Mode shift to micromobility

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An important note for the reader

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Abbreviations and acronyms

ACC	Accident Compensation Corporation
BLE	Bluetooth Low Energy
CAS	Crash Analysis System
CBD	central business district
CPTED	crime prevention through environmental design
LiDAR	light detection and ranging
MaaS	mobility as a service
MDS	Mobility Data Specification
MSM	Auckland Macro-Strategic Model
PT	public transport
SacRT	Sacramento Regional Transit District
SAE	Society of Automotive Engineers
SAMM	Auckland Strategic Active Modes Model

Contents

Executive summary

This research was carried out for Waka Kotahi NZ Transport Agency between November 2019 and August 2020, with a view to enabling better-informed transport planning and project evaluation.

The research consists of:

- a review of existing literature on micromobility
- a review of data being collected on micromobility use in New Zealand
- modelling of the likely use of micromobility and the effect of this on ‘conventional’ transport modes
- an evaluation of the potential impacts of micromobility use in terms of the Ministry of Transport’s Transport Outcomes Framework
- a discussion on the factors that will affect mode shift to micromobility.

Recommendations for future research are also included.

Literature review

A review was undertaken of available research on micromobility from around the world, including both formal academic literature and industry-driven research. The review considered research and literature on:

- micromobility modes (available modes and their relevance for this research)
- models for micromobility use (eg, shared models, mobility as a service (MaaS), private ownership)
- mode shift to micromobility (scale of mode shift and influencing factors; trip purposes and distances for micromobility trips; impact on public transport)
- impacts of micromobility (known impacts of micromobility use on health and safety, accessibility and socio-economic equity, and the environment).

The literature review highlighted substantial gaps across the latter two areas, especially in relation to the likely scale and nature of mode shift to micromobility. The proposed Waka Kotahi Accessible Streets Regulatory Package and the Society of Automotive Engineers’ micromobility mode definitions framework were used as a basis for determining that, of all the micromobility modes identified by the literature review, e-scooters, e-bikes and e-accessible devices (devices whose core purpose is supporting mobility, such as mobility scooters) were the modes of significant relevance to the New Zealand context.

New Zealand data review

A review was undertaken of data that is being, or is planned to be, collected on micromobility use in New Zealand. This review considered data, and gaps in available data, across five main categories:

- survey counts (mode share for micromobility modes)
- trip data (micromobility trip numbers, purposes and lengths)
- sales data (rate of micromobility device ownership and sales trends)
- injury statistics (micromobility injury statistics, including causes)
- expressed interest (desire to shift to a micromobility mode, and perceived barriers thereof).

Gaps were identified across all five areas, with the quality of data available varying significantly by region, and often lacking in detail such as trip purpose and demographics. The current state of data on micromobility use is not yet adequate to inform transport planning and project evaluation. There is a need to develop and implement a strategy for collecting data in relation to privately owned micromobility. Further analysis of Accident Compensation Corporation (ACC) injury data for micromobility is also required, as current understanding of injury rates, causes and trends is limited. Overall, the data review highlighted the lack of a consistent national data collection methodology, and the need for a national strategy for collecting data on micromobility use.

Transport modelling

The literature and data reviews identified the lack of quantitative information available on the likely uptake of micromobility modes, as well as on the likely impact this will have on the use of other modes, including walking, cycling, cars and public transport. The aim of the modelling section of the research was to take the first steps towards filling that gap, with a focus on the New Zealand context. Two different use cases of micromobility were considered as part of the modelling process – 'end-to-end' trips, where a micromobility mode was used for the full length of the trip, and multi-modal 'first/last mile' trips, where micromobility is used for the beginning and/or end section of a journey to facilitate connections with public transport.

The Auckland Macro-Strategic Model (MSM) and the Auckland Strategic Active Modes Model (SAMM), both developed by the Auckland Forecasting Centre, were chosen as a base for this work because of their suitability and complexity, and their inclusion of a broad variety of geographies, densities and land-use types. 2028 was used as the forecast year.

The MSM was used to model the potential increase in public transport if micromobility was used to facilitate connections with public transport services. Micromobility use was modelled here by proxy, through the use of an increased assumed 'walking' speed to represent a composite of some walking and some micromobility. The reference trip profiles (no micromobility use) from both the MSM and the SAMM were then used to model the 'market' for end-to-end trips that could potentially shift to a micromobility mode. A set of assumptions was then applied to this 'market' of trips to identify likely ranges for mode shift.

Impact evaluation

The Ministry of Transport's Transport Outcomes Framework states that the core purpose of New Zealand's transport system is 'to improve people's wellbeing, and the liveability of places' by contributing to five key outcomes: inclusive access; healthy and safe people; environmental sustainability; economic prosperity; and resilience and security.

An impact evaluation was carried out to assess the potential impacts of an increased micromobility mode share in New Zealand in relation to each of these five key outcomes. The evaluation also sought to identify appropriate interventions that:

- mitigate those impacts where they conflict with one or more of the five wellbeing outcomes, or
- ensure and amplify those impacts where they align with one or more of the five wellbeing outcomes.

As a result of the evaluation, 38 impacts were identified, with 'inclusive access' and 'healthy and safe people' emerging as the areas of greatest concern. Twenty-one interventions have been proposed to address these impacts. These include, but are not limited to, infrastructure interventions, regulatory/legislative interventions, funding interventions, education/awareness-based interventions, operational interventions, and collaboration/partnership-based interventions.

Results

The table below gives scenarios for the likely effect on public transport and private vehicle use if some micromobility is used in a first/last mile capacity. Results are shown separately for various contexts; these results represent the median of forecast ranges.

Scenario	Context	Effect
Central business district (CBD)/fringe (~5 km radius)	• High levels of public transport • High availability of micromobility	• 2% decrease in car trips • 6% increase in public transport patronage
CBD/fringe (~5 km radius)	• High levels of public transport • Low availability of micromobility	• 1.5% decrease in car trips • 3% increase in public transport patronage
Suburban	• High levels of public transport • High availability of micromobility	• 1% decrease in car trips • 9% increase in public transport patronage
Suburban	• High levels of public transport • Low availability of micromobility	• 0.5% decrease in car trips • 6% increase in public transport patronage
Suburban	• Low levels of public transport	• 0.5% decrease in car trips • 7% increase in public transport patronage

Overall, public transport patronage is expected to grow by up to 9% by 2030 as a result of first/last mile micromobility use, depending on context, with car trips expected to decrease by up to 2% for CBD and fringe areas, and 1% or less for other areas. The scale of these changes is expected to vary depending on six context factors:

- presence/maturity of MaaS
- quality of public transport provided
- availability of shared micromobility
- provision for micromobility parking at connection points
- ability to take devices on board public transport services
- maturity of micromobility culture in the location of interest.

The table below gives ranges for the likely mode share for e-bikes and e-scooters for end-to-end trips, for various contexts.

Land-use	Modelled scenarios	Mode share range
Major city – CBD	• High uptake scenario for e-scooters • Medium uptake scenario for e-bikes	• E-scooter mode share: 1.6%–5.7% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Major city – fringe (~5 km radius)	• Medium uptake scenario for e-scooters • High uptake scenario for e-bikes	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 7.7%–8.1% of all trips
Major city – suburban	• Medium uptake scenario for e-scooters • Medium uptake scenario for e-bikes	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Regional city – CBD/fringe	• Medium uptake scenario for e-scooters • Medium uptake scenario for e-bikes	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Regional city – suburban	• Low uptake scenario for e-scooters • Low uptake scenario for e-bikes	• E-scooter mode share: 0.3%–1.2% of all trips • E-bike mode share: 1.8%–2.0% of all trips

Overall, micromobility mode share is expected to be between 3% and 11% by 2030, depending on the following six context factors:

- proximity of routes to 'attractive' destinations
- quality and safety of route infrastructure
- attractiveness of mode alternatives
- maturity of network/transport culture
- amenity and aesthetic value of routes
- socio-economic factors.

Recommendations for future research

Forecasting micromobility use is important for transport project and policy evaluation. Monitoring is required of the use of micromobility on the existing shared path and cycling infrastructure in New Zealand to identify current (benchmark) levels of micromobility use and to track micromobility mode share growth in a consistent manner. The research has identified further work required on data collection, assessment of injury rates, investigation of equity considerations, a focus on the uptake of 'e-moped' form factor micromobility outside of New Zealand, and a review of transport models for major New Zealand centres to incorporate mode shift to micromobility so that this mode can be included for statistics provided to project evaluations and business cases.

Abstract

A review into the global use of micromobility in 2019 identified current use and trends in technology and shared models, as well as gaps in information on mode share. Using trip information from strategic transport models, a market potential analysis forecast that the likely range of mode shift to micromobility in New Zealand could be between 3% and 11% of all urban trips by around 2030. Six context factors were developed to help practitioners identify where in this range actual growth is likely to occur. The number of people using shared or separated infrastructure is forecast to increase by three to eight times, which will have a significant impact on project evaluation. The growing use of micromobility in association with public transport/transit could increase patronage in New Zealand by up to 9% by around 2030; consideration of public transport vehicle and network design is required to enable this. The growth of micromobility has both positive and negative impacts on transport outcomes, which were evaluated using the five key outcomes in the New Zealand Ministry of Transport's Transport Outcomes Framework. Twenty-one key interventions were identified that will help deliver wellbeing and liveability outcomes.

1 Introduction

The transport system has always been dynamic, with changes in pricing, infrastructure and technology changing the ways that people choose to travel.

The introduction of small, electrically powered transport devices has gained momentum in recent years, to the point where transport planning practitioners, urban designers, and design professionals are interested in how significant the future impact of micromobility could be in the way people choose to travel.

This research is focused on filling the gap in information on the forecast mode shift from private cars to micromobility for short trips, and the initiatives that can be taken to encourage or remove barriers to this mode-change. Similarly, the research examines the potential for micromobility (particularly shared micromobility) to enhance the use of public transport through providing quicker and more convenient 'first/last mile' connections.

This research project has the specific purpose of providing guidance to transport planning practitioners on how to incorporate micromobility growth forecasts into project evaluation and suggest a range of interventions to mitigate positive and negative impacts of the growth of micromobility. These details are contained in section 8 of this report.

1.1 Research objectives

The objectives of the research are to estimate the likely scale and impacts of a shift to micromobility by:

- reviewing existing international research and information on the use of micromobility
- reviewing existing data on the use of micromobility in New Zealand
- developing mathematical forecasting methods for forecasting the mode shift to micromobility in the next decade
- using existing transport models to forecast how the use of micromobility as part of a public transport trip will increase patronage
- identifying the positive and negative impacts of mode shift to micromobility on the five key outcomes of the New Zealand Ministry of Transport's Transport Outcomes Framework, and identifying potential interventions and mitigations to optimise these impacts
- providing information to transport planning and policy practitioners for use in project evaluations and strategy development.

This report is structured as follows.

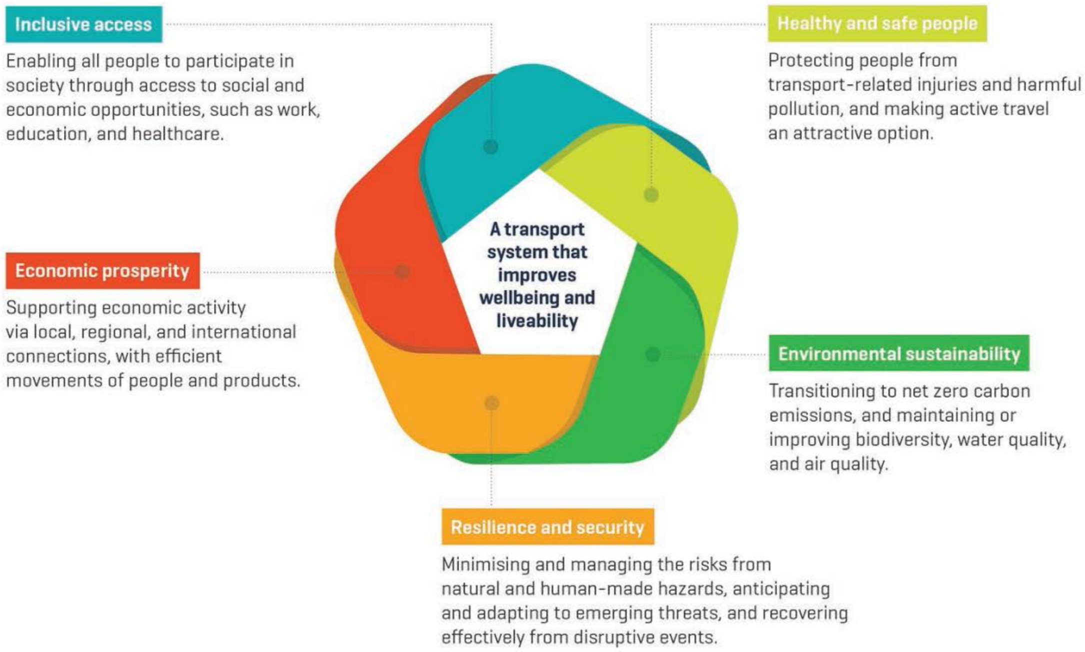
- **Section 3** summarises a literature review on the pipeline of non-traditional modes and operating systems, as well as the potential enablers and barriers to the uptake of these new modes. These include accessibility, safety and infrastructure, and autonomy.
- **Section 4** summarises a data review of the current state of data collection on micromobility use in New Zealand.
- **Section 5** reports on transport modelling to estimate the potential mode share for micromobility vehicles, including first/last mile scenarios, and the estimated mode shift from other transport modes.
- **Section 6** evaluates the impacts of mode shift to micromobility on five key outcomes: inclusive access; health and safety; environmental sustainability; economic prosperity; and resilience and security.

- **Section 7** discusses the results of the research, including mode shift forecasts and context factors that influence mode shift.
- **Section 8** outlines the recommendations for project evaluations of urban cycleways and shared paths, for the integration of micromobility with public transport, and for micromobility policy, strategy and planning.
- **Section 9** summarises the conclusions of the research and its intended use.

1.2 Transport Outcomes Framework

The New Zealand Ministry of Transport's Transport Outcomes Framework describes an enduring set of outcomes to guide decision making across the transport sector. The framework sets out that the purpose of the transport system is to improve wellbeing and liveability for New Zealanders (Ministry of Transport, 2018). This purpose is supported by the five outcomes outlined in Figure 1.1.

Figure 1.1 Transport Outcomes Framework (Ministry of Transport, 2018, p. 3)



2 Research methodology

The research was conducted between November 2019 and June 2020. The research team was led by Matt Ensor, Technical Director (Beca). The research team met with the Steering Group at milestones during the research project.

Oliver Bruce (Micromobility Industries) is the co-host of the *Micromobility* podcast with Horace Dediu, organises the annual Micromobility Summits that occur in the United States and Europe, and invests in companies building the future of transport. In terms of investments in micromobility, Oliver worked at Uber from 2015 to 2018 in marketing, operations and strategic projects and has sold his equity stake in the company since then. He has a financial interest in Weel Autonomy, an autonomous bike start-up. He also held shares in Spring, a software solution for scooter operators.

Oliver's role in the research was compiling aggregated information and data from a large variety of international sources to provide a comprehensive 'state of the market' for micromobility in 2019, which is used in sections 2 and 3 of this report. This included substantial information on the operations of shared micromobility and the current and planned developments in micromobility technologies and form-factors.

The Beca research team examined this information along with relevant material from a literature search. This part of the research project identified that there were substantial gaps in data on the current use of micromobility, and little information available from independent/peer-reviewed studies.

The Beca research team consulted with New Zealand's central and local government on the data that is currently available on the sales and use of micromobility, and data collection programmes. The planned methodology was that current data would be used to test/benchmark the recommendations of this research project. During this stage of the research project, New Zealand moved into Level 4 COVID-19 lockdown, which meant that only essential travel occurred. Anecdotally, this led to a large increase in cycling activities and a new question on whether the COVID-19 lockdown would accelerate mode shift to micromobility. As there is no significant benchmark data or relevant data collection activities for micromobility, it has not been possible to address this question in this research. Recommendations on data collection programmes are made in section 4 of this report.

Beca developed two approaches to forecast the potential mode shift to micromobility:

- a market-potential model built up from first principles by exporting the total inventory of trips within the Auckland Forecasting Centre's Macro-Strategic Model (MSM) and Strategic Active Modes Model (SAMM) and using a range of assumptions to examine each trip by trip length to forecast how many trips would mode shift to micromobility
- use of the above models to forecast how many additional trips would be made on public transport through increasing the speeds that people could make their trips to and from public transport. This increase in speed was based on a range of assumptions around uptake and availability of shared micromobility.

As there was insufficient data available on the reasons and trip characteristics that would cause people to mode shift, for each assumption applied in the modelling, a range was applied. Assumptions included the range (km) of micromobility types and the likely uptake rates. By selecting low, medium and high values for each of the assumptions, the modelling provided upper and lower bounds of what forecast mode shift would be.

The research team discussed with practitioners the potential factors that could increase mode shift in a particular context to the higher end of the range. There is insufficient data to determine the specific impact of each on mode shift.

For the forecasting of the increase in patronage due to the use of micromobility for the first/last mile of a public transport trip, the Beca research team developed a method to produce a proxy for the availability and uptake of micromobility in each zone of the transport model. This was then used to develop a synthetic walking speed to and from public transport, which was the average of those assumed to continue to walk, and those who are assumed to use micromobility. The results of this model were sensitive to the assumptions around uptake of micromobility, and a range of model runs were done to determine what is an appropriate forecasting range. The results were used to provide guidance on the likely demand for taking micromobility on board public transport or leaving/picking up at the station/bus stop.

Details on the modelling are contained in section 5 of this report.

While the modelling provides a more objective method to forecast mode shift, there were a range of views amongst the research team about whether the mode shift values were overly conservative. The differences are around the likelihood of people shifting modes from their private car to a micromobility device. This reinforces the need to collect data on micromobility mode share to monitor mode shift.

In New Zealand there have been strong public discussions on the positive and negative impacts of the use of micromobility. A key focus has been on the health and safety implications for both riders and for pedestrians where micromobility is being ridden on footpaths or shared paths. An area of concern has been for pedestrians who are more vulnerable given the speed differential between them and the riders of micromobility. At the same time, there was significant public and media interest in the safety of e-scooters, with reported injuries from shared e-scooters being regularly highlighted in the mass media.

The Transport Outcomes Framework outlines how to assess the impact of transport activities on the wellbeing and liveability of the community, including ‘healthy and safe people’. The Beca research team assessed all of the information from the literature review to identify known aspects of the impact of micromobility on each of the five outcomes. This included identifying whether the impact was positive or negative, the members of the community who were affected, and potential mitigations to either maximise a positive impact or minimise a negative impact. This is detailed in section 6 of the report.

This created a ‘stock-take’ of initiatives or interventions that planners and policymakers could consider when designing or evaluating projects that support mode shift. This is presented as recommendations for practitioners in section 8.

The research concluded with the development of recommendations for filling the gaps in information that were identified during the research, particularly in the area of data collecting and monitoring. As more statistically relevant information becomes available, further refinement of the forecasting models will be possible.

3 Literature review

The literature review examined the range of information available on the current use of micromobility, potential changes that would increase the use of micromobility, and information on the impacts and effects of growing micromobility use.

The structure of the literature review is:

- defining micromobility (section 3.1)
- micromobility mode descriptions (section 3.2)
- privately owned and shared micromobility (section 3.3)
- mode shift to micromobility (section 3.4)
- impacts of micromobility (section 3.5)
- conclusions of literature review (section 3.6).

3.1 Defining 'micromobility'

The working definition of micromobility for this research has been derived from two sources – the Society of Automotive Engineers (SAE) classification system and the Waka Kotahi (2020a) Accessible Streets Regulatory Package.[1] The SAE classifications were used to align this research with international understandings of and approaches to micromobility, and the latter provided a New Zealand context on the approach to micromobility in the transport system.

3.1.1 SAE definitions

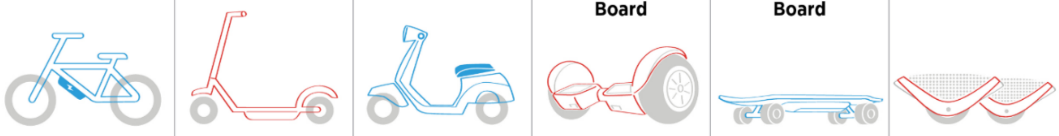
The SAE introduced a classification system for powered micromobility vehicles in November 2019. The system defines six types of powered micromobility vehicles by physical attributes – including powered bicycles, standing and seated scooters, self-balancing and non-self-balancing devices, and skates – with descriptors for curb weight, vehicle width, top speed and power source (Chang et al., 2019a). A graphic summary of the SAE definitions is shown in Figure 3.1.

'Powered micromobility vehicles' refers to the class of vehicles that (i) are partially or fully powered by a motor/engine (ie, excludes solely human-powered vehicles like pedal-only bikes); (ii) have a top speed of no greater than 30 mph (48 km/h); and (iii) have a curb weight of no greater than 500 lb (227 kg).

[1] The Accessible Streets Regulatory Package is under consideration as of the time of publication; however, regardless of the future of the regulatory package, its contents and definitions contribute to existing knowledge about micromobility in New Zealand.

Figure 3.1 SAE micromobility vehicle definitions (Source: SAE International, 2019, p. 1)

TYPES OF POWERED MICROMOBILITY VEHICLES[1]



	Powered Bicycle	Powered Standing Scooter	Powered Seated Scooter	Powered Self-Balancing Board	Powered Non-Self-Balancing Board	Powered Skates
Center column	Y	Y	Y	Possible	N	N
Seat	Y	N	Y	N	N	N
Operable pedals	Y	N	N	N	N	N
Floorboard / foot pegs	Possible	Y	Y	Y	Y	Y
Self-balancing[2]	N	N	N	Y	N	Possible

[1]All vehicles typically designed for one person, except for those specifically designed to accommodate additional passenger(s)
[2]Self-balancing refers to dynamic stabilization achieved via a combination of sensors and gyroscopes contained in/on the vehicle

3.1.2 Accessible Streets definitions

The Accessible Streets Regulatory Package proposal produced by Waka Kotahi defines six categories of ‘vehicles and devices’ allowed to be used on paths. Based on the consultation document *Accessible Streets – Summary to the Overview* (Waka Kotahi, 2020a), these categories would be:

- **Pedestrians** – people on foot, those using wheelchairs (unpowered), and those pushing wheeled items such as prams, trolleys or zimmer frames. Under the proposal, pedestrians would be able to use footpaths or, if a footpath is not available, shared paths, cycle paths, cycle lanes or roads.
- **Powered wheelchairs** – powered wheelchairs will be treated as pedestrians and hence can also use the footpath. Where no footpath is available, like pedestrians, powered wheelchairs may be used on shared paths, cycle paths, cycle lanes or the road.
- **Mobility devices** – powered devices for those requiring mobility assistance for medical purposes, up to 150 W. Under the proposal, mobility devices would be able to be used on footpaths as long as they are less than 750 mm in width or have an exemption permit, as well as shared paths, cycle paths, cycle lanes and roads if no footpath is available or permitted by a road controlling authority.
- **Unpowered transport devices** – small, unpowered devices propelled by human power or gravity, such as skateboards, rollerblades or push scooters; notably, the wheel diameter requirement would be removed under this proposal. Unpowered transport devices would be able to be used on footpaths under certain conditions (including the 750 mm width restriction), cycle paths, shared paths, and cycle lanes (unless a road controlling authority excludes them).
- **Powered transport devices** – low-powered devices propelled by a motor that have been declared by Waka Kotahi not to be a motor vehicle – currently, this is limited to e-scooters and YikeBikes. Waka Kotahi can declare that a device is not a motor vehicle if its maximum power output is under 600 W. Powered transport devices would be able to be used on footpaths under certain conditions (including the 750 mm width restriction), cycle paths and cycle lanes (unless excluded by a road controlling authority), roads and, if a road controlling authority permits, shared paths. Waka Kotahi may choose to impose further conditions on the use of a powered transport device if the maximum power output is between 300 W and 600 W.

- Cycles and e-bikes – as well as devices already classified as cycles or e-bikes, this category would also include small-wheeled cycles and e-bikes that are propelled by cranks. E-Cargo-Bikes are also understood to fit within this definition so long as they do not exceed the maximum width requirement of 750 mm. The road, cycle paths, and cycle lanes can be used by this category, and also shared paths where permitted by a road controlling authority.

All other devices would be considered motor vehicles unless Waka Kotahi declares otherwise. As the proposal currently stands, this includes powered devices such as e-skateboards, powered unicycles and self-balancing boards; none of which have been declared not to be motor vehicles.

3.1.3 Definitions used for this research

For the purposes of this research, the term ‘micromobility’ will be used as an umbrella term for transportation using *small, electrically powered transport devices* only – noting that the term may be (or may have been) used elsewhere to refer more generally to the use of small transport devices, including non-powered or petrol-powered devices that are excluded here.

In order to maximise the practical value of this research for the New Zealand context, this research (outside of the literature review) will be focused only on micromobility modes that are able to be used on footpaths, shared paths or cycle infrastructure under the Accessible Streets Regulatory Package proposal: that is, e-bikes, e-scooters and mobility devices.

As such, when the term ‘micromobility’ is used in sections 4 through 7, it can be broadly understood as referring to those modes only, unless stated otherwise.

In order to align with international terminology on micromobility, specific modes will be distinguished based on the SAE classification system. All these modes will be explored for the purposes of the literature review.

- ‘E-bike’ will be used to refer to devices fitting the SAE description of a ‘powered bicycle’.
- ‘E-scooter’ will be used to refer to devices fitting the SAE description of a ‘powered standing scooter’, including those with a seat fitted and power output below 30 W.
- ‘E-moped’ will be used to refer to devices fitting the SAE description of a ‘powered seated scooter’ with power output between 300 W and 600 W.
- ‘Powered skates’, ‘powered self-balancing board’ and ‘powered non-self-balancing board’ will be used as per the SAE descriptions.
- ‘E-accessible’ will be used to refer to powered micromobility devices that are used to provide mobility assistance for medical purposes, excluding powered wheelchairs (which will be treated as pedestrians, as per the Accessible Streets Regulatory Package, and therefore not micromobility devices). This subset of devices has no parallel in the SAE framework but was considered important to include as a specific category here in order to align with the practical distinctions made by Waka Kotahi. Note that such devices are termed ‘mobility devices’ in the Accessible Streets documents; however, this term was not used here to avoid confusion with the umbrella term ‘micromobility devices’.

E-mopeds will still be included as part of the modelling process because excluding these risks over-predicting mode shift to e-bikes and e-scooters. However, because e-mopeds are defined as motor vehicles under the Accessible Streets Regulatory Package proposal (and therefore unsuitable for use on footpaths, cycle paths and shared infrastructure) they will not be considered as part of the impact evaluation or implementation sections.

3.2 Micromobility mode descriptions

The following sub-modes of micromobility are used in this research.

3.2.1 E-bikes (powered bicycles)

E-bikes are traditional bicycles that have the addition of an electric motor to assist with propulsion. The motors are typically mid-mounted (at the pedals) or hub-mounted and are referred to as mid-drive or hub-drive respectively.

Currently, Waka Kotahi regulates these bikes to a maximum power output of 300 W. This only applies to bikes that will be used on road, and there is a regulatory grey area for off-road bikes. E-bikes typically have batteries ranging from 180 Wh to 1 kWh, providing a range from 15 to 100 km (Lieswyn et al., 2017).

Figure 3.2 Stromer ST5 e-bike[2]

Different form factors of e-bikes include cargo e-bikes, which are able to carry people or goods in addition to the rider.

In Figure 3.3, two models available for purchase in New Zealand in 2020 are shown.

There are also velomobiles/recumbents, which are similar to e-bikes in being propelled by pedals with a mix of human and electric effort (Lieswyn et al., 2017). They have three or more wheels and are enclosed, which gives protection against the weather as well as cargo and passenger space. Podbike and ELF are two velomobiles available for purchase, although ELF has recently stopped production because of bankruptcy, and podbikes are yet to commence production in 2020. Because of their width being greater than 750 mm, and their uptake in New Zealand being minimal, they are excluded from the definition of e-bikes for this research project.

[2] https://electrek.co/2018/04/25/stromer-st5-first-look/

Figure 3.3 eZee Expedir T4 and Christiania 2-wheeler cargo e-bikes[3]

3.2.2 E-scooters (powered standing scooters)

Electric kick scooters (e-scooters) are currently classified in New Zealand as 'recreational' vehicles, and do not require a licence or helmet to operate (Waka Kotahi, 2020c). They are restricted to 300 W maximum power output, and typically have batteries between 100 and 500 Wh, providing a range of 10–30+ km. An example of one of these scooters is shown in Figure 3.4.

Newer electric kick scooters coming onto the personally owned market have substantially higher power outputs than the 300 W recreational class category; however, there is no data available on sales as the power rating of the vehicle is not tracked.

Figure 3.4 Segway Ninebot ES2 e-scooter[4]

3.2.3 E-mopeds (powered seated scooters: 300 to 600 watts)

E-mopeds are uncommon in New Zealand, and in 2019 did not conform to New Zealand regulations because of their power rating being over 300 W. The key feature of e-mopeds is their higher speeds, longer range and higher comfort compared to e-scooters and e-bikes.

[3] https://ebiketeam.co.nz/shop/product-category/cargo-ebikes/

[4] https://www.blacksheeptrading.co.nz/product/pre-order-bluetooth-folding-electric-scooter/

E-mopeds take several different design forms. The Ojo e-moped (Figure 3.5) takes the form of a scaled-up e-scooter with a seat, the Bird Cruiser (Figure 3.6) looks like an e-bike with no pedals, and the NIU e-moped (Figure 3.7) takes the form of a more traditional moped.

Figure 3.5 Ojo e-moped (500 W e-moped)[5]

Figure 3.6 Bird Cruiser e-moped (power output adjusted to local regulations)[6]

Figure 3.7 NIU G0 (400 W e-moped)[7]

[5] https://electrek.co/2019/01/22/ojo-electric-scooters/

[6] https://cruiser.bird.co/

[7] https://www.niu.com/product/gova/g0

3.2.4 E-accessible devices (powered self-balancing boards/mobility scooters)

Traditional mobility scooters are commonly used by people who may have difficulty walking or are unable to drive. These electric devices have existed since the 'friendly wheelchair' Amigo in 1968, and current variants are similar to the Pathrider shown in Figure 3.8.

