresponding to increments/decrements in traffic volumes
Dependencies on other topics – inputs	• None
Dependencies to other topics – outputs	• None
Risks, uncertainties	• Data availability
Other comments, issues	• None

C11.10 Topic 7: Long distance rail passenger

Scope/coverage	• Costs of investing in and operating KR long distance tourist pax trains (excluding Capital Connection and Hamilton train). • Below rail costs attributable to LD pax services – to be assessed on a marginal/incremental basis (could also undertake sensitivity tests as to effect of allocating joint costs on a GTK basis): refer further details in section C11.2
Key outputs (incl sample tables)	***Above rail:*** • Investment costs for carriages and stations (locos from freight analysis) • Operating costs by staff, fuel, maintenance, other for train operation • Average and marginal costs • Review of cost drivers (train km and hours, locomotive number, and carriage km, hours and number) • On board costs (excluding catering) • Costs expressed per pax km. • Revenue, incl per pax km • Surplus/deficit, by train if available • Tables examples (by train): costs and revenues; patronage, unit costs, summary of costs and charges ***Below rail:*** • Marginal costs attributable to passenger services • Safety and capacity impacts • Average costs from freight analysis, allocated by gtkm (with sensitivity tests)
Key inputs	• Cost and revenue data from KR
Data sources – specification	• By train if available
Data sources – organisation	• KiwiRail
Data issues	• Estimating passenger km from ticketing data
Proposed analyses (summary or example)	• Cost, revenue and surplus of each train (on a comparative basis)
Dependencies on other topics – inputs	• Below rail costs to come from below rail investment and operating costs topics (principally topic 6)
Dependencies to other topics – outputs	• None
Risks, uncertainties	• KR willingness to supply information, or allocate time to its supply
Other comments, issues	• None

C11.11 Topic 8: Metro passenger rail

Scope/coverage	• Below rail costs of metro rail only (investment and operating): refer further commentary in Section C11.2
Key outputs (incl sample tables)	• Metro below rail investment and operations costs (and operating statistics) for AKL and WLG metro areas • These will then be passed on to the Urban PT analyses (paper C12) for the two regions (relevant RCs directly responsible for all other metro rail costs, along with regional bus and ferry costs)
Key inputs	• Output from below rail topics above • Additional data on enhanced cost of signalling; electrification
Data sources – specification	• Gross tonne km for metro pax trains, Auckland and Wellington • Potentially need timetable and consist data (can come from regional council sources) • Electrification and electricity costs
Data sources – organisation	• As for freight below rail operation and investment
Data issues	• Calculation of metro gtkm • Conversion of freight below rail calculations to gtkm basis
Proposed analyses (summary or example)	• As for investment (topics 3, 6), but limited to metro regions • Analyse the marginal and average costs of non-metro pax costs in these areas • Review current arrangements for allocation • Critical evaluation of current freight: metro split for common/joint costs • Include analysis of safety risk of denser traffic, from the Safety topic C5
Dependencies on other topics – inputs	• Investment and operation, below rail
Dependencies to other topics – outputs	• None within the rail area, but the Metro Pax topic area analysis (paper C12) depends on this
Risks, uncertainties	• As for investment and operation
Other comments, issues	• None

C11.12 Topic 9: KiwiRail ferry costs

Scope/coverage	• Costs and revenues of operating KR ferries; allocation of total ferry costs between rail/CV/pax • Based on existing ferry arrangements. • Rail, commercial vehicles and pax (including cars) • To be undertaken in close liaison with the Bluebridge assessment (within the Coastal Shipping paper C 14) so as to ensure consistency of approach and enable the two sets of analyses to be brought together on a comparable basis
Key outputs (incl sample tables)	• Allocation of overall costs to rail, CV, and pax/cars • Marginal cost of each relative to average costs likely to be small • Costs per lane metre for rail, CV • Conversion to ntkm for rail
Key inputs	• Replacement costs - vessels and terminals • Operating costs by type • Understanding of cost drivers and allocation • Charges to rail business • Charges for CVs and pax, including 'drivers' of pricing
Data sources – specification	• Current replacement cost estimates • Staff costs by function • Fuel • Maintenance costs • Current charges
Data sources – organisation	• KiwiRail Interisland
Data issues	• Confidentiality • Allocation methodology • Consistency of approach with the Bluebridge Ferry assessment
Proposed analyses (summary or example)	• Allocation of total costs by type • Assessment of marginal costs by sub-market, if any • Calculation of unit costs per lane metre and tkm (rail)
Dependencies on other topics – inputs	• None
Dependencies to other topics – outputs	• Ferry costs, as input to the Coastal Shipping paper C14.
Risks, uncertainties	• Willingness to supply data
Other comments, issues	• Primary focus will be on existing ferry arrangements; but will also include summary of proposed future arrangements. • For final study assessment and reporting purposes, the KR ferry appraisal will be brought together with the Bluebridge ferry appraisal, ensuring consistency of approach between the two operations. Final reporting will be undertaken as a sub-mode within the Coastal Shipping paper.

C12. Urban public transport

Principal author: Ian Wallis, Ian Wallis Associates

C12.1 Coverage of section:

- Urban public transport

C12.2 Scope and methodology summary

Table C12.1: Scope and methodology	
Topic	*Urban public transport (by public bus, train and ferry services). *National picture for all regions and modes (train, ferry, bus, Total Mobility). *More detail to be covered for selected regions – Train: AKL/WGN; Ferry: AKL; Bus: all major urban centres (AKL, WLG and CAN); a proportion of medium-size centres (WAI, BOP, OTA, HOR); and a lesser proportion of smaller centres. * Ministry of Education (school contract) services are managed separately and are outside the scope of this study.
Key outputs – National picture	***Total and average costs and revenues (2018/19 FY):*** *Total operational costs pa (by mode/region). *Average costs (by mode/region), by dividing total costs by available measures of outputs (eg bus kms) and/or outcomes (pax kms or passenger boardings). *Total revenues (by mode/region) – analyse fares and fare substitutes (i.e. SGC reimbursement). *Total subsidies (ie total costs–fare revenues) by mode/region: could be expressed per passenger, per passenger km or as cost recovery ratio.
Key outputs – Selected centres	***Allocated costs and revenues:*** * Estimates of allocated costs and revenues for peak and off-peak periods (by mode/region). ***Marginal costs and revenues:*** *Estimates of marginal costs for peak and off-peak periods (by mode/region), based on adjustment of levels of service (in response to changes in demand or for other reasons). Marginal costs likely to be expressed both per marginal vehicle km (or vehicle hr) and then per marginal passenger (or marginal pkm). *Estimates of marginal revenues and net costs for peak and off-peak periods (by mode/ region) by applying demand elasticity estimates or similar approaches.
Data inputs and sources	*Primary data sources: (i) NZTA reported data for 2018/19 (refer https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/transport-data/data-and-tools/). We note some 2018/19 data has not yet been published and will need to be obtained from NZTA. A further breakdown by work categories will also be required from NZTA (e.g. PT services by mode). (ii) GTFS data feeds (schedule data) will be requested from each region for peak/offpeak allocations and analysis (estimates of PVR, Hrs, Kms). *To be supplemented as necessary through discussion with individual regional councils. If required, further data on 'below rail' costs for the metro train services will be obtained from the Rail workstream (paper C11).
Data issues (known or anticipated)	*Not all regions have consistent estimates for passenger kms (e.g. some regions based on actual tag on/off data, other regions estimated through surveys). *Note that NZ passenger data is primarily based on passenger boardings rather than origin-destination journeys (limited data is available on O-D journeys for some regions and modes).

	*Allocation of revenues between modes may not be fully consistent between regions: this primarily affects AKL/WLG. *Definition of peak/off-peak periods can vary between regions. *IWA has always in the past had excellent cooperation when requesting NZ PT data from RCs and from NZTA, so we don't expect any difficulty in this regard. We therefore consider any risks are small (assuming the relevant data is already held by NZTA or the RCs).
Additional notes on marginal user benefits (Mohring effect)	*For bus services, earlier IWA work made estimates, for typical bus-based centres, of the marginal user benefits per incremental passenger arising from user economies of scale: these analyses (generally known as the Mohring effect) represent the benefits to existing bus users resulting from increased (exogenous) demand and hence enhanced bus service frequencies. *Recent discussions that Ian Wallis has had with European experts on this topic indicate that the 'state of the science´ has not advanced significantly since the earlier IWA work. Given this, we propose to adopt a similar methodology this time to that applied in the earlier work. *Our previous analyses on this aspect found that the marginal user benefit (associated with increased services) was typically less than, but still significant, relative to the marginal operator costs. Depending on the DTCC analysis results, we anticipate bringing out the policy implications of these findings (e.g. for setting bus service levels). *Results from these analyses would be brought together with analyses of marginal costs and revenues (refer above) to derive overall socio-economic benefits and financial impacts from bus service improvements. Estimates of externality impacts from other work streams (eg emissions, public health impacts) could also be included here, to provide a more complete picture of the overall socio-economic impacts of providing more and better bus services in urban areas.
Dependencies on other topics - inputs	Minimal -- largely self-contained. The 'below rail' data (AKL, WLG) held by NZTA/RCs may be supplemented if required by additional data drawn from the study's Rail workstream (paper C11).
Dependencies to other topics - outputs	None in terms of study outputs.
Risks, uncertainties	*Small. We are confident that most of the data required will be available: should we find any data gaps in relation to bus statistics, we will have the options of (i) exploring with the relevant RC alternative data sources or the generation of additional data; and/or (ii) selecting other regions for analysis.

C13. Aviation

Principal author: Phil Barry, TDB Advisory Ltd

C13.1 Introduction

This section of the DTTC report covers commercial air-passenger transport within New Zealand.

This transport mode mainly uses three types of planes (ATR72, Q300 and A320).

The three route types this report covers are primary, intermediate and secondary routes. These three categories differ by their passenger volumes and the planes used.

The domestic passenger aviation analysis will be comprised of two core components:

- economic costs of commercial domestic passenger aviation; and
- prices faced by passengers for domestic air travel.

C13.2 Economic costs of domestic passenger aviation

Cost estimates would be provided where possible on a total, aircraft type, route and marginal cost basis.

C13.2.1 Costs of aviation services

The cost of domestic passenger aviation services will be calculated by aggregating the costs that the providers of domestic passenger aviation services incur. These costs can be broken down into the costs of:

- airlines' services;
- airports' services;
- Civil Aviation Authority's (CAA) services; and
- Airways Corporation of New Zealand's (Airways) services.

Non-monetary costs like greenhouse gas emissions, noise pollution and other social costs arising from domestic passenger aviation will be addressed in the relevant 'impact' work areas and would be brought together in the main study report.

The monetary costs of airline services will be split into operating costs and capital costs. Operating costs are the costs incurred through the day-to-day operations of the airline and include direct and indirect operating costs. Operating costs will be categorised as labour, fuel, maintenance, aircraft operations, passenger services, sales and marketing and other expenses. Capital costs will be calculated as total assets multiplied by the weighted average cost of capital (WACC) plus depreciation. Therefore, capital costs will take into account the return on assets (WACC) and also the return of assets (depreciation). Assets will be valued where possible at depreciated replacement cost (DRC).

Airport services costs are the charges that airports impose on operators of passenger services utilising terminal facilities. These costs are charged by the airports to the airlines using the airport. The charges are determined by the airports following consultation with the airlines.[16] Airports use the revenue from their charges to airlines to cover the cost of managing and maintaining airport facilities such as runways, taxiways, terminal activities like baggage handling and check-in as well as hangar and storage facilities.

The CAA's services are also a cost of providing domestic passenger aviation transport. CAA oversees aviation safety and the rules that govern aviation transport. This includes managing licencing and safety standards. CAA's services also include the services of the Aviation Security Service (Avsec). Avsec provides

[16] The three main international airports, Auckland, Christchurch and Wellington are subject to the Commerce Commission's financial disclosure requirements.

aviation security services through screening and searching bags, passengers and aircraft as well as security patrols and managing identity card systems. CAA passes on the cost of these services to airlines.

Airways provides air traffic control and infrastructure, controlling all air movements in New Zealand controlled airspace. The cost of these services is charged directly to the airlines using them.

Together airlines' services, airports' services, CAA's services and Airway's services make up the monetary costs of providing domestic passenger aviation services.

As noted above, the non-monetary costs that arise from the provision of domestic passenger aviation are greenhouse gas emissions, noise pollution and other social cost. Some non-monetary costs are accounted for through taxes, levies and voluntary offsets and are therefore embedded in the ticket prices of passenger aviation. The report will discuss the tax component of airline prices, distinguishing between general taxes and specific taxes.

C13.2.2 Detailed calculations

Total costs

The total cost of domestic passenger aviation services will be calculated by aggregating all the costs of providing domestic passenger aviation services. Joint or common costs (such as overheads and costs associated with joint domestic and international flights) will need to be attributed based on an assumed cost-driver (eg passenger kms).

Total cost (TC) = Airlines' services costs + Airports' services costs + CAA's services costs + Airway's air traffic control services costs (+ non-monetary costs).

Airlines' costs will be calculated by summing operating costs, capital costs and tax.

Airlines' costs = operating costs + depreciation + (Assets x WACC) + tax

Where assets are valued at depreciated replacement cost (DRC).

We will investigate cost- causality relationships as part of the study (probably splitting these between time variable, distance variable, and (peak) aircraft type variable).

Aircraft-type direct operating costs

Aircraft-type costs will be calculated as aircraft cost per aircraft kilometre as a function of aircraft size (number of seats). Aircraft size relates to the aircraft model which in order of smallest to largest are Q300, ATR72 and A320. These are the only three aircraft models used in NZ by Jetstar and Air New Zealand for commercial domestic passenger aviation services.

The costs we will include in the aircraft-type cost calculation will only be the direct operating costs. Direct operating costs are the costs directly associated with flying the aircraft. These are costs that change in relation to kilometres flown or flight time. Direct operating costs are: fuel, crew, maintenance and depreciation. Aircraft-type costs will be calculated on a cost per aircraft-type kilometre basis but can also be calculated in relation to time.

An aircraft-type cost calculation will need to be done for each of the three plane models.

Cost per aircraft type kilometre (c/km) = aircraft type costs/ kilometres flown

c = cost

km = kilometres flown

Route costs

Route costs estimate the cost incurred on a particular route over a period of time. Route cost will need to first be calculated for each of the different plane models servicing the route. Multiplying this by the particular routes distance will give the aircraft types operating cost, for that particular route.

To calculate the route cost, we would begin with the aircraft-type direct operating cost and add the other operating costs the airline incurs in servicing the route. These are the indirect operating costs such as sales and marketing. The indirect operating cost can be allocated on a per kilometre basis or a per passenger basis. We will calculate these costs separately and include them as appropriate.

Next, we will add the other route costs: i.e. the costs of airport services, Airways services and CAA services. These costs are not affected by distance or time, rather they are affected by the number of passengers or aircraft weight. This will give the total cost of a single aircraft on the particular route.

Multiplying the route cost of a single flight by the volume of that particular aircraft type operating that route over a period of time will give the route cost per plane model, for a period of time. Aggregating the route costs for each model will give the total route cost for a particular route for a period of time.

Route costs will be calculated for the ten routes identified in section C6.3.2 below.

Route cost (RC) = (((Aircraft type (A) operating costs + allocated indirect operating costs) x route distance) + other route costs) x volume of aircraft type (A) deployed, + (((aircraft type (B) operating costs + allocated indirect operating costs) x route distance) + other route costs) x volume of aircraft type (B) deployed)…

Marginal costs

Air New Zealand and Jetstar operate timetabled services where the service offered can only be increased in discrete steps. The social marginal cost is the cost to users and non-users consequent upon a marginal additional user without any adjustment to the service offered. We estimate this as the probability of an existing passenger being displaced times the value that passenger places on travel, which at the margin is the fare paid. For routes where the airline is able to price such that the plane is always full, this is just the fare. At times when the service consistently runs at less than capacity, the best estimate is the revenue per seat kilometre.

The operator marginal cost is the cost of increasing capacity times the probability that an increase is necessary. We calculate this as the cost of increased capacity divided by the number of seat-kilometres that provides. The cost of a step in capacity potentially varies by time of day and route. We will use the disaggregated costs described above to determine the appropriate costs to include as the cost of a step in capacity depending on the circumstances.

C13.2.3 Information sources

The data on domestic passenger aviation services costs required to make these calculations will be obtained from a variety of public sources. These sources include:

- Airlines' services: will be sourced from Air New Zealand's and Jetstar's latest annual reports including financial reports and Air New Zealand data books[17]. Air New Zealand publishes more data than Jetstar. Therefore, to get total route cost we may only use Air New Zealand data with the knowledge that Air New Zealand makes up 82% of total market share.[18]

[17] In addition, MoT publishes data on aircraft movements (and associated GHG emissions), which may be accessed from this link: https://www.transport.govt.nz/mot-resources/transport-outlook/transport-outlook-future-state-model-results/

[18] Other operators – eg Air Chathams and Sounds Air - are minor players with very little financial information publicly available. Given their small market share, excluding them from the analysis is likely to have little practical effect.

- Airports' services: information can be found through the airports' disclosures to the Commerce Commission as well as their financial statements. Airports are required to produce disclosure information about their aeronautical services in accordance with the Commerce Act Determination 2010.
- CAA's services: information can be found through its financial disclosures as well as cost recoveries and other financial statements.
- Airway's services: information can be found in its end of year annual report as well as pricing frameworks, cost recovery and other financial disclosures.

To carry out these calculations will require a high-level breakdown of the costs. Therefore, with the Ministry's approval we will liaise directly with the service providers and their regulatory bodies to request non-public information. This information may include load, distance, cost and price data from airlines as well as data on charges imposed by airports, CAA and Airways. We would primarily request information from Air New Zealand and Jetstar.

We may also supplement NZ data with international data on the costs faced by domestic passenger aviation along with typical industry estimates to help with these calculations.

C13.3 Prices faced by passengers for domestic air travel

Prices faced by passengers for domestic air travel in NZ will be collected by online research. We will collate and assess prices for selected routes at differing times of advance booking and travel, over a period of time. Prices will be collected for the two major airlines operating in New Zealand, Air New Zealand and Jetstar. These two airlines account for over 95% of passenger air travel in NZ.

C13.3.1 Ticket type

The prices collected will be for tickets that are one-way, single adult, direct flights. The fare selected will be the most basic ticket possible, being a seat with 7kg of carry-on baggage only. This is the Air New Zealand 'Seat Only' ticket and the Jetstar 'Starter' ticket. The incremental price for baggage will also be estimated.

C13.3.2 Routes

The routes for which the price data will be collected are:

Primary routes:

- Auckland – Christchurch
- Auckland – Wellington
- Wellington – Christchurch

Intermediate routes:

- Auckland – Queenstown
- Christchurch – Queenstown
- Wellington – Queenstown

Secondary routes:

- Auckland – Napier
- Auckland – New Plymouth
- Wellington – Napier
- Wellington – New Plymouth

This sample of primary, intermediate and secondary routes captures travel throughout New Zealand, both North and South Islands. Primary routes are between major urban centres like Wellington and Auckland. Intermediate routes are to Queenstown which attracts lots of tourists. Secondary routes are to rural centres like Napier and New Plymouth. Our analysis will show the differences in prices for the different routes in New Zealand and how the price of different services/routes change over time.

