The road safety and multi-modal impacts of on-street parking

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Abbreviations and acronyms

ACC	Accident Compensation Corporation
AIS	Abbreviated Injury Scale
ASD	approach sight distance
AUSPDG	Aotearoa Urban Street Planning and Design Guide
CAS	Crash Analysis System
CNG	Cycling Network Guidance
CSD	crossing sight distance
DSI	death and serious injury
IPRU	Injury Prevention Research Unit (University of Otago)
MAIS	Maximum Abbreviated Injury Score
MGSD	minimum gap sight distance
NLTF	National Land Transport Fund
NPS-UD	National Policy Statement on Urban Development 2020
NZTA	NZ Transport Agency Waka Kotahi
ONF	One Network Framework
ONF-DD	One Network Framework – Detailed Design (guide)
PNG	Pedestrian Network Guidance
RCA	road controlling authority
SAAS	safe and appropriate speed
SISD	safe intersection sight distance
SUV	sport utility vehicle
TCD	traffic control device
vpd	vehicles per day

Contents

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Executive summary

Why was this research needed?

There is a lack of aggregated evidence about how on-street parking can impact safety and multi-modal outcomes, particularly applied to the New Zealand transport context, and the potential benefits of changes to parking arrangements. On-street parking provides a core function in some of our streets for servicing various land uses but needs to be consistent with keeping people safe from harm and the other roles of our streets, particularly when road space is limited. It is noted that this is more challenging when the removal of parking to avoid severe road trauma and achieve better multi-modal outcomes needs to be achieved in the context of the removal of minimum parking requirements for developments. In particular, residential development is likely to increase on-street parking demand as it may be relied on more when developers are not required to provide on-site parking.

Over the last century, many of our roads have been designed around the increasing prevalence of private vehicle movement and parking. Both can affect the look and feel of a street and thus the experience for people travelling by a range of modes. With limited space on our road corridors, achieving multi-modal outcomes often involves road space reallocation in existing streets. On-street parking is sometimes removed as part of the design process when other uses are prioritised for this space. This process will involve consideration of the local parking strategy/policy and associated parking management plans. In some cases, there is public resistance to the reduction or changes in on-street parking, and this can create challenges in delivering the multi-modal outcome sought and/or have negative safety impacts when parking is retained or provided in a suboptimal way.

What was the purpose of the research?

While there is a growing body of data and statistics about road safety, there are few data specifically and comprehensively focusing on how parking can impact the safety of other travel modes. This research sought to identify how on-street parking impacts safety and multi-modal outcomes and to develop strategies that contribute to improving these outcomes. It is noted that safety in the context of this research is road safety only, not safety outcomes that might arise from personal security issues that are generally addressed through Crime Prevention through Environmental Design principles but could also be part of the decision on what type of parking layout is used. The road safety aspects focused on alignment with Road to Zero, New Zealand’s Road Safety Strategy 2020–2030, which sets out a vision for a New Zealand where no one is killed or seriously injured in road crashes. The research also recognised that minor injuries and perceived safety and inconvenience issues (eg, a parked car blocking a footpath) can be barriers to achieving better multi-modal outcomes.

This research focused on urban on-street parking rather than off-street parking, which is subject to different types of risks and management regimes. The research did not examine parking management practices in detail or examine where parking should or should not be located for economic reasons. However, it is acknowledged that there are aspects of parking management that can also improve safety, such as reducing the amount of time that drivers spend searching for car parking, as this reduces the risk of conflicts. The issue of the best use of kerbside space (eg, using it for parking or cycle lanes/wider footpaths) was also not the focus of the research.

How was the research conducted?

A literature review examined New Zealand and international research on the relationship between safety, multi-modal outcomes and parking; this included identifying approaches that may offer risk-mitigation strategies. An interrogation of Crash Analysis System (CAS) data focused on identifying any relationships between safety and on-street parking. The CAS analysis was focused on deaths and serious injuries (DSIs). Claims data from the Accident Compensation Corporation (ACC) had too many limitations to inform the research.

The way that parking is laid out in New Zealand streets was examined in the context of the One Network Framework (ONF) urban street types and the Speed Management Guide. The advantages and disadvantages of different layouts were investigated along with how road controlling authorities (RCAs) select various parking layout options. Existing safety and design strategies to mitigate the risk of various layouts were identified, and any improvements to these were also established. Brief case studies for a range of street projects and street types were developed to examine real-life situations where road space allocation decisions involved on-street parking and how the design may have changed because of those decisions.

What did the research find?

The analysis of CAS data found that there were 14,030 crashes of all severities involving parked cars or as a result of the act of parking between 2017 and 2021. This is 7.7% of all reported crashes and 2.5% of all DSIs that occurred during the five-year period. The parking-related DSIs included nine fatal crashes and 286 serious injury crashes.

The majority of DSI crashes involving parking were vehicle collisions with parked cars. Many of these crashes were due to loss of control, visibility being obscured (sunstrike or fog), or inattentive driving. Some were also due to the driver experiencing a medical event while driving or falling asleep at the wheel.

Vulnerable road users (pedestrians, cyclists and motorcyclists) made up almost half of all serious injuries from parking-related crashes and over two-thirds of all deaths in parking-related crashes in this five-year period. Cycle DSI crashes related to parking are the highest for vulnerable road users.

Bus-related crashes associated with parking are generally related to the bus being parked, rather than crashes where parked cars impact the safety of buses.

There are several clear causes for parking-related DSI outcomes in New Zealand that could allow a focus for improvement in how streets are designed and managed, and also how driver behaviour may be influenced, that could contribute to the Road to Zero goal of a 40% reduction in DSIs. The causes are:

- car door opening into cyclist's path (this issue is also clearly noted in the literature review as a key risk for cyclists in relation to parking)
- cyclists colliding with parked cars
- pedestrians crossing the road from the driver's left side and being struck by the vehicle because their visibility is obscured by parked cars.

It was found that determining the total number of crashes caused by a parked vehicle limiting visibility is difficult to quantify given the number of factor codes used for this scenario. It is also likely that crashes due to parked cars limiting visibility are not reported as such at all.

As well as the safety issues found to be related to on-street parking, there are other impacts that can affect achieving good multi-modal outcomes. Illegal parking behaviours can create issues for people using cycle facilities and footpaths (particularly people with mobility impairments). It was also found that cyclists feel less safe riding in places where there are parked cars, even if there is a cycle lane. This can contribute to people choosing not to cycle. A key concern for bus users is when a bus cannot pull into a stop parallel with the kerb due to on-street parking hindering this, as this creates a gap between the door and footpath making it less safe and convenient to board and alight the bus.

There are various ways that parking can be provided within a street, each having advantages and disadvantages depending on the context. A range of aspects need to be considered as part of the parking layout decision, including the role of the street, speed management, traffic characteristics, space available and external factors. Good street design and safe and appropriate speed (SAAS) limits can reduce both the likelihood of a crash and the severity of any injuries. The Speed Management Guide sets the SAAS for the ONF street types in New Zealand, and RCAs are now in the implementation phase. The research recognises this by reinforcing the importance of the SAAS being in place to help reduce the safety impacts of on-street parking.

In several of the case studies some of the initial designs involved removing some on-street parking to accommodate space for cycling. In each case the business owners on those streets were concerned about how this would impact their businesses. Generally, they saw this as a negative impact. This generally resulted in a change to the design with car park spaces being added back into the design, with the potential to result in unsafe design outcomes.

The issue of road safety and multi-modal outcomes being influenced by stakeholders is a common one, and regardless of how much information is provided to the decision makers, the design can be overridden by external influences. This can be despite processes such as road safety audits raising serious or significant safety issues. It is noted that in 2014 the Cycling Safety Panel recommended that RCAs should progressively remove parking from arterial roads where it is a safety risk.

The research recommends that a legislative tool may be required to give RCAs more control over what is ultimately approved for construction. Ideally the Safe System audit process should capture any serious parking-related safety issues and be used by RCAs to engage with stakeholders lobbying for an unsafe design. A Safe System audit is required for a transport improvement or renewal activity that involves vehicular traffic when funding assistance from the National Land Transport Fund (NLTF) is proposed. It is not clear if RCAs apply the procedures for roads being built as part of developments that are then vested in the RCA (ie, when NLTF funding is not being used). Ideally, the Safe System audit would apply for all street design projects, and the audit findings would be given serious consideration by all involved, particularly decision makers (such as elected members).

Recommendations

The following regulatory, driver behaviour, safety campaign, design guidance and crash data collection recommendations are made to help address parking-related safety issues and contribute to better multi-modal outcomes.

- Legislation affecting decisions on road space allocation include a requirement that such decisions are subject to a Safe System Audit, to ensure that any safety risks associated with on-street parking are considered and mitigated as appropriate.
- Fine levels for parking infringements that negatively impact safety should be increased to influence people's decisions about how and where to park and hence reduce the risks associated with parking violations on other users.
- A review of the legal requirements should be undertaken for the distance that parking is prohibited either side of intersections, driveways and pedestrian crossings, in relation to road user visibility.
- The Speed Management Guide should be updated to recognise parking configurations for all ONF types and associated speed considerations.
- The ONF Detailed Design Guide, the Aotearoa Urban Street Planning and Design Guide and the Speed Management Guide should reflect the findings of this research with respect to parking design and safety outcomes when they are next updated.
- District plans and codes of practice should have requirements for new roads to align with the ONF modal outcomes and consider the need for sufficient space for all modes, including parking where it is to be provided. This is related to achieving good design outcomes.

- *Traffic Control Devices Manual: Part 13 – Parking Control* should be updated, with specific matters raised in the research being part of the update.
- The Cycling Network Guidance should be updated with respect to the specific matters raised in the research.
- The Pedestrian Network Guidance should be updated with respect to the specific matters raised in the research.
- The left-hand ('Dutch Reach') method, already in the Road Code, should be promoted through publicity campaigns, added to the defensive driving course and added to the driver licensing process (eg, the multichoice quiz).
- Cycle skills training should include (if not already) the awareness of car door opening and lateral positioning when riding in cycle lanes and shared traffic lanes.
- Transportation practitioners and street designers (including landscape architects and urban designers) should be informed of the findings of this research and the design recommendations, as the findings are likely to take some time to be included in the respective legal requirements or guidance documents.
- CAS data fields should record the type of vehicle (car vs sport utility vehicle (SUV) etc). This is because the vehicle type could have an influence on the crash cause.
- ACC claims data should make a clear differentiation between on-street and off-street parking-related accidents. Currently there is no differentiation, and this makes it difficult to use the data from a context perspective.

Abstract

There is a lack of aggregated evidence about how on-street parking can impact safety and multi-modal outcomes, particularly applied to the New Zealand transport context, and the potential benefits of changes to parking arrangements. On-street parking provides a core function in some of our streets for servicing various land uses, but its design needs to ensure that people are safe from harm, and it needs to be balanced with the other roles of our streets, particularly when road space is limited.

This research focused on urban on-street parking rather than off-street parking, which is subject to different management regimes and types of risk. The research did not examine parking management practices or where parking should or should not be located for economic reasons. The road safety aspects focused on alignment with Road to Zero, New Zealand’s Road Safety Strategy 2020–2030, which sets out a vision for a New Zealand where no one is killed or seriously injured in road crashes. The research also recognised that minor injuries and perceived safety and inconvenience issues (eg, a parked car blocking a footpath) can be barriers to achieving better multi-modal outcomes.

Parking activity occurs in the road space, so it is important to understand how parking policy changes may affect Road to Zero targets. Road safety was examined from a perspective of eliminating deaths and serious injuries, and how perceived risk might affect travel behaviour, particularly walking and bicycling activity. A range of regulatory, driver behaviour, safety campaign, design guidance and crash data collection recommendations are made to help address parking-related safety issues and contribute to better multi-modal outcomes.

1 Introduction

1.1 Background

There is a lack of aggregated evidence about how on-street parking can impact safety and multi-modal outcomes, particularly applied to the New Zealand transport context. Thus, the safety and multi-modal outcomes of the wide range of parking types are not clearly evidenced in one place, and nor are the potential benefits of changes to parking design guidance.

The vision of Road to Zero, New Zealand's Road Safety Strategy 2020–2030 (Te Manatū Waka Ministry of Transport, 2019), is a New Zealand where no one is killed or seriously injured in road crashes. The strategy takes a Vision Zero approach to road safety and embeds the Safe System approach, which recognises that people make mistakes and are vulnerable in a crash. Safe System considerations for this research are discussed below in section 1.2.

Road to Zero includes a target of a nationwide 40% reduction in deaths and serious injuries (DSIs) by 2030 and proposes to achieve this through actions in five key focus areas:

- infrastructure improvements and speed management
- vehicle safety
- work-related road safety
- road user choices
- system management.

Parking activity occurs in the road space, so it is important to understand how parking policy changes may affect Road to Zero targets. Road safety should be examined from a DSI perspective and how perceived risk might affect travel behaviour, particularly walking and bicycling activity. For example, if people perceive a street to be unsafe for cycling, they may be less likely to use that mode.

The impact of parking on cyclist safety was recognised by the Cycling Safety Panel following the 2013 coronial review of cycle safety in New Zealand (Cycling Safety Panel, 2014). The panel identified that parked cars create a number of hazards for cyclists and recommended that RCAs progressively remove parking from arterial roads where it is a safety risk. Noting that arterials at that time would have been high traffic volume roads, a new movement and place framework has been developed for New Zealand and is discussed in this research in relation to on-street parking.

Similarly, parking planning decisions can impact public transport travel by affecting bus operation and how passengers access bus stops and stations.

The Government Policy Statement on Land Transport (Te Manatū Waka Ministry of Transport, 2021) and the Transport Outcomes Framework (Te Manatū Waka Ministry of Transport, 2018) set the strategic direction for our transport environment, and they both seek multi-modal outcomes. Multi-modal outcomes are about ensuring our streets safely accommodate all modes of travel so that people have the choice to move by a range of modes safely and conveniently, as appropriate for the street type.

The One Network Framework (ONF) (Waka Kotahi, n.d.-a) defines street types through a national classification system that determines the function of our roads and streets and informs decision making. Achieving better multi-modal outcomes also supports Te Hau Mārohi ki Anamata, Aotearoa's Emissions Reduction Plan (New Zealand Government, 2022).

Over the last century, many of our roads have been designed around the increasing prevalence of private vehicle movement and parking. Both can affect the look and feel of a street and thus the experience for people by a range of travel modes. With limited space on road corridors, achieving multi-modal outcomes often involves road space reallocation in existing streets. On-street parking is sometimes removed as part of the process when other uses are prioritised for this space. This process will involve consideration of local parking strategy/policy and associated parking management plans. In some cases, there is public resistance to the reduction or changes in on-street parking, and this can create challenges in delivering the multi-modal outcome sought or have negative safety impacts. For example, this could result in suboptimal walking and cycling facilities, turning bays that are too short or tapers that cause vehicles to block cycle lanes, insufficient sight distances, and the inability to provide pedestrian islands and bus priority where it is needed.

While there is a growing body of data and statistics about road safety, there are few studies that specifically and comprehensively focus on how parking in particular can impact the safety of other travel modes.

1.2 Safe System considerations

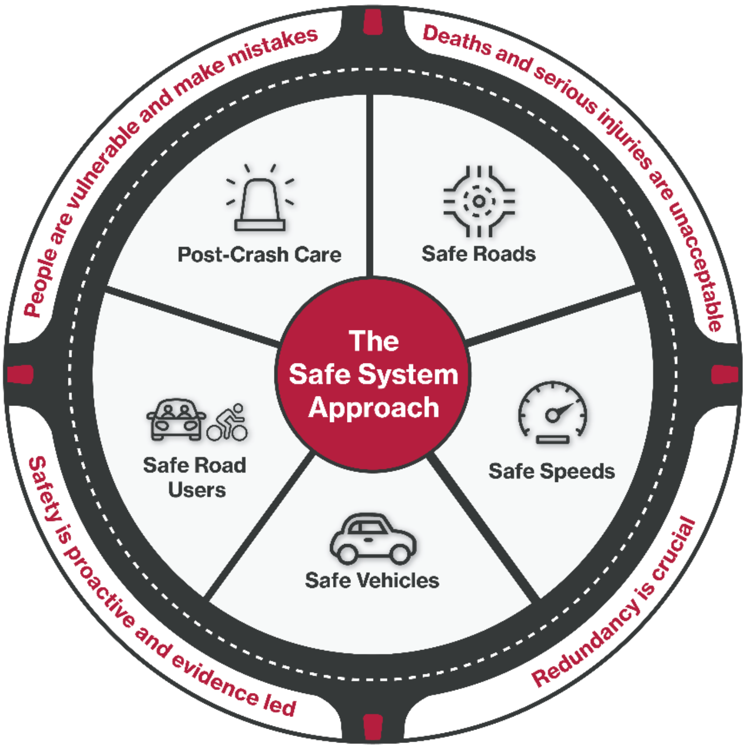
The Safe System approach establishes that, while everyone shares responsibility within the transportation system, blame should not be placed on individual users, because people make mistakes. Instead, it acknowledges that humans are physically vulnerable, and the transport system needs to be designed and managed to reduce the energy transferred in crashes. While a Safe System does not prevent all crashes, managing this energy transfer ensures that, when crashes inevitably occur, they don't result in DSIs.

Various parking designs and policy choices will be discussed throughout this report with consideration given to their Safe System alignment. Specific consideration will be given to whether parking designs achieve Safe System outcomes, work towards Safe System outcomes, or prevent Safe System outcomes from being achieved.

There are five Safe System pillars (as shown in Figure 1.1):

- Safe Roads
- Safe Speeds
- Safe Road Users
- Safe Vehicles
- Post-Crash Care.

Figure 1.1 The Safe System approach



Primarily, a Safe System approach moves away from trying to reduce all crashes and instead focuses on reducing DSI crashes, as these have the greatest impact on communities compared with minor and non-injury crashes. Due to the vulnerable nature of cyclists and pedestrians, these road users have been found to be overrepresented in urban DSI statistics. With parking normally situated in urban environments, to align with the Safe System approach, cyclists and pedestrians are a primary consideration in the research. However, it is acknowledged that minor injuries and perceived safety issues due to parking are still important as they can deter people from using other modes, hence they can contribute to poor multi-modal outcomes.

The Safe System approach to **Safe Roads** is network wide, where designers focus on moving the entire network towards the elimination of DSIs rather than optimising crash reductions per project. Additionally, the Safe Roads pillar is broader than safety treatments alone – it requires that all changes to the physical road network utilise Safe System principles.

While Road to Zero recognises that safe roads are a foundation of a safe New Zealand, it also recognises that road safety goes beyond our obligation to prevent deaths and injuries – it means improving lives and lifestyles too. It ensures everyone, even our most vulnerable road users, feels safe to use our transport network. This contributes to good multi-modal outcomes.

Safe Speeds are at the heart of the Safe System. This is because humans are vulnerable in crashes, and the square of the speed dictates the amount of energy transferred in a crash. If speeds can be managed to cater for the limitations of the human body's tolerance, then minor and property-damage-only crashes can occur without them resulting in DSIs.

The **Safe Road Users** pillar covers both individuals' recognition of the risk they pose to themselves and others, and their responsibility in minimising that risk. It also covers how system designers communicate these ideas to road users and how they can manage their risk. This could be through campaigns, advertisements, and all other interactions with the public. The Safe Road Users pillar also covers enforcement efforts to deter future unsafe behaviours.

Safe Vehicles refers to the physical vehicle and vehicle technologies. Vehicles have become progressively safer over the years, which has reduced the likelihood and severity of crashes.

The most recent addition to the Safe System approach, **Post-Crash Care** refers not only to the response time of emergency services but also the level of care received.

Table 1.1 shows how the pillars of the Safe System approach relate to parking.

Table 1.1 Safe System considerations in parking

Safe System pillar	Parking-related considerations
Safe Roads	In terms of Safe Roads, the research considers what elements of on-street parking design increases or decreases the safety of the road environment. Moreover, it discusses what design best practice can be used to reduce high severity crash risks.
Safe Speeds	In terms of parking, the research examines examples where speed is influenced by different parking arrangements.
Safe Road Users	The Safe Road Users aspect of the research primarily focuses on how road user choices on parking affect safety. In addition, it covers how these interactions can be influenced to decrease DSI crash risks.
Safe Vehicles	The Safe Vehicles pillar is considered in this research in terms of how different vehicle technologies can be used to influence risk. Additionally, the Safe Vehicle pillar considers parking for various vehicles and how this can affect safety.
Post-Crash Care	Post-Crash Care is considered in terms of how parking designs affect the access for emergency services onto various sites.
Cross-pillar considerations	The two key pillars relating to parking are Safe Roads and Safe Speeds. These are also the two pillars the RCAs directly manage. Thus, while the rest of the pillars are considered and discussed within the report, the key focus is on Safe Roads and Safe Speeds.

1.3 Purpose and objectives of the research

The purpose of the research is to identify how on-street parking impacts safety and multi-modal outcomes, and to make recommendations on parking legislation and guidance that contribute to improving these outcomes – for example, through changes in parking facility design or operation.

Safety in the context of this research is road safety only, not safety outcomes that might arise from personal security issues that are generally addressed through Crime Prevention through Environmental Design approaches.

This project focuses on urban on-street parking, as off-street parking is subject to different management regimes and risks. The research does not examine parking management practices or where parking should or should not be located for economic reasons. However, it does recognise that parking management can affect safety, such as by affecting the amount of time that drivers spend searching for parking and the risks of that activity.

The research also does not consider parking on rural roads.

The objectives of the research (as defined in the Scope) are to:

1. review the local and international literature and experience of the road safety and associated impacts (positive and negative) of on-street parking, and compile an evidence base
2. interrogate the NZTA Crash Analysis System (CAS) and other identified information sources to identify key statistics related to parking and road safety related crashes and injury

3. identify unique features of, and rationales for, decisions about on-street parking in New Zealand – for example, a preference for reverse angle or nose-in angle parks rather than tail-in as in other jurisdictions, vehicle size considerations, pros and cons of different layouts
4. identify some specific parking-related risk-mitigation strategies for different road contexts in New Zealand, notably linking in with ONF classifications
5. test proposed strategies on selected New Zealand case studies within different contexts, notably with a range of multi-modal infrastructure and levels of service for different modes
6. synthesise the research findings and make recommendations for policies and management of parking to enhance safety for all transport modes, while also supporting parking's core functions.

1.4 Structure of the report

This report is structured as follows:

- Chapter 2 outlines the study methodology, including the research approach.
- Chapter 3 provides some context for how parking is regulated and managed in New Zealand.
- Chapter 4 presents the findings of a literature review, including relevant design guidance.
- Chapter 5 presents the findings of a New Zealand safety data review.
- Chapter 6 examines how parking is provided in New Zealand streets and the relationship with the ONF and the Speed Management Guide.
- Chapter 7 discusses a range of safety and design risk-mitigation strategies.
- Chapter 8 outlines a range of case studies that examined road space allocation and design issues.
- Chapter 9 provides the key conclusions of the research.
- Chapter 10 makes recommendations for consideration.

2 Methodology

2.1 Provide New Zealand context

An overview of how on-street parking is legislated, designed and managed in New Zealand provides context for the research. This includes the legal framework under which on-street parking is provided, aspects of law relevant to multi-modal outcomes, and the parking policy and management environment of New Zealand.

2.2 Literature review

The literature review examines New Zealand and international research on the relationship between safety/multi-modal outcomes and parking. This included identifying approaches that may help with risk-mitigation strategies. Design guidance was also reviewed to establish what already exists to address safety issues and multi-modal outcomes related to on-street parking.

2.3 Safety data review

The analysis focuses on identifying any relationships between safety and particular types of on-street parking layouts. This involved interrogation of CAS data and any Accident Compensation Corporation (ACC) data that pertain to crashes that may not have been included in CAS but are clearly linked to on-street parking.

There are some current CAS codes directly related to parking, in the most part being parking manoeuvring crashes and crashes into parked vehicles. The analysis attempts to understand any crashes that may not be coded as parking related but involved parking, such as parked cars blocking visibility at intersections or driveways. This stage of the work looks at statistics or conclusions around the impact of on-street parking on safety, particularly DSIs.

2.4 Establish New Zealand parking layouts

This stage of the research examined the way that parking is laid out in New Zealand streets, the rationale behind the various layouts in the context in which they apply, and any features that may be critical for the various layout arrangements. This is in the context of the ONF urban street types (Waka Kotahi, n.d.-b) and the Speed Management Guide (Waka Kotahi, 2022a). The advantages and disadvantages of different layouts are outlined along with a review of how RCAs select various parking layout options. The literature review and safety analysis findings are used to clearly outline the implications of various layout types from both a positive and negative perspective. Any innovations being used in New Zealand with respect to on-street parking provision are identified.

2.5 Safety and design risk-mitigation strategies

This stage of the research identified existing safety and design strategies to mitigate the risk of various layouts, recommend any improvements to these, and identify new strategies where appropriate. The output of this stage is risk-mitigation tables focused on improvements for each mode.

2.6 Case studies

Brief case studies for a range of street design projects were developed to examine real-life situations where road space allocation decisions involved on-street parking and how the design changed because of the parking. Any negative impacts are discussed with recommendations on how any appropriate strategies developed could assist. The focus of the case studies was higher traffic volume roads with parking, where safety risks are therefore potentially higher.

3 Context – Parking in New Zealand

3.1 Legal and regulatory frameworks

3.1.1 Legal definitions

Within the Land Transport (Traffic Control Devices) Rule 2004 (known as the TCD Rule) and the Land Transport (Road User) Rule 2004 (known as the Road User Rule), 'parking' is defined as meaning:

> *(a) in relation to any portion of a road where parking is for the time being governed by the installation of parking machines placed under a bylaw of a local authority, the stopping or standing of a vehicle on that portion of the road for any period exceeding five minutes;*
>
> *(b) in relation to any other portion of a road, the stopping (whether attended or unattended) or standing of a vehicle (other than a vehicle picking up or setting down passengers in a loading zone or reserved parking area, and entitled to do so) on that portion of the road.*

The TCD Rule also goes on to define 'standing' as stopping:

> *(a) for the purpose of picking up or setting down passengers, or, in the case of a taxi stand, for the purposes of waiting for hire; and*
>
> *(b) while a vehicle remains attended by the driver at all times.*

A 'road' is defined in New Zealand legislation as a number of different places (street, motorway, beach and others), but in the context of this research it relates to the 'street'. Another term used in the legal context is 'roadway', which means that portion of the road used or reasonably usable for the time being for vehicular traffic in general.

'Road controlling authority' (RCA) in relation to a road means the authority, body or person having control of the road, and includes a person acting under and within the terms of a delegation or authorisation given by the controlling authority.

3.1.2 Legal control of parking

RCAs manage on-street parking spaces. They may also own and operate off-street public parking facilities; however, these are not examined in this research.

Parking spaces or other kerbside use can be time restricted or allocated to certain uses. The other uses beyond car parking include bus stops, mobility parking, taxi or small passenger vehicle zones, motorcycle zones and loading zones. Each of these uses can have differing design requirements such as width and length of the space, and in the case of mobility parking, step-free access to the footpath. These requirements are generally well defined in standards. This research is focused on how these uses can be provided in a Safe System environment.

Parking restrictions and prohibitions are typically set by the RCA through 'bylaws'. Bylaws are rules or regulations that can be made with respect to an Act; in the case of parking that is the Transport Act 1962 and Local Government Act 2002. Council RCAs generally do this by council or committee resolution while the NZTA RCAs do this by published gazette. The bylaws are enforced by RCA-appointed parking enforcement officers, who may issue parking notices or impose other forms of penalty, such as the towing away of illegally parked vehicles. An example of a bylaw that some RCAs have in place is the banning of parking on berms where there is a kerb, such as shown in Figure 3.1.

The scale of infringement fines for parking is set by the New Zealand Government (Land Transport (Offences and Penalties) Regulations 1999). At present, the magnitude of fines is generally known by the public to be low, and therefore people often risk a parking violation due to the low-scale financial penalty. An increase in the scale of fines has the potential to influence behaviour but would most likely need to be in conjunction with more stringent enforcement to have the desired impact.

Figure 3.1 Illegal berm parking example that reduces footpath width

Other parking behaviours that impact safety and multi-modal outcomes include the example in Figure 3.2, where a vehicle in a driveway is blocking the footpath, requiring footpath users to detour around this obstacle, which could be difficult for someone with a mobility device. This is covered by the Road User Rule (clause 6.14), which states: 'A driver or person in charge of a vehicle must not stop, stand, or park the vehicle on a footpath or on a cycle path.' However, this is unlikely to be enforced unless someone makes a complaint.

Figure 3.2 Driveway parking blocking footpath

The existence of underlying legislation prohibiting parking in certain locations as prescribed in the Road User Rule removes the need for such restrictions to be specifically identified within a local authority bylaw, and they may not need to be specifically marked or signed. Examples of this include no parking within 6 m of an intersection or obstructing vehicle entrances and exits. However, where appropriate, they can be reinforced and identified to road users through the provision of appropriate traffic control devices (TCDs), such as no-stopping lines in a kerbside cycle lane discussed below.

3.1.3 Aspects of law relevant to multi-modal outcomes

Below are some aspects of law that relate to road safety and multi-modal outcomes with respect to parking. Drivers learn about some of these rules in the driver licensing process, which involves studying and being tested on the New Zealand Road Code (Waka Kotahi, n.d.-c). Drivers sit a multichoice test to obtain their learner licence and then sit practical tests at restricted and full licence stage.

Walking

- **Marked pedestrian crossing (‘zebra crossing’):** A pedestrian crossing or ‘zebra crossing’ must be marked in accordance with the TCD Rule, Schedule 2 (M1-1, M1-1.2 or M1.13). The rule does not require that parking restrictions be applied to the approaches to the pedestrian crossing; however, the Road User Rule states drivers must not park (or stop) on, or within 6 m of the driver’s approach to, the marked pedestrian crossing.
- **Other pedestrian facilities (eg, refuges/traffic islands):** Under clause 6.7 of the Road User Rule, a driver or person in charge of a vehicle must not stop, stand or park the vehicle on a traffic island or flush median.
- **School crossing points (‘kea crossings’):** A school crossing point must be marked in accordance with the TCD Rule, Schedule 2 (M1-3), which sets out a number of parking restrictions around the crossing location.

Cycling

- **Special vehicle lanes:** Where part of a road is defined as a ‘special vehicle lane’ (such as a bus lane or cycle lane) for 24 hours, seven days a week, and is suitably marked or signed in accordance with the TCD Rule, no additional signing or marking to restrict or prohibit parking is legally required. In such cases, the driver or person in charge of a vehicle must not stop, stand or park the vehicle in a special vehicle lane unless the vehicle belongs to the permitted class of vehicle for which the lane is reserved and the stopping or standing of the vehicle is permitted by signs or markings (eg, a bus stop within a bus lane).
- **The risk of car doors opening into cyclist:** Clause 7.2 of the Road User Rule says: ‘A person must not cause a hazard to any person by opening or closing a door of a motor vehicle, or by leaving the door of a motor vehicle open.’ It is noted that the New Zealand Road Code also includes safety advice on parking, such as how to open a car door to avoid injuring a cyclist if you open your door into their path, and always checking the road carefully for cyclists before reversing or moving out of parking spaces.