Figure 3.8 Mobility Pathrider 130XL mobility scooter[8]

Figure 3.9 TravelScoot Deluxe portable mobility scooter[9]

Various types of self-balancing electric wheelchairs exist in the market. Some have a battery that can be clamped on, and some allow for hands-free operation. For example, the Omeo – which is produced in New Zealand – operates by the user leaning forward to accelerate, back to brake, and side-to-side to navigate. The Omeo (Figure 3.10) can travel up to 20 km/h, travel on rough terrain (gravel and sand), and the battery lasts 40 km before needing a recharge. Omeo wheelchairs sold globally cost US$19,950 (Omeo Technology, n.d.). Nino – a robotics company based in France – also produces a similar device (Nino Robotics, n.d.)

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[8] https://ilsnz.org/products/pride-mobility-pathrider-130xl-mobility-scooter?_pos=5&_sid=318ce8b70&_ss=r

[9] https://travelscootnz.co.nz

Figure 3.10 Electric wheelchair (Omeo)[10]

Segway has unveiled designs for a seated two-wheeled self-balancing device called an S-Pod, with a top speed of around 35 km/h, which may be available from as early as 2021. The S-Pod is shown in Figure 3.11 and takes the form of a seat with wheels like the electric wheelchairs; however, it is not solely designed for those with specific mobility needs (Leskin, 2020).

Electric unicycles are also available in the micromobility market and can be used for longer trips, but they have remained a small niche.

Figure 3.11 Segway S-Pod[11]

At the high end, there are enclosed cabin (all weather) mobility scooters, such as the M+ Cabin Scooter[12] shown in Figure 3.12. These vehicles will not meet a 750 mm width restriction, but their relatively low top speed (12 kph) likely makes them a candidate for an exemption.

[10] https://www.stuff.co.nz/national/health/111154718/lifechanging-wheelchair-made-in-new-zealand-ready-for-world-market

[11] https://www.techspot.com/news/83393-segway-s-pod-personal-transporter-fit-king.html

[12] https://www.mobilityplus.co.nz/m+_cabin_scooter.html

Figure 3.12 All-weather mobility scooter being used in Havelock North, New Zealand (photo by Matt Ensor, 2019)

Another variant of the powered self-balancing device that is instead focused on the able-bodied market is the ‘hoverboard’ that was produced by Segway and others. Characterised by a wheeled platform where users stand, these devices may or may not have handlebars and can largely remain balanced without much input from the user. These devices target both the recreational market and the professional market but sell in very small numbers in New Zealand.

3.2.5 Powered non-self-balancing board (ESK8s)

Non-self-balancing boards are typically electric skateboards. Electric skateboards were first produced in the 1990s and retailed for around US$1,200. With the improvements in electric motors and batteries in the mid-2000s, sales and use of the boards grew slowly until the early 2010s, when companies such as the US-based ‘Boosted Boards’ produced boards capable of longer trips and higher performance (Figure 3.13). Reportedly, over 80% of the Boosted e-skateboard riders in the US use the board as part of their commute, and about two-thirds use it daily or very frequently (Bruce, 2019).

Sales of electric skateboards are still small; the market is small and the demographic who use them is niche. Boosted Boards went bankrupt in 2020, with production ceasing.

There are no indicators that this non-traditional mode will grow substantially in mode share.

Figure 3.13 A Boosted Board being used for urban transport[13]

[13] https://cleantechnica.com/2018/07/17/the-future-of-light-electric-vehicles-an-interview-with-ceo-of-boosted-jeff-russakow/

3.2.6 Powered skates

Powered skates are a pair of platforms with a roller wheel for each foot and operate by tilting the feet forwards or backwards.

Segway offers the Drift W1 e-skates in New Zealand (retail NZ$470; PB Technologies, n.d.), shown below in Figure 3.14, which have been described as a lightweight and portable form of personal transportation. They weigh 3.5 kg, can reach 12 km/h, and have a 45-minute typical riding time depending on riding style and terrain.

It is unknown how many have been sold globally, or in New Zealand. Reviews of the product emphasise the recreational value rather than the transport value because of their poor ride quality on most surfaces and small solid wheels.

Figure 3.14 Segway Drift W1 e-skates in use[14]

3.3 Privately owned and shared micromobility

3.3.1 Introduction

It is expected that shared micromobility and privately owned micromobility will have different usage patterns.

Privately owned micromobility has a very low cost per km, balanced by a higher ownership cost. Shared micromobility has high levels of convenience in areas with high availability, but this is balanced by high per km costs and potentially unreliable access where there is low or no availability.

The unknown proportion of privately owned versus shared micromobility has been dealt with by:

- the choice of the range of micromobility, which includes the typical ranges of both shared and privately owned devices
- the use of a lognormal demand curve, where shorter trips in the range of the device are more likely to be taken up with micromobility.

[14] https://ie-en.segway.com/Products/DriftW1

For the assessment of the use of micromobility for the first/last mile with public transport, the research method has calculated the increased uptake of micromobility due to the higher likely availability of shared micromobility. This is detailed in section 5.2.

Micromobility Industries (2019) created a ‘Micromobility Landscape’, which tracks all the relevant owned and shared vehicle manufacturers, policy organisations, software, mobility as a service (MaaS) and accessory companies currently in the market for lightweight electric vehicles. The Micromobility Landscape is included in Appendix A.

3.3.2 Dockless micromobility

Dockless refers to shared vehicles (e-bikes and e-scooters) that are unlocked generally via a smartphone application and can be left at the user’s destination; that is, they do not have to be returned to a docking station. There are generally limits within a city as to where the vehicles can be left.

Shared dockless micromobility vehicles include e-scooters and e-bikes that are hired via a smartphone app. The service is typically regulated by the local authority’s appropriate bylaws if available, although new unregulated commercial models are appearing. Auckland Council publishes a code of practice for shared e-scooters and e-bikes along with licence assessment criteria (Auckland Council, 2019a).

In New Zealand, shared dockless e-scooters have been adopted through a combination of trials and permits in Auckland, Hamilton, New Plymouth, Hutt Valley, Wellington, Christchurch and Dunedin. The trips made on shared e-scooters tend to be short (less than 1.5 km). Figure 3.15 shows an example of a Flamingo shared e-scooter in New Zealand. As at December 2019, there are seven shared-use micromobility companies operating in New Zealand that offer pay-per-ride services: Lime, Flamingo, Beam, Wave, Jump, Blip and Neuron.

Shared dockless e-bikes were proposed in New Zealand, starting with Jump launching in Auckland in 2020. An example is shown below in Figure 3.16. These e-bikes generally have some sort of carrying accessory, such as the front basket on the Jump e-bike, and operate as a pedal-assist e-bike, where the user must continue to pedal to activate the electric motor.

Figure 3.15 Flamingo e-scooter[15]

Figure 3.16 Jump e-bike[16]

[15] https://idealog.co.nz/tech/2019/07/nz-owned-e-scooter-company-flamingo-flaps-its-way-auckland-market

[16] https://www.wired.com/story/how-jump-designed-a-global-electric-bike/

Monthly subscription packages to e-scooters and e-bikes are a new service, which both reduce the barrier of purchase price and may avoid council bylaws. There are many companies offering monthly subscription services. Examples of three different business models are:

- **Single vehicle, user responsible for charging**
  In Berlin, GroverGo offers users the rental Xiaomi e-scooter M365 at the monthly subscription of approximately NZ$87 (€49.90). The monthly subscription is inclusive of Grover Care damage protection (O'Hear, 2019). Similarly, Vanmoof offers a subscription service starting from €19 per month, which includes maintenance, service and insurance for a standard bike (with expansion to e-bikes planned). This is available in Amsterdam, Berlin, Tokyo, London, Paris, San Francisco, and New York and can be used by businesses or individuals (Ricker, 2018).
- **Single vehicle, operator responsible for charging**
  In San Francisco, Bird offers a monthly subscription for US$25 (approximately NZ$40), which includes dropping an e-scooter off to the user and picking it up when finished (typically overnight) (Fingas, 2019). Beam has started a subscription model in Christchurch where it is possible to rent a Beam e-scooter for exclusive personal or company use for a weekly, fortnightly or monthly fee (Beam Mobility New Zealand, 2020). These e-scooters are branded differently to the main Beam fleet.
- **Vehicle fleet, operator responsible for charging**
  Jump offers a US$25/month 'Ride Pass' that provides 30 minutes per day use of the Jump scooters and e-bikes in relevant US markets, and discounted use beyond that, while also offering discounts for Uber rideshare rides and UberEats food deliveries (Dorsey, 2019). The Lime 'Week Pass' offers unlimited free scooter unlocks (typically a $1 saving per ride) for seven consecutive days (Lime, 2019a).

The commercial model for shared mobility is still maturing, and further changes are expected because of improvements in efficiency of re-charging activities, longer lifetimes for devices, and potential efficiencies of scale.

3.3.3 Technology

As technology changes and grows rapidly, so has vehicle hardware performance. Current issues that are being addressed include:

- **Batteries**
  For e-bikes manufactured in the US and the EU, there are two main types of battery fitted to e-bikes: lithium ion (Li-Ion) and lithium polymer (LiPo). The benefits of improvements in battery technology will be passed on to micromobility. Because the typical battery size for micromobility devices is small when compared to electric vehicles, the challenges around battery supply chains affecting electric vehicle manufacturers (Barclays, 2019) are not expected to slow the production of micromobility devices.
- **Build quality**
  E-scooter sharing companies are beginning to roll out more durable, longer-lasting versions of their scooters that may improve their ability to stay in service longer. The latest models from TIER, as an example, are expected to last in service for 24 months (TIER, 2019). This is a substantial improvement on the early versions of shared systems, where the scooters were lasting 1–3 months (Hours, 2019).
- **Software**
  The first shared micromobility services had proprietary systems to track their assets. Many were prone to damage, leaving the scooter or bike in an unknown location. In the period that the industry has been around, new services have emerged from companies such as CoModule and Particle offering an end-to-

end service that is fully maintained, substantially improving connectivity. The dominant companies in shared micromobility have improved their own proprietary systems.

- **High-accuracy GPS**
  Existing shared micromobility systems typically rely on GPS to provide their location. In high-density areas, this signal can substantially degrade to the point that the vehicle is not able to be easily located by the user. New systems are being deployed for higher accuracy location, including the Lumo system being trialled with Blue Duck Scooters on the Dublin City University campus, providing 1 cm accuracy positioning.

Micromobility vehicles employ the same base technology as consumer computing technology. For this reason, it is expected that these vehicles will soon adopt similar technological features as those found in smartphones, including cameras, computing power, accelerometers and other sensor types. These will form the basis of computing platforms that can be used for autonomy for micromobility vehicles, similar to the efforts to infuse autonomy into automobiles.

Autonomous e-scooters are scooters with self-repositioning capability that are remote-controlled. The roll-out of these is expected to achieve up to 10 times higher utilisation than is currently possible in docked systems (Kondor et al., 2019). This is due to the current high effort and cost of moving e-scooters from where they accumulate (trip end point) back to areas of high demand (eg, train stations). The benefit of autonomous e-scooters is that fewer scooters are required to meet demand; however, appropriate infrastructure is an important component to make this successful.

The additional cost of hardware and software to enable autonomy was estimated as anything from 20% to three times the current purchase cost of an e-scooter depending on the level of capability built into the vehicle. Therefore, autonomy becomes financially viable if it can reduce the shared fleet size by more than a half. The autonomous e-scooter service would need to be reliable, but if available within a short wait time (similar to Uber), it could become a genuine transport choice.

To avoid conflicts with other road users, particularly pedestrians and cyclists, infrastructure would be required to allow the autonomous vehicle to relocate at a speed to enable a reliable service to the customer – there are likely to be issues here around the acceptability of reallocating road space.

The advantages of autonomous scooters compared to dockless scooters are that cities would need fewer scooters to meet demand, scooters could drive themselves to a charging point, and e-scooters could become a more attractive travel choice because people would not have to walk to find a scooter. However, the perceived safety of autonomous scooters and public acceptance of self-relocating e-scooters may be barriers to their implementation.

Tortoise has developed an operating system and has agreed with the city of Peachtree Corners in Georgia, USA, to trial semi-autonomous e-scooters at the Atlanta Tech Park (Hawkins, 2019a). The system uses cameras, radar, a processor, a motor and retractable training wheels. The three repositioning scenarios envisioned by Tortoise are:

- relocating a scooter to a high-demand area after a trip is complete
- creating a stop where scooter users can request a scooter to go to a particular spot
- user requests the e-scooter go directly to where they are.

Figure 3.17 Segway T60 autonomous scooter[17]

Uber had an autonomous micromobility division for its Jump service (Hawkins, 2019b), Segway Ninebot has developed (and is currently trialling) its T60 autonomous scooter (Yang & Goh, 2019), and Weel (a start-up based in Seattle) is developing a self-balancing/driving bicycle to be developed into a service for university campuses (Gauquelin, 2019). All are expected to be deploying initial trials in 2020/21.

3.4 Mode shift to micromobility

A key objective of this research is to identify growth in the use of micromobility modes to 2030 due to behaviour change when people switch their travel, or parts of their travel, from other modes.

This part of the literature review examines:

- the range of mode shift that is occurring to micromobility in New Zealand and internationally
- evidence on the reasons why the mode shift is occurring, and the characteristics of the trips being made using micromobility devices, including differences between micromobility vehicle types
- evidence on mode shift occurring due to integration of micromobility with public transport trips
- identification of elements that affect mode shift (eg, infrastructure) and what contributes to the effects.

3.4.1 Range of mode shift

International and New Zealand research on mode shift illustrates that micromobility is replacing private vehicle, public transport, cycling and walking trips to varying degrees. Barclays (2019) reported that in Copenhagen, speed (ie, travel time) is the most cited reason to prefer cycling, above convenience, exercise, cost and environment. It is expected that if an e-bike or e-scooter becomes the quickest way to travel within or across a city, it will replace many car and public transport trips.

3.4.1.1 Replacing vehicle trips

- In some car-dominated countries such as Australia, the US and Canada, it was observed that e-bikes mainly replace vehicles trips (Jahre et al., 2019). A recent meta-review of e-bike mode shift studies suggests that as e-bike adoption increases, the percentage of e-bike trips that are replacing car trips is also increasing (Bigazzi & Wong, 2020).

[17] https://www.ces.tech/Innovation-Awards/Honorees/2020/Honorees/K/KickScooter-T60-by-Segway.aspx

- In a US e-bike owners survey, 28% of respondents cited a core reason for them making an e-bike purchase was to replace car trips (MacArthur et al., 2018).
- In San Francisco, a survey of Lime e-scooter users showed that if an e-scooter was unavailable for their most recent trip, 51% of respondents would have considered using a ride-hailing service (Uber, Lyft or taxi), while 9% would have considered driving their personal vehicle, and 4% would have considered car-sharing (Chang et al., 2019b).
- In a trial of e-scooters and e-bikes in Santa Monica, California, 2.7 million trips were taken between October 2018 and September 2019. Of those, 49% replaced trips that would have otherwise been made by car (City of Santa Monica, 2019).
- Barclays (2019) also reported that from a global survey of Lime users, 30% had replaced a car trip with a bike or e-scooter trip.
- Fitt and Curl (2019) reported that 28% of e-scooter trips replaced a private vehicle or ride share trip.

3.4.1.2 Replacing active mode trips

- A report by Chang et al. (2019b) suggested that shared e-scooters in two US cities are largely replacing walking and cycling. In Denver, Colorado, 57% of respondents to the online survey stated that e-scooter trips replaced walking (43%) and biking (14%) trips. In Portland, Oregon, 46% of respondents stated that they would have either walked (37%) or cycled (9%) if a shared e-scooter had not been available for their last trip.
- In New Zealand, a 2019 online survey of Auckland and Christchurch residents found that 14% had replaced a private vehicle trip with an e-scooter, and 10% had replaced an Uber/taxi trip with an e-scooter (Kantar TNS, 2019). Private e-scooter owners reported that the trip types they replaced most were those by public transport, cycling and walking.
- In the Santa Monica trial of e-scooters and e-bikes, 39% of trips replaced walking trips, which appears to be mainly due to people using the vehicles to speed up their commute or running errands (City of Santa Monica, 2019).
- Fitt and Curl (2019) reported that 57% of e-scooter trips replaced active mode trips (walking, biking, e-biking, skateboarding).

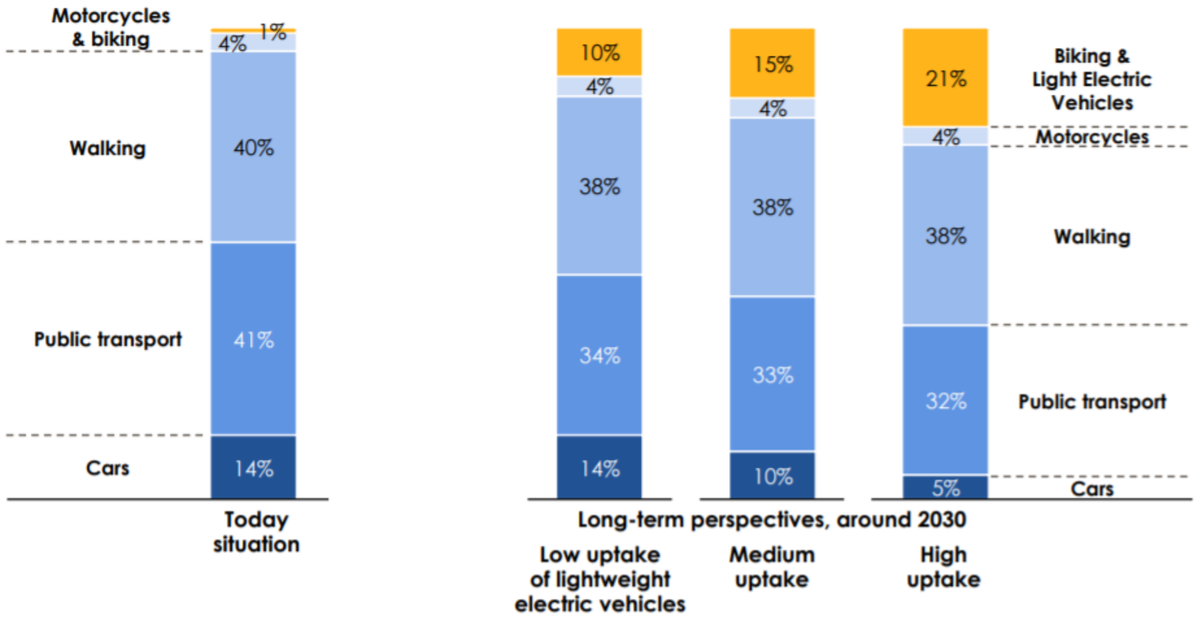
3.4.1.3 Replacing public transport trips

- Four percent of e-scooter trips in Christchurch replaced public transport trips (Lovett, 2019).
- Ten percent of e-scooter trips in Portland, Oregon, replaced bus/light rail/streetcar trips in the 2018 e-scooter pilot (Portland Bureau of Transportation, 2019).

3.4.1.4 Mode share

Carbone 4 (2019), in a study for Bird, reported biking and shared dockless micro-modes had around 1% mode share in Paris in 2019, which had been increasing rapidly. The maximum predicted mode share for cycling and light electric vehicles (micromobility) is 21% of all trips by 2040. The results of the study are shown in Figure 3.18.

Figure 3.18 Current and predicted mode share in Paris (Source: Carbone 4, 2019, p. 11)



3.4.1.5 New trips

Shared micromobility vehicles are also generating new trips that would not have been taken before shared e-scooters were available. These trips appear to be mainly for shopping and recreation. Surveys of shared e-scooter users in the US have shown that 7%–8% of people state that if an e-scooter was not available, they would not have travelled (Chang et al., 2019b). The Fitt and Curl (2019) New Zealand study also reported that 7% of e-scooter trips were new trips that would not otherwise have been made.

There are also anecdotal reports from retailers located in and around downtown Auckland and those in the wider central business district (CBD) area saying e-scooters have increased foot traffic to their stores, resulting in more sales (A. Shaw, 2019).

3.4.2 Trip purpose

Two US cities have completed research on shared e-scooter trip purpose:

- Santa Monica – 29% of trips were work related and 26% were for recreation (City of Santa Monica, 2019)
- Portland – 71% of trips were for utility (ie, to a destination), while 29% were for recreation (Portland Bureau of Transportation, 2019).

Chang et al. (2019b) reported that work and school commuting was the top reason for using shared e-scooters in Austin, Portland and San Francisco.

A global study by Lime (2019b) demonstrated that the majority of rides are for local, everyday trips. The survey showed that 37% of users rode a Lime e-scooter to commute to/from work or school, 14% used them to run personal errands, and 9% used them for first/last mile trips to and from public transport. The same survey reported that speed and fun were the main reasons users chose an e-scooter over other modes, with convenience and affordability also motivating users.

A study in early 2019 found that people who had used e-scooters more than once reported using them to travel to work, social engagements, and to shops or supermarkets (Fitt & Curl, 2019).

A mode shift study in Christchurch (Kantar TNS, 2019) reported that the top three uses by e-scooter owners are:

- fun/recreation
- for socialising (eg, travelling to cafes, sports activities)
- commuting.

Most shared e-bikes are designed with a front or rear rack, allowing users to carry a small amount of shopping.

- Jump e-bikes are designed with a front basket that allows users to carry a handbag or small amount of shopping.
- The Bykko shared e-bikes in Newcastle, Australia, have a small front basket and a rear rack, which allows users to carry luggage on the front and rear.
- In Milan, the BikeMi bikes have front baskets.
- The Oslo City bikes have a small rack that can fit a handbag or satchel.
- Smide e-bikes in Zurich have a large basket on a rear rack.
- The Lisbon e-bikes have a small front basket.
- In the Netherlands, e-cargo bikes with a large box on the front that can carry two children can be rented by the hour or per day.

The provision of baskets, seats, and a more stable platform (e-mopeds, e-accessible devices) is likely to make these vehicles more attractive for a wider range of trip purposes.

A survey by Waka Kotahi (2018) of 52 staff at Tauranga City Council who own e-bikes showed:

- 92% of participants use their e-bikes to commute to work
- 58% of respondents reported riding to work four to five days a week, with an additional 24% riding two to three days a week
- 72% were using the e-bike to commute instead of the car
- every survey participant would recommend others try riding an e-bike to work.

3.4.3 Trip length

Wild and Woodward (2018) reported on how e-bikes are assisting towards active transport mode shift in Auckland. The research found that e-bike users were comfortable commuting up to 15 km each way, and users were able to carry more (children and shopping), thereby making trip-chaining easier. Overseas e-bike studies have also reported an average e-bike trip radius of 10 km in Norway (Fyhri & Fearnley, 2015) and 15 km in the Netherlands (Wiersma, 2020). This is two to three times the average pushbike trip radius. Intelligent Energy Europe (2010) conservatively estimated that each e-bike on the road removes on average 900 car kilometres per year from the transport network.

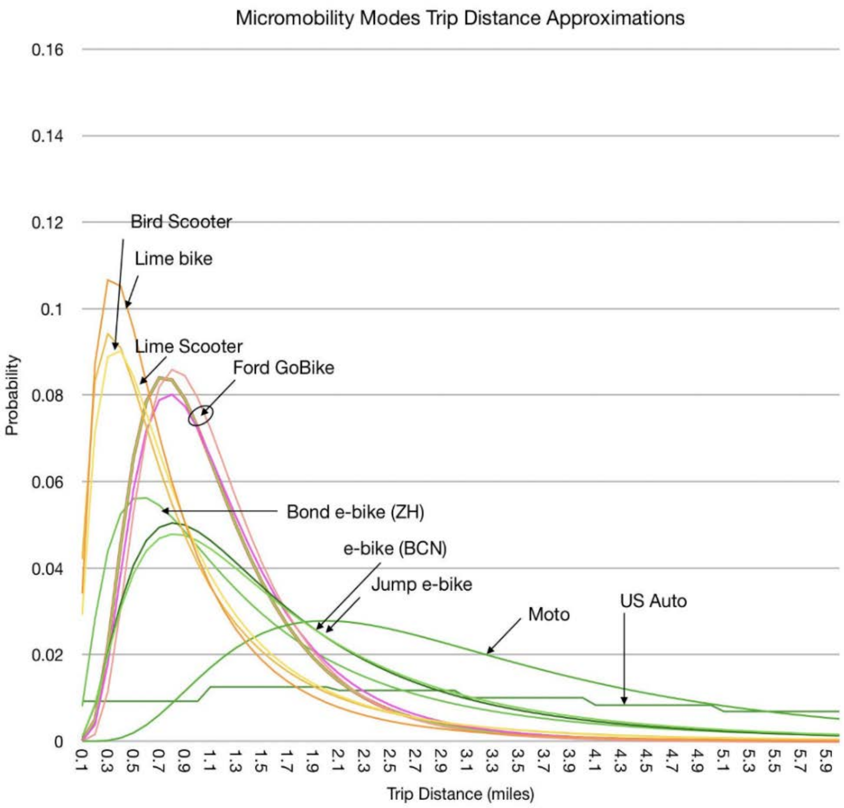
There are some differences in the usage of private and shared micromobility vehicles.

All shared micromobility vehicles have in-built capability to allow measurement of trip distances. However, personal e-scooters and e-bikes do not have this ability, and therefore rely on self-reporting of trip distances.

A review of trip lengths by shared micromobility modes in the San Francisco Bay Area was completed by Dediu (2019) and is illustrated in Figure 3.19. The key observations were:

- e-scooters were shown to have the shortest average trip distance – approximately 1.6 km (1 mile)
- shared conventional bicycles had an average range of 2 km (1.3 miles) and shared e-bikes generally around 2.5 km (1.5 miles) but with a larger spread up to 8 km (5 miles).

Figure 3.19 Trip length for various shared micromobility vehicles (Source: Dediu, 2019)



Dockless e-bikes and e-scooters may be more attractive for short trips (less than 5 km (3 miles)) because they are cheaper and possibly faster, which may potentially reduce ride-hail services (eg, Uber).

Fitt and Curl (2019) reported that the average trip distance by e-scooter was 1.9 km. When considering which mode was replaced by the e-scooter trip, the distance varied from 1.5 km (walking) to 3.7 km (taxi).

3.4.4 Integration with public transport

One of the main deterrents to the uptake of public transport is how people get from the start of their trip to the public transport pickup point and/or from the public transport drop-off point to their final destination (Hyde & Smith, 2017). This is known as the ‘first/last mile’ deterrent.

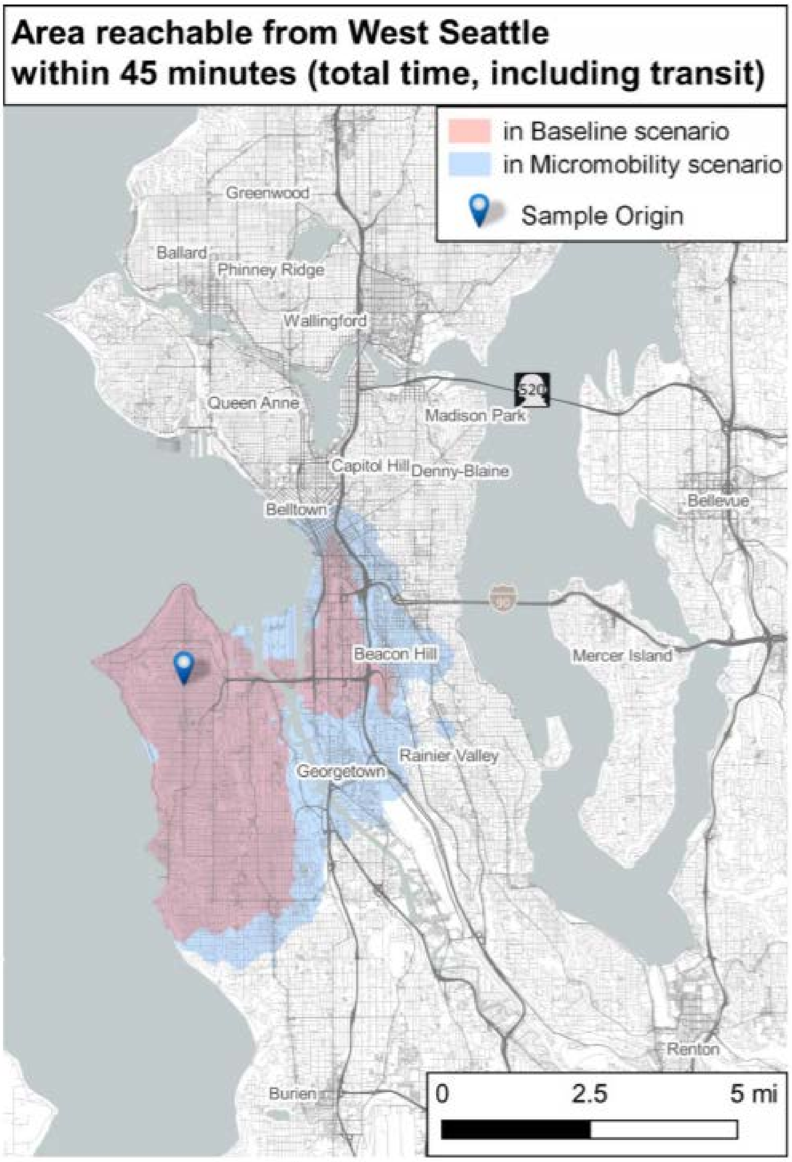
Reducing this deterrent – by providing a quicker trip to/from public transport or by increasing the distance that people are willing to travel to/from public transport when compared to walking – would likely increase public transport patronage (Wang & Odoni, 2016).

It would also reduce the predominant factors contributing to society’s inability to connect people with jobs (Hyde & Smith, 2017).

It may be possible to increase the use of micromobility with public transport through the integration of accessing and paying for shared micromobility within the same system used for public transport. These mobility-as-a-service (MaaS) apps are further described in Section 3.4.5.3.