C13.3.3 Dates and times

Prices will be collected at five different stages of advanced booking, so as to track how prices change in relation to how long before departure the tickets are purchased.

The stages of advanced bookings that prices will be collected for are:

- Day of departure
- Day before departure
- 10 days before departure
- 30 days before departure
- 60 days before departure

This data will enable us to analyse how prices change as the date and time of flight departure approaches, showing how prices for a flight change over time.

Prices will be collected at two times for each of the five stages of advanced bookings. These two times are peak and off-peak. Peak times are from 07:00 to 09:00 as well as 17:00 to 19:00, with a slight variation of up to half an hour. Off-peak times are all other times, outside of 07:00 to 09:00 and 17:00 to 19:00. During off-peak times we expect domestic air travel to be less busy as most people travel within the peak times. Data will be collected seven days per week, permitting separation of week and weekend prices.

For peak prices, we will use the morning peak period of 07:00 to 09:00. For off-peak prices, we will use the early afternoon, 13:00 to 15:00, being careful to avoid potential midday increases in activity.

C13.3.4 Collection

The price data will be collected in the morning seven days per week. It is important to note that when recording prices on the day of departure there will be less data available as some of the flights will have already departed before the data was collected.

It is also important to note that for some dates, routes and times there may not be a complete data set to fill all the categories e.g. if there are no flights for that route that day or only flights during off-peak hours.

Prices will be collected over a three-month period, starting on the 9th of December 2019 and ending 1st March 2020.

Through this method we will collect 12,600 observations which will be recorded in an Excel spreadsheet which can be used for analysis and calculation.

C13.3.5 Information sources

The source of the price data will be www.webjet.co.nz. Webjet accurately presents the data on the Air New Zealand and Jetstar websites in an easy to use way.

It should be noted that there have been claims of airlines creating profiles of users, using algorithms to attain how much customers are willing to pay and therefore changing prices accordingly. For example, regular fliers and people regularly searching for flights may be identified and charged more. However, by using third party sites such as Webjet this concern should be alleviated.

C13.4 Revenue by route group

In addition, if the Ministry wishes and if suitable data is available, we will calculate estimates of the revenue generated for each of the three route groups for which fare data has been collected. Such revenue estimates will require information on the passenger numbers on each route. It is highly unlikely the major airlines will provide such data. We will investigate the availability of proxy data (eg average load factors by route). Any such estimates will likely have to be heavily qualified.

With the information that is publicly available, route revenue may be calculated by using our knowledge on the volume of planes on each particular route over a period of time and how many seats are on these planes. This would give the total seats available on a route, over a period of time. We would then incorporate the utilisation rate for domestic passenger aviation, supplied by Air New Zealand. This would estimate passenger volume (revenue seats) for each route over a period of time. Combining this with the findings from the pricing analysis would give the route revenue.

If revenue by route can be estimated, it would be possible if the Ministry requires, to compare estimated average revenue with the estimated costs on the three route groups.

C13.5 Proposed key contacts

- Air New Zealand
- Jetstar
- BARNZ
- NZ Airports Association
- Airways New Zealand
- Civil Aviation Authority

Note: the study has been de-scoped following the impact of Covid-19 on the aviation sector. As a result, only published data on Air New Zealand was gathered.

C14. Coastal Shipping

Principal author: Chris Stone, Rockpoint Corporate Finance Ltd

C14.1 Introduction

The scope of this coastal shipping section of this DTCC study covers all sea freight movements between New Zealand ports, both by NZ-based ships and international ships. The DTCC scope covers the Cook Strait ferry services between Picton and Wellington, which cater for both road (and rail) freight and passenger/car movements. This section covers only the Bluebridge services, while the KiwiRail Interislander services are analysed as part of the rail section. Both the Bluebridge and Interislander results will be combined in the final reporting stage. Various harbour ferry (principally passenger) operations in the Auckland, Wellington and Christchurch areas are covered in the urban public transport section.

Mapping the coastal domestic freight task can be achieved from reliable public sources, notably from Ministry of Transport reports, NZ Transport Agency, Statistics NZ, The Treasury and Productivity Commission. Information is also available from industry groups such as Road Transport Forum and Shipping Federation. Many industry stakeholders (shipping, ports, logistics, regulatory) provide valuable information and data on their websites, while research and literature on shipping and transport is available both locally and internationally.

C14.2 Background

NZ's coastal shipping task was estimated (NFDS 2019[19]) at 4.04 billion tonne-km in 2017-18, representing 13.3% of the national freight task (Table C14.1).

Table C14.1

NZ Freight Task (source: NFDS 2019)

Mode	Million tonnes	%	Billion tonne-km	%
Rail	15.6	5.6%	3.5	11.6%
Coastal Shipping	4.6	1.6%	4.0	13.3%
Road	258.5	92.8%	22.6	75.1%
Total	278.7		30.2	

The nature of the coastal shipping sector differs from road or rail in several material aspects.

1. Most of the coastal domestic freight task is undertaken by international ships operating on their international schedules between NZ ports (cabotage).
2. Those NZ-domiciled ships account for only a small subset of the coastal freight task, primarily focussed on specialist bulk trades (petroleum and cement). They operate under NZ laws, regulations and taxes (typically tighter than those imposed on international shipping).
3. Unlike for the road and rail modes, NZ central government has a no direct stake in shipping, (the exception being KiwiRail's inter-island ferry operations) or land-side shipping infrastructure (ports, warehousing, logistics). All NZ ports are owned (outright or majority) by regional / local government. Arguably, this has made shipping a lower policy priority for central government.
4. The logistics chain for coastal shipping is more complex than for truck movements, being longer and dependent upon inter-modal capability (predominantly trucking and storage) to complete its freight task (to a lesser extent, this is also true of rail).
5. Shipping offers large capacity (many train loads), low service frequency and limited routes, relegating coastal shipping to niche, less-time-sensitive, trades.

[19] a Ministry of Transport, National Freight Demand Study, 2019

The complexities of prices and costs for coastal shipping include:

- competing shipping lines each establish different routes, employ different ship sizes, target different cargo types.
- ports differ in their scale, cargo mix from/to their hinterlands and asset intensity.
- access to financial data is uncertain, given almost all shipping companies are privately owned under no or limited obligation to provide data to this study.

The coastal shipping task (derived from NFDS) comprises the following key freight categories[20]:

Containers – 0.8 million TEU p.a.

- Cabotage, being the carriage of domestic cargo between NZ ports by foreign ships operating on international routes, accounts for 80% of NZ's coastal container freight task.
- Domestic shipping companies operating on scheduled services carry the balance.

Bulk Freight – 4.6 million tonnes

- Petroleum products from Northland refinery distributed nationally.
- Cement distribution, by Golden Bay Cement from its Northland facility, and by Holcim of imported cement from Timaru.
- Distribution of various occasional cargo; bulk (such as wheat, dolomite, cement and fertiliser) and project cargo (machinery, manufactured and palletised goods), principally by Coastal Bulk Shipping.

Inter-island ferries

- Two operators provide RORO ferry across Cook Strait between Wellington and Picton, servicing cars, trucks, trains and passengers. Bluebridge is covered in this section while Interislander (KiwiRail) is covered in the rail section

Table C14.2

Coastal Shipping Freight Task - million tonnes (source: NFDS 2019)

Origin \ Destination		NTH	AKL	WAI	BOP	GIS	HBY	TAR	MNW	WGN	TNM	WCT	CAN	OTG	STH	Total	Principal Cargo
Northland	NTH		0.6		0.6		0.2	0.1		0.3	0.3		0.4	0.3	0.2	2.9	Petroleum, cement
Auckland	AKL										0.1		0.6			0.7	Containers
Waikato	WAI																
Bay of Plenty	BOP												0.2			0.3	Containers
Gisborne	GIS																
Hawke's Bay	HBY																
Taranaki	TAR															0.1	Crude Oil
ManawatuWanganui	MNW																
Wellington	WGN																
TasmanNelsonMarlb	TNM																
West Coast	WCT																
Canterbury	CAN		0.1		0.1					0.1			0.1			0.5	Containers, cement
Otago	OTG																
Southland	STH																
Total	Total	0.1	0.7		0.7		0.3	0.1		0.4	0.4		1.3	0.4	0.2	4.6	
Principal Cargo		Crude Oil	Petroleum, cement,		Petroleum, containers		Petroleum, cement,	Cement		Petroleum, cement,	Petroleum, cement,		Petroleum, cement,	Petroleum, cement,	Petroleum, cement,		

Note: excludes inter-island ferries

[20] Also, MoT publishes data on sea freight movements, which can be accessed at: https://www.transport.govt.nz/mot-resources/transport-outlook/transport-outlook-future-state-model-results/

Coastal shipping cost components include land-based infrastructure (port assets and their operations) and sea-based infrastructure (ships and their operations), plus ancillary services such as storage, inter-modal activity and support services (freight forwarders). The categories of costs and charges for coastal shipping are logically broadly consistent with road and rail modes: we would endeavour to achieve direct comparisons to the extent possible.

Cargo owners have choices of transport mode, driven by cargo type (perishability, fragility), scale, urgency and price. Rockpoint, in a previous stakeholder survey for NZTA (Coastal Shipping and Modal Freight Choice)[21] suggested service reliability, product care, safety and timeliness all ranked higher than price.

C14.3 Coastal Shipping Components

This Domestic Transport Costs and Charges (DTCC) study seeks to quantify the collecting 'hard dollar' financial costs and associated charges and 'soft dollar' costs (environmental, public health etc) for each NZ transport mode. Accordingly, for coastal shipping, we aim to develop a data collection methodology able to be periodically and reliably repeated to yield costs and charges across key categories.

C14.3.1 Ship Operators

Domestic shipping companies are the more likely to participate in this study. They are privately owned (excepting only KiwiRail's Interislander), minority transport players, and collectively account for just 2% of the national freight task. Their share is far less excluding specialised petroleum and cement distribution. The prospect of considerable market growth is attractive, especially with more favourable government policies (such as Zero Carbon), and they will benefit from DTCC's analysis of costs and of modal competitors.

International shipping lines have previously proven open to engage, although given intense global competition, will likely be reluctant to provide any detailed data. We note that for international ships, the carrying of domestic containers is opportunistic, depending upon their inclination and the random availability of time and capacity. As such coastal movements are often marginally priced.

We anticipate the most comprehensive and coherent data for shipping lines' capital and operating costs will be sourced from international research, with local management of international shipping lines providing principally commentary and some approved data.

Price data is more readily available. Route charges for time-, type- and route-specified containerised cargo may be available from freight forwarders, if the requests are focussed and discrete.

C14.3.2 Ports

NZ ports are obliged under the Port Companies Act to publish annual reports and disclose their charging schedules (prices). The DTCC study will seek greater disaggregation of revenues, expenses and assets than available from their financial statements. All NZ ports are council owned or controlled, are local monopolies and core community assets. Past engagement with the ports has shown their willingness to share some additional information for national-good studies.

C14.3.3 Regulation

NZ has established a regulatory framework for maritime activities, the core being the Maritime Transport Act 1994, the key elements of which reflect International Maritime Organization (IMO) conventions recognised in New Zealand law such as MARPOL 73/78 (for the prevention of pollution from ships), OPRC (for Oil Pollution Preparedness, Response and Co-operation) and ISPS (International Ship and Port Security). Maritime New Zealand, the agency responsible for shipping safety, security and environmental protection, is materially funded by its Maritime Levy on domestic and foreign

[21] NZ Transport Agency, Coastal Shipping and Modal Freight Choice

commercial vessels operating in New Zealand waters, and to lesser extent by the Oil Pollution Levy. Other government agencies with responsibilities in shipping include Ministries of Transport, Environment and Primary Industries, and New Zealand Customs, Police, and the Navy. Adhering to the accepted principle of "user pays", these agencies apply a variety of levies and charges such as Fuel Excise Duty. Collating these various charges and levies will form part of this study.

C14.3.4 External Factors

Social (external) costs for shipping are relatively low, given the task is undertaken by a handful of parties with limited direct engagement with the wider public. Shipping utilises large dedicated assets (ships and ports), employing relatively few staff, and operates in coastal waters. Ships operate to clear NZ and international rules and standards (NZ is a signatory to IMO and ISPS). Similarly, the environmental impact of shipping is largely confined to the consumption of bunker fuels, bio-hazard risks of invasive organisms, and growing marine congestion. Ports face RMA hurdles for periodic development and dredging and their land-side connections. Environmental impacts will be addressed within the environmental section of DTCC, with data collection and analysis tasks being coordinated between this study workstream and the environmental workstream. We anticipate that the environmental impacts of shipping will account for only a small component of the overall environmental assessments and costings relating to the NZ transport sector.

C14.4 Project Methodology

C14.4.1 Data

Data will be sought from (refer table C14 .3)

- Public sources: comprising academic, government, conference, industry association, journals, databases, and industry stakeholders (annual and financial reports, media statements)
- Direct sources: engagement with industry stakeholders, gathering both hard data (financial, volumes, other metrics) and soft data (opinions, perspectives)

Table C14.3

Data Sources by freight category

	Containers - cabotage	Containers - domestic	Petroleum	Cement	Bulk Cargo	Inter-island RORO
Cargo owner	various	various	Refinery shareholders	Golden Bay, Holcim	various	various
Ship operator	international shipping lines	Pacifica	COLL	Golden Bay, Holcim	Coastal Bulk Shipping	Kiwirail, Bluebridge
Volume	FIGS, ports, NFDS	FIGS, ports, NFDS	FIGS, ports, NFDS	FIGS, ports, NFDS	FIGS, ports, NFDS	II operators, ports, NFDS
Price	ship operators, freight forwarders, various	ship operators, freight forwarders, various	ship operators, proxies	ship operators, proxies	ship operators, proxies	ship operators, freight forwards, various
Costs	global opcost research, ship operators	global opcost research, ship operators	global opcost research, ship operators	global opcost research, ship operators	global opcost research, ship operators	global opcost research, ship operators

C14.4.2 Data Issues

Potential data issues include data availability and confidentiality. We note that shipping is a very competitive game, and industry stakeholders are largely private companies with no obligation to share commercially sensitive information. While we anticipate cooperation for the DTCC study, they will need to see merit in the study, be assured of confidentiality, and recognise some benefit to themselves.

The DTCC study participants will coordinate their efforts to avoid duplication, and will communicate the scope, rationale and value of the DTCC study report to government. All companies being approached will be advised how the study will benefit from their participation, and only information targeted to this study will be sought.

C14.4.3 Contacts

It is proposed to meet with four sets of industry stakeholders:

- Shipping lines – parties that own and/or operate the ships plying coastal waters
- Ports – land-based infrastructure for ships and cargo
- Government – policy setter, regulator, data collector/provider
- Other - industry and representative bodies, other industry stakeholders

C14.5 Key outputs

The objective is to establish a breakdown of costs and prices:

- Across chosen market categories – Appendix C14.B
- Broken down in a consistent form across modes – Appendix C14.C
- Methodology/analysis required to source and present available data

Key deliverables will comprise:

C14.5.1 Project coordination

DTCC consultants will agree which stakeholders to approach (once only, all relevant consultants present), what information to seek, how the data will be processed, and by whom.

C14.5.2 Project management

- Agree project scope and consistent methodology across all modes and sectors
- Establish base questionnaire / interview guide
- Agree target parties, who makes contact and who leads and attends interviews,

C14.5.3 Research – be informed

- Research of global and national shipping, port and transport issues and trends
- Compile national and global data – being informed
- Evaluate global shipping prices and costs – where available
- Compile background on all industry participants to be interviewed

C14.5.4 Interviews – emphasise the benefits

- Provide background and scope for DTCC – describe benefits to government, how the study will be used, the value of industry participation,
- Structured discussion of global and national cargo markets, insights, changes past and anticipated, and participant's business and aspirations
- Provide assurances on data confidentiality, and seek only information/data relevant to DTCC study (volumes, prices and costs – validate against global benchmarks)

C14.5.5 Reporting back

- Compilation and analysis
- Reporting back to IWA and interim feedback to study participants

C14.6 Industry Engagement Considerations

To ensure that the analysis and recommendations are well grounded, we propose to interview a wide range of industry stakeholders.

Transport is a highly competitive and capital-intensive industry, with business models and commercial advantages closely guarded. Further, shipping sector participants are overwhelmingly private companies with no obligation and presumably limited incentive to share insights. In contrast, NZ ports are largely council-owned and obliged to publish annual reports and pricing schedules).

Our approach, ideally mirrored across all modes, will first describe the nature, scope and importance of this study, highlighting its benefits to the government, the industry, and to them. We will have undertaken the research necessary to understand the shipping markets and relevant public information (schedules, routes and ships, the global markets, generic costings). Discussions should cover, first, wider industry issues, and then the role and activities of the interviewed party. We should be prepared/willing to share our insights, views and knowledge, to so encourage interviewees to share (a *quid pro quo*). We will seek only information relevant to this DTCC study and will fully respect confidentiality. Project team coordination will avoid duplication.

The proposed question categories for shipping lines:

- The shipping line: nature of activity, scale of operations, alliances, differentiators
- NZ market: key activities in NZ, observed market conditions (risks), recent and anticipated changes, implications for NZ operations
- Key operational metrics: containers/cargo handled, changing patterns, trends and forecast growth, drivers for change of market position
- Costs structures: generic global cost structures and price trends, how shipping lines in NZ compare. Why the differences?
- Financial metrics: prices per unit (container/tonne) or voyage, costs (capital requirements, operating costs, voyage costs)
- Supporting infrastructure; land transport services, logistics and storage, ports, services. Current adequacy, suggested options for enhancement/investment.
- Government: Perceived/optimal role of government - in regulation, information gathering, infrastructure investment, policies, and influencing modal choice.

The questions will be modified for port companies, industry organisations and government agencies.

The optimal outcome is to obtain full disclosure / maximum co-operation from all shipping sector companies operating in NZ. It is recognised that they are not obliged to provide that information, and indeed commercial sensitivities in this highly competitive shipping market may discourage them.

Should targeted companies elect not to share (much) information, the key objectives of this DTCC study can still be met. First, generic global ship operating costs (by ship type and size and age), which are presumably of greatest importance to MoT, remains publicly available. Second, even limited disclosure on how an individual operator costs may differ to reflect/meet their specific market or strategy will usefully inform the study on cost flexibility.

This DTCC study will certainly be enhanced by detailed local data, but not derailed in its absence – so long as comprehensive, representative global benchmarks are available. Our research to date provides confidence that a robust price and cost model for coastal shipping can be established for New Zealand.

Annex C14.A: Summary – Scope and methodology

Table C14.A1: Scope and Methodology – Coastal Shipping

Table A1: Scope and methodology - Coastal Shipping

Topic	
Key Outputs	Derivation of unit price and cost information by category, uncertainties, dependencies
Key inputs	Stakeholder data, public data such NFDS/FIGS and global industry research
Data sources	Appendix 3 - industry stakeholders, public sources
Data issues	For industry: privacy, commercial confidentiality, perceived relevance
Proposed analyses	Volumes, and financial data to derive unit prices and costs by category
Dependencies - inputs	Data access, data quality and consistency
Dependencies - outputs	All transport modes require inter-modal links
Risks, uncertainties	Stakeholder participation - data availability, detail and consistency
Other comments	Rockpoint expects shipping industry stakeholders will be willing to engage but the shipping lines in particular may be reticent to provide detailed information. However, international research will provide a meaningful cost structure for shipping to complete the unit-price-cost picture

Annex C14.B: Market Segments for Coastal Shipping

C14.B1 Coastal containers – international ships – 3.7 million tonnes p.a.