Bus stops

- Road users may not park, stand or stop on or within 6 m of a bus stop sign (Road User Rule, clause 6.8). Bus stops are loading zones; therefore, no parking is permitted within a marked bus stop. Bus stops must be marked out where the space reserved for the bus extends for more than 6 m on either side of a single bus stop sign. Where bus stops are marked out, they should be marked in accordance with the TCD Rule Schedule 2 (M3-2 or M3-2A).

Sight distance at intersections

- Parking is not permitted closer than 6 m to an intersection unless there are marked parking spaces or a notice allowing parking. Parking is also not permitted closer than 1 m to a vehicle entrance. This is to provide some visibility for motorists and active mode users at intersections and vehicle entrances.

3.2 Parking policy and management

Good parking policy and management can contribute to better safety and multi-modal outcomes. For example, guiding where on-street parking is located through a parking space hierarchy that prioritises the types of parking in different areas or street types can support using the road space for other uses such as cycle facilities. There are also supporting aspects such as efficient ways for people to search for parking that can reduce the number of vehicles circulating for parking, thereby reducing risk to other road users.

RCAs develop their own parking policies and management plans. Until recently there has not been a national guideline for parking management plans. In 2021, NZTA released its *National Parking Management Guidance* (Waka Kotahi, 2021a), which provides RCAs with consistent, best-practice support for the management of public parking throughout New Zealand. This guidance is intended to support councils in the development of parking strategies and parking management plans. The guide is not a design guide, but it does acknowledge that while parking can contribute towards the success of a place, parking that is poorly managed and designed can also undermine efforts to create highly liveable urban areas by, among other things, creating safety issues for other users such as pedestrians (eg, moving through off-street car parks) and cyclists (eg, dooring and reversing).

The *National Parking Management Guidance* also supports the *National Policy Statement for Urban Development* (NPS-UD) 2020, developed by the Ministry for the Environment Manatū Mō Te Taiao and Te Tūāpapa Kura Kāinga Ministry of Housing and Urban Development. The NPS-UD, which sets out the objectives and policies for planning well-functioning urban environments under the Resource Management Act 1991, includes a policy that requires higher-population local authorities[2] to remove minimum car parking requirements for land developments from their district plans, other than for accessible car parks. This policy is likely to impact on-street parking demand as it may be relied on more when developments do not provide on-site parking. Therefore, the policy also strongly encourages local authorities to manage effects associated with the supply and demand of car parking through comprehensive parking management plans.

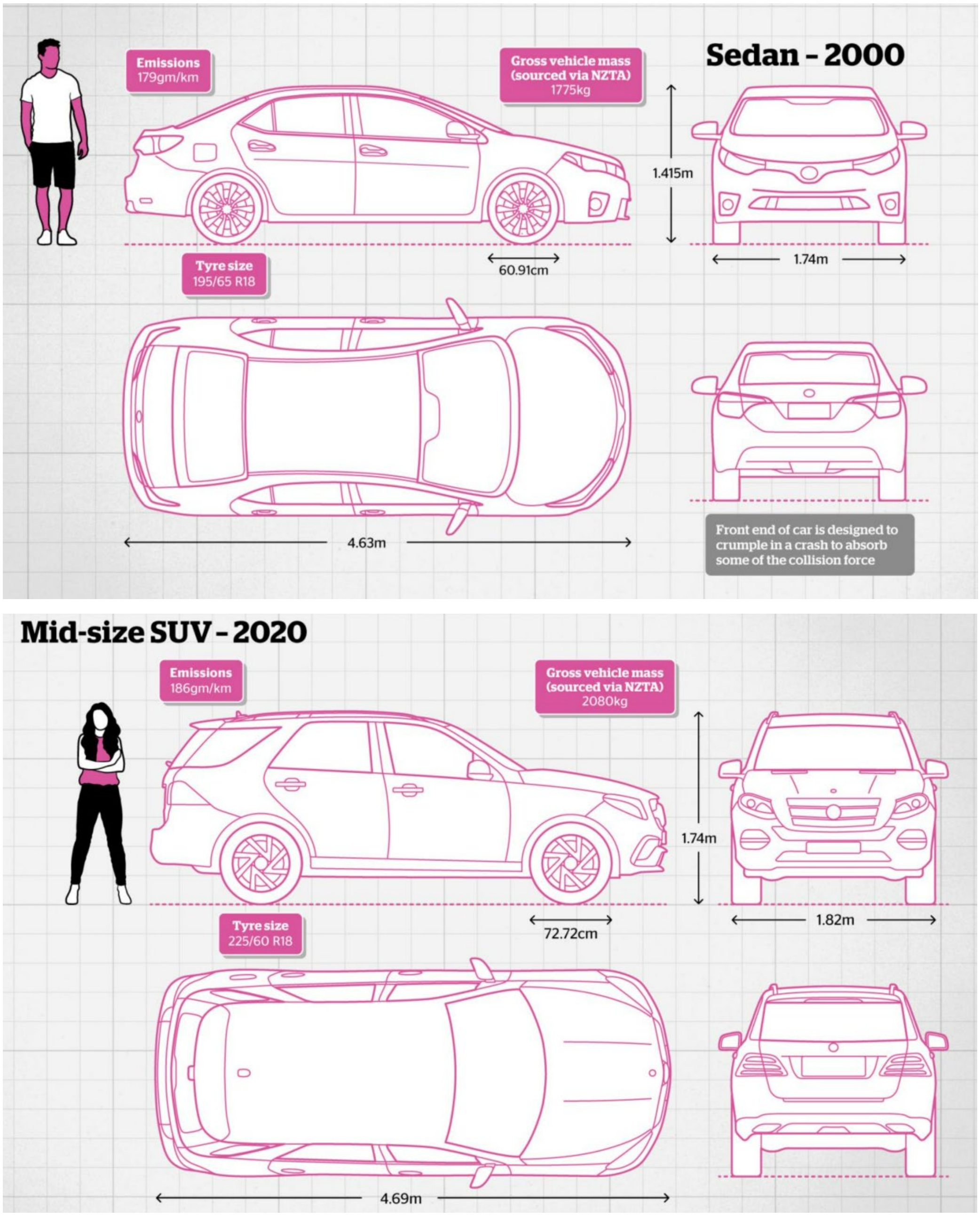
The NPS-UD does not prevent a district plan from including objectives, policies, rules, or assessment criteria in relation to parking. The plans can also include parking dimensions or manoeuvring standards that apply if a developer chooses to provide car parking.

3.3 New Zealand's vehicle fleet

Historical fleet data show that in the last two decades, the fully laden weight (known as the gross vehicle mass) of the average passenger vehicle in New Zealand has increased by nearly 300 kg, from 1,783 kg to 2,079 kg (Newton, 2021). Sport utility vehicles (SUVs) made up 18% of new vehicle purchases in 2002 but made up 55% of new purchases in 2021. Also, the number of double-cab utes relative to single-cabs has also increased, and vans are larger. The impact on parking is not just the increased size of the vehicles from a space perspective but also how the increased height of vehicles could be contributing to decreased visibility past these vehicles when parked near intersections or pedestrian crossings. Figure 3.3 shows the size of a sedan versus a mid-size SUV, the height difference being approximately 320 mm.

[2] Tier 1, 2, and 3 territorial authorities.

Figure 3.3 Vehicle size infographics (reprinted from Newton, 2021)



4 Literature review

This chapter explores local and international literature and experience of the road safety and associated impacts (positive and negative) of on-street parking, particularly in relation to multi-modal outcomes. It also explores local design guidance related to parking.

Parking safety is focused on Safe System metrics. This includes looking at effects on serious and fatal crashes rather than all crashes, as the Safe System approach is concerned with preventing serious and fatal injuries, rather than eliminating minor and non-injury collisions. Due to the vulnerable nature of pedestrians and cyclists, they are also a key focus area of the research.

While the literature found may not have been framed through a Safe System lens, considerations that are aligned with Safe System principles may still have been made. However, Safe System aligned literature is limited, and thus even literature that considers outdated safety metrics is discussed.

The literature review was undertaken in July 2022.

4.1 Literature review key themes

The body of literature that explores safety and other impacts of on-street parking is not extensive. Key themes emerged from the literature, including:

- the effects of on-street parking on traffic speed, crashes and congestion
- the angle of on-street parking
- driver workload in environments with on-street parking and in the task of parking
- the safety of cyclists with respect to parked cars, specifically dooring
- on-street parking as one of many predictors of pedestrian safety outcomes
- street parking/kerb management in the changing transport landscape and for future transport needs
- crash prediction models that relate to parking
- relevant design guidance that reduces the safety risk posed by some parking layouts.

These themes are discussed in more detail below.

4.2 Effects of on-street parking

A number of the papers discussed the effects that on-street parking has on lowering vehicle travel speed, by virtue of narrowing the road space. Lower travelling speeds are generally associated with lower crash rates and less severe injury outcomes. However, the literature indicates that a reduction in travelling speed associated with on-street parking may not translate into crash reductions, because of other risk factors. While the role of speed in traffic applies universally around the globe, research conducted internationally must be carefully considered in terms of its applicability to the New Zealand context due to vastly different environments and traffic mix in North America, Europe and Asia.

4.2.1 Speed and safety impacts

Praburam and Koorey (2015) investigated the impact of on-street parking utilisation on 10 residential streets in Christchurch (all with 50 km/h speed limits). The streets in the study ranged from 8 to 13 metres in width. Analysis of vehicle speeds showed that as parking occupancy increased, the traffic speed fell gradually. Interpolation of the data (assuming a linear relationship) indicated that a 10% increase in parking occupancy is associated with a 1 km/h speed reduction. Speed reductions were less clear on narrow streets than on wider streets. Crash outcomes were not part of the research. The authors suggest that parking on residential streets plays a role in speed management in those environments; however, the overall safety benefits are not clear, since parked vehicles can also obstruct sightlines. This research is consistent with the idea that heavily used parking decreases the optical width of the road and that road optical width influences driver travel speed (Lindenmann, 2007).

Morrison (2006) investigated the utilisation of on-street parking on residential roads (163 road segments) in Sydney (New South Wales) with a range of widths and relatively low traffic volumes. Parking surveys were conducted during the daytime on weekdays. Crash data (deaths and injuries) from five years prior to the study were used to calculate mid-block crash rates per metre. It was found that for wider roads (12–13 metre widths), those that had higher utilisation of on-street parking had higher crash rates per metre. In contrast, higher levels of parking occupancy were associated with either no increase or even a reduction in crashes on more narrow residential roads. Speed surveys were not taken, so it is not known if crash trends may be mediated by changes in traffic speed.

Recent research (Bismark, 2020) analysed crashes on 2,025 road segments across four cities in Nebraska (USA) over a 10-year period, looking specifically at parallel parking. It was not clear from the research whether the severity level of the crash data was included in the research (death/injury only or if it included property damage). The research examined the likelihood of crashes with respect to features of the road. The modelling showed that the chance of a crash where there is on-street parking:

- is reduced with a speed limit below 35 miles per hour (56 km/h)
- increases with increasing traffic volume
- is lower where there is a shoulder
- is reduced when there is traffic travelling only in one direction
- is lower where there is a median
- increases with longer segments of on-street parking.

The research indicates that simply comparing crash rates in places where on-street parking exists to places where it is not permitted, without also considering other features of the environment, may be misleading.

Marshall et al. (2008) found that injury crash rates per mile in low-speed environments (less than 35 mph) are lower in places where there is on-street parking compared to those with no parking, hypothesising that drivers compensate for the increased complexity of the environment. The research also showed that in higher speed environments on-street parking is associated with high injury crash rates. Marshall et al. do not discuss alternative methods for slowing of vehicles, which could be achieved through different means.

In a multifaceted paper intended to inform the development of a vehicle reversing/parking assistance technology, Green (2006) reports data on parking crashes (fatality, injury or property damage crashes) in Michigan (USA). Green concludes that reversing out of parking spaces results in more crashes than other parking manoeuvres (by a factor of 2.6), accounting for about half to three-quarters of parking crashes. Backing out of an angle parking space is the most common scenario for a parking crash. Green’s analysis showed that reversing into a moving vehicle, followed by into a parked vehicle, are the most common outcomes, and in 85% of cases the crashes resulted in property damage only. It was concluded that the high rate of reversing crashes points to the assistance that reversing cameras could provide to drivers.

Biswas et al. (2017) undertook a review of the positive and negative effects of on-street parking, considering its effects on safety, traffic and the local economy. This review summarises much of the literature. A similar review was conducted by Sisiopiku (2001), which reached very similar conclusions. Safety-related impacts of on-street parking outlined in these reviews were as follows.

- Parking can have a traffic calming function.

  - Slower streets have safety benefits, have less noise and emissions, and are more desirable places to walk.
  - Speed reductions are greater for heavy vehicles than cars or motorcycles.
- Parking can act as a comfort buffer between pedestrians on the footpath and vehicles on the carriageway.
- Parking can block visibility between road users – for example, pedestrians emerging from between parked cars and vehicles reversing out of a car park into the traffic stream (particularly with angle parking).

Several reviewers conclude that on-street parking is associated with higher crash rates (Biswas et al., 2017; Box, 2004; Sisiopiku, 2001). All three reviews discuss the same research from the 1970s, which found that the crash types 1 and 3 below are the most common and account for a significant number of crashes on urban streets (percentages reported vary widely, and each has a different denominator, so there is little value in reporting them here). The crash types relevant to on-street parking include:

1. lane changes caused by parked vehicles – side swipe and rear end crashes
2. vehicles intending to park slow down or stop – side swipe and rear end crashes
3. vehicles leaving parking spaces – side swipe and rear end crashes (often angle parking)
4. crashes into an opening car door (often cyclists)[3]
5. drivers failing to see other road users (often pedestrians) due to lack of visibility associated with parked cars.

Likewise, all reviews present data from the same studies from the 1940s to 1960s with respect to reductions in crashes that are reported to be due to changing angle parking to parallel parking. On the basis of the reviewed literature, the authors of all three review papers recommend that on-street parking should be restricted on major roads. It has the potential to provide safety improvements on minor roads but should be parallel rather than angle parking. On-street parking should not be permitted near schools, pedestrian crossings or intersections.

The older historical studies that led the reviewers to these conclusions, however, have been criticised for failing to take into account the diverse character of road environments – for example, the road class, the number of traffic lanes, road width, speed zones, size of parking bays and traffic flow (Bismark, 2020). Understanding the local crash picture with contemporary data is required to understand the magnitude of the crash picture associated with on-street parking. Vehicle technologies (especially reversing technology), different travel speeds and different road environments may mean that outcomes from 60-year-old studies from the USA lack applicability in the current environment in New Zealand.

Marshall (2014), in his book chapter covering all elements of on-street parking, paints a somewhat different interpretation of the evidence. He argues that many studies fail to consider injury severity reductions that would be associated with lower speed environments and therefore underestimate the beneficial effects of on-street parking. Removing on-street parking, if it requires more traffic to turn into side streets or off-street parking lots, may shift the problem to intersections and driveways via an increase in exposure at these locations. There is some evidence to support this from research on bicycle safety in Copenhagen, discussed below.

Marshall (2014) concludes that in low-speed environments on-street parking is favourable to off-street parking lots in terms of land use, cost of providing parking, its regeneration effect in 'downtown' areas,

[3] Cases involving bicyclists crashing into a car door are often excluded from US crash databases because the motor vehicle is not moving (parked) and the bicycle is not classified as a motor vehicle (Schimek, 2018).

walkability and safety. However, his conclusions assume a heavy reliance on vehicles, against a backdrop in the USA where on-street parking had been removed from many central business districts to encourage flow of through traffic, and does not consider advantages that may be associated with mode shift or more sustainable travel as an alternative to private motor vehicles. Marsden (2006) argues parking must be considered as part of land use policy and transport planning at the local and regional levels.

4.2.2 Traffic flow and other impacts

Wijayaratna (2015) examined the influence of on-street parking (parallel parking) on road capacity at six locations in Sydney, New South Wales. The capacity of the road was estimated (using the methodology outlined in Austroads' *Guide to Traffic Management*) along with the likely reduction in capacity that would be expected with permitted on-street parking. The author states that the disruption to traffic flow in the lane adjacent to on-street parking is analogous to that associated with traffic signals and that the delay is mostly associated with entering the parallel parking bay rather than when the vehicle leaves the bay. Locations with short-term parking had a greater impact on traffic flow than those where longer-term parking was permitted; all day parking had minimal impact. Wijayaratna suggests capacity disruption can be mitigated by restricting parking in peak travel times (eg, via clearways) or to create longer parallel parking bays, which allow drivers to drive into the parking space rather than reverse in.

Cao et al. (2016) investigated the effect of on-street parking on road capacity and traffic safety on four road segments in Hangzhou, China. The roads are 'secondary' or 'branch' roads, and they were reported to be not congested during peak travel times. Parallel parking was permitted on all studied streets. Data were collected during peak hours. Traffic safety is measured via traffic conflicts defined as the reduction in travel speed caused by another nearby vehicle, observed as the application of brake lights, not crashes. It is not known to what extent crashes are associated with conflicts. The results clearly outlined a reduction in capacity on the roads with parked vehicles. Conflicts appeared to be related to traffic density, which led the authors to conclude that where traffic density is high, on-street parking should not be permitted, in order to improve safety. The presentation and interpretation of results relating to traffic conflicts were somewhat lacking in clarity. The results regarding traffic safety are therefore inconclusive.

Against a backdrop of problems with highly congested urban roads in Indonesia, research was conducted on a typically congested road in Bandung (Sutandi & Oktavianto, 2016). Motorcycles make up the majority of vehicles travelling on this road both on weekdays and weekends. Results showed that when there is no on-street parking, compared to parking in place, the capacity of the road is 25% higher and travel speeds increased by 33%.

Some reviews (Biswas et al., 2017; Box, 2004; Sisiopiku, 2001) outline a number of traffic flow or congestion impacts of on-street parking:

- Decreased road capacity due to the reduced width of a road, and traffic needing to wait for vehicles in the traffic stream to park and 'unpark', result in slower travel speed.
- Perpendicular (angle) parking can be associated with greater traffic delays than parallel parking due to the time and road space needed to exit the parking.
- On-street parking can block emergency vehicle access along a street.
- The negative effects of on-street parking on traffic are greater when the parking spaces experience higher turnover.

Searching for on-street parking and the act of parking increases traffic, contributes to traffic congestion, adds to pollution and noise, contributes to traffic delay, and because of the increased exposure/traffic volume, it is thought to impact on safety (Brooke et al., 2014). It is suggested that off-street parking with competitive pricing contributes to a reduction in the search for on-street parking, although some argue that off-street parking feeds the reliance on private passenger vehicles and contributes to urban sprawl (Marsden, 2006). Brooke et al. (2014) outline a variety of other factors that influence driver search behaviour. The issue of driver search is relevant to the extent that it impacts on safety and exposure. Although relevant to parking search, driver decision making, along with managing parking demand and network-wide parking policy, is outside the scope of this review.

4.2.3 Economic impacts

According to several reviews (Biswas et al., 2017; Box, 2004; Sisiopiku, 2001), on-street parking makes an economic contribution by allowing easy access to shopping by vehicle occupants and thereby supporting commercial activity. Marshall (2014) argues on-street parking can contribute to regeneration of 'downtown' areas.

Road space reallocation schemes often face significant opposition in local shopping areas, particularly when on-street parking is removed or reduced. A New Zealand study (Fleming et al., 2013) investigated the impact that people who walk, cycle and use public transport have on local shopping areas. It found from a series of interviews undertaken in nine shopping areas that sustainable transport users accounted for 40% of the total spend in the shopping areas. It also showed that pedestrians and cyclists contribute a higher economic spend proportionately to the modal share and are important to the economic viability of local shopping areas. The interviews also showed that the majority of shoppers, especially in arterial shopping areas, intended to visit the centre (ie, as a primary journey purpose) and hence 'passing trade' trips were relatively low, representing less than 30% of total trade. Another conclusion was that retailers generally over-estimate the importance of parking but do acknowledge the need for better facilities for walking, such as wide footpaths and safe crossings. However, the evidence from the shoppers was that they would be willing to forgo or walk further to parking at the shopping area to ensure that a safe and attractive shopping experience is provided.

A recent study from Toronto (Arancibia et al., 2019) explored the effect of removing on-street parking and replacing it with separated bicycle lanes (on Bloor St – a popular cycling route). There was an observed increase in economic activity. Cyclist visitation increased while driver visitation remained steady, using parking in alternative locations. Data from London showed that walkers spent more than car drivers in a sample of activity at 11 shopping centres (Sharp, 2005, cited in Marsden, 2006). These studies show that removing on-street parking does not necessarily have a negative effect on commercial activity.

4.2.4 Key messages

Most authors reached the conclusion that the impact of on-street parking on safety is a negative one. However, on-street parking also appears to lower travel speed, performing a traffic calming function, via narrowing the road width. The safety impact of on-street parking varies depending on the features of the environment. Little work has sought to understand the severity of crash outcomes, but lower speed environments appear to be less risky than higher speed environments.

On-street parking, and the search for parking, is associated with delays in traffic and congestion, leading many to conclude that on-street parking is not appropriate for arterial roads. Economic benefits are asserted as a benefit of on-street parking, giving vehicle occupants access to retail or other commercial premises. However, some evidence suggests that removing parking does not necessarily produce a reduction in economic activity, especially if the area is frequented by cyclists and pedestrians.

4.3 Angle parking and parallel parking

In the three reviews mentioned above, there was a discussion of the merits of angle parking and parallel parking (Biswas et al., 2017; Box, 2004; Sisiopiku, 2001). Box states outright that angle parking results in a substantially greater number of crashes than does parallel parking; the data used to substantiate this claim are old but consistent across several case studies (from the 1970s). Angle parking is estimated to be associated with a 1.3 to 5 times greater rate of crashes than parallel parking. However, there was some evidence that pedestrians are less likely to dart onto the road from between angle-parked cars and that they provide a bigger buffer space (Biswas et al., 2017; Sisiopiku, 2001).

Examining a large dataset state-wide, McCoy et al. (1990) looked in detail at the road features to better understand the contribution of the angle of parking to crashes. The analysis of over 4,000 segments of state roads in Nebraska considered land use, population, angle of parking, painted versus unpainted parking, number of lanes, if the road was divided or undivided, and exposure. Taking these factors into account it was found that crash rates were higher with angle parking than with parallel parking, especially on two-lane, two-way roads. The rate of crashes was greater with high angle than low angle parking (30 degrees or less).

McCoy et al. (1990) question the findings from the 1970s research and argue the observed results could be an artefact of exposure; fewer vehicles are parked along the road length when parallel parking is allowed, compared to angle parking. This conclusion is supported by data from a case study from Lincoln, Nebraska, where parking was changed from parallel to angle along 19 block faces (McCoy et al., 1991). The analysis showed that when both exposure and parking turnover are taken into account there was no increase in the crash rate coincident with the change in parking angles.

More recently, Findley et al. (2020) compared the contribution of different parking manoeuvres to crashes in North Carolina, comparing combinations of different parking manoeuvres when entering a 90-degree angle parking space (backing in vs pulling in) and leaving the parking space (backing out vs pulling out). Parking observations were made around North Carolina State University in parking lots and on streets. Although this study does not directly examine safety effects of on-street parking, the risk associated with reversing manoeuvres is informative. The pull in and back out combination accounted for more than 90% of the crashes, which was found to be a significantly higher percentage than the proportion of vehicles that were parked in that way, indicating an increased risk associated with reversing out of a car parking space compared to driving forwards out of the space.

Angle parking uses more road width than parallel parking but yields more parking spaces along the length of the kerb. Parallel parking is recommended if required on collector or arterial roads (Sisiopiku, 2001), since their traffic function is the efficient movement of traffic. Angle parking could be allowed where the smooth flow of traffic is not the highest priority and congestion is not a problem (Box, 2004). In an examination of parking manoeuvres, it was found that the reversing part of the parking/unparking manoeuvre is the most time consuming (Purnawan & Yousif, 1999). This effect is greater when reversing into the traffic lane (ie, when reversing out of an angle car park) than reversing as a part of entering a parallel parking space where some of the reversing component is within the parking space.

4.3.1 Key messages

The data indicate that angle parking is associated with a higher crash risk than parallel parking; however, this higher risk may be explained, at least in part, by the greater number of vehicles that can be parked using angle parking than parallel parking, along a given length of roadway. The characteristics of the environments studied vary and may contribute to the differences observed in the research. Most authors recommend parallel parking over angle parking, especially on higher volume/arterial roads, though on-street parking on arterial roads may be inappropriate, as discussed in section 4.2.4.

4.4 Behaviour and driver workload

Edquist et al. (2012) investigated the driver workload associated with on-street parking and complex road environments in a simulator study. Outcome measures were travel speed, reaction time, lane positioning, response to a hazard (a pedestrian) and performance on a peripheral task. In the simulator study, drivers were presented with four environments: an arterial road (no parking – least complex) and three types of commercial (shopping strip) environments (no parking bays, empty parking bays and parking bays 90% occupied – the most complex). The road width, number of traffic lanes and traffic volumes were constant across the simulated environments. The results showed that:

- speed variability increased and travel speed reduced with complexity of the environment
- mistakes on the peripheral task were most common in the 90% occupied parking environment, and performance was also slower in the occupied condition compared to the other environments
- detection of a pedestrian was slowest and subsequent braking hardest in the 90% parking condition
- drivers tended to position the vehicle closer to the centre of the road when there were parked cars
- drivers experienced greater workload in commercial environments (the commercial environment workload was slightly higher when there were parked vehicles).

The results show that the behavioural adaptations made by drivers (slowing down, lane positioning) did not compensate for their higher workloads; safety-critical performance was poorer in the complex environment with on-street parking. The applicability of these findings to real-world situations is not known.

The amount of traffic that is accounted for by drivers searching for a car park varies across studies, but it is agreed to be a contributor to congestion and pollution (Biswas et al., 2017; Brooke et al., 2014; Ponnambalam & Donmez, 2020; Sisiopiku, 2001). Less is known about driver behaviour when searching for a parking space. Ponnambalam and Donmez (2020) used an instrumented vehicle and eye-tracking equipment to examine how the search for parking might influence driver behaviour and workload. Participants drove a predetermined route in Toronto and were required to find a place they could legally park but were not required to actually park the vehicle. The analysis showed that compared to the baseline, when searching for parking:

- average speed was lower
- more time was spent looking away from the road
- the lane position was closer to the parking lane (further away from oncoming traffic)
- the subjective workload rating was higher
- there was a slight but non-significant increase in the heart rate.

It was concluded that the lower travel speeds were adopted to compensate for the additional workload and increase in time spent looking away from the road. Searching for a parking space adds to the workload for a driver in what Edquist et al. (2012) have shown is an already demanding environment.

The difficulty of the parking manoeuvre further adds to the driver workload. Evidence suggests reversing into a parking bay is a more difficult task than driving into a parking bay (Setiawan et al., 2021). Research reviewed in the previous section indicated that reversing out is more dangerous. However, there is a strong driver preference for driving forward into a parking space. Survey research summarised in an American Automobile Association (2015) fact sheet shows that about three-quarters of drivers do not frequently reverse into a parking space. Of all drivers, about half report that they never reverse into a parking space. The American Automobile Association reports that this preference does not align with its recommendation that, wherever possible, drivers should reverse into the parking space.

While occupied car spaces may make the environment more complex, one study (Setiawan et al., 2021) demonstrated that drivers find reversing into empty angle parking (60- or 90-degree bays) more difficult than reversing into a space where there is an adjacent object/car/sign, presumably because the line marking is difficult to see and there is no visual assistance that adjacent objects provide. Understanding the difficulty of parking tasks, especially when many vehicles in the fleet do not have reversing technology to assist, should contribute to policy settings around on-street parking.

A brief search of reversing technology and its effects on ease of reverse parking was undertaken but did not reveal any research on this subject. Most of the literature of reversing technology was about technical specifications or whether it can detect moving objects, and objects and road users of different sizes.

4.4.1 Key messages

On-street parking is associated with several challenges for drivers. Shopping strip environments with parked vehicles are complex due to high turnover parking and pedestrian activity. This increases the workload for drivers, which seems to increase the likelihood they make mistakes and fail to respond appropriately or as quickly compared with less demanding environments. The process of searching for a car park is also demanding for drivers with increased perceived workload and time spent glancing away from the road. Completing a parking manoeuvre, especially when required to reverse into a car space, appears to be challenging, with many drivers actively avoiding it. It would be expected that reversing technologies might provide assistance for reverse parking, although no research was found on the difference reversing cameras might make to the ease of parking.

4.5 Bicyclist safety

As outlined in the above discussion of on-street parking crash types, car doors being opened in the path of cyclists is the main crash type of concern regarding parallel parking. A number of studies explore the prevalence of car dooring crashes and the issue of on-street parking. Other published papers discuss design guidelines relevant to bicycle travel, including on-street parking.

4.5.1 On-street parking and bicycle safety

A recently released review published by the Institute for Road Safety Research (SWOV; Nabavi Niaki et al., 2021) pulls together research evidence on infrastructure that enhances the safety of cyclists. Parts of this review discuss on-street parking. Citing several of the papers reviewed in this section, the evidence is that on-street parking contributes to bicycle crashes, with car dooring a key risk.

A study sought to understand how New Zealand cyclists perceive the levels of service provided by different types of cycling infrastructure, considering complex external factors (such as motor vehicle traffic, land use, hills and environmental conditions) (Bowie et al., 2019). A further purpose of the study was to provide a user-centred approach to assess existing and proposed facilities that would enable better-informed decisions about target cycling levels of service and key factors to manage in the planning and design of cycle facilities in New Zealand. Through a series of user surveys, the study found that even when riders rated road sections with a relatively high level of service based on the experience they had on the day of their ride, they often included comments about the danger of car doors opening, vehicles being stopped in the cycle lane, and cars entering and leaving parking spaces.

Research was undertaken in New Zealand to identify key cycle safety interventions through the development and application of a cycling safety system model, developing a cycling competency system model and providing guidance on how best to prepare New Zealanders for riding on the network (Mackie et al., 2017). The research focused on fatalities and examined three key crash scenarios, one was ‘cyclist hit by car door and falling under truck'. Despite being relatively less common than other scenarios, this was examined because it has many different system elements to it. It also relates to car parking in urban areas, which is one of the greatest obstacles to creating safe and user-friendly cycling networks. There is also a connection between actual and perceived safety, with the latter very important for attracting more cycle trips in towns and cities. The car dooring occurrence, providing the cyclist does not fall under a truck, is likely to be relevant for non-fatal crashes and many near misses, which have no doubt caused many cyclists to give up cycling for fear of their safety.