The Micromobility Coalition (2019) reported that widespread availability of micromobility services, particularly for first/last mile connections, would increase access to 35% more jobs for Seattle city residents while shortening commute time and reducing reliance on cars. This is illustrated in Figure 3.20.

Figure 3.20 Potential increase in access to jobs by implementing shared micromobility vehicles in Seattle (Micromobility Coalition, 2019, p. 4)



3.4.4.1 First/last mile

Micromobility can increase the catchment for public transport, as users who previously considered an 800 m (10 minute) walk to or from a station or stop being too far can now use an e-scooter or e-bike to make this first/last mile of their trip.

Pilot programmes have been conducted in cities across the world to test the ability of micromobility to increase public transport ridership. It has been challenging to isolate the impact of micromobility in an independent study.

In 2018 the Sacramento Regional Transit District (SacRT) adopted a micromobility strategy to address the first/last mile problem. The agency partnered with Jump, an electric micromobility provider, to offer on-demand access to and from light rail stations via e-bikes. SacRT worked with Jump to install charging bays inside seven light rail stations, which allowed commuters to park an e-bike within the station, where it could charge while docked. On the return trip, the commuter could unlock a charged e-bike at the station and ride it to their final destination.

After the year-long trial, ridership on SacRT's light rail system grew by 18.5% from July 2018 to July 2019 (American Public Transport Association, 2019). A lesson learned from this pilot was the importance of data sharing in order to evaluate the trial robustly. SacRT officials could not isolate the extent to which their micromobility programme contributed to that growth. SacRT and Jump did not have a data-sharing agreement that allowed them to measure the extent of influence of the bike-sharing trial. The information needed included the utilisation rates for the bikes parked at the light rail stations, the number of micromobility trips taken to and from stations, and the percentage of requested rides that are unfulfilled (American Public Transportation Association, 2019). The agency mentioned the importance of collaborating with academics to better understand the marginal impact on ridership of its micromobility devices.

The Fitt and Curl (2019) study reported that, in New Zealand:

- 28% of respondents had completed a journey using a combination of e-scooter and public transport.
- 20% of e-scooter users had travelled to or from a public transport station.

To date, there have not been any prominent examples of shared micromobility being integrated into transport systems and receiving subsidy funding for their first/last mile connection capabilities.

Theoretically, this approach could mean higher volumes of people accessing key employment and social centres; however, to fully understand the level of increased access, aspects such as land-use and travel behaviour need to be assessed and modelled. This is covered in sections 5.1 and 5.2.

3.4.4.2 Carriage on public transport vehicles

During the SacRT trial in 2018 it was noted that some passengers tried to board the train with an e-bike, which was not allowed in the agreement between SacRT and Jump.

In New Zealand, Ensor et al. (2010) found that the design of public transport vehicles either enabled or prohibited the carrying of bicycles on board. They forecast the demand for taking bicycles on public transport as 1.2% of patrons for buses and 3% of patrons for trains and ferries.

In New Zealand, whether micromobility devices may be carried on public transport services is determined by the code of conduct or conditions of carriage of each individual operator. Often, specific vehicle types are named in addition to specific vehicle characteristics, including dimensions, weight, and batteries. The majority of the local public transport operators have specific regulations on e-bikes, e-scooters and skateboards. However, none of them mentioned or described the on-board permissions of any other non-traditional mobility vehicle. Table 3.1 shows a review of the regulations across several cities in New Zealand.

Table 3.1 On-board restrictions from conditions of carriage, code of conduct and terms and conditions

City/region	Public transport	Bikes allowed on board	Other non-traditional transport devices/vehicles
Auckland	Bus	Folding bike only	• Anecdotal data indicates that small, foldable e-scooters are permitted.
	Train	Yes (folding bikes anytime, other bikes OK outside peak hours)	• Personal motorised mobility devices, such as Segways, are not permitted on passenger services. Anecdotal data indicates that small, foldable e-scooters are permitted.
	Ferry	Yes (except to Department of Conservation managed islands)	• E-scooters allowed (except to Department of Conservation managed islands)
Wellington	Train, ferry	Yes	• Small, foldable scooters, skateboards and similar equipment may generally be carried inside Metlink ferries, buses and trains. Bikes are restricted to three bikes per service.
	Bus	Folding bikes are permitted	• Compact scooters are permitted on board buses. • By 2020 most Metlink buses will have bike racks that can carry two standard bikes at a time.
Otago	Bus	Yes, bike racks can carry up to two bikes at a time (Otago Regional Council, n.d.)	• Skateboards and similar equipment may generally be carried inside the bus. • Scooters should be folded before boarding. Mobility/motorised scooters are not allowed on the bus. • E-bikes (less than 25 kg) can be mounted on bus bike racks. E-bikes with liquid lead acid batteries, and petrol and other similarly powered bikes, are not permitted on bike racks.
Christchurch	Bus	Yes, only on bike racks on the front. Folding bikes can be taken on the bus (Metro, n.d.)	• Skateboards and similar equipment may generally be carried inside the bus. • In one trial, if the bike rack is full, a rider can utilise the bike rack that is in the wheelchair space (if it is not occupied). • E-bikes (less than 24 kg) can be taken on Metro buses after removing the battery. • Wheelchairs and power wheelchairs can be carried on most buses subject to the dimension.
	Ferry	Yes (Black Cat Cruises, n.d.)	–
Nelson	Bus	Yes (only on bike racks on the front) (Nelson City Council, n.d.)	• Skateboards and similar equipment may generally be carried inside the bus. • Can bring bikes on N-Bus with new racks that will carry two bikes at a time.
Northland	Bus	Yes (folding bikes only) (Northland Regional Council, n.d.)	–
	Ferry	Yes	–

City/region	Public transport	Bikes allowed on board	Other non-traditional transport devices/vehicles
Hawke's Bay	Bus	Yes (only on bike racks on the front) (Hawke's Bay Regional Council, 2018)	• Skateboards and similar equipment may generally be carried inside the bus. • Wheelchairs with less than 240 kg can be carried on all buses (subject to certain dimensions).
Waikato	Bus	Yes (only on regional routes and only on bike racks on the front), and folding bikes can be taken on board (BUSIT, n.d.)	• BUSIT does not allow mobility/motorised devices on the bus.
	Train	Yes (Waikato Regional Council, 2020)	• Four bike spaces will be available on the Hamilton to Auckland train (commencing mid-2020).
Bay of Plenty	Bus	Yes (only on bike racks on the front) (Baybus, n.d.)	• E-bikes are not permitted on bus bike racks because of weight restrictions.
Gisborne	Bus	Yes (only on bike racks on the front) (Gisborne District Council, n.d.)	–
Taranaki	Bus	Yes (all buses have bike racks) (Taranaki Regional Council, n.d.)	–
Manawatū	Bus	Yes (only one route has bike racks on the buses) (Horizons Regional Council, n.d.)	• Uzabus and Tranzit Coachlines do not allow e-scooters or mobility/motorised scooters on board (because of weight restriction), but manual ones are fine.

3.4.5 Elements affecting mode shift to micromobility

This subsection of the report details those elements that were identified during the literature review as contributing to the level of mode shift to micromobility, beyond the trip characteristics themselves.

3.4.5.1 Trip cost

Trip costs are made of both capital expenditure (purchase) and operating expenditure (fees or maintenance/electricity).

Capital costs

The cost of purchasing an e-scooter is typically between NZ$500 and NZ$1,500, with the cost of an e-bike starting at approximately NZ$1,500. While significantly cheaper than other powered forms of transport, capital cost is still a significant barrier.

There are examples of where access to an e-bike without a capital cost has increased usage. Some countries and businesses have recognised that high purchase cost is a barrier and offer a subsidy on e-bikes to enable more people to afford them. Some examples are listed below.

- In Brighton in the UK, 80 employees were loaned an e-bike for 6–8 weeks. The average distance travelled per week was 24–32 km, the time spent cycling was 2–2.5 hours per week, and the reduction in car mileage was 20% (Cairns et al., 2017).
- Sweden subsidised e-bikes by €1,000 (NZ$1,714) per bike, which is approximately 25% of the purchase price, and saw strong growth in e-bike sales because of this (Barclays, 2019). This scheme ran between September 2017 and September 2018. Sales grew over 50% when the scheme was first introduced but

dropped just 16.5% since it came to an end. In the September 2018 to August 2019 period, 86,000 e-bikes were sold, compared to 103,000 the year before (Groves, 2020).

- Tauranga City Council negotiated with e-bike supplier Electrify to offer staff a discount on e-bikes and payment via a salary advance, resulting in 52 staff purchasing e-bikes in 2018. In 2018, Waka Kotahi launched a guide on employer e-bike purchase support schemes, which is intended to support schemes similar to the one by Tauranga City Council (Waka Kotahi, 2018). Salary advances are not possible at the central government level.
- In response to the view that purchase prices were a barrier for growth in e-biking, the New Zealand Government has developed a scheme to offer employees a discount on e-bikes through bulk buying negotiation with suppliers (Genter, 2019), and Waka Kotahi (2020b) has published guidance to employers on how to subsidise or assist employees with e-bike purchases.

Operating costs

Operating costs vary between shared and privately owned micromobility.

Shared micromobility has significant operating costs per km through the labour and direct costs of recharging, repositioning and maintaining the shared fleet. These costs are recovered through charging users. For shared e-scooters, typical rates are $1 to unlock the vehicle and around 40 cents per minute (Keogh, 2020a). At an average speed of 8.4 km/h (Auckland Council, 2019b), this equates to around 140 metres per minute, or roughly $3.85 for a 1 km trip, or $15.25 for a 5 km trip ($3.05/km).

This is cheaper than car rideshare. For example, Uber in Auckland in 2019 charged a similar 41 cents per minute, but also added a $1.16 charge per km.

Operating costs for privately owned micromobility are insignificant and limited to the cost of charging, repairs and maintenance, and potentially insurances.

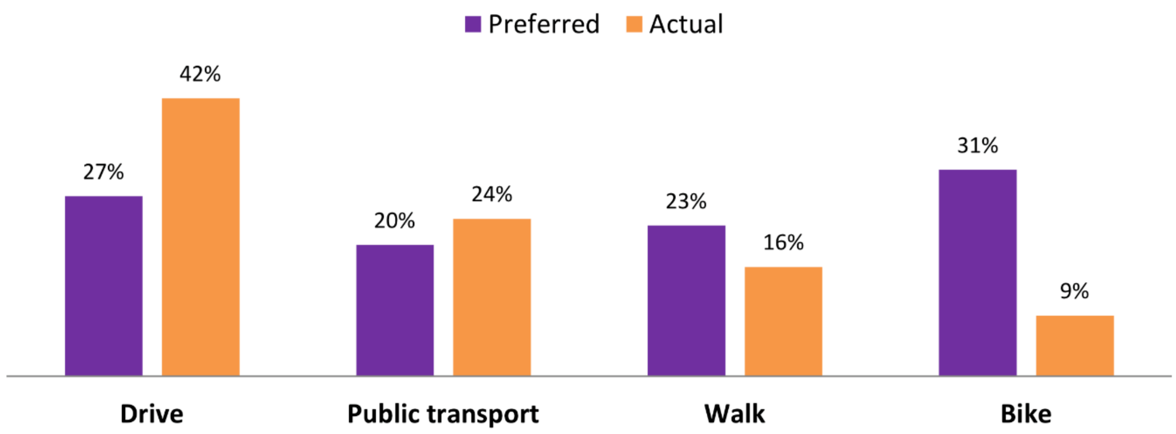
3.4.5.2 Infrastructure

In no cases in the research were mixed-traffic roads preferred by micromobility users. Research on e-scooter rider preferences shows the following results.

- A study by Christchurch City Council (2019a) found that e-scooter users preferred riding on shared paths, followed by separated paths and footpaths.
- In Portland, 68% of e-scooter users chose bike lanes as their preferred location to ride (Chang et al., 2019b).

The Wellington Cycle Demand Analysis 2014 survey of Wellington residents (Pettit & Dodge, 2014) showed that people would prefer to travel by active modes more than they currently do, as illustrated in Figure 3.21.

Figure 3.21 Preferred mode of travel for Wellington commuters (Source: Pettit & Dodge, 2014, p. 9)



This shows that the most preferred mode of travel (biking) had the lowest actual use.

Survey research by Auckland Transport showed that 60% of Aucklanders said that they would like to bike in their neighbourhood if the street conditions were made safer for cycling (Auckland Transport et al., 2017).

When paired with the data that the primary motivator for getting riders to increase their riding activity is having dedicated on-street infrastructure to improve the feeling of safety, there is a strong suggestion that building better quality infrastructure to support the use of these modes will help improve uptake.

3.4.5.3 Mobility as a service (MaaS)

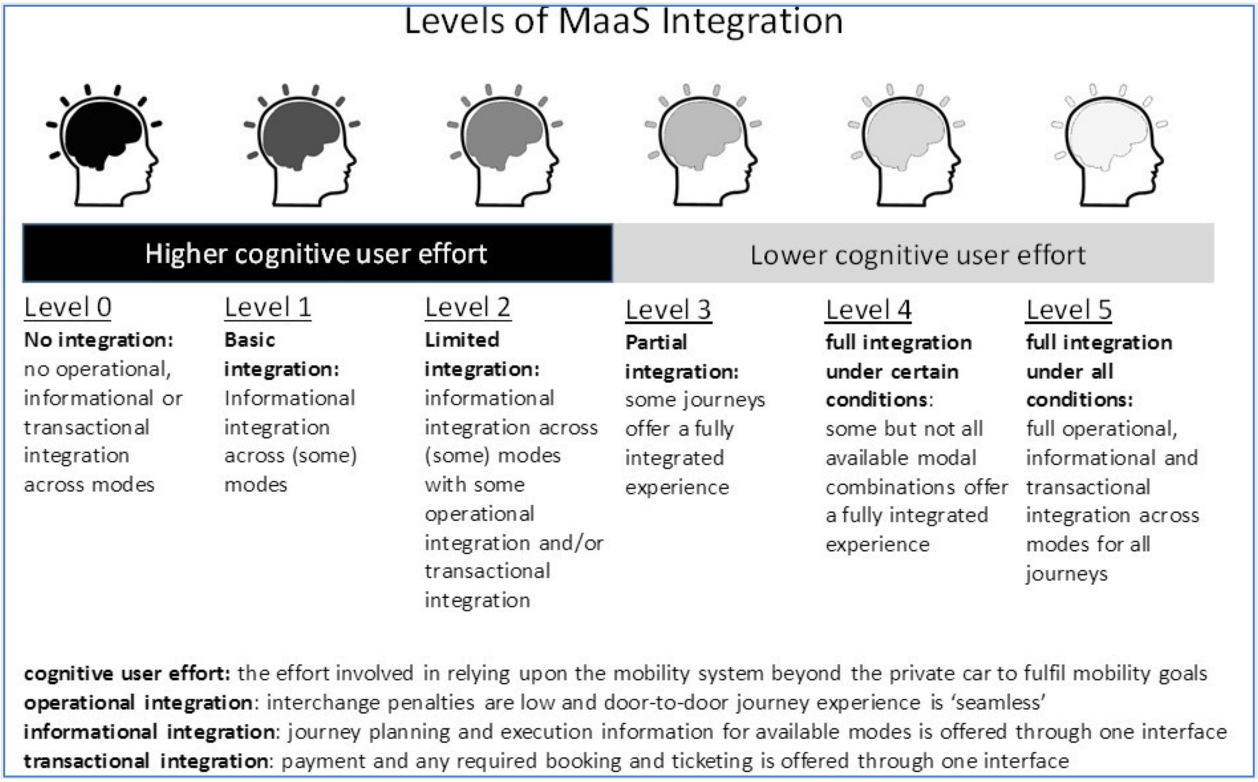
MaaS is the concept of offering a 'frictionless' transport solution that requires a single point of planning and payment for journeys spanning multiple modes – and, potentially, multiple providers, public and/or private. This would generally be offered in the form of a web-based platform or app, allowing users to view end-to-end trip solutions and select their preference based on cost, time or convenience.

The key barriers reduced by MaaS are a lack of information on various modes (including non-traditional) and a lack of integrated payment.

MaaS has the potential to enhance the growth and uptake of micromobility, although evidence of this occurring so far is unclear.

Figure 3.22 identifies a potential schema for MaaS design and functionality (Sochor et al., 2017). It could be expected that the higher the 'Level' (the lower the cognitive user effort required), the greater the influence MaaS will have on micromobility mode shift. MaaS can take time to establish, with many of the current systems operating at Level 2 and below.

Figure 3.22 Levels of MaaS integration (Source: Lyons et al., 2019, p. 27)



In 2019 Uber integrated its Jump e-scooter share into its proprietary Uber app in New Zealand. With the purchase of Jump by Lime in June 2020, this integration may change and expand beyond the Uber app.

There are no other known New Zealand MaaS integrated payment implementations for micromobility in 2020.

There are several MaaS platforms outside of New Zealand that already integrate shared micromobility with public transport.

- The Google Maps journey planner[18] currently provides four options (driving, public transport, walking, or biking) with estimated travel times for each. In 2019, Google Maps began showing Lime vehicles (e-scooters and e-bikes) as a transport option in some cities. The app displays where Lime vehicles are available, how long to walk to the vehicle, a cost estimate, battery range, total journey time and expected time of arrival (Intelligent Transport, 2019).
- The Whim app,[19] developed by MaaS Global, was first used in Helsinki, Finland, and has expanded across Europe. The app allows customers to plan and pay for trips using public transport, bikeshare, taxi and car-share. Customers can choose to pay per ride or pay a monthly subscription.
- The Citymapper app[20] is available in 39 cities worldwide, and includes public transport, bikeshare and taxis. It has a weekly subscription service available in London, which has a 4-week minimum length.

[18] maps.google.com

[19] www.whimapp.com

[20] www.citymapper.com

- Trafi[21] partnered with BVG (Berlin Transport Company) to develop the Jelbi mobility app in Berlin, which launched in 2019 (Busvine, 2019). The MaaS platform connects all types of transport (public transport, car-sharing, scooters and bikes) and enables the user to plan and purchase all trips through the one app.
- Wunder Mobility[22] operates a 'white label' software-as-a-service tech backend for carpooling, car sharing and fleet tracking services. They permit traditional transport companies to 'digitise' their offerings and bring their services into a MaaS digestible format.
- The GoLA app was developed by the Los Angeles City Council in partnership with Xerox. It gave customers the option to select their preferred transport mode by time, price, and environmental impact using the language 'sooner', 'cheaper', 'greener' (Koorey, 2019). It is no longer operational.
- In Colorado, Uber added public transport information to their app because of customer demand for the app to encompass their entire trip, including first/last mile travel (Koorey, 2019); however, uptake has been limited, with only around 40 trips/day occurring on this option.

Integrating payment into one MaaS system is a key challenge. The US Federal Transit Administration Mobility Payment Integration Program is designed to integrate payment system technologies into the innovative and emerging mobility systems being developed under Mobility on Demand. This is part of a 2019 funding opportunity for three areas of inquiry: Mobility on Demand, Strategic Transit Automation Research and Mobility Payment Integration (Federal Transit Administration, 2019).

3.4.5.4 Perception of safety

Safety is a contentious issue for micromobility. Following the introduction of shared e-scooters in New Zealand, injury incidents were commonly reported in the media. The actual injury rates and statistics are outside the scope of this research project; rather, it is the perceptions of safety that impact on mode shift.

In terms of safety perceptions affecting mode share to micromobility:

- A survey by Kantar TNS (2019) reported that compulsory helmets would discourage 24% of people from trying an e-scooter.
- The Kantar TNS (2019) survey reported that banning e-scooters from footpaths or cycle lanes was likely to hinder uptake.
- Perceived safety is a barrier for people to try e-scooters. The Kantar TNS (2019) study showed 31% of non-users were put off trying e-scooters because of safety concerns.

3.4.5.5 Weather

Weather and climate play an important part in which transport mode is selected. For example, Barclays (2019) reported that in New York City the bike share scheme has much lower usage in the winter months, with up to a 40%–50% decline in bikeshare usage. Shared e-scooter and e-bike use is much lower in winter and in poor weather conditions. For example, in heavy rain, Jump e-bike trips reduced by 78% (Chang et al., 2019b). In areas with severe winters, such as Alberta, Canada (Conrod, 2019), and Spokane, Washington (Smay, 2019), shared micromobility is removed between November and March.

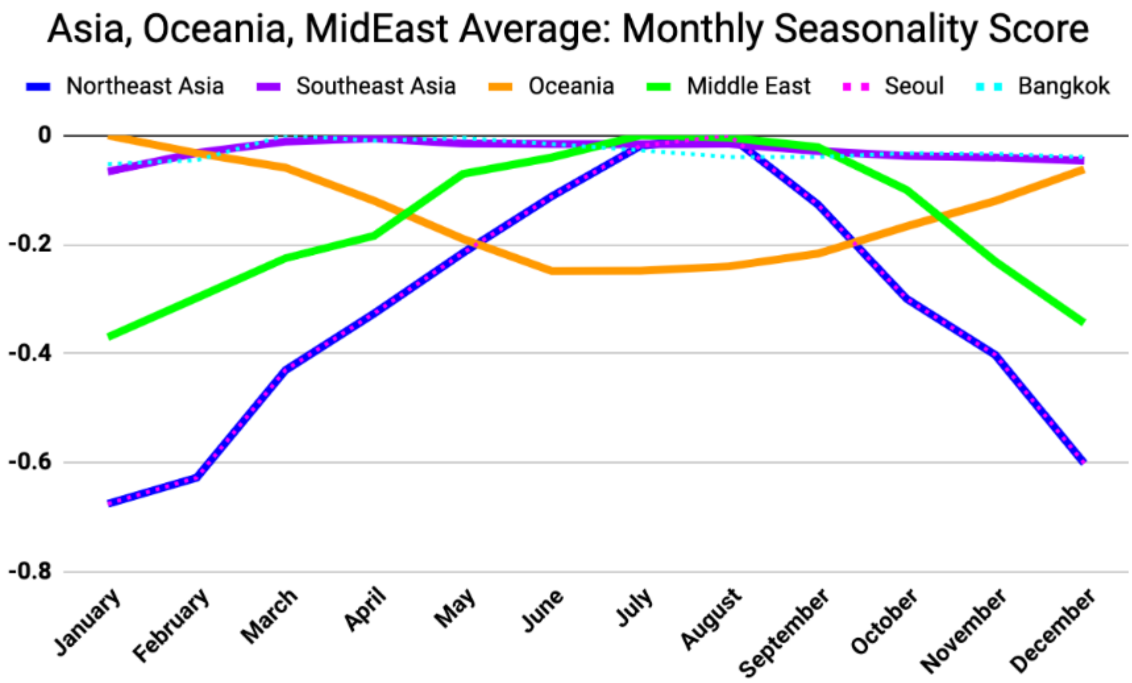
Duncan (2019) used monthly weather datasets, including precipitation and temperature, and correlated this with a New York City bike share operator's data to train a model that predicts relative changes in demand as

[21] www.trafi.com

[22] www.wundermobility.com

a function of weather. Market weather data was fed into the model to get rough estimates of how demand will change throughout the year. This approach hinges upon the strong assumption that people around the world react similarly to weather changes and that use of all forms of micromobility is similar to Citi Bike in New York City. Figure 3.23 shows the results of Duncan's model.

Figure 3.23 Seasonality score for demand of cycling (Source: Duncan, 2019)



Duncan's model suggests a reduction in New Zealand (Oceania), although given a relatively temperate climate, only a 25% or so reduction from summertime. The detail is not sufficient for robust demand estimation; rather, it suggests the relative suitability of micromobility in the New Zealand climatic context, and that counts will be lower outside of summer months.

Data from Auckland's Northwestern Cycleway at Kingsland suggests around a 25% drop between summer and winter cyclist counts. Data from Christchurch on shared e-scooter trips between October 2018 and September 2019 showed a decline from a peak of around 4,000 trips per day in peak summertime to around 2,300 trips per day in the mid-winter, which is around a 40% reduction.

While this suggests that there may be a greater reduction in trips on e-scooters than e-bikes during winter, there is insufficient data at this stage to make a conclusion.

3.4.5.6 Demographics

Demographics in New Zealand affect travel mode choice.

Gender

Gender plays a part in the transport mode chosen. Women represent approximately one-quarter of cyclists in New Zealand, Australia, the UK and the US. A recent analysis of New Zealand Household Travel Survey data (C. Shaw, 2019) showed that only 1 in 50 women are regular cyclists, compared to 1 in 20 men. There have been many studies on the effects of infrastructure on women cycling. A US study (Broach, 2016) showed that if there is no cycling infrastructure, women are 38% less likely to choose to bike, but when separated infrastructure is provided, women are just as likely to ride as men.

Johnson and Rose (2015) reported that e-bikes enable more women to ride bikes – that almost four in ten female e-bike riders had not been regular cyclists before purchasing or riding an e-bike.

A Strava study (Moore, 2019) in New York found that trips made by women increased 40%–50% within a year on roads where separated bike lanes were installed.

A study in Auckland by Wild and Woodward (2018) reported that e-bikes are making active transport a more attractive choice for women. E-bike counts on the Northwestern Cycleway showed that while women represented 27% of cyclists overall, they made up 41% of e-cyclists on the separated cycleway. Female e-cyclists reported that riding an e-bike improved arrival time reliability, gave them greater capacity for trip-chaining, and gave them the ability to carry children.

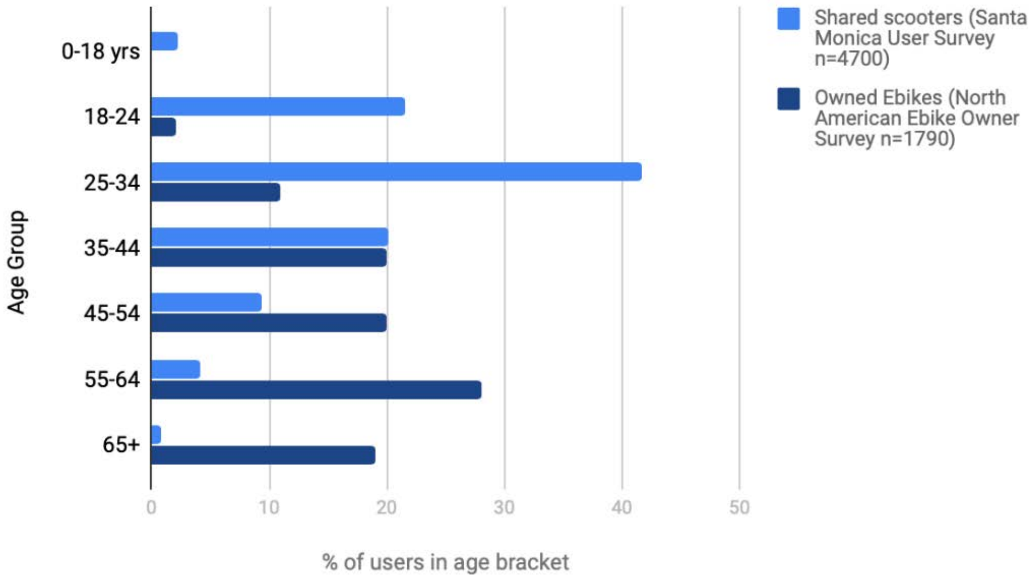
Age and health

Both age and level of health appear to make a difference to micromobility use.

While demographics of e-bike purchasers are not tracked in New Zealand, a US study (MacArthur et al., 2018) showed that e-bike owners tended to skew older than the rest of the population (Figure 3.24). For riders who did use their e-bike, the primary reasons were given as:

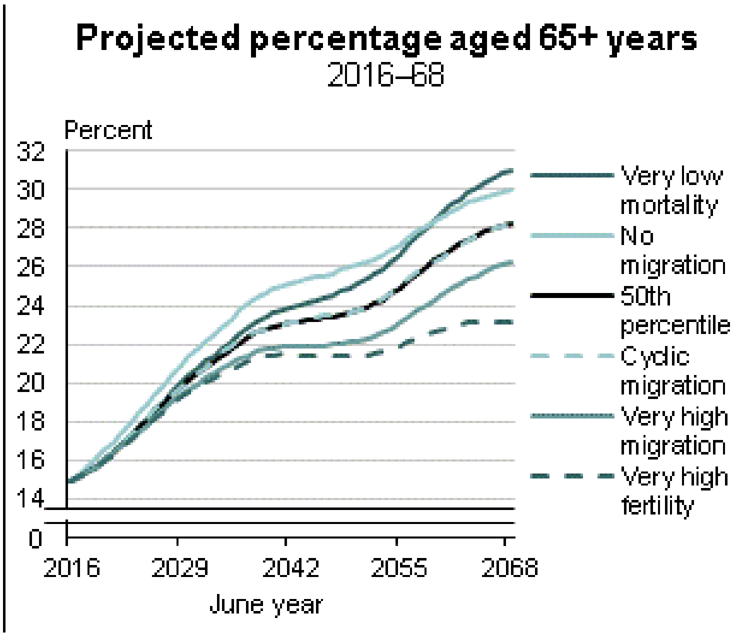
- living or working in a hilly area (11.2%)
- recreational purposes (9.9%)
- having a medical condition that made riding a standard bicycle difficult (9.4%).

Figure 3.24 Demographics of shared scooter users and e-bike owners (Source: MacArthur et al., 2018, p. 12)



New Zealand, along with many other countries, has an aging population because people are living longer and fertility rates are declining. This will increase the importance of inclusive access and is likely to affect mode share, with personal e-bike ownership likely to become increasingly popular as an easy transport choice for older people. The population prediction by Stats NZ (2016) is illustrated in Figure 3.25.

Figure 3.25 New Zealand's aging population (Source: Stats NZ, 2016)



- A Waka Kotahi research report (Rive et al., 2015) found that members of Generation Y (born between 1979 and 1999) use public transport at a higher rate than older generations, and there is a high latent demand for active transport modes.
- Frost & Sullivan (2018) found that members of Generation Z (born between 1995 and 2009) are more interested in integrated, multi-modal usage rather than brand-centric, single ownership. Generation Z members choose mode based on what gets them from A to B more efficiently, and will consider time, cost and environmental impact. They are more willing to switch between travel modes depending on what makes most economic sense.
- A recent survey by KantarTNS (2019) of Auckland and Christchurch residents found that 46% of e-scooter users were under 25 years old, and most who owned e-scooters were aged under 35 years old.