International ship operating on their scheduled services between NZ ports carry some 80% of NZ's coastal container freight task – termed cabotage. 10% of this volume are transhipments, being import/export containers being moved between NZ ports on a different ship to the international leg. International shipping lines incur the cost of domestic legs regardless of whether they use available capacity for cabotage. Accordingly, domestic containers may be marginally priced, so not providing a full or direct comparison with domestic shipping lines (which must recover all their costs from these shipments). Our analysis will seek to identify any extra costs international shipping lines may incur through cabotage (port costs, loading time, and variable costs), understanding targeted market segments (higher volume shippers or cargo aggregators) and their pricing strategies.

C14.B2 Coastal containers – domestic ships – 0.9 million tonnes p.a.

Domestic ships which operate on scheduled services carry 20% of coastal (domestic) containers, including some transhipment cargos. Domestic ships operate under NZ laws, and receive no subsidies or tax protections available to foreign registered or owned ships. To remain viable, revenues must cover all costs plus margins.

C14.B3 Coastal bulk – regular (but not scheduled) services – 4.6 million tonnes p.a.

This category covers specialist ships dedicated to the distribution of bulk cargos nationwide from a single production site for one/(or a fixed few) customers.

- Coastal Oil Logistics: the matching shareholders of the Marsden Point Oil Refinery operate two ships to distribute refined petroleum products to their regional storage facilities. Note: 35% of consumed petroleum products are transported from the refinery by barge or imported directly.
- Golden Bay Cement: distributes cement from its Northland plant to their regional storage facilities using their own ships
- Holcim, having closed its Westport facility, imports cement from Japan into Auckland and Timaru, using their ship to distribute from the latter being to the South and lower North islands.

C14.B4Coastal bulk – irregular (tramp) services – est < 0.5 million tonnes p.a.

Various bulk and project cargos are carried for multiple independent customers to and from various regional ports on an as-required basis, including fertiliser, limestone, aggregate, grain.

- Coastal Bulk Shipping operates the M V Anatoki.
- Foreign ships may periodically be chartered for specialist cargos

C14.B5Inter-island ferries.

A unique category, RORO ferries act as a land-bridge for road and rail freight between Wellington and Picton, using dedicated port facilities.

- Interislander, owned by KiwiRail (100% government) – 3 RORO ships (one rail-enabled)
- StraitNZ Bluebridge, privately owned, operating 2 RORO ships.

Further segmentation may be considered warranted (e.g. for the ferries, between road freight, walk-on passengers, passengers with cars).

Annex C14.C: Costs and Charges by Category

C14.C1 Shipping Lines

Shipping line costs - capital, operating and voyage - are typically considered separately given many/most ships are chartered (so requiring a separation of capital and operating costs), and each voyage (port-to-port transit) incurs specific costs (port, bunker, agency).

Prices:

- Sourced from shipping lines, public research, freight-forwarders

Capital Costs:

- Capital cost of the ship, including pre-delivery costs, registration, and insurance,
- Financing costs: debt interest and equity dividends, WACC
- Asset Life – depreciation rate

Operating Costs:

- Crew costs: wages, travel, training, medical, visa and permits, insurance
- Consumables: Spares, stores and lube
- Insurance and P&I
- Maintenance & Repair
- Overhead: Vessel registration costs and management fees

Voyage Costs.

- Bunker fuel charges
- Port Charges
- Cargo Handling Costs
- Canal/Other Dues
- Agency Costs

C14.C2 Ports

Prices:

- Sourced from port companies (reports), pricing schedules

Capital Costs:

- Capital cost of port infrastructure, and insurance,
- Financing costs: debt interest and equity dividends, WACC
- Asset Life – depreciation rates

Operating Costs:

- Staff costs including training, medical, insurance
- Maintenance & Repair
- Consumables: Spares, stores and lube
- Insurance and P&I
- Management and administration fees

Variable Costs – by ship visit.

- Pilotage and Towage
- Agency Costs

C14.C3 Other

Prices:

- Sourced from government agencies, third parties

Costs:

- Regulatory costs and fees
- Storage and inter-modal transfers
- Third Party agency costs

Annex C14.D: Industry Contacts by Category

Shipping Companies

- Maersk Line Oceania (and Hamburg Sud):
- CMA CGM
- MSC
- Mitsui OSK
- COSCO
- Hapag Lloyd
- NYK
- China Navigation Company (Swire, Pacifica)
- Coastal Bulk Shipping

Port Companies

- Northport
- Ports of Auckland
- Port Tauranga
- Port Taranaki
- Port of Napier
- CentrePort
- Port Nelson
- Port Marlborough
- Lyttelton Port
- PrimePort Timaru
- Port Otago:
- Southport:

Government

- Maritime NZ
- Ministry of Transport
- NZ Transport Agency
- Ministry of Business Innovation and Employment
- NZ Customs
- Statistics NZ

Industry Bodies and Other

- NZ Shipping Federation,
- NZ Council of Cargo Owners,
- Customs Brokers and Freight Forwarders Federation of NZ
- Rohlig
- Mondiale

Part D: Impact (Externality) Topics

D1. Social Costs of Transport Crashes

Principal author: Glen Koorey, ViaStrada Ltd

D1.1. Overview

Note: The primary focus of this section is on road crashes, which are dealt with as a separate topic given the significance of their impact on the New Zealand transport system. The approach to the assessment of safety and crash costs for other modes (rail and coastal shipping) is discussed throughout this section as well.

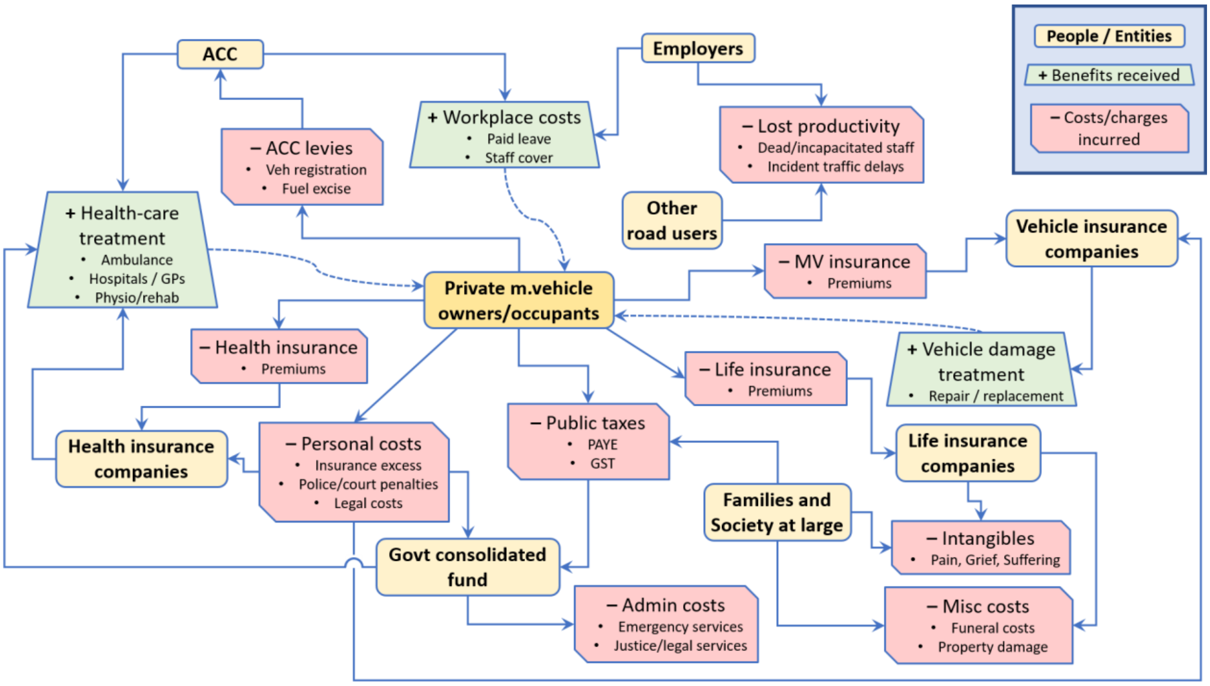
This section outlines the proposed methodology to derive estimates of the Total (Social) Costs, Average Costs, Marginal Costs and Marginal Externality Costs of transport crashes (accidents) in New Zealand.

The key output will be a working paper explaining the background, derivation and calculation of these updated costs, together with accompanying Excel spreadsheet data.

The analysis will consider the various inter-relationships between the funding and charging for costs related to crashes. This will include the role of ACC and private insurance coverage to cover many of the medical, work-interruption, and property damage costs associated with road crashes and other transport mode accidents (otherwise largely borne by individuals, employers and the public health service).

The following conceptual model (Figure D1.1) illustrates some tentative thinking around flows of costs and charges relating to road crashes for private motor vehicles (similar relationships would need to be developed for commercial vehicles, public transport services, active modes, and other transport modes).

Figure D1.1: Indicative costs/charges flow relationships for NZ (private motor vehicles)



Task outline:

1) Literature review of methodologies from previous studies and more recent work. Development of a conceptual cost/charges flow model for each sub-mode. Selection of a comparable and repeatable methodology for each cost and charge item and for each mode.

2) Obtain latest ACC/CAS/MoT/etc safety and usage data (adjust for under-reporting). Analyse the road crash costs for marginal/average costs, having regard to crash rates and unit valuations, and new valuation methods. The analyses will include active transport modes.
3) Investigate the extent to which road crash rates/costs vary in different conditions, especially in regard to traffic volumes (e.g. quiet vs congested road networks), traffic speeds (e.g. urban vs rural roads), and user-type involvement (e.g. single-user crashes vs multi-party collisions).
4) Investigate costs of crashes on rail networks (including multi-mode collisions) and assess to what extent the costing approach is comparable with the road system (in liaison with the Rail modal consultant). Assess the average crash costs per usage metrics (passenger-km or tonne-km).
5) Obtain modal safety data for maritime accidents to discern typical numbers and total costs of incidents. Assess the average crash costs per usage metrics (passenger-km or tonne-km).
6) Engagement with academic community and other key stakeholders (including Client). Identify longer-term research needs to progressively improve data quality. Revise/refine draft working paper accordingly.

D1.2 Key outputs

The key deliverables for this work are:

- A review of previous work and valuation exercises and methods in New Zealand and internationally
- A theoretical overview and model of NZ costs & charges associated with road crashes and other transport accidents
- A summary of the latest evidence relating to traffic volume and speed effects on costs
- Identification of appropriate data sources and issues identified with their veracity
- Estimates of Total (Social) and Average Costs of road crashes in New Zealand
- Estimates of Marginal Costs and Marginal Externality Costs of road crashes in New Zealand
- Estimates of Total (Social) and Average Costs of rail and maritime accidents in New Zealand

The results will be segmented where possible by:

- Private costs vs ACC/insurance costs vs Govt/Public costs
- Private vs Commercial road movements (i.e. private car, public transport, freight movements)
- Different modes (motor vehicles, cycles, pedestrians, micro-mobility)
- Different road types (State Highway vs local road, arterial vs local streets, urban vs rural)
- Different traffic conditions (peak vs off-peak)
- Different crash types (single-vehicle vs multi-user)
- Different users (general public vs transport workers)

Whilst disaggregation by road type is likely to be possible for motor vehicle travel, it is probably not possible for other less-used modes. For rail and maritime accidents, disaggregation is likely to only be in terms of passenger and freight services.

D1.3 Key inputs

The following data inputs are proposed for this work:

- NZ road crash statistics (and associated severities) for the 3-year period 2017-19
- Latest Value of Statistical Life (VOSL) and social cost estimates

- ACC levies and claims made for the 2016/17-18/19 financial periods for motor vehicles and active modes
- Transport usage data (in terms of person-km/vehicle-km) for different transport modes by different road types where possible
- Insurance market data on motor vehicle, health and life premiums and claims (2017-19)
- Health sector data on road crash treatment costs
- National rail/maritime agency statistics on accidents for the 2010-19 period
- National data on transport sector workplace accidents and injuries
- Relevant latest research on valuation methods and effects of traffic parameters on safety

Where possible, three-year periods are proposed for estimating annual averages, to reduce any variability in individual years. For modes with low annual accident numbers (e.g. rail, sea), longer analysis periods will be used. Where possible some triangulation between multiple sources will be undertaken (e.g. transport agency vs workplace safety agency) to confirm the appropriate orders of magnitude.

Road transport usage data (person/vehicle-km) will be sourced from the team undertaking the assessment of road operations. Equivalent data for the rail and shipping networks will be obtained separately by the rail/sea modal consultants and compared.

D1.4 Data sources – specification

The following data sources are proposed for this work:

- NZTA Crash Analysis System (CAS): Total NZ road crash statistics (and associated severities/costs) for the 3-year period 2016-19
- ACC open data or OIA requests: Total ACC levies and claims made for motor vehicles and active modes made for the 2016/17-18/19 financial periods
- MoT Transport Dashboard: data on household travel, road transport, public transport, walking & cycling, and domestic road freight, in terms of road lengths, veh-kms or person-kms
- Insurance Council NZ, HealthFunds NZ, Financial Services Council: Insurance market data on motor vehicle, health and life premiums and claims (2016-19)
- MOT (2019): Current Value of Statistical Life (VOSL) estimates from June 2018
- NZ Injury Query System (NIQS) hospital discharge data: Health sector data on road crash treatment costs
- NZ Transport Agency rail safety unit: All rail incidents for the period 2010-19
- Maritime NZ annual reports: data on annual maritime accidents for the period 2010-19
- Worksafe NZ data centre: all transport-related workplace accidents for the period 2010-19
- Transport Accident Investigation Commission: data on all transport incidents investigated
- Latest research on valuation methods and effects of traffic parameters on safety: see Reference List later for background documents to be referred to

To the extent that the data allows, active transport modes will be included in the analysis, i.e. walking, cycling, mobility scooters, wheeled recreational devices (e.g. scooters and skateboards). This will be via a combination of Police, hospital and ACC crash/injury data (e.g. recent ACC investigation of injuries with e-scooters and other wheeled devices), and will also reference recent NZTA research (Lieswyn *et al* 2017) into safety and regulations for e-bikes, mobility scooters, and other low-powered devices.

Generally, most data sources are publicly available (or available via OIA request), with few confidentiality issues. Although we have ready access to most of these data sources, where necessary we will also liaise with agency contacts regarding more customised datasets or issues of data quality.

If possible, we will also explore the relative role that private insurance plays in covering many of the medical and property damage costs associated with road crashes. Some insurance market data is already in the public domain, and we would look to request any other data as aggregated information for the whole sector (it is not clear whether a cost might be incurred to obtain additional data).

D1.5 Data sources

To be determined. A lot of the data required can be obtained remotely.

D1.6 Data issues (known or anticipated)

No major issues are anticipated regarding obtaining the required data, as most of it is from public organisations. As noted previously, some insurance market data may be difficult to obtain, but this has not been tested yet.

Depending on the timeframes of when annual data is released, we may be limited as to which data is available; the target is the end of the 2018/19 financial year (i.e. to June 2019).

D1.7 Proposed analyses

Studies elsewhere (e.g. CE Delft 2019) have noted that there are six main components of road crash costs:

- **Human costs**: A proxy for estimating the pain and suffering and loss of utility caused by traffic crashes in monetary value, through injuries and fatalities.
- **Medical costs**: The costs of the victim's medical treatment provided by hospitals, rehabilitation centres, general practitioners, etc. as well as the costs of ambulances and medicines. Often partly covered through health insurance premiums and ACC levies.
- **Administrative costs**: The expenses for deployed emergency services at crash sites, as well as the administration of justice/legal costs, and administrative costs related to insurances.
- **Production losses**: The net production losses due to reduced working time of victims and the human capital replacement costs. Partly covered by insurance and ACC.
- **Material damages**: The value of damages to vehicles, infrastructure, freight and personal property resulting from crashes, largely covered through insurance.
- **Other costs**: Includes the costs of congestion/delays resulting from road crash incidents, and funeral costs. May already be incorporated in other external cost categories.

These valuations are typically determined by a combination of "Restitution" costs (the resources needed to restore victims and their families and friends to the situation where the crash hadn't happened), "Human capital" costs (the value for society of the productive capacities that are lost in road crashes), and "Willingness to pay" (WTP) costs (the amount that individuals are willing to pay for a risk reduction). In New Zealand, WTP largely determines the Value of Statistical Life (VOSL); last reviewed by MOT (2009) and currently incorporated into crash cost statistics for 2018 (MOT 2019).

A key issue in comparing costs and charges is assessing the perception of causality by the user, and its relationship to primary fault in multi-party crashes, with a likely assumption being that drivers of larger vehicles do not adequately assess the risk imposed by them on more vulnerable users. Previous analysis identified different cost concepts, including "perceived" costs, costs "caused", and costs "suffered". We will review this approach, and also consider updated valuation methods (e.g. those provided in CE Delft 2019). Some different options include:

- Assigning victim costs to the vehicle type that they were in
- Assigning victim costs to the vehicle deemed to be at fault in the crash

- Assigning victim costs to the other vehicle (that inflicted the damage)

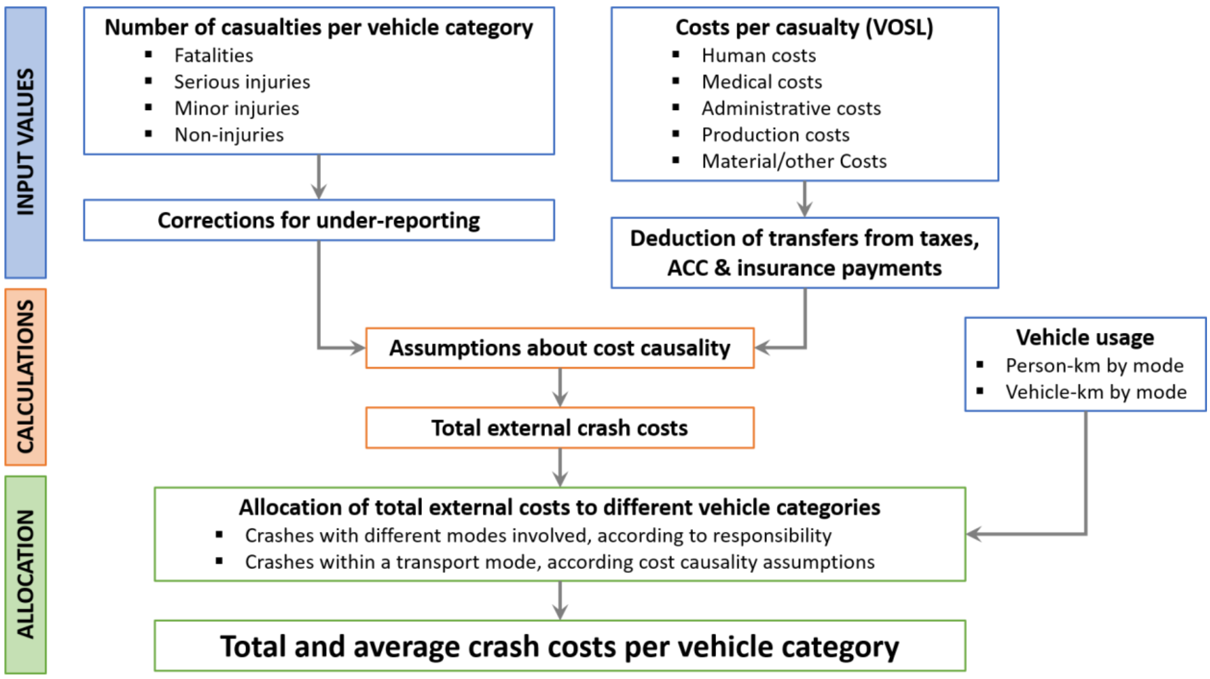
It is proposed that two costing concepts (total/average costs and marginal costs) will be applied for the road crash costing analyses in DTCC. The following sections illustrate the intended process for determining the total and marginal crash costs.