Johnson et al. (2013) investigated the extent and nature of cyclist car dooring crashes using police-reported crash data, hospital presentations and some of the video footage from a previously conducted naturalistic study involving commuter cyclists in Australia (see Johnston et al., 2010). Car dooring accounted for 3% of cyclist emergency presentations and 8% of police-reported crashes involving cyclists. Most car dooring crashes were in urban Melbourne (Victoria) in peak travel times and in speed zones of up to 60 km/h. Most of the time the car dooring involved a driver, but in 20% of cases the door was opened by a passenger. Some of the passenger cases involved a vehicle that was stationary in the traffic lane (not in a parking space). Among emergency presentations, most cyclists (84%) were treated in emergency only and discharged rather than being admitted to hospital. The video footage showed that the commuter cyclists passed by over 6,000 parked vehicles in an average trip (duration 38 minutes). A total of 13 events involving a car door opening in front of cyclists were found in the video footage; none resulted in a collision as cyclists were able to take evasive action. Interestingly, three of the car door events involved commercial vehicles with doors partly open but no driver visible (delivery vans etc). Commuter cyclists in urban environments are exposed to a vast number of parked cars. Whilst cyclists are often able to avoid crashing into car doors, they do feature in the crash and hospital data. Reconfiguring road space to allow for wider bicycle lanes and shifting the lane to the kerb side of parking were both recommended by the authors.

In a naturalistic study, using bicycles equipped with GPS and video cameras, Lawrence et al. (2018) also investigated the incidence of cyclist car door collisions in Melbourne, Victoria. The research focused on mixed function activity centre environments where there is typically on-street parking, a traffic lane (often with tram lines) and usually no bicycle lane. The presence of parked cars was established from the video footage and three conditions of car door events were identified: the car door opening after the cyclist passed (give way event); the door opened in the path of a cyclist not resulting in a collision (obstruction event); and the door opened resulting in a collision (collision event). Cyclists travelling in mixed function activity centre environments were exposed to 1,166 parked vehicles per hour. On average there were 6.9 give-way events per hour and 2.3 obstruction events ($n = 9$) per hour. There were no collision events. In the obstruction events, cyclists adapted their position on the road, made easier in nearly half of the cases because the driver was entering the car and therefore more visible to the cyclist. The rate of exposure to parking events was reported to be comparatively high and demonstrated the higher risk to cyclists in mixed function activity centres.

A study reviewed the evidence from Australia and elsewhere on interventions that seek to reduce the frequency of dooring crashes and documented a pilot intervention activity undertaken to raise awareness of the issue (Munro, 2012). The study found limited evidence on the efficacy of countermeasures to reduce car dooring, and few countermeasures that have been developed to target car dooring crashes specifically. Most education and communication campaigns where car dooring is a component, such as 'share the road' style campaigns, were concluded to be ineffective as they are often undertaken in isolation of other interventions (such as enforcement) and fail to be immediate to the behaviour (ie, car door opening) and a direct, personal communication. The absence of evidence or experience of implementing a car dooring intervention makes it difficult to identify a set of countermeasures that can confidently be predicted to be effective. However, the study offers general principles that would be supported by wider road safety practices as having the greatest likelihood of being effective. Most of these were design related, such as buffered cycle lanes.

Isaksson-Hellman (2012) used data from insurance claims to investigate the types of crashes in which cyclists are injured (at the MAIS2+ level of severity[4]) in Sweden. The percentage of mild injuries according to the Abbreviated Injury Scale (AIS) was 72% (MAIS1), moderate injuries 21% (MAIS2), and severe injuries 5% (MAIS3+). One percent were uninjured, 1% had unknown injury severity, and 1.6% (7) of the collisions resulted in a fatal injury. Only crashes involving passenger cars and bicycles were included in the analysis. Intersection crashes represented the majority of cases (76%), while car dooring accounted for 4%. The dooring crashes were generally in large cities alongside on-street parking. There was no breakdown of severity for dooring crashes specifically. This research was unique in that it was able to capture injuries to cyclists that were not reported in police crash data.

Teschke et al. (2014) surveyed injured bicyclists treated in the emergency departments of five hospitals in Vancouver and Toronto, Canada. Crashes with motor vehicles accounted for 40% of cycle crashes on street locations. The highest number of crashes with motor vehicles or with car doors were observed in major streets with parked cars. There were fewer crashes on major streets with no parking, and fewer on local streets. After controlling for exposure, bicycle crashes with motor vehicles, including car doors, were overrepresented on major roads with on-street parking. In contrast, crashes with motor vehicles were rare at locations where there was separated bicycle infrastructure.

Schimek (2018) reviewed the literature regarding on-street parking adjacent to bicycle lanes, with a specific interest in car dooring. In the USA it has been difficult to quantify this crash type because bicycles are not classified as motor vehicles, and parked vehicles are not regarded as being in transport, resulting in the exclusion of these crash types from some US crash databases. Available data from a range of jurisdictions (USA, Canada, Australia) suggest that car dooring crashes account for about 12% to 27% of all bicycle–motor vehicle crashes. Schimek's review also indicates that car dooring related injuries may be more severe than for other types of cyclist crashes.

Interesting research from Denmark, commissioned by the City of Copenhagen, investigated the effect of banning on-street parking and the construction of cycle tracks on crashes (Jensen et al., 2007). In Copenhagen, some cycle tracks are separated from traffic in that they are raised and alongside pedestrian paths, others are wide lanes alongside the kerb. A range of different cycling facilities are also discussed in the report, although the discussion here is limited to the topic of on-street parking. Installation of cycling facilities resulted in an increase in cycling and a reduction in car traffic. The provision of cycling facilities was found to have increased perceived safety, consistent with the increase in cycling. The analysis showed that removing parking and constructing cycle tracks resulted in, at mid-block locations, a decrease in crashes by 10% and injuries by 4%, but at intersections there was an 18% increase in crashes and injuries, resulting in a net increase in crashes of about 9–10% on the treated parts of the network. Further analysis found the interventions resulted in a reduction of cyclists crashing into a parked car (and rear-end crashes too) but resulted in more vehicles turning into side streets to access parking spaces, and more crashes at intersections.

Survey research from Germany (Hagemeister & Kropp, 2019), which presented a range of road environments for which cyclists rated perceived safety and appeal, showed that having no on-street parking is the key determinant of perceived safety and contributed to the appeal of on-road cycling facilities. Providing a buffer but allowing parking is perceived as being less safe by cyclists. To compensate for the presence of parked cars, a much wider space is required for cyclists to feel safe. Similarly, Stintson and Bhat (2003) found, in their survey research with commuter cyclists, a preference for separated paths and bicycle lanes in urban areas, but the value of the bicycle lane was reduced if on-street parking was allowed. A body

[4] Maximum Abbreviated Injury Score – measures the threat to life of an injury; 0 means there is no chance of death while 6 is the maximum, which means almost certain death due to the injury.

of research exists on places where cyclists prefer to ride. According to Hardinghaus and Papantoniou (2020), Nabavi Niaki et al. (2021) and Monsere et al. (2012), cyclists prefer separated infrastructure, quiet side streets, low speed limits and a buffer from the car dooring zone. On-street parking contributes to cyclist preferences.

Much of the research above is related to car door opening risk. The literature review found there is a method of opening the door that can reduce the risk (New Zealand Automobile Association, 2020). This method is called the 'Dutch Reach'. It is a technique that involves using the far arm to open your car door, as opposed to opening it with the hand closest to it. Using this method forces people to turn around and means they are more likely to notice if a cyclist is coming past, before they open the car door. The Dutch Reach was introduced in the Netherlands in the 1970s and has since become common practice in Dutch society. A number of other countries have embraced the method by adding it to traffic safety handbooks and official driver's manuals around the world. In January 2022, the UK government added the Dutch Reach to the Highway Code as a measure to protect bike riders, pedestrians and other road users (Department of Transport UK, 2022). This is in Rule 239 of the Highway Code as follows:

- *you **MUST** ensure you do not hit anyone when you open your door. Check for cyclists or other traffic by looking all around and using your mirrors,*
- *where you are able to do so, you should open the door using your hand on the opposite side to the door you are opening; for example, use your left hand to open a door on your right-hand side. This will make you turn your head to look over your shoulder. You are then more likely to avoid causing injury to cyclists or motorcyclists passing you on the road, or to people on the pavement.*

A study (Large et al., 2018) has revealed some tentative evidence to support far-hand door opening in the context of the Dutch Reach technique. These include an increase in head rotation (when participants were seated in the driver's seat) and recognition from participants that far-hand door-opening affords better awareness of rear-approaching hazards (even despite their ignorance of the study aims). However, this was a preliminary investigation, and it was acknowledged that further work is required to substantiate these results.

It is noted that the New Zealand Road Code (Waka Kotahi, n.d.-b) already suggests using your left hand to open the car door as follows; however, it is unknown if any promotion of this is undertaken during driver training or in road safety campaigns:

- *Opening a car door – You can injure a cyclist if you open your door into their path. Always check carefully for cyclists before you open your door. Using your left hand to open the door will turn your shoulders and increase your chances of seeing an approaching cyclist.*

4.5.2 Key messages

Overall, the research on cycling and on-street parking shows that on-street parking has a negative impact on the safety of cyclists, accounting for a small proportion of the cyclist crash/injury picture. Intersection crashes remain the biggest contributor to bicyclist trauma. However, it is possible that car dooring crashes are under-reported if cyclists do not actually hit the vehicle but swerve and fall or crash trying to avoid the door. Falling while avoiding a car door can lead to severe injury due to striking the ground or surrounding objects, or being struck by following vehicles. Once cyclists are exposed to vehicle-related crashes, either due to avoiding parking hazards or falling on the road, the speed of the vehicle will be the key indicator in the severity of the crash. Thus, parking-related crash severity in many situations will still be dictated by vehicle speeds. Providing Safe Speeds, aligned to the Safe System principles, is therefore a key consideration.

Cyclists also feel less safe riding in places where there are parked cars, even if there is a bicycle lane. Naturalistic studies show that cyclists regularly experience near misses with opening car doors, which is likely to contribute to how safe they feel in environments with on-street parking. Lessons from Denmark indicate that banning parking and providing bicycle infrastructure may have a negative impact on safety if it encourages more traffic through intersections, where cyclists are not protected, due to drivers turning into side streets to access parking spaces. The width of bicycle lanes is generally thought to be insufficient to keep cyclists out of the dooring zone of vehicles parked on-street.

4.6 Pedestrian safety

Compared to bicyclist safety there was comparatively little research found on pedestrian safety impacts of on-street parking. Indeed, a special investigation report into pedestrian safety by the US National Transportation Safety Board (2018) made no mention of parking. Amiour et al. (2022) undertook a systematic review of the effects of the built environment on objective and perceived safety of child pedestrians. Little research was found specifically regarding on-street parking and safety; other factors attracted far more research attention. A handful of individual research papers explored the relationship between pedestrian safety or perceived safety and on-street parking.

Congui et al. (2019) explored, in Alghero, Italy, a range of built environment characteristics and their relationship to pedestrian crashes. An extensive list of built environment attributes was collected, including whether on-street parking was authorised. Logistic regression analysis revealed that on-street parking doubled the risk of a pedestrian crash.

Barón et al. (2021) investigated, for 40 roads in two counties in Portugal, the effect of the built environment, infrastructure and traffic factors on pedestrian crashes. The research found that the presence of on-street parking was associated with greater safety for pedestrians. The authors suggest that in the locations studied the parked vehicles contribute to congestion and the slowing of traffic; indeed, higher traffic volumes were associated with fewer pedestrian crashes. Increasing slope (steeper road incline) and distance between crosswalks were both related to increased pedestrian crashes. Barón et al. (2021) suggested that steeper roads may be related to higher speeds practised by drivers and lead to a higher probability that pedestrians will choose the fastest and easiest way to cross the street.

Morency et al. (2015) explored the relationship of intersection characteristics with pedestrian injury in Montréal, Canada. Injury data used in the study were collected by the ambulance service, pre-hospital presentation. Via site visits, information on the presence of on-street parking within five metres of the intersection was collected among other road and traffic characteristics. It was commonly found that parked vehicles obstructed the visibility at intersections. Pedestrian injury was related to the number of traffic lanes and traffic volume. With respect to parking, across all intersection types it was found to be associated with a significant increase in the number of injured pedestrians. This was found to hold true with modelling of signalised intersections and locations where there was a multilane road on at least one of the intersection legs.

A study from Greece (Basbas et al., 2009) about perceived safety among child pedestrians in the municipality of Thessaloniki found that when children are walking to school, their reasons for feeling unsafe are most commonly the high speed of traffic (41%) or the high traffic volume (21%). Some mentioned the presence of parked cars contributing to their perceptions of being unsafe (14%).

Research in Guadalajara, Mexico, identified among pedestrians the elements of the built environment that are associated with perceived safety and risk (Aceves-González et al., 2020). The research explored a five-block environment along a busy avenue in the central business district. Pedestrians surveyed identified lack of traffic lights, too much traffic, lack of signs, and parked cars that obstruct visibility as key factors that contribute to pedestrian risk.

4.6.1 Key messages

With the exception of the Portuguese study, the literature showed that on-street parking has a negative association with pedestrian safety or perceived pedestrian safety. None of the studies in the literature review identified that on-street parking is seen by pedestrians as an additional buffer to moving traffic, although it is often mentioned in design guides as an advantage of parallel parking (Auckland Transport, n.d.) and most likely related to the footpath width. For example, a narrow footpath, say less than 2 m, next to traffic moving at 50 km/hour will feel very uncomfortable, and the presence of parked cars is likely to improve comfort levels.

4.7 Parking policy and the future of parking

Since the proliferation of motor vehicles, the road environment has primarily been designed for drivers of motor vehicles (Lindenmann, 2007), maximising traffic flow and minimising travel time for vehicle occupants. However, since the 1990s, planning and traffic engineering efforts have increasingly sought to redistribute road space to enable different types of uses to have traffic speed low enough to improve safety for all road users and to enhance the attractiveness of central areas of towns and cities for visitors (Lindenmann, 2007). At present, street space is not always allocated in a way that reflects transport mode usage. Historically, motor vehicles have been favoured with the allocation of on-street parking, while street space for pedestrians is under-allocated. Research from Melbourne (Victoria) showed that on-street parking accounted for 21% of street space across the 57 activity centre sites surveyed, although the occupants of these vehicles accounted for only 13% of travellers (De Gruyter et al., 2021).

Some of the wider context to the issue of parking emerged from the literature search. Although it may not impact on parking policy and guidelines presently, there are emerging trends that could impact on the demand for parking and may in turn influence its safety impacts. Rosenblum et al. (2020) outline some emerging issues (in the USA) that may reduce future demand for parking, and may be relevant to the New Zealand context:

- Car licensing and ownership is lower among ‘millennials’ than previous generations, with a higher proportion choosing to use alternatives such as ride share or car share.
- The cost of constructing parking areas (especially underground) is very expensive. The cost charged to consumers of car parking is disproportionately low compared to the cost of construction.
- Provision of large (and low cost) areas for parking feeds the reliance on private motor vehicles (especially in the USA where on-street parking is often free).
- The benefits of dynamic pricing models for parking are discussed in the literature, and it is suggested that this, along with improvements in bicycle infrastructure and public transport, could reduce parking demand by 60%.
- Zoning and planning regulations requiring minimum numbers of parking spaces may need to change with the decline in vehicle ownership.
- Autonomous vehicle fleets are expected to reduce parking demand as private vehicle ownership decreases.

It is noted that automobile ownership and use have peaked in New Zealand and are likely to decline in the future, and current economic and demographic trends are increasing demands for other modes (Denne & Wright, 2017).

Marsden et al. (2020) make many of the same points but add several emerging issues that are likely to impact on parking demand and the role of the kerb as a place for car parking:

- Online ordering and delivery of goods will mean that pick-up and drop-off is likely to increase, as will ride share pick-up and drop-off.
- Kerbside charging for electric vehicles is likely to be in demand in the future.
- Users of e-vehicles such as e-scooters are likely to seek to use the footpath for parking.

4.8 Crash prediction models

Crash prediction modelling studies look at the relationship between crashes and predictor variables, including road layout and operating conditions. New Zealand has undertaken a number of these studies, but kerbside (on-street) car parking has rarely been featured in these studies. One of the key issues with parking is that it is a dynamic process that can be difficult to model. Both parking turnover and occupancy can vary quite a lot on some streets based on the time of day and day of week, and purpose.

4.8.1 Cycling safety research

One crash modelling study that looked specifically at the impact of parking on cycle crashes (all injury types) was *Cycle Safety: Reducing the Crash Risk* (Turner et al., 2009). The mid-block crash models included several layout variables, in addition to traffic/cycle volumes and speeds, including:

- presence of parking lane with low occupancy (Factor 1)
- routes with no parking lane (Factor 2)
- presence of cycle lane (Factor 3)
- (effective) width of kerbside traffic lanes and cycle lanes (when present) (Factor 4)
- presence of a painted (or flush) median (Factor 5).

A number of crash prediction models were developed, looking at specific cycle-related crashes and all vehicle crashes. Models were developed for mid-blocks and traffic signals. The mid-block models were as follows, with the key variables from above:

- total mid-block cycle versus vehicle crashes (Factors 5) – 37% reduction with flush median provided
- turning mid-block cycle versus vehicle crashes (Factors 2 and 5) – 50% reduction where flush median present or no parking but almost double the risk when very low parking utilisation (as compared to higher utilised parking)
- non-turning mid-block cycle versus vehicle crashes (Factors 1 and 5), with limited impact from flush medians and no parking
- all mid-block crashes (involving all users) (Factor 2) – 75% reduction where no parking and 64% increase when there is very low parking utilisation
- all mid-block turning crashes (Factor 2) – 75% reduction with no parking but double the crash risk when there is very low parking utilisation
- all mid-block non-turning crashes (Factor 2) – 75% reduction with no parking.

The models indicate that for both cycle and all mid-block crashes, on-street parking has an impact on crash risk, and no parking reduces the crash risk by up to 75% for all crashes. The research also looked at very low utilised parking, where the parking bay is effectively a cycle lane, except where there is a car parked and the cyclist needs to move into the traffic lane. On such roads it is also likely that speeds are higher than where there is more on-street parking. There is good evidence that this low utilised parking does impact on crash rates, both all and cycle-related crashes; up to double that of more highly utilised parking.

In summary, this New Zealand research supports the literature review findings that parking does impact on crash rates.

4.8.2 Priority intersection models

Another study focused on the safety of rural and urban priority intersections, including channelised (or seagull) intersections. The research report is titled *The Crash Performance of Seagull Intersections and Left-Turn Slip Lanes* (Turner et al., 2018). In this study the safety impacts of a large number of road layout and operating condition variables were assessed, including all injuries.

Of relevance in this work is the presence of vehicles (and other objects) near three-leg priority intersections, with the potential for this to impact on inter-vehicle visibility and crash risk. The two key variables being nearside (to side road) upstream (to the left of the side road) and downstream (to the right of the side road) features. To be included in the models, a feature, such as a parked car (or bus stop), had to occur within 200 m of the centre of the intersection. Objects were recorded in distance bands from the intersection.

The type of feature was also recorded. Car parking was the most common feature recorded near the intersection. Vegetation and road-side furniture were also identified within these zones.

The main crash type that is affected by parked vehicles are vehicles turning right out of the side road being hit by a vehicle travelling straight through – from the left and right sides, with the right side dominating. Approximately one-third of all crashes at T-intersections are from the right side (crash type JA). For each model there were three key factors: (conflicting) traffic volume; operating speed; and design index. The road features near the intersection were included within the design index. The presence of features on the nearside of the intersections were evident in the following models:

- rural standard T-junctions (JA crashes) – near-side upstream (to right side).
- urban standard T-junctions (JA crashes) – near-side downstream (to left side).

The first result, for rural intersections, makes sense as restrictions in visibility to the right do make it more difficult for drivers turning right out of a side road to pick a suitable gap. They may not see a vehicle in time and be struck from the right by a through-vehicle (the JA crash type). Where parked vehicles (or other objects) are in the sight line, the design index and hence crash risk increases. The closer the feature is, in this case a parked vehicle, to the centre of the intersection, the greater the risk of a JA crash.

The urban result is less clear, as the JA crash type does not involve collisions with through drivers coming from the left. However, when a driver is turning right from the side road, then drivers must give way to vehicles coming from both directions. To select a safe gap in traffic, drivers must split their attention by scanning vehicles from both the left and right. Where visibility is restricted to the left, drivers may spend too much time looking to the left and may be less likely to observe vehicles coming from the right. Interestingly, for seagull (channelised) intersections, this variable does not feature as in this case the driver can focus on vehicles coming from the right first (as they cross to the median) before merging with drivers coming from the left. The urban environment is also much more complex and so drivers' attention may be focused in multiple directions. Typically, there are many more layout variables that impact on safety at urban intersections.

To summarise, this research shows that for both rural and urban priority T-intersections, restricted visibility due to features like car parking both up- and down-stream impacts on the risk of crashes involving drivers turning right out of the side road being hit by through vehicles from the right. The nearer the feature is to the intersection, the greater the crash risk. So, vehicles parked within 50 m of the centre of the intersection cause a higher crash risk than vehicles 100 m or more from the centre of the intersection. While not assessed directly in this research, it is highly likely that the same effects would occur at major accessways, which more commonly have nearby kerbside parking.

4.9 Design guidance

4.9.1 Design guidance in New Zealand and Australia

The review of design guidance focused on the safety impacts of parking on walking and cycling, and general road use. Table 4.1 outlines the review findings.

The impact of parking on public transport is generally related to efficiency, which can be hindered by lack of access to and from bus stops, and this is covered by design requirements of no-stopping restrictions on the entrance and exit to stops. However, it is noted that this could also cause a safety issue if a following distracted driver hits a bus protruding into the traffic.

It is noted that a key geometric safety parameter in road design is the sight distance provided at intersections. This parameter has a relationship with parking as it defines the length of no-stopping restriction that should be imposed either side of an intersection/driveway to ensure suitable visibility. Meeting sight distance requirements can mean that parking is banned for quite some distance, and often this is weighed up during the design process. Sight distance requirements are outlined in Austroads' (2021b) *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections*. These sight distance requirements are generally adopted by New Zealand RCAs in their local design guides/codes of practice and often specified in district plans for intersections and high-use driveways, with the speed limit and the road classification being the variables. Sight distance is directly proportional to vehicle travel speed, meaning that inadequate sight distances can be overcome with lower speed limits.

Table 4.1 Design guidance related to parking design with consideration of safety

Name of document and purpose	Relevant guidance
***Traffic Control Devices Manual Part 13 – Parking Control* (Waka Kotahi, 2007)** **Purpose:** To provide guidance on the use of TCDs to transport and parking practitioners, management and enforcement staff. It is understood this Part will be updated in the near future.	• States that: *the Road User Rule stipulates parking prohibitions in certain specific locations, such as near intersections, pedestrian crossings and bus stops.* (p. 3-1) • States that: *The [TCD] rule does not require that parking restrictions be applied to the approaches to the pedestrian crossing; however, the Road User Rule states drivers must not park (or stop) on, or within 6 m of the driver's approach to, the marked pedestrian crossing.* (p. 3-4) • States that: *Where parking prohibitions exist through other enactments (eg … on or near pedestrian crossings), the TCD Rule allows RCAs to install regulatory signs or markings to draw attention to the restriction … The bylaw process however is recommended for the installation of such regulatory signs and markings.* (p. 3-3) • States that a negative of parallel parking is: *Some cyclists may ride into an opening car door.* (p. 5-2) • States that angle parking is: *not suitable next to a cycle lane unless there is extra clearance for parking manoeuvres.* (p. 5-2) • States that a negative of angle parking in the centre of a road is: *Pedestrians have to cross the road to reach the vehicle.* (p. 5-2) • Provides dimensions for parking spaces; however, it is noted that some of these conflict with other NZTA guidance (eg, minimum width of a parallel space being 2.5 m as opposed to 2 m in *Traffic Control Devices Manual* (TCD Manual) Part 5). Also does not provide advice on the design of indented parking.

<table>
<tr><th>Name of document and purpose</th><th>Relevant guidance</th></tr>
<tr><td>

***Traffic Control Devices Manual Part 5 – Between Intersections* (Waka Kotahi, 2020a)**

Purpose: To provide guidance on the use of TCDs for treatments between intersections.

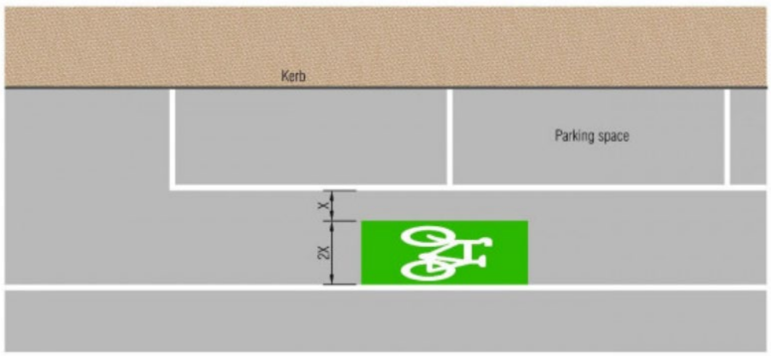
</td><td>

- States that:

  Where the combined width of a cycle lane and parking space is limited, the parking space should be kept narrow, so that good parking discipline is encouraged, allowing cyclists to avoid open car doors.
- Requires that cycle lanes next to parallel parking be at least 1.8 m wide in 50 km/h or less environment and at least 2 m in 70 km/h environments.
- Illustrates a typical configuration of a cycle lane next to parallel parking.

  The cycle symbol and coloured background road surface should be placed in the two-thirds of the cycle lane furthest from the parked cars. This will encourage cyclists to avoid the hazard posed by car doors being opened.

  Figure 8-11: Cycle lane next to parallel parking



- States that:

  People require a high level of protection when cycling adjacent to angle parking, and therefore when implementing angle parking, the needs of cyclists should be given appropriate consideration.

  Cycle lanes should be a suitable distance away from angle parking to encourage cycling in a position that aids visibility between drivers and cyclists and allows cyclists to avoid vehicles that are emerging from a car parking space.

  … Cycle lanes next to angle parking assist in reminding drivers of the potential presence of cyclists.

  The cycle lane requirements are outlined in the table below.

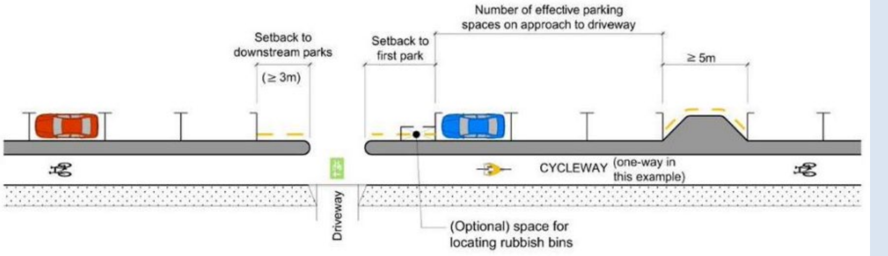
  Table 8-11: Cycle lane clearance from angle parking

<table>
<tr><th></th><th colspan="3">Clear space between parked vehicles and cycle lanes</th></tr>
<tr><td>Parking angle (degrees)</td><td>45</td><td>60</td><td>90</td></tr>
<tr><td>Desirable clearance (m)</td><td>2.0</td><td>2.5</td><td>3.0</td></tr>
<tr><td>Minimum clearance (m)</td><td>1.5</td><td>2.0</td><td>2.5</td></tr>
</table>

- Advises that:

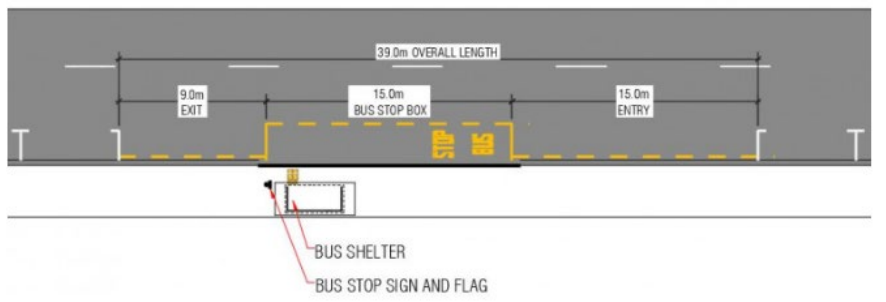
  The provision of kerbed projections or other treatments including channelisation are important in locations next to parking (especially angle parking) when motor vehicle drivers might drive in a parking area when parking demand is light. They should be installed immediately to the left of the cycle lanes at the start of the facility and at frequent intervals to limit the incidence of motor vehicles travelling over, or to the left of, the cycle lane.

