Towards a safe system for cycling

Development and application of a cycling safety system model
Preparing New Zealanders for utility cycling

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H Mackie, G Hawley and R Scott, Mackie Research & Consulting
A Woodward, University of Auckland, School of Population Health

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NZ Transport Agency
Private Bag 6995, Wellington 6141, New Zealand
Telephone 64 4 894 5400; facsimile 64 4 894 6100
research@nzta.govt.nz
www.nzta.govt.nz

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An important note for the reader

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Abbreviations and acronyms

CREAM	Cognitive Reliability and Error Analysis Method
DREAM	Driving Reliability and Error Analysis Method
FRAM	Function Resonance Accident Model
HFACS	Human Factors Analysis Classification System
MoT	Ministry of Transport
ONRC	One Network Road Classification System
SNACS	SafetyNet Accident Causation System
STAMP	System-Theoretic Accident Model and Processes
Transport Agency	New Zealand Transport Agency

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Executive summary

Research purpose and objectives

Making urban cycling a safer and more attractive transport choice is now a NZ Transport Agency ('the Transport Agency') strategic priority, in growing recognition of the health, environmental and congestion benefits of cycling. However, unless a safer system for cyclists is developed, it is likely there will be an increase in cyclist road trauma with increased investment and promotion.

The purpose of this research was to a) identify key cycle safety interventions through the development and application of a cycling safety system model (Part A); and b) develop a cycling competency system model and provide guidance on how best to prepare New Zealanders for riding on the network (Part B). This research was carried out from October 2015 to June 2016.

Part A: Development and application of a cycling safety system model

There are now several studies that estimate transport cycling risks and describe cycling casualties; commonly cited risk factors are intersections, older people, males, heavy vehicles, high-speed roads, drivers failing to notice cyclists and cyclist errors. However, the NZ Cycling Safety Panel's recommendations in *Safer Journeys for people who cycle* explain, in addition to immediate situational factors such as road users, the environment and vehicles, broader system elements distal to immediate crash situations need consideration within a safe system approach.

Moving beyond describing the characteristics of cycling casualties, there is an emerging research emphasis on applying 'systems thinking' models and methods to the road safety domain. Incident analysis methods such as the Haddon Matrix, Human Factors Analysis Classification System, AcciMaps and STAMP have been used to analyse adverse events in other safety critical domains, and have recently been applied to road safety.

In this study, the most relevant aspects of contemporary incident analysis methods were used to develop a cycling safety system model and analysis method. Road safety stakeholders provided comment on a draft model, which was subsequently revised. The model was then used to analyse three cycling fatality crash types (cyclist turns into the path of vehicle, cyclist hit from behind and cyclist hit by car door and falls under truck), derived from 30 actual fatal cases. The 30 cases were matched with earlier descriptions of cycling casualties that have happened in New Zealand between 2006 and 2015.

Fatal crash information, expert workshops and document review were then combined to create 'causation pathway analyses' which showed how aspects of the system had failed for each crash type. Related current and proposed mitigating initiatives were also identified.

Examples of key areas for improvement include:

- a clearer story about the benefits of cycling in New Zealand's future mobility system
- better integration of walking and cycling requirements into speed management initiatives
- identifiable and user friendly rural cycling routes
- designing infrastructure and training to address cyclist speed
- more involvement by the cycling industry in cycling safety
- a range of initiatives to address cycling/heavy vehicle interactions

- well understood 'standard operating procedures' for motorists and cyclists within an improved cycling skills training system
- addressing road infrastructure that affords unsafe road user behaviour and cycling crashes in the way it is designed.

With some modification, application of contemporary incident analysis methods to cycling fatalities has proven useful in moving beyond describing the characteristics of crashes, to obtaining a deeper and broader understanding of causal factors. Many factors within all levels of the cycling safety system have been identified as problematic by the sector and this information could help prioritise effort.

Building on the methods explored within this study, a key recommendation is to develop crash analysis methodologies that take a broader view of causal factors across the road safety sector. Safe system interventions at all levels can then be planned, dovetailing with the Transport Agency's investment selection processes.