A similar approach will be employed when calculating accident costs for other modes; however, it may be more difficult to obtain all the same necessary input data. A cursory investigation of alternative valuation methods for non-road accidents will be undertaken, but a simple assumption may be to use the same VOSL values for all modes.

D1.7.1 Total and Average Costs

Total and average crash costs are calculated using a top-down approach, starting with total reported crashes, assuming under-reporting rates, and then allocating them to different road or vehicle types (knowledge of person/freight/vehicle-km data would also allow for averages against these metrics). Fatal crashes are assigned a cost based on the current VOSL; injury and non-injury crashes are assumed to cost a certain percentage of the VOSL. The flowchart below (Figure D1.2) illustrates the basic procedure.

Figure D1.2: Methodology for total and average crash costs (adapted from CE Delft 2019)

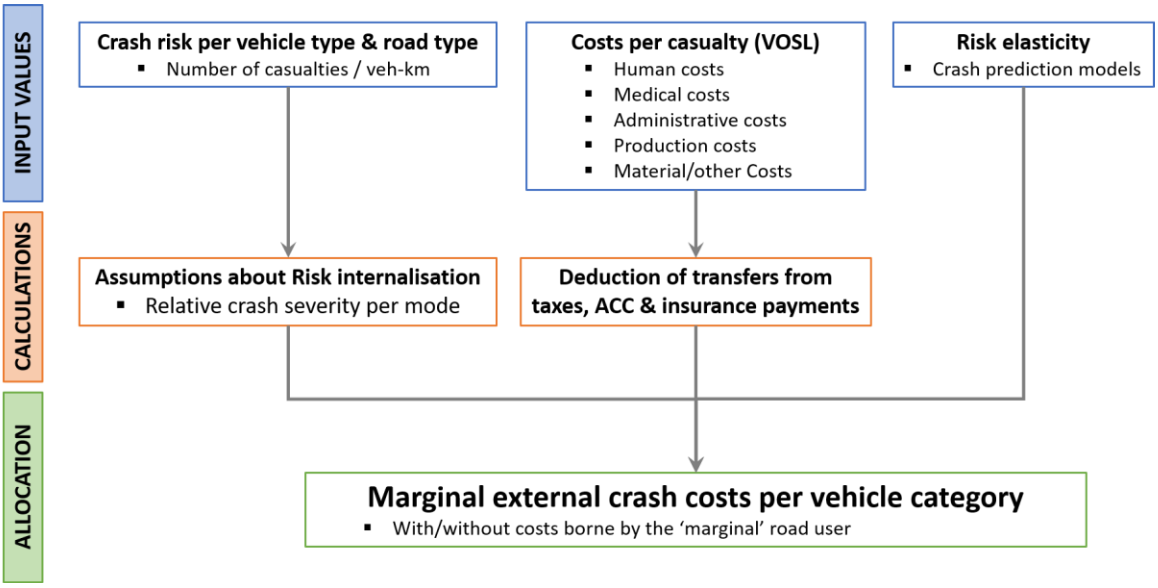


Having determined total crash costs, the exercise can then be extended to consider how much the road (or other transport mode) user already contributes to these costs (through taxes, ACC levies, premiums, direct costs, etc) and how much is paid for by external parties (e.g. other road users, employers, society at large). We will then review ways of allocating these costs to different parties.

D1.7.2 Marginal Costs

The marginal costs for road crashes represent the extra costs that adding an extra vehicle-km to the traffic flow pattern brings. The main input values for marginal crash costs are the crash risk per vehicle type and road type, the costs per casualty and the “risk elasticity” (the change in crash risk per change in traffic flows). The costs per casualty are the same as those used for the calculation of total and average costs. The flowchart below (Figure D1.3) illustrates the basic procedure.

Figure D1.3: Methodology for marginal external crash costs (adapted from CE Delft 2019)



Risk elasticity values can be derived from either similar overseas studies or local crash prediction models, such as the work by Turner (2001) and Turner *et al* (2012); we will undertake only limited review of the existing elasticity assumptions and test the relative sensitivity of using different values. Risk internalisation can be estimated from an analysis of fatalities/injuries sustained across crashes involving multiple vehicle types relative to the fatality/injury rates for each vehicle type.

While similar analyses could be applied to other transport modes, it is not likely that they can be broken down to the same degree of detailed disaggregation.

Annex D1.A: Methodology report summary structure for topic area

Table D1. A1: Scope and methodology – by topic: Transport Crash Costs	
Topic	**Updated estimates of the social costs of road crashes**
Key outputs	Key deliverables for this work are: • A review of previous work and similar valuation exercises/methods internationally • A theoretical overview and model of NZ costs & charges associated with road crashes and other transport accidents • A summary of the latest evidence relating to traffic volume and speed effects on costs • Identification of appropriate data sources and issues identified with their veracity • Estimates of Total (Social) and Average Costs of road crashes in NZ, overall and by segment • Estimates of Marginal Costs and Marginal Externality Costs of road crashes in NZ • Estimates of Total (Social) and Average Costs of rail and maritime accidents in New Zealand
Key inputs	The following data inputs are proposed for this work: • NZ road crash statistics (and associated severities) for the 3-year period 2017-19 • Latest Value of Statistical Life (VOSL) and social cost estimates • ACC levies and claims made for the 2016/17-18/19 periods for motor vehicles and active modes • Transport usage data (in terms of person-km/vehicle-km) for different transport modes by different road types where possible • Insurance market data on motor vehicle, health and life premiums and claims (2017-19) • Health sector data on road crash treatment costs • National rail/maritime agency statistics on accidents for the 2010-19 period • National data on transport sector workplace accidents and injuries • Relevant latest research on valuation methods and effects of traffic parameters on safety
Data sources - specification	The following data sources are proposed for this updated work: • NZTA Crash Analysis System (CAS): Total NZ road crash statistics (and associated severities/costs) • ACC open data or OIA requests: Total ACC levies and claims made for m.vehicles and active modes • MoT Transport Dashboard: data on household travel, road transport, public transport, walking & cycling, and domestic road freight usage • Insurance Council NZ, HealthFunds NZ, Financial Services Council: Insurance market data on motor vehicle, health and life premiums and claims • MOT: Current Value of Statistical Life (VOSL) estimates from June 2018 • NZ Injury Query System (NIQS) hospital discharge data on road crash treatment costs • NZ Transport Agency rail safety unit: All rail incidents for the period 2010-19 • Maritime NZ annual reports: data on annual maritime accidents for 2010-19 • Worksafe NZ data centre: all transport-related workplace accidents for 2010-19 • Transport Accident Investigation Commission: transport incidents investigated • Latest research on valuation methods and effects of traffic parameters on safety

Data sources - organisation	To be determined. A lot of the data required can be obtained remotely.
Data issues (known or anticipated)	No major issues are anticipated regarding obtaining the required data, as most of it is from public organisations. As noted previously, some insurance market data may be difficult to obtain, but this has not been tested yet. Depending on timeframes of annual data release, we may only have data up to 2018 rather than 2019.
Proposed analyses	It is proposed that the same two costing concepts as before (total/average costs and marginal costs) will be applied for the road crash costing analyses in DTCC: (1) Total and average crash costs are calculated starting with total reported crashes, assuming under-reporting rates, and then allocating them to different road or vehicle/vessel types. Fatal crashes are assigned a cost based on the current VOSL[22]; injury and non-injury crashes are assumed to cost a certain percentage of the VOSL. Having determined total crash costs, the exercise can then be extended to consider how much the road (or other transport mode) user already contributes to these costs (through taxes, ACC levies, premiums, direct costs, etc) and how much is paid for by external parties (e.g. other road users, employers, society at large). (2) The marginal crash costs represent the extra costs that adding an extra vehicle to the traffic flow brings. The main input values are the crash risk per vehicle type and road type, the costs per casualty (based on VOSL as before) and the "risk elasticity" (the change in crash risk per change in traffic flows).
Dependencies on other topics - inputs	Road-rail crashes (i.e. at level crossings) have costs associated with both modes; therefore, liaison will be made with the overall Rail modal consultant to discuss the best approach.
Dependencies to other topics - outputs	The outputs from this topic will feed into the overall Roading, Rail and Sea modal costs; therefore, ongoing liaison with the overall Roading/Rail/Sea modal consultant will be required. The outputs related to the active travel modes (walking, cycling, micro-mobility) will help to inform the modal consultant for these
Risks, uncertainties	There is a risk that some private market data might not be able to be obtained. The likelihood of encountering any data supply problems will be determined early on in the study work. Actual crash numbers depend on how under-reporting rates get applied to official reported crash statistics. Some triangulation can be applied via hospital, ACC, and other data sources.
Other comments and issues	We are aware that NZTA is currently undertaking new market research into the value of life for the road sector. Given this, and subject to further discussions with MoT, we would not propose to further investigate social cost unit values for fatal and injury crashes.

[22] Outputs from the new VOSL study are not expected to be available in time for inclusion in this DTCC Study

D2. Congestion costs

Principal author: David Lupton, David Lupton & Associates

D2.1 Coverage of Section

- Road congestion costs

D2.2 Scope and Methodology

Table D2.1: Scope and methodology

Topic	**Road Congestion**
Key outputs	Methodology for measuring social cost of congestion with calculated values at representative times and locations.
Key inputs	Travel times at selected locations by time of day. Data for estimating the value of time for peak period motorists. Construction costs for road widening.
Data sources - specification	Vehicle speed and volume from monitoring sites and mobile phone and GPS time and location data from moving vehicles. Behavioral data for estimating value of time. Construction costs and capacity estimation.
Data sources - organisation	NZTA provide vehicle speed and volume data from fixed monitoring sites. Traffic-Congestion-info provide travel time information based on vehicle GPS data while AT have been working with Nokia Data Analytics for mobile network data. NZTA for value of time data – possibly also AT and GW model data. NZTA for construction costs.
Data issues (known or anticipated)	We will obtain travel time data from several sources. We understand NZTA data are only available from certain fixed sites. We are not sure yet how difficult it will be to find the data on value of time. We may need to use indicative ranges. For road widening costs it is often difficult to separate widening from other works such as interchanges, etc.
Proposed analyses	We will use the observed travel time data to calculate the externality in minutes at a range of locations and times. We will develop methodology for estimating the value of time and estimating costs for capacity enhancement.
Dependencies on other topics - inputs	Some data may come from the road issues work
Dependencies to other topics - outputs	None
Risks, uncertainties	Estimation of the externality in minutes is the easy bit. Estimating the appropriate value of time and estimating the per-vehicle cost of road expansion has greater uncertainty.
Other comments and issues	See detail

D2.3 Methodology

Road congestion is a phenomenon where the demand for road infrastructure exceeds its capacity. Similar situations occur for other modes of transport and are dealt with in various ways (eg with high peak and discounted off-peak fares for airlines). These are discussed in other sections as appropriate. Road congestion is different, at least in New Zealand, in that no pricing mechanism is currently used to manage demand. Motorists in New Zealand make no monetary payment for their travel’s contribution to road congestion and there is no clearly defined financial ‘cost’. However the cost to society (including the user) created by use of a congested road is readily discernible in the form of lengthened travel times, while the long term effect of increasing demand on an already congested road could arguably be said to be the cost to the road agency of increasing capacity either by road widening or building new roads in the corridor (and/or by providing subsidised alternatives).

We will update our previous NZ congestion charging analysis, drawing on work by Ian Wallis and David Lupton for the NZTA 'Costs of Congestion Reappraised' study (RR 489, 2012) and the NZTA 'Economic Benefits of Park-and-ride' study (RR 562, 2014) as well as recent international literature. The park-and ride-study developed relatively simple methods to derive the social marginal cost on a road section by using the travel time and the free flow time to calculate the elasticity of speed with respect to traffic density[23]. The general result is that the externality $E = \mu\varepsilon t = \mu\, t_{c\,(}t - t_{f)/(}\, t_{c-}\, t_{f)}$

where t = travel time

t_f = free-flow travel time

tc = travel time when the road is at capacity

ε = travel time elasticity

μ = value of time

This methodology can be used with NZTA data on traffic volumes and speeds collected on major roads to show how the optimum price varies by time of day and location. A second potential source of data is GPS data available through Traffic-Congestion-info. These data sources provide travel data relating to one point or section of the network. Another approach would be to use the work being undertaken by Nokia Mobility Analytics in association with Auckland Transport. This study is based on mobile phone network data and is able to track trips through the entire Auckland network by origin and destination, route, time of day, day of week. By comparing speeds on road sections at different times of the day it is possible to develop a fine-grained map of where congestion is occurring and relate this to the number of vehicles attempting to travel at that time. We will investigate data from each of these sources to see what is the most suitable.

A key variable in the estimation of congestion costs is the value of time[24]. In the economist's definition of the optimum price as $\mu Q dt/dQ$, (t=time, Q=demand) the answer is entirely dependent on the choice of the value of time μ. The problem is estimating its value. While there are many international studies relating to optimum congestion charges, these appear all to have used externally-estimated values based, for example, on average wage rates. Until recently little other data were available. However in theory the value should be the value of time of the marginal driver at that specific place and time, which will be higher where the demand is high relative to the capacity of the road. There are now a number of examples of variable toll systems internationally from which, it is hoped, appropriate relationships can be derived. Singapore uses an approach to setting an optimal toll that is to heuristically change the toll to achieve a target speed under the gantry.

The economist's rule for congestion pricing is to price equal to the externality. This is a short run marginal cost concept – it varies by time of day and its purpose is to ensure that the existing infrastructure is used efficiently. There is a second concept - the long run marginal cost – which is the cost of increasing the capacity of the road by one unit. Road construction involves lumpy investments so this concept has practical issues, but the theoretical result is simple, ie that the optimum network is where the short run and the long run costs are the same. This leads to the rule in an un-tolled network

[23] The Marginal Cost of Traffic Congestion and Road Pricing: Evidence from a Natural Experiment in Beijing. Shanjun Li Avralt-Od Purevjav Jun Yang. Cornell University.

[24] Updated EEM values of time (with/without a specific congestion allowance) are the subject of current research by NZTA, but the new values will not be available in time for DTCC use. We also understand that some recent work for NZTA (by Neil Douglas) examined evidence on values of time for toll road users: this will be investigated further as to its relevance.

to expand capacity if the benefit/cost ratio is greater than 1.0[25] and in a tolled network to expand capacity if the toll revenue exceeds the cost of expansion[26].

In summary, the main outputs of this workstream will be:

(i) total (national) costs of congestion in a similar structure to that adopted in previous work (covering main urban centres, other urban centres for peak and off-peak periods, rural State Highway network); and
(ii) average and marginal costs for the main centres/peak periods (c/vkm and c/pkm)

Three broad areas of work will be involved: i) review of data sources and estimation of the externality expressed in minutes at selected locations and times; ii) developing a methodology and estimating values of time that are consistent with the externality measurement; and iii) review of road construction costs and estimation of long run marginal costs.

[25] ie where the social marginal cost imposed by the marginal vehicle (which by definition is the short run marginal cost) exceeds the cost of expanding the capacity by one vehicle (which is by definition the long run marginal cost)

[26] ie where the toll (which theory says should be set equal to the short run marginal cost) exceeds the cost of expansion (which is by definition the long run marginal cost)

D3. Public Health Impacts

Principal authors: Anja Mizdrak and Ed Randal, University of Otago (Wellington

Wider societal impacts associated with walking and cycling (relative to non-active modes) include positive health impacts as a result of increased physical activity and reduced air pollution. In the NZ context, these outweigh harms associated with small increases in injury risk[1], as well as the costs of infrastructure to encourage active travel[27]. Insufficient physical activity is a key risk factor for non-communicable diseases such as cardiovascular disease and cancers, which dominate health system expenditure in New Zealand. As physical activity is the largest contributor to health gains from increased active transport use, it is important to consider health impacts associated with all conditions related to physical activity in addition to road traffic injury.

The health gains associated with unit increases in walking and cycling can be estimated using proportional multi-state life table (MSLT) methods: MSLT methods are commonly used to estimate the health gains of increasing active transport, and are able to estimate the overall impact of increasing walking and cycling over the life course of the current NZ population. In NZ, these methods have also been used to assess the impact of a wide variety of interventions on health system costs. Adapting MSLT methodologies will provide an opportunity to incorporate health impacts and health system cost impacts into a valuation of the societal impacts associated with active transport modes relative to other transport modes. The MSLT model used includes health benefits to individuals from increasing levels of activity, including coronary heart disease, stroke, type 2 diabetes, and selected cancers. For this project, we also scale the modelled costs associated with different transport modes to cover wider public health impacts of transport that are not included in the model where evidence allows (e.g. through the health impacts associated with mental health).[28]

To produce estimates of the public health costs and benefits associated with walking and cycling, Dr Mizdrak and colleagues will run an established MSLT model with scenarios representing different changes in transport patterns (e.g. small decrease in driving compensated for with an increase in walking, increase in cycling without change in other modes). The model is currently set up to output changes in health (measured in quality-adjusted life years (QALYs) and changes in health system costs.

Using the existing model, we will create a probabilistic sampling framework to ensure that the scenarios capture a broad range of different transport intervention options (e.g. to capture both large and small changes in time or distances travelled for a specific mode). For each scenario, the model will produce estimates of the health gains and health system costs associated with the specific changes in distances travelled in that scenario. By averaging results across the many scenarios, we will be able to establish relative public health costs per kilometer for walking, cycling, and driving (household travel only).[29]

Costs for (pedestrian) walking, cycling, and driving will be used to estimate costs for other modes where there is presently insufficient data to model modes separately (e.g. valuation of public health impacts of e-bikes will draw on estimates of cycling and known differences in energy expenditure between cycling and e-biking). For all modes covered, costs will be separated into direct costs to the health system and indirect costs associated with changes in health status.[30] These costs will be bespoke to the New

[27] Chapman, R., Keall, M., Howden-Chapman, P., Grams, M., Witten, K., Randal, E., & Woodward, A. (2018). A Cost Benefit Analysis of an Active Travel Intervention with Health and Carbon Emission Reduction Benefits. *International Journal of Environmental Research and Public Health, 15*(5), 962.

[28] Health impacts associated with changes in air quality resulting from modal shift are not included here as they are covered in the Emissions work stream.

[29] Health benefits of walking and cycling will be modelled separately and provided as per kilometre benefits for each mode to facilitate comparison and combination with other costs estimated in DTCC. Time estimates of the benefits of each mode can be derived using average speeds for walking or cycling.