</td></tr>
</table>

Name of document and purpose	Relevant guidance
***Traffic Control Devices Manual Part 4 – Intersections – Draft for consultation* (Waka Kotahi, 2021b)** **Purpose:** Provides guidance on industry good practice for intersections, including, where necessary, practice mandated by law.	• The guidance states that no-stopping lines may be marked at uncontrolled, priority, roundabout and signalised intersections if the RCA considers it is necessary to reinforce the prohibition of parking at intersections and/or extend the length over which parking is prohibited in the vicinity of intersections. It does not provide advice on the extent of the parking prohibition.
***Aotearoa Urban Street Planning and Design Guide* (Waka Kotahi, 2022b)** **Purpose:** A national guide to support inclusive access and safe, vibrant communities through street design.	• Encourages parking assessments of existing use and that parking management plans be developed. • Advises that: *Mobility parking [is] located convenient to key destinations.* (p. 49) • Advises that: *Service and delivery parking are located close to destinations but in places that do not compromise public space and walking paths.* (p. 63) • Recognises that parking is context specific for the area and street type. No specific design advice is provided except for some visual examples showing the use of indented parking so that amenity strips can be incorporated. • Suggests the following specific design technique: *Mountable kerb loading zones provide space for managed access (time restricted) for servicing, loading and deliveries outside of peak times while allowing for continued public transport operations. At other times, they form additional space within the pedestrian environment.* (p. 63)
***Cycling Network Guidance* (Waka Kotahi, n.d.-c)** **Purpose:** Promotes a consistent, best-practice approach to cycling network and route planning throughout New Zealand. It sets out a principles-based process for deciding what cycling provision is desirable, and provides best-practice guidance for the design of cycleways.	• Echoes the advice from TCD Manual Part 5 regarding cycles next to parallel and angle parking. • Provides guidance on buffered cycle lanes – these are conventional cycle lanes with a painted buffer space separating the cycle lane from the adjacent parking and/or general traffic lane. States that if the buffer is used next to the parking: *A well-defined line is required at the side adjacent to vehicle parking, so that drivers do not consider the buffer as an extension of the parking zone.* A technical note provides more detailed information on this. • Provides guidance on contra-flow cycle lanes: *Site-specific factors to consider include: Type and location of parking – in particular, be cautious of high-turnover parking and reverse-out angle parking.* • Provides advice on restriction of parking either side of driveways to ensure intervisibility between cycleway users and drivers. See *Technical Note: Separated cycleways at side roads and driveways* (TN002), section 2.5.  **Figure 16: Setbacks for parking at driveways along separated cycleways**

Name of document and purpose	Relevant guidance
	• Provides advice for streets with shared traffic lanes and parking: *A corridor providing marked or unmarked on-street car parking that is significantly under-utilised at some or all times of the day has the potential to create uncertainty for cyclists and/or motorists if sharrow markings are implemented. This is because, as stated in the official New Zealand road code, cyclists should generally keep 'as near as practical' to the left side of the roadway. In the absence of kerbside parked vehicles, a sharrow marking may be viewed as positioned right-of-centre within a traffic lane (for example, during the operation of a clearway that is otherwise occupied by parking). Given the fair assumption that some cyclists will view the sharrow marking as a guide to their road positioning, this situation may cause confusion as to where the cyclist should be located because cyclists normally position themselves as far left towards the kerb as is practical and safe. In situations where on-street parking is observed as being significantly under-utilised for extended lengths and/or time periods, the implementation of sharrow markings should be considered very carefully and may not be a desirable treatment. It may be appropriate to add a parking lane line to encourage better riding line discipline.* • Provides advice for bus lanes in relation to cycling and parking: *As for general mixed traffic lanes, bus lanes should be either:* – *wide enough for cyclists to ride adjacent to buses* – *narrow enough that cyclists and buses must travel in single file.* *In-between widths should be avoided, as these can result in buses or cyclists attempting to pass each other when it is not safe to do so. The width of bus lanes is a critical consideration.* *Wide bus lanes can be part time, ie allow parking during non-bus lane hours. Narrow bus lanes must be permanent (ie no parking), because when parking were to be permitted, people on bikes would be forced to ride within the door opening zone.*
Pedestrian Network Guidance **(Waka Kotahi, n.d.-d)** **Purpose:** Provides best practice for planning, designing and creating walkable communities throughout New Zealand.	• States that: *Crossing sight distance should be provided at crossings where pedestrians do not have the priority*[5] *and must choose gaps in the traffic stream to cross safely. This means pedestrians must be able to see the approaching traffic in good time and be able to cross the road clear of approaching traffic. Crossing sight distance is a critical element in ensuring pedestrians can cross the road safely.* • Crossing sight distance would ensure that cars are not parked too close to the crossing.
Public Transport Design Guidance **(Waka Kotahi, n.d.-e)** **Purpose:** To support regional and local councils to deliver high-quality, user-centric public transport.	• States that: *Lead-in and lead-out space is required where the bus needs to pull out of and back into the kerbside traffic lane because of an obstruction, usually on-street parking (see the figure below). When on-street parking is too close to a kerbside bus stop, the bus may have trouble entering and exiting the stop and aligning close and parallel to the kerb.* • Shows the lead-in and lead out dimensions, as per example below.

[5] For example, at kerb buildouts, pedestrian refuges, or when there are no formal or informal crossing facilities present.

Name of document and purpose	Relevant guidance
	 *Kerbside bus stop for a standard 13.5m bus with mounted bike rack and parking on either side.* View larger image [JPG, 38 KB]
***Guide to Traffic Management Part 11: Parking Management Techniques* (Austroads, 2020)** **Purpose:** Provides guidance on parking policy, demand and supply, data and surveys, on-street and off-street parking as well as types of parking and parking controls.	• States that parallel parking has the following advantage: – *Road crashes associated with parking manoeuvres are minimised compared to angle parking.* (p. 78) • States that: – *All angle parking presents a greater hazard to road users than parallel parking. This situation is mainly due to the fact that parking at an angle always requires reversing which causes bottleneck effects in the moving traffic and may lead to collisions directly involving the reversing vehicle.* – *There can be sight/visibility issues and increased conflict with pedestrians crossing mid-block.* (p. 79) • States that: *Reversing into rear-to-kerb angle parking bays may reduce many of the problems associated with forward entry parking. However, it creates a traffic hazard as the vehicle stops in the moving traffic stream prior to reversing into a parking bay and the nose swings into the adjacent through traffic lane at the start of the back-in manoeuvre. Rear-to-kerb angle parking may also create excessive footpath obstruction from the rear overhang and will produce exhaust fumes on the footpath.* (p. 80) • States that: *Motorist leaving a front-to-kerb space must reverse approximately 1 m or more before gaining a clear view of approaching traffic and cyclists. This is aggravated by increasing numbers of large 4WDs and vans.* (p. 81) Recommends rear-to-kerb angle parking to address this (Table 9.2).
***Guide to Road Design Part 3: Geometric Design* (Austroads, 2021a)** **Purpose:** To provide the information necessary to enable designers to develop safe and coordinated road alignments that cater for the traffic demand at the chosen speed.	In section 4.9 'Bicycle Lanes': • States that: *Contra-flow bicycle lanes may be placed between parked cars and the kerb where bicycle access is important. In such cases it is imperative to provide a separator (preferably a raised island) to allow for vehicle overhang or opening of car doors.* (p. 94) • Provides angle parking buffer advice as per the TCD Manual Part 5. In section 4.11 'On-Street Parking': • States the following need to be considered: – *preservation of adequate intersection sight distances* – *preservation of safe and convenient pedestrian access … [for example] wheel stops to prevent angle parked vehicles intruding on narrow footpaths (less than 2 m wide) and unsafe parking locations.* (p. 113) • States that: *…all forms of angle kerbside parking present a greater hazard to road users than parallel parking. Similar issues that arise with parallel parking arise with angle parking where parking manoeuvres utilising the through lane create conflict points.*

Name of document and purpose	Relevant guidance
	Studies show that when parking is changed from angle to parallel kerbside parking, the accident rate along a length of road decreases substantially and the traffic capacity is greatly increased. These conflicts preferably would be removed, or if unable to be removed, the speeds managed to reduce the likelihood of conflict occurring. (p. 114) • Does not mention specific safety hazards to cyclists (eg, dooring or reversing into cyclists).
***AS 2890.5 Parking Facilities: On-street Parking* (Australian Standards, 2020)** **Purpose:** Sets out requirements for the location, arrangement and dimension of on-street parking facilities.	• States that: *On-street parking should consider pedestrian and cyclist amenity and safety. Parking should minimise obstructions to pedestrians and cyclists.* (p. 6) • Lists the following requirements: – *Angle parking, front in – Provide minimum 2.0m of clear width for footpaths and 2.4m for bicycle paths. Wheelstops may be required to control vehicle overhang encroachment.* (p. 6) – *Angle parking, reverse-in – Provide minimum 2.4m of clear width for footpaths and bicycle paths. Wheelstops may be required to control vehicle overhang encroachment.* (p. 6) – *Noting that the effects of exhaust fumes on people should be considered in the determination of whether reverse-in parking is appropriate (e.g. outdoor dining area).* (p. 6) • Outlines some unsafe parking locations, such as: *on the inside of sharp curves, within a T-junction, kerbside parking part way around a left-hand curve with limited sight distance across the curve, parking just beyond a crest, a parking area which starts just beyond a roadway narrowing or lane reduction, parking on the right-hand side of a one-way roadway, or any other location where a parking zone protrudes significantly into a roadway (this is particularly true of angle parking).* (pp. 8–9)
***Transport Design Manual: Parking design* (Auckland Transport, n.d.)** **Purpose:** Provides guidance on the provision of off- and on-street parking. (This is an example of a local RCA with a parking-specific guide.)	• States that: *The design of on-street parking has to suit the function of the road, e.g. reverse out angled parking is unsuitable on roads carrying high volumes of traffic, where high speeds are the norm or cycle facilities are between the angled parking bays and the carriageway.* (p. 6) *Consider the amount of separation between parked vehicles and through-traffic, allowing for the opening of doors (parallel parking) and for reversing out of angle-parking spaces. Particular care with these issues is required for cycle lanes or on other routes where cycling is likely to occur. Manoeuvring space for parking in Table 1 must not encroach on a marked road centre line on arterial roads, and may not encroach on the minimum lane width for opposing through traffic on an unmarked road except for local roads with low speeds (30kph maximum design speed) and traffic volumes (<1500vpd).* (p. 7)

<table>
<tr><th>Name of document and purpose</th><th>Relevant guidance</th></tr>
<tr><td>

Traffic Engineering Manual: Volume 3 – Guidance on Treating Bicycle Car Dooring Collisions **(VicRoads, 2016)**

Purpose: This document lists possible treatments to address the issue of car dooring

</td><td>

- Offers guidance on:
  - **elimination treatments**, which virtually eliminate the risk of dooring
  - **reduction treatments**, which reduce the risk of dooring
  - **supporting treatments**, which enhance the safety benefits already provided by the ‘elimination’ and ‘reduction’ treatments. Multiple ‘supporting’ treatments may be used to improve cyclist safety.

Example of guidance:

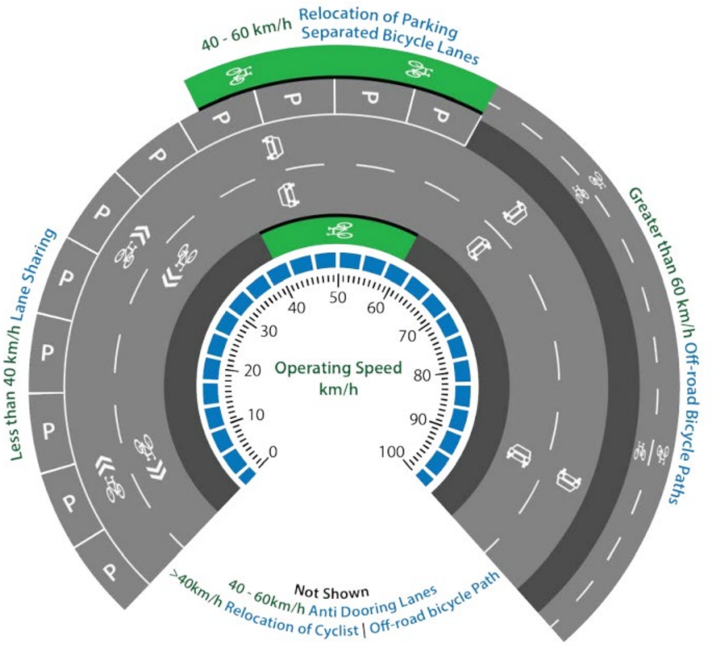


Figure 2: Treatment options based on operating speed[1]

</td></tr>
</table>

4.9.2 Bicycle infrastructure design guidelines – International

This section is not intended to be a comprehensive summary of design guidelines for bicycle infrastructure and/or on-street parking; the documents reviewed here are those that were found in the published literature as part of the safety-related search. Design guidance tends not to be published in the peer-reviewed research but exists within transport/planning/government departments. The key theme of the work published in the scientific literature is that US guidelines need revision to properly account for cyclists.

Design guidelines for bicycle lanes adjacent to on-street parking were discussed in the review by Schimek (2018). The following were key findings:

- The American Association of State Highway and Transportation Officials guide suggests minimum dimensions for parking and bicycle lanes and recommends wider parking lanes and/or bicycle lanes when parking turnover is high. Buffers are discussed in the guide but there were no recommended widths for buffer zones.
- Guidelines from Ontario recognise the value of buffers in encouraging cyclists to ride beyond the dooring zones. Guidelines from Ontario state that only low-volume, low-speed environments can operate using a 1.8 m bicycle lane without a buffer.

- When considering bicycle lanes between the kerb and the parking lane, guidelines from North America recommend a 3-foot (0.9 m) buffer between the bicycle and parking lanes, but this is not the case for bicycle lanes on the traffic side of parking bays.
- Standard guidelines in the USA for a 5-foot (1.5 m) bike lane and a 7-foot (2.1 m) parking lane mean that cyclists will almost always be riding within the dooring zone.
- The design guidelines in the USA reflect the lack of data to properly quantify the impact of car dooring on bicyclists and need to be revised.

Furth et al. (2010) also explored how the width of the road can be shared between cycle lanes and parking spaces. They found that providing extra width in car spaces to provide a buffer not to be effective as it encouraged drivers to park further out from the kerb. Narrowing the width of parking spaces was thought to be an effective way to regain road width, which can be used as a buffer between traffic and the parking space or included in cycle lanes. It was also recommended that the width of vehicles in the fleet be used to determine how narrow the on-street parking spaces can be. They suggest that the US guideline of recommended minimums should be reconsidered and that maximum widths of parking spaces be specified as is done in some parts of Europe.

4.10 Conclusions

Key themes emerged from the literature, including the effects of on-street parking on traffic speed, on crashes and congestion, and on cyclists and pedestrians. A small amount of research explored driver workload when vehicles are parked on-street and tasks of searching and executing of parking manoeuvres.

General safety

- Most authors reached the conclusion that the impact of on-street parking on safety is a negative one, citing higher crash rates associated with parking, particularly on higher volume/arterial roads. However, this conclusion is not a simple one. On-street parking also appears to lower travel speed, performing a traffic calming function by narrowing the road width. The safety impact of on-street parking varies with the features of the street environment. Little work has sought to understand the severity of crash outcomes, but lower-speed environments appear to be less risky than higher-speed environments.
- The research indicates that angle parking is associated with a higher crash risk than parallel parking, and as with parking research generally, the characteristics of the environments studied may contribute to the observed outcomes. Most authors recommend parallel parking over angle parking, especially on higher volume/arterial roads.
- It is noted that a significant amount of the research in the literature review focused on non-Safe System aligned measurements. Available research primarily looked at the total number of crashes or even the number of conflicts, rather than focusing on injury severity of crashes. Safe System thinking accepts that collisions will occur, due to inevitable human error, but designs to prevent high-severity outcomes.

Driver workload

- On-street parking is associated with several challenges for drivers. Shopping strip environments with parked vehicles are complex, increasing the workload for drivers and the likelihood they make mistakes or respond more slowly. The process of searching for a car park is also demanding, increasing drivers' perceived workload and time spent glancing away from the road. Completing a parking manoeuvre involving reversing appears to be challenging, with many drivers actively avoiding it entirely. Vehicle reversing technologies could be expected to provide assistance for reverse parking, although no research was found on the difference reversing cameras or other parking assistance systems make to the difficulty of reverse parking.

Cyclist safety

- Overall, the research on cycling and on-street parking shows that it generally has a small but negative impact on the safety of cyclists, accounting for a small proportion of the cyclist crash/injury picture. Intersection crashes remain the biggest contributor to bicyclist trauma. Cyclists feel less safe riding in places where there are parked cars, even if there is a bicycle lane. Naturalistic studies show that cyclists regularly experience near misses with opening car doors. The Dutch Reach car door opening method adopted in road codes in several countries has potential as a risk-mitigation strategy but relies on behaviour change, which is often unreliable and may require many years for change to occur.
- Design guidance focuses on reducing the risk of 'dooring' and of cyclists being struck by reversing cars from angle parking.

Pedestrian safety

- The body of research literature on pedestrian impacts of on-street parking was limited but showed that on-street parking has a negative association with pedestrian safety and/or perceived pedestrian safety. None of the studies identify that on-street parking is seen by pedestrians as an additional buffer to moving traffic.
- Design guidance focuses on improving visibility of pedestrians crossing the road and on risk-mitigation strategies when angle parking is used so that the footpath width is not reduced significantly by vehicle overhang.

Other impacts

- On-street parking and the search for parking are associated with traffic delays and congestion, leading most researchers to conclude that on-street parking is not appropriate for arterial roads. Economic benefits, in the form of increased custom for shops and related businesses, are claimed to be one of the positive impacts of on-street parking. However, removing parking does not necessarily produce a reduction in economic activity, especially if the area is visited by bicyclists and pedestrians.

Guidance

- Current New Zealand guidance in relation to parking is integrated into modal-specific guidance with particular attention given to pedestrian and cyclist safety. The Auckland Transport (n.d.) example was the only standalone parking design guide found.
- There is some inconsistency in the design guidance for parallel parking in New Zealand and a lack of guidance for designing indented parallel parking and parking on kerbless, flush streets.
- The application of guidance is reviewed in the case studies in chapter 8, from which areas for improvement in guidance may emerge.

5 New Zealand safety data

5.1 Crash Analysis System findings

The Crash Analysis System (CAS) data for the last 5 years (2017–2021) were used to understand the crashes that are related to parking and the potential outcomes that might result from those types of crashes. Any rural parking-related crashes were excluded. The data have limitations; however, they are likely to be helpful in guiding what risk-mitigation strategies could be considered to help address safety issues related to parking. The data review will identify DSIs clearly related to parking, as reducing these will contribute to the goals of Road to Zero.

The way that crashes are coded involves a movement code and factor codes. The vehicle movement code is a two-letter code that identifies the principal movements of the vehicle or vehicles involved in the crash. Factor codes are a set of three-digit numerical codes that identify reasons why the crash occurred. These factors are coded after consideration of the written explanation of what happened in the drivers', witnesses', and any other involved parties' statements, and in the Police descriptions and comments.

Movement codes related to parking as discussed in section 5.1.2. Cyclist, pedestrian and bus crashes that involved parking are outlined in sections 5.1.3, 5.1.4 and 5.1.5. Issues with parked cars blocking visibility are discussed in section 5.1.6.

It should be noted that there are likely to be other crashes that involved parking, but none of the codes above have been used to reflect that, and hence they do not appear in the data discussed below. An example is a fatal cyclist crash that was coded as 'swinging wide (BC)' and not related to a parking code. However, when examined, this crash involved two vehicles parked opposite each other on a narrow street near a bend, which forced a cyclist into the middle of the road. A car came around a blind corner in the opposite direction and hit the cyclist head-on. Historical images of the street where the crash occurred on Google Street View show there were no no-stopping lines painted near the bend before the crash. More recent images show that no-stopping lines have now been painted at the bend.

A key safety aspect that is difficult to assess using CAS data is how operating speeds, which may be influenced by the presence of on-street parking, impact the safety of a street and hence crashes. The police may record the 'suspected speed before crash'; however, this field is not always completed. The impact of on-street parking on operating speeds will be explored in more detail in the case studies.

5.1.1 Limitations of CAS

The information in CAS is valuable and gives insight into road safety issues. However, it does not provide the whole picture. For example, crash reports often only reflect a human error aspect and do not reflect safety issues associated with the design of roads or other Safe System aspects. Crashes can have several causes, and reports rarely reflect all of them. Therefore, though some crashes described in the sections below may indicate that road users were at fault, it is important to note that CAS often does not give insight into all aspects of the crash.

Additionally, CAS only includes crashes that are reported to the Police. It does not capture near misses, which are expected to be more prevalent than crashes.

It is also noted that the size of a vehicle is not usually mentioned in the CAS report except when obvious, such as 'truck' or 'bus'. In the case of SUVs or other vehicles larger than cars, this is generally not noted. This could be useful when crashes involve visibility-related causes.

5.1.2 All parking-related crashes

There were 14,030 crashes of all severities coded as having involved parked cars or as a result of the act of parking (see Table 5.1); this is 7.7% of all reported crashes that occurred between 2017 and 2021. There were nine fatal crashes and 286 serious injury crashes. These DSIs are broken down by mode in Table 5.2.

Motorcycle-related crashes were included as they contributed to a large proportion of DSIs. This breakdown was established by working out the number of cycling, pedestrian and motorcycling related DSIs and then assuming that the remainder were vehicle occupants.

From Table 5.1 it is evident that vulnerable road users (pedestrians, cyclists and motorcyclists) made up almost half of all serious injuries and over 65% of all deaths in parking-related crashes in this five-year period. It is noted that DSIs related to parking make up a comparatively low proportion (2.5%) of the total number of DSIs in the same five-year period (12,070).

The majority of DSI crashes were collisions with parked cars. Many of these crashes were due to loss of control, visibility being obscured (sunstrike or fog), or inattentive driving. Some were also due to the driver experiencing a medical incident while driving or falling asleep at the wheel. There was a car dooring cyclist death, and several deaths caused by parked cars rolling back.

Table 5.1 All reported parking-related crashes, by movement code and severity, 2017–2021

Movement code	Non-injury crash	Minor injury crash	DSI crashes	Total
Collison with an obstruction – parked car (EA)	9,368	1,697	208	**11,273**
Collison with an obstruction – car door opening driver's side (EE)	344	154	37	**535**
Collison with an obstruction – car door opening passenger's side (EF)	7	5	1	**13**
Manoeuvring – parking or leaving (MA)	1,040	178	18	**1,236**
Manoeuvring – entering or leaving an angle park from opposite side (ME)	104	11	22	**117**
Manoeuvring – entering or leaving an angle park from same side (MF)	358	27	4	**389**
Pedestrian – attending to vehicle (PE)	4	29	5	**38**
Pedestrian – entering or leaving vehicle (PF)	2	24	5	**29**
Miscellaneous – parked vehicle ran away (QD)	328	52	17	**397**
Head-on – swinging wide (BC)	1	2	1	**4**
Total	**11,556**	**2,179**	**295**	**14,030**

Table 5.2 Number of parking-related DSIs, by mode, 2017–2021

Injury severity	Pedestrian	Cycling	Motorcyclists/mopeds	Car occupants
DSI	40 (13% of DSIs)	73 (25% of DSIs)	32 (11% of DSIs)	150 (51% of DSIs)

5.1.3 Parking-related cycle crashes

The parking-related crashes that involved cyclists are shown in Figure 5.1. It is clear that car door opening into the path of cyclists is the main cause of cycle/parking-related crashes and has the highest proportion of

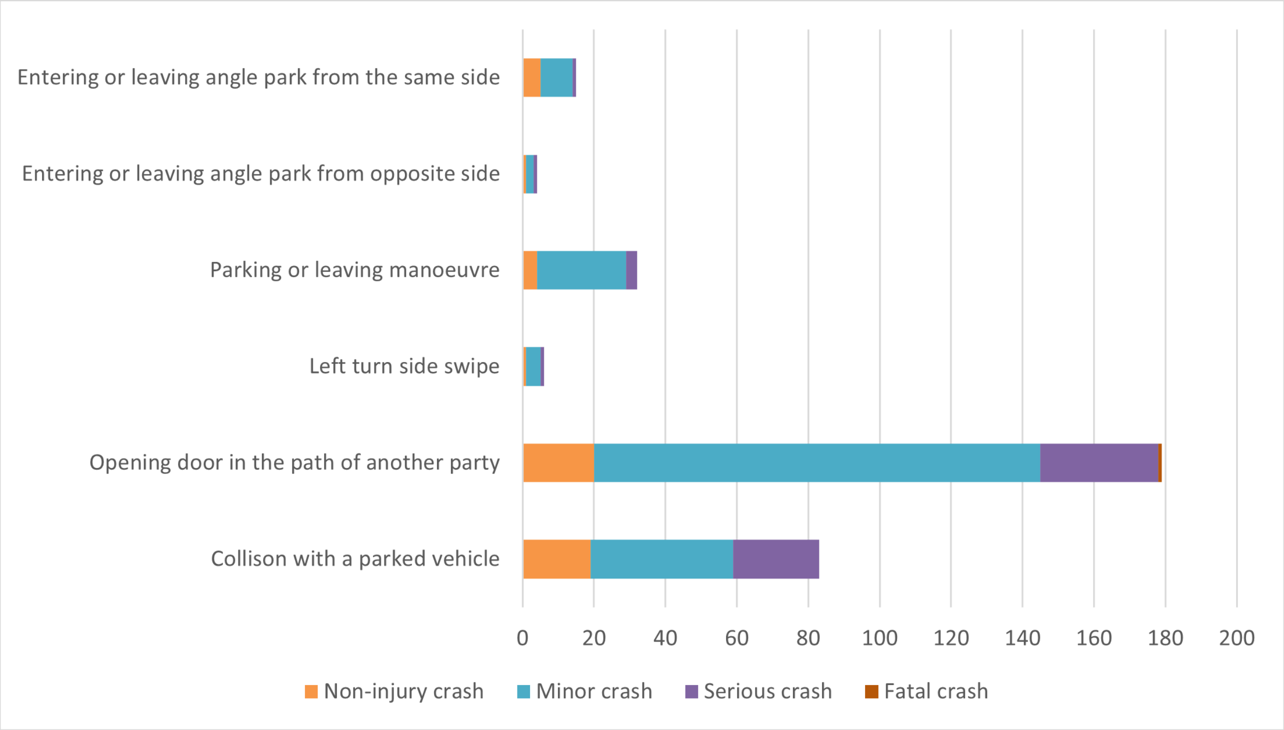
DSI outcomes. Most of these crashes were due to the door hitting the cyclist and knocking them off their bike, usually into the traffic lane.

A cyclist colliding with a parked vehicle was also a clear crash type. Some of these crashes included illegally parked cars (eg, cars parked in cycle lanes), parking near bends or intersections, cyclists being distracted/sunstrike, handlebars clipping wing mirrors and taking evasive action.

There were also several serious injuries related to angle parking. Most of these crashes were due to vehicles pulling out of car parks and hitting cyclists going past.

There was one serious crash on a street with a one-way separated cycleway where there is parallel parking between the separated cycle lane and traffic. A car turned left into a driveway and the driver did not see the cyclist due to parked vehicles blocking the view of the cycle lane. Separated cycleways are a relatively recent development in cycle provision, so there are not expected to be many crash data related to these with respect to parking interactions.

Figure 5.1 Parking-related crashes involving cyclists, 2017–2021



The dooring crash data were compared with the findings of the University of Otago Injury Prevention Research Unit (IPRU) demonstration project that resulted in a New Zealand cyclist/dooring map (IPRU, n.d.). The purpose of the IPRU project was to determine the feasibility of developing and displaying a publicly accessible interactive web-based map of police-reported dooring-related bicycle injuries among New Zealand cyclists.

IPRU used the 2007 to 2011 CAS data and found that 245 cycle dooring injuries were reported in New Zealand (mean = 49/year). These represented 6% of all cyclist injuries involving motor vehicles. They found this compared to 19.4% in Victoria, Australia. They also found that doorings made up a much higher proportion of adult (age ≥ 19) cyclist injuries: 7%, versus 2% for ages < 19. Two-thirds of the cases were male, and most victims were adults. The mean age for females was 31.4 years and for males 39.1. About

20% of these cases were seriously injured; two deaths were reported (counted within 30 days of the crash, by definition).

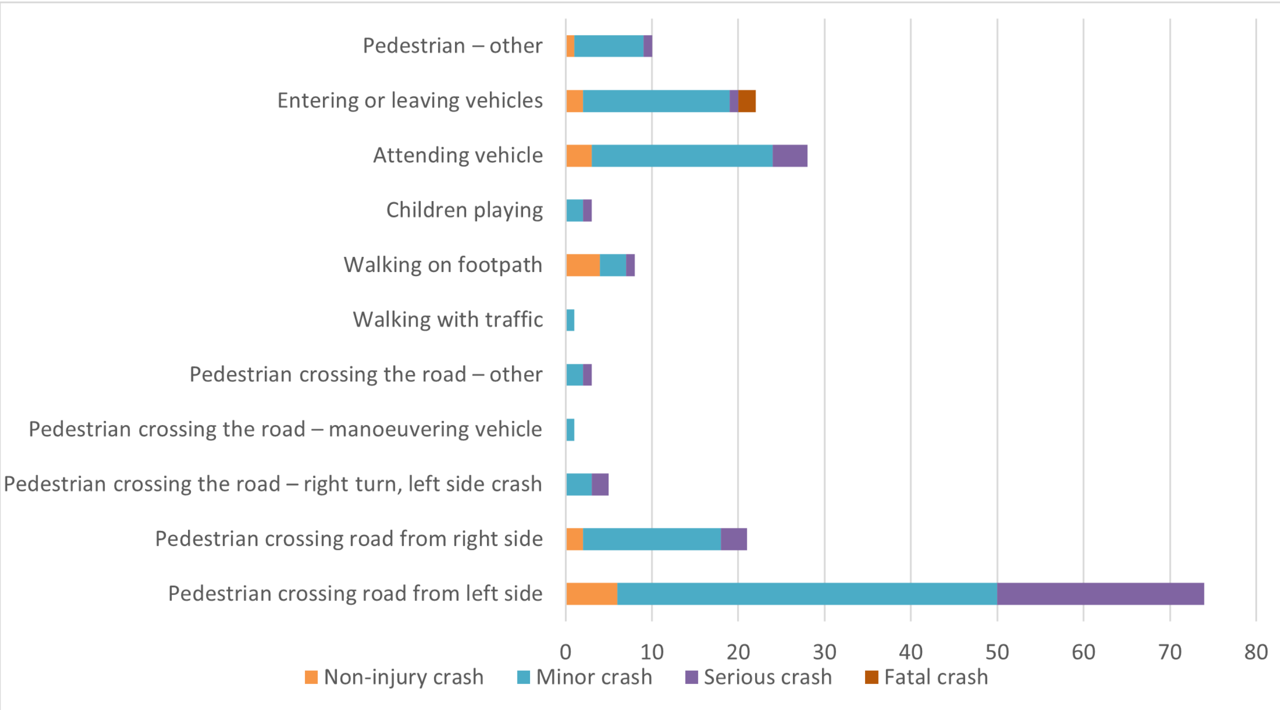
5.1.4 Parking-related pedestrian crashes

Data for parking-related crashes involving pedestrians (including wheeled devices such as e-scooters) are shown in Figure 5.2. There were two fatal parking-related crashes involving pedestrians. These collisions were due to cars being parked in the wrong gear or the brakes failing. These are considered rare and random events.

The highest proportion of parking-related crashes involved pedestrians crossing the road (pedestrians struck when emerging on the driver's left side when crossing the road). This included streets that were lined with parked cars, potentially obstructing the driver's view of pedestrians attempting to cross. The data did not always state whether the crash occurred at a formal pedestrian crossing facility.

Many of the pedestrians in these crashes (particularly serious crashes) were children and many were near a school where buses and cars are parked on the street at the end of the school day. Parked vehicles can obstruct the view of oncoming vehicles. Some were related to parked cars being too close to pedestrian crossings. Some crashes occurred when a person was trying to get into the vehicle from the traffic side and was hit by a passing vehicle travelling too far left. In one instance, an e-scooter hit a car door as the passenger opened it.