3.4.5.7 Regulation

Regulations have a key role to play in the growth or otherwise of mode shift to micromobility. Regulations for micromobility vary across the world, and because of the quick emergence of micromobility, many regulations may not be able to respond quickly, or may not allow flexibility to accommodate new modes.

In New Zealand, e-bikes are considered bicycles, which have long-standing regulations. In 2020, the New Zealand Government introduced the Accessible Streets Regulatory Package (Waka Kotahi, 2020a), which looks at refreshing the regulations to match micromobility and expectations of the use of bicycles and other transport devices.

Shared micromobility is licensed by local councils, and the restrictions applied can have an impact on the amount of mode shift to micromobility.

Regulation is subject to change, and the effect of regulation on mode shift is excluded from the research methodology.

3.5 Micromobility impacts

The purpose of this section of the literature review is to review existing literature concerning the impacts of the mode shift to micromobility.

3.5.1 Socio-economic impacts

Socio-economic impacts generally relate to the influence of education, income and occupation on the destinations accessible by the range of transportation options afforded to an individual (American Psychological Association, n.d.).

Transport poverty is a closely related aspect to the impact socio-economic factors have on transportation. The Verne Transport Research Centre (2018, para. 3) in Finland defines transport poverty as ‘a phenomenon that consists of four concepts: mobility poverty, transport affordability, accessibility poverty and exposure to transport externalities’. Transport poverty is also linked to many issues, including wellbeing, housing and social exclusion. Transport poverty has a strong linkage with transport services and services near the homes.

Groups that are especially exposed to transport poverty include:

- low-income households
- households without a motorised vehicle
- persons too young or old to drive
- persons with mobility issues
- minority households and immigrants.

The range of micromobility has the potential to provide low-cost travel options for people who either cannot drive or have no access to a private vehicle or a ride in one.

While comprehensive studies on the effects of micromobility on addressing mobility poverty are yet to be published, the Micromobility Coalition’s report from Seattle shows that

> *on average, workers living in the city of Seattle have access to 382,000 jobs within a 45-minute walk, e-bike/e-scooter, or transit commute, versus 283,000 jobs within a 45-minute commute from home by walk or transit only. This increase is equivalent to making 35% more jobs reachable without lengthening commutes or adding cars to the road.* (Micromobility Coalition, 2019, p. 1)

Many shared micromobility programmes in the US include a low-income subsidy programme, including Los Angeles (Nelson, 2018) and New York (City of New York, 2018).

The One Bird programme, which is available in the United States where Bird operates, offers discounted rides to low-income riders (Sisson, 2018). For most users, rides using the dockless e-scooter network include a $1 flat fee and 15 cents for every additional minute. The One Bird programme would waive the $1 base fee for anybody currently enrolled in, or eligible for, state or federal assistance programs, such as CalFresh, Medicaid, or SNAP.

There has historically been very low (<1% of trips) use of these programmes, and comprehensive research into the reasons for this has not yet been completed.

Lime plans to launch a half-price e-scooter scheme for low-income communities in New Zealand (Keogh, 2020b). The initiative allows people who might not otherwise be able to afford to rent Lime's shared e-scooters to get a 50% discount.

3.5.2 Accessibility

Accessibility relates to the ability to connect people, goods, services and opportunities and thereby engage in economic and social activity. An uptake in new mobility modes has the potential to increase accessibility.

The level of accessibility of any given service or destination can be influenced by several factors, including:

- its location in relation to that of those needing to reach it (micromobility devices such as shared e-scooter and e-bikes can be placed at high demand areas, and easily deployed where short distance travel is required; for example, train stations)
- availability of transport alternatives
- physical accessibility of the destination and/or transport available
- physical infrastructure for new mobility modes, including riding and parking locations
- travel cost (shared e-scooters and e-bikes are price competitive for short distances in city centres and have the advantage of no parking costs).

Barclays (2019) reported that by 2050, approximately 70% of the global population are expected to live in urban areas. The increased population density means more people will have access to public transport and micromobility vehicles.

City administrators in a number of cities around the world are looking to reduce or remove cars from the centres of their cities. Cities such as Oslo and Madrid are planning to make their city centre areas car-free within the next five years (O'Sullivan, 2018). Initiatives such as these will have an impact on the accessibility of the cities by vehicle and provide space for non-traditional modes of transportation.

3.5.3 Physical activity impacts

The Ministry of Transport (2018) reported that only half of New Zealand adults are sufficiently active, so incorporating active transport into daily life could have substantial health benefits. Use of non-traditional modes such as e-bikes is one way to achieve this. Three surveys undertaken in Europe and the UK show positive results in terms of increased physical activity due to the use of e-bikes.

The most frequently reported motivations for first riding an e-bike include riding with less effort to improve health, for long distance commutes to work, to overcome hilly terrain, and age (Johnson & Rose, 2015).

A European survey by Castro et al. (2019) involving 10,000 e-bike and standard bike users on their self-reported physical activity levels found that:

- the physical activity levels of e-bikers and standard bikers were similar
- where people switched mode from car or public transport to e-bike, there was a substantial increase in activity level
- where people switched from a standard bike to an e-bike, the overall distances travelled were greater (9.4 km vs 4.8 km), so net losses in physical activity were low
- governments considering subsidising e-bikes should consider the health benefits of e-bikes as a factor

- there are particular benefits to the elderly (60 years old and above) age group of regular physical activity via e-bike, as inactivity increases the risk of chronic diseases.

A study in Norway (Jahre et al., 2019) showed that e-bike users cycled more frequently to work than standard bike users, and they reported lower levels of additional physical activity time (outside of the commute) because commuting on the e-bike allowed for incorporation of moderate to vigorous levels of physical activity into daily routine.

A study in Brighton where staff were loaned e-bikes resulted in 21% of trial participants saying they had significantly increased their physical activity level (Cairns et al., 2017).

A disbenefit of micromobility use is that some people get less physical activity because some micromobility trips replace walking and cycling trips. Section 3.4.1 identifies that around half of trips on shared micromobility may have replaced walking or cycling trips.

Based on Ministry of Transport (2018) figures, a 5% increase in cycling and walking for trips of 2 km or less in Auckland could bring estimated health benefits of $225 million per year; therefore, a decrease in walking and cycling could have the opposite effect.

A recent report by Beca (Waka Kotahi, 2020d) investigated the health benefits of e-bikes and e-scooters, with the purpose of updating the *Economic Evaluation Manual*. The key findings are listed below.

- E-bikes can provide moderate physical level intensity.
- A local case study carried out in Auckland found that e-bike commuters travel up to 15 km each way for work, compared with 5 km on a conventional bicycle.
- The median distance travelled by e-scooter users utilising shared devices is 1.1 km per trip, which suggests this is not a key mode for commuting to work purposes.
- Forty percent of surveyed e-scooter users in Christchurch indicated that they would have walked otherwise.
- The majority of surveyed users also indicated their main trip purposes to be for recreation, social outings, and running errands.

The report made the following recommendations to update the Investment Decision-Making Framework.

- The health benefits for electrically assisted cycling should be $1 per kilometre, which is just under half the recommended economic benefit of conventional cycling ($2.20 per kilometre).
- The health benefits for e-scooters should not be applied because there is a lack of evidence on the level of physical activity provided by e-scooters.

3.5.4 Injury rate impacts

There are likely to be different reporting rates for injuries on micromobility between New Zealand (Accident Compensation Corporation (ACC) data) and internationally. Because of the incentive to report micromobility injuries to ACC in New Zealand in order to receive coverage for the costs of treatment, it is expected that ACC data will be highly accurate. Through using the data provided by shared e-scooter providers, it should be possible to identify accurate injury rates.

A search of recent crash statistics for various non-traditional vehicles, including e-scooters, e-bikes and e-mopeds, revealed the following crash risk results. It shows the large range of rates of injury, which are likely due to differing reporting rates.

- A study in the Netherlands found that e-biking has been associated with a higher likelihood of crashing compared to conventional cycling, while severity of injuries seems to be similar (Schepers et al., 2014). This was based on hospital data and e-bikes with a maximum speed of 25 km/h.
- In Santa Monica, there is 1 crash per 22,000 rides for e-scooters and e-bikes (City of Santa Monica, 2019).

US studies on injuries from micromobility are based on surveys of particular emergency departments, noting the number of cases and their injury characteristics. Because of the medical insurance approach in the US, it is expected that minor injuries will be highly under-reported.

Chang et al. (2019b) reported on the main way US e-scooter riders suffer injuries, based on hospital records. Eighty percent of injuries were due to a fall, 11% were from a collision with an object, and 9% were from being hit by a moving vehicle or object.

In Germany, as a result of crashes and public feedback about their discomfort with sharing e-scooters on footpaths, in 2018 e-scooter users were banned from using footpaths, limited to a 25 km/h speed and forbidden from using headphones while riding. Failure to comply with the rules will result in a €135 (NZ$231) fine (Tidey, 2019).

Because of likely bias in the reported injuries in other countries, further research is required to determine the exposure and injury rates in New Zealand. This is covered in the data review in section 4.

3.5.4.1 Speed and zone restrictions

In New Zealand, e-scooters have a 300 W motor limit and a range of top speeds. Some cities have implemented location-based speed restrictions and time restrictions for safety reasons, particularly places with high pedestrian traffic.

A trial in Santa Monica used geofencing technology tools to implement a deactivation zone around the beach area to decelerate e-scooters and e-bikes to a full stop (0 mph) in this zone, which largely eliminated safety issues and conflicts along the beach path (City of Santa Monica, 2019).

Paris introduced speed limits of 20 km/h in Paris as a whole and 8 km/h in pedestrian zones.

A study of actual travel speeds in San José, California, found that e-scooter riders travelled at an average speed of 15 km/h on footpaths and 20 km/h on roads. This means they are travelling three times faster than pedestrians on the footpath.

Globally in 2019 there was a large variation in the top speeds e-scooters and e-bikes were limited to. In New Zealand, e-scooter maximum speeds range from 16 km/h (Beam) to 27 km/h (Lime), and most e-bikes are software restricted to 32 or 35 km/h, but there are no specific speed restrictions in place, even when using shared paths.

New Zealand’s road code states that e-bikes should be used on their lowest setting when on shared paths, and riders should keep left and cycle at a speed that does not put others at risk.

A summary of speed-limiting of micromobility is provided in Table 3.2.

Table 3.2 Speed limiting of micromobility

Country	Vehicle type	Speed limit	Restrictions/additional information
Germany	E-scooter	20 km/h	Age restricted to 15 years old and above, power restricted to ≤ 500 W.
France	E-scooter	None (unregulated)	E-scooter usage was restricted to bike lanes in 2018.
Spain	E-scooter	25 km/h	–
Austria, Switzerland	E-scooter	25 km/h	Allowed on road or in cycle lane.
United States	E-scooter	24 km/h	Varies per state. In some regions, e-scooters can only be ridden on roads with a speed limit below 25 mph (40 km/h). In some cities, e-scooters can only be ridden in bike lanes and traffic lanes.
Singapore	E-scooter	15 km/h (on footpaths), 25 km/h on shared paths	Cannot be ridden on roads.
United States	ELF*	32 km/h	Top allowable speed is 32 km/h but can reach speeds up to 48 km/h.
China	E-bike	30 km/h	E-bikes above 20 kg and 30 km/h require a licence to operate.
Singapore	E-bike	–	Not allowed on footpath, can go on cycle paths and roads.
United States	E-bike	32 km/h	E-bikes with higher speeds may require a helmet, driver licence and insurance to operate.

* ELF, which stands for 'Electric, Light, Fun', is halfway between a car and a bike. It is powered by a combination of battery, solar panels and pedal power (Paulin, 2015).

Speed restrictions can have unintended consequences, including:

- increased price of a trip on shared micromobility that is based on time, which decreases affordability (Abrahams, 2019)
- increased ridership on footpaths in highly pedestrianised zones because riders judge that to be safer than riding on the road mixed with other, faster vehicles.

A study by Fitt and Curl (2019), which included people who had not yet tried an e-scooter, reported that 35% of these respondents were concerned about safety.

A recent New Zealand survey by Kantar TNS (2019) reported that 81% of e-scooter users in Auckland and Christchurch felt safe riding them. Fifty-two percent of residents felt unsafe when sharing footpaths with e-scooters, mainly because of the speed they are ridden at.

In Christchurch, an online survey was undertaken after a three-month trial of Lime e-scooters in the city (Christchurch City Council, 2019a). The survey had 8,000 responses, and results on the perceived safety of e-scooters were mostly positive.

- When survey respondents were asked about sharing footpaths and other public spaces with e-scooters, 62% reported feeling fairly or very safe.
- People that had not used an e-scooter before were much more likely to feel unsafe, with 55% reporting that they felt a bit unsafe and 23% very unsafe.

- Seventy percent of respondents said they feel that most or all Lime e-scooter users were using them in a safe and responsible manner. Lime e-scooter users were more likely to say this (85%) than non-users (56%).

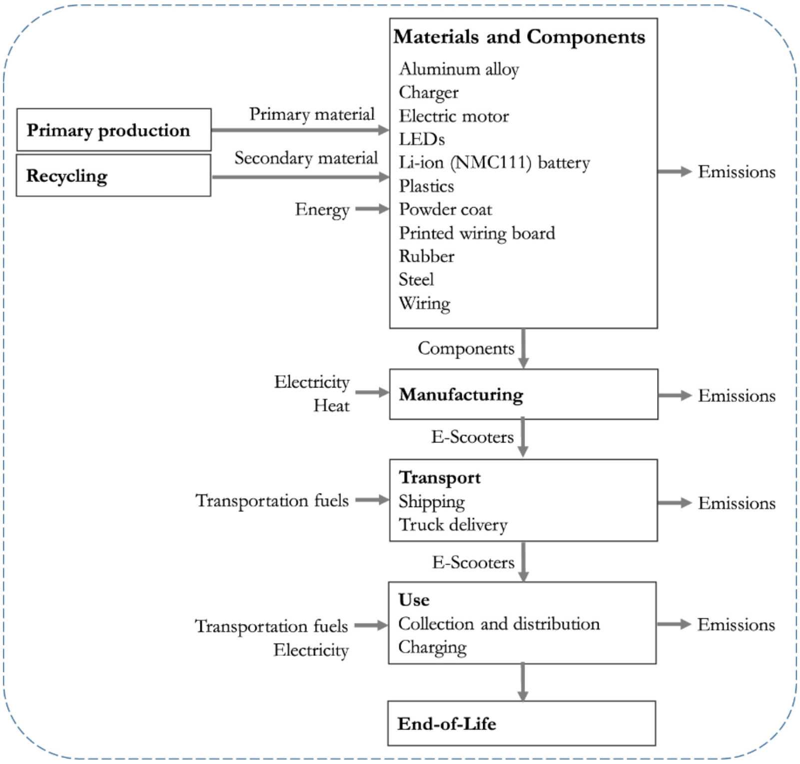
3.5.5 Environmental impacts

Tillemann and Feasley (2018) conducted an analysis of the energy use of e-scooters as compared to driving and walking. They found that a human would burn about nine times as much energy walking and about four times as much energy bicycling the same distance as an e-scooter. Micromobility requires less than 1% of the energy than an internal combustion engine car to travel the same distance.

Shared dockless micromobility operations have a different environmental footprint than personally owned devices because of the need for charging, re-positioning and maintenance. It is possible to evaluate this using a life-cycle assessment (Figure 3.26; Hollingsworth et al., 2019).

The environmental burdens from charging the e-scooter are small relative to the materials and manufacturing burdens of e-scooters and the impacts associated with transporting the scooters to overnight charging stations. The results of a Monte Carlo analysis showed an average value of life-cycle global warming impacts of between 202 g CO_2-eq/passenger-mile, driven by materials and manufacturing (50%), followed by daily collection for charging (43% of impact).

Figure 3.26 System boundary diagram for a life-cycle assessment on shared dockless e-scooters (Source: Hollingsworth et al., 2019, p. 3)



The analysis in Hollingsworth et al. (2019) assumed a practical life for a shared dockless e-scooter of three months. The analysis proved to be highly sensitive to e-scooter lifetime; ensuring that the shared e-scooters are used for two years decreases the average life-cycle emissions from 202 to 141 g CO_2-eq/passenger-mile (30% reduction). The latter figure is more likely to be relevant in the longer term because at the time of writing, shared micromobility operators have substantially improved the longevity of their vehicles through more rugged designs, and expect a 12- to 24-month life (Rose et al., 2020).

The equivalent emissions per passenger mile are sensitive to the life of the e-scooter and on whether the e-scooters are transported to be recharged. If shared micromobility operators move to replaceable batteries, the life-cycle carbon footprint would be reduced.

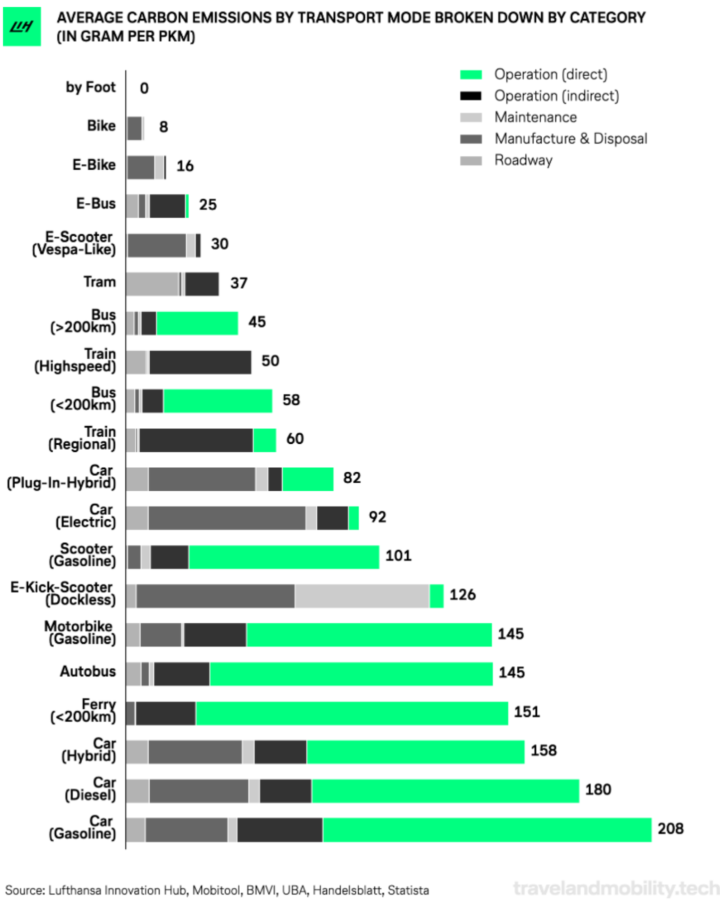
The mode shift to micromobility will improve air quality where trips shift from trips that would have been made using internal combustion engine powered vehicles.

A key finding relevant to this research is that where e-scooter usage replaces average personal automobile travel, there is nearly a universal net reduction in environmental impacts.

The greatest opportunities for carbon savings may be in suburban and rural settings, as city dwellers already have many low-carbon options (Philips et al., 2020).

TNMT (2019) identified and combined existing third-party research to produce a graphic illustrating the estimated differences in g CO_2 per passenger km from different transport modes (Figure 3.27). Operation (indirect) refers to the production of energy for the use of the device/vehicle. The 126 g per passenger km for shared dockless e-scooters is comparable to the 141 to 202 g per passenger km calculated by Hollingsworth et al. (2019). Removing the roadway and maintenance component of dockless e-scooters suggests a carbon emission for privately owned e-scooters of approximately 80 g per passenger km, which is similar to an electric car. This is primarily due to the low distance travelled by e-scooters. A privately owned e-bike is assumed to have a corresponding 16 g per passenger km.

Figure 3.27 Relative carbon emissions from privately owned and shared micromobility (Source: TNMT, 2019)



3.5.6 Resilience impacts

There is no apparent research on the contribution of micromobility to the day-to-day resilience of transport systems.

A number of studies, however, have shown evidence of a temporary increase in bicycle use following disruptions to the roading and public transport networks due to earthquakes (Kirkpatrick, 2018), tsunamis (World Bicycle Relief, 2018), hurricanes (Page, 2014), terrorist attacks (Fasolo et al., 2008), and public transport strikes (Saberi et al., 2018).

Electrically powered micromobility may similarly provide evacuation and travel during civil emergencies, where traditional modes are unavailable to use because of fuel shortages or infrastructure damage. E-bikes, which still can be ridden as a traditional bicycle if the electricity network fails, may provide greater opportunities for resilience in an emergency than e-scooters or electric cars.

3.6 Conclusions of literature review

This section summarises the conclusions of the literature review. The conclusions of the data review (review of relevant data available in New Zealand) are summarised in section 4.

3.6.1 Definition of micromobility

- The scope of micromobility of this research project should reflect the likely categorisation under the New Zealand Government's Accessible Streets Regulatory Package. This includes the use of e-bikes, e-scooters, and mobility devices.
- E-skates, non-self-balancing boards (ESK8s), uni-wheels and other niche micromobility devices that require high levels of skill to use have not been specifically considered, as the number of devices will be small compared to e-scooters and e-bikes.
- There is an emerging micromobility mode that can be categorised as e-moped, which has a longer range and more power than e-bikes or e-scooters. As it is unlikely to be exempted to use shared paths, it is more likely to be used as an electric motorcycle.

3.6.2 Mode shift

- Shared micromobility has different use patterns than privately owned and may be particularly useful for short trips. The commercial model is maturing as is the technology/design of the 'vehicles', including potentially the development of autonomous drive.
- It is expected that private micromobility vehicles will be used for longer trips and more often per user than shared micromobility vehicles because of the low cost per km.
- There is little information on the mode shift to micromobility that is occurring, although it is possible to identify indicative ranges of shift (Table 3.3), purpose (Table 3.4) and distance (Table 3.5).

Table 3.3 Mode shift by mode

Mode to	Mode from	Mode shift range	Survey data
E-scooter/ E-bike (shared)	Cars	24%–61%	• 24% of e-scooter trips replaced a car trip (New Zealand) • 28% of e-scooter trips replaced private vehicle trip (New Zealand) • 30% of global Lime users had replaced a car trip • 49% of Santa Monica shared e-scooter/e-bike users would otherwise have travelled in a car • 61% of San Francisco Lime e-scooter riders would have used a car (including Uber/Lyft)
	Public transport	4%–10%	• 4% of e-scooter trips replaced public transport (Christchurch) • 10% of e-scooter trips replaced public transport (Portland)
	Walking	33%–43%	• 33% of San Francisco e-scooter/e-bike trips replaced walking • 37% of Portland e-scooter trips replaced walking • 39% of Santa Monica e-scooter/e-bike trips replaced walking • 40% of Christchurch e-scooter trips replaced walking • 43% of Denver e-scooter trips replaced walking
	Cycling	9%–14%	• 9% of Portland e-scooter trips replaced cycling • 14% of Denver e-scooter trips replaced cycling
	New trip	7%–8%	• 7% in New Zealand were new trips • 7%–8% in Portland/Denver were new trips
E-scooter/	–	–	• No survey results found
E-bike (private)	–	–	• No survey results found
E-moped	–	–	• No survey results found

Table 3.4 Mode use by trip purpose

Mode	Trip purpose	Percentage of trips	Source of information
E-scooter (shared)	Recreation/ social	26%–29%	• 26% in Santa Monica (Chang et al., 2019b) • 29% in Portland (Portland Bureau of Transportation, 2019)
	Commute (work/school)	37%	• 37% in global Lime survey (Lime, 2019b)
	Utility/work related	14%	• 14% personal errands from global Lime survey (Lime, 2019b)
	Public transport (first/last mile)	9%–28%	• 9% in global Lime survey (Lime, 2019b) • 28% in New Zealand (Fitt & Curl, 2019)
E-scooter (private)	–	–	• No survey results found
E-bike	–	–	• No survey results found
E-moped	–	–	• No survey results found
E-accessible	–	–	• No survey results found

Table 3.5 Mode use by trip distance

Mode	Trip purpose	Trip distance range (typical)	Source of information
E-scooter (shared)	–	1.6–1.9 km	• 1 mile in San Francisco (Dediu, 2019) • 1.9 km in New Zealand (Fitt & Curl, 2019) – depends on mode replaced
E-scooter (private)	–	–	• No survey results found
E-bike (shared)	–	2.5–8 km	• 1.5–5 miles in San Francisco (Dediu, 2019)
E-bike (private)	–	5–15 km	• 5–15 km in New Zealand (Wild & Woodward, 2018) • 15 km in the Netherlands (Wiersma, 2020) • 10 km in Norway (Fyhri & Fearnley, 2015)
E-moped	–	–	• No survey results found
E-accessible	–	–	• No survey results found

- A Carbone 4 (2019) Paris study suggests that a potential mode share of up to 20% for cycling plus micromobility could be possible by 2030, assuming high uptake.
- The capital cost of non-traditional modes is still a significant barrier to uptake. The shared modes are relatively expensive per km, which limits their mode shift potential/trip length. It is expected that private ownership of non-traditional modes will grow more quickly.
- Physical infrastructure is a key enabler/barrier for non-traditional modes. Where there is no safe separated infrastructure provided, uptake may be reduced by up to 90%.
- There is great potential for micromobility to be used with public transport, as it increases the catchment at both ends of the trip or may enable riders to avoid parts of a route that do not have safe infrastructure.
- MaaS may increase the uptake of micromobility as it allows trip-chaining. The most potential for MaaS to grow mode shift is where public transport and shared micromobility are combined.
- The emissions benefits of non-traditional modes are significant. A life-cycle analysis of e-scooters shows that emissions per km is sensitive to the length of life (km) of the device. This is particularly significant when considering the benefits for shared micromobility.
- Safety for non-traditional modes is still unclear, particularly for e-scooters. Safety is a barrier for uptake, and mandatory helmets reduces uptake (24% wouldn't e-scooter). There appears to be a difference between genders, with women more likely to not use micromobility modes because of safety concerns.
- There is limited information on the impact of weather. Research suggests that utilisation may reduce approximately 25% in winter/wet periods in New Zealand.
- Non-traditional modes appeal to a different demographic than traditional cycling. It is likely that the uptake will be far greater than for cycling.
- Regulations vary around the world, ranging from very restrictive (eg, classifying micromobility devices as illegal mopeds in the states of New South Wales and Victoria in Australia) to very enabling. New Zealand's regulations are currently on the very enabling part of this spectrum. This means that uptake in New Zealand is likely to be on the high end of the range internationally, without taking into account the effects of physical infrastructure.

3.6.3 Micromobility impacts

The literature review identified the following possible areas of change as a result of uptake of non-traditional modes:

- reduced transport poverty and increased access to employment (related to presence of subsidies)
- reduced gender disparity in the use of active modes
- improved options for those with physical disabilities
- improved access to public transport (and therefore, to local businesses and services)
- increased range of demographic groups who will consider active modes
- altered rates of physical activity, including activity due to more use of public transport
- altered rates of injury for micromobility users and bystanders
- reduced emissions and improved air quality
- accelerated introduction of car-free zones
- altered energy cycle for transport modes
- reduced vehicle ownership
- improved evacuation capability/mobility of populations during a disaster.

3.6.4 Gaps in information

The literature review has identified that there is little peer-reviewed research information available because of the recent arrival of non-traditional modes and technology development.

Significant gaps in information include:

- mode shift, trip distance and trip purpose information for privately owned micromobility
- statistics on the use of non-traditional modes in association with public transport
- objective analysis of the safety of micromobility
- increase in mode shift due to MaaS
- demographics of users of the various micromobility modes.

4 New Zealand data review

The objective of this section of the research is to present the data sources currently available in New Zealand related to micromobility usage, identify the gaps in current data collection, and suggest improvements to data collection. Also addressed in this section are the steps currently being taken to develop a national benchmarking system for council spending on infrastructure for non-traditional modes of transportation.

Data is required in the following areas:

- survey counts (mode share for micromobility by micromobility mode)
- trip data (data on trips being made by shared and private micromobility devices)
- sales data (growth rates for ownership of micromobility devices)
- injury statistics (micromobility injury statistics by kilometre of travel)
- expressed interest (data on desire for mode shift to micromobility).

Within each required data type section, the existing data, identified gaps and potential solutions for that data type are presented. This section concludes with some primary recommendations for actions that are required to develop an appropriate data strategy for monitoring and responding to the mode shift to micromobility.

4.1 Survey counts

Survey counts for the purposes of this section are defined as localised volume counts of vehicles or transport devices passing a defined point. Counts of this type can be categorised into different mode types, but often individual survey counts may focus on a certain mode type.

Counting is typically conducted by using induction loops or pneumatic tubes, or by an individual observing the movements of people. Survey count data is important for quantifying the mode shift to micromobility occurring in practice across different locations.

Survey count data where all modes are counted will show the actual changes in mode shift to micromobility compared to earlier counts. It is important that there are a series of counts using a consistent methodology.

The best understanding will be where survey count data is collected in a variety of locations (eg, urban, rural, suburban). This will potentially provide the ability to calibrate the research findings on mode shift and the effect of different contexts, providing useful information to support investment decisions and multi-modal infrastructure upgrades.

4.1.1 Existing data

In general, survey count data is currently collected only for vehicles, pedestrians and cyclists by several councils around New Zealand. Micromobility devices may be ignored in this counting or may be counted as either a pedestrian or a cyclist for simplicity. Survey count data at this stage is more commonly collected for the larger urban areas of New Zealand.

Auckland Transport has modified two of its automatic induction loop bicycle counters to also detect scooters. However, the technology is not distinguishing between bicycles, e-bikes, scooters or other potential micromobility types (Auckland Transport, n.d.).

Waka Kotahi maintains a central database of bicycle and pedestrian counts from across the country. Data is collected on an ongoing basis, and as of November 2019, data has been sourced from approximately 260 pedestrian and bicycle count sites (Pascoe, 2020).

Figure 4.1 displays the dashboard that is produced internally by Waka Kotahi. It includes location information, annual trends and regional comparisons. Work continues at Waka Kotahi to develop a guideline to support councils in selecting and purchasing new counters for their jurisdictions with the intention to collect data from these new counters in this centralised manner. New counters will have the ability to count e-scooters separately but will still lack the ability to distinguish between pushbikes and e-bikes.