[30] Indirect costs are the costs to the individual of the lost (or gained) quality of life, for example lost earnings due to illness.

Zealand context owing to the model being parameterised with NZ specific data (e.g. NZ specific transport patterns, physical activity patterns, and disease rates) and are relative to current transport patterns. We will also estimate the broader social costs (and benefits) associated with the estimated health gains using established New Zealand-specific methods based on the Value of Statistical Life (VoSL). Various methods have been used to value the health benefits associated with an increase in active transport with the VoSL providing the monetary estimate of a year of healthy life. In the New Zealand context, Genter et al (2008) estimated the value of health gains from active transport for the New Zealand Transport Agency for the purpose of updating the Economic Evaluation Manual. We are aware that NZTA is currently undertaking new market research to establish VoSL estimates for the NZ transport sector: we would discuss this work with them, so as to avoid any unnecessary duplication or overlap of effort. Similar methods have also been used to value health benefits of modelled future transport scenarios (Keall et al 2016) and the expected health gains of local active transport interventions (Chapman et al 2018). These reports will provide the starting point for a literature review of methods to estimate the value of a year of healthy life. Details of the methods, along with the monetary values captured and any key limitations of the approach, will be reported. This review will then be used to estimate the current value of a Quality Adjusted Life Year and a per km per person estimate of the relative health value of each mode.

The values will be validated against previous New Zealand and international estimates of the value of benefits gained from increases in walking and cycling to ensure the accuracy and reliability of our approach. We will also examine the sensitivity of costs to factors such as baseline physical activity levels and demographics (age, gender). Where there is substantial variation in per person costs per km based on these factors, we will provide these as supplementary tables in the working paper. We will also present the timeline over which costs are likely to occur – a unique characteristic of this work that would not be possible with other modelling types (e.g. comparative risk assessment methodologies [ref ITHIM]).

Our methodology has several advantages. First, it accounts for the large potential gains from increasing physical activity due to the low current levels of physical activity in NZ (around half of adults failing to meet physical activity recommendations). It also accounts for decreasing marginal returns on increasing physical activity that reflect the dose-response relationship between physical activity and various non-communicable disease outcomes. Our methodology also means that we capture the individual level health impacts in addition to health system impacts of poor health resulting from physical inactivity. We will present the relative size of these two components of the public health costs associated with different modes of transport. Owing to the use of MSLT modelling methodology, we will also be able to present the timeline over which health-related costs are likely to accrue (i.e. 0-10years, 10-20years, lifetime). This would not be possible with simpler modelling methodologies such as comparative risk assessment models that have been used in previous work estimating the health impacts of transport [ref NZ ITHIM work]. Finally, it accounts for small increases in the road injury risk associated with active modes – risks that we will quantify and compare with other experts on the team to ensure that we do not double count/double cost these injury related impacts.

Table D3.1 below provides an overview of the quantitative outputs from this component of the work (all values would be expressed in relative terms). These values relate to travel by the specific modes listed. They may be applied to derive the health benefits of a typical (door-to-door) trip by multiplying and summing the unit rates per kilometre for each mode used.

Table D3.1: Overview of outputs

Mode	Segment	Sub-segment	Coverage (costs provided in 2019NZD unless otherwise specified)
A: Roads (& parking) system	Person	Car/Parking	Per person per km
		Coach	Per person per km (scaled from car)
		PT ride-hail	Per person per km (scaled from car)
		Micro-mobility	Per person per km (scaled from walking and cycling)
		Cycle	Per person per km (e-bike value provided by scaling)
		Walk	Per person per km
	Freight	Truck	N/A
B: Rail system	Person	Long distance	Narrative summary in working paper
		Inter-island	Narrative summary in working paper
	Freight		N/A
C: Sea (domestic freight)	Freight	To be defined	N/A
D: Air (domestic passenger)	Person	To be defined	Narrative summary in working paper
E: Urban public transport	Person	Bus	Per person per km (scaled from car, walking, and cycling)
		Train	Per person per km (scaled from car, walking, and cycling)
		Ferry	N/A

The work will be conducted in several (overlapping) stages:

1) Input to methodology report (i.e. this document)
2) Literature review
3) Model adaptation and methodological development
4) Evaluation of differential impacts
5) Scaling of outputs
    a. For un-modelled modes (where evidence allows)
    b. For un-modelled health impacts (where evidence allows)
6) Draft working paper
7) Peer review of draft paper and finalisation.

Annex D3.A: Structure for each topic area

D3.A1 Coverage of Annex

- Modes/sub-modes/segments or impact areas covered
  Roads
  Rail (brief narrative summary only)
  Air (brief narrative summary only)
  Urban public transport

D3.A2 Scope and Methodology.

Table D3.A1: Scope and methodology	
Topic (brief title/explanation)	**Public health impacts**
Key outputs (include sample tabulations)	Costs associated with public health impacts of different modes (due to health impact and health system cost impacts)
Key inputs	Physical Activity and Active Transport Model (PAATM) developed by Dr Mizdrak and colleagues (model includes data from the Household Travel Survey and Ministry of Health National Collections)
Data sources - specification	No additional data sources required beyond what is currently in the model
Data sources - organisation and/or individual (if known)	No additional data sources required beyond what is currently in the model
Data issues (known or anticipated)	Updates to PAATM health data in progress and anticipated to be completed in August 2020
Proposed analyses (summary or example)	See detailed information provided above
Dependencies on other topics - inputs	We anticipate contact with modal experts will be required for quantifying modes not explicitly included in PAATM (e.g. e-bikes, micro mobility)
Dependencies to other topics - outputs	Need to assess potential under-counting or over-counting where overlap may occur (especially injury, but also possibly emissions)
Risks, uncertainties	We hope to use the updated model version for this work (i.e. with latest available health and health system cost data). This work is being conducted independently (but partially led by Dr Mizdrak).
Other comments and issues	Detailed information on approach provided above.

D4. Local Air Quality and Greenhouse Gas Emissions

Principal author: Gerda Kuschel, Emission Impossible Ltd

D4.1 Coverage of topic

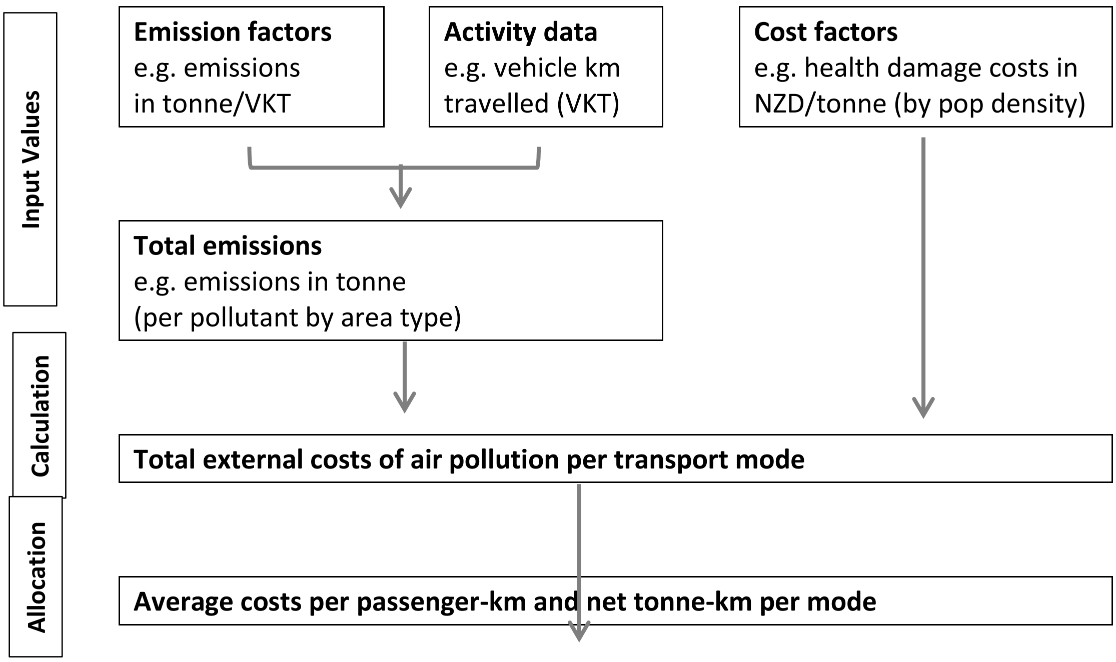
This topic covers the environmental and public health impacts of local air quality and greenhouse gas emissions (**GHG**) for:

i. road transport (including freight but excluding urban bus)
ii. rail (long distance passenger and freight)
iii. domestic air (passenger only)
iv. coastal shipping (freight only)
v. urban public transport (**PT**) (urban bus, urban rail and urban ferry)
vi. walking/cycling (e-bikes)
vii. ride-hailing (as a subset of road transport)
viii. micro-mobility (e-scooters etc.)

D4.2 Scope and Overall Methodology

Total and average costs of air pollution and greenhouse gas (**GHG**) emissions for all modes will be calculated by a bottom up approach (where data availability allows), as shown in Figure D4.1. This proposed approach is consistent with that outlined in the 2019 European Commission *Handbook on External Costs of Transport* [31].

Figure D4.1 Generic methodology for total and average costs for air pollution*



* but similar for GHG emissions

The scope/boundary will be limited to those emissions resulting from the use (only) of the various modes on their typical routes - in other words emissions resulting from the fuel (including electricity used in e-modes), brake and tyre wear, and road abrasion (dust from sealed and unsealed roads).

[31] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Emissions will be reported separately for:

- **harmful** emissions, including particulate matter (**PM_{10}** – smaller than 10 µm), oxides of nitrogen (**NO_X**), carbon monoxide (**CO**), hydrocarbons (**HC**) and sulphur oxides (**SO_X**). These pollutants cause adverse health effects at a local level.
- **greenhouse** gas emissions as carbon dioxide equivalents (**CO_{2-e}**) which act globally.

We will **not** be attempting to estimate the emissions resulting from the '**upstream'** impacts associated with vehicle manufacture etc., or the '**downstream'** emissions associated with vehicle 'end-of-life' disposal (scrappage). We will include a high-level review of well to wheel transport energy costs based on available literature, but a detailed estimate of these costs in the New Zealand context is beyond the scope of the current study. Estimation of the extent of these 'upstream' and 'downstream' emissions would be a very complex exercise due to the data required for the myriad of different vehicles (individual models of car, truck, train, ship etc.) that would need to be covered. It may be possible (and subject to further investigation in the study itself) to derive indicative estimates of these effects based on international research sources.

Emissions resulting from the **construction of transport infrastructure** to support each of the modes **will also be excluded** because these emissions are typically regulated as part of conditions of resource consent and are required to be minimised and/or managed during the construction phase. This exclusion applies not only to emissions to air but also noise, sediment, biodiversity, marine and freshwater impacts.

D4.2.1 Emissions

Estimated emissions from the transport sector are available in the National Air Emissions Inventory[32] for 2015. This national inventory provides estimated emissions of PM_{10}, $PM_{2.5}$ (a subset of PM_{10}), CO, NOx, and SOx for road transport, aviation, domestic shipping and rail. The inventory was prepared using internationally recognised methodologies. Similarly, greenhouse gas emissions estimates for the transport sector are available in the NZ Greenhouse Gas Emissions Inventory[33]. However, both inventories use primarily top-down methods which draw mostly from national-scale data to provide estimated emissions at a national level only.

Where data availability allows, emissions will also be estimated in more detail to enable disaggregation by modal sub-segments (e.g. road trucks vs passenger cars) and by finer spatial resolution (e.g. major urban areas and rural settlements). The development of detailed emission estimates will build on the National Air Emissions Inventory and will be undertaken using internationally recognised methodologies. The methods were reviewed in some detail for the Ministry of Transport (**MoT**) in a 2011 review of information gaps for aviation[34] and maritime[35] emissions.

Emissions resulting from use of electric modes of transport will be estimated from the NZ Greenhouse Gas Emissions Inventory figures for CO_{2-e} emissions per kWh of electricity combined with typically running times and battery capacities of these vehicles.

Much of the activity data required to undertake the emissions calculations (such as VKT, aircraft takeoff and landings etc.) will be provided by the modal experts on the project team (see next section by mode for details).

[32] Metcalfe J & Sridhar S (2018). *National Air Emissions Inventory 2015*. Report prepared for Ministry for the Environment by Emission Impossible Ltd.

33 MfE (2019). *New Zealand's Greenhouse Gas Inventory 1990-2017*. Ministry for the Environment, Wellington

[34] Metcalfe JL & Sridhar S (2011*). Transport Monitoring Information Framework Aviation Emission Data Gaps*. Report prepared for Ministry of Transport, June.

[35] Metcalfe JL & Sridhar S (2011*). Transport Monitoring Information Framework Maritime Emission Data Gaps*. Report prepared for Ministry of Transport, June.

D4.2.2 Damage unit costs

Damage costs are a way to value changes in air emissions in order to compare the benefits to society of a change in policy/operation versus the cost of implementing the change. They can also be used to compare a range of options to see which will yield the best overall outcome. Most government agencies internationally[36] publish relevant values to be used in the assessment of costs and benefits of various policy options in their jurisdictions.

Damage costs for PM_{10}, NOx, CO and HC are published by NZ Transport Agency for use in project evaluations[37]. These were developed by Emission Impossible Ltd based on the results of the 2012 Health and Air Pollution in New Zealand study (**HAPINZ**)[38]- denoted HAPINZ 2.0.

The HAPINZ study is currently being updated and, amongst other things, will produce a suite of damage costs for NZ for key air pollutants. Damage costs will be developed for areas by population density and are intended to align with the Statistics NZ Urban Rural classification[39]. Emission Impossible Ltd (**EIL**) is leading the HAPINZ 3.0 team[40] and the models and reports are expected to be finalised by late 2020. MoT is a stakeholder and a member of the steering committee. The DTCC study will run in parallel with the HAPINZ update to avoid duplication of effort and to ensure that the findings and recommendations are consistent.

In the event that the HAPINZ 3.0 results are not available in time, the outputs will allow for the new values to be processed when they are available. If this is the case, we will recommend updated damage costs for this study based on a review of recent literature. This alternative review would consider some key issues, including: (i) whether damage costs should be based on Value of Statistical Life (**VoSL**) or the Value of a life year lost (**VoLY**), or both; (ii) development of sector specific (transport) damage costs; and (iii) adjustment of damage costs according to population density.

We understand that recommended damage costs for greenhouse gas emissions are not expected to be addressed in the study, as they will be provided on a cross-government basis: it may be appropriate to apply these unit costs in the study, to provide a full picture of transport's environmental costs.

D4.2.3 Calculation of air pollution costs

Emission quantities will be multiplied by the costs per tonne to provide estimated costs at the level of segmentation and disaggregation that is required. Information will be obtained on consultation with modal experts to enable outputs by passenger-km (**PK**) and by net tonne-km (**NTK**).

Sensitivity analyses for key variables will be undertaken.

D4.3 Detailed Methodology by Mode

The emission factors and activity data used will vary depending on the mode as shown in the following tables. In some instances, data are only available top down so information will need to be disaggregated spatially.

[36] UK Defra (2019). *Air Quality damage cost update 2019.* Report prepared by Ricardo-AEA Ltd for UK Department for Environment Food and Rural Affairs, February.
[37] Appendix 9 of *The New Zealand Transport Agency's Economic evaluation manual*. First Edition, Amendment 2. Effective from July 2018. Downloaded from: https://www.nzta.govt.nz/assets/resources/economic-evaluation-manual/economic-evaluation-manual/docs/eem-manual.pdf
[38] Kuschel et al (2012). *Updated Health and Air Pollution in New Zealand Study*. Prepared by Emission Impossible and others for Health Research Council of New Zealand, Ministry of Transport, Ministry for the Environment and NZ Transport Agency, March.
[39] StatsNZ (2018). *Statistical standard for geographic areas 2018*. Statistics NZ, Downloaded from http://archive.stats.govt.nz/methods/classifications-and-standards/classification-related-stats-standards/geographic-areas/pg2.aspx
[40] In addition to EIL staff, the HAPINZ 3.0 team includes Dr Simon Hales (University of Otago), Dr Alistair Woodward (University of Auckland), Kylie Mason (Massey University), Dr Tim Denne (Resource Economics), Keith Hastings (Jacobs NZ), Dr Perry Davy (GNS Science), and Dr Jess Berentson-Shaw (The Workshop).

Table D4.1: Scope and methodology – by topic: Road transport

Topic	Road transport (excluding Urban Bus)
Key outputs	**Emissions** • Total tonnes emitted from road transport nationally and by urban-rural area types (see example table 1) • Relative emission rates by different vehicle types for urban VKT (see example table 2) • Costs • Summary of health costs from road transport by VKT (see example table 3) • Total health costs from road transport by vehicle type (see example table 4)
Key inputs	**Transport data** • Road transport fleet profile (by VKT) by vehicle type, fuel type and gross vehicle weight (as per the categories in example table 2) • Typical running times and average battery capacities for electric vehicles • Annual road transport fuel consumption • Freight tonnes carried for each HCV size category (as per the categories in example table 2) • Vehicle occupancy data **Emission factors** • NZTA Vehicle Emission Prediction Model (**VEPM**) for bottom up estimation of exhaust emissions and brake/tyre wear (largely based on COPERT emission factors)[41] • NZTA National Vehicle Emissions Database (**NVED**) emission tool[42] for apportioning emissions spatially • EMEP/EEA methodology for bottom up estimation of emissions from sealed road abrasion[43] • USEPA methodology for bottom up estimation of unsealed road abrasion[44] but NZTA review pending • MfE GHG Inventory for CO_{2-e} emissions per kWh electricity and for liquid transport fuels[45] as a cross check **Damage costs** • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[46]
Data sources - specification	Covered in the previous section under 'Key inputs'
Data sources - organisation	• MoT for fleet profile by VKT (already have data for years to end 2017) • EECA for electric vehicle battery/running information • Road Transport Forum for road freight data • NZTA for access to VEPM and NVED (publically available or already granted) • EMEP/EEA for sealed road dust method (publically available)

[41] NZTA (2019). *Vehicle Emission Prediction Model, version 6.0.* NZ Transport Agency. Downloaded from https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/air-quality-climate/planning-and-assessment/vehicle-emissions-prediction-model/

[42] Currently being finalised

[43] EMEP/EEA (2016). *Air pollution emission inventory guidebook - 2016.* European Environment Agency Report No 21/2016.

[44] US EPA (2006). *AP42 Miscellaneous Sources, Unpaved Roads (section 13.2.2).* Office of Air Quality Planning & Standards, US Environmental Protection Agency, 2016.