Figure 5.2 Parking-related crashes involving pedestrians, 2017–2021



5.1.5 Parking-related crashes involving buses

Some parking-related crashes involved buses. The vast majority of these were collisions with parked vehicles, sometimes the bus being the parked vehicle, some in bus stops, while others involved coaches parked kerbside. Some crashes involved a bus clipping a parked car when trying to access a bus stop, but it is not clear whether the car was parked illegally. There were no fatal crashes involving buses. There were 13 serious crashes involving a range of crash scenarios predominately related to parked buses. These included a child crossing the street from behind a parked bus and being struck by an oncoming vehicle, and a person on a mobility scooter riding onto the pedestrian crossing from behind a parked bus into the path of a van. These two scenarios support the best practice guidance that pedestrian crossings between paired bus stops are located behind the buses, not in front. This is a safer location for pedestrians and more operationally efficient for the buses. Some crashes were related to medical events or sunstrike. The data did not capture the scenario of a following driver hitting a bus that has not been able to gain access to a bus stop due to parked cars.

5.1.6 Parked cars limiting visibility

The total number of crashes caused by a parked vehicle limiting visibility is harder to quantify given the number of factor codes used for this scenario. The factor code for this is 839 (road factor – visibility limited by other feature – Parked vehicle); however, there were also crashes where the visibility was obscured by parking coded as vehicle causes 371, 375, or 377 (driver-only factors – all related to ‘did not see or look for other parties until too late’) without including the code 839. It is also likely that crashes due to parked cars limiting visibility are not reported as such at all. Therefore, crashes due to limited visibility are likely to be under-reported.

Of the total crashes in the query:

- 609 crashes were coded as ‘parked cars limiting visibility’ (code 839)
- 1,366 were coded as ‘did not check or notice other party behind’ (code 371)
- 805 crashes were coded as ‘did not check or notice other party’ (code 375)
- 1,055 were coded as ‘visibility obstructed by other traffic’ – recorded in the notes as parked cars (code 377).

It is important to note that several codes can be included within a crash report, so there will be double counting of some crashes. Overall, these data show that parked cars obstruct visibility, and contribute to crashes.

5.2 ACC claims data

Injury claims data in relation to parking were requested from ACC for the 2017 to 2021 period. The data focused on pedestrian and cyclist claims for the situations outlined in Table 5.3 below. The key limitation with the data was that there was no way to differentiate between on-street and off-street parking. There is also the chance of false positives due to the nature of the way the data are extracted.

It was noted that 16% of total accepted cycling claims involved a motor vehicle, and 6% of total accepted pedestrian claims involved a motor vehicle.

Overall, there was limited alignment with the CAS data due to the way the claims are recorded.

Table 5.3 ACC claims data for the 2017–2021 period

Claim query	2017–2021 Total ACC claims	Relativity to overall ACC claims related to motor vehicles	Correlation with 2017–2021 CAS data
Pedestrian and cyclist interaction with cars moving into and out of car park space	32	NA	No correlation due to the mix of on-street and off-street parking.
Pedestrian tripping when entering or leaving parked cars (because of an obstruction such as a kerb, wheel stop, sign, bollard etc)	170	These claims account for 1.5% of the total motor vehicle/pedestrian claims	These types of injuries are not generally attended by a Police officer and therefore are not reported in CAS.
Cyclists being hit by car doors opening	69	These claims account for 5% of the total motor vehicle/cycling claims	Difficult to establish as it is unknown how many CAS minor injuries would have made a claim.
Cyclists hitting parked cars (combination of sport-related (on gravel roads) versus on-road)	341		No correlation due to the mix of sport-related claims and on-road claims.

5.3 Conclusions

There were 14,030 crashes of all severities coded in CAS involving parked cars or as a result of the act of parking; this is 7.7% of all reported crashes and 2.5% of DSIs that occurred between 2017 and 2021. These included nine fatal crashes and 286 serious injury crashes. Due to CAS under-reporting rates, it is likely that the actual number of serious injuries is more than double the reported amount. One source estimates that, while 1 in 2 vehicle serious injuries are reported, only approximately 1 in 7 cyclist serious injuries and approximately 1 in 8 pedestrian serious injuries are reported in CAS (ViaStrada Ltd, 2021). These under-reporting rates are estimated from comparing CAS data to hospitalisation data.

The majority of DSI crashes involving parking were vehicle collisions with parked cars. Many of these crashes were due to loss of control, visibility being obscured (sunstrike or fog), or inattentive driving. Some were also due to the driver experiencing a medical event while driving or falling asleep at the wheel. Cycle DSIs make up approximately 10% of crashes with parked cars.

Vulnerable road users (pedestrians, cyclists and motorcyclists) made up almost half of all serious injuries from parking-related crashes and over 65% of all deaths in parking-related crashes in this five-year period. Cycle DSI crashes related to parking are the highest for vulnerable road users.

Bus-related crashes associated with parking are generally related to the bus being parked, rather than crashes where parked cars impact the safety of buses.

Determining the total number of crashes caused by parked vehicles limiting visibility is hard to quantify given the number of factor codes used for this scenario. It is also likely that crashes due to parked cars limiting visibility are not reported as such. Therefore, crashes due to limited visibility are likely to be under-reported.

A key safety aspect that is difficult to assess using CAS is how operating speeds, which may be influenced by the presence of on-street parking, impact the safety of a street and hence crashes. This will be explored in more detail in the case studies.

There are several clear causes for parking-related DSI outcomes that could allow a focus for improvement in how streets are designed, how safety audits of existing layouts are undertaken, and also how driver behaviour might be influenced that could contribute to the Road to Zero goal of a 40% reduction in these outcomes. These are discussed below, but note that other minor and non-injury crashes are also important as they may be enough to deter walking and cycling (multi-modal outcomes).

- **Car door opening into cyclist's path** – This is covered to some extent in the design guidance but is more about cycle facility type selection, which is subject to many variables. Driver behaviour (eg, education) could also contribute to reducing the car door opening crash risk. This issue is also clearly noted in the literature review as a key risk for cyclists in relation to parking.
- **Cyclists colliding with parked cars** – Although the scenarios where this happened are varied, from a design perspective this can be addressed by ensuring that cycle facilities do not end abruptly, and that no-stopping restrictions are important in locations where the space available for cyclists is constricted.
- **Pedestrian crossing the road from the driver's left side** – The crash data did not always state whether the crash occurred at a formal pedestrian crossing facility, but this highlights the importance of adequate sight distance at all crossing types. Guidance on this is provided in several guidance sources.

6 Parking layouts in New Zealand

This chapter summarises parking layouts and the findings of the literature review and safety analysis in terms of impacts. It then examines how RCAs/designers currently make decisions on what type of parking layout to provide in a street, any innovations being used in New Zealand and how parking relates to the ONF.

6.1 Parking layouts and associated impacts

In New Zealand, on-street parking is usually either parallel (with the kerb or road edge) or angle (angle varies from 30 to 90 degrees). Some streets may have parallel parking on one side and angle parking on the other side. Angle parking can also be located in the middle of the road on very wide streets. Examples of the typical configurations are shown in Figures 6.1 to 6.4.

Figure 6.1 Parallel parking on both sides (Nelson)

Figure 6.2 Angle parking on both sides (Nelson)

Figure 6.3 Angle parking on one side, parallel parking on the other side (Marton)

Figure 6.4 Angle parking on the side (60 degree) and the middle of the road (60 degree) (Fielding)

Parking, both parallel and angle, can be indented between kerb buildouts (Figure 6.5). The zone containing parking and the kerb buildouts is often referred to as the 'amenity zone'. A key benefit of this arrangement is that when the parking is not being used, the street width from a driver's perspective is less conducive to speeding. The kerb buildout areas provide an opportunity for pedestrian crossings (reduced crossing distance and improved visibility between pedestrians and drivers), for placemaking (landscaping, seating, etc) and for cycle parking.

The design of indented parking, particularly for parallel parking, needs to consider the ease of access and egress so that drivers are not in the traffic flow or blocking cycle lanes longer than needed, but ideally not at all. Square-edged bays (as opposed to those with curved entry and exit) are more difficult for drivers to use, unless they have been made longer than standard. There is limited design guidance for this aspect.

Figure 6.5 Angle parking with a kerb buildout (crossing point/seating/landscaping) (Dunedin)

Chapters 4 and 5 found through a literature review and safety analysis a range of potential impacts related to on-street parking, both positive and negative. These impacts can be examined from several perspectives as shown in Table 6.1, where transport mode and parking type perspectives are summarised.

Chapter 7 will outline possible designs and strategies to help address the impacts, what current mechanisms exist (policy, legislation or guidance) to support the strategies, and where new policy, legislation or guidance may be required.

Table 6.1 Summary of on-street parking impacts, by mode and parking type

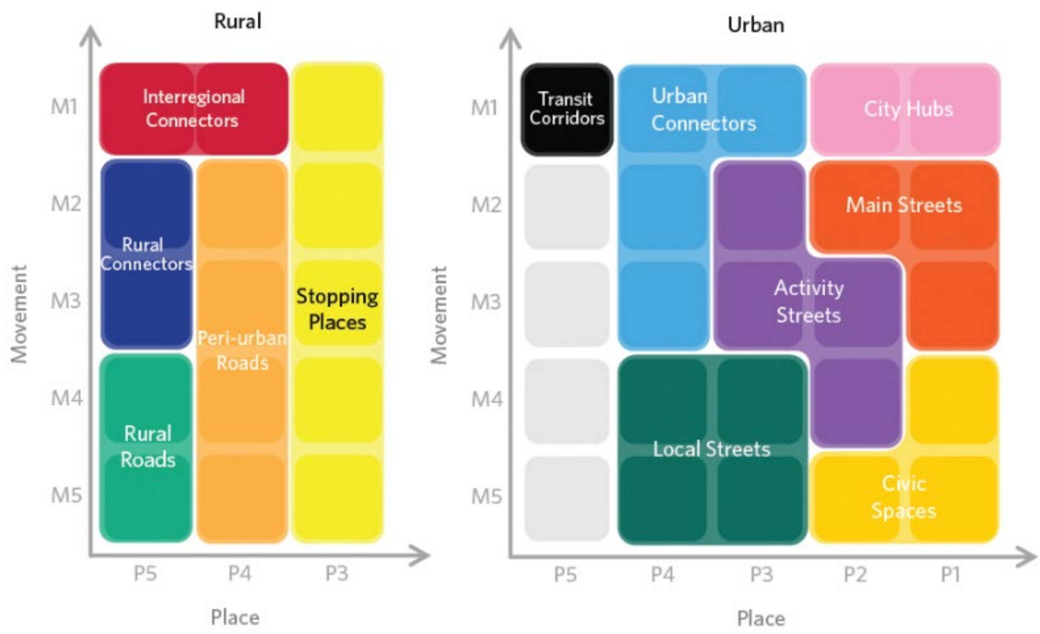
Mode	Parallel parking	Angle parking
Pedestrian	• Can block intervisibility with oncoming traffic/cyclists when crossing the road – this was shown to be the highest cause of on-street parking crashes for pedestrians in New Zealand. • People entering a parked vehicle from the traffic side are exposed to the risk of being struck by passing vehicles (second highest cause). • Can create a buffer from fast moving traffic that potentially provides a feeling of safety for people on the footpath.	• Can overhang onto the footpath and therefore interfere with pedestrian movement. • Reversing drivers can strike pedestrians waiting for a safe gap in traffic to cross the road.
Cyclist	• Can cause 'dooring' issues, especially where there is insufficient road width for a safe buffer zone – this was shown to be the highest cause of on-street parking crashes for cyclists in New Zealand. • Can restrict space for cycling and create pinch points and potential collisions. • Driveway and intersection sight distance can be reduced (particularly an issue with two-way cycleways where drivers are not expecting cyclists from the left). • Parking on bends can result in a pinch point where cyclists are forced into the path of vehicles approaching from behind the cyclist.	• Can cause conflict with cyclists when drivers are reversing out of angle spaces.
Buses	• If a bus cannot pull in parallel with the kerb, passengers may be subjected to a large gap between the kerb and bus doors. This may increase both the horizontal and vertical gaps between the kerb and bus doors, increasing the risk of falls. • Can restrict access and exit from a bus stop. • Intersection sight distance can be reduced. • Parking on bends can result in buses moving into the path of other drivers.	• High turnover parking could impact general traffic flow and public transport travel times. • Can cause safety conflict with buses when reversing out of angle spaces.
Emergency services	• Parking on both sides of narrow streets can restrict the remaining movement width to an extent that fire trucks or ambulances cannot travel on the street.	• High turnover parking could impact general traffic flow and hence emergency responses.
Cars/vans/trucks/ motorcycle drivers	• Intersection sight distance can be reduced. • Parking on bends can result in drivers moving into the path of other drivers.	• Can cause conflict with vehicles when reversing out of angle spaces.

6.2 One Network Framework and parking

The ONF (Waka Kotahi, n.d.-a) is the framework used for the classification of roads and streets within the New Zealand transport network[6]. It provides a foundation for nationally consistent conversations and helps to establish the function of a road or a street. While it contributes to design or investment conversations, the ONF doesn't seek to determine the form of a road or street. Other guidance such as the *Aotearoa Urban Street Planning and Design Guide* (AUSPDG) (Waka Kotahi, 2022b) is available to support that purpose, alongside local centre plans and street design manuals.

The ONF is shown in Figure 6.6. There are two street families (rural and urban), and within each family, street categories as per each box in the movement and place matrix (eg, city hubs). M1 indicates the highest level for movement priority, and P1 is the highest level for place-making priority. This research is focused on the urban street family.

Figure 6.6 ONF Movement and Place frameworks (reprinted from Waka Kotahi, n.d.-a)



A document called *One Network Framework: Detailed Design – D02:2022* (ONF-DD guide) (Waka Kotahi, 2022c) sets out and describes the components of the ONF. It explains the meaning of place and movement in the context of the ONF and provides an explanation of each street category from each of the street families, including functional descriptions and defining attributes. This document assists RCAs with classifying roads and streets under the ONF by defining the relationship between the ONF street family, road or street category, movement/place function ranking, and modes.

The modes sit under each road or street category and have been given a modal ranking based on how the road or street fits into the modal network or the strategic significance of that mode. The modes are walking, cycling, public transport, freight and general traffic. For example, an urban connector with a place/movement function ranking of P4/M2 may be a primary public transport corridor and therefore have a public transport modal class ranking of PT3.

[6] Except in the Auckland Transport network where the Roads and Streets Framework is used, however this aligned with the ONF.

Parking is not considered a 'mode'; rather, it is an attribute within the 'movement' column of the tables for each street category that define the primary attributes of place and movement, these being:

- the place function – level of on-street activity, typical adjacent land use and level of on-street activity – pedestrian activity (P)
- the movement function – movement significance (M), general traffic (GT), freight (F), public transport (PT), cycling (C), walking (W).

A table in the ONF-DD guide defines density of on-street activity, intensity of use (dwell time), adjacent land use (indicative), place function – primary attributes and movement function. Anticipated parking is listed in the movement function column.

Another relevant NZTA guidance document is *The Speed Management Guide: Road to Zero edition* (Speed Management Guide) (Waka Kotahi, 2022a), which sets out an approach to speed management planning that draws together Land Transport Rule: Setting of Speed Limits 2022 and the main elements of Road to Zero with Toitū te Taiao (the NZTA sustainability action plan) and the ONF. The safe speed limits for each urban street category are shown in Table 6.2. The guide doesn't specifically advise on parking for all street categories but does advise that on-street parking is 'prohibited' on urban connectors with a speed limit of 60 km/h.

Table 6.2 ONF and safe speed limit ranges (reprinted from Waka Kotahi, 2022a, p. 20)

Category	Description	Safe and appropriate speed limit*
Civic spaces	These streets have a higher place classification than other urban street categories, representing a higher level of on-street activity and higher-density adjacent land use generating that activity. These streets have a lower movement classification because they are mainly intended for localised on-street activity with little or no through movement.	10-20km/h
Local streets	These streets provide quiet and safe residential access for people of all ages and abilities and foster community spirit and local pride. They are part of the fabric of Aotearoa New Zealand neighbourhoods, and they facilitate local community access.	30km/h
Activity streets	These streets provide access to shops and services by all modes. They have a significant movement demand as well as place, so competing demands need to be managed within the available road space.	30-40km/h
Main streets	These streets have an important place function and a relatively important movement function. They support businesses, on-street activity and public life and connect with the wider transport network.	30-40km/h
City hubs	These are dense and vibrant places that have a high demand for people movement.	30-40km/h
Urban connectors	These streets provide safe, reliable and efficient movement of people and goods between regions and strategic centres and mitigate the impact on adjacent communities.	40-60km/h
Transit corridors	These streets provide for the fast and efficient long-distance movement of people and goods within the urban realm. They include motorways and urban expressways.	80-100km/h

*The safe and appropriate speed limit will typically be at the lower end of the range unless design and infrastructure criteria are met to justify a higher speed limit. For details on the criteria for each ONF street category see tables 4 and 5.

Table 6.3 includes a description of each street category within the urban street family, and parking information from the ONF-DD guide and the AUSPDG.

The likely parking layouts are then listed to show the range of options, including examples of parking layouts for each street family. The decision on how to select the appropriate parking layout and how to allocate the parking types will be context specific. This is discussed further in section 6.3.

Table 6.3 ONF street category parking context (Waka Kotahi, 2022b, 2022c)

Street category	Description	Likely parking context	Examples
Transit corridors	Transit corridors provide for the fast and efficient long-distance movement of people and goods within the urban realm. This includes motorways and urban expressways. By definition all dedicated, high movement and mode specific transport corridors such as heavy rail networks and busways are included in this classification.	No mention of parking in ONF-DD guide or AUSPDG. Likely parking features: • Very unlikely that parking will be present. • Some urban transit corridors may have marked parallel parking depending on land use.	NA
Local streets	Local streets provide quiet and safe residential access for all ages and abilities and foster community spirit and local pride. They are part of the fabric of our neighbourhoods, where we live our lives, and they facilitate local community access. Local streets are the most common and most diverse streets in urban areas. They are generally important components of walking and cycling networks and should support these transport choices for local trips.	No mention of parking in the ONF-DD guide. AUSPDG: Suburban residential street: • *Comprehensive parking management strategies of time restrictions and pricing should be implemented to increase the liveability of the street.* (p. 91) Likely parking features: • Likely to feature parallel or angle parking. • Parallel parking could be indented. • Parallel parking unlikely to be marked. • Angle parking likely to be marked. • Low turnover parking with low demand during the day and high demand at night (unless used by commuters as located near employment lane uses). • Generally unrestricted time limit and could include residential parking permit scheme. • Could feature some time restriction for land uses such as schools or local dairy (convenience store).	 Unmarked parallel parking, Hawford Road, Christchurch  Unmarked indented parallel parking, Cholmondeley Ave, Christchurch

Street category	Description	Likely parking context	Examples
Urban connectors	Urban connectors provide safe, reliable and efficient movement of people and goods between regions and strategic centres and mitigate the impact on adjacent communities. The purpose of urban connectors is to provide for efficient movement of people and goods from A to B. There are low levels of interaction between the adjacent land use and the street. Servicing adjacent land has a lower priority, as the key role of these streets is to move along them rather than accessing adjacent properties. Note: Some urban connectors may look like local streets, but as they are major cycleways they are classified as urban connectors (eg, as done in Christchurch).	ONF-DD guide: • *Usually on-street parking* (p. 25) AUSPDG: • *General parking should be removed* [sic] *minimised and managed by timing or pricing. Kerbside activity can be managed in different ways across the day to provide for peak period bus lanes for example.* • *Service and delivery parking are located close to destinations but in places that do not compromise walking paths or cycleways.* (p. 83) Likely parking features: • Could feature parallel parking depending on land uses but given movement role parking may have low priority. • Unlikely to feature angle parking. • Parallel parking could be indented. • Parallel parking likely to be marked. • Likely to feature mobility parking spaces. • Demand and turnover dependent on land uses. • Could feature some time restrictions depending on land use. • Likely to feature bus stops.	 Marked parallel parking, cycle lanes, Centaurus Road, Christchurch  No parking, cycle lanes, Linwood Ave, Christchurch
Activity streets	Activity streets provide access to shops and services by all modes. There is significant demand for movement as well as place with a need to manage competing demands within the available road space. Activity streets aim to ensure a high-quality public realm with a strong focus on supporting businesses, traders and neighbourhood life. Activity streets are where people spend a significant amount of time, working, shopping, eating, residing, and undertaking recreation.	ONF-DD guide: • *Often on-street parking or driveway access for motor vehicle drivers to be able to access carparks of desired destinations* (p. 19) No information for activity streets in AUSPDG. Likely parking features: • Likely to feature parallel parking. • Could feature angle parking but likely to be set back to reduce potential conflicts and impact on traffic flows. • Parallel parking could be indented.	 Angle parking with rear buffer, Centaurus Road, Christchurch

Street category	Description	Likely parking context	Examples
		• Parallel and angle parking very likely to be marked. • Likely to feature mobility parking spaces. • High demand and turnover expected. • Time restrictions are likely and will depend on land uses. • On-street loading and other uses such as taxis expected to be catered for to some extent. • Likely to feature bus stops.	
City hubs	City Hubs are dense and vibrant places that also have a high demand for people movement. They are also places providing focal points for businesses and culture. These streets should aim to reduce the impact of high traffic volumes while accommodating high pedestrian numbers, multi-modal journeys and access to public transport and essential emergency services. Managing the large number of competing demands along city hubs requires careful consideration and generally involves significant trade-offs. These streets have a high number of people moving through and across them and so require efficient modes of transport, with lateral movement access prioritised to mitigate the impacts of congestion and ensure a safe environment. Examples include major city centre streets such as Queen Street in Auckland and Lambton Quay in Wellington.	ONF-DD guide: • *Limited time-bound, or no parking for private motor vehicles* (p. 16) AUSPDG: • *Service and delivery parking are located close to destinations but in places that do not compromise public space and walking paths. Service and delivery activities should be managed with access limited to certain times of day.* • *Disabled parking should be located convenient to key destinations in determination with key stakeholders. General parking should not be located on a City Hub.* (p. 63) Likely parking features: • Could feature parallel parking with priority to mobility parking spaces. • Parallel parking could be indented. • Parallel parking very likely to be marked. • High demand and turnover expected. • Time restrictions likely and will depend on land uses. • On-street loading and other uses such as taxis expected to be catered for to some extent. • Likely to feature bus stops.	AUSPDG suggests: ***Mountable kerb loading zones** provide space for managed access (time restricted) for servicing, loading and deliveries outside of peak times while allowing for continued public transport operations. At other times form additional space within the pedestrian environment.* (p. 63)  Parallel parking (one-way street), Beswick Street, Timaru

Street category	Description	Likely parking context	Examples
Main streets	Main streets have an important place function but a relatively important movement function as well. They aim to support businesses, on-street activity and public life while ensuring connections with the wider transport network. While not having the scale of through movement of city hubs, they provide a similar function, needing to balance the interaction between people and goods movement and on-street activity. Examples include rural or district townships and provincial cities where the main through road also doubles as the main commercial centre.	ONF-DD guide: • *Often on-street, time-bound parking for motor vehicle drivers to be able to access desired destinations.* (p. 17) AUSPDG: Urban centres: • *General parking should be minimised and managed by timing or pricing. Kerbside activity can be managed in different ways across the day.* (p. 71) AUSPDG: Towns and townships: • *General parking is an important provision for towns and townships (especially for larger towns that lack public transport) but may require management by timing or pricing to provide turnover to support local businesses. Kerbside activity can be managed in different ways across the day.* (p. 75) AUSPDG: Urban centres and townships: • *Service and delivery parking are located close to destinations but in places that do not compromise public space and walking paths. Consider a range of transport activities that require parking like food delivery e-bikes.* • *Disabled parking should be located convenient to key destinations in determination with key stakeholders.* (p. 71) Likely parking features: • Likely to feature parallel parking. • Could feature angle parking. • Parallel parking could be indented. • Parallel and angle parking very likely to be marked. • Likely to feature Mobility parking spaces. • High demand and turnover expected. • Time restrictions likely and will depend on land uses.	 Marked parallel parking, East Street, Ashburton

Street category	Description	Likely parking context	Examples
		• On-street loading and other uses such as taxis expected to be catered for to some extent. • Likely to feature bus stops.	
Civic spaces	These streets have a higher place classification representing the increased level of on-street activity and higher density adjacent land use generating that activity. The lower movement classification indicates that these streets are mainly intended for localised on-street activity with little or no through movement. The lateral movement of pedestrians is usually given priority in these spaces. Examples include pedestrianised streets, plazas and low-speed shared streets. These are spaces that people are encouraged to spend time in, and where people on foot can relax and move freely.	ONF-DD guide – no content AUSPDG: • *Removal of general parking reduces cruising traffic. General parking is provided in nearby off-street facilities or in strategic areas where kerbside activity is less important.* • *Service and delivery parking (loading zones) are located close to destinations but in places that do not compromise public space and walking paths. As pedestrian demands increase service and delivery can be limited to certain times of day.* • *Disabled parking should be located convenient to key destinations determined through consultation with stakeholders.* (p. 67) Likely parking features: • Likely to feature some parallel parking with priority to mobility parking spaces. • Unlikely to feature angle parking. • Parallel parking very likely to be marked or delineated through use of street furniture, etc. • High demand and turnover expected. • Time restrictions likely and will depend on land uses. • On-street loading and other uses such as taxis expected to be catered for to some extent. • Unlikely to feature bus stops.	 Parallel mobility parking, Whangārei

6.3 Parking layout and type selection

6.3.1 Considerations

When designing or configuring a street layout there is a range of aspects to consider that can impact on the parking supply, management and design decisions. Design aspects follow after the decision has been made to include on-street parking within the layout. The supply decision is generally associated with a parking management plan for the area, which is not the focus of this research, but it is important as part of the decision of how much and what type of parking needs to be accommodated. The key layout aspects to consider if parking is to be provided are discussed below.

6.3.1.1 Role of the street

The ONF, local network operating frameworks, cycling networks, bus routes and parking strategies will inform this consideration. If parking is to be provided, the design of on-street parking needs to align with the role of the street. In a street with high place function, parking can facilitate access to places of high value, provide a buffer between moving vehicles and pedestrians, and reduce traffic speeds by narrowing the available carriageway. Parking can also be located as a buffer between traffic lanes and a cycle facility. However, the benefits of such parking should be considered in the context of urban design, including pedestrian access, street planting, furniture and visual character.

Shopping environments with parked vehicles, such as is present on activity streets and main streets, are complex due to high turnover parking and pedestrian activity. The literature review found this complexity increases the workload for drivers, which seems to increase the likelihood that they make mistakes and fail to respond appropriately or as quickly as they do in less demanding environments. In these environments the consideration of interaction between parking, cyclists and pedestrians, and travel speed will need careful consideration.

6.3.1.2 Speed environment

The Speed Management Guide and speed management plans are also a consideration. Speed limits will align with the safe and appropriate speeds (SAAS) as determined by the guide over time, and although speed limits may not directly impact the decision to provide parking or not, they do impact the risk of crashes and the result of crashes if parking is provided.

6.3.1.3 Traffic characteristics

On roads carrying high volumes of traffic, angle parking is unsuitable unless a very wide buffer can be provided. This is because of the risk of reversing in or out of spaces into passing traffic and increased rear-end crashes that might result if a driver stops or slows to accommodate or avoid a reversing driver. The type of vehicles or classes of users and their relative priority in terms of time and space allocation will need to be identified when developing a parking layout for a street area. This includes the consideration of vehicle sizes and dimensions, which are included in TCD Manual Part 13 (Waka Kotahi, 2007). The types of vehicles include cars, taxis, heavy vehicles, cycles, motorcycles and buses, while classes of users include disabled, commercial and local residents.

6.3.1.4 Space available

Ultimately the design of the street will also be a function of the road space available. Most existing road reserves in New Zealand are 20.1 m wide and the kerb-to-kerb width will vary. Some street design projects are focused on reallocation of road space within the existing carriageway, and some have the scope to rebuild within the entire road reserve space. Angle parking uses more road space than parallel parking but can result in more parking spaces.

6.3.1.5 External factors

External factors may include stakeholder influence during the design process, which can impact the parking design decisions, both in terms of supply and layout. This can be from numerous sources, but are commonly from adjacent residents/businesses or political stakeholders.

6.3.2 Parking layouts – Summary of advantages and disadvantages

Table 6.4 outlines the advantages and disadvantages of various parking layouts that need to be considered when determining the parking layout for a street.

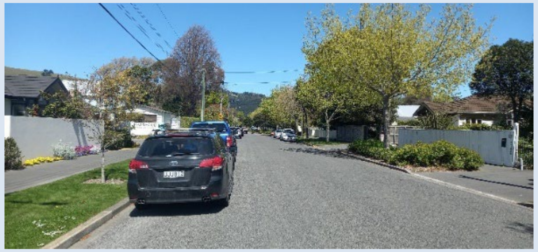
Table 6.4 Advantages and disadvantages of parking layouts that inform decision making

Parking type	Advantage	Disadvantage
Parallel parking	• Has less disruption on flow of traffic • Has fewer crashes associated with manoeuvring out of parking spaces than angle parking	• Accommodates fewer spaces along the kerb edge than angle parking • Creates a car door opening risk to cyclists on the road, pedestrians on the footpath, or pedestrians and cyclists on shared paths
Angle parking – 90 degrees	• Provides more spaces than parallel parking • Can access the spaces from both traffic directions • Services more spaces per paid parking terminal if using walking distance as a parameter	• Roadway width needs to be able to accommodate spaces • Not suitable next to a cycle lane unless there is an adequate buffer for parking manoeuvres • Crash risks when vehicles exit
Angle parking – 30–60 degrees	• Provides more spaces than parallel parking • Works better on a one-way street due to direction of access and egress	• Roadway width needs to be able to accommodate spaces, this can mean that parking is only feasible on one side of the road • Depending on angle, it may be difficult for drivers parked to enter the traffic stream • Not suitable next to a cycle lane unless there is an adequate buffer for parking manoeuvres • Crash risks when vehicles exit
Reverse-in angle parking	• Reduces the risk to cyclists passing behind the parking as drivers are facing the road (but a buffer still recommended) • Safer for drivers and passengers accessing the rear of the vehicle, such as for loading/unloading prams/young children, shopping	• This type of parking is uncommon in New Zealand and therefore may not be familiar to road users

Parking type	Advantage	Disadvantage
Angle parking in middle of the road (usually 90 degree)	• Can help create a traffic calming effect but needs landscaping at intervals so that when spaces are empty the road width does not look excessively wide • Allows access from both directions of traffic	• Requires very wide road reserve • Should not be used on arterial roads • Pedestrians have to cross one carriageway when leaving and returning to the vehicle • Crash risks when vehicles exit

Table 6.5 outlines the considerations for the various parking layouts and the associated ONF street categories where these are likely to be utilised.