Currently, the counters monitored by Waka Kotahi are mostly positioned in urban locations, with some on the route of the Great Rides. At this stage, the dashboard is not publicly accessible; however, there are plans to connect the data with mapping software and make it more available for wider use.

Figure 4.1 Waka Kotahi dashboard for bicycle and pedestrian counts (Pascoe, 2020, p. 4)

4.1.2 Identified gaps

The following gaps have been identified.

- Automatic cycle counters, where installed, are not currently able to distinguish between different modes of either active transport or micromobility as defined for the purposes of this research.
- Collection of count data is not spread over a range of locales.
- No standard collection method is used across New Zealand.

The implication of this gap is that there is no baseline or trends on the growth of micromobility, and in some cases micromobility growth where counted is indistinguishable from traditional active modes.

4.1.3 Solutions

The following solutions are proposed to address the identified gaps related to survey data.

- Modify existing automatic counter technology to classify the type of device being counted.
- Install new counters at a range of different locales capable of classifying different active modes and micromobility types.
- Visual recognition using a camera-based system paired to artificial intelligence (AI) machine learning could be used to differentiate between owned and shared bicycles and scooters, runners and walkers by looking at the size and speed of the moving item.
- Remote sensing using light detection and ranging (LiDAR) to count and distinguish between mode types. LiDAR shines a laser light across a path and by measuring the reflection with a sensor can classify people, bicycles and e-scooters, recording the position on the path cross-section and speed.
- Potentially, Bluetooth detection technologies could be used (see section 4.2.3).
- Develop a common framework across authorities within New Zealand for conducting manual survey counts.
- Centrally collect and make available the survey count data from around New Zealand.

Both a strategy and enacting the solutions listed above will assist in addressing the identified gaps in the existing survey count data and will allow for better monitoring of the mode shift to micromobility and how this varies between routes and land-use.

4.2 Trip data

Trip data for the purposes of this research refers, on an individual user level, to the following information regarding the use of micromobility: number of trips, trip lengths, trip purpose, trip origins and destinations.

Collecting trip data from both shared micromobility devices and privately owned devices assists in measuring how different people are adapting to using micromobility for different uses. This is an important aspect for understanding the form in which the shift to micromobility is occurring.

Trip data will also provide greater transparency on equitable access measures – for example, which areas of a city are seeing the greatest mode shift to micromobility and for what purposes is micromobility being used.

4.2.1 Existing data

4.2.1.1 Shared micromobility operators

All shared micromobility vehicles (Lime, Jump, Flamingo, Beam, etc) have built-in GPS and all companies charge customers based on the journey from unlocking the vehicle to when they park up and lock the vehicle via a smartphone. This allows the companies to collect statistics on usage (how many times each scooter is used per day), journey length, journey duration, speed travelled (maximum and average) and, potentially, incidents that occur.

Transport providers are required to share their trip data as a condition of their licence to operate, and some require proof of utilisation statistics. For example, some cities require each e-scooter to be used at least three times per day to allow continued usage (Barclays, 2019).

Mobility Data Specification (MDS) is the standard that New Zealand cities use to collect usage data from operators in Auckland, Wellington, Christchurch and Dunedin. MDS data is available from all e-scooter companies in New Zealand (Lime, Flamingo, Beam, Jump, Blip and Neuron), which are required to provide this data to the council areas in which they operate. It is up to the councils how they evaluate and use this data for making decisions on the road network.

4.2.1.2 Privately owned devices

No widely adopted or standardised method of capturing trip data from privately owned micromobility devices currently exists.

New Zealand census data includes information on the number of people commuting to work and educational institutes for each region by age group, sex, study type (full-time or part-time), work status (full-time or part-time) and status in employment (paid employee, employer, self-employed and without employees, unpaid family worker). Mode options in the census that could include micromobility are 'bicycle' and 'other' (Stats NZ, 2018).

The New Zealand Household Travel Survey is an ongoing yearly survey that collects information on day-to-day travel within New Zealand. The survey determines how, why and when people travel and collects the mode of travel too. The survey also records time spent travelling, and demographics of road users (Ministry of Transport, 2020a).

The latest 2019/20 survey questionnaire recorded the following modes of transport: motor vehicle (driver); motor vehicle (passenger); walked/ran; bus; bicycle; train; ferry; plane; taxi passenger; mobility scooter or wheelchair; other (specify). Based on these categories, micromobility devices may be captured under bicycle; mobility scooter or wheelchair; or other (specify) (Ministry of Transport, 2019b). However, in the publicly published datasets, results for only the following modes are included: car/van driver; car/van passenger; pedestrian; cyclist; public transport (bus/train/ferry) (Ministry of Transport, 2019a).

Private micromobility trip data would be useful to see what kind of trips are being taken (eg, trip purpose, trip length, mode shift). Currently this private data can be collected via apps such as Strava (self-reported trips) or online surveys, but there may be self-reporting bias in the results.

4.2.2 Identified gaps

Gaps in the current trip data collection that exists have been identified to inform the solutions that could be enacted to improve the quantity and quality of micromobility usage data being collected. The following main gaps have been identified.

- Some territorial authorities might not have the right regulatory tools or evaluation and monitoring resources required for the effective analysis of micromobility devices.
- New Zealand census data does not include the number of people commuting via e-bike, e-scooter or other non-traditional modes.
- The New Zealand Household Travel Survey does have a specific question for e-bikes but does not yet have a category for e-scooters.

4.2.3 Solutions

Potential solutions to the identified gaps for the collection of trip data for micromobility include the following.

- Produce a standard licence clause for all councils to adopt in order to allow them to require shared micromobility operators within their jurisdiction to provide detailed trip data.
- The New Zealand census commuting questions should allow for usage of micromobility modes to be captured.

- The New Zealand Household Travel Survey should include categories for e-scooters in the questionnaire and provide access to results for all modes.
- Bluetooth is wireless technology that enables a wireless connection between two electronic devices. Almost all e-scooters have Bluetooth Low Energy (BLE) devices embedded in them. However, as BLE devices are also on personal activity tracking devices (such as Fitbit), it would be difficult to detect whether a BLE device was an e-scooter or a Fitbit. The option here is to oblige all e-scooter providers to supply a list of unique IDs for privately owned scooters, which could be used to filter the collected data.
- LiDAR technologies are now available for counting pedestrians, scooters, and bikes on shared paths. This type of technology will likely be of great use for collecting e-scooter counts, although it will not differentiate between bicycles and e-bikes.

4.3 Sales data

Sales data refers to information regarding the number of micromobility devices being sold within New Zealand or being imported into New Zealand. Ideally, this information would be categorised into sub-types of micromobility.

Sales data is an important metric for understanding the mode shift to micromobility because it provides a greater understanding of ownership levels of micromobility. Import data alongside the sales data can also provide some indication for expected future sales and the expected growth of the market as determined by individual importers, given that there is negligible local production.

In relation to an increased uptake in micromobility usage, sales data will allow for greater understanding of the impact of micromobility on household spending on transportation and can provide insights into the demand for micromobility devices. Consumer demand for the devices has an impact on the potential for new micromobility-related industries and services; better data on this demand helps to better position the economy and businesses for capturing value in relation to emerging micromobility trends.

4.3.1 Existing data

At this stage, customs import data is the only source of information related to the number of micromobility devices being sold in New Zealand. The New Zealand Customs Service maintains a database of imports into New Zealand, which are categorised for the purposes of import tariffs, which vary between different items. Micromobility devices are captured as lightweight electric vehicles (motorcycles (including mopeds) and cycles fitted, etc) under tariff items 8711900000 (prior to 1 January 2017) and 8711600000 (with electric motor for propulsion) and 8711900010 (with other) (from 1 January 2017 onwards).

Combining categories 8711900010 and 8711600000, imports into New Zealand for 2018 were 47,350, while imports for 2019 were 63,855, an increase of 35% (Stats NZ, n.d.).

4.3.2 Identified gaps

The following gaps in the current sales data information that exists in New Zealand have been identified.

- Currently, the import categories that micromobility devices are captured under do not distinguish between different types of micromobility. For example, the New Zealand Customs Service database does not distinguish between e-scooters, e-bikes or e-mopeds being imported into New Zealand.
- The current categories that it is assumed most e-scooters and e-bikes are classified into for import purposes may not capture all micromobility devices being imported into New Zealand. Some devices

may be classified as toys rather than lightweight electric vehicles, hence falling outside of the currently used proxy for import volume.

- Relying on import data as an indicator for sales of micromobility devices in New Zealand does not allow for conclusions to be drawn about where – within New Zealand – the devices are sold.
- Currently, no point-of-sale data for micromobility is captured within New Zealand, so there is no way of gaining an overall understanding of how the devices are being sold in New Zealand – for example, whether devices are being sold through dedicated micromobility stores, through online shops or at bicycle shops.

4.3.3 Solutions

To address the identified gaps above in relation to how sales data for micromobility is collected within New Zealand, the following solutions are proposed.

- Better categorisation of New Zealand Customs Service import information is needed, by either creating a dedicated section for each type of micromobility device or creating sub-type tags for the current import category of lightweight electric vehicles. However, this may still present issues as importers may still be able to classify their product under a different category, such as the toy category, as mentioned previously.
- Directly collecting information about micromobility sales from retailers – whether from physical stores or online shops – would be difficult because of the commercial sensitivity of the data. However, developing a national system for tracking these sales by sub-type in an anonymised way would provide a clearer picture on what micromobility devices are being sold across the different parts of the country and across different parts of cities themselves. As the official data agency for New Zealand, Stats NZ is well-placed to source the number of sales while protecting commercial sensitivity.

4.4 Injury data

Injury data for the purposes of this research refers to information on injuries directly caused or related to the use of micromobility devices.

Injury data is important for understanding the mode shift to micromobility because it provides insight into how the rate or severity of injuries may influence the uptake of the mode.

Furthermore, the impact of micromobility usage on the health and safety of the population can be measured if reliable injury data is collected. This helps inform the overall impact of an increased uptake of micromobility and can better inform infrastructure investment for how to provide a safer environment for this emerging transportation mode.

4.4.1 Existing data

Currently, injury data related to micromobility can be sourced from several locations.

ACC collects information on all injuries that occur where medical attention is provided. Initially when e-scooters and e-bikes first were beginning to be used in New Zealand, injury data related to these two modes was grouped together. However, this data is now being categorised separately into each mode. ACC collects data on the number of claims where medical attention is required and the cost to the healthcare system in treating the injury. Data from ACC can be obtained through publicly accessible published reports through their website or through an Official Information Act request.

Waka Kotahi manages a database for all road crashes within New Zealand. This database, known as the Crash Analysis System (CAS), includes detailed information about where and when crashes occur as well as the vehicles involved and environmental conditions. Where micromobility devices are involved in road crashes, this should be captured in CAS.

Depending on their conditions of operation as stipulated by the relevant council, operators of shared e-scooters must report on injuries that occur while using their devices. In addition to injury crashes, this data may also include non-injury crashes and crashes where damage to the device or to other property has occurred.

4.4.2 Identified gaps

Gaps in the current injury data that exists in New Zealand have been identified to inform the development of solutions that could improve the quality and availability of injury data related to micromobility. The following main gaps have been identified.

- ACC does not currently distinguish between e-bike related injuries and pushbike injuries nor between e-moped and standard moped injuries.
- Injury data is only collected by ACC when an injury required medical attention.
- CAS does not currently allow for easy identification of crashes involving micromobility. Often the specific crash report needs to be analysed to know if a micromobility device was involved, and if so, what type.
- Not all conditions of operation for shared micromobility operators require the reporting of crashes that occur while using their devices.

4.4.3 Solutions

To address the identified gaps above in relation to how injury data for micromobility is collected within New Zealand, the following solutions are proposed.

- Analyse ACC data on where the micromobility injuries occurred and factors leading to the injury.
- Adapt CAS to have an option for selecting micromobility devices as being involved in a crash to facilitate easier identification of crashes involving micromobility.
- Develop standard shared micromobility operating conditions for councils to require operators to report on crashes. This would allow for the same information to be collected across all jurisdictions where shared micromobility devices are used.

4.5 Expressed interest

Expressed interest in micromobility use refers to the desire for an individual to use micromobility devices and may capture information about what purposes individuals are hoping to use micromobility for. In connection with data for total travel by all modes in New Zealand, expressed interest data could help predict the shift to micromobility usage for various individuals or groups and determine the size of existing travel volumes that might be replaced by trips using micromobility.

Expressed interest in micromobility also has important ramifications for the impacts of increased uptake because investment decisions are impacted by public perception and desires. It also allows for greater forward planning to determine when mode shift to micromobility may occur.

4.5.1 Existing data

Auckland Council and Christchurch Council both conduct regular surveys on ‘active modes’ (Auckland Transport’s Active Mode Survey and Christchurch City Council’s (2019b) Life in Christchurch Transport Survey), which attempt to gauge public opinion on the state of walking and cycling in the city. E-bikes have been captured in these surveys – with the Life in Christchurch Transport Survey also asking questions about e-scooter usage – and the councils have looked at potentially identifying the changeover rate from private mobility to shared mobility (Auckland Transport, n.d.; Christchurch City Council, 2019b).

Auckland Transport’s Active Mode Survey does collect some information about demographics, including age and gender; however, neither council readily provides the raw survey data for public use.

Waka Kotahi also conducts what is currently a yearly attitudes and perceptions survey for urban areas, which has gathered information predominantly on pushbike usage; however, recent surveys have included questions about e-bikes. This survey also gathers information on gender, device usage, household composition and ethnicity. Waka Kotahi plans to roll this out continuously as an ongoing survey to monitor perceptions closely across the country.

4.5.2 Identified gaps

The main gaps in the current data collection are as follows.

- Not all councils conduct active mode surveys, which can capture some information about the interest in using micromobility.
- For the two councils already conducting ‘active mode’ surveys, questions surrounding micromobility usage are not standardised, which reduces the comparability of the surveys.
- Existing expressed interest surveys do not ask specific questions about a range of micromobility types.
- Surveys are limited in their reach and can be expensive to conduct.

4.5.3 Solutions

As listed above, gaps in collecting expressed interest information for micromobility usage present a barrier to better understanding the ongoing mode share transition to micromobility. The following solutions may be appropriate.

- Add a section about ‘preferred mode’ to the New Zealand census to provide a nationwide standard approach to gauging travel mode interest.
- Develop a standard group of questions that can be asked by councils as part of their active mode surveys to better understand public perception of micromobility and the desire for increased uptake and infrastructure to support it.

4.6 National benchmarking

In this section thus far, a focus has been placed on data that relates to the end user whether in the use of micromobility, interest in it, or the purchasing of micromobility devices. However, equally important is the measuring of data related to the contributors to success for micromobility usage.

Waka Kotahi currently has plans to develop a national benchmarking system to connect councils to a database of inputs and outputs related, at the moment, to cycling. This system has the potential to also capture data for micromobility. For example, this system may include inputs such as the number of council staff working on cycling projects, infrastructure spending on cycling infrastructure, and footpath quality.

Through the benchmarking system, these input factors could be compared against outputs such as footpath use and number of cycling trips. Waka Kotahi envisages that the system would allow councils to better understand contributing factors to cycling (or micromobility) usage and invest based on evidence for success.

4.7 Conclusions

This section of the report has focused on the data that would be required in order to understand the mode shift to micromobility. Specifically, this section dealt with the following five data areas related to micromobility usage: survey counts, trip data, sales data, injury statistics and expressed interest. For each of these data areas the currently existing data, gaps in the existing data, and solutions to address these gaps were discussed.

The main conclusions of this data review are as follows.

- A strategy is required that identifies what information is needed to inform transport planning and project evaluation. New Zealand does not have sufficient data currently available to monitor and manage the mode shift to micromobility.
- A consistent national data collection methodology across New Zealand and a nationally coordinated plan to immediately start collecting counts of micromobility use are required.
- Investigation and creation of an implementation plan for collecting data on the use of privately owned micromobility is required, followed by the installation of appropriate counting technologies.
- The ACC data collected on injuries due to micromobility trips requires further analysis to provide more useful information on injuries.

5 Transport modelling of micromobility

5.1 Approach

The literature and data reviews identified the lack of quantitative information available on the likely future usage of micromobility across different scenarios and land-use contexts. This includes both information on likely uptake of micromobility modes in their own right, as well as information on the likely impact this will have on the use of other modes, including walking, cycling, cars and public transport. The aim of the modelling section of the research was to take the first steps towards filling that gap, with a focus on the New Zealand context.

Two different use cases of micromobility were considered as part of the modelling process:

- ‘end-to-end’ trips, where a micromobility mode is used for the full length of the trip
- multi-modal ‘first/last mile’ trips, where micromobility is used for the beginning and/or end section of a journey to facilitate connections with public transport.

The Auckland Macro-Strategic Model (MSM) and the Auckland Strategic Active Modes Model (SAMM), both developed by the Auckland Forecasting Centre, were chosen as a basis for this work because of their suitability and complexity. While there are potential limitations associated with using an Auckland-only model to draw insights about New Zealand more generally, Auckland consists of a broad variety of geographies, densities and land-use types that, collectively, offer a reasonable representation of the spectrum of geographies and land-use types found across New Zealand as a whole. Each part of Auckland in the model was used, for example, to identify the sensitivity of forecasts to land-use and public transport provision.

Micromobility modes are not currently included in the MSM or the SAMM in their own right. Rather, they are able to be accounted for by proxy by increasing the assumed average walking speed to reflect a composite average of walking and e-scootering speeds, and the same for push-cycling and e-cycling speeds. This process is explained in further detail in section 5.2.

This approach is useful for exploring the effects of first/last mile micromobility use on public transport and mode shift to public transport from private cars.

When it is used to draw conclusions about the number of ‘end-to-end’ trips that may shift to a micromobility mode or where these trips are likely to shift from, the model uses average speed of travel for micromobility compared to walking and cycling. Without substantive existing counts of micromobility, it is not possible to calibrate the SAMM to take into account the barriers to uptake of micromobility from behavioural aspects, or the characteristics of the micromobility when it comes to passengers, weather, demographics etc. Without calibration, the SAMM was likely to substantially overestimate mode shift and mode share for micromobility, particularly for e-scooters.

Therefore, for ‘end-to-end’ micromobility trips, a new ‘market potential’ model was developed using data from the MSM and the SAMM from a first-principles basis to identify a range of likely scenarios for mode shift and mode share of trips.

The modelling incorporates a set of assumptions around the likelihood that a particular existing trip, given its characteristics (length, current mode), will shift to a micromobility mode. The literature and data reviews showed that there is a lack of suitable data available to support applying any one fixed value to these assumptions. Therefore, for each assumption, a set of possible values was used, resulting in various combinations. Expected mode shift and mode share predictions are thus given as a range of likely values, rather than a single value. It is expected that where within this range the actual values fall will depend on modifying context factors. These factors are discussed in detail in section 7.

5.2 First/last mile trips

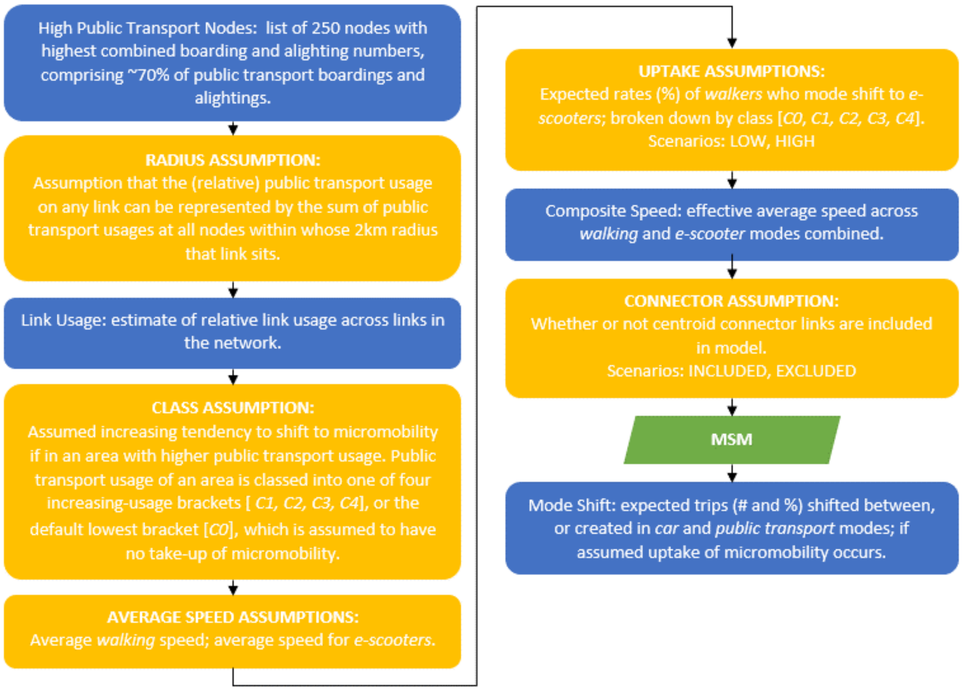
The MSM, previously known as the Auckland Regional Transport Model (ART3), is a multi-modal travel demand estimation model developed and maintained by the Auckland Forecasting Centre, using the EMME software platform. Outputs including vehicle and passenger demands and flows are modelled based on the spatial land-use patterns and quantities passed over from Auckland Forecasting Centre's Auckland land-use model, from the current base year of 2018 through till 2048. For the purposes of this research, 2028 was used as the reference year for land-use.

The MSM was adapted to include higher than normal speeds in the first/last mile of trips for the portion of people who swap walking for a quicker micromobility mode. These are assigned to links in the network where there are a high number of public transport connections (based on usage).

5.2.1 Methodology

Figure 5.1 identifies the methodology used to forecast mode shift to micromobility for the first/last mile of public transport trips. A process was used to identify the different levels of potential for first/last mile micromobility, combine these with assumptions on the range of likely uptake of micromobility for those trips, and then use these to create a composite average speed to get to and from public transport.

Figure 5.1 First/last mile modelling methodology flow diagram



A zone centroid connector in the MSM is the distance assumed from the start of a trip to when that trip is connected to the MSM transport network. These mimic, as an example, the distance people will need to travel before they reach a main road. Results were produced for the zone centroid connector being at both walking speed and at the composite speed to check for sensitivity to this assumption.

In addition, five classes (C0, C1, C2, C3, C4) were calculated to mimic the likely availability of shared micromobility, with C4 having the highest levels. Assumptions were made for the range of uptake of micromobility in each of these zones for current walking trips to and from public transport.

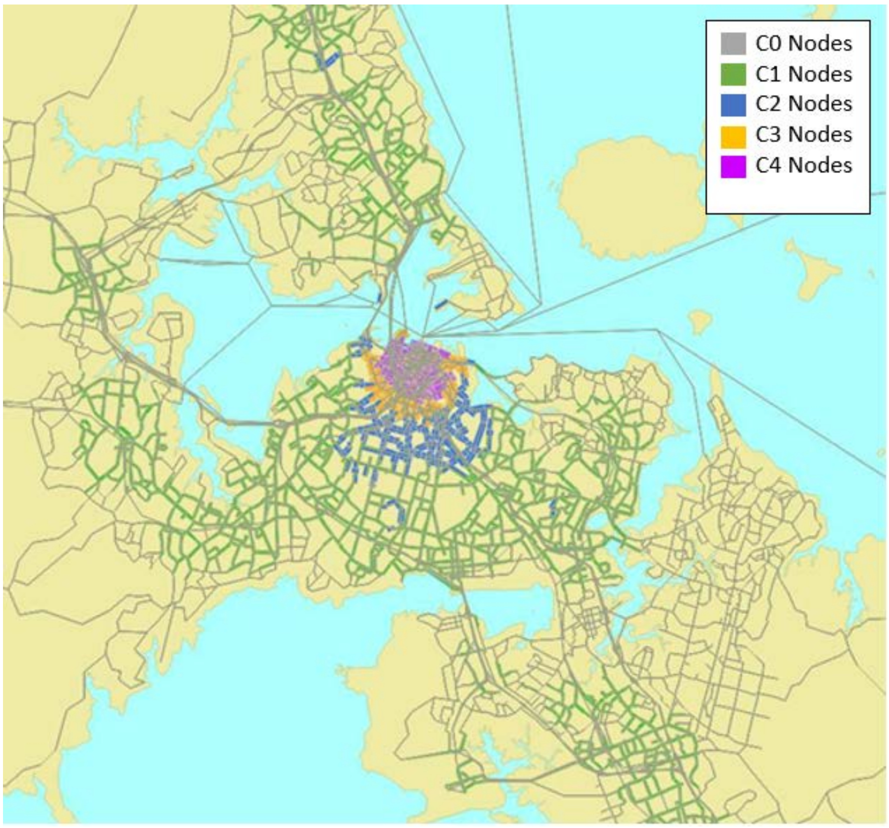
The methodology for introducing the auxiliary transit modes is as follows.

1. Prepare a list of nodes in the network that have high public transport usage. Select the top 250 nodes based on their combined initial boarding and final alighting numbers. Collectively, these 250 nodes cover around 70% of public transport boarding and alighting.
2. Copy an existing network scenario. For all nodes selected in step 1 above, assign a dummy public transport usage number to any links within a 2 km radius of that node. This should be done additively such that, if a link is within the radius of multiple nodes (overlapping), then its public transport usage number will be accumulated as a sum across all those nodes.
3. Get the maximum public transport usage number for the whole network. Add five new auxiliary transport modes (Class 0–4) as follows:
    a. The Class 1 Mode (C1) is assigned to links whose public transport usage numbers are 3%–10% of the maximum usage number (ie, all first/last mile travel along these links will be assumed to be in auxiliary transit mode C1, as opposed to, say, a pure walking mode).
    b. The Class 2 Mode (C2) is assigned to links whose public transport usage numbers are 10%–40% of the maximum usage number.
    c. The Class 3 Mode (C3) is assigned to links whose public transport usage numbers are 40%–80% of the maximum usage number.
    d. The Class 4 Mode (C4) is assigned to links whose public transport usage numbers are 80%–100% of the maximum usage number.
    e. The Class 0 Mode (C0) will be the assumed travel mode for all other links (ie, those links whose public transport usage numbers are 0%–3% of the maximum usage number).

For the Auckland Network, this results in the distribution of modes shown in Figure 5.2, where purple-coloured links are traversed using mode C1, orange-coloured links using C2, and so forth to C0, which are grey and have the assumed lowest levels of micromobility uptake.

This provides the ability to select parts of Auckland to reflect different land-use and public transport provision that are used in Table 5.2.

Figure 5.2 Auckland network with colour-coded public transport class modes



4. Assign (composite) speeds to the new modes, based on the assumed uptake of micromobility under each of two scenarios: high and low. The composite speed is calculated by:

$$Comp_{Speed} = Micro_{Speed} \times Percent_{Micro_{Uptake}} + Walk_{Speed} \times \left(1 - Percent_{Micro_{Uptake}}\right)$$

(Equation 5.1)

The assumptions on speed and uptake by class, and the resultant composite speeds, are as shown in Table 5.1 below.

Table 5.1 Assumed model speeds for transport class modes

Assumed speeds (of base modes)					
Walk	4 km/h				
Micromobility	15 km/h				
% usage/uptake of micromobility					
	C4	C3	C2	C1	C0
High	20%	20%	15%	10%	5%
Low	10%	10%	5%	5%	2%
Assumed (composite) speed (km/h)					
	C4	C3	C2	C1	C0
High	6.2	6.2	5.7	5.1	4.6
Low	5.1	5.1	4.6	4.6	4.2

5.2.2 Results

The following results were produced by the MSM using the year 2028 as the reference scenario for Auckland. For each of the three scenarios, the effect (on the number of car trips and public transport trips) of introducing micromobility for the first/last mile of trips is shown in Table 5.2 below.

Table 5.2 Forecast car and public transport (PT) trips for different micromobility uptake scenarios

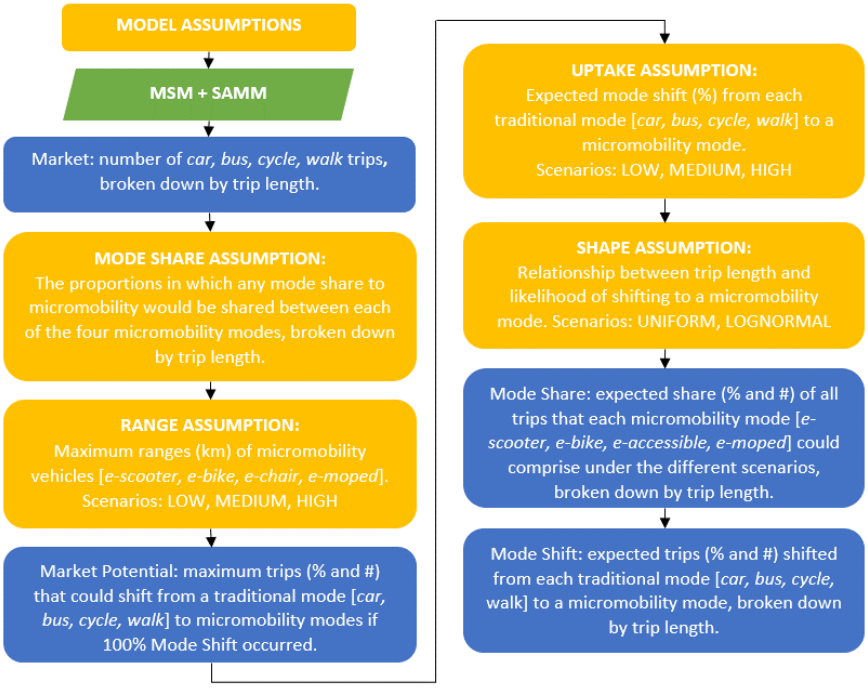
Access to micromobility	Major city fringe/ regional city CBD (high levels of PT)	Major city suburbs/ regional city fringe (high levels of PT)	Suburban (low levels of PT)
Limited access to micromobility (low to moderate availability of shared devices, low rate of device ownership)	• PT patronage up 2.1% • Car usage down 1%	• PT patronage up 2.8% • Car usage down 0.4%	• PT patronage up 3.4% • Car usage down 0.3%
Moderate access to micromobility (high availability of shared devices, low to moderate rate of device ownership)	• PT patronage up 4.7% • Car usage down 2.3%	• PT patronage up 8.5% • Car usage down 1%	• PT patronage up 9.8% • Car usage down 0.9%
Easy access to micromobility (high availability of shared devices, high rates of device ownership)	• PT patronage up 7.3% • Car usage down 3.4%	• PT patronage up 10.2% • Car usage down 1.3%	• PT patronage up 10.1% • Car usage down 1.1%

5.3 Market potential modelling for ‘end-to-end’ trips

Using the trip numbers generated by the MSM and the SAMM (for car, public transport, walking and cycling modes), a market potential analysis was conducted to forecast the mode shift to micromobility modes and mode share between those modes under different assumptions on the use of micromobility and uptake scenarios.