Part B: Preparing New Zealanders for utility cycling

The Transport Agency required guidance on a best practice 'cycle skills training system' which results in: confident, skilled and courteous bike riders, who know the road rules and use techniques to keep themselves and others safe; and significantly increased numbers of people cycling to school (under 18 component); and, increased numbers of people cycling for utility purposes (18+ component). While investment in infrastructure that supports cycling is of upmost priority, strengthening the approach to cycle training and education, in conjunction with other measures is also warranted under the 'Safe road use' pillar.

A literature review was undertaken focusing on: the rationale for cycle training; the skills, knowledge and attitudes needed to ride on the network (including on facilities such as shared paths); the effectiveness of cycle training; and the current reach and approach to cycle training in New Zealand. Semi-structured interviews were undertaken with 44 stakeholders and end users (cycle training funders and providers, road safety professionals, schools, parents/caregivers, school students and other adults). The interviews were complemented by an online survey for people who rode a bike or who were interested in doing so. Key findings from the literature review and qualitative research were combined to form of a cycling competency system model, as well as accompanying critical success factors and recommendations. This approach provided the balance between evidence from the literature and the factors perceived as practically and contextually significant for New Zealand.

Evidence for a causal link between cycle training and improved cycle safety or increased cycling participation is limited, and training programmes may not always have the expected positive outcomes. However, cycle training approaches can reduce individual cycling competence as a barrier to cycling, improve knowledge of key safety behaviours and be a channel for promoting the benefits and normalisation of utility cycling. Similarly, cycle training as part of a wider behaviour change approach, including development of cycling infrastructure, shows some promise. In fact, evidence is emerging that educational and promotional initiatives may be necessary to 'activate' use of cycling infrastructure.

There are some well-established cycle training programmes in New Zealand that focus on developing the cycle skills of participants. There are also examples of more innovative approaches, which dually aim to develop skills and encourage cycling. However, the need for consistent, coordinated and more comprehensive approaches that are underpinned by pedagogical principles, the involvement of families, the need to provide more experience riding 'on the network' and the opportunity for all New Zealanders to ride from a young age, are examples of critical gaps. Similarly, while 'formal' cycle training is valued by some end users, there is a large proportion of the population, particularly adults, who may be unlikely to attend a cycle training course. Therefore, thinking about innovative ways to support the development of cycling competencies in this group is important.

The cycling competency system model developed through this work presents the development of cycling competencies as a process, requiring multiple initiatives and channels to create touch points and the habitualisation of key safety behaviours. A focus on cycling 'competency' replaced the focus on cycle 'skills', as this more effectively represents the set of knowledge, skills and attitudes required to ride a bike for utility trips. The model describes how traditional cycle training may need to be combined with other formal and informal education approaches (eg supervised riding with parents), for individuals to reach the required level of competence. Similarly, the model presents how training initiatives may need to be combined with cycling infrastructure, cycling promotion, spaces to ride and positive community perceptions of cycling to ultimately contribute to cycling uptake. Going forward, there is a need to evaluate this more comprehensive approach, with greater consideration of the context in which training is delivered.

Critical success factors and recommendations were developed in order to operationalise the cycling competency model, and align cycle training in New Zealand with good practice. Key recommendations are:

- Consider the whole system of people, initiatives and places that could contribute to preparing New Zealanders to ride for transport and utilise the cycling competency system model to identify gaps and opportunities.
- Develop cycle training and education initiatives in conjunction with other safe system measures.
- Develop opportunities to ride a bike from a young age, in order to create a solid foundation of New Zealanders who can ride a bike and who enjoy riding a bike.
- To be consistent with road safety education guidelines, cycle training approaches in schools need to be based on principles of effective teaching and learning.
- Examine ways to improve parent and family engagement in formal training, as well as ways to encourage parents to ride with their children, ie supervised practice or informal training.
- As part of the system, increase the proportion of 'on-road' or 'on the network' formal training.
- Develop a nationally consistent and robust approach to evaluating cycle training and education initiatives, including quality assurance processes.
- Re-examine the content in the current Cycle Skills Training Guidelines (or future iterations) related to: route-selection, the clarity of share the road and pathway messages; managing speed on a bike; reinforcement of head checks; and riding safely around heavy vehicles.
- Consider different aims of cycle training depending on the context (eg initiatives as part of a behaviour change package to increase cycling, initiatives to prepare New Zealanders for transport cycling in the future, and initiatives targeted at high-risk cycling situations or groups).