Table 6.5 Parking layout and likely ONF context (Waka Kotahi, n.d.-a)

Parking type	Likely context (ONF)	Safety and multi-modal positives	Safety and multi-modal negatives
Parallel – kerbless street – marked 	• City hubs • Main streets	• Allows all parking spaces to be accessible for mobility impaired people through the easy, trip-free transition to the footpath • Better parking discipline as markings guide parking location and less risk of overhang onto adjacent traffic lane or cycle lane • Can help reduce speeds by creating side friction/activity that influences driver behaviour • Can create a sense of safety for pedestrians due to buffer from moving traffic	• Drivers could overshoot the parking space into pedestrians on the footpath area • Dooring risk to cyclists • Can impact visibility at intersections and driveways • Can impact visibility at pedestrian crossing locations • Can impact access/egress at bus stops • Some safety impacts strongly dependent on travel speeds and hence speed limits
Parallel – kerbside – marked 	• Main streets • Activity streets • Urban connectors	• Better parking discipline as markings guide parking location and less risk of overhang onto adjacent cycle lanes • Can help reduce speeds by creating side friction/activity that influences driver behaviour	• Dooring risk to cyclists • Can impact visibility at intersections and driveways • Can impact visibility at pedestrian crossing locations • Can impact access/egress at bus stops • Some safety impacts strongly dependent on travel speeds and hence speed limits
Parallel – kerbside – unmarked 	• Local streets	• Can help reduce speeds by creating side friction/activity that influences driver behaviour	• Less parking discipline as no markings guide parking location and therefore a risk of reducing space for other road users • Dooring risk to cyclists • Can impact visibility at intersections and driveways • Can impact visibility where pedestrians cross • Can impact access/egress at bus stops

Parking type	Likely context (ONF)	Safety and multi-modal positives	Safety and multi-modal negatives
Parallel – indented – unmarked 	• Local streets • Main streets • Activity streets • Urban connectors (less than 60 km/h)	• Less risk of impacting visibility at intersections and driveways • Less risk of impacting visibility where pedestrians cross • Less risk of impacting access/egress at bus stops	• Less help with reducing speeds as less side friction/activity that influences driver behaviour • Dooring risk to cyclists
Parallel – indented – marked 	• City hubs • Main streets • Activity streets • Urban connectors (less than 60 km/h)	• Less risk of impacting visibility at intersections and driveways • Less risk of impacting visibility where pedestrians cross • Less risk of impacting access/egress at bus stops	• Less help with reducing speeds as less side friction/activity that influences driver behaviour • Dooring risk to cyclists
Angle – kerbside – 90 degree 	• Local streets • Main streets • Activity streets • Urban connectors	• No dooring risk to cyclists	• Lack of visibility while reversing impacts on cyclists and other traffic • Can overhang into footpath (both front and reverse-in spaces)

Parking type	Likely context (ONF)	Safety and multi-modal positives	Safety and multi-modal negatives
Angle – kerbside – 30–60 degree 	• Local streets • Main streets • Activity streets • Urban connectors	• Can create traffic calming effect as drivers are conscious of angle parking	• Lack of visibility while reversing impacts cyclists and other traffic • Can overhang into footpath (both front and reverse-in spaces)
Angle – middle of road – 90 degree 	• Main streets • Activity streets • Urban connectors	• Can create traffic calming effect as drivers are conscious of angle parking	• Pedestrians exposed when crossing from the central parking • Lack of visibility while reversing impacts cyclists and other traffic • Can overhang into footpath (both front and reverse-in spaces)

6.4 Parking design innovations in New Zealand

6.4.1 Reverse-in angle parking

Some off-street car parks in New Zealand have changed angle parking layouts to reverse-in angle parking spaces as a health and safety measure. Benefits include less risk to other users within the car park and quicker exit in an emergency. This arrangement is generally used in staff car parks where users become familiar with the arrangement. This type of parking has not been introduced to the street context except for one instance that the authors are aware of in Kaiapoi. In this case, after a local community board member had been on an overseas trip and saw reverse-in angle parking being used, he requested this be used in a local street. As Raven Quay was being designed after the Canterbury earthquakes and angle parking was proposed, it was agreed to make the spaces reverse-in only. A sign (see Figure 6.7) was developed to inform car park space users on the intent and to reflect the Road User Rule, clause 6.13(1), which states:

> *If the road controlling authority has indicated that vehicles may be parked only at an angle to the direction of the road-way, a driver must not stand or park a vehicle (other than a cycle) otherwise than in accordance with the direction indicated.*

The use of the spaces has not been monitored, so the success of the arrangement is not known. As no wheel stops were used, the reverse-in arrangement has the potential for the rear of vehicles to overhang the footpath more than the front depending on the vehicle type. Rear overhang can be a particular hazard to pedestrians due to tow bars protruding (as shown in Figure 6.8). This is a problem for longer vehicles such as the ute shown below. Utes and SUVs are becoming more prevalent in New Zealand.

Figure 6.7 Reverse-in angle parking sign (Raven Quay, Kaiapoi)

Figure 6.8 Footpath overhang for reverse-in and forward-in angle parking

6.4.2 Kerbless streets

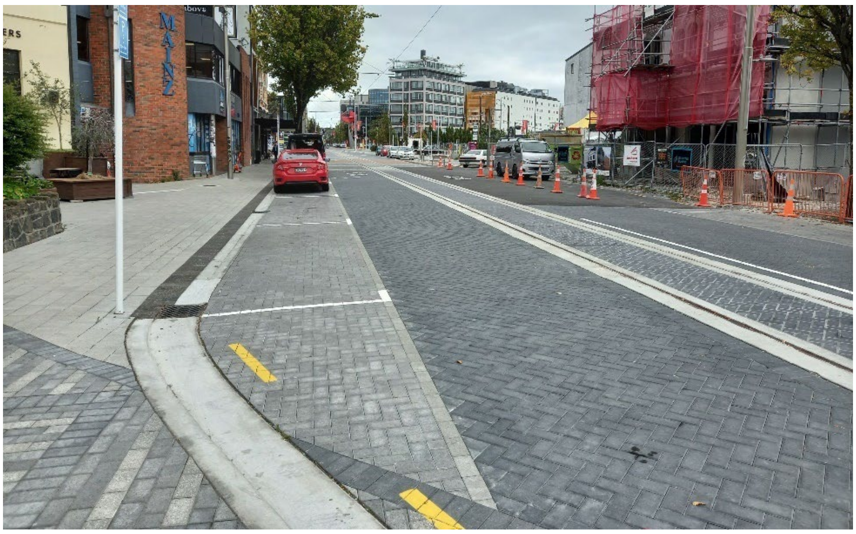
Kerbless streets are increasingly popular street designs across New Zealand for main streets and city hubs, noting that shared space streets tend to be more appropriate for civic spaces. The purpose of these streets is to better allocate road space in favour of pedestrians and the public realm and provide an attractive environment for commercial and public activities.

A fundamental feature of these streets is the absence of kerbs and conventional traffic road markings. This change of environment is intended to alert drivers to slow down and take more care. Removing kerbs also adds useful flush space for people to use while entering and exiting parked cars. This design means that each space is accessible albeit without the required mobility parking space width of 3.5 m.

Kerbless streets make service and delivery easier by providing more vehicle circulation space and more seamless loading from vehicles to businesses. If service and delivery is limited to certain times of day, parking spaces can be converted to seating and dining space. If closed to traffic, kerbless streets can more readily become an event space or street market. These streets require clearly demarcated vehicle and pedestrian user paths and more conventional street crossings.

Figure 6.9 Kerbless street (Queen Street, Richmond)

Figure 6.10 Kerbless street (High Street, Christchurch)



6.5 Conclusion

There are various ways that parking can be provided within a street, each having advantages and disadvantages depending on the context. When people are designing streets, they have a range of aspects related to parking to consider as part of the parking layout decision, including role of the street, speed management, traffic characteristics, space available and external factors.

The ONF has associated guidance and modal context. Parking is not considered a ‘mode’; rather, it is an attribute that seems to be primarily associated with ‘Movement’. However, it is also related to ‘Place’ for some street types as it supports or affects street activity. A table of parking layouts and likely ONF contexts has been developed as part of this research. A version of this table could be integrated into the ONF guidance to support design processes.

There has been limited use of reverse-in angle parking in New Zealand as far as the researchers are aware. The use of kerbless streets is increasing and allows better flexibility of the space.

7 Safety and design risk-mitigation strategies

Integral to the decision-making process of parking layouts, safety and design strategies will need to be applied to improve road safety and multi-modal outcomes. A range of safety and design strategies to help mitigate the risk of various layouts has emerged from the literature review and are consolidated in this chapter. Further risk-mitigation strategies that are currently not in any regulations, practices or guidance are also identified.

Section 7.1 discusses overarching risk-mitigation strategies, and sections 7.2 to 7.5 outline specific risk-mitigation strategies by mode.

7.1 Overarching risk-mitigation strategies

A range of overarching strategies that apply to the process of street design and its relationship to speed and parking management are outlined in Table 7.1.

The first strategy relates to the audit of designs from a Safe System perspective. NZTA recently updated the previously used road safety audit procedures (Fleming et al., 2013) to a Safe System audit (Waka Kotahi, 2022d). NZTA requires that Safe System audit procedures be applied to any improvement or renewal project or activity that involves vehicular traffic, and/or walking and/or cycling, proposed for funding assistance from the National Land Transport Programme (Waka Kotahi, 2022d). The new procedures bring together a Safe System assessment and safety concern ratings. The Safe System assessment evaluates a project's alignment with Safe System principles and identifies ways to improve the alignment with a focus on minimising DSIs. It investigates the inherent risk of the infrastructure and includes consideration of road user exposure. For example, the risk of dooring when a design has cycle lanes next to parking would be raised, which would focus the consideration of applying the strategies identified in section 7.2 below to eliminate or lower the risk. The safety concern ratings are to identify individual aspects of the project that are a concern with an associated risk profile as per a concern ratings matrix.

It is noted that the requirement for a Safe System audit does not apply to auditing of the existing network or specialist applications, such as traffic control at roadwork sites. Also, it is not clear if RCAs would adopt the procedures for roads being built as part of developments that are then vested in the RCA. Ideally, the Safe System audit would apply for all street design projects and the audit findings would be given serious consideration by all involved, particularly decision makers (such as elected members).

Also, importantly, lower speeds help reduce crash risk and the severity of some of the outcomes, particularly for pedestrians and cyclists. Some parking-related crash risks will only be Safe System aligned if impact speeds can be managed to survivable levels for all road users. Managing speeds is therefore, arguably, an important element of making sure that parking is aligned to the Safe System approach – noting that parking design has not be found to have a large enough impact to either prevent or achieve these desirable speeds. Thus, parking design associated with adapting road users' movements (ie, more pedestrians), should consider other elements that can help achieve SAAS, including speed management infrastructure and speed limit reviews. However, some outcomes that have been identified in the research are related to road space, such as 'dooring' of cyclists. This risk is not about speed management, but the risk can be reduced through better design.

Table 7.1 Overarching risk-mitigation strategies

Overarching issues	Mitigation strategies	Existing mechanisms	Potential mechanisms
Designs do not align with Safe System principles	Ensure that a Safe System audit is undertaken at the appropriate project stages and the findings are addressed. 	Safe System audit procedures and requirements	**Ensure the Safe System audit is applied to all street design projects and that the audit findings are given serious consideration by all involved, particularly decision makers (such as elected members)**
Impact speeds in a collision related to parking	Lower speeds will help reduce crash risk and the severity of the outcomes, particularly for pedestrians and cyclists. 	Speed Management Guide – currently only mentions speed concerns for parking on urban connectors	**Update the Speed Management Guide to recognise parking configurations for all ONF types and speed considerations**
Unnecessary traffic movements whilst searching for parking spaces (leading to increased crash risk)	Parking management plans that include appropriate tools, such as wayfinding and technology (variable message signs and apps), to influence driver behaviour to reduce parking search circulation. 	*National Parking Management Guidance* and local parking management strategies and plans	**The use of technology to assist drivers searching for parking where it is currently not being used.**
Insufficient road corridor space	Introduce Safe System design standards for new roads that consider the various uses for a range of contexts. This may include wider footpaths, more space for cyclists and micro-mobility users, more space for buses, and overall wider corridors, depending on whether parking and/or flush/medians are required. 	District plans and codes of practice have requirements for new roads (these do not necessarily align with the ONF or Safe System approach)	**Ensure road design standards adhere to a Safe System approach and align with the ONF modal outcomes**

7.2 Cyclist safety and design risk-mitigation strategies

A range of key risks is discussed below. The planning and design guidance in relation to mitigating these risks is summarised in Table 7.2 along with any potential further guidance or actions identified during the research.

7.2.1 Car dooring

A car door opening into a cyclist's path was clearly noted in the literature review and safety analysis as a key risk for cyclists in relation to parking. When a car door is opened, it extends approximately 1 m out from the car body. Mitigating this risk requires a combination of car driver/passenger and cyclist awareness, as well as design aspects. Awareness initiatives are unlikely to be enough on their own as they rely on behaviour change and thus are not a Safe System approach.

Car drivers need to check their rear vision mirror, and the driver and rear passengers need to look over their shoulder for cyclists as encouraged with the Dutch Reach method, where people use their left hand to open the door, forcing them to look over their shoulder. It is noted that Uber has added messaging to customer apps when customers are being dropped off in a street with on-road cycle lanes to check for cyclists before exiting the vehicle. An extension of this messaging directed at customers could include reminders by drivers to passengers at the time of drop-off.

There are also steps cyclists could take to limit their risk. For example, in a cycle lane located next to on-street parking (which should be at least 1.8 m wide), a cyclist is best positioned to the outside part of the cycle lane, as shown in Figure 7.1, to avoid car dooring. Many cyclists may think the greater risk is the adjacent traffic and hence travel in the inner part of the cycle lane, exposing themselves to increased dooring risk. The optimum positioning for the cyclist to minimise car dooring risks and the risks of being struck by an overtaking vehicle is not clear or well-understood, which makes the provision of adequate cycle lane widths an important design element.

While cyclists need to be aware of the door opening risk and positioning themselves appropriately to avoid impacts with doors, roads must be designed to be forgiving of such mistakes by riders and vehicle occupants.

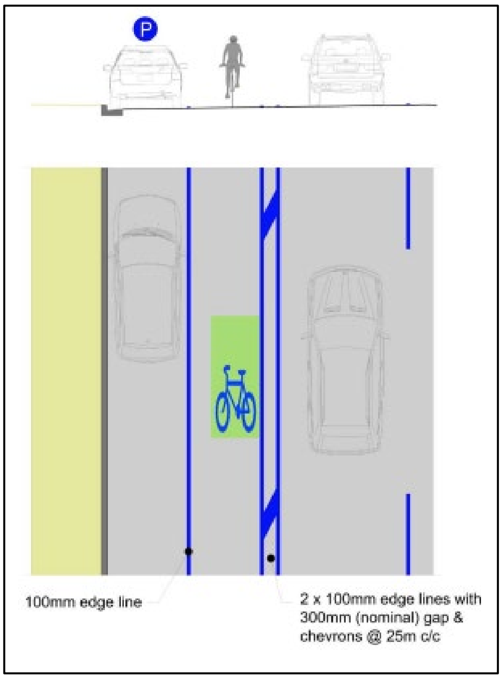
Figure 7.1 Cycle lane next to parking – dooring zone

Buffered cycle lanes are a conventional on-road cycle lane with a marked buffer between the cycle lane and moving traffic lane and/or parking lane as shown in Figure 7.2. The use of the buffer can encourage people riding a bicycle to travel outside the door opening zone.

Figure 7.2 Buffered cycle lanes next to parking (reprinted from Waka Kotahi, n.d.-c)

The door zone of parked vehicles is an actual safety concern for people on bikes, but the current default is to not mark a painted buffer between the parking lane and cycle lane. Instead, the space between the cycle lane and the traffic lane is marked, as shown in Figure 7.3. The Waka Kotahi (2020b) Cycling Network Guidance (CNG) *Technical Note: Buffered Cycle Lane Design* recommends that to encourage cyclists to keep away from the door opening zone, the cycle lane symbol and green surfacing are marked closer to the general traffic lane.

Figure 7.3 CNG buffered cycle lanes marking recommendation (reprinted from Waka Kotahi, 2020b, p. 2)



The note also acknowledges there is scope for further research into the design of this facility type and a need for more research to identify how much influence such an offset marking has on the position of the rider in the lane. It is also noted that a buffer between parking and the cycle lane will only keep people on bikes safe from the door zone if good parking discipline is achieved.

Sharrow markings also help cyclists locate themselves away from car doors, as shown in Figure 7.4. A cyclist's riding position is also an aspect of education, which is assumed to be covered in cycle skills training through schools.

Figure 7.4 Sharrow marking next to parking

The turnover of parking is a key consideration as the exposure to the car door opening risk increases when there is short duration parking, especially at high demand locations. Physically separated cycle lanes where there is high turnover parking (see Figure 7.5), such as through shopping areas, could provide a better outcome but need to be balanced with the risk to people moving between the parked cars and the footpath.

Figure 7.5 Separated cycleway next to high turnover parking (Waka Kotahi, n.d.-c)

7.2.2 Collison with parked cars

The safety analysis found the second highest cause of parking-related cycle DSIs was ‘collisions with parked vehicles’. This can be caused by cycle lanes ending abruptly at a parked car (see Figure 7.6), cars parked at pinch points/bends and cars parked too close to a cycle bypass merge zone (see Figure 7.7).

Figure 7.6 Cycle lane ends at parked car

Figure 7.7 Parking restriction extents at cycle bypasses

7.2.3 Parked cars blocking cycle lanes

There is a safety risk associated with vehicles parking in cycle lanes (see Figure 7.8) as this can result in people on bikes being required to travel out of the cycle lane into the general traffic lane in order to pass parked vehicles.

In New Zealand, cycle lanes marked adjacent to the kerb are not legally required to have no-stopping lines. Some RCAs that have marked cycle lanes without no-stopping lines have found this to be insufficient. This experience shows that it is preferable to mark no-stopping lines within kerbside cycle lanes. The CNG advises:

> *Having a mixture of some kerbside cycle lanes with, and some without no-stopping lines in the same district should be avoided. Even more so, having some parts of a kerbside cycle lane with no-stopping lines and other parts of the same cycle lane without no-stopping lines sends confusing messages to drivers. This is undesirable, and requires either the removal of all existing no-stopping lines in kerbside cycle lanes, or, preferably, the addition of no-stopping lines where they are not marked.* (Waka Kotahi, n.d.-c)

Figure 7.8 Parked car in cycle lane (reprinted from Greater Auckland, 2015)

7.2.4 Angle parking

When cycling adjacent to angle parking, a high level of protection is required to allow for the fact that drivers have reduced visibility, and therefore when implementing angle parking the needs of cyclists should be given appropriate consideration. Reverse-in angle parking may be an option but is generally not well tested in New Zealand.

The CNG (Waka Kotahi, n.d.-c) advises that:

- *Cycle lanes should be a suitable distance away from angle parking to encourage cycling in a position that aids visibility between drivers and cyclists and allows cyclists to avoid vehicles that are emerging from a car parking space.*

- *Angle parking is appropriate only where the speed limit is 50 km/h or less. Cycle lanes next to angle parking assist in reminding drivers of the potential presence of cyclists.*
- *Cycle lanes adjacent to angle parking should be installed in accordance with the clearance details.*
- *Cycle lanes should be coloured green and marked with standard cycle pavement symbols to enhance their visibility.*

The guidance does not mention the relationship between turnover, cycle volumes and traffic volumes. Even with a buffer area alongside angle parking, the dooring risk increases with higher turnover and high cycle volumes. There is also no mention of central angle parking, which may expose cyclists further.

When there are no cycle lanes, sharrow markings can be used to show cyclists where to ride to avoid the angle parking hazard zone, as shown in Figure 7.9, where a 30 km/h speed limit applies. Figure 7.10 shows an example where a neighbourhood greenway design used both sharrow markings and a paved 1.5 m buffer behind the angle parking to discourage cyclists from riding close behind the parking.

Figure 7.9 Angle parking on a narrow shared traffic lane street (Wellington)

Figure 7.10 Angle parking on a wide shared traffic lane street (Kaiapoi)

These risks are summarised in Table 7.2 along with any potential further guidance or actions identified during the research.

Table 7.2 Cyclist risk-mitigation strategies

Cyclist issues	Mitigation strategies	Existing mechanisms	Potential mechanisms
All types	Reduced speed limits in urban areas will lower the risk of crashes, and the severity of crashes if they occur.	Speed Management Guide – apply SAAS recommendations for street types	–
Dooring	Safety campaigns	Road Code includes the left-hand reach method as advice to drivers	• **Promote the left-hand (Dutch Reach) method through publicity campaigns** • **Add to the Defensive Driving course** • **Add to the driver licensing process (eg, the multichoice quiz)**
	Cycle network planning – Consider not providing parking where a defined cycle route is provided or at least where on-road cycle lanes are being provided.	CNG: Planning guidance	**CNG: Strengthen guidance on this aspect**
	Mark cycle lanes of at least 1.8 m width to encourage cyclists to travel away from the car.	CNG and TCD Manual Part 5: Cycle lane minimum widths	–
	Mark buffered cycle lanes, with buffer on parking side or mark as per guidance with no colour block close to the parked cars.	CNG: Technical Note: Buffered cycle lane	**CNG: Noted in the CNG that further research is required to refine marking for door risk mitigation**
	Use separated cycleways with separator that accommodates the door opening width.	CNG: Separator minimum widths (1 m minimum, 700 mm absolute minimum)	**CNG: Review the separator minimum width by evaluating the effectiveness of this guidance in practice**
	Place sharrow markings in shared lanes to encourage cyclists to travel away from the car door zone.	CNG: Mixed lanes guidance	–
	Having no or very little parking next to contra-flow cycle lanes.	CNG: Contra-flow cycle lanes	**CNG Needs further and stronger guidance on appropriateness of parking next to contra-flow cycle lanes**

Cyclist issues	Mitigation strategies	Existing mechanisms	Potential mechanisms
	Mark car door zone on shared path to deter cyclists from riding too close to doors.	CNG: Shared paths	–
	Avoid in-between bus lane widths. Avoid narrow part time bus lanes. Bus lanes must be permanent (ie, no parking).	CNG: Bus lanes	**Ensure this is reflected in Public Transport Design Guidance content yet to be uploaded**
Collison with parked vehicles	Cycle lane transitions to no cycle lane need to ensure parking does not create an unexpected obstruction/pinch point.	CNG	**CNG: Needs transition guidance in relation to parking restrictions**
	Cycle bypass facilities need sufficient merge zones at each end.	CNG	**CNG: Needs transition guidance in relation to parking restrictions**
	Restrict parking on bends where cycle lanes can be pinched and put into the path of approaching/following vehicles.		**CNG: Needs transition guidance in relation to parking restrictions**
Interaction with parking vehicles	Design car park spaces to ensure ease of access and egress from vehicles, thereby reducing the risk to passing cyclists.	Limited guidance found	**TCD Part 13: Update to include indented parking guidance**
	Vehicles parking in cycle lanes can result in cyclists being required to travel out of the cycle lane into the general traffic lane in order to pass a parked vehicle. &	CNG: Cycle lanes – suggests marking no-stopping restrictions	**Support with enforcement of no-stopping restrictions along high-risk routes**
Reversing out of angle parking	Provide buffers between angle parking and traffic lanes.	CNG: Cycle lane guidance	–
	Consider reverse-in parking.	–	**CNG: Add this as a potential mitigation strategy with advice on design and speed limits for such circumstances**

Cyclist issues	Mitigation strategies	Existing mechanisms	Potential mechanisms
Visibility of separated cycleway users blocked by parked cars	Restrict parking for a safe distance from driveways.	CNG: Advice note with setback	**CNG: Review the setback requirements by reviewing arrangement of cycleways that have been implemented since the guidance was developed to ensure they are effective and fit for purpose.**

7.3 Pedestrian safety and design risk-mitigation strategies

A range of key risks is discussed below, with planning and design guidance on mitigating these risks summarised in Table 7.3, along with any potential further guidance or actions identified during the research.

7.3.1 Crossing the road

The safety analysis found that the highest proportion of parking-related crashes involved pedestrians crossing the road (pedestrians struck by vehicles when crossing from the left side of the road). This included streets that were lined with parked cars obstructing the driver's view of pedestrians attempting to cross. The data didn't always state whether the crash occurred at a formal pedestrian crossing facility, which is potentially important in deciding on opportunities to mitigate risks.

The provision of well located and designed pedestrian crossings with good sight distance will help mitigate, to some extent, the risks caused by sightline obstructions. However, people can still cross the road legally at locations without formal crossing facilities, and this is difficult to manage from a sight distance/parking perspective unless parking is completely removed on existing roads or new roads provide sufficient space for pedestrian islands or medians.

It is noted that cycle lanes have been shown to improve pedestrian safety as they provide a safe area for pedestrians to wait next to parked vehicles before proceeding to cross the roadway, and motorists can more easily see them as occurs with a kerb buildout. On streets without a cycle lane, this is a difficult issue to address through design without having a special buffer next to parking for pedestrians to use when checking for a gap in traffic. A buffer would make a street wider and could be confused with a cycle lane that would be under-width.

A key crossing design input is the crossing sight distance (CSD), which ensures a clear view between approaching drivers and pedestrians on the crossing or waiting to cross a roadway. CSD is a function of the width of road section to cross (noting that crossings can be undertaken in two stages where a refuge/median is present), walking speed and vehicle speed. Ideally, CSD should at least be provided at crossing locations where the pedestrian does not have priority, to allow sufficient time to cross the road, clear of any approaching traffic. It is noted that people can cross at countless other locations along a roadway, making the provision of CSD problematic, by essentially removing all parking for a street. In such circumstances, it may be feasible to retain parking and eliminate the risks of DSI to pedestrians by ensuring safe travel speed aligned with the Safe System approach and the Speed Management Guide.

At crossings where pedestrians have the priority, approach sight distance (ASD) should still be used; ASD is a function of vehicle speed and driver reaction time. With ASD provided, the driver should be aware of the crossing by seeing the associated pavement markings and other cues, and therefore be alerted to take the appropriate action if a pedestrian steps onto the crossing. It is important that CSD and ASD are not obstructed by any object, including parked vehicles. Note that the CSD measurement line in Figure 7.11 will vary depending on whether there is a kerb buildout.

The parking restriction distances required in the scenario of a two-stage crossing (refuge island in the middle with 5.5 m width to cross each side) in a 50 km/h environment are shown in Figure 7.11. For a non-priority crossing, 65 m of parking restriction is required. For a zebra crossing or traffic signals, 55 m is required. Figure 7.12 illustrates a zebra crossing with the same attributes. It has 65 m of parking restriction, so complies with ASD and also provides CSD.

Figure 7.11 Parking restriction (in 50 km/h street) required if following guidance (adapted from Waka Kotahi n.d.-d)

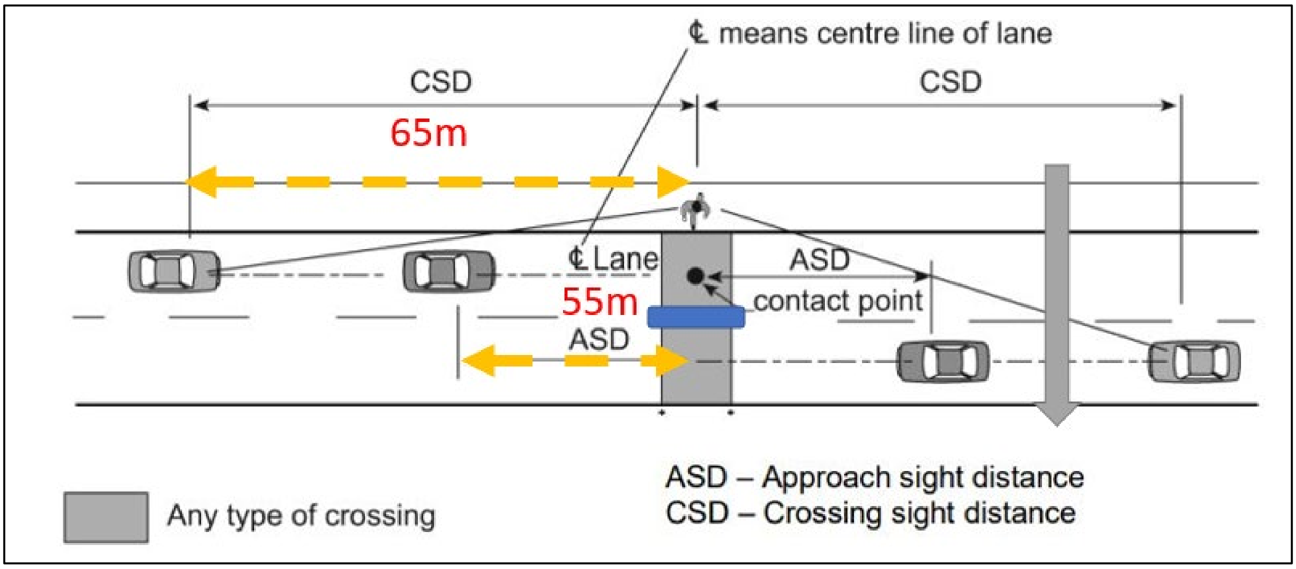


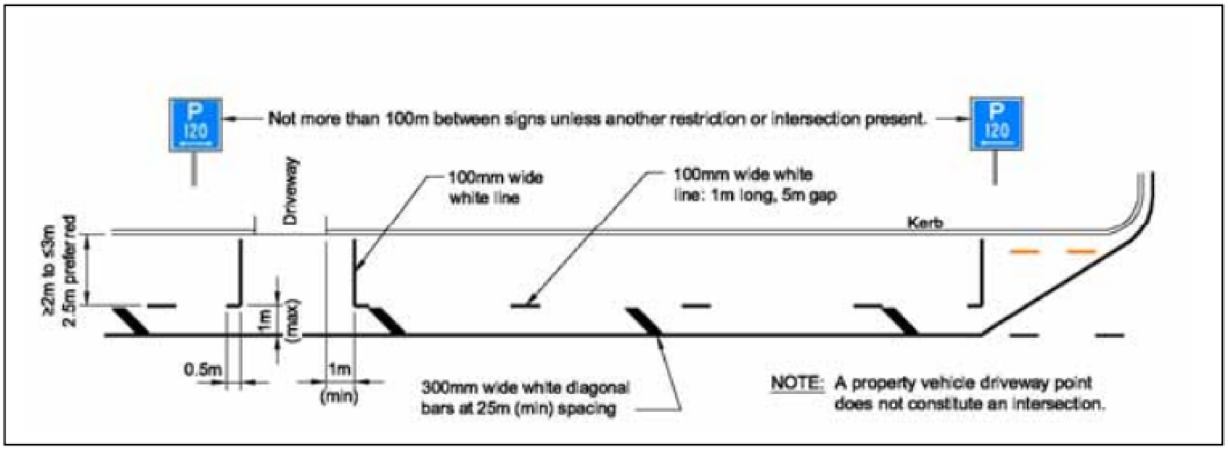
Figure 7.12 Parking restriction at zebra crossing in 50 km/hour area (65 m provided)

7.3.2 Attending a parked car

The safety analysis found that the second highest pedestrian/parking crash cause was people ‘attending’ the parked car being injured – that is, when a person was getting into or out of the vehicle from the traffic side being hit by a passing vehicle. This is a difficult issue to address through design without having a special buffer for this activity on streets without cycle lanes, which then makes streets wider and could be confused with a cycle lane that would be under-width. It could also result in poor parking discipline. Figure 7.13 shows an example of this type of marking, which may have been used to reduce the traffic lane width. TCD Manual Part 13 (Figure 7.14) has this marking shown as an example for moderate parking demand but does not explain the 1 m wide buffer function. The scale of the issue is low as this mostly results in minor injuries but could be appropriate on some streets.