A flow diagram of the methodology is shown in Figure 5.3.

Figure 5.3 Market potential modelling methodology flow diagram



5.3.1 Methodology

For this analysis, the available market to mode shift to micromobility was considered to be the sum of all 'existing' car, public transport, cycling and walking trips (based on the output of the MSM).

These trips were downloaded from the model and allocated into bins by trip length. The distribution of trip lengths, and the mode share of those trips, are shown in Figure 5.4 and Figure 5.5 below.

Figure 5.4 Distribution of the existing 'market' of trips for each major mode, by trip length

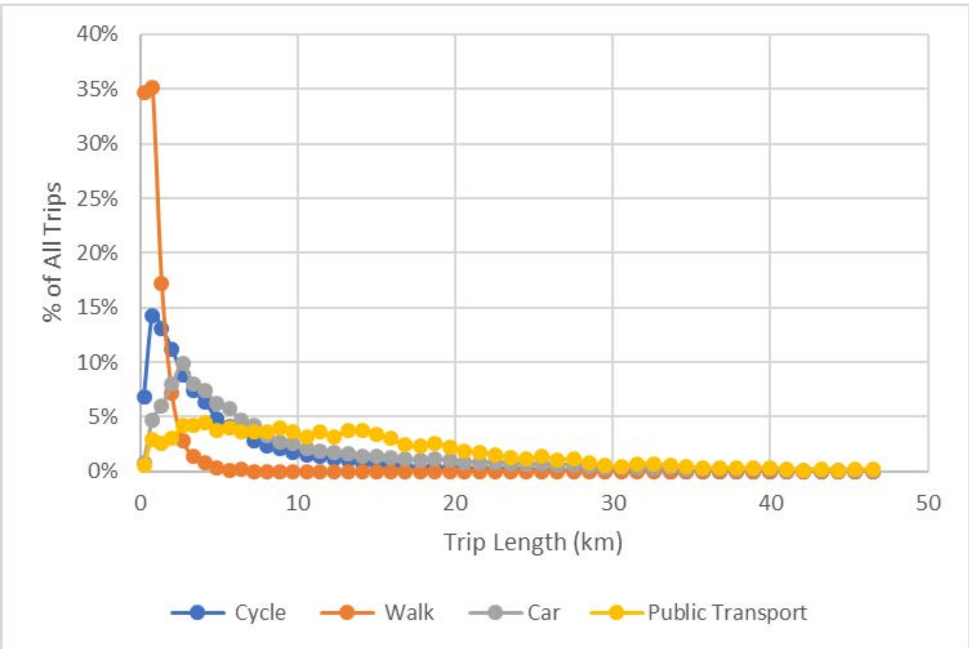
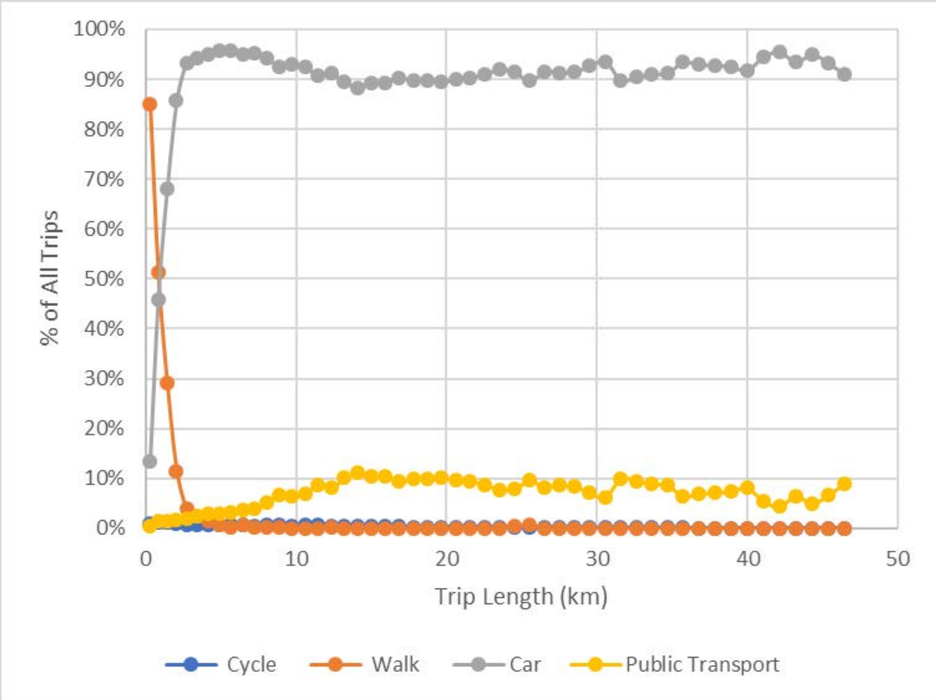


Figure 5.5 Mode share of trips between current major mode options (public transport, private vehicle, walking, cycling), by trip length



Two assumptions were then applied to this trip data in order to calculate market potential:

1. **Mode share assumption** – the proportion in which any mode shift to micromobility would be shared between each of the four micromobility modes being considered. This assumption was applied to prevent 'double-dipping' of trips across micromobility modes.

   The mode shift to micromobility was assumed to occur 50% to e-scooters, 2% to e-accessible devices, 33% to e-bikes, and 15% to e-mopeds (Table 5.3).

   These proportions apply as stated up until the maximum range of each mode (Table 5.4), when the proportions are then split amongst the remaining modes. So, for example, at a distance of > 5 km under the high-range scenario (which is assumed to exceed the travel range of e-scooters and e-accessible devices), mode shift to micromobility would be split in a 33:15 ratio between e-bikes and e-mopeds.

Table 5.3 Assumed proportion in which trips shift to a micromobility mode

	E-scooter	E-accessible	E-bike	E-moped
Mode share split	50%	2%	33%	15%

2. **Range assumption** – the maximum usual range (km) of each type of micromobility vehicle. Low, medium and high scenarios were identified here to account for variation and development of micromobility technology. The ranges assumed for each case are as per Table 5.4 below.

Table 5.4 Assumed travel range parameters ('typical maximum trip distance')

Assumed travel range (km)	E-scooter	E-accessible	E-bike	E-moped
Low	1.5	3	10	5
Medium	3	4	15	10
High	5	5	20	15

By applying these two assumptions to the market trip data, micromobility market potential was identified: that is, the maximum number of trips that could shift to a micromobility mode based on the range assumption, shared between micromobility modes as per the mode share assumption. This represents, in essence, a 100% mode shift scenario that can be taken to the next step of forecasting. The resultant maximum percentage (of all existing trips) that could shift to each micromobility mode is shown in Figures 5.6 to 5.9 below.

Figure 5.6 Market potential for e-scooters

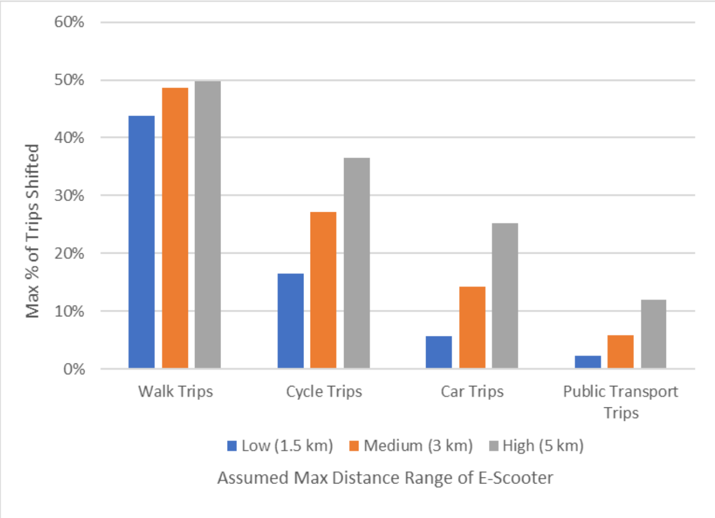


Figure 5.7 Market potential for e-bikes

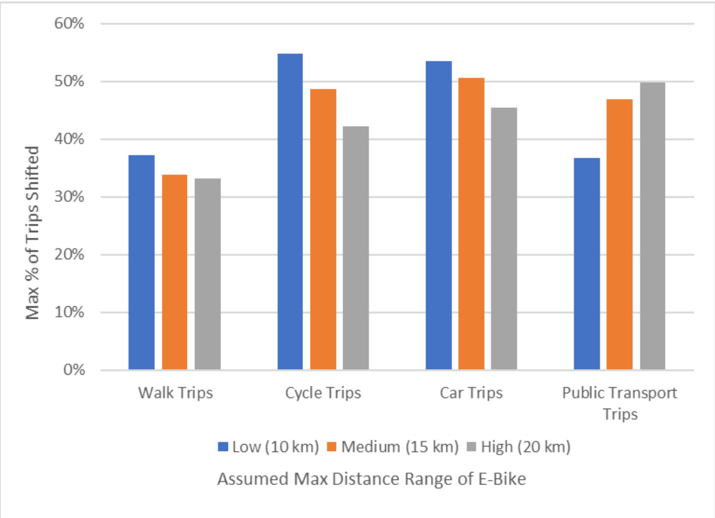


Figure 5.8 Market potential for e-mopeds

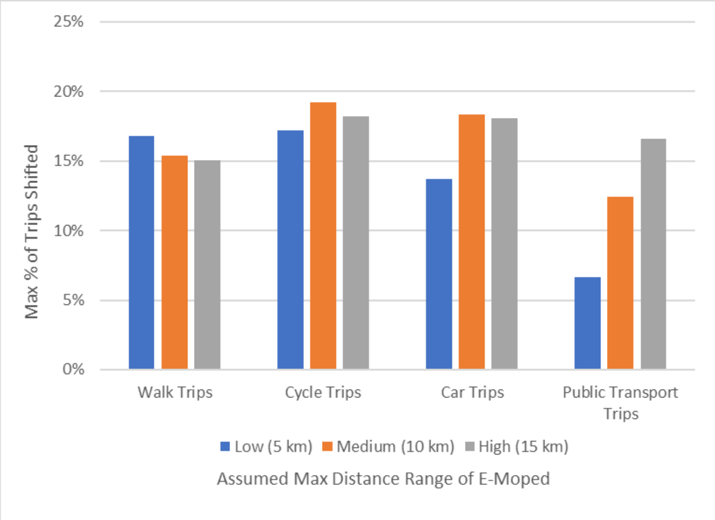
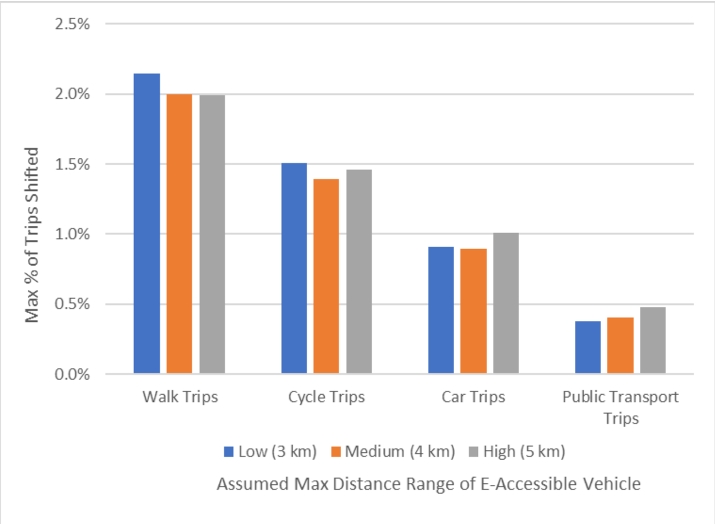


Figure 5.9 Market potential for e-accessible devices



Market potential represents an upper bound on mode shift. In order to identify scenarios for likely actual mode shift (and the resultant mode share), three further assumptions were then applied to this data:

3. **Uptake assumption** – the percentage of all available trips (ie, of the market potential) that are assumed to actually be shifted to each micromobility mode. Low, medium and high scenarios were identified here to serve as proxies for different real-world scenarios (eg, quality of infrastructure available, accessibility of micromobility ownership). This is shown in Table 5.5.

Table 5.5 Assumed uptake assumptions for four micromobility modes

Assumed uptake	E-scooter	E-accessible	E-bike	E-moped
Low	5%	5%	5%	5%
Medium	15%	15%	15%	15%
High	25%	25%	25%	25%

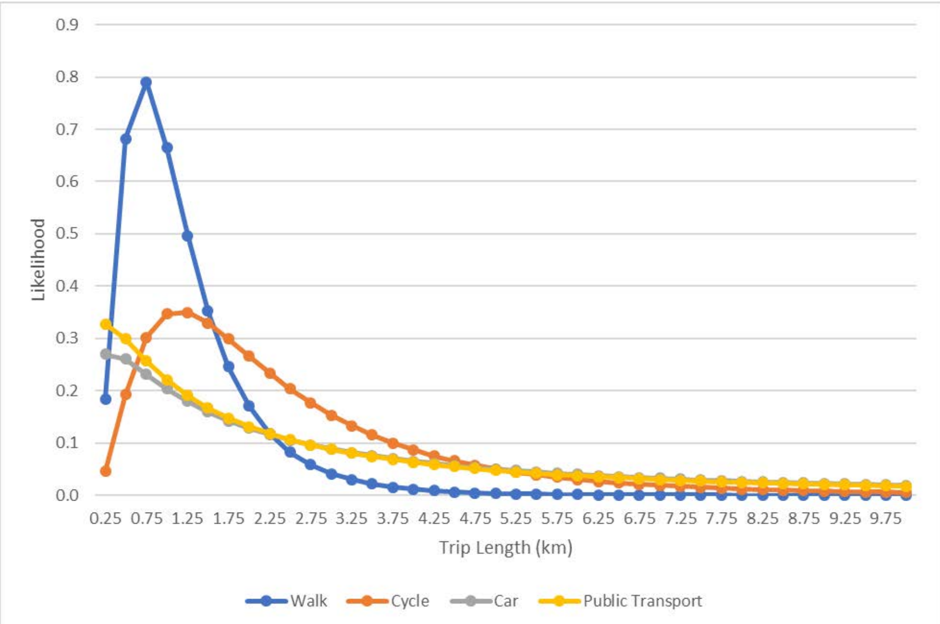
4. **Initial mode assumption** – distribution of what initial mode all trips shifted to a micromobility mode were shifted from. This is shown in Table 5.6.

Table 5.6 Assumed source (initial mode) make-up of trips that shift to each micromobility mode

Initial mode	E-scooter	E-accessible	E-bike	E-moped
Walk	50%	10%	20%	30%
Cycle	0%	0%	20%	0%
Car	40%	70%	50%	50%
Public transport	10%	20%	10%	20%

5. **Shape assumption** – the assumed relationship between trip length and likelihood of shifting to a micromobility mode – either uniform (trip length has no bearing on likelihood that trip is shifted to a micromobility mode) or lognormal (shifting to a micromobility mode is more desirable for shorter trips). It is assumed that lognormal would best represent the effect of shared micromobility. Figure 5.10 shows the distributions used for scenarios where a lognormal distribution was assumed.

Figure 5.10 Likelihood of shifting to a micromobility mode by trip length



'Likelihood', as shown in the figure above, is a scaling coefficient applied to the available 'market' of trips at any given length such that when the uptake assumptions (given in Table 5.5) are applied, the *total mode shift* across trips of all lengths will be equal to if the uptake percentage assumptions were applied flatly across all trips. In practice this means that, for instance, ~80% of 'available' walk trips that are ~1 km long can shift to a micromobility mode, whereas only ~15% of 'available' walk trips that are ~2 km long can shift to a micromobility mode.

By combining the trip numbers calculated for market potential with the three assumptions above, a number of possible scenarios are created for what the uptake of micromobility might look like, and therefore what the resultant mode shift and mode share might be.

For each micromobility mode, uptake is calculated by sampling from the market potential trips for that mode at the assumed uptake rate, either uniformly by trip length, or in a lognormal pattern (selecting the majority of trips from the shorter trips available).

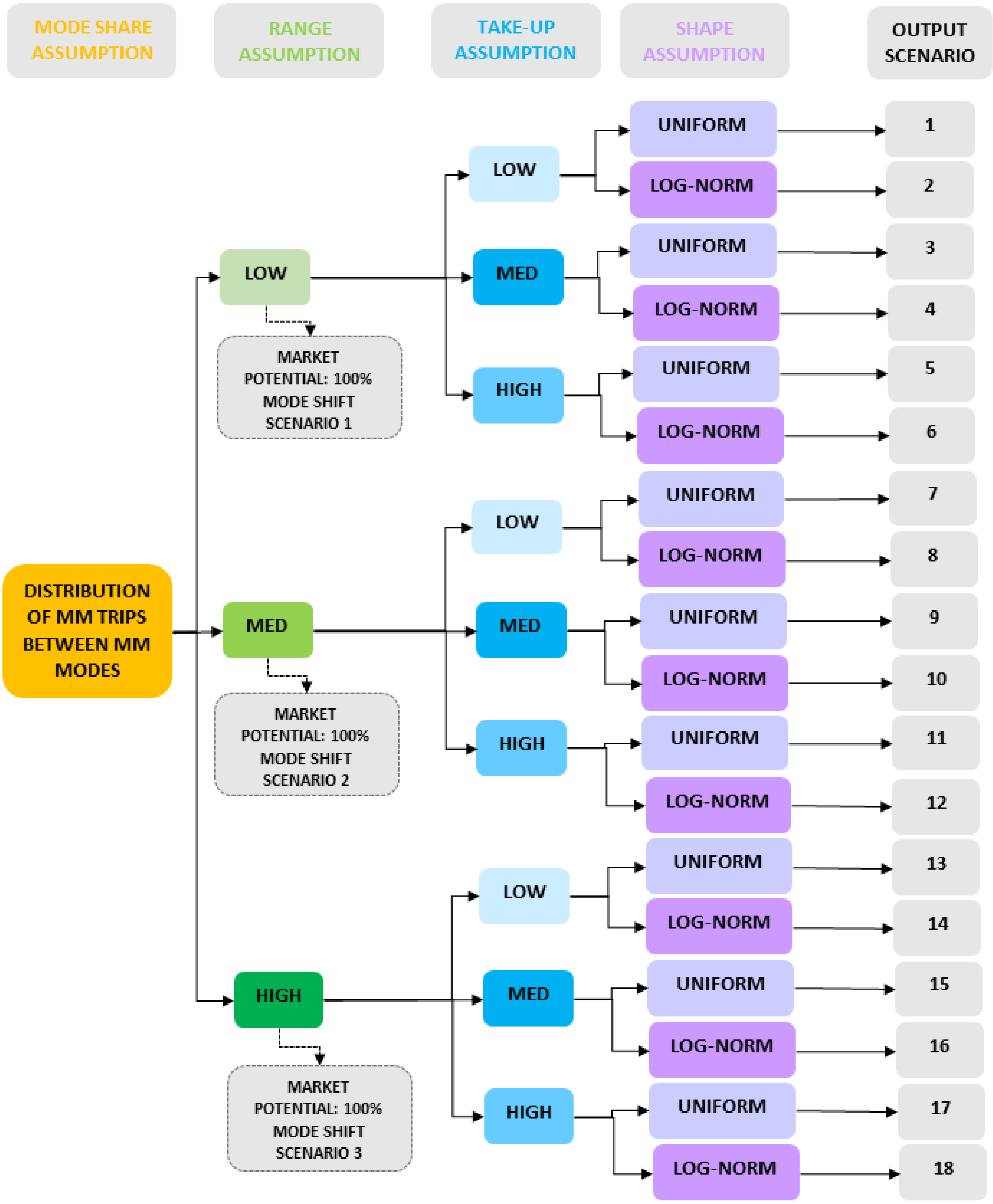
This trip uptake is assumed to have been shifted from each of the four standard modes (walking, cycling, car, public transport) in the proportions given by the initial mode assumption – this straightforward division gives the mode shift from each current mode to each micromobility mode.

Mode share is then calculated by dividing the number of trips shifted to each micromobility mode by the total number of trips across all modes.

Note: The lognormal shape assumption tends to produce estimates slightly below those produced by the uniform shape assumption. This is because the lognormal is sampling in a fixed shape, and at some points (especially peaks) of this shape there may not be enough actual trips available of that trip length to 'fill out' the desired sample shape.

Figure 5.11 provides a visual representation of the flow through each set of assumptions to the resultant mode share.

Figure 5.11 Explanation of assumptions for each output scenario



MM = micromobility

5.3.2 Mode shift results

Table 5.7 shows the forecasted range of mode shift from each current mode to micromobility.

Table 5.7 Micromobility mode shift – percentage of trips (by initial mode) shifted to each micromobility mode

Initial mode	Micromobility mode	Mode shift
Walk	E-scooter	3%–15%
	E-bike	3%–16%
	E-moped	2%–9%
	E-accessible	< 0.2%
Cycle	E-scooter	< 0.1%
	E-bike	34%–46%
	E-moped	< 0.1%
	E-accessible	< 0.1%
Car	E-scooter	0.2%–1.2%
	E-bike	1.3%–6.1%
	E-moped	0.5%–2.1%
	E-accessible	< 0.1%
Public Transport	E-scooter	1%–3%
	E-bike	3%–10%
	E-moped	2%–5%
	E-accessible	< 0.3%

Note that the above mode shift ranges assume that the 'medium' maximum travel distance assumptions are applied (listed in Table 5.4 above). Although the mode shift from pushbikes to e-bikes appears particularly high in comparison to other mode shifts, this represents a relatively small fraction of overall trips: pushbike trips represented less than 1% of all trips used in the base (2028) trip data for this modelling.

It is not necessarily appropriate to simply 'add together' the mode shift ranges above to produce an overall estimate, as the contexts in which the extremes of each range occur may differ between micromobility modes. For example, although the estimates above suggest that up to 15% of walked trips could shift to e-scooters, and up to 16% could shift to e-bikes, it would not be appropriate to conclude that up to 31% of walked trips will shift to micromobility. This is because the contexts that are likely to result in upper-end mode shift occurring for e-scooters (eg, major city CBD contexts) are not necessarily the same as the contexts that are likely to result in the upper-end mode shift occurring for e-bikes (eg, city fringe-type contexts); thus the two should not be simply added together at face value.

It is important to note that this modelling was conducted independently of the first/last mile modelling discussed in the previous section. The mode shift figures given above are based on 'existing' mode share between private vehicles and public transport; that is, without any first/last mile use of micromobility in connection with public transport or the resultant expected increase in patronage. In practice, the actual effect on public transport patronage as a result of micromobility is expected to be a combination of these two influences: some increase due to first/last mile connections; some decrease due to (whole-of-trip) mode shift to e-scooters and e-bikes. The exact balance of these effects has not been quantified in this research.

5.3.3 Mode share results

Table 5.8 shows what the resultant micromobility mode share could be expected to look like under various uptake/device travel range scenarios.

A note on interpreting these results: As a consequence of the modelling approach (using a range of assumptions rather than a single fixed value), there is some interdependency of results. The e-bike high travel range results, for instance, include an inbuilt assumption that high travel ranges are also in place for e-scooters and e-accessible devices. This means, perhaps counterintuitively, that the resultant e-bike mode share is slightly lower under a high travel range scenario than under a medium travel range scenario, because trips in the 3–5 km range are now picked up by e-scooters instead. Collectively this means that, although the results above are a valuable guide, there are limitations associated with attempting to 'pick and mix' scenarios from Table 5.7 across different modes.

If there is a specific real-world scenario of interest to a practitioner where the uptake and/or travel range assumptions differ across micromobility modes (eg, high use of e-scooters but only moderate use of e-bikes), it is recommended that the model be run specifically for that combination of assumptions, calculating them as a single scenario. This is a straightforward, fast process – the only reason these types of 'composite' results are not presented here is due to the sheer number of possible combinations of assumptions that may be of interest.

With that context in mind, the results are shown in Table 5.8.

Table 5.8 Micromobility mode share for each output scenario

Mode	Low-range assumption			Medium-range assumption			High-range assumption		
	Low uptake	Med uptake	High uptake	Low uptake	Med uptake	High uptake	Low uptake	Med uptake	High uptake
Uniform demand assumption									
E-scooter	0.6%	1.7%	2.7%	0.9%	2.7%	4.3%	1.3%	3.6%	5.6%
E-accessible	0.1%	0.1%	0.2%	0.1%	0.1%	0.2%	0.1%	0.2%	0.2%
E-bike	2.3%	5.6%	8.5%	2.1%	5.3%	8.4%	1.9%	4.8%	7.6%
E-moped	0.7%	1.7%	2.5%	0.8%	2.2%	3.4%	0.7%	2.1%	3.3%
Lognormal demand assumption									
E-scooter	0.3%	1.0%	1.6%	0.7%	2.1%	3.5%	1.2%	3.4%	5.7%
E-accessible	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.2%
E-bike	2.0%	5.1%	8.0%	2.0%	5.2%	8.1%	1.8%	4.9%	7.7%
E-moped	0.5%	1.4%	2.3%	0.7%	2.0%	3.3%	0.8%	2.2%	3.5%

Figures 5.12 through 5.15 demonstrate how this mode share is expected to be spread across trip distances for each of the micromobility modes of interest.