45 MfE (2019). *New Zealand's Greenhouse Gas Inventory 1990-2017*. Ministry for the Environment, Wellington

[46] Currently underway

	• MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)
Data issues	The USEPA (2006) methodology for estimating emissions from unsealed road abrasion recommended in the MfE National Air Emissions Inventory 2015 is yet to be endorsed by NZTA. We understand that NZTA is researching alternatives so we recommend leaving space in the emissions workbooks for confirmation/inclusion at later date. Regardless, the emissions and subsequent effects (given these roads are typically in rural/low population density areas) are likely to be minimal relative to the other road transport sources. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in D4.1 for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[47].
Dependencies on other topics - inputs	We will liaise closely with the modal experts for roading system, long-distance coaches and urban PT to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need. Data on road freight volumes and vehicle occupancy are likely to be needed by all.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key **risks** are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless, we will flag in the working paper any pending datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of **uncertainty**. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	Total road transport emissions will be estimated and then urban bus emissions will be subtracted to enable overall urban PT emissions to be calculated separately (topic A1.5). Results from this topic area will also feed into the analyses being undertaken on the effects of: • different modes, such as Walk/Cycle (topic A1.6), Ride-Hailing (topic 1.7), and Micro-Mobility (topic A1.8) and • congestion.

[47] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Example Table D4.1: Local air quality emissions and damage costs from road transport by StatsNZ urban rural classification (as at 2018)

Urban rural classification	Emissions, tonnes/yr							Damage costs, $
	CO	VOC	NO_X	SO_2	PM_{10} exhaust	PM brake & tyre	PM road dust	
National								
Major urban areas (7))								
Auckland								
Hamilton								
Tauranga								
etc.								
Large urban areas (13)								
Whangarei								
Hibiscus Coast								
Rotorua								
etc.								
Medium urban areas (22)								
* But reported as a total only								
Small urban areas (136)								
* But reported as a total only								
Rural settlements (400)								
* But reported as a total only								

Example Table D4.2: Relative emission rates and damage costs from road transport by vehicle type (as at 2018)

Vehicle type	Relative emission rates, g/km							Damage costs, $
	CO	VOC	NO_X	SO_2	PM_{10} exhaust	PM brake & tyre	PM road dust	
Fleet weighted average								
Light passenger car <3.5t								
Petrol								
Diesel								
Hybrid								
Electric								
Light commercial vehicle <3.5t								
Petrol								
Diesel								
Hybrid								
Electric								

Vehicle type	Relative emission rates, g/km							Damage costs, $
	CO	VOC	NO_X	SO_2	PM_{10} exhaust	PM brake & tyre	PM road dust	
Heavy commercial vehicle								
Diesel 3.5-7.5t								
Diesel 7.5-10t								
Diesel 10-20t								
Diesel 20-25t								
Diesel >30t								
Electric <10t								
Electric >10t								
Buses (excl urban PT)								
Diesel >3.5t								
Electric >3.5t								

Example Table D4 3: Environmental costs - road transport (as at 2018)

Impact	Total costs, $M/year	Average cost, cents/VKT		Marginal cost, cents/VKT	
		Urban VKT	National VKT	Urban VKT	National VKT
Local Air Quality	442	Fleet: 2.7 Car, petrol:0.2-0.7 HCV diesel: 14.9-40.3	Fleet: 1.1	Fleet: 2.7 Car, petrol : 0.2-0.7 HCV, diesel: 14.9-40.3	Fleet: 1.1
Greenhouse Gas	317	As National	Fleet: 0.8 Car: 0.6 Truck/bus:1.9	As National	Fleet: 0.8 Car: 0.6 Truck/bus:1.9
Totals (fleet)	**1,174**	**6.0**	**3.0**	**4.1**	**2.2**

Example Table D4.4: Total road costs by vehicle type ($Mpa) - light versus heavy duty (as at 2018)

Vehicle group (and % urban VKT)	Air	GHG	Totals
Light duty (96%)	245	263	867
Heavy duty (4%)	197	54	307
Totals	**442**	**317**	**1,174**

Table D4.2: Scope and methodology – by topic: Rail	
Topic	**Rail (Long Distance and Freight)** Note: Urban rail is covered in Table A1.5
Key outputs	**Emissions** • Total tonnes emitted from rail nationally and *possibly* by urban-rural area types • Relative emission rates for long distance and freight rail transport by PK and NTK **Costs** • Summary of health costs from rail by PK and NTK (see example table 5) • Total health costs from rail by locomotive type
Key inputs	**Transport data** • Rail fleet profile by fuel type (including electric trains) and motive power rating • Annual rail transport fuel and electricity consumption • Freight tonnes carried, passenger numbers, distances traveled, hours of operation, loading and nominal power output by different locomotive types **Emission factors** • EMEP/EEA methodology for bottom up estimation of rail emissions if data available[48] (a top-down method is also available) • MfE GHG Inventory for $CO_{2\text{-}e}$ emissions per kWh electricity and for liquid transport fuels[49] as a cross check **Damage costs** • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[50]
Data sources - specification	**Covered in the previous section above**
Data sources - organisation	• KiwiRail for rail data covering fleet profile and the usage • Dunedin Railways for local tourist rail information (if appropriate) • EMEP/EEA for rail emissions method (publically available) • MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)
Data issues	The extent of disaggregation possible for rail emissions is heavily dependent on the resolution of the base data (eg. breakdown by locomotive type). We will aim for bottom up but may have to settle for top-down or a hybrid approach. Some level of spatial disaggregation will be possible at the very least from the geographical extent of the rail network. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in D4.1 for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[51].

[48] EMEP/EEA (2019). *Air pollution emission inventory guidebook - 2019. Chapter 1.A.3.c Railways.* European Environment Agency, 2019.

49 MfE (2019). *New Zealand's Greenhouse Gas Inventory 1990-2017*. Ministry for the Environment, Wellington

[50] Currently underway

[51] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Table D4.2: Scope and methodology – by topic: Rail	
Dependencies on other topics - inputs	We will liaise closely with the modal experts for rail to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need. Data on rail freight volumes and passenger numbers are likely to be needed by all.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key risks are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless we will flag in the working paper any pending datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of uncertainty. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	None

Example Table D4.5: Local air pollution costs - long distance rail (as at 2018)

Rail mode	Total costs, $M/year	Average cost, Cents/PK	Average cost, Cents/VKT
Passenger train - electric			
Passenger train - diesel			
Rail mode	**Total costs, $M/year**	**Average cost, Cents/NTK**	**Average cost, Cents/VKT**
Freight train -electric			
Freight train - diesel			

Table D4.3: Scope and methodology – by topic: Aviation	
Topic	**Aviation (Domestic Passenger only)**
Key outputs	**Emissions** • Total tonnes emitted from domestic passenger aviation nationally and for selected urban areas with domestic airports **Costs** • Summary of health costs from aviation by PK and VKT
Key inputs	**Transport data** • Aircraft type and movements (takeoff and landing cycles) for all major airports (if not available, could pro-rate based on existing data for Auckland airport from the 2015 National Air Emissions Inventory[52]) • Annual domestic aviation fuel consumption • Passenger numbers and distances traveled by different aircraft types

[52] Metcalfe J & Sridhar S (2018). *National Air Emissions Inventory 2015*. Report prepared for Ministry for the Environment by Emission Impossible Ltd.

Table D4.3: Scope and methodology – by topic: Aviation	
	Emission factors • EMEP/EEA methodology for bottom up estimation of aviation emissions if data available[53] (a top-down method is also available) • MfE GHG Inventory for $CO_{2\text{-}e}$ emissions for liquid transport fuels[54] as a cross check **Damage costs** • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[55]
Data sources - specification	Covered in the previous section
Data sources - organisation	• NZ Airports Association for annual domestic aviation movements, passenger numbers and routes by major airport • Individual airports for annual domestic aviation movements, passenger numbers and routes • EMEP/EEA for aviation emissions method (publically available) • MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)
Data issues	The extent of disaggregation possible for aviation emissions is heavily dependent on the resolution of the base data. We will aim for bottom up but may have to settle for top-down or a hybrid approach. Some level of spatial disaggregation will be possible at the very least from the geographical locations of the airports. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in **Figure A1.1** for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[56].
Dependencies on other topics - inputs	We will liaise closely with the modal experts for aviation to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need. Data on aircraft movements and passenger numbers are likely to be needed by all.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key **risks** are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless we will flag in the working paper any pending datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of **uncertainty**. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best

[53] EMEP/EEA (2019). *Air pollution emission inventory guidebook - 2019. Chapter 1.A.3.a, 1.A.5.b Aviation.* European Environment Agency, 2019.

54 MfE (2019). *New Zealand's Greenhouse Gas Inventory 1990-2017*. Ministry for the Environment, Wellington

[55] Currently underway

[56] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Table D4.3: Scope and methodology – by topic: Aviation	
	estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	None

Table D4.4: Scope and methodology – by topic: Coastal Shipping	
Topic	**Coastal Shipping (Freight only)** Note: Passenger ferry is covered in Table D4.5
Key outputs	**Emissions** • Total tonnes emitted from coastal shipping nationally and for selected urban areas with seaports **Costs** • Summary of health costs from coastal shipping by NTK and VKT
Key inputs	**Transport data** • Vessel types, gross tonnages and main engine power • Visits by vessel types for all major seaports (if not available could pro-rate based on existing data for Ports of Auckland from 2016 Auckland Air Emissions Inventory[57]) • Annual coastal shipping fuel consumption • Freight volumes and distances traveled by different vessel types **Emission factors** • EMEP/EEA methodology for bottom up estimation of shipping emissions if data available[58] (a top-down method is also available) • MfE GHG Inventory for $CO_{2\text{-}e}$ emissions for liquid transport fuels[59] as a cross check **Damage costs** • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[60]
Data sources - specification	Covered in the previous section
Data sources - organisation	• NZ Shipping Federation for annual coastal shipping movements, freight volumes and routes by major seaport • Individual port companies for annual coastal shipping movements, freight volumes and routes • EMEP/EEA for shipping emissions method (publically available) • MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)
Data issues	The extent of disaggregation possible for coastal shipping emissions is heavily dependent on the resolution of the base data. We will aim for bottom up but may have to settle for

[57] Peeters S (2018). *Auckland Air Emissions Inventory 2016 - Sea Transport*. Technical report 2018/017 prepared for Auckland Council, July.

[58] EMEP/EEA (2019). *Air pollution emission inventory guidebook - 2019. Chapters 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii International maritime and inland navigation, national navigation, national fishing, recreational boats.* European Environment Agency, 2019.

59 MfE (2019). *New Zealand's Greenhouse Gas Inventory 1990-2017*. Ministry for the Environment, Wellington

[60] Currently underway

Table D4.4: Scope and methodology – by topic: Coastal Shipping	
	top-down or a hybrid approach. Some level of spatial disaggregation will be possible at the very least from the geographical locations of the seaports. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in D4.1 for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[61].
Dependencies on other topics - inputs	We will liaise closely with the modal experts for coastal shipping to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need. Data on vessel movements and freight volumes are likely to be needed by all.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key **risks** are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless we will flag in the working paper any pending datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of **uncertainty**. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	None

Table D4.5: Scope and methodology – by topic: Urban PT	
Topic	**Urban PT (Urban Bus, Rail and Ferry)**
Key outputs	**Emissions** • Total tonnes emitted from Urban PT nationally and for selected urban areas • Relative emission rates by different Urban PT types for urban VKT **Costs** • Summary of health costs from Urban PT nationally and for selected urban areas • Total health costs from Urban PT by PK and VKT
Key inputs	**Transport data** • Urban bus fleet profiles for major urban areas by bus type, fuel type, gross vehicle weight, max pax and typical passenger loading • Urban rail fleet profiles for Auckland and Wellington by locomotive type, fuel type, gross vehicle weight, max pax and typical passenger loading • Urban bus and rail annual travel and average speeds

[61] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Table D4.5: Scope and methodology – by topic: Urban PT	
	• Urban ferry fleet profiles for major urban areas by vessel type, gross vehicle tonnage, main engine power and typical passenger loading • Urban ferry annual travel • Annual public transport fuel and electricity consumption **Emission factors** • Various regional models developed for assessing urban bus fleet exhaust emissions and brake/tyre wear (largely based on COPERT emission factors)[62] • EMEP/EEA methodology for bottom up estimation of emissions from sealed road abrasion[63] • EMEP/EEA methodology for bottom up estimation of urban rail emissions if data available[64] (a top-down method is also available) • EMEP/EEA methodology for bottom up estimation of urban ferry emissions if data available[65] (a top-down method is also available) • MfE GHG Inventory for CO_{2-e} emissions per kWh electricity and for liquid transport fuels[66] as a cross check **Damage costs** • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[67]
Data sources - specification	Covered in the previous section
Data sources - organisation	• Relevant regional councils for urban PT fleet profiles for all modes, annual VKT, average route speed (where relevant), and passenger numbers • EMEP/EEA various methods (publically available) • MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)
Data issues	The extent of disaggregation possible for urban PT emissions is heavily dependent on the resolution of the base data. We will aim for bottom up but may have to settle for top-down or a hybrid approach. Some level of spatial disaggregation will be possible at the very least for Auckland and Wellington, with results pro-rated to other urban areas if possible. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in D4.1 for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[68].

[62] EIL has undertaken detailed assessments of different bus fleets previously for Greater Wellington, Environment Canterbury, Auckland Transport and Otago Regional Council.

[63] EMEP/EEA (2016). *Air pollution emission inventory guidebook - 2016.* European Environment Agency Report No 21/2016.

[64] EMEP/EEA (2019). *Air pollution emission inventory guidebook - 2019. Chapter 1.A.3.c Railways.* European Environment Agency, 2019.

[65] EMEP/EEA (2019). *Air pollution emission inventory guidebook - 2019. Chapters 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii International maritime and inland navigation, national navigation, national fishing, recreational boats.* European Environment Agency, 2019.

66 MfE (2019). *New Zealand's Greenhouse Gas Inventory 1990-2017.* Ministry for the Environment, Wellington

[67] Currently underway

[68] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Table D4.5: Scope and methodology – by topic: Urban PT	
Dependencies on other topics - inputs	We will liaise closely with the modal experts for urban PT to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need. Data on road freight volumes and vehicle occupancy are likely to be needed by all.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key **risks** are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless we will flag in the working paper any pending datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of **uncertainty**. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	Urban bus emissions will be **in addition** to the road transport emissions (estimated in topic D4.1).

Table D4.6: Scope and methodology – by topic: Walk/Cycle	
Topic	**Walk/Cycle (including e-Bikes)**
Key outputs	**Emissions** • Relative emission rates/savings by walking, cycling and e-cycling for urban areas **Costs** • Summary of health costs/benefits from walking, cycling and e-cycling across NZ
Key inputs	**Transport data** • Typical trip lengths for active modes and annual trip replacements (percentage of overall trips not taken by car etc.) • Typical vehicle occupancy rates • Typical running times and average battery capacities for e-bikes **Emission factors** • Same as in topic area A1.1 **Damage costs** • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[69]
Data sources - specification	Covered in the previous section
Data sources - organisation	• Relevant regional councils for surveys of active mode travel • Regional or national e-bike sales data plus indications of typical running times/battery capacities • MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)

[69] Currently underway

Table D4.6: Scope and methodology – by topic: Walk/Cycle	
Data issues	The extent of disaggregation possible for walking/cycling is heavily dependent on the resolution of the base data. We will aim for bottom up but may have to settle for top-down or a hybrid approach. Some level of spatial disaggregation may be possible for major urban areas, with results pro-rated to other urban areas as appropriate. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in D4.1 for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[70]. The analysis will likely be indicative rather than definitive. We will endeavor to develop equivalency factors for a typical trip via active modes versus a typical trip by car.
Dependencies on other topics - inputs	We will liaise closely with the modal experts for walking/cycling to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key risks are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless we will flag in the working paper any pending datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of uncertainty. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	None

Table D4.7: Scope and methodology – by topic: Ride Hailing	
Topic	**Ride-Hailing**
Key outputs	**Emissions** • Typical emission rates for ride-hailing vehicles in urban areas **Costs** • Summary of health costs from ride-hailing vehicles across NZ
Key inputs	**Transport data** • Typical specifications or fleet details for vehicles from major ride-hailing operators • Number of trips and average distance travelled by urban area • Typical vehicle occupancy rates **Emission factors** • Same as in topic area A1.1

[70] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Table D4.7: Scope and methodology – by topic: Ride Hailing	
	Damage costs • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[71]
Data sources - specification	Covered in the previous section
Data sources - organisation	• Major ride-hailing companies (eg, Uber, Ola, Zoomy etc) for trip and fleet data • NZTA for access to VEPM (publically available or already granted) • EMEP/EEA for sealed road dust method (publically available) • MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)
Data issues	The extent of disaggregation possible for ride-hailing is heavily dependent on the resolution of the base data. We will aim for bottom up but may have to settle for top-down or a hybrid approach. Some level of spatial disaggregation will be possible for major urban areas but operators do not operate everywhere in NZ. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in D4.1 for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[72]. The analysis will likely be indicative rather than definitive. We will endeavor to develop equivalency factors for a typical trip via ride-hailing modes versus a typical trip by car.
Dependencies on other topics - inputs	We will liaise closely with the modal experts for ride-hailing to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key risks are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless we will flag in the working paper any pending datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of uncertainty. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	The ride-hailing results will be a subset of the road transport results (topic area A1.1).

[71] Currently underway

[72] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Table D4.8: Scope and methodology – by topic: Micro-Mobility	
Topic	**Micro-mobility (including e-Scooters)**
Key outputs	**Emissions** • Relative emission rates for typical micro vehicles in urban areas **Costs** • Summary of health costs from micro vehicles across NZ
Key inputs	**Transport data** • Typical trip lengths for micro modes and annual trip replacements (percentage of overall trips not taken by car etc.) • Typical running times and average battery capacities for e-micro **Emission factors** • Same as in topic area A1.1 **Damage costs** • Health and Air Pollution in New Zealand (**HAPINZ**) 3.0 study[73]
Data sources - specification	Covered in the previous section
Data sources - organisation	• Major e-scooter rental companies (eg, Lime, Flamingo, Jump etc) for trip and fleet data • Regional or national e-micro vehicle sales data • MfE for GHG information (emission factors available for years to end 2019 , results available for years to end 2016) • HAPINZ 3.0 for access to NZ specific damage costs (already granted if available in time)
Data issues	The extent of disaggregation possible for micro-mobility is heavily dependent on the resolution of the base data. We will aim for bottom up but may have to settle for top-down or a hybrid approach. Some level of spatial disaggregation may be possible for major urban areas, with results pro-rated to other urban areas as appropriate. The HAPINZ 3.0 project is underway but final damage costs may not be available until end 2020. However, draft values should be available in time for preparing the draft working papers. Final values will be available in time for the final DTCC report.
Proposed analyses	Total and average costs of air pollution and GHG emissions will be calculated by a bottom up approach (where data availability allows) as shown earlier in D4.1 for all modes in accordance with method outlined in the 2019 European Commission *Handbook on External Costs of Transport*[74]. The analysis will likely be indicative rather than definitive. We will endeavor to develop equivalency factors for a typical trip via micro mobility versus a typical trip by car.
Dependencies on other topics - inputs	We will liaise closely with the modal experts for walking/cycling to ensure we are all using the same base datasets. We will liaise with the DTCC team to ensure that all data requests to third parties cover any data we might specifically need.
Dependencies to other topics - outputs	None
Risks, uncertainties	The key **risks** are associated with getting the most up to date information in time to deliver against the project timeline. In all cases we have a Plan B should our preferred option not be available in time. Regardless we will flag in the working paper any pending

[73] Currently underway

[74] Essen et al (2019). *Handbook on the external costs of transport, Version 2019.* Report prepared for European Commission, Directorate-General for Mobility and Transport, January.