Figure 7.13 Buffer marking example

Figure 7.14 TCD Manual Part 13 marking for high parking demand (reprinted from Waka Kotahi, 2007, p. 6-9)



7.3.3 Footpath overhang

In angle car parks, vehicles can overhang onto the footpath. This is an inconvenience and a risk to people on the footpath, albeit unlikely to result in a serious injury.

Table 7.3 Pedestrian risk-mitigation strategies

Pedestrian issues	Mitigation strategies	Existing mechanisms	Potential mechanisms
Lack of intervisibility with drivers when crossing the road at a pedestrian crossing	Ensure sufficient no-stopping restrictions are provided either side of a defined crossing point.	Pedestrian Network Guidance (PNG)/ Austroads: CSD and ASD requirements	–
	Create kerb buildouts to reduce crossing distance and make pedestrians more visible to approaching drivers even with parked cars.	PNG: Advice in the crossing design section	–
	Reduced speed limits in urban areas will reduce CSD requirements and reduce crash risk and the severity of crashes if they occur.	Speed Management Guide – apply SAAS recommendations for street types.	–
Attending a vehicle	Mark a buffer adjacent to parking lane to allow space between car occupant and passing traffic.	TCD Manual Part 13 buffer marking	**TCD Part 13: Clarify when this marking is appropriate**
Footpath width reduced by angle-parked car overhang	Provide a wider footpath to allow for overhang.	PNG	**TCD Part 13: Update to include angle parking design guidance**
	Install wheel stops to prevent or reduce overhang.	PNG	**TCD Part 13: Update to include angle parking design guidance**

7.4 Public transport safety and design risk-mitigation strategies

A range of key risks is discussed below, with planning and design guidance on mitigating these risks summarised in Table 7.4, along with any potential further guidance or actions identified during the research.

The issues identified for pedestrians at crossings due to parked cars can also be an issue when a bus blocks visibility. This is why the Public Transport Design Guidance and Pedestrian Network Guidance recommend that crossings are to be located upstream from bus stops so pedestrians can be seen by approaching drivers from the right. There may be scenarios where the use of landscaping, and on rare occasions fencing, can help to discourage pedestrians crossing in front of buses.

The impact of on-street parking on public transport is generally related to safety and efficiency, which can be hindered by lack of access to and from bus stops. A key concern for bus users when a bus cannot pull in parallel with the kerb is the increased horizontal and/or vertical gap created between the door and footpath. Examples are shown in Figure 7.15 and Figure 7.16.

Figure 7.15 Parking restricts ability for bus for pull in parallel with the kerb

Figure 7.16 Gap created at the bus rear door

Table 7.4 Public transport risk-mitigation strategies

Public transport issues	Mitigation strategies	Existing mechanisms	Potential mechanisms
Insufficient bus stop access and egress	Marking appropriate no-stopping restrictions will facilitate access and egress of buses. 	Public Transport Design Guidance: Bus stop design	–

7.5 General traffic risk-mitigation strategies

A range of key risks is discussed below, with planning and design guidance on mitigating these risks summarised in Table 7.5 along with any potential further guidance or actions identified during the research.

7.5.1 Restricted sight distance

The safety analysis found that parked cars can contribute to obstructing driver visibility and cause crashes at intersections and driveways. Determining the total number of crashes caused by a parked vehicle limiting visibility was harder to quantify given the number of factor codes used for this scenario, and it was concluded that crashes due to limited visibility are likely to be under-reported.

The current legal requirement for restricting on-street parking at intersections is 6 m either side of an intersection and 1 m either side of a driveway. A key geometric safety parameter in road design is the sight distance provided at intersections. This parameter has a relationship with parking as it defines the length of no-stopping restriction that should be imposed either side of an intersection/driveway to ensure suitable visibility. Meeting sight distance requirements in the urban context can mean that parking is banned for quite some distance, and often this is weighed up during the design process.

From a safety perspective, safe intersection sight distance (SISD) is the minimum sight distance that should be provided on the major road at any intersection. SISD is outlined in Austroads' (2021b) *Guide to Road Design Part 4A – Unsignalised and Signalised Intersections*. It is measured along the carriageway from the approaching vehicle to the conflict point; the line of sight having to be clear to a point 7.0 m (5.0 m minimum) back along the side road from the conflict point.

Figure 7.17 shows a typical New Zealand urban side road intersection with a design speed of 50 km/h. The SISD requirement is 97 m; the line of sight from a driver 5 m back from the limit line to see the approaching vehicle 97 m from the point of contact results in a no-stopping restriction of 65 m. Reducing speeds helps to reduce the SISD requirement and resulting no-stopping restriction. It is noted that the minimum gap sight distance (MGSD) could be applied as a minimum. MGSD is based on distances corresponding to the critical acceptance gap that drivers are prepared to accept when undertaking a crossing or turning manoeuvre at intersections. In this 50 km/h scenario, the MGSD results in a parking restriction of 30 m from the intersection. It is noted that both sight distances do not reflect the 6 m minimum legal requirement.

Figure 7.17 Sight distance requirements versus actual no-stopping restriction

This SISD requirement is generally adopted by New Zealand RCAs in their local design guides/codes of practice and often specified in district plans for intersections and high use driveways, with the speed limit and the road classification being the variables.

Table 7.5 General traffic risk-mitigation strategies

General traffic issues	Mitigation strategies	Existing mechanisms	Potential mechanisms
Sight distance at intersections	Restrict parking at intersections to reflect geometric design safety requirements.	• Austroads recommends sight distances based on speed • Legal requirement significantly less	**Consider a review of the legal requirements**
	Reduced speed limits in urban areas will reduce sight distance requirements and reduce crash risk and the severity of crashes if they occur.	Speed Management Guide – apply SAAS recommendations for street types.	–
Sight distance at driveways	Restrict parking at driveways to reflect geometric design safety requirements.	Legal requirement significantly less	**Consider a review of the legal requirements**
Parking on bends restricts space and sight distance	Restrict parking on bends where vehicles can be pinched.	TCD Part 13	–

7.6 Conclusion

Integral to the decision-making process of parking layouts are what safety and design risk-mitigation strategies are available to help improve road safety and multi-modal outcomes. A range of existing and potential strategies has been identified. Cyclist safety issues have the greatest number of strategies due to their risk in a range of parking layout scenarios.

Many of the issues raised generally relate to insufficient road space for all modes as well as parking. The general lack of road space is a function of the existing standard carriageway and corridor widths in New Zealand. Mitigating this involves design standards for new roads, which may include wider road corridors and wider carriageways, depending on whether parking and or flush/medians are required. It is noted that the AUSPDG (Waka Kotahi, 2022b) recognises this to some extent in the indicative layouts – for example, urban connectors being 27–30 m wide.

8 Case studies

Brief case studies for a range of street projects and street types were developed to examine real-life situations where road space allocation decisions involved on-street parking and how the design changed because of these. Any negative impacts are discussed with recommendations on how any appropriate strategies developed in chapter 7 could assist. The focus of the case studies was generally higher traffic volume roads with parking, where safety risks are therefore potentially higher.

The case studies listed in Table 8.1 are desktop studies with some site visits where required and a review of CAS data to determine any relevant crash information.

Table 8.1 Case studies used

Project name and location	ONF street category	Reason for case study
St Asaph Street cycleway, Christchurch	Activity street (30 km/h)	Street with a separated cycleway where a business group opposed first design due to parking loss
SH1 One-way pair cycleway (Castle and Cumberland Streets – southbound and Great King Street – northbound)	Urban connector (50 km/h)	High traffic volume street with separated cycleway where a business group opposed first design due to parking loss
Queen Street upgrade, Richmond	Main street (30 km/h)	Kerbless shopping street with parallel parking with flush separator; achieves low speed environment but some initial usage issues
Franklin Road upgrade, Auckland	≈ Activity street (30 km/h)	Wide indented bays with confusion over how to use them and potential accessibility issues to and from the spaces
Carrington Road, Auckland	≈ Urban connector (50 km/h)	High traffic volume street with width constraints and some parking still remaining
Mt Roskill Safer Communities Programme	Various	Street changes near a school to improve safety of children and the general community

8.1 St Asaph Street

Project name: St Asaph Street Cycleway	Location: Christchurch	Traffic volume: 8,300 vehicles per day (vpd) Speed limit: 30 km/h	Cycling network: Yes Bus route: Yes

Description:

The St Asaph Street cycleway is a one-way separated cycling facility on a one-way street with two traffic lanes with parking on both sides of the road. Traffic and cycle movement is in the westbound direction. It is an activity street.

St Asaph Street is also part of the public transport network and serves seven routes. There are bus stops along the route, adjacent to the cycle facility, which requires bus users to cross the cycleway. This cycleway serves a number of businesses (eg, hospitality, car sales yards and a St John depot) and education centres in the Christchurch city centre.

The project was between Madras Street to the east and Hagley Ave to the west (Figure 8.1) and was completed in 2017. Figure 8.2 shows the cycleway with no on-street parking, and Figure 8.3 shows a location where there is adjacent on-street parking.

Figure 8.1: Case study location map

Figure 8.2: Separated cycleway next to no parking

Figure 8.3: Separated cycleway next to parking

Relevance to this research:

This case study is an example of how stakeholders can influence the design where compromises are made to accommodate on-street parking. In this case, compromises included a cross-section with most elements at minimum width, which can have negative impacts on both safety and multi-modal outcomes.

Investigation:

The initial design consulted on in 2015 included a one-way separated cycleway and no parking on the south side of the street. This was subsequently altered to include parking on the south side adjacent to the cycleway due to stakeholder feedback. This change required the traffic lanes to be reduced to 3 m width with no clearance between the traffic lane and parking. The street was also initially intended to have a 30 km/h posted speed limit but retained the 50 km/h speed limit following consultation.

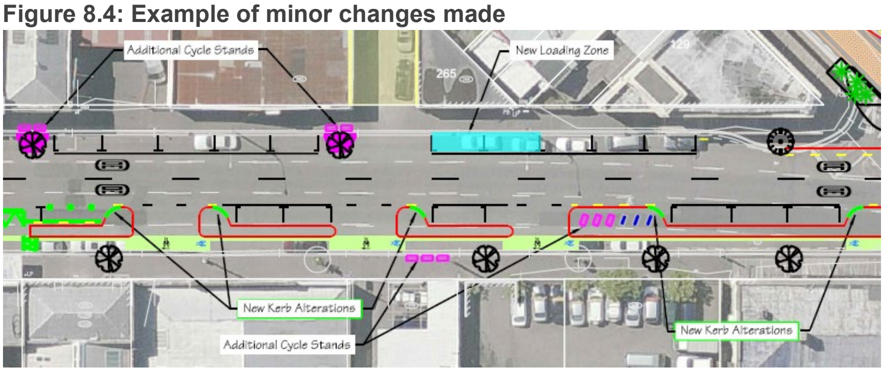
Project name: St Asaph Street Cycleway	**Location: Christchurch**	**Traffic volume: 8,300 vehicles per day (vpd)** **Speed limit: 30 km/h**	**Cycling network: Yes** **Bus route: Yes**

The upgrade was completed in December 2016 and provoked negative reactions from cyclists regarding visibility at driveways, and negative reaction from drivers regarding the narrowed traffic lanes. The constructed upgrade was not favoured by the Central City Business Group, who then proposed an alternative design that reinstated more parking. An independent safety audit of the constructed design was completed and recommended changes to the layout, including a speed limit reduction and improved access to the remaining on-street car parks. Two options were then presented to the public for consultation:

1. **Minor changes option**: 30 km/h speed limit and other changes such as smoothing the exits of the car park bays
2. **Major changes option**: Developed by Central City Business Group, this design would add approximately 53 additional car parks, reduce the width of the northern footpath by 1 m to widen traffic lanes, remove some tree pits, and cost about $1.2 million.

A road safety audit concluded the major changes options was not safe. The minor changes option (an example section is shown in Figure 8.4) was progressed, and those changes have been in place since 2017.

Figure 8.4: Example of minor changes made



Between 2017 and 2021, there was one serious crash and five non-injury crashes on St Asaph Street where parking was a factor. The serious crash involved a car and a cyclist. A cyclist was travelling on the separated cycleway and was struck by a vehicle turning left into an accessway due to the driver's view being obstructed by parked vehicles between the cycleway and the traffic lane. The Christchurch City Council traffic counts show that the operating speed is 37.5 km/h.

Findings:

- The initial design was not favoured by the businesses on the street due to the amount of parking removed. This resulted in parking being reintroduced on the same side as the cycleway.
- The constructed design was still not supported by the businesses, and they then presented an alternative option that introduced more car park spaces. The road safety audit process deemed this option unsafe, and it was therefore not progressed.
- A speed limit reduction and some minor design changes were made in response to safety concerns raised post-implementation from both cyclists and drivers, which improved the street's functionality and safety. The average operating speed is higher than the speed limit of 30 km/h but less than the previous speed limit of 50 km/h.
- The implemented design meets the current best practice guidance (CNG) for parking restrictions to allow driver visibility of cyclists before the driver turns into a driveway. However, as many of the drivers are unfamiliar users, such as customers visiting the car sales yards, there appears to be a lack of awareness regarding this layout and issues are still arising (albeit not resulting in recorded crashes). This has led to a recent retrofit of more prominent driveway markings, stick-on speed humps for drivers and cyclists, and even some businesses using their own signage to inform their visitors of cyclists (Figure 8.5). A review of the CNG parking restrictions at driveways guidance is recommended.

Figure 8.5: Signage to alert drivers to the presence of cyclists

8.2 Dunedin SH1 one-way pair cycleways

Project name: SH1 one-way pair cycleways	Location: Dunedin	Traffic volume: 15,000 vpd Speed limit: 50 km/h	Cycling network: Yes Bus route: Yes

Description:

This project was about improving cycle safety on the SH1 one-way system through central Dunedin, a busy route that caters for heavy freight vehicles and general traffic as well as other road users, including pedestrians and cyclists. This latter group of road users was overrepresented in crashes on this state highway corridor. The design involved replacement of the existing painted cycle lanes, which were directly next to the busy traffic lanes, and placing the new cycle lanes alongside the footpath, together with a series of islands to keep traffic and cyclists separated. At the signalised intersection, depending on extent of vehicles turning across the cycle lanes, two approaches were taken: a fully shared approach and a signal-controlled approach.

The project was between Rattray Street in the south and Pine Hill Road to the north (Figure 8.10) and was completed in 2019. Both routes are urban connectors.

Figure 8.11 shows the cycleway with no on-street parking and Figure 8.12 shows a location where there is adjacent on-street parking.

Figure 8.6: Case study location map

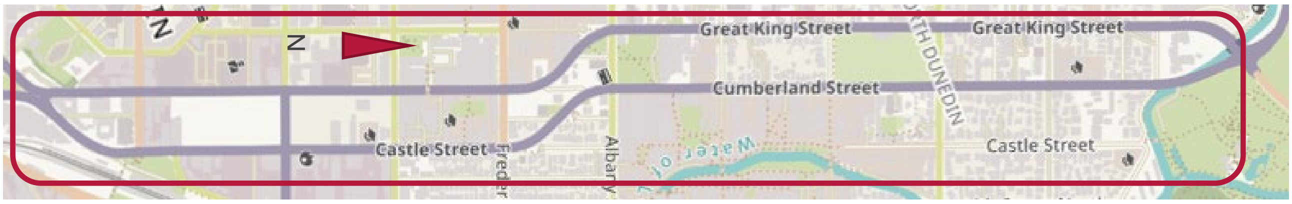


Figure 8.7: Separators with no parking

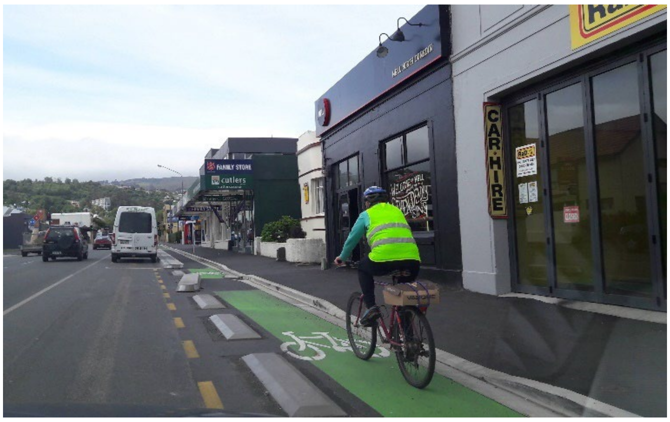


Figure 8.8: Separators next to parking

Relevance to this research:

This case study is a good example of a design that specifically addressed safety issues, some being related to on-street parking. Separators that account for the width of car doors were provided in areas where parking was retained.

Investigation:

The design of the separated cycle lanes resulted in changes to the availability and use of parking on parts of the one-way system. Initially, 390 car parks were to be removed to accommodate the cycle lanes. In response to public and business feedback, a variety of design changes were made to reduce the overall effect on car parking, including creating new parking bays within the cycle lane design. Car parks were also re-introduced on the opposite side of the road to the new separated cycle lane. These measures reduced parking losses on the one-way system to 210 car parks. Net parking losses were lowered further as prior to work starting on the new cycle lanes the Dunedin City Council provided 50 extra car parks on streets adjacent to the one-way system, reducing the net loss of car parks to 160.

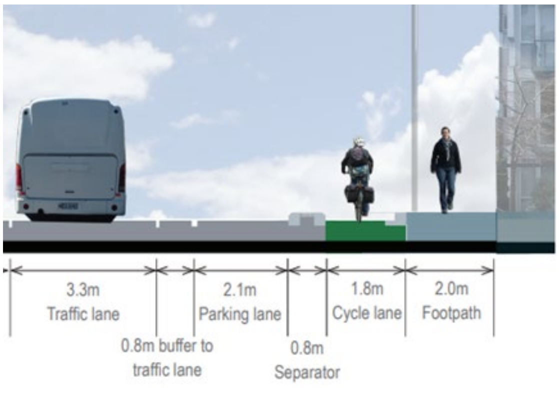
Meeting the parking needs of businesses and maintaining access to public facilities were a key focus of the cycle lane design. Of the parking bays that were re-introduced on the one-way system, priority was given to matching existing business short stay car parks, and parking near Dunedin Hospital, Otago Museum and Otago University. The design, which was

Project name: SH1 one-way pair cycleways	Location: Dunedin	Traffic volume: 15,000 vpd Speed limit: 50 km/h	Cycling network: Yes Bus route: Yes

ultimately consulted on, had parking on both sides of the street with buildouts to ensure parking did not completely obscure the view of approaching cyclists when vehicles turn into accesses.

The design (see Figure 8.13) was developed prior to the CNG advice that separators between a cycleway and parking lane should be 1.0 m wide (0.85 m tolerable minimum, 0.7 m absolute minimum). The 0.8 m separator and the use of 2.1 m wide parking spaces appears to provide good protection from dooring, as shown in the photograph below of the open door over the separator (Figure 8.14).

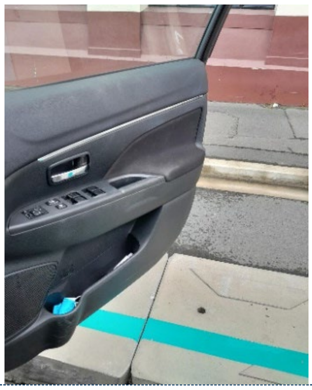
Figure 8.9: Initially proposed cross section



The project business case analysed crashes between 2009 and 2014. Eleven percent of crashes recorded in CAS involved pedestrians and cyclists. However, pedestrian and cyclist crashes accounted for approximately 60% of the high severity crashes (15 high severity crashes resulting in 15 DSIs). This shows that pedestrians and cyclists were overrepresented in high severity crashes along the project length; the majority of these occurred due to drivers failing to give way or parked vehicle doors opening into the cyclist's path. Of the 13 cyclist crashes, two were fatal and four were serious. One of the fatal crashes was a cyclist avoiding a car door and then being struck by an adjacent moving truck. It was difficult to ascertain if any pedestrian crashes were related to parking; however, obstructed sight lines due to parked vehicles is a common contributor to pedestrian crashes in commercial settings.

In the period between 2019 and 2022, since the separated cycle lanes were installed, there were a total of seven crashes reported that involved cyclists. Six of the crashes occurred at various intersections along the corridor, and one was a mid-block crash. One crash was related to parking; this was a mid-block crash when a cyclist collided with the left rear of a stationary van on Cumberland Street (immediately south of the St David Street intersection). This caused the cyclist to fall off their bike, but it did not result in any injuries.

Figure 8.10: Open car door overhangs the separator



During the same period there have been 12 pedestrian crashes. Eight occurred at intersections, and four were mid-block crashes (two when crossing the road and two were at driveways). There does not appear to be a direct relationship between parking and pedestrian crashes arising from these crash data. It is noted that the implementation of the separated cycle lanes included the retro-fit of existing traffic signals, as well as new traffic signals, to provide for protected pedestrian movements including two fully protected Barnes Dance installations.

Findings:

- The initial design was not favoured by the businesses/organisations on the street due to the amount of parking being removed. This resulted in a revised design that kept more car park spaces. The revised design does not appear to have made any design compromises that negatively impact safety outcomes.
- Although a full 5-year period has not passed since installation of separated cycle facilities, the data to date indicate a significant reduction in the number of DSI crashes involving pedestrians and cyclists. In particular, it is noted that there have been no fatalities and two serious injury crashes involving pedestrians and cyclists.
- Overall, it appears that the separated cycle facilities have improved cycle safety in relation to cyclists' interaction with parked cars following the installation of parallel parking spaces. Pedestrian safety outcomes in relation to parked cars are more difficult to ascertain from the data. However, from first principles, it is clear that pedestrians tend to be at higher risk when crossing, and drivers, even those travelling at legal speeds, have their sightlines to the pedestrians obscured by parked vehicles.
- It is noted that to accommodate the separated cycle lane within the 20m wide road reserve, all the cross-sectional elements were at the minimum widths outlined in relevant guidance. This creates traffic and parking lanes narrower that what users of these corridors are traditionally accustomed to, requiring additional situational awareness, particularly when entering or alighting a vehicle from the passenger side (i.e when parked on the right-hand side of these one-way corridors).

8.3 Queen Street, Richmond

Project name: Queen Street upgrade	Location: Richmond, Nelson	Traffic volume: 7,000 vpd Speed limit: 30 km/h	Cycling network: No Bus route: No

Description:

Richmond's town centre is a key commercial hub, with Queen Street being the main street. Figure 8.15 shows the extent of the Queen Street project. Due to severe flooding the main street's stormwater infrastructure needed upgrading. This involved lowering Queen Street's crown and creating a continuous central slot drain to direct water away from buildings, creating a kerbless street, as shown in Figure 8.16. This project allowed a complete redesign of the street to improve streetscape character and amenity and improve safety. The speed limit was lowered from 50 km/h to 30 km/h. Richmond has an ageing population, so it was important to consider accessibility. This resulted in wider footpaths, a flush buffer strip between parked cars and the footpath (Figure 8.17), slower traffic speeds, and power outlets to charge mobility scooters.

The project was between Gladstone Road to the north and Wensley Road to the south as shown below and was completed in 2018.

Figure 8.11: Case study location map

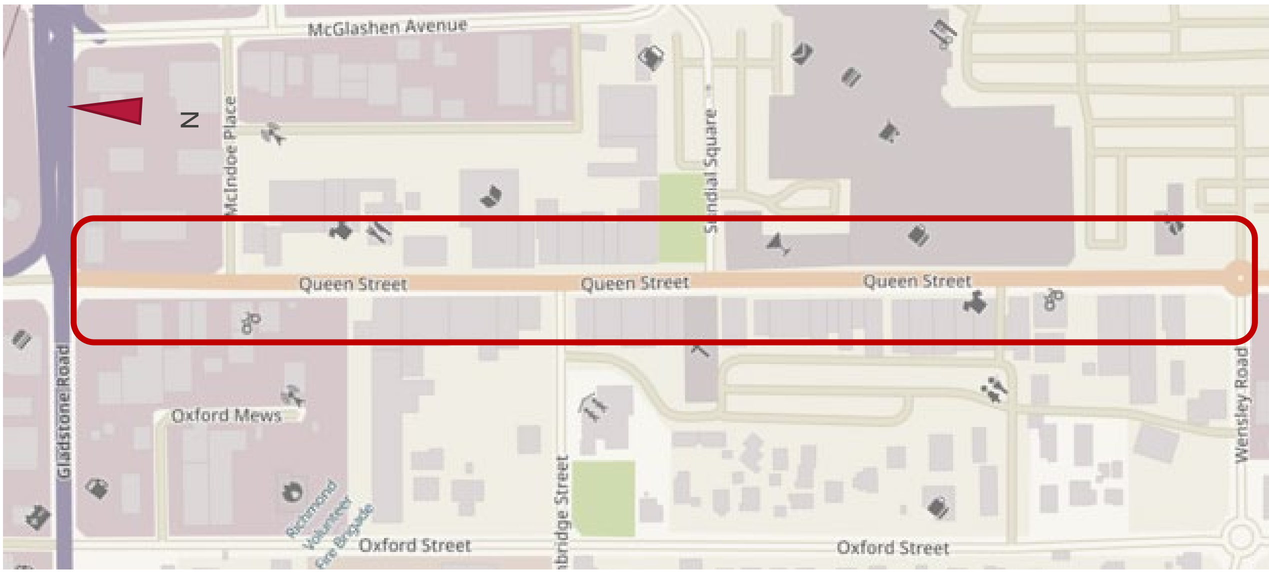


Figure 8.12: Slot drain in the centre of the street with 3 m traffic lanes

Figure 8.13: Flush buffer between the footpath and the parking spaces

Relevance to this research:

This case study is an example of a kerbless street that experienced initial user issues resulting in education and minor design alterations. It also features narrow traffic lanes and on-street parking that could contribute to low operating speeds.

Project name: Queen Street upgrade	Location: Richmond, Nelson	Traffic volume: 7,000 vpd Speed limit: 30 km/h	Cycling network: No Bus route: No

Investigation:

The kerbless street makes all parking spaces accessible and provides a flexible street space for other uses, such as market days.

There was some initial poor driver behaviour associated with the kerbless design. Some drivers were using the footpath to do U-turns, reversing and driving up to a bank ATM. This could be because the 700 mm wide flush buffer strip did not prevent these movements, compared to a standard street kerb and channel. This was putting pedestrians at risk, so a street education programme was put in place. The slogan was 'Queen Street has changed but the rules are the same. No driving on the footpath', as seen in the signage in Figure 8.18, which was used as part of the education programme. It is understood that the instances of poor behaviour have reduced significantly.

A design learning was the detailing of the square garden planters next to adjacent car parking. Many drivers drove over the planter edges, which damaged the corner plants and scoured out the bark. The mitigation strategy was to retrofit steel grates in the corners (see Figure 8.19).

It was also observed that wheel stops have been added in some locations to ensure that parking manoeuvres do not impact street furniture (the example in Figure 8.20 includes a cycle parking staple that has been reversed into). We note that a cycle stand in this exposed location is not going to appeal to cyclists regardless.

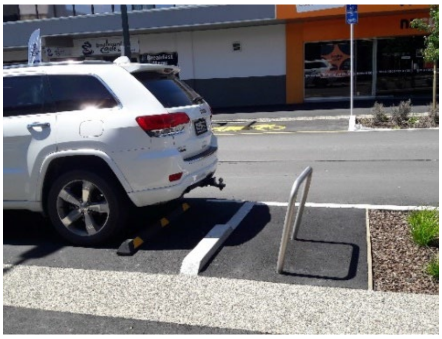
The 3 m wide traffic lanes require cyclists to share the lane; however, no sharrow road markings are present to show where cyclists should ride away from car doors. There is one recorded 'dooring' crash since the project was completed. The crash involved a driver opening their door into a person on an e-bike, causing the rider to fall off and suffer a serious injury.

The configuration of narrow traffic lanes and on-street parking appear to be contributing to an operating speed less than 30 km/h (as advised by the Tasman District Council). Since the project was completed, there have been eight recorded parking manoeuvre crashes, mostly reversing but some as cars were pulling out and scraping passing cars. There were two crashes that involved car doors being opened into the paths of adjacent traffic. Two crashes related to loss of concentration of drivers that resulted in crashing into a parked car and a planter box. These crash types are generally common for busy main street environments but may be accentuated by the narrow traffic lanes. There was one crash where a vehicle went through a front window of a shop on Queen Street. The crash was recorded as 'driver error' and may have been prevented or the severity reduced had kerbs been constructed, thereby preventing an errant driver from overshooting the parking space.

Figure 8.14: Parking education sign

Figure 8.15: Parking/landscaping interface

Figure 8.16: Cycle stand that has been damaged



Findings:

- The operating speed is well aligned with the 30 km/h speed limit, with additional calming effects due to the narrow traffic lanes and on-street parking activity creating greater driver awareness.
- The narrow traffic lanes mean drivers need to be careful opening their car doors as the traffic lanes are shared by cyclists. There has been one dooring crash that resulted in a serious injury. The addition of 'sharrow' markings centrally located within the traffic lane should help cyclists position themselves away from car doors and alert drivers to the presence of cyclists.
- The kerbless design resulted in a few early parking-related design adjustments being made. These are good learnings for future designs. There has been one instance of a vehicle going through a shop front due to 'driver error', but there were no associated injuries. Ultimately, the issue of cars over-running into the footpath could have been a deterrent to walking on Queen Street, so it needed to be addressed.

8.4 Franklin Road, Auckland

Project name: Franklin Road	Location: Auckland	Traffic volumes: 9,800 vpd Speed limit: 30 km/h	Cycling network: Yes Bus route: Yes

Description:

Franklin Road was upgraded for multiple reasons, including poor pavement surfacing, safety for all road users, creating a low maintenance berm, lack of street lighting, improving utilities, and stormwater improvements to separate stormwater and wastewater pipelines. The road provides a vital link between Ponsonby and the central city for all modes. The Auckland Transport (2020) Roads and Streets Framework classification is local place P1 and local/regional movement M2. This could be an activity street from an ONF perspective.

The project aimed to provide safe movement of pedestrians, cyclists and vehicles, whilst retaining as much street parking as possible due to the high demand from commercial and residential properties.