Figure 5.12 Mode share for e-bikes under various scenarios, by trip length

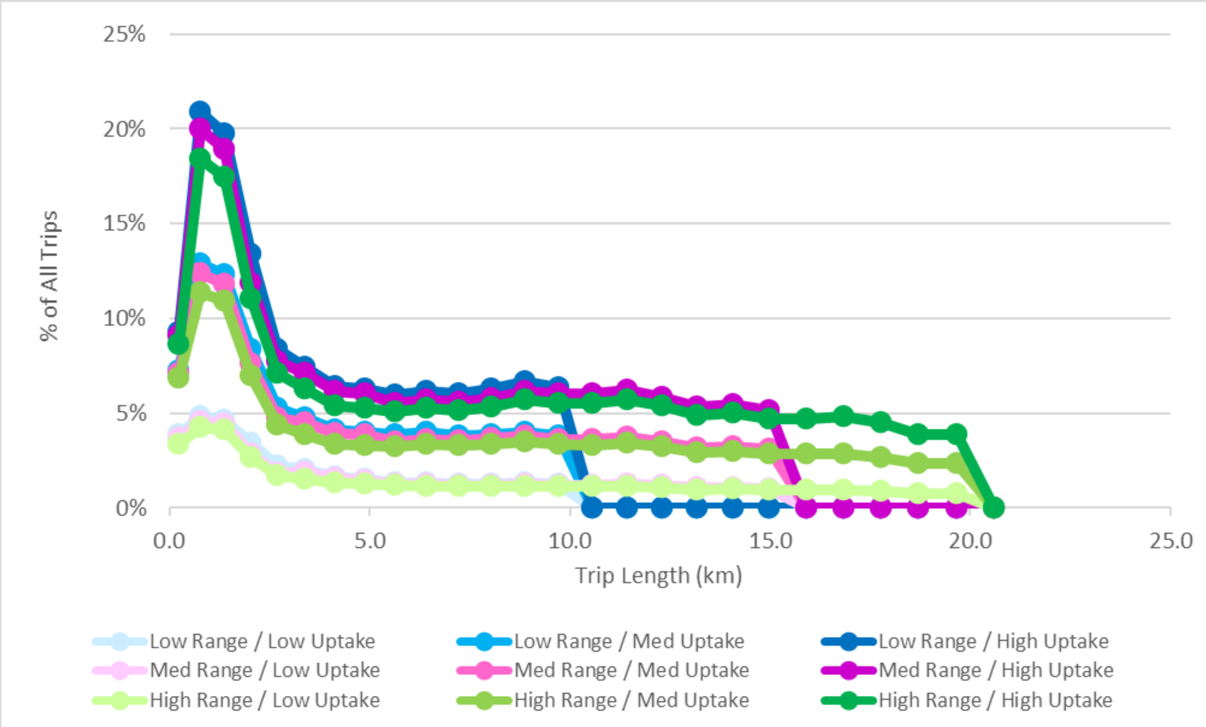


Figure 5.13 Mode share for e-scooters under various scenarios, by trip length

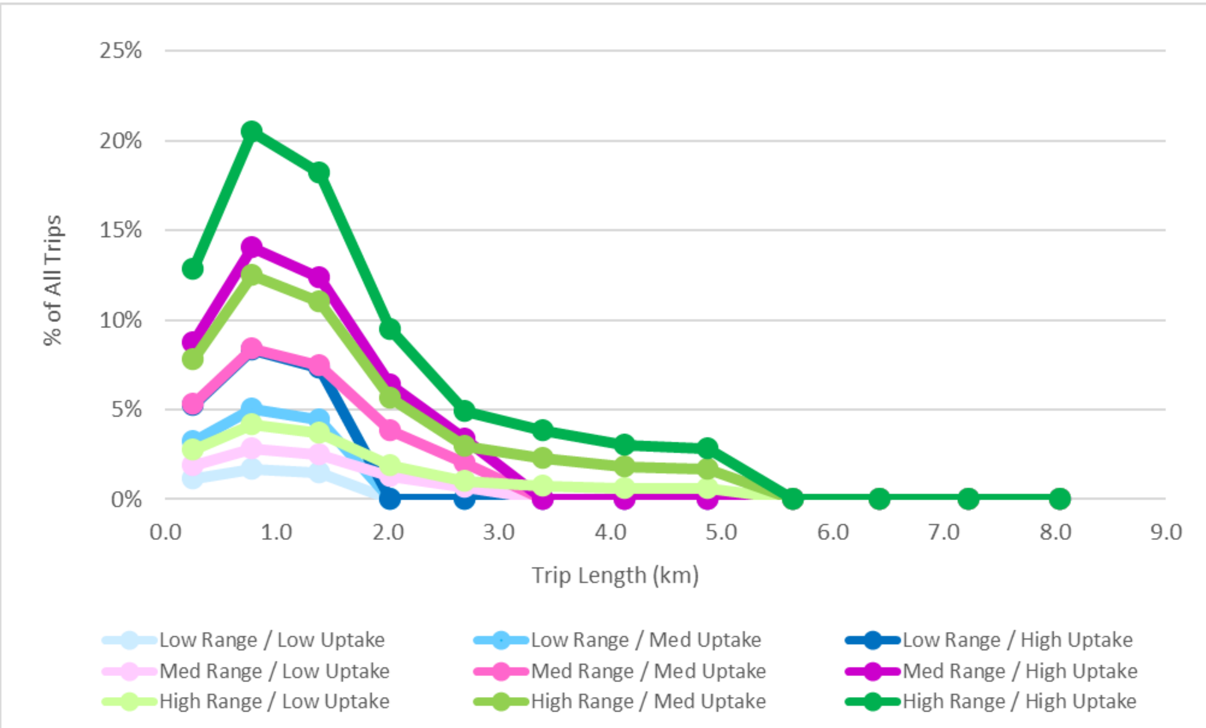


Figure 5.14 Mode share for e-mopeds under various scenarios, by trip length

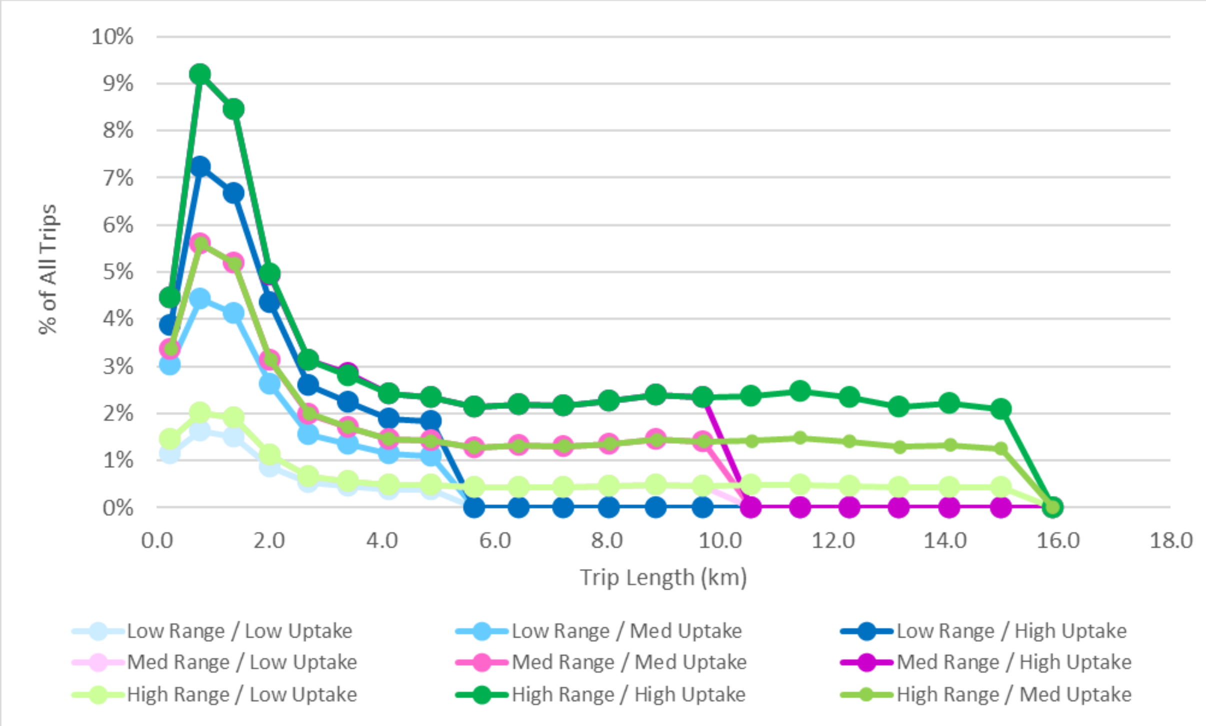
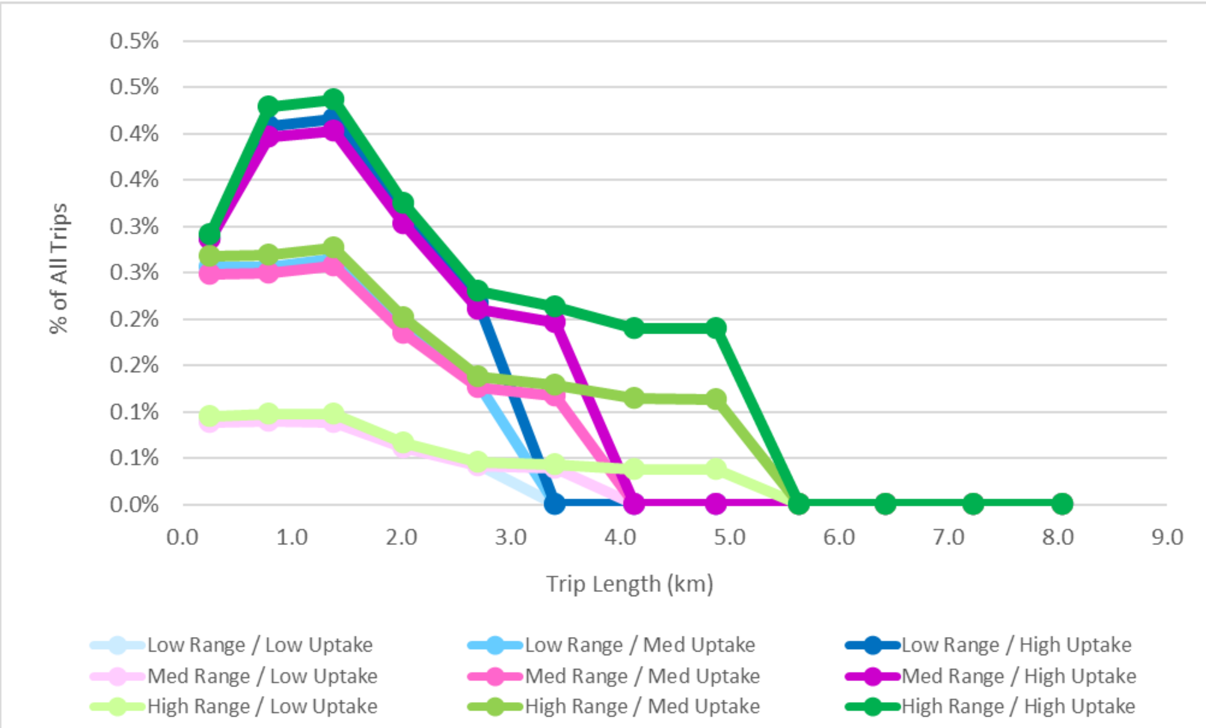


Figure 5.15 Mode share for e-accessible devices under various scenarios, by trip length



5.3.4 Mode share for land-use scenarios

Based on the behavioural trends identified by the literature review, five distinct ‘land-use’ scenarios were developed, which are expected to induce different uptake behaviours for e-scooters and e-bikes. Table 5.9 maps these land-use scenarios to the set of modelled scenarios that are anticipated to be a good fit. It is acknowledged that the evidence on this subject available at the time of writing was limited, so these scenarios may require review as more detailed data comes to light in future.

Table 5.9 Modelled mode share ranges for several common land-use types

Land-use	Modelled scenarios	Mode share range
Major city – CBD	• High uptake scenario for e-scooters (scenarios 13–18 as set out in Figure 5.11) • Medium uptake scenario for e-bikes (scenarios 7–12)	• E-scooter mode share: 1.6%–5.7% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Major city – fringe (~5 km radius)	• Medium uptake scenario for e-scooters (scenarios 7–12) • High uptake scenario for e-bikes (scenarios 13–18)	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 7.7%–8.1% of all trips
Major city – suburban	• Medium uptake scenario for e-scooters (scenarios 7–12) • Medium uptake scenario for e-bikes (scenarios 7–12)	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Regional city – CBD/fringe	• Medium uptake scenario for e-scooters (scenarios 7–12) • Medium uptake scenario for e-bikes (scenarios 7–12)	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Regional city – suburban	• Low uptake scenario for e-scooters (scenarios 1–6) • Low uptake scenario for e-bikes (scenarios 1–6)	• E-scooter mode share: 0.3%–1.2% of all trips • E-bike mode share: 1.8%–2.0% of all trips

5.4 Summary of micromobility modelling

As discussed in Section 5.1, the lack of benchmarking data for mode shift to micromobility required an approach that split mode shift into a series of assumptions, where a range from low to high for each assumption could be applied, to in turn produce a final range for forecast mode shift.

It is assumed that uptake of micromobility will occur over time. 2028 trip data was used in the modelling, and the forecast for mode shift to micromobility is for around 2030.

The e-moped micromobility mode is not currently legal in New Zealand and will require exceptions to be granted for them to be able to be used. While the forecasts include a mode shift to e-mopeds, this has not been carried through to the results in section 7 or the recommendations in section 8. Including e-mopeds in project evaluations may overestimate the mode shift that will be achieved, given the uncertainty of the uptake of the e-moped mode in New Zealand.

6 Impact evaluation

The Ministry of Transport's Transport Outcomes Framework, introduced in section 1.2 of this report, sets out that the core purpose of New Zealand's transport system is 'to improve people's wellbeing, and the liveability of places' with regard to intergenerational wellbeing and quality of life across cities, towns and provinces alike (Ministry of Transport, 2018, p. 3). This purpose is understood in relation to five key interconnected outcomes: inclusive access; healthy and safe people; environmental sustainability; economic prosperity; and resilience and security.

This section assesses the potential impacts of micromobility in relation to each of these five key outcomes and identifies appropriate interventions to either:

- mitigate those impacts where they conflict with one or more of the five wellbeing outcomes, or
- ensure and amplify those impacts where they align with one or more of the five wellbeing outcomes.

6.1 Inclusive access

Enabling people to participate in society through access to social and economic opportunities, such as work, education, and healthcare.

Micromobility will impact the degree to which individuals can access social and economic opportunities. The magnitude of this impact will vary depending on a variety of factors.

In general, more transportation options will support greater individual choice. Depending on local infrastructure, income, physical ability, demographics and urban geography, the effects may not be spread evenly across the population.

Benefits of micromobility are – at least initially – likely to accrue more to males and wealthier individuals who are more likely to use micromobility and live in areas with better infrastructure (City of Santa Monica, 2019; Groth, 2019).

Women may be less inclined to use micromobility because of safety concerns where there is little or no safe infrastructure (Krizek & McGuckin, 2019).

Greater usage of micromobility may detrimentally impact the elderly, disabled and other vulnerable footpath users because of the shared use of a limited space with a potentially high speed-differential (Auckland Council, 2019b, p. 13).

Despite being less expensive in general than private vehicle ownership, micromobility does have an upfront cost that may be a barrier for less wealthy sections of society. Furthermore, many shared micromobility options require personal technology, such as a smartphone and cellular data, for use, which may further restrict the benefiting population.

Micromobility has the potential to both increase public transport usage in some areas and reduce it in others. Micromobility can help solve the first/last mile issue for access to public transport, thereby improving journey times overall for public transport and potentially increasing usage (Fitt & Curl, 2019). However, in other places micromobility has the potential to replace trips that would otherwise have taken place via public transport (Auckland Council, 2019c, p. 16). This may be more prevalent in areas that currently are poorly served by public transport.

Micromobility devices have been shown to increase the number of jobs accessible within a reasonable commute time, which improves equitable access to jobs. By reducing the impact of where people live on the jobs they have access to, micromobility can have an impact on increasing job access (Micromobility Coalition, 2019).

6.2 Healthy and safe people

Protecting people from transport-related injuries and harmful pollution and making active travel an attractive option.

One widely touted advantage of micromobility is that it makes ‘active’ travel a more attractive and convenient option for many people because of increased travel speeds for reduced effort (relative to walking or cycling, especially in a first/last mile context) and ease of navigation and parking (relative to car travel). Mental health related benefits can be expected to accrue for those newly shifting to an active mode (Sustrans, 2017), but exactly how any shift translates into physical health impacts is less clear-cut: while there may be an increase in active travel mode share overall, the ‘quality’ of active travel may actually be reduced sometimes because of the lower physical effort required to operate an e-powered scooter or bike (Cairns et al., 2017). However, e-bike studies have shown that e-bike users tend to use their bikes more often and for longer distances than pushbike users, off-setting at least some of these reductions in exercise intensity that occur when switching from a pushbike to an e-bike (Fyhri & Fearnley, 2015; Langford et al., 2013). On average, e-bike users are able to achieve recommended daily levels of moderate intensity exercise, even when using the highest levels of assistance, because of the tendency to take more frequent, longer trips (Gojanovic et al., 2011). Studies have also shown that when older people switch from a pushbike to an e-bike it is often because pushbike use is becoming too physically difficult, thus e-bikes can help to sustain physical activity amongst older people, and prevent them from switching to car use (Groth, 2019; Jones et al., 2016). These findings are important, as the largest cycling-related health gains accrue to older cyclists.

Because the user is still required to pedal, e-bikes are assumed to provide more physical activity than e-scooters. While there have been no published papers on the physical activity associated with using an e-scooter, it is likely that there are some physical activity benefits, depending on the terrain it is used in, including requirements to stand, balance and push the scooter at times.

Mode shift to micromobility has the potential to reduce the health impacts associated with poor air quality in proximity to busy roads, both by promoting increased separation of ‘cycle’ infrastructure from roads, and by reducing traffic volumes more generally.

From a safety perspective, micromobility has the potential to introduce a range of new risks. Some of these risks are a product of the modes themselves (higher speeds, device balance), some are linked to the specific road/pavement environment (steepness, camber, surface quality), and others may arise as a result of different modes sharing the same physical space. These impacts will be able to be managed to an extent through infrastructure design and carefully considered separation of micromobility from other modes. Policy interventions would also be beneficial in this area; speed restrictions (potentially digitally reinforced in key locations) are examples of this. Work in the infrastructure and policy space here could also have additional safety benefits for those already cycling and walking.

There are likely to be transitional impacts on safety, as some new micromobility users may initially lack good handling skills, as well as more general ‘active travel’ skills such as spatial awareness. This is particularly relevant for uptake of e-scooters and e-bikes. These transitional safety impacts will be particularly apparent if there is a period of lag between when an observable increase in micromobility uptake takes place, and when micromobility-specific policy or infrastructure is implemented.

Although mode shift to micromobility will likely reduce the volume of cars on the road on average, it is unlikely that this will result in a proportionate reduction in vehicle-related casualties because micromobility tends to replace suburban or urban trips, rather than higher-risk travel such as higher speed rural travel. Any benefits in a reduction of car transport-related injuries are likely to be at least balanced, if not outweighed, by the safety risks associated with micromobility travel itself.

6.3 Environmental sustainability

Transitioning to net zero carbon emissions, and maintaining or improving biodiversity, water quality and air quality.

Micromobility will have an impact on environmental sustainability both positively and negatively.

Core factors of micromobility that create the potential for a positive impact on environmental sustainability are that it is electrically powered, releases zero emissions at point of use, creates minimal noise, requires less physical space for use and storage than traditional means of transportation, and requires less space for supporting infrastructure than other motorised modes.

New Zealand has a high percentage of electricity production from sustainable sources (Ministry of Business, Innovation and Employment, 2018). Micromobility transportation options can leverage this environmentally sustainable energy production sector to reduce the contribution of transportation to national emissions. Widespread adoption of e-bikes would not require any modification to the electricity grid given the comparably small energy requirements required to propel the vehicles (around 1/20th that of an electric car) (Tillemann & Feasley, 2018).

Electrically powered micromobility vehicles will release no emissions at point-of-use. When compared to traditional internal combustion powered vehicles, this will reduce both greenhouse gas emissions and particulate matter emissions, both of which are indirectly and directly harmful to the environment.

Micromobility vehicles typically produce no noise. Noise pollution from conventional transportation options can disturb wildlife and affect the mental health of those nearby. Balancing this, the silent running of micromobility can increase the danger for vulnerable groups such as the visually impaired, who may rely on sound to detect approaching vehicles.

Micromobility devices require much less space for parking than private automobiles. They are well suited as a transport option in higher density living and could enable higher density urban development.

Micromobility continues to develop. Earlier versions of e-scooters (particularly shared versions) had a relatively short lifespan. As discussed in section 3.5.5, the environmental footprint of the production and disposal of micromobility vehicles depends on the obsoletion rate, where shorter lifespans of devices reduce their environmental benefits. In a similar way to other battery-powered consumer devices such as laptop computers and phones, the disposal of batteries associated with micromobility devices could create a new waste stream if there is no suitable facility for their disposal or recycle.

6.4 Economic prosperity

Supporting economic activity via local, regional, and international connections, with efficient movements of people and products.

With a higher economic justification for shared paths/cycle lanes relative to other potential transport infrastructure, this could enable councils to build high-throughput transport infrastructure at lower costs than traditional automobile infrastructure.

Mode shift to micromobility may lead to increased ‘foot-traffic’ or foot traffic in entirely new places. This may facilitate growth for retailers and other on-street small businesses. It may create opportunities for ‘micro-delivery' economies, lowering the barrier to entry for delivery-style retail offerings. At a broader level, the low capital and ongoing costs of owned micromobility, relative to both private vehicles and even (over a longer term) public transport, may enable some individuals and families to access jobs and opportunities previously denied to them because of poor transport options or affordability.

There is the potential for tangential benefits to the freight transport industry in the form of the use of micromobility for freight pick-up and delivery in locations where there is congestion or impacts from heavy traffic mixing with other users of the road space.

At the direct level, growing micromobility mode share has the potential to create and grow a new sector focused on the provision, maintenance, and day-to-day logistics management of micromobility devices, as well as the development of supporting infrastructure such as docking and charging stations at public transport hubs.

That growth notwithstanding, there are corresponding negative economic impacts for the automotive industry and associated service providers such as mechanics and petrol stations, in the form of a reduction in demand. There may also be some impacts on the taxi and ride-share industries, although there is potential for companies in the ride-share space to enlarge their offering to include micromobility.

6.5 Resilience and security

Minimising and managing the risks from natural and human-made hazards, anticipating and adapting to emerging threats, and recovering effectively from disruptive events.

Micromobility has the potential to add an extra layer of resilience to public transport systems in New Zealand by providing a viable alternative in cases of short-term network failure or compromised operations, such as driver strikes, rail network outages, or construction/event/emergency-based road closures. The COVID-19 pandemic also throws light onto the potential for micromobility to contribute to a resilient network in a more sustained manner, as a 'socially distanced' transit mode, should the need for distancing persist or re-occur (Naka, 2020). A reduced dependence on petrol, the price and supply of which are largely beyond New Zealand's control, may also be enabled by micromobility; this would further contribute to the resilience of transport networks.

These positive impacts notwithstanding, high dependency on micromobility modes may leave transport systems vulnerable to electrical grid failure during significant weather events. E-bikes will be the least vulnerable because they can still be used without power, but e-scooters, e-mopeds and e-accessible devices lose most of their utility without electricity. The higher obsolescence rate of micromobility vehicles (relative to cars in particular) may also make transport systems more vulnerable to major disruptive events in international manufacturing. Actively growing capacity within New Zealand to manufacture and maintain micromobility devices is a strategy that may be of interest in developing resilience to this vulnerability.

Micromobility – particularly, 'shared' micromobility – has the potential to impact privacy and security outcomes for New Zealanders in a range of ways, depending on the digital and policy solutions put in place. The operations model of shared micromobility services requires that data be recorded on personal journeys and locations; this represents a substantial risk to privacy if good data security practices are not in place (University of Texas at San Antonio, 2020). Equally, the collection of such data may present an opportunity for transport planning and investment, facilitating a better-informed approach that fulfils the principles of mode neutrality.

6.6 Transport Outcomes Framework interventions

This section sets out to summarise, in a consistent framework, the identified impacts of an increased micromobility mode share across each of the Ministry of Transport's five identified wellbeing outcomes, and to propose interventions for those impacts. The suggested interventions may either be of a supporting nature (where the impact is desirable relative to Ministry of Transport wellbeing outcomes) or of a mitigating/eliminating nature (where the impact is not desirable). The legend in Table 6.1 provides a guide as to the nature of each impact identified in Table 6.2, and which groups of people and/or sectors may be particularly affected by it.

Table 6.1 Symbol legend for the impact interventions listed in Table 6.2

Impacts legend
Mostly positive
Varies with context
Mostly negative

People		Sectors	
	Affects those with reduced mobility		Affects transport infrastructure, services or planning
	Affects pregnant mothers or parents with small children		Affects retail or small and medium-sized enterprises
	Affects the elderly		Affects resource use, supply, or waste
	Affects those who are visually impaired		Affects freight and logistics
	Affects children and/or families with children		Affects housing, land-use or (sub)urban density
	Affects low-income households		Affects health services or infrastructure
	Affects cyclists		Affects air or water quality, or biodiversity
	Affects pedestrians, including those walking and running		Affects transport culture
	Affects those who are hearing impaired		
	Affects women		

Table 6.2 Transport Outcomes Framework impacts, affected groups and interventions

Wellbeing outcome	Impact of increased micromobility mode share	Affected people and sectors	Interventions (supporting or mitigating)
Inclusive access	Increases number of people within 'commutable distance' of business districts and facilitates reduction in commute times and/or costs; particularly by enabling connections with public transport.		• Ensure supporting infrastructure provides good amenity for all areas. • Allow some micromobility devices to be taken on board public transport. • Integrate micromobility with public transport, including MaaS. • Update planning and consent documents to reflect changing needs of households and businesses.
	Supports use and enjoyment of transport infrastructure for those with diverse mobility needs.		• Provide safe infrastructure. • Ensure any micromobility infrastructure is accessible. • Support priority or tailored access at destinations for those with differing needs or abilities.
	Risk that high purchase cost of owned micromobility (or high purchase cost of smartphone to access shared platforms) creates barrier to entry.		• Subsidise shared micromobility in lower socio-economic areas. • Develop grant schemes for device purchase (eg, government e-bike scheme).
	Risk that higher speeds of micromobility devices and obstructive 'parked' devices deter vulnerable users or those with children from using shared transport infrastructure.		• Require shared mobility devices to have software-imposed speed limits in high-risk zones. • Introduce lower posted speed limits on shared infrastructure. • Manage impacts on guide-dogs. • Provide micromobility parking.
	Risk that low frequency/suburban public transport routes become non-viable due to significant replacement of trips with micromobility.		• Ensure public transport usage can be integrated with micromobility. • Support micromobility initiatives that enhance public transport.
	Risk that first/last mile use of micromobility creates conflicting demand for 'priority spaces' on public transport due to increased number of devices being brought on board.		• Provide high-quality storage space for micromobility devices at public transport hubs/stations. • Provide additional and/or clearly demarcated spaces on trains and buses for storage of micromobility devices as well as pushbikes/kick scooters to deter incorrect use of pram/wheelchair spaces.

Wellbeing outcome	Impact of increased micromobility mode share	Affected people and sectors	Interventions (supporting or mitigating)
	Disproportionately lower access to benefits of micromobility for women due to safety-related reluctance to shift to active modes.		• Design and/or upgrade 'cycle' infrastructure to meet crime prevention through environmental design (CPTED) principles, especially in relation to lighting and 'natural surveillance'. • Provide safe infrastructure.
	Disproportionate access to benefits of micromobility and/or disproportionate safety burden for those not living in proximity to appropriate infrastructure.		• Provide shared path/separated cycleway infrastructure in a network to give access across wide geographies.
Healthy and safe people	Supports physical and mental health outcomes by making active lifestyle choices more accessible and/or appealing.		• Facilitate uptake with shared path/separated cycleway infrastructure. • Provide routes with high aesthetic value.
	Supports increased and/or safer provision of infrastructure targeted to active transport modes.		• Facilitate uptake with shared path/ separated cycleway infrastructure.
	Facilitates reduction in harmful pollution, especially as experienced by active commuters, by supporting separation of 'cycle'/footpath infrastructure from roadways and supporting a reduction in car travel generally.		• Provide separation between active modes/micromobility and other transportation modes.
	Facilitates change in driving culture towards increased awareness and acceptance of active mode users; supports safer driver behaviour towards cyclists.		• Provide awareness campaigns focused on drivers' attitudes and acceptance of vulnerable users/ active modes as part of the transport system.
	Risk that walking and cycling are substituted by 'less active' micromobility modes that require lower physical effort.		• Encourage the use of e-bikes over e-scooters, as these require comparable or increased physical effort to current modes.

Wellbeing outcome	Impact of increased micromobility mode share	Affected people and sectors	Interventions (supporting or mitigating)
	Risk of injury to micromobility users due to higher collision impact of heavier devices, and high sensitivity of micromobility devices to surface conditions.		• Improve pavement standards for shared paths and cycle paths.
	Risk that intoxicated behaviour on shared micromobility increases the risk, or severity, of injury.		• Minimise night-time use of shared devices on weekends or high-risk dates (eg, New Year), especially in the vicinity of bars and venues, through management of fleet placement and/or time restrictions for operators.
	Disproportionate risk of injury to, or discomfort of, those who are visually impaired, due to low in-use noise.		• Segregate micromobility from pedestrians clearly using signage or physically to support the visually impaired and hearing impaired public. • Require devices to be fitted with bells or other sound-producing devices.
	Increased risk of injury for users of shared transport spaces due to higher throughputs and speed differentials between modes.		• Minimise lag between micromobility uptake and corresponding policy/ infrastructure developments. • Education/ad campaigns. • Segregate micromobility from pedestrians clearly using signage or physically to support the visually impaired and hearing impaired public.
	Increased risk of injury to pedestrians due to tripping hazard posed by 'parked' shared micromobility devices.		• Work with to shared micromobility operators to incentivise or require safe parking practices. • Provide/clearly demarcate parking zones for shared devices.
Environmental sustainability	Facilitates reduction in air pollution due to zero point-of-use emissions and reduced noise		• Encourage higher use of micromobility in dense urban areas and along congested corridors. • Provide destination parking facilities in CBDs and significant destinations.
	Opportunities to re-purpose/ maximise use of space due to small storage/parking footprint of micromobility devices.		• Prioritise micromobility parking to maximise use-of-space. • Reallocate carriageway space to support micromobility use.
	Facilitates high efficiency of movement per person due to low embodied energy of device.		• Encourage higher use of micromobility in dense urban areas and along congested corridors.

Wellbeing outcome	Impact of increased micromobility mode share	Affected people and sectors	Interventions (supporting or mitigating)
	Opportunities to provide and maintain high throughput infrastructure at a low environmental cost relative to roading infrastructure.		• Incorporate forecast micromobility growth into project evaluations.
	Increases the social acceptability of low-emissions travel.		• Support this culture shift in (local) government/Waka Kotahi messaging.
	Risk that high obsoletion rate of new micromobility devices poses sustainability issues due to resource intensity of device manufacture/ distribution, especially with regard to batteries.		• Encourage producers to design for whole-of-life and maximise recyclability/upgradability and/or longevity, especially for batteries.
Economic prosperity	Opportunities for new businesses in the micromobility space, including design, manufacture, sales/hire and maintenance of micromobility devices and micromobility infrastructure (eg, for charging).		• Support businesses that support micromobility sales and service.
	Facilitates 'placemaking' for local retailers and eateries by enabling the transformation of car-parking and/or road lane space, and by increasing 'foot traffic'.		• Support 'placemaking' through tactical urbanism and streetscaping work. • Provide adequate micromobility parking facilities near retail or businesses.
	Opportunities for 'micro-delivery' economies to flourish, supports the creation of 'carless' CBDs by providing alternative ways to meet goods delivery/couriering requirements.		• Facilitate 'micro-delivery' for businesses. • Prioritise goods movements via micromobility through CBD and retail precincts.
	Facilitates increased cash spend into local economies due to increased disposable income as a result of lower (relative) costs of owned micromobility.		• Incentivise purchases of micromobility.
	Opportunities to provide and maintain high throughput infrastructure at a low cost relative to roading infrastructure.		• Encourage consideration of the 'network effect' in infrastructure planning – that is, the potential value of 'cycle' paths as components of a (future) fully connected network, rather than as stand-alone corridors.
	Volatile market for investors and business owners in companies involved in micromobility – high risk/high return context.		• Consider longer-term partnerships with local authorities to provide stability to shared micromobility services.
	Reduction in demand for automotive industries and associated services.		• Provide support for re-training and re-education.

Wellbeing outcome	Impact of increased micromobility mode share	Affected people and sectors	Interventions (supporting or mitigating)
Resilience and security	Opportunity for better-informed, mode-neutral transport planning due to increased data collection from shared micromobility.		• Include targeted data collecting/sharing as a condition of licensing for shared micromobility operators.
	Increased resilience of public transport networks to short- and longer-term disruption.		• Encourage micromobility usage during disruptions to public transport. • Develop procedure for corralling shared micromobility devices and redeploying at key locations during public transport network outages or strikes.
	Increased resilience to disruptions in petrol supply or price, particularly during natural disaster events.	–	• Support infrastructure funding mechanisms that incentivise sustainable transport activity.
	Risk of short-term disruption to transport systems during electrical grid failure events.		• Encourage people to understand the value of keeping their micromobility devices charged during extreme weather events.
	Increased vulnerability of transport systems to (significant) disruptions in international manufacturing/trade conditions due to high obsoletion rate of devices.		• Support growth in New Zealand based manufacturing capability. • Require producers to design for upgradability and maintenance.
	Risk of privacy breaches due to increased data collection from shared micromobility.	–	• Require producers to follow privacy laws and adequate security measures.

7 Results

7.1 Project evaluation

The results of this research project have two key applications for project evaluation.

- The range of possible mode shift/share scenarios prepared in the modelling section of the research have practical applications for quantifying future usage, and therefore the scale of benefits of micromobility-related transport projects, such as cycle paths. This can be referred to as shared and cycle paths benefiting from 'economies of scope' because the growth of micromobility use means that there is a wider use base for the cycleways and a decrease in the cost in trips per dollar of facility constructed as well as a corresponding increase in the benefits produced. Section 7.2 discusses this in further detail.
- The wellbeing interventions set out in Table 6.2 have applications for project evaluation by facilitating a consistent approach to qualitative assessments of micromobility-related projects, in line with the Ministry of Transport's core outcomes.