Table D4.8: Scope and methodology – by topic: Micro-Mobility	
	datasets we are aware of that could be incorporated in future updates of the DTCC results. Modelling always includes a degree of **uncertainty**. We will highlight clearly the likely uncertainty in any of the parameters we employ and also present our best estimate with a range of likely upper and lower bounds to enable users to analyse the sensitivity of any parameter.
Other comments and issues	None

D5. Environmental - Noise

Principal Author: Michael Smith, Altissimo Consulting Ltd
Discipline lead: Dr Stephen Chiles, Chiles Ltd

D5.1 Introduction

Long-term exposure to transportation noise can have detrimental effects on human health, amenity, and productivity. These effects have costs which are borne by the individual, the health system and the broader economy. The purpose of this study is to estimate the total cost of this noise exposure for different transport modes.

Previous attempts to quantify the noise cost of surface transport have been limited primarily to road traffic from the state highway network. The 2015 STCC study[75] used broad approximations of exposure rather than undertaking noise modelling. That study used a hedonic approach for costing noise exposure.

Nationwide noise mapping is beyond the scope of this study, however we will use recent work by the Transport Agency which modelled exposure from road-traffic noise on all state highways and major arterial roads. Methods will be developed to approximate sound levels at residences from rail, domestic air and coastal shipping from currently available movement data.

Monetisation methods will be reviewed, prioritising those directly addressing health effects.

Vibration effects are generally limited to people living adjacent to rail, and roads in poor condition. Such properties are also subject to high noise levels adverse health effects would be largely overlapping. Given this, we do not propose to undertake any separate assessment of vibration issues and costs.

The proposed assessment process for this study is shown in Figure D5.1.

D5.2 Exposure modelling

D5.2.1 Introduction

Large scale strategic noise mapping is common overseas (particularly Europe) for informing policy and quantifying health effects. While a nationwide noise model is not being established for this project, determining noise exposure is still the most significant part of this current study.

- The choice of exposure modelling method should consider the following
- Simple / affordable
- Transparent inputs and methodology
- Able to be applied consistent across the country
- Repeatable, with updated data in the future with updated movement data, or new routes
- Allow estimation of sound levels at individual dwellings in 5 dB bands

[75] Ministry of Transport (2005), Surface Transport Costs and Charges: Main Report, prepared by Booz Allen Hamilton with the Institute for Transport Studies, University of Leeds, and associated consultants, Wellington.

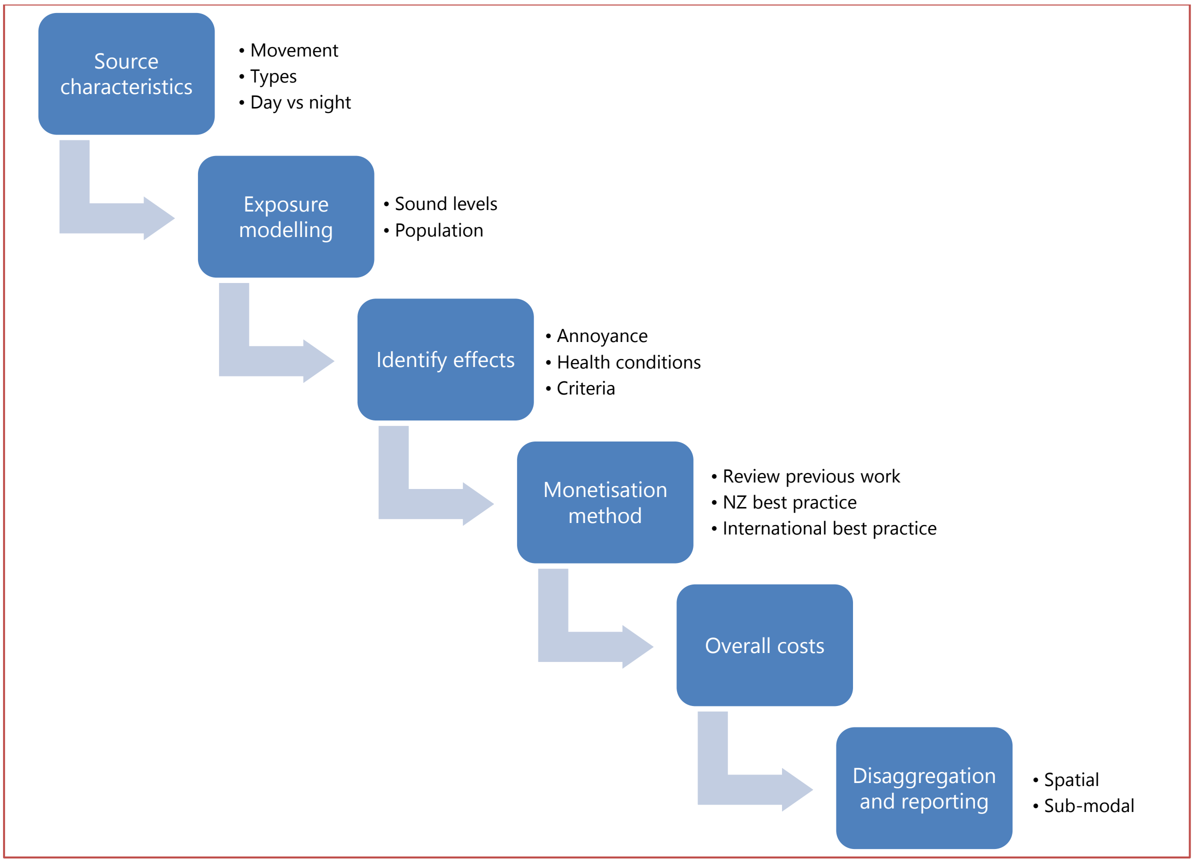


Figure D5.1: Assessment process

Only existing operational networks will be considered and not future planned or under construction alterations.

Noise exposure is assessed at the outside of residential dwellings and is expressed in decibels (dB). Values may be expressed as a daily average ($L_{Aeq(24h)}$) or as a day-night level (L_{dn}) where a penalty is included for the night-time period.

There is not a public dataset for residential dwellings. The LINZ building dataset includes commercial buildings and ancillary buildings (e.g. garages). We will use the dwelling dataset from the 2019 Project Report (see Section 2.2). The number of people per building will be taken from census data apportioned equally across all dwellings in a meshblock.

The exposure modelling methodology will be fully detailed in the Working Paper. All relevant spreadsheets / files will also be provided to assist with periodic updating of results.

D5.2.2 Road

The Transport Agency undertook noise mapping in 2019 for the state highway network and arterial / collector roads (by ORNC). Our methodology assumes that this complete dataset can be made available for the current study. Noise contours were produced in 1 dB increments along with a dataset of buildings (that are assumed to be residential). These will be used to estimate the number of people exposed to different bands of road-traffic noise.

We will review the available data with aim of establishing the range of received sound levels. Further noise mapping will not be undertaken but simple GIS queries may be used to aggregate available data with other modes if required. Noise from minor roads not modelled by the Transport Agency will not be included in this study.

Table D5.1: Scope and methodology – by topic: Road transport

Topic	Road transport
Key outputs	**Noise exposure** Predicted sound levels in 5 dB bands at all dwellings, summarised nationally, regionally, and by urban-rural area types **Costs** Summary of indicative health costs from road transport by VKT Total health costs from road transport by vehicle type
Key inputs	Sound level at individual houses from 2019 NZTA/AECOM Transport study either in GIS or spreadsheet with full attributes (NZTA) Centrelines for roads including ORNC definition (NZTA) Hourly traffic counts by vehicle class at a number of locations (NZTA) Urban / rural boundaries (LINZ/Stats) Population data (Stats NZ)
Data sources - specification	Covered in the previous section under 'Key inputs'
Data sources - organisation	Covered in the previous section under 'Key inputs'
Data issues	Potential delay in obtaining data from Transport Agency
Proposed analyses	No new noise predictions will be done as part of this study, but conversion to other metrics may occur to compare with criteria. Indicative breakdown between cars and heavy vehicles to be compared for different road classes
Dependencies on other topics - inputs	No specific dependencies

D5.2.3 Rail

Movement data will be determined by reviewing the KiwiRail schedules for freight and passenger movements. This will include estimating the number of day and night movements.

Where the building dataset from the road model (extending approximately 600m from all road centrelines) does not provide the necessary coverage for buildings by rail, we will adopt a similar methodology for receiver identification, noting improved coverage of the LINZ building outline dataset since the 2019 road noise mapping.

Noise from key marshalling yards will be considered as part of this study, with noise emissions attributed equally between all rail movements on that line. Noise from maintenance, private rail sidings and container handling storage facilities will not be addressed. In addition, the use of horns at level crossings will not be included in this study.

The sound level at houses will be estimated based on the distance from the rail calculated using GIS. The noise level will be calculated as an L_{dn} level using the assumed number of movements and day/night split.

Table D5.2: Scope and methodology – by topic: Rail transport

Topic	Rail transport
Key outputs	**Noise exposure** Predicted sound levels in 5 dB bands at all dwellings, summarised nationally, regionally, and by urban-rural area types **Costs** Summary of indicative health costs from rail transport by tonne / km Total indicative health costs from road transport by vehicle type
Key inputs	Rail geometry (KiwiRail - obtained) Rail speeds (KiwiRail via Modal Expert) Freight and passenger schedules (KiwiRail via Modal Expert) Dwelling locations (NZTA model / LINZ) Population data (Stats NZ)
Data sources - specification	Covered in the previous section under 'Key inputs'
Data sources - organisation	Covered in the previous section under 'Key inputs'
Data issues	Movement data is not directly available in terms of the number of movements per day for each section of track. It will be derived from the KiwiRail timetables. This will be confirmed against tonnage between destinations.
Proposed analyses	Predict sound levels at each dwelling based on distance from rail, and number of train movements / speed on the section of track.
Dependencies on other topics - inputs	Schedules and bulk quantities from modal expert

D5.2.4 Aircraft

Noise modelling has been performed for most major airports in New Zealand primarily by their respective operating companies. Modelling is used both for controlling the effects of airport activities on neighbours, as well as land use controls to prevent the encroachment of new residential neighbours.

Noise contours often exist in the form of a 55 L_{dn} 'Outer Control Boundary" as defined in New Zealand Standard NZS 6805, and are generally published in Resource Management Act district plans. The published contours are for future noise exposure (typically at least 10 years ahead) allowing for growth at the airport.

For international airports, we will obtain these contours where practical and use this data to estimate the current aircraft noise exposure, correcting for differences in movement numbers. The boundaries will be interpolated using simple GIS routines and queries as necessary to estimate the range of exposure levels, including to lower sound levels (45 dB L_{dn}) as aircraft noise effects extend beyond the published contours.

For other airports, we will obtain domestic passenger movement data in terms of number of turboprop and A320 movements per day from Airways (or from the modal expert). Freight movement data is also required. We will develop a simple GIS model developed using the runway alignment and basic aircraft performance data to estimate the domestic exposure based on this movement data. This modelling approach will be evaluated for accuracy against published contours for a small airport.

The incremental exposure of domestic aircraft movements over international aircraft will be determined.

Table D5.3 Scope and methodology – by topic: Air transport

Topic	Air transport
Key outputs	**Noise exposure** Predicted sound levels in 5 dB bands for international and domestic aircraft Increase in sound level due to domestic aircraft **Costs** Summary of indicative health costs from aviation Total indicative costs from air transport by passenger / freight
Key inputs	Noise contours from airports / district plans Domestic passenger / freight movements by airport (Modal Expert) Dwelling locations (NZTA/LINZ) Population data (StatsNZ)
Data sources - specification	Covered in the previous section under 'Key inputs'
Data sources - organisation	Covered in the previous section under 'Key inputs'
Data issues	
Proposed analyses	Interpolate published contours to determine exposure Apply geometric model to estimate exposure from domestic movements Calculate incremental exposure from domestic aircraft over international aircraft
Dependencies on other topics - inputs	Movement data from modal expert

D5.2.5 Coastal shipping

Similar to airports, seaports also often have an Outer Control Boundary at 55 dB L_{dn} which is used for emissions control and land-use planning. Sound levels for dwellings will be determined by interpolating the published noise contours where available.

Domestic freight will be estimated by apportioning received sound levels, based on tonnage or number of containers. The majority of domestic container transport occurs on international ships. Significant domestic-only services are petroleum from Marsden Point to regional pots, and cement to Holcim's terminals in Auckland and Timaru.

Ships at sea are not addressed by the Resource Management Act, and won't be assessed as part of this study. There would be negligible effect at houses on land from ships at sea.

Similar to airports, the exposure of international shipping will be considered as the baseline with the incremental domestic exposure determined.

Table D5.4: Scope and methodology – by topic: Coastal shipping

Topic	Costal shipping
Key outputs	**Noise exposure** Predicted sound levels in 5 dB bands for combined port noise Increase in sound level due to domestic apportionment **Costs** Summary of indicative health costs from coastal shipping Total indicative costs from coastal by freight type (CT / petroleum / cement etc)
Key inputs	Noise contours from ports / district plans Domestic vs international movement data (modal expert) Dwelling locations (NZTA / LINZ) Population data (Stats NZ0
Data sources - specification	Covered in the previous section under 'Key inputs'
Data sources - organisation	Covered in the previous section under 'Key inputs'
Data issues	
Proposed analyses	Interpolate published contours to determine exposure Apportion received noise based on domestic / international split
Dependencies on other topics - inputs	Movement data from modal expert

D5.2.6 Output

The output of the exposure modelling will be sound levels at individual properties. Sound levels will be aggregated to 5 dB bands prior to cost calculations, as shown in Table D5.5..

Table D5.5: Number of people by mode, dB L_{dn} / L_{den}

Mode	45-49	50-55	55-59	60-64	65-69
Road					
Rail					
Air					
Sea					

D5.3 Effects of transportation noise

The effects of transportation noise on people has been extensively researched, with a number of reports published by the World Health Organisation and others. These effects can be broadly categorised as follows:

- Annoyance
- Sleep disturbance
- Disturbed cognitive functioning (learning and understanding)
- Cardiovascular disease
- Adverse effects on mental health

Criteria for annoyance for road and rail in New Zealand were recently reviewed by the Transport Agency in their *Community Response* report[76].

Health effect onset criteria for different modes have been recently established by the WHO and are listed in Table D5.6.

Table D5.6: Thresholds for effects (WHO 2018)

Mode	Adverse health effects	Adverse effects on sleep
Road	53 dB L_{den}	45 dB L_{night}
Rail	54 dB L_{den}	44 dB L_{night}
Air	45 dB L_{den}	40 dB L_{night}

D5.4 Monetisation method

D5.4.1 Previous Costs & Charges studies

The 2005 STCC study[77] applied the hedonic cost factors estimated in LTPS-EE[78] and broad estimates of the population exposed to road-traffic noise. It assumed that people exposed to sound levels higher than 60 dB $L_{Aeq(24h)}$ experienced a reduction in property values. The total depreciated value was calculated using a Noise Depreciation Index (NDI) of 0.5 ($3,000 per house) and 215,000 households. The Marginal Costs were then calculated by dividing the annualised costs by the number of vehicle kilometres.

The 2005 STCC study did not address rail, aviation or coastal shipping.

The 2009 Understanding Transport Costs and Charges literature review[79] recommended that future reviews adopt a similar hedonic approach, but use refined assumptions on noise thresholds and an updated valuation as per the Economic Evaluation Manual (EEM). It also provided two long-term recommendations:

- Better exposure mapping. This has been partly addressed by the recent Transport Agency noise mapping for road-traffic noise, and this current study can also partially address this.
- Conduct an Impact Pathway Analysis to determine a New Zealand specific dose-response relationship between exposure and health effects, and a willingness-to-pay to mitigate these effects. While dose-response curves were generated by the Transport Agency for annoyance from road and rail, they did not address health effects. We understand that the Transport Agency is currently procuring a study to determine the full social cost of road-traffic noise. We understand that the scope of that project will be available prior to completing this DTCC study, however the results of that work will not.

D5.4.2 Current NZ practices

Absolute noise costs are not routinely calculated in New Zealand, however the EEM has a method for pricing reductions in noise which is routinely used. For example, road-traffic noise levels are calculated for a proposed rural state highway project with chip-seal as the default surface. The reduction in sound level is then calculated for a number of mitigation options (porous asphalt / noise walls) and then this reduction is monetised using the EEM approach of 1.2% of median house price per dB. This valuation

[76] NZ Transport Agency research report 656 Evidential basis for community response to land transport noise
[77] Booz Allen Hamilton (2005), Surface Transport Costs and Charges Study Environmental Impacts – Working Paper
[78] Ministry of Transport (1996), Land Transport Pricing Study – Environmental Externality, LTPS-EE, Wellington.
[79] Ministry of Transport (2009). UTCC Phase 2 – Social and environmental costs

allows a marginal cost and benefit to be determined for the mitigation. This approach does not address negative effects of new projects, just the benefit of mitigation over the base design.

The Transport Agency is in the processing of procuring a research project on *Social cost (health) of land transport noise exposure in New Zealand.* Key components of that project will be:

- Undertake a study to determine the recommended dose-response relationship for health, hedonic, productivity and cognitive impacts of transport noise exposure.
- Develop a cost model, with an associated report, for the impacts of transport noise exposure.
- The results of that study will not be available prior to the completion of this DTCC project, however the methodology is expected to be confirmed by the end of 2020.

D5.4.3 International best practices

- The monetisation of transport noise effects is regularly done in Europe and North America using multiple methods. The methods used can be split in two categories:
- Estimation of the Disability Adjusted Life Years (DALY) which relates to the cost of lost productivity caused by exposure to noise. This approach combines mortality and morbidity into a single number.
- Estimation of the willingness to pay to avoid (WTP) or to accept (WTA) a certain level of noise. There are multiple methods within this approach:
    - Hedonic Pricing, which uses house market prices as a proxy of the preference that consumers revealed for noise. This is the approach adopted in the EEM
    - Stated Preference / Contingent Valuation, which requires surveying people to determine their preferences based on hypothetical situations. This approach is commonly used to monetise the "cost of aircraft noise", without a specific reference to any particular effect.

While multiple methods are used, there is not a consistent international approach to valuations. The European Environment Agency has a *Good practice guide on noise exposure and potential health effect* which provides a method for determining DALYs for different health conditions, using published Disability Weights. A subset of these conditions is provided in Table D5.7.

Table D5.7: Example Disability Weights for different health conditions

Effect	**Onset criterion by mode, dB**				
	Disability weight	**Road**	**Rail**	**Air**	**Sea**
Hypertension and associated cardiac diseases	0.35				
Sleep disturbance	0.1				
Annoyance	0.02				

The number of DALYs could be then simplified to noise ranges, combining multiple effects, to produce a table like Table D5.8.

Table D5.8: DALY for different noise levels, dB

Mode	45-49	50-55	55-59	60-64	65-69
Road					
Rail					
Air					
Sea					

D5.4.4 Recommended approach

As discussed in the introduction, a purely hedonic approach does not address health effects, which is the key impact of transportation noise. As such, a health-based metric such as a DALY is preferred.

There is likely to be some 'double counting' where receivers are exposed to noise from multiple modes. This will not be explicitly addressed in this study.

D5.5 Overall costs

To determine the total cost, the value of a DALY will need to be determined for New Zealand conditions. We understand that this can be determined using the outputs of other disciplines (air quality) as part of this study, potentially using a multiplier on the Value of Statistical Life used for the social cost of vehicle crashes.

D5.6 Disaggregation and reporting

D5.6.1 Marginal costs

Marginal costs will be calculated using an approach similar to the previous study for road-traffic noise, by dividing total costs by vehicle kilometres. The assumption that a truck has 5 times the effect of a car will be reviewed. A similar approach will be derived for other modes.

For all modes, tables/formulae will be provided to determine the number of additional movements required to generate increases in noise exposure. In the case of road-traffic, this can be determined using a standard logarithmic approach, noting difference between cars and heavy vehicles. For ports and airports with a noise baseline from international movements, a greater increase in domestic movements will be required to have an overall increase.

The increase in noise level will generally result in the 'footprint' of the activity and a greater number of dwellings exposed to noise above the relevant contours.

D5.6.2 Disaggregation

Costs will be reported spatially as required, nominally by regions and by urban/rural boundaries. The required categories will be reviewed with the project team.

D6. Biodiversity and biosecurity

Principal author: Stephen Fuller, Boffa Miskell Ltd

D6.1 Overview

The study is essentially concerned with the financial and (socio-) economic costs and the (financial) charges associated with each NZ transport mode and sub-mode/market segment. 'Impact' consultants will focus on the 'softer dollar' costs (environmental, public health etc) caused by each mode.

The previous STCC study had a limited approach to the environmental cost of transport, as follows:

- Of the various forms of transportation, it limited itself to roading.
- Of the various forms of environmental impact, and while acknowledging biodiversity and biosecurity as areas of concern, it limited its analysis to "water ecosystem quality" and air quality
- Finally, the STCC approach to pricing the impact of roading on water ecosystem quality was to apply a mitigation cost approach, using annualised cost indices for provision of stormwater system infrastructure (road run-off) which was then applied to other UAs based on local road length km.

Since 2005 there has been a significant shift in national and regional policy related to freshwater, wetlands, estuaries, harbours and coastlines (Draft NPS Indigenous Biodiversity, Draft NPS freshwater, Draft NES freshwater, the NZ Coastal Policy Statement 2010, and ongoing RMA reforms, the recently announced overhaul of the Biosecurity Act 1993). This policy shift has bought new and expanded obligations to "avoid" an increasing number of biodiversity effects increasing the ongoing cost of operation, and the compliance costs associated with reconsenting existing infrastructure in marine and estuarine environments.

In recognition of these, we have reframed the key areas of environmental concern to cover:

- Freshwater ecosystems
- Coastal and marine ecosystems
- Biosecurity

We believe that these three topic areas best reflect the range of environmental effects that need to be considered in relation to the different transport modes. The three topic areas each impact on the Environmental Sustainability outcome from the Transport Outcomes Framework, and the Biosecurity topic also impacts on Resilience and Security.

The three topic areas defined above will be impacted differently by each transport mode as presented in Table D6.1.

Table D6.1: Study coverage by mode and topic area

Topic Area	Road	Rail	Shipping	Air
Marine Biodiversity	✖	-	✖	-
Freshwater Biodiversity	✖	○	-	-
Biosecurity	✖	○	✖	○

"✖" = major effect. "○" = minor effect & warrants comment. " – " = negligible effect.

Importantly it is noted that this assessment only considers the annualised costs associated with the operation and, where necessary, the upgrading to meet new national standards of existing transport infrastructure. This assessment does not consider the costs of consenting or construction of new roads or rail, or the consenting and expansion of ports and airfields.

We also note that this assessment will be relying entirely on existing information and tools, and the knowledge of key people within the identified agencies. No new research or investigation will be carried out. The sources of all information will be detailed within the assessment.

D6.1.1 Costing Basis and Inputs for Each Transport Mode

ROADING

For marine and freshwater environments where the impact is roading runoff

- Firstly, we will use a mitigation cost approach, using annualised cost indices for provision of stormwater system infrastructure that fully or partly mitigate impacts. This will require a review of both advances in technology and an update of the costs of relevant infrastructure.
- However, we are concerned that this is too simplistic an approach, in particular in relation to urban streets where a mitigation approach is unlikely to be practically. We will therefore test the outputs of the mitigation approach by:
    - Firstly, establishing a do-nothing baseline and estimating damage costs through a modelling approach using ecosystem services or similar.
    - Then considering the proportion of reduction possible through best practice stormwater management (which cannot be zero)
    - Then calculating the difference.

For bio-security:

- We will be quantifying the likelihood and severity of contamination risk due to invasive species distribution along the roading network, or to key destinations, and providing estimates of the costs of:
    - Do nothing
    - Eradiation

RAIL

For marine and freshwater environments

- The focus will be on quantifying the likelihood and severity of contamination risk associated with significant discharge events (disasters). This may not be a significant cost, but we consider it needs comment.

SHIPPING

For Marine & Coastal:

- We will be looking at the costs of maintaining ports (channel dredging, accidental discharge, impacts on marine fauna.

For bio-security:

- We will be quantifying the likelihood and severity of contamination risk due to invasive species arrival and the predicted costs of:
    - Do nothing
    - Eradication

AIR TRAVEL

- This mode of transport is not seen as an environmental issue for terrestrial, aquatic and marine systems. There is a small component of risk associated with biosecurity, however, this is already managed at a high level.

D6.1.2 Summary of deliverables

The main study outputs will be a working paper, with sections relating to the impacts from each mode, within a common framework and methodology. The contents from these working papers will then be brought together and summarised to form the Main Report.

The study outputs will to be provided in a form that will be relatively readily updatable, potentially on an annual basis. In order to achieve this, our working papers will provide comprehensive documentation and be supported by a set of spreadsheets (or analyses in alternative forms).

D6.1.3 Summary of key data sources (New Zealand)

While each topic will require a specific set of data sources, we anticipate the following to be key New Zealand-specific data providers for this component of the project.

- MoT
- NIWA
- NZTA
- KiwiRail
- Regional Councils
- International literature

D6.1.4 Data issues

- Absence of suitable and transferable New Zealand data - Where data does not already exist specific to New Zealand, international literature will be reviewed and assessed for relevance to New Zealand conditions.
- Risk of applying international modelling/data/findings to the New Zealand context and conditions – If this is required, potential limitations and their impacts on the analysis will be clearly stated. New Zealand data and modelling will be the preferred
- Poor record keeping by the contacted agencies, such as errors, omissions and/or previous loss of data, may mean analysis is incomplete or inaccurate. For example, the lack of coordinated databases among regional councils and within industry may result in poor data quality nationwide. All potential avenues of obtaining the required data will be explored until the required data is obtained or determined to be truly missing. All instances of missing data will be clearly noted in the analysis. Any figures that do not add up to either expected or given total values will be investigated further.

D6.1.5 Dependencies on other topics – inputs

- We consider that the only dependencies lie within these three topic areas (freshwater, marine, biosecurity). We are not reliant on other topics (air, noise, health) for inputs.

D6.1.6 Dependencies on other topics – outputs

- We consider that the only dependencies lie within these three topic areas (freshwater, marine, biosecurity). We are not reliant on other topics (air, noise, health) for outputs.

D6.1.7 Risks and uncertainties

- Data is not made available with enough time to allow comprehensive analyses to occur within the requested timeframes - We are experienced in stakeholder consultation and will engage with the identified stakeholders early, with the requirements and timeframes clearly stated, to maximise the likelihood of a successful response within the required timeframe.

- Lack of cooperation by the contacted agencies, such as due to confidentiality concerns or perceived information security risks, may result in incomplete data sets for analysis - We expect our list of contacts and agencies will be fully supportive of the study. They will be approached in a timely manner with clear explanation of what we need and why.
- Information security risks, such as data theft, may cause concern among contacted agencies regarding data provision and commercially sensitive information for some companies may become publicly available –a dedicated IT team will manage company firewalls, data backup and other cyber security risks, minimising risk of data loss or leakage.
- The obtained costs may change significantly soon after the analysis is complete and render the analysis. This risk is mitigated through the provision of a readily updatable analysis and working papers for each ecological environ, which may occur on an annual basis.

D6.2 Freshwater Environment

Roading and rail are expected to be the key drivers in transport-derived impacts related to invasions and transport of invasive weeds and pests. Therefore, coastal shipping and air travel are not likely to be considered at this stage.

D6.2.1 Topic brief and explanation

- The STCC applied a mitigation cost approach, using annualised cost indices for provision of stormwater system infrastructure (road run-off) which was then applied to other UAs based on local road length km.
- We consider this an appropriate proxy for effects of State Highways on water quality, where improvements are practically achievable and can be costed. However, we consider that this analysis is flawed for two reasons:
    - urban streets throughout NZ have been designed to capture, transport and discharge water to streams, harbours and coastlines via reticulated stormwater systems. Stormwater treatment is not practically achievable for the great majority of these urban streets. We propose that this requires an alternative approach based on the valuation of lost or modified ecological systems assuming untreated stormwater.
    - No stormwater mitigation method is 100% effective and there will always be a residual impact. For some contaminants this can approach 80%, of others only 50% of treatment can be reliably achieved.
- Since 2005 there has been a significant shift in national and regional policy related to freshwater, wetlands, estuaries, harbours and coastlines (Draft NPS freshwater, Draft NES freshwater, the NZ Coastal Policy Statement 2010, and ongoing RMA reforms). This policy shift has bought new and expanded obligations to "avoid" an increasing number of biodiversity effects increasing the ongoing cost of operation, and the compliance costs associated with reconsenting existing infrastructure.
- There have also been advances in stormwater treatment technology, and development of best practice guidelines since 2005.
- We also now have greater clarity of the effect of climate change on rainfall frequency and volume, which will impact the cost associated with managing flooding & erosion, and how this will determine ongoing requirements for management and upgrading of existing infrastructure.

For this component of work, we have concluded that potential biodiversity decline, or loss will be primarily associated with discharge of contaminants to freshwater and marine ecosystems and so is directly associated with water quality. Where a mitigation cost approach is not appropriate (e.g. residential roading) valuation of ecosystem and biodiversity loss will be needed to support costing for water quality.

D6.2.2 Key outputs

- Considering the 4 transport modes, this study will focus largely on modelling existing roading costs. Comment will be made on rail where some costs are likely. Domestic air and shipping will have a negligible impact on water quality at a national scale.

ROADING

- For state highways, the mitigation cost approach will be used, with costs for appropriate levels of treatment (stormwater system infrastructure, passive and active) updated. Costs for road runoff collection and treatment will need to be updated to meet the new NPS & NES freshwater requirements, such that we can develop cost per km to treat to a higher standard.
- For urban roads, the assessment of water quality effects overlaps with the Biodiversity Assessment (see below). Here we will seek to value the impact and loss of aquatic and marine biodiversity assuming a predicted level of decline associated with uncontrolled discharge to streams, rivers and harbours.
- The issue of the introduction and spread of invasive species through ports and harbours will be addressed in the biosecurity investigations described below.

RAIL

- For rail the focus will be on quantifying the likelihood and severity of contamination risk associated with significant discharge events (disasters). This may not be a significant cost, but we consider it needs comment.

D6.2.3 Key data sources

The following organisations are expected to be primary data sources. Where possible, notable 'first port of call' persons are also named.

- Cost of do nothing
  - Ecosystem services type analysis
  - Supported by NZ case studies of contaminated rivers and harbors (Porirua Harbour, Manakau Harbour).
- For State Highways - we will update costs for road runoff collection and treatment for state highways with NZTA being the primary source.
  - NZTA
  - Costs to build stormwater infrastructure vegetated swale, wetland treatment systems, NZTA guidelines. Efficiencies, levels of contaminant loading.
  - Treatment efficiency (NIWA).
- For Urban Roads –we will largely rely on published international studies.
  - International research North America and England and USA studies;
  - Regional councils for SOE rivers - stormwater departments re loadings of contaminants Auckland, BOP, Wellington

However, for evaluating the costs for residential street networks there is little quantitative data available in New Zealand and we propose to focus on a number of comprehensive studies that have been carried out internationally.

- For rail (KiwiRail)
  - Lead hazards or disaster team for probability and severity of disaster.
  - For Rail Regional Councils for clean-up cost estimates E.g. EBOP (Rena response), Canterbury (disaster plan), Taranaki (Fonterra response).

D6.2.4 Costing Basis

- A review will be undertaken across all relevant information sources listed above to obtain costs for road runoff collection and treatment that have been updated to meet the new NPS & NES freshwater requirements and using the improved technologies that have been developed in recent years, such that we can develop cost per km to treat to a higher standard. These costings will seek to include both:
  - Cost of installation of mitigation infrastructure (This will rely on many assumptions which will be identified)
  - Cost of annual maintenance of mitigation infrastructure.
- The mitigation method results will then be tested by:
  - Reviewing the range of contaminants of most concern and literature on their dominance within road discharges.
  - Reviewing our knowledge of knowledge of treatment efficiencies by various stormwater treatment devices which, even under best practice may only reach 70% or 80%. The impact of a residual contaminant loading will then be investigated.
  - Reviewing our knowledge of the levels of contamination that are significant, i.e. some levels of some contaminants are tolerated by flora and fauna.
  - Costing “do nothing” using models of ecosystem value. Costing the residual impacts assuming best practice mitigation methods and determining the difference between the two.
- This analysis will include consideration of coastal and marine impacts of roading discharge but will be limited to those areas of our coastal environment where roading and traffic are sufficiently extensive that impacts have been explored and are measurable.
- This alternative approach will be used to test the mitigation cost approach, and if the results are considered sufficiently robust may be considered as an alternative.

D6.3 Marine environment

Roading and shipping are expected to be the key drivers in transport-derived impacts on the marine environment. Therefore, rail and air travel are not likely to be considered at this stage.

D6.3.1 Topic brief and explanation

- The STCC did not explicitly assess the impacts of transport modes on the marine environment, although the mitigation cost approach used for roading infrastructure did, by default, also apply to road discharge impacts on the coastal and marine environments.
- Since 2005 there has been a significant shift in national and regional policy related to freshwater, wetlands, estuaries, harbours and coastlines (Draft NPS freshwater, Draft NES freshwater, the NZ Coastal Policy Statement 2010, and ongoing RMA reforms). This policy shift has bought new and expanded obligations to “avoid” an increasing number of biodiversity effects increasing the ongoing cost of operation, and the compliance costs associated with reconsenting existing infrastructure. There have also been advances in stormwater treatment technology, and development of best practice guidelines since 2005.

D6.3.2 Key outputs

- Considering the 4 transport modes, this study will focus largely on roading and shipping. Comment will be made on rail where some costs are possible. Domestic air will have a negligible impact on water quality within harbours, estuaries and the coastal environment.

EXISTING ROADS

- The impact of discharge from roading upon marine environments will be addressed as part of the analysis described under Freshwater Environments above. This analysis will apply equally to freshwater and marine environments.

SHIPPING

- This study will largely focus on the operation effects large-scale shipping has in New Zealand Harbours. It will focus on harbours which contain commercial shipping operations outside of small-scale fishing. The process for determining this threshold will be developed once further information and data is obtained.
  - This study will focus on three main adverse and quantifiable effects of commercial shipping on harbours, including:
  - Channel dredging, and the disposal of the dredged material
  - Accidental discharge of cargo
  - Accidental discharge of oil
  - Impacts on marine mammals
  - Invasive species. The issue of the introduction and spread of invasive species through ports and harbours will be addressed in the biosecurity investigations described below.

D6.3.3 Key data sources

The following organisations are expected to be primary data sources. Where possible, notable 'first port of call' persons are also named.

- NIWA
- NZTA
- MPI
- National Science Challenge - Sustainable Seas research
- Regional Councils (especially where major ports reside) – including their State of the Environment monitoring data.
- Marine Oil Spill Risk Assessment (MOSRA)
- Where data does not already exist specific to New Zealand, international literature will be reviewed and assessed for relevance to New Zealand conditions.

D6.3.4 Costing Basis

- This review will start by prioritising those harbours which have sufficient ship movements, and where the operational management of shipping are likely to result in significant costs to the environment. Investigation will be limited to these sites. We will not explore effects around the wider NZ coastline which will be more related to roading discharges and biosecurity issues.
- A review will then be undertaken across all relevant information sources listed above to identify those operational activities in harbours/ports which have an environmental impact.
- The review will then explore the ecological costs of those impacts.

D6.4 Biosecurity

Roading and shipping are expected to be the key drivers in transport-derived impacts related to invasions and transport of invasive weeds and pests. Therefore, rail and air travel are not likely to be considered at this stage.

D6.4.1 Topic brief and explanation

- The impact of invasive species and their distribution around New Zealand by various transport modes is of major concern, particularly in relation to climate change. With a cost to NZ estimated at $1.28B-$2.45B p.a. NZ's agricultural sector and Government place maintenance of a high-quality biosecurity system as their top priority. As a result of this, the policy framework for Biosecurity including the recently announced overhaul of the Biosecurity Act 1993, is now looking at the role transport infrastructure has as a conveyance for invasive pests and pathogens, given increased trade and tourism, and climate change.

D6.4.2 Key outputs

- Considering the 4 transport modes, this study will focus largely on modelling roading and domestic shipping. Comment will be made on rail and domestic air where some risks lie but these transport modes are considered to have a relatively minor impact at a national scale.
- The costs of biosecurity threats posed by the transport sector are fairly well known, and include direct costs including surveillance, detection and control, as well as significant indirect costs on both the economy and the environment.
- For all four transport modes, the output will be a risk analysis, looking at the predicted likelihood, frequency and severity of invasive species arrivals, and the likely range of costs of control or eradication, based on NZ case studies and industry related modelling.

D6.4.3 Key data sources

Most data relevant to the study will be sourced within New Zealand. The following organisations are expected to be primary data sources. Where possible, notable 'first port of call' persons are also named.

- MPI/Biosecurity NZ – Border control (import costs/fees associated with inspection and diagnostics at the border, as well as incursion response costs for post-border invasions e.g. fruit fly, painted apple moth).
- NZTA
- Treasury (official information requests)
- Bio-Protection Research Centre
- Manaaki Whenua – Landcare Research
- B3 – BETTER BORDER BIOSECURITY
- Regional Councils – particularly biosecurity managers (TBC)
- DOC (management of incursions in conservation estate)
- Industry – importers and exporters in New Zealand
- National Science Challenge – Bio-Heritage Challenge as it is known – New Zealand's first integrated science initiative to protect our biodiversity, improve biosecurity, and enhance the country's resilience to harmful organisms
- International ports in New Zealand

- Where data does not already exist specific to New Zealand, international literature will be reviewed and assessed for relevance to New Zealand conditions.

D6.4.4 Costing Basis

- A review will be undertaken across all relevant information sources including the Ministry of Primary Industries, Government resources, Councils, Department of Conservation and relevant port and transport industry providers to obtain detailed cost data.
- Risk and cost analysis will be undertaken for all four transport modes for incursions that are new to New Zealand.
- Risks and costs associated with the spread of pest species that are already established in New Zealand, will be evaluated, including those associated with surveillance, monitoring, incursion response and ongoing control.
- Analyses of costs and risks will cover for each of the above the three main areas: financial/economic, environmental and social. Costs may be either direct (e.g. associated with monitoring and control) or indirect (e.g. costs to industry due to presence of pest species).