Cycle training and wider cycling education in isolation is unlikely to have a widespread effect on the safety or mode choice of New Zealanders; however, high-quality cycling education delivered as part of a package of safe system measures, and coordinated with other behaviour change approaches, may be a necessary piece of the overall puzzle.

Overall conclusion

This research provides: an improved understanding of the root causes of cycling crashes; and a method for future application to cycling safety, and road safety more generally. Critical gaps in New Zealand's current approach to cycle training are presented with recommendations for the development of a more comprehensive and coordinated approach. These two different, yet complementary pieces of work, are important elements of proactive approach to make cycling 'safer and more attractive'.

Abstract

Making urban cycling a safer and more attractive transport choice is now a NZ Transport Agency strategic priority. Currently, road trauma for cycling is lower than other modes; however, unless a safer system for cyclists is developed, including more effective cycling education, an increase in road trauma is likely with increased investment and promotion. The research first identified key cycle safety interventions through the development and application of a cycling safety system model. The development of this model, a first for New Zealand, was informed by contemporary models of crash causation, which examined distal and proximal crash causation factors. Key findings were the need for a strong mandate and strategic direction for cycling, and improved systems to provide for cyclists in road design. Second, the report provides guidance on how best to prepare New Zealanders for utility cycling, drawing on key literature and engagement with stakeholders and end users. The need for consistent and comprehensive approaches, involving a variety of initiatives and touch points over the course of people's lives, were indicated. Together, these two distinctly different, yet complementary, pieces of work provide actionable recommendations that can improve safety for cyclists and facilitate increased cycling uptake.

1 Background to the research

1.1 Research purpose and objectives

Making urban cycling a safer and more attractive transport choice is now a NZ Transport Agency strategic priority. A recent study, as part of growing evidence for significant cycling benefits, demonstrated that a ‘global high shift scenario’ for cycling could save society US$24 trillion cumulatively between 2015 and 2050, and significantly cut CO2 emissions (Mason et al 2015). However, unless a safer system for cyclists is developed, an increase in road trauma involving cyclists is likely to accompany any cycling growth and cycling uptake will not reach its potential.

In 2014, the NZ Cycling Safety Panel was established to examine the risks and causes of cycle crashes in New Zealand and recommended a suite of actions to improve cyclist safety. During this process, a better understanding of crash causation was recognised as a significant gap. Part A of this report addresses this by outlining and applying contemporary incident causation methods to better understand cycling casualties.

Competent cyclists, along with better cycling routes, are a key component of an overall system for safe and attractive cycling, and there is a need to improve the consistency of and overall approach to cycle training in New Zealand. Part B focuses on the development of a cycling competency system model, and guidance to achieve this, drawing on available evidence and the expertise of stakeholders.

The purpose of this research was a) identify key cycling safety interventions through the application of a cycling safety system model; and b) provide guidance on a cycling skills training system that provides positive outcomes for cycling.

The objectives of the research were to:

- review literature that identifies cyclist risk, methods of evaluating risk, evidence for cycling risk mitigation and evidence for components of a cycling skills training system
- develop a cycling safety system model and data collection method for cycling casualties
- collect cycling casualty data, and apply a cycling safety system model to previous cycling crashes, identify system failures
- complete a cycling safety system analysis with connected recommendations for cycling safety interventions
- identify critical success factors for cycling training for children, youth and adults
- provide guidance on a cycling skills training system, which includes design, delivery and evaluation components.

This report is subsequently divided into two distinct parts: Part A, which deals with a cycling safety system and Part B, with a cycling skills training system. For readability, the term ‘cyclists’ is used in this report to describe ‘people who cycle’, in a similar manner to how the term ‘drivers’ or ‘motorists’ is used to describe ‘people who drive’. These terms do not aim to undermine or dehumanise road users in any way.

PART A: DEVELOPMENT AND APPLICATION OF A SAFETY SYSTEM MODEL

2 Introduction to Part A

Large improvements in road safety over recent decades have come about through vehicle, road and other improvements, but many countries including New Zealand are faced with persisting road safety problems. There are extensive personal, social and financial costs associated with road trauma; in 2014 in New Zealand, 295 people were killed and 3,667 seriously injured, with social costs of $3.47 billion (MoT 2016).

Cycling safety is relatively unique in that cycle fatalities only account for 3.4% of all road fatalities in New Zealand and 6.5% of injuries (MoT 2015a). However, allowing for the risk of serious or fatal injury per kilometre travelled it is relatively risky compared with other modes and there has been a groundswell of support for cycling safety, particularly following a recent spike in cycling fatalities. At the same time, like many other countries, there is recent evidence of an increase in cycling (Gravitas Research and Strategy 2015) although regional and national estimates using different methods may differ. This unique situation presents an opportunity for New Zealand. In the face of growing cycling numbers, instead of permitting deaths and serious injuries to accumulate alongside increased participation, a proactive approach could be taken to prevent future trauma among those who cycle. This would represent a fundamental departure from the current road safety approach which tends to be backward looking, and determines priorities on the basis of historical deaths and serious injuries.

In the Netherlands, despite being one of the safest countries in the world from a road safety perspective, approximately 185 cyclists were killed in 2014 (Statistics Netherlands 2015) due to the enormous numbers of cyclists who interact with the road system on a daily basis. While a ‘safety in numbers’ effect may exist, without concerted efforts to make cycling inherently safe, a greater number of cyclist fatalities and serious injuries can be expected in New Zealand with increased cycling participation.

Cycling injuries can strongly affect perceptions of cycling safety which in turn affects cycling participation (Macmillan et al 2014). This means that actually and perceptually dangerous cycling environments can limit the health, environmental, congestion and other benefits that cycling brings, which are potentially very large (Mason et al 2015). Although cycling safety is the main focus of this report, there is a clear and inextricable link between cycling safety, participation and the benefits that come from it. This makes it all the more important that a systematic approach is taken for cycling safety.

Such changes are underway. The recommendations of *Safer Journeys for people who cycle* (Cycling Safety Panel 2014) explain that broader system factors distal to immediate crash situations, such as a lack of strategic and fiscal emphasis on cycling, a relatively untrained engineering workforce across the country for implementing best practice cycling facilities and inconsistent adherence to standards, need to be considered in addition to more obvious situational factors. Reason’s (1990) ‘Swiss cheese’ model was introduced in the Cycling Safety Panel recommendations under the broader title of ‘Taking a safe system approach’. However, it appears that the next steps to address these system factors are relatively ad hoc and are not nested within a structure showing how these contributing factors are ultimately important for cycle safety (or wider road safety), or how road controlling authorities might begin to address them.

The approach taken by the Cycling Safety Panel fits well with New Zealand’s safe system approach and in particular the principles ‘Whole of system approach’ and ‘People make mistakes’. However, while New Zealand’s (and other countries’) interpretation of the safe system approach infers a need to consider all parts of the road safety system to improve road safety, very little direction is provided about the system itself and what methods, focusing on the wider system, should be used to help improve road safety (Salmon and Lenné 2009). The concept of 'shared responsibility' is also important; unless the various actors in the safety system are understood, along with their lines of influence, then it is difficult to know who is responsible for cycling trauma, and reducing it.

An example of how 'systems thinking' has not extended into 'systems practice' is how the causes of crashes are determined. In New Zealand and in most other countries, the causes of road casualties are determined through on-scene investigations and police reporting, which provide some understanding of immediate crash causal factors, but a limited understanding of a fuller range of influencing factors and how they came together to result in a casualty.

Although some system factors are typically considered, eg road user errors, vehicles and immediate environmental factors, there is much less emphasis on indirect factors such as policies, practices and organisational influences. This may be an appropriate focus when the police are seeking to determine who is culpable in a crash; however, the higher level yet relatively more influential 'levers' that ultimately affect environmental form and road user behaviour are often overlooked. For cycling casualties, this is made worse when analyses are based on incomplete and biased crash data (Tin Tin et al 2014).

Looking to the health and safety sector, a key turning point for 'systems thinking' in New Zealand came, sadly, with the Pike River Mine tragedy. Twenty-nine men were killed when the Pike River Mine exploded following methane build up. Although there has been a lot of attention in occupational health on the upstream causes of injury and disease, the Pike River tragedy provided a turning point, along with earlier events such as the Mt Erebus disaster, away from workplace fatalities being treated as the fault of front-line staff and the immediate situation within which they operate. The enquiry into Pike River took advice from human factors experts. Reason's Swiss cheese model (explained later) was introduced to help explain that latent conditions, including financial pressure for the mine to be profitable, created the conditions from which more direct errors would emerge, such as a lack of safety systems (Royal Commission on the Pike River Coal Mine Tragedy 2012; Macfie 2013). The subsequent recommendations focused strongly on higher level system factors such as legislation, regulation and codes of practice, reflecting a comprehensive understanding of how disasters like this typically played out. There are lessons here for road safety and more specifically cycling safety.

The main objective of the next chapter is to briefly review available literature to identify key considerations for a cycling safety model and provide a framework for analysing fatal cycle crashes, ultimately to identify areas that could be improved to make cycling inherently safer. First, existing literature that has sought to understand cycling crash causation factors is reviewed and human factors incident causation models are introduced. Key considerations for their practical use in understanding a cycling safety system are discussed, taking a view that road casualties, including those involving cyclists, involve complex interactions between a range of situational and more indirect and distal factors.

3 Literature review

3.1 Existing understanding of cycle casualty causation

Along with understanding the relative risk of injury while cycling compared with other modes of transport, previous studies and policy documents have explored the special characteristics of cycle crashes and injuries. Some key findings are presented below. For New Zealand and Australian findings, the literature has been summarised in and categorised under the headings of ‘Cycling crash characteristics’, ‘Risk and risk factors’ and ‘Participation’. For a more detailed understanding of this literature see Hatfield et al (2015).

Table 3.1 Characteristics of cycling crashes, risk and participation

Cycling crash characteristics	Risk and risk factors	Participation
Intersections, older people, high-speed roads, males and heavy vehicles are over-represented in cycling fatalities (Koorey 2014; Boufous et al 2012; De Rome et al 2011). For collisions and near misses during on-road commuting, drivers found to be at fault in 87% of cases (Johnson et al 2010). The majority of cycling crashes and fatalities happen in urban areas (Boufous et al 2012; Koorey 2014).	In 2014 in New Zealand, 10 cyclists died, 158 were seriously injured and 573 suffered minor injuries in police-reported crashes on New Zealand roads. This is about 6% percent of the total number of casualties from police reported crashes in 2014. (MoT 2015a). In Australia, 50 people died while cycling in road-related areas (including paths) and 4,092 were hospitalised in road-related crashes in 2013 (Hatfield et al 2015).	There is low participation in cycling in New Zealand and Australia. Cycling makes up 1.6% of total time travelled and just over 1% of the number of trip legs (MoT 2015b). Cycling participation in Australia has not materially changed between 2011 and 2015 and may have even decreased (Australian Bicycle Council 2015).
Poor vehicle driver observation is a very common factor in cycle crashes (Koorey 2014; Cycling Safety Panel 2014).	Relatively high risk when exposure is accounted for (Tin Tin et al 2010, MoT 2015a; Palmer et al 2014) (eg observed rate of death or injury of 31 per million hours, second only to motorcyclists (Tin Tin et al 2010). 5–19 times the rate of fatal and serious injuries per hour or km travelled compared to car occupants (Tin Tin et al 2010; Garrard et al 2010). However, rates depend on age group and location (Koorey and Wong 2013).	In 1989/90 19% of secondary school students biked to school but in 2010−2014 this had reduced to 3% (MoT 2015c).
While high visibility clothing may help with physical conspicuity (Tin Tin et al 2013), attentional conspicuity (motorists recognising cyclists) may be a more important factor (Koorey 2014). However, overall 75% of police reported bicycle crashes in Victoria occurred in daylight (Boufous et al 2012).	Cycling deaths tend to result from collisions with vehicles but cycle only crashes are more common (Cycling Safety Panel 2014). Crashes that did not involve a motor vehicle are not usually reported to police and 2.41 times more bike rider crashes were reported to hospital compared with all police-reported bike rider crashes (Garratt et al 2015).	In 1989/90 12% of primary school students biked to school but in 2010–2014 this had reduced to 2% (MoT 2015c)

Cycling crash characteristics	Risk and risk factors	Participation
On off-road paths, the number of vehicle crossings and the priority at each crossing, the visibility of the markings at crossings and the width of the path are important safety considerations for cyclists (Turner et al 2009).	People who ride bicycles have lower all-cause mortality risk than those who do not (Rissel 2015a).	
Traffic speed reduction is an important mechanism for improving cycle safety (Turner et al 2009).	The more cyclists there are, the lower the personal risk of injury (Turner et al 2009; Robinson 2005).	
Cycle only, drivers turning left across a cyclist's path or turning right against, cross-traffic and car doors are some of the most common crash types (Johnson et al 2014; Boufous et al 2012; Koorey 2014).		

Beyond New Zealand and Australia, a number of studies and policy documents have examined cyclist risk and related underpinning risk factors (Knowles et al 2009; Hamann and Peek-Asa 2013; Talbot et al 2014). Many of the key issues common to these studies have been summarised by the International Transport Forum's Working Group on Cycling Safety (OECD/ITF 2013). Some of the key points are listed below:

- On balance, the positive health impacts of cycling far outweigh negative health impacts.
- There is generally poor data regarding cycle crashes and travel exposure.
- With increased exposure the cycle casualty rate may reduce (due to 'safety in numbers') but the absolute number of crashes is likely to increase.
- Vehicle speeds above 40km/h greatly increase the risk of severe cycle crash outcomes.
- Crashes not involving another motor vehicle are likely to be more common than those with motor vehicles, but less is known about non-motor vehicle cycle casualties due to the fact these events are seldom included in official road crash statistics.
- Cyclists are reported in the official crash statistics to be at fault in less than half of all collisions with motor vehicles.
- In cycle vs motor vehicle collisions the driver failing to give way or 'look properly' is a common cause.
- Metropolitan areas dominate in terms of crash numbers; rural crashes tend more often to be fatal or severe.
- A disproportionate number of crashes occur at intersections, including intersections between cycling infrastructure and roads.
- Poor maintenance of the road increases the risk of cycling crashes.
- Heavy vehicles are involved in a disproportionate number of serious or fatal cycle collisions.
- Younger cyclists and older cyclists are over-represented in cycle crashes.
- Night cycling and poor weather are likely to be riskier for cyclists.

In all the studies of cyclist casualties, descriptors of the characteristics of road users, road user movements and environmental conditions are usually the main focus, thereby leading to an understanding of the various situational factors associated with cyclist crashes, as listed above. However, this information falls short of providing a comprehensive understanding of the various conditions that come together to result in a cyclist crash.

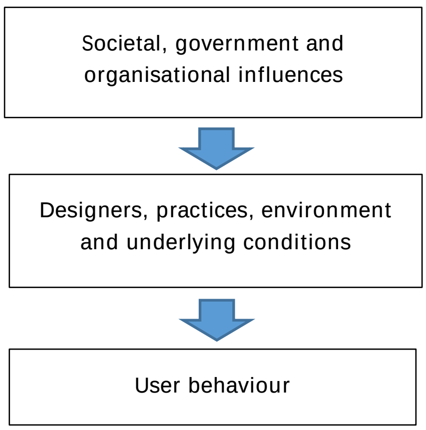
Yet for some time, in a range of safety critical domains, there has been a recognition that safety-related incidents typically involve a range of proximal and distal factors which interact in a way that permits an event to happen with possible associated casualties. It is therefore desirable to understand the crash causation theory that has been developed in other sectors and consider how the various approaches might be applied to road safety or more specifically, cycle casualties.

3.2 A brief background to incident causation models and methods

Moving beyond describing the characteristics of cycling casualties, there is an emerging research emphasis on applying 'systems thinking' models and methods to the road safety domain (Salmon et al 2009) and recently, the peer-reviewed academic journal *Accident Analysis & Prevention* published a special issue on this area (Salmon and Lenné 2015).

A characteristic common to all models and methods is the principle that adverse events are a result of direct and indirect factors coming together to allow the event to happen. In addition to the more obvious user and environmental considerations, indirect factors generally include practices, policies, procedures, organisational influences and culture, government regulation and even societal norms and culture. This approach is important as it points to the design of a system rather than simply the actions of individuals at the coalface of a system. This in turn means that any initiatives to improve safety outcomes are likely to be more successful as the 'root cause' of errors and events can be identified and addressed. A simplified outline of this concept is shown below in figure 3.1.

Figure 3.1 A simplistic representation of the approach to contemporary incident