7.2 Mode shift scenarios

The set of modelling output scenarios developed in section 5.3 can be used to forecast mode shift to micromobility for various contexts. This section provides a guide as to which modelling scenarios can be expected to map to different real-world geographic/land-use contexts.

This provides a bounded range for potential mode shift to micromobility.

Land-use scenarios have been included in section 7.2.1 to provide scenarios that reflect the modelled scenarios.

7.2.1 Geographical/land-use context

Table 7.1 Modelled mode share ranges for several common land-use types

Land-use	Modelled scenarios	Mode share range
Major city – CBD	• High uptake scenario for e-scooters (scenarios 13–18 as set out in Figure 5.11) • Medium uptake scenario for e-bikes (scenarios 7–12)	• E-scooter mode share: 1.6%–5.7% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Major city – fringe (~5 km radius)	• Medium uptake scenario for e-scooters (scenarios 7–12) • High uptake scenario for e-bikes (scenarios 13–18)	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 7.7%–8.1% of all trips
Major city – suburban	• Medium uptake scenario for e-scooters (scenarios 7–12) • Medium uptake scenario for e-bikes (scenarios 7–12)	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 4.9%–5.1% of all trips
Regional city – CBD/fringe	• Medium uptake scenario for e-scooters (scenarios 7–12) • Medium uptake scenario for e-bikes (scenarios 7–12)	• E-scooter mode share: 1.0%–3.4% of all trips • E-bike mode share: 4.9%–5.1% of all trips

Regional city – suburban	• Low uptake scenario for e-scooters (scenarios 1–6) • Low uptake scenario for e-bikes (scenarios 1–6)	• E-scooter mode share: 0.3%–1.2% of all trips • E-bike mode share: 1.8%–2.0% of all trips

The modelling carried out for this project (described in section 5.3) uses assumptions on the trip market potential for micromobility. This is summarised in Table 7.2. For instance, given that a certain number of trips shifted to e-scooters, 50% of those trips were assumed to have been made by people who previously walked, 40% by people who previously used a private vehicle, and 10% by people who previously took public transport.

Table 7.2 Assumed source (initial mode) make-up of trips that shift to each micromobility mode

Initial mode	E-scooter	E-accessible	E-bike	E-moped
Walk	50%	10%	20%	30%
Cycle	0%	0%	20%	0%
Car	40%	70%	40%	50%
Public transport	10%	20%	20%	20%

7.2.2 Contexts with a modifying effect on mode shift scenario

The information summarised in section 3 on the barriers and enablers for micromobility has been used to develop guidance on further contextual factors to provide guidance on where within the range to forecast mode shift.

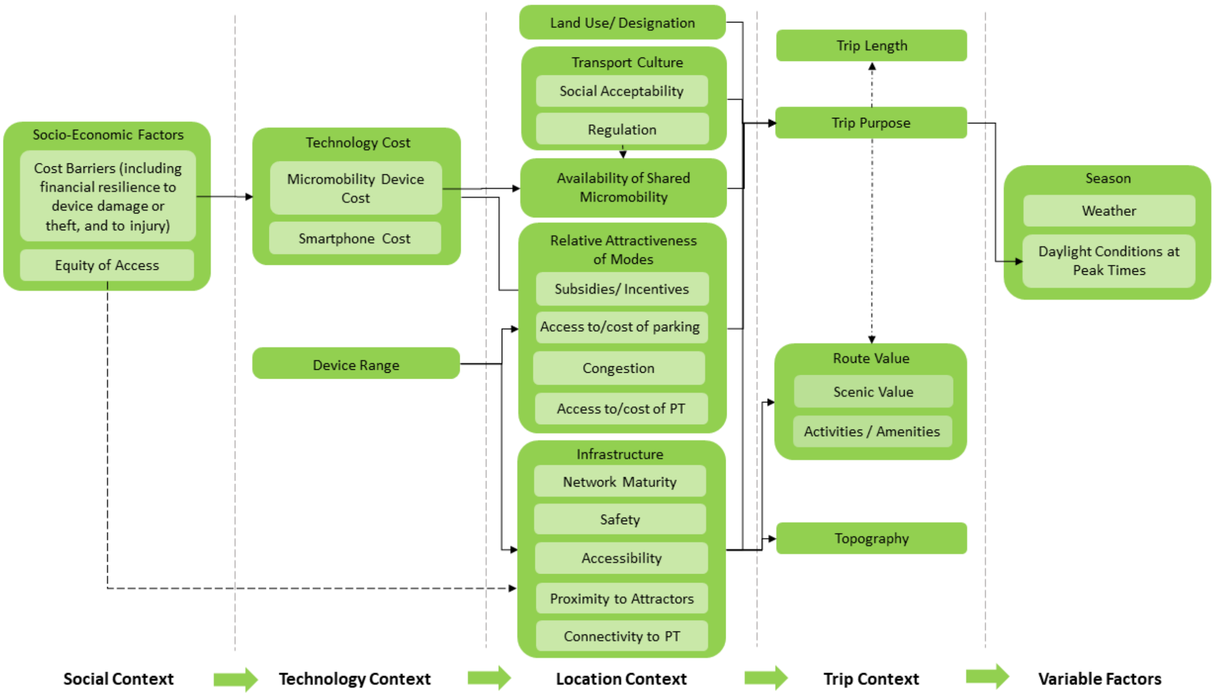
Beyond the base land-use-linked mode shift scenarios set out in section 7.2.1 above, five additional contexts have been identified that are expected to affect mode shift (that is, they have a modifying effect, positive or negative, on the base scenario for that location). These additional contexts are listed below and further explained by Figure 7.1.

- **Proximity to attractors:** Mode shift to micromobility will vary depending on proximity of available routes to major ‘attractors’, such as schools or education facilities, business hubs (especially CBDs), retail destinations and high-density living sites.
- **Route factors:** The quality – especially safety and accessibility (real and perceived) – of available infrastructure will influence mode shift to micromobility. Lanes and paths that are separated from motor traffic will provide the highest levels of mode shift.
- **Mode alternatives:** Mode shift to micromobility will be affected by the relative ‘attractiveness’ of alternative options. For instance, micromobility will be more attractive in contexts where car parking facilities are limited or costly, or where there is significant congestion (ie, high potential for time savings), but may be less attractive in contexts where viable lower ‘entry cost’ modes are available (eg, public transport, which does not require an initial purchase of a device/vehicle).
- **Maturity of network/culture:** The transport culture in any given location will affect mode shift to micromobility. This includes factors such as the extent to which well-connected and broad-spanning networks of mode-appropriate infrastructure already exist, and the commitment of workplaces to encouraging an active commuting culture (eg, through provision of secure device storage and shower facilities).

- **Amenity/aesthetics:** The variety and quality of amenities along travel routes – such as cafes, parks, playgrounds, drinking fountains and toilets – will likely have an impact on mode shift to micromobility, as will the aesthetic/scenic value of routes.
- **Socio-economic factors** – the presence and scale of socio-economic disparities will have an impact on mode shift because of cost barriers associated with purchase and maintenance of devices or hire of shared devices (including the requirement for a smartphone) as well as reduced financial resilience to device theft and to accidents resulting in injury. Subsidised schemes will help to reduce these barriers.

The model in Figure 7.1 shows the modifying factors for mode shift to micromobility.

Figure 7.1 Modifying factors for mode shift to micromobility



PT = public transport

7.3 Integration with public transport

The modelling described in section 5 suggests a maximum increase in public transport patronage of 10% where there is both a high density of public transport routes and high availability of micromobility.

As a result of the modelling methodology, this forecast includes a small number of:

- public transport trips that will be new trips, not previously made without micromobility
- shorter public transport trips that mode shift to micromobility trips.

The results of the modelling are shown in Table 7.3 below.

Table 7.3 Public transport (PT) mode shift ranges for several land-use and PT availability options

Scenario	Context	Mode shift range
Major city CBD and fringe (~5 km radius)	• High levels of PT • High availability of micromobility	• 2.3%–2.4% mode shift from cars • 4.7%–7.3% increase in PT patronage
Major city CBD and fringe (~5 km radius)	• High levels of PT • Low availability of micromobility	• 1%–2.3% mode shift from cars • 2.1%–4.7% increase in PT patronage
Suburban with high levels of PT, high availability of shared micromobility/MaaS	• High levels of PT • High availability of micromobility	• 1%–1.3% mode shift from cars • 8.5%–10.2% increase in PT patronage
Suburban with high levels of PT, low availability of shared micromobility/MaaS	• High levels of PT • Low availability of micromobility	• 0.4%–1% mode shift from cars • 2.8%–8.5% increase in PT patronage
Suburban with low levels of PT	• Low levels of PT	• 0.3%–1.1% mode shift from cars • 3.4%–10.1% increase in PT patronage

In addition, there are two different usage contexts for first/last mile travel:

- 'park and ride' – (sometimes referred to as 'bike and ride'), where the micromobility device is left parked at the point of connection or picked up at the point of disembarkation
- 'carry on', where the micromobility device is taken with the user onto the public transport vehicle.

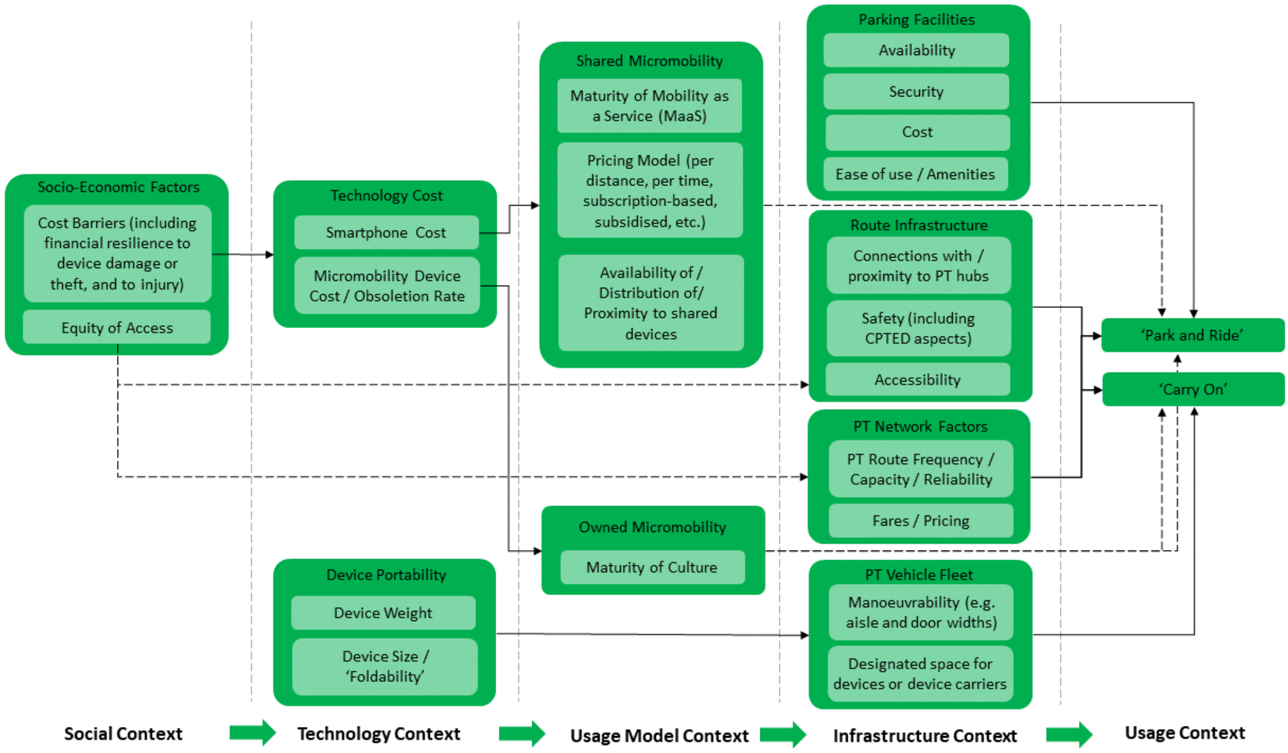
The implications of 'carry on' micromobility trips are discussed in section 8.

7.3.1 Contexts with a modifying effect on mode shift scenario

The likely uptake of micromobility for first/last mile purposes will be influenced by more complex factors than simply density of routes and availability of micromobility. These are shown below and in Figure 7.2.

- **Presence/maturity of MaaS:** The provision of a service where integrated (multi-modal) journeys can be planned, paid for and, if necessary, booked, from end to end from within a single platform/interface will impact the scale of first/last mile micromobility use.
- **Quality of public transport:** Fare price, service frequency, and the quality of network design (route layout) will impact the scale of first/last mile micromobility use.
- **Availability of shared micromobility:** The availability of shared micromobility, including quantity, cost, geographic distribution, and whether or not this is reliably consistent will also have an impact.
- **Micromobility parking at connection point:** The availability, cost, and security of parking facilities for micromobility devices at public transport boarding points will affect uptake of micromobility for the first/last mile context, especially for e-bikes.
- **Ability to take micromobility on board public transport:** Provisions for, and public attitudes towards, taking devices on board transport services will impact first/last mile use of micromobility, especially e-scooters.
- **Maturity of micromobility culture:** The maturity of (micromobility) transport culture in any given location, including ease of access to device purchase, maintenance and charging services, will have an impact on the scale of first/last mile use of micromobility.

Figure 7.2 Modifying factors for uptake of first/last mile use of micromobility



CPTED = crime prevention through environmental design; PT = public transport

7.4 The impact of COVID-19

On 11 March 2020 the World Health Organization declared COVID-19 to be an official pandemic. On 23 March the Prime Minister of New Zealand announced a lockdown, and at 11:59 pm on 26 March New Zealand moved to Alert Level 4 and the entire nation went into self-isolation. Seven weeks later, on 14 May, New Zealand began a staggered return to normal activities, returning to full normal activity (excluding the closure of the international border) at 11:59 pm on 8 June 2020.

In New Zealand and in similar countries internationally, neighbourhood cycling increased during lockdown, primarily due of the lack of motorised vehicles on the road, the value put on the exercise benefits of cycling, and the need for social distancing (Bike Auckland, 2020; Wild, 2020). In line with this, New Zealand bike shops reported a surge in sales of e-bikes (Abaño, 2020).

This increase in ownership could accelerate the mode shift to micromobility, although it is expected that, in line with the findings of this research, the six context factors outlined in section 7.2.2 will continue to determine the mode shift rates to micromobility. Without safe, separated infrastructure, for example, those who cycled during lockdown are not expected to continue cycling in significant numbers.

Cycling numbers can continue to be monitored, but a lack of comprehensive micromobility counting means that it is difficult to benchmark the change in micromobility.

8 Recommendations

Micromobility remains a rapidly developing space, both in the capabilities of already 'established' modes such as e-bikes and e-scooters, as well as the evolution of novel modes. This research has examined the potential for mode shift to micromobility by 2030 and the impacts that this mode shift may have in terms of the New Zealand Ministry of Transport's Transport Outcomes Framework.

This section presents recommendations for:

- forecasting mode shift for project evaluations
- micromobility policy, strategy and planning
- further research.

8.1 Recommendations for project evaluations

There is very little data or independent peer-reviewed research available globally on likely mode share for micromobility. This research contributes to filling a substantial gap in current knowledge. The research results have significant implications for the project evaluation of active mode infrastructure and initiatives. The following sections offer guidance to practitioners on how to incorporate the research results into project evaluation and transport planning activities.

8.1.1 Urban cycleways and shared paths

For urban contexts, an assumption of 3% mode shift to micromobility (2% e-bike and 1% e-scooter) is recommended for 2030.

This mode shift can be assumed to be able to increase to a maximum of 11% (maximum 5% for e-bikes and 6% for e-scooters for CBD contexts; maximum 8% for e-bikes and 3% for e-scooters in other urban contexts) when the following modifying factors are accounted for:

- proximity of routes to 'attractive' destinations
- quality and safety of route infrastructure
- attractiveness of mode alternatives
- maturity of network/transport culture
- amenity and aesthetic value of routes
- socio-economic factors.

Pushbike cycling is used for typically around 1.4% of all trips in New Zealand cities. Micromobility use is expected to grow to at least double this mode share across e-bikes and e-scooters combined, effectively tripling their use. The majority of this growth is expected to occur on shared path and cycling infrastructure, where this is provided. In the highest long-term case, usage of this infrastructure could rise to as much as eight times that offered by existing pushbike trips alone. This directly impacts the evaluation of shared path and cycling infrastructure projects, and the revision of existing business cases that did not specifically consider the growth of micromobility.

The original modes that trips will shift from is unclear, particularly for e-bikes. Around 30% of trips to e-scooters will shift from short walking trips. This is expected to decrease as a percentage as trips get beyond 1.5 km in length.

8.1.2 Micromobility on the first/last mile of public transport

In major cities, public transport patronage could increase by up to 7% in urban contexts and 9% in suburban contexts as a result of first/last mile micromobility use.

Table 8.1 shows the recommended mode shift percentages to use for forecasting increases in public transport usage as a result of growth in first/last mile micromobility use. These forecasts are the median of the range produced in the modelling described in section 5.2.1.

Table 8.1 Public transport (PT) mode shift forecasts for several land-use and PT availability options

Scenario	Context	Micromobility
CBD/fringe (~5 km radius)	• High levels of PT • High availability of micromobility	• 2% decrease in car trips • 6% increase in PT patronage
CBD/fringe (~5 km radius)	• High levels of PT • Low availability of micromobility	• 1.5% decrease in car trips • 3% increase in PT patronage
Suburban	• High levels of PT • High availability of micromobility	• 1% decrease in car trips • 9% increase in PT patronage
Suburban	• High levels of PT • Low availability of micromobility	• 0.5% decrease in car trips • 6% increase in PT patronage
Suburban	• Low levels of PT	• 0.5% decrease in car trips • 7% increase in PT patronage

Actual mode shift for specific real-world scenarios can be expected to vary either side of these median forecasts, depending on the following six context factors:

- presence/maturity of MaaS
- quality of public transport provided
- availability of shared micromobility
- provision for micromobility parking at connection points
- ability to take devices on board public transport services
- maturity of micromobility culture in the location of interest.

The number of public transport users who will want to take micromobility devices on board will be determined by the availability and attractiveness of shared micromobility. There is insufficient data to be able to forecast the ratio of shared and owned micromobility used for first/last mile. If 50% of micromobility users take their e-bikes, e-scooters etc on board, then this will equate to around two devices per bus and 15 per three-carriage train. Similarly, for the design of corrals at stations, if 50% of micromobility users will leave or pick up their e-bikes or e-scooters at stations, assume that this represents up to 4% of patrons.

8.1.3 Micromobility policy, strategy, and planning

Alongside mode shift modelling, this research also evaluated the range of potential positive and negative impacts of an increasing micromobility mode share, using the Transport Outcomes Framework. Of the five outcomes in the framework, ‘inclusive access’ and ‘healthy and safe people’ were identified as the most complex areas to work through in relation to micromobility use.

In order to guide planners and practitioners on how to maximise the overall contribution of micromobility to wellbeing and liveability, the following list of 21 interventions has been developed for practitioners to consider when planning or implementing micromobility initiatives.

Infrastructure

1. Provide or upgrade shared path and cycleway infrastructure to offer high quality pavement, comfortable and safe path widths, and physical separation or separators from other transport modes. Consider reallocating carriageway space to support this outcome.
2. Provide sufficient path/route infrastructure to facilitate access to destinations of interest (schools, business districts, leisure destinations, transport hubs, etc) across a wide range of locations, with consideration given to equity of access. Encourage consideration of the ‘network effect’ in infrastructure planning – that is, the potential value of paths as components of a (future) fully connected network, rather than as stand-alone corridors.
3. Design and/or upgrade shared and cycle path infrastructure to meet CPTED principles, especially in relation to lighting and ‘natural surveillance’.
4. Provide parking space for micromobility devices near retail and businesses, with destination parking facilities in CBDs and significant destinations, giving consideration to security issues. Provide and clearly demarcate parking zones for shared devices, and work with shared micromobility operators to incentivise or require safe parking practices. Where appropriate, prioritise micromobility parking to maximise use-of-space on transport corridors.
5. Prioritise infrastructure on routes where there is high aesthetic value (eg, scenery) and/or good supporting amenities (eg, cafes, services). Leverage the ‘placemaking’ potential that micromobility offers for retail and hospitality destinations, through tactical urbanism initiatives and streetscaping work.
6. Review planning and consent processes, including transport project evaluation procedures, to ensure these reflect the changing needs of households and businesses and support sustainable transport activity.

Integration with public transport

7. Provide secure, affordable storage space for micromobility devices at public transport hubs/stations.
8. Provide additional and/or clearly demarcated spaces on trains and buses for storage of micromobility devices as well as pushbikes/kick scooters.
9. Develop or support the development of MaaS platforms that facilitate integrated journey planning and payment.

Inclusive access

10. Support priority or tailored access to shared/cycle path facilities at destinations for those with differing needs or abilities.
11. Clearly separate micromobility users from pedestrians, physically or using signage, to support the visually impaired and hearing impaired public. Require devices to be fitted with bells or other sound-producing functionality.
12. Investigate and manage implications of micromobility for assistance dogs.

13. Introduce grant schemes for device purchase and/or subsidies for micromobility, especially for socio-economically disadvantaged groups.
Healthy and safe behaviours 14. Support culture shift through local government/agency messaging, including targeted education/ad campaigns to promote safe behaviours and encourage use of micromobility, especially in dense or congested areas. Included in this, publicise the evidence of the physical health benefits of riding e-bikes. 15. Introduce posted speed limits on shared infrastructure, and work with operators to require shared mobility devices to have software-imposed speed limits in high-risk zones. 16. Minimise night-time use of shared devices on weekends or high-risk dates (eg, New Year), especially in the vicinity of bars and venues, through management of fleet placement and/or time restrictions for operators.
Community and business partnerships 17. Support businesses involved in micromobility, including those who sell or service micromobility devices, and support the growth of New Zealand based micromobility manufacturing capability. Encourage or incentivise the manufacture and sale of devices whose design prioritises recyclability, upgradability and/or longevity, especially in relation to batteries. 18. Include targeted data collecting/sharing as a condition of licensing for shared micromobility operators, with appropriate consideration given to privacy and data security. Consider longer-term partnerships between shared micromobility operators and local authorities to support stable provision of shared micromobility services. 19. Support businesses to develop and grow ‘micro-delivery’ capability. Prioritise goods movements via micromobility through CBD and retail precincts.
Resilience 20. Develop procedures for corralling shared micromobility devices and redeploying at key locations during public transport network outages or strikes. Support this by actively encouraging micromobility use during disruptions and raising awareness of the value of keeping micromobility devices charged during extreme weather events. 21. Plan for installing temporary lanes for micromobility and clearing lanes for micromobility during disasters as a way to keep/get people moving.

8.2 Recommendations for further research

In order to best leverage the results of this research project for transport planning and project evaluation purposes in New Zealand, we recommend that substantial ongoing research into and monitoring of micromobility use be carried out, using this research as a foundation for future work.

In particular, we recommend the following activities.

1. Review and monitor existing shared/separated cycling infrastructure in New Zealand to identify the current (benchmark) levels of micromobility use and growth in mode shift. Where possible, survey users

in a consistent way to identify trip purpose, trip length, the alternative modes, and the impact that the six context factors have on their choice to use the micromobility mode.

2. Further develop the Waka Kotahi national benchmarking tool that aggregates counts for active modes to include micromobility, broken down by shared and privately owned micromobility, and with details collected on the six context factors outlined in this report.
3. Investigate and pilot the use of novel technologies for counting the use of shared paths, including visual recognition and LiDAR based technologies.
4. Undertake more robust analysis of injury rates for micromobility from New Zealand ACC data, including identification of trends and contributing factors, and opportunities to improve both safety and the perception of safety.
5. Monitor and periodically review the literature review of micromobility undertaken in this research project to identify emerging data on the mode choice behaviour change related to micromobility. Test whether COVID-19 restrictions have accelerated the uptake of micromobility.
6. Further review the barriers to and opportunities for equitable access for micromobility use in New Zealand, with particular regard to socio-economic, disability and gender factors, and how these factors shape user experience.
7. Further analyse the potential improvement in access and options that micromobility may present for those with physical disabilities, particularly with regard to e-accessible devices/mobility scooters and adapted e-bikes.
8. Monitor the uptake of e-moped form factor micromobility outside of New Zealand to identify if this could become a significant mode choice if permitted under the Accessible Streets Regulatory Package.
9. Review the transport models for New Zealand’s major centres to incorporate the mode shift to micromobility so that this mode is included in statistics provided to project evaluations and business cases.
10. Consider the recommendations in section 8.1 for incorporation into Waka Kotahi project evaluation procedures.

9 Conclusions

This research project has examined the potential for mode shift to micromobility in New Zealand by around 2030 and the impacts of micromobility on the health and wellbeing of New Zealanders.

There is very little data or independent peer-reviewed research available globally on the mode share for micromobility, and this research project has filled a substantial gap in current knowledge.

Transport modelling was used to forecast micromobility growth for complete trips and for trips in association with public transport.

This suggests that the usage of shared paths and separated cycle facilities will be three to eight times higher than for forecasts of pushbikes alone. This will have a significant impact on the economic evaluation of path and cycling infrastructure in New Zealand. To maximise mode shift, paths/cycleways should be routed via safe, aesthetic routes and where there are amenities such as cafes, retail, rest areas, and toilets.

The growth in availability and ownership of micromobility will lead to an increase in public transport patronage by up to 7% in urban contexts and 9% in suburban contexts as a result of first/last mile micromobility use. Mode shift to public transport from private car drivers will be a maximum of around 2% in dense CBDs and CBD fringe, and 1% or less in urban and suburban areas.

A list of 21 interventions has been developed to guide planners and practitioners on how to maximise the overall contribution of micromobility to wellbeing and liveability. Of the New Zealand Ministry of Transport’s five wellbeing outcomes, ‘inclusive access’ and ‘healthy and safe people’ will be the more complex challenges from a mode shift to micromobility.

The results of this research are applicable in New Zealand. Further work is required to determine their suitability globally.

A consistent national data collection programme for monitoring the mode share of micromobility is recommended so that the results of this research can be periodically updated.

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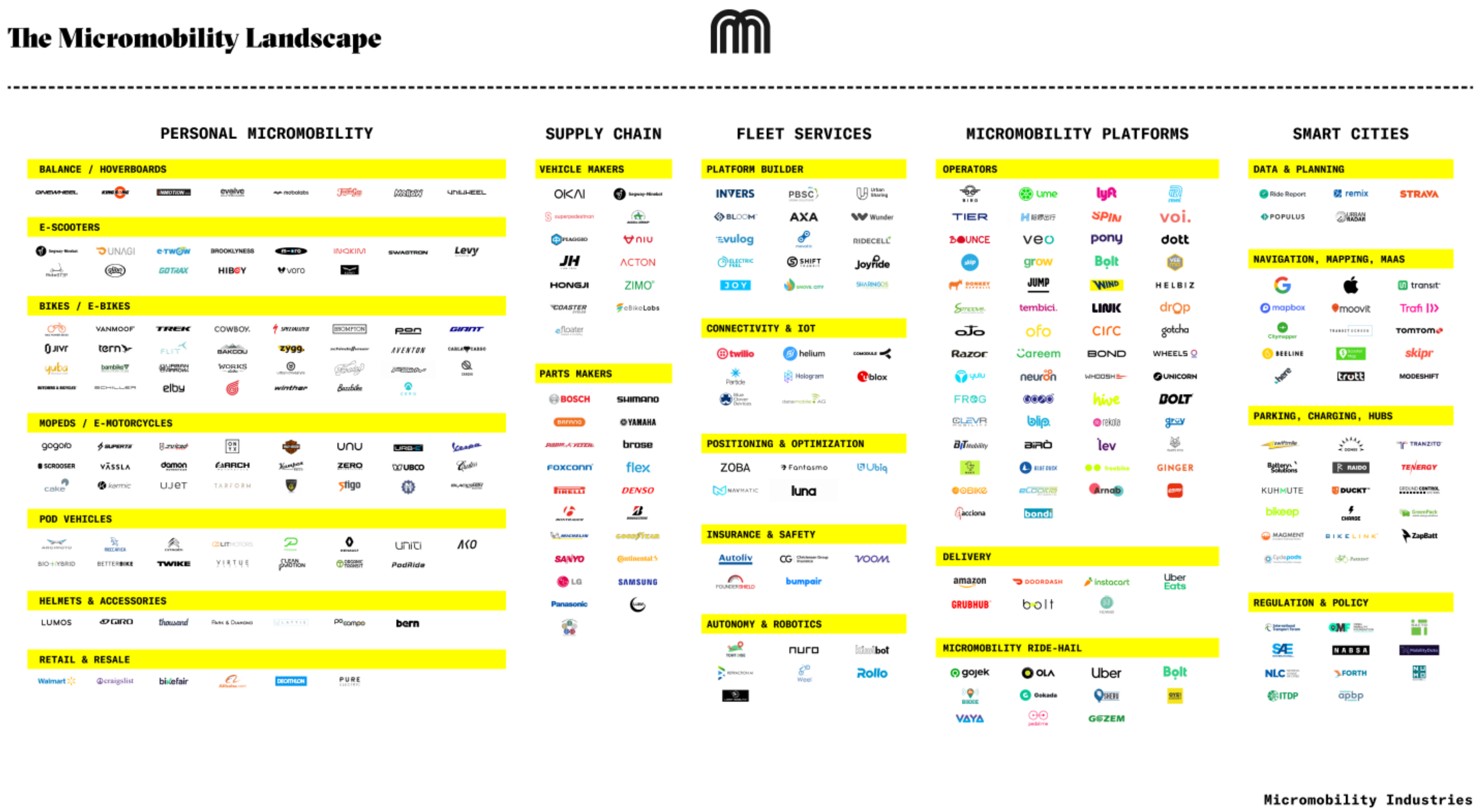
Appendix A: The micromobility landscape (July 2020)



Source: https://micromobility.io/landscape