The project was between Victoria Road to the north and Ponsonby Road to the south (as shown in Figure 8.21) and was completed in 2019. Parking bays were created (as shown in Figure 8.22); however, some berm areas have also been used for parking (Figure 8.23).

Figure 8.17: Case study location map

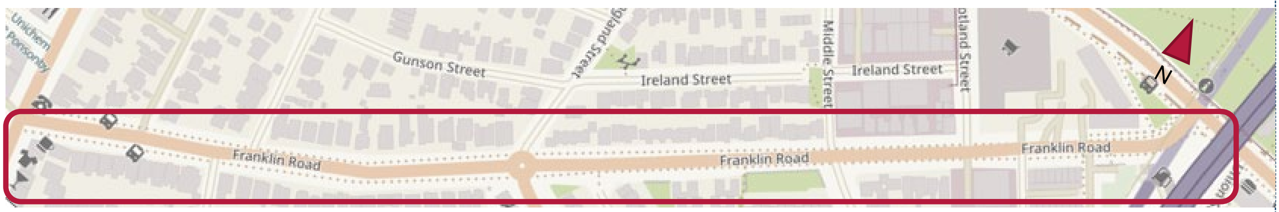


Figure 8.18: Parking bay

Figure 8.19: Illegal parking in a berm

Relevance to this research:

This case study is a good example of a design where parking was integrated between street trees but in a way that caused some unintended parking behaviour that impacted the cycle lanes.

Investigation:

On-street parking needed to be retained given the existing parking demand generated by the commercial and retail activity towards the west (Ponsonby Road) and the residential nature of the street. The consultation process went through many iterations – some with cycle lanes, some without – and multiple discussions were held regarding street parking and how this should be catered for given the significant trees and protection of their tree roots.

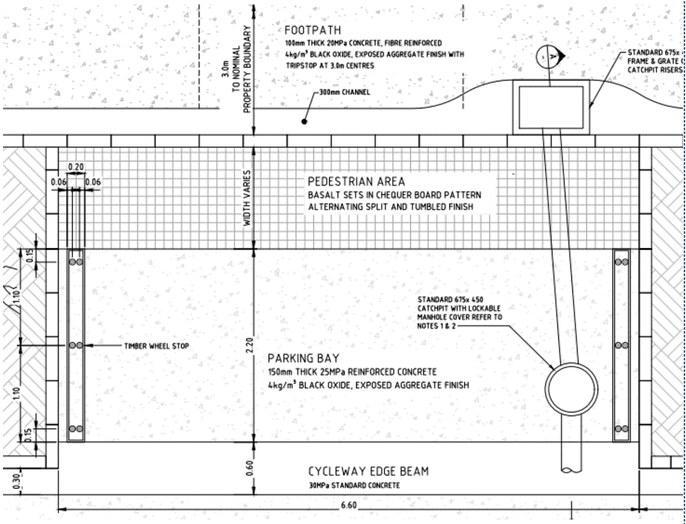
Raised cycle lanes (sometimes referred to as Copenhagen-style cycle lanes) have been introduced with this upgrade on both sides of the road that are raised above the road by 50–70 mm. The kerb is rounded, which makes it easier for people on bikes and vehicles to negotiate when they move from the carriageway to the parking spaces.

Project name: Franklin Road	Location: Auckland	Traffic volumes: 9,800 vpd Speed limit: 30 km/h	Cycling network: Yes Bus route: Yes

Recessed parallel parking bays were created in the berm area (between the street trees). Timber wheel stops are used to ensure vehicles do not track onto tree roots. The parking spaces are of a darker aggregate to the cycleway and footpath colour to differentiate the zone. A concrete cycleway edge beam is intended to be the dooring buffer (see Figure 8.24). Extra bay width is also provided on the passenger side to allow passengers to exit the car away from the footpath. However, the overall extra-wide parking bays have resulted in some illegal parking, and this can encroach on the cycle lane as described below.

Some vehicles are not using the parallel spaces as intended – they are parking on an angle so that two cars can use one parallel space. This results in cars protruding into the cycle lane. Auckland Transport developed signs to show people how the spaces should be used as it may not be clear to drivers how they should park (Figure 8.25). These signs are located along the street.

Figure 8.20: Detail showing cycleway edge beam



Drivers are also using the berm areas for parallel and angle parking.

Due to not disrupting tree roots, parking had to be raised above the pedestrian footpath, this can lead to a pedestrian tripping hazard, especially if leaf fall builds up such that this separation is not noticed (Figure 8.26).

There have been no cycle crashes related to parking since the road was upgraded in 2019. The recorded cycle crashes are generally occurring at intersections due to drivers turning in front of cyclists. Some cyclists have also mentioned cars are also parking in the cycle lane.

Figure 8.21: Parking education sign

Figure 8.22: Parking bay elevated above footpath level

Findings:

- The street design hinged around the protection of the trees and how parking would integrate with these.
- Unintended parking configurations are occurring due to the width of the parking bays. This is likely to be because the design is not standard, therefore people do not understand how to use them but maybe also because people have found a way to use them to maximise the capacity of the space. This behaviour was resulting in potential safety risks posed by the overhanging of vehicles into the cycle lane. The intent of parallel parking may need to be reinforced with paint marking to reduce the risk of vehicles overhanging into the cycle lane.
- Education was required to help address the incorrect parking bay use.
- The issue of accessibility to and from the parking due to height difference that can be hidden by leaves is likely to be an issue for users, particularly those who are mobility impaired.

8.5 Carrington Road

Project name: Carrington Road	Location: Auckland	Traffic volume: 10–15,000 vpd Speed limit: 50 km/h	Cycling network: Yes Bus network: Yes

Description:

The Carrington Road project was between Sutherland Road and New North Road (as shown in Figure 8.27).

The existing road layout is a combination of cycle lanes next to parking with no flush median (Figure 8.28) and next to the kerb with a flush median (Figure 8.29). The Auckland Transport (2020) Roads and Streets Framework classification is highest place P3 and highest movement M3. This could be an urban connector from an ONF perspective.

In April 2022, Auckland Transport consulted on a proposal to install a physical barrier (low profile separator) between motorists and cyclists on Carrington Road to improve cycle safety and experience along this stretch of road. After reviewing all the feedback, the project web page states they are proceeding with the work as proposed.

Figure 8.23: Case study location map

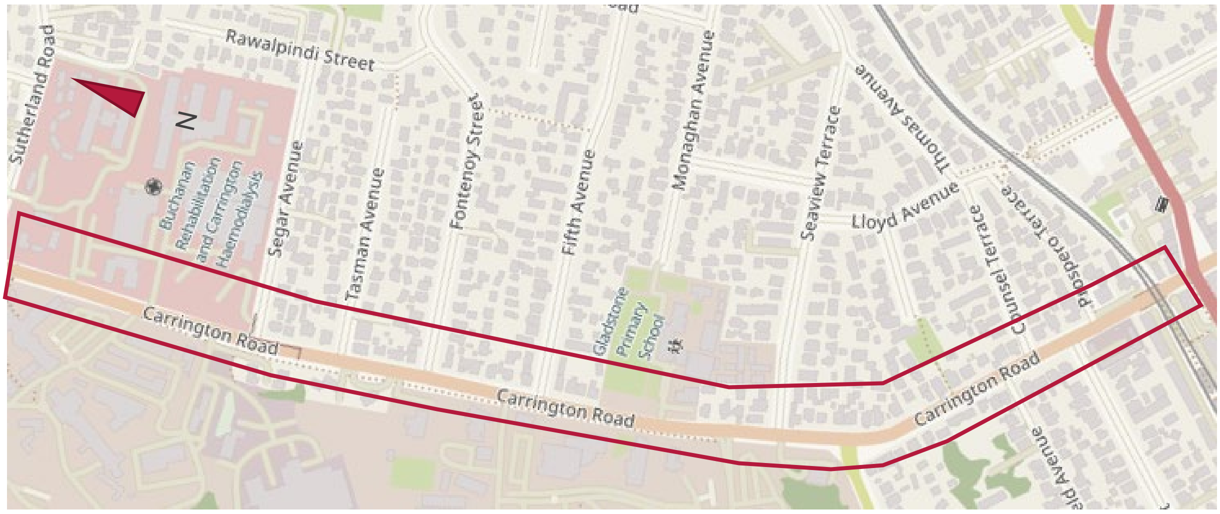


Figure 8.24: Existing cycle lanes next to parking

Figure 8.25: Existing cycle lanes next to kerb

Relevance to this research:

This case study is a good example of how design compromises to accommodate on-street parking and deviate from best practice can have the potential to negatively impact safety and multi-modal outcomes. In this case, it appears that as part of the consultation the design was amended to address this.

Investigation:

The crash records for the last five years show no cycle crashes related to parking. There have been two cycle crashes at the dual zebra crossing and one related to an intersection. None of these have parking as a contributor in terms of visibility. Auckland Transport is currently making changes to the road layout to improve cycling. This involves using low profile cycle lane separators, mostly between the cycle lane and the traffic lane but in some locations between the cycle lane and on-street parking. The project website states that there was concern from stakeholders about the lack of parking and that parking will be more difficult on Carrington Road. However, it is stated that parking has only been removed where required to achieve separation for the cycle lane. This will create a safer environment for cyclists.

Project name: Carrington Road	Location: Auckland	Traffic volume: 10–15,000 vpd Speed limit: 50 km/h	Cycling network: Yes Bus network: Yes

The consultation plans show a 600 mm wide separator at those locations (see Figure 8.30). It appears that following consultation Auckland Transport has undertaken design modifications to ensure that the separator will be of a minimum width that aligns with the CNG.

The proposal includes a section south of Fifth Avenue with car parks on the kerb side with a standard marked cycle lane next to the parking. There was a request from submitters to remove these car parks, or to move them outside of the bike lane, as cyclists will be riding in the door zone. The response was that there is not sufficient road width to provide separation here whilst maintaining the parking, and that any changes to the parking will need to be explored with the school and community to ensure a workable solution is found. This risk has been recognised and is being investigated separately to this project.

It is noted on the plans that some car park locations are very close to intersections (see Figure 8.31) and could contribute to visibility issues for vehicles turning out of the side road. They also appear to create alignment that could create safety issues for drivers. The retention of these car park spaces could be the result of discussions with adjacent landowners.

For this type of street the ideal outcome would be that no on-street parking is permitted.

Figure 8.26: Cross section from consultation plan

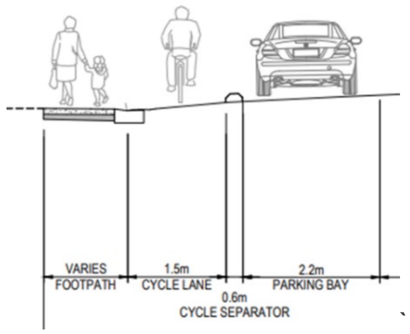
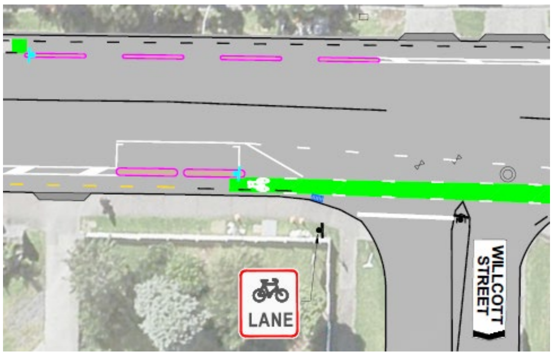


Figure 8.27: Parking close to intersection



Findings

- This project aims to improve the existing cycle lanes with the available kerb-to-kerb road width. This made it difficult to meet guideline widths. Auckland Transport states that the provided widths have been assessed individually to ensure they are still fit for purpose and increase safety for cyclists. Parking has already been removed where absolute minimum widths cannot be achieved.
- The consulted design did not meet the current best practice guidance (CNG) on the cycle lane/parking separator width.
- Although this project is considered an interim treatment, it is important to ensure that dooring and visibility issues related to parking are addressed in the design.

8.6 Mt Roskill Safer Communities

Project name: Mt Roskill Safer Communities Programme	Location: Auckland	Traffic volumes: Vary Speed limit: Varies	Cycling network: Varies Bus network: Varies

Description:

This project involved safety improvements and traffic calming at three streets in Mount Roskill (Carr Road, Frost Road, and Mount Albert Road) along with intersection improvements at the Three Kings Intersection. Some of the proposed changes included removal of on-street parking to contribute to better safety and multi-modal outcomes.

Indented parking outside Mount Roskill Primary School has been removed (with one space retained as a loading zone) and the footpath widened to allow more room for children and parents to walk to and from the school. Some parking was initially proposed to be removed from Carr Road. However, only a few spaces were removed or relocated following engagement with stakeholders.

Several of the proposals are shown in Figure 8.32 and Figure 8.33.

Figure 8.28: Initial concept design of Frost and Carr Road School Zone

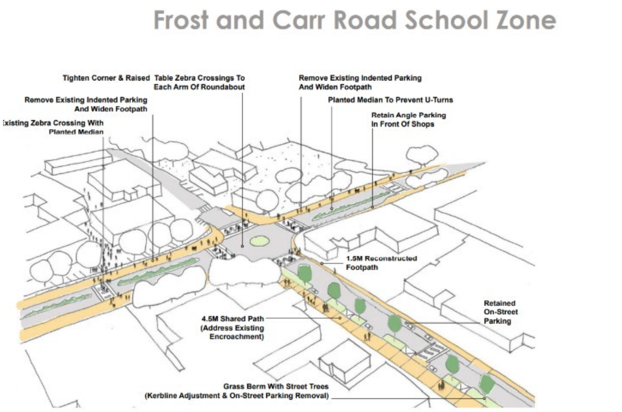
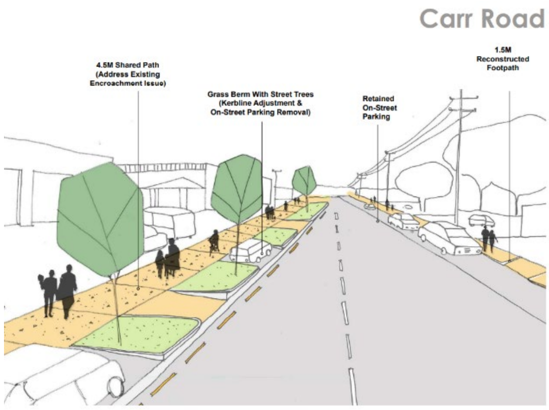


Figure 8.29: Initial concept design of Carr Road



Relevance to this research:

This case study is a good example of how removing parking could enable improved outcomes for pedestrians but in some cases, design compromises may limit multi-modal outcomes.

Investigation:

Auckland Transport carried out community consultation in Mount Roskill regarding the safety of the area for walking. Key themes that arose regarding traffic behaviour included traffic speed and the volume of traffic. Some comments from the community highlighted the difficulty they faced in the morning and afternoon with students needing to walk between cars at intersections. Some community members commented on removing parking near the schools to make crossing the road safer. Figure 8.34 shows where the crossing has been improved by parking removal.

With the removal of parking outside the schools on Frost Road, there are fewer vehicle movements directly outside the school, making it a safer, more predictable environment for students accessing the school. The removal of parking also improves sightlines to the footpath so motorists and children can see each other on approach. It is important to have this line of sight as children can behave unpredictably. However, this parking removal is a trial using planter boxes (Figure 8.35) to assess whether removing the pick-up/drop-off area creates additional issues. To mitigate the loss of a pick-up/drop-off area during the trial, Auckland Transport engaged with the schools and

Figure 8.30: Where indented parking was previously located on Frost Road outside Mount Roskill Grammar School

Project name: Mt Roskill Safer Communities Programme	Location: Auckland	Traffic volumes: Vary Speed limit: Varies	Cycling network: Varies Bus network: Varies

families to identify three streets where caregivers could park and walk 5–10 minutes to the school.

Carr Road is an industrial area that some community members found difficult and unsafe to cross. The typical road layout is shown in Figure 8.36. There are generally incompatible land uses around Carr Road and Frost Road. Carr Road is industrial, with three schools immediately to the west on Frost Road (Mount Roskill Primary School, Mount Roskill Grammar School, and Mount Roskill Intermediate School). The proposed design for Carr Road took this into account, and some on-street parking was removed to widen the footpath to make it a shared path and improve the amenity of the street. The issue of parking removal was heavily contested by the businesses on Carr Road, which resulted in further engagement to adjust the design such that the loss of parking was reduced. In the end, only a few spaces were removed or relocated to accommodate raised crossings.

The footpath on Carr Road was widened to a lesser extent than initially proposed. It was widened such that encroachment issues could be resolved, and a few parking spaces were removed. This meant that the footpath could not be turned into a shared path. Though the Mount Roskill Safer Communities project was initially described as having a high potential for mode shift, this design does not enable or encourage cycling along Carr Road.

Figure 8.31: Parking removed on Frost Road outside Mount Roskill Grammar School

Figure 8.32: The existing Carr Road layout

Findings

- Land use conflicts such as industrial zones being adjacent to schools creates major conflicts between different road users. These conflicts are heightened by the number of vulnerable road users who travel through the industrial area to access their schools. Therefore, it is important that walking and cycling safety is managed through the industrial street.
- The proposed removal of parking on Carr Road would have enabled the footpath to be used as a shared path and enhance the streetscape. The removal of parking on Carr Road was heavily contested by the businesses on Carr Road, which led to the path being widened to a lesser extent. This meant that streetscape improvements could not take place.
- The parking that has been removed from Frost Road has been done so with temporary planter boxes. Removal of this parking creates a more predictable environment for students crossing the road, and it improves sightlines between pedestrians and motorists, which enables safer crossings.

8.7 Case study conclusions

The case studies identified a number of themes, as discussed below.

8.7.1 Re-allocating space on existing streets

In several of the case studies the initial designs removed some on-street parking to accommodate space for cycling. In each case the businesses on those streets were concerned about how this would impact their businesses – generally they saw this as a negative impact. This then resulted in a change to the design with car park spaces added back into the design, which has the potential to result in suboptimal design outcomes that don't align with Vision Zero, such as in the St Asaph Street case study.

- The retention of parking on the south side of St Asaph Street created visibility issues for drivers turning left into driveways seeing cyclists on the inside of the parking. Although the CNG was adhered to, there still appears to be concerns from road users, and additional risk-mitigation strategies have been added to the design over time. This indicates that a review of the setback requirements is warranted, which could involve reviewing a range of cycleways that have been implemented since the CNG was developed to ensure they are fit for purpose and aligned with Safe System principles for the protection of vulnerable road users. The Dunedin SH1 case study was similar to St Asaph Street in terms of design but does not appear to have had the same challenges with driveway visibility.

8.7.2 Road user behaviour

Two of the case studies found that unexpected driver behaviour resulted from designs that the public is not used to. Some of the behaviours can be addressed through design changes, and some required road user education.

- In the case of Queen Street, the kerbless street had initial issues with people parking over the footpath and undertaking U-turns that encroached on the footpath. This required an education campaign, and the issues appear to have settled down. Some parking over the flush gardens was causing damage, which was addressed using simple design changes.
- In the case of Franklin Road, the wide indented car park bays between the trees have been used as angle parking, and this has resulted in vehicles encroaching into the cycle lane. Education with road users was required.

8.7.3 Safety and design risk-mitigation strategies

In several of the case studies, some of the risk-mitigation strategies outlined in chapter 7 were identified as a way to improve the safety outcomes.

- In the case of Queen Street, the use of sharrow markings would help communicate to cyclists and to drivers that cyclists need to ride away from the parked car doors, hence reducing the risk of dooring crashes (noting that one serious crash has occurred since the street upgrade was completed).
- In the case of Franklin Road, the wide bays could be marked as parallel parking spaces to help communicate to drivers that they should not be parking on an angle and therefore reducing the risk of them overhanging into the cycle lanes and hence creating a pinch point for cyclists that may put them into the traffic lane.

9 Conclusions

9.1 Impacts of on-street parking on road safety

While the CAS data analysis found that slightly more of the DSIs relating to parking were vehicle occupant related, more of the fatalities were related to vulnerable road users. In addition, the number of interactions that vulnerable road users have with parked vehicles is likely to be far lower. Therefore, in terms of the individual risk, parking seems to have a far greater risk to pedestrians, cyclists and motorcyclists. The Safe System approach puts greater focus on these road users because of their vulnerability and the higher likelihood for them to be killed or seriously injured if a collision occurred.

There are several clear causes for parking-related DSI outcomes in New Zealand that could allow a focus for improvement in how we design our streets, and also how we might influence driver behaviour, that could contribute to the Road to Zero goal of a 40% reduction in these outcomes. The causes are:

- car door opening into cyclist's path (this issue is also clearly noted in the literature review as a key risk for cyclists in relation to parking)
- cyclists colliding with parked cars
- pedestrians crossing the road from the driver's left side and being struck by the vehicle because their visibility is obscured by parked cars.

It was found that determining the total number of crashes caused by a parked vehicle limiting visibility is hard to quantify given the number of CAS factor codes used for this scenario. It is also likely that crashes due to parked cars limiting visibility are not reported as such at all. Therefore, crashes due to limited visibility are likely to be under-reported.

9.2 Impact of on-street parking on achieving multi-modal outcomes

As well as from the safety issues found to be related to on-street parking, there are other parking issues that can impact achieving good multi-modal outcomes.

Illegal parking behaviours can create issues for people using cycle facilities and footpaths (particularly those with mobility impairments). Road user rules or bylaws are generally in place, but enforcement of the rules is problematic. Unless an RCA observes a parking infringement or is informed of one through a complaint, the rules are generally not enforced. Although not investigated in the research, it is likely this kind of inconsiderate parking behaviour could impact people's choice to walk.

The research found that cyclists feel less safe riding in places where there are parked cars, even if there is a bicycle lane. This can contribute to people choosing not to cycle.

A key concern for bus users is when a bus cannot pull in parallel with the kerb and there is a wide gap between the bus door and footpath. This issue can be caused by on-street parking hindering the bus entry to the bus stop.

9.3 Relationship between parking management, street design and speed management in New Zealand

A range of factors can contribute to reducing parking-related crash risk. At a system level this includes parking management, street design and speed management.

Good parking policy and management can contribute to better safety and multi-modal outcomes. For example, reducing parking search circulation reduces exposure to crash risk. Parking management can also guide where on-street parking is located through a parking space hierarchy that prioritises the types of parking in different areas or street types. This can support using the road space for other uses such as cycle facilities.

Removal of parking to achieve better safety and multi-modal outcomes will need to be balanced with the removal of minimum parking requirements for developments; in particular, residential development, as this is likely to increase on-street parking demand as it may be relied on more when developments do not provide on-site parking. Street design and parking management plans will need to consider this. Opportunities when developing requirements for new roads are that widths could be designed to allow for both safety and multi-modal outcomes and appropriate parking supply.

There are various ways that parking can be provided within a street, each having advantages and disadvantages depending on the context. When people are designing streets, they have a range of aspects related to parking to consider as part of the parking layout decision, including the role of the street, speed management, traffic characteristics, space available and external factors. Good street design can reduce the likelihood of a crash. Safe System audits (Waka Kotahi, 2022d) are undertaken for RCA and land development street designs (to be ultimately vested in RCAs) in New Zealand. This process should capture any parking-related safety issues and can be used by RCAs to engage with stakeholders lobbying for a design that creates a suboptimal safety outcome.

The ONF-DD guide and the AUSPDG include some parking design information, but this could be supplemented with more detail, including examples of parking layouts for each street family. A table of parking layouts and likely ONF contexts has been developed as part of this research. A version of this table could be integrated into the ONF guidance to support design processes.

The Speed Management Guide currently only mentions speed concerns for parking on urban connectors, but overall, the application of SAAS will assist with some of the safety issues arising from parking. Speed reduction can address severity (even where parking is causing visibility issues).

9.4 Safety and design risk-mitigation strategies

Integral to the decision-making process of parking layouts are what safety and design risk-mitigation strategies are available to help improve road safety and multi-modal outcomes. A range of existing and potential strategies have been identified. Cyclist safety issues have the greatest number of strategies due to their risk in a range of cycle facility and parking layout scenarios.

Current New Zealand guidance in relation to parking is integrated into modal-specific guidance with particular attention given to pedestrian and cyclist safety. There is some inconsistency in the design guidance for parallel parking in New Zealand.

Many of the issues raised in the research generally relate to insufficient space for all modes, including parking. This is a function of the existing standard carriageway and corridor widths in New Zealand. Addressing this involves design standards for new roads with consideration of what needs to be catered for on the range of street types.

The next chapter contains a range of regulatory, driver behaviour, safety campaign and design guidance improvement recommendations to help address safety issues and contribute to better multi-modal outcomes.

10 Recommendations

The following recommendations have emerged from the research.

10.1 Legislation/regulatory recommendations

10.1.1 Addressing road space allocation decisions that are not considered to provide a Safe System

The case studies identified that designs that remove parking to achieve road safety and multi-modal outcomes can be influenced by stakeholders to the point that the design is changed and potentially compromised. This is a common issue, and regardless of how much information is provided to the decision makers, the design can be overridden by the external influences. This can be despite processes such as road safety audits raising serious or significant safety issues, and even recommendations from the Cycling Safety Panel that parked cars create a number of hazards for cyclists and that RCAs should progressively remove parking from arterial roads where it is a safety risk. The research has not identified a definitive solution to resolve this issue. It is likely that a range of measures will be needed; however, the Safe System audit is the most commonly used and required measure, so it has the greatest potential to influence design outcomes.

It is recommended that legislation affecting decisions on road space allocation include a requirement that such decisions are subject to a Safe System Audit, to ensure that any safety risks associated with on-street parking are considered and mitigated as appropriate.

10.1.2 Infringement fines

The financial scale of infringement fines for parking are set by the New Zealand Government (Land Transport (Offences and Penalties) Regulations 1999). At present, the magnitude of fines is generally perceived by the public to be low, and therefore people often risk violation due to the low-scale financial penalty. However, it is acknowledged that the scale of the fines is not the only factor influencing behaviour; the low risk of the infringement being enforced is also likely to be a key factor.

It is recommended that fine levels for infringements that negatively impact safety are increased to influence people's decisions about how and where to park and hence reduce the risks associated with parking violations on other users.

10.1.3 Road User Rule – No-stopping restrictions at intersections and pedestrian crossings

The legal requirements of the distance that parking is prohibited either side of intersections, driveways and pedestrian crossings are significantly less than the geometric design requirements defined in best practice guidance. This is becoming more important as vehicle sizes increase. The restrictions would need to be marked as no-stopping lines.

It is recommended that a review is undertaken of the legal requirements of the distance that parking is prohibited either side of intersections, driveways and pedestrian crossings.

10.2 Speed management

10.2.1 Ensure speeds are safe and appropriate for the context

It is important the recommendations in the Speed Management Guide are implemented to support better outcomes in relation to safety associated with parking (noting that the current guide is generally silent on the issue of parking).

It is recommended that the Speed Management Guide be updated to recognise parking configurations for all ONF types and associated speed considerations.

10.3 Design guidance recommendations

10.3.1 NZTA overarching frameworks

At a high level, the ONF-DD guide and the AUSPDG include some parking design information, but this could be supplemented with more detail, including examples of parking layouts for each street family. This could include a recommendation that parking on some roads is not appropriate because of the safety implications (as per the Cycle Safety Panel recommendation). The Speed Management Guide currently only mentions speed concerns for parking on urban connectors, but overall, the application of SAAS will assist with some of the safety issues arising from parking. This could be discussed in the guide.

It is recommended that when the NZTA ONF-DD guide, the AUSPDG and the Speed Management Guide are next updated, they reflect the findings of this research with respect to parking design and safety outcomes.

10.3.2 District plans/Codes of practice

District plans and codes of practice in New Zealand generally do not have requirements for new roads that align with the ONF modal outcomes and consider the need for sufficient space for all modes, including parking where it is to be provided. Mitigating this involves developing design standards for new roads, which may include wider road corridors and wider carriageways that reflect catering for the modes relevant to the road type.

It is recommended that district plans and codes of practice have requirements for new roads to align with the ONF modal outcomes and consider the need for sufficient space for all modes, including parking where it is to be provided.

10.3.3 TCD Manual Part 13 – Parking

It is recommended that TCD Manual Part 13 is updated, with specific matters below being part of the update:

- Include guidance for parking on kerbless streets, and point out any user education that may be required to support the safe and appropriate use of the street.
- Include guidance on indented parking bays in terms of geometry to allow safe access and egress, and to avoid parking bays being used incorrectly for angle parking.
- Update guidance on parallel parking space widths to align with TCD Manual Part 5.
- Clarify where a buffer next to parking would be appropriate.

- Add guidance for different sized vehicles (such as campervans), as larger vehicles can obstruct visibility if parked inappropriately.
- Update to include angle parking design guidance regarding the impacts on pedestrians using the footpath, and include reverse-in angle parking guidance.

10.3.4 Cycling Network Guidance

It is recommended that the CNG is updated with respect to the specific matters below:

- Strengthen the cycling network planning guidance with regard to not providing parking where a defined cycle route is provided or at least where on-road cycle lanes are to be provided.
- Align the CNG with the ONF and the Speed Management Guide.
- Provide guidance in relation to parking restrictions at cycle bypass facilities and other merge zones.
- Provide guidance on cycle lane transitions to no cycle lane to ensure parking does not create an unexpected obstruction/pinch point.
- Provide guidance on restricting parking on bends where lateral width for cyclists reduces, forcing them into the path of conflicting vehicles.
- Provide further and stronger guidance on appropriateness of parking next to contra-flow cycle lanes.
- As noted in the CNG, further research into buffered cycle lanes is required to refine marking for door risk mitigation.

10.3.5 Pedestrian Network Guidance

It is recommended that the Pedestrian Network Guidance is updated with examples of effective and non-effective kerb buildouts in relation to intervisibility between pedestrians and drivers.

10.4 Behaviour change/safety campaign recommendations

10.4.1 Car door opening method (to address dooring of cyclists)

It is recommended that the left-hand (Dutch Reach) method, already in the Road Code, is promoted through publicity campaigns, added to the defensive driving course and added to the driver licensing process (eg, the multichoice quiz).

10.4.2 Cycle skills training

It is recommended that cycle skills training includes (if not already) the awareness of car door opening and lateral positioning when riding in cycle lanes and shared traffic lanes.

10.4.3 Industry planning and design training

It is recommended that transportation practitioners and street designers (including landscape architects and urban designers) are informed of the findings of this research and the design recommendations, as the findings are likely to take some time to be included in the respective legal requirements or guidance documents.

10.5 Data recording to support ongoing monitoring of safety related to parking

10.5.1 CAS data

It is recommended that the CAS data fields record the type of vehicle (car vs SUV etc).

10.5.2 ACC data

It is recommended that ACC makes a clear differentiation between on-street and off-street parking-related accidents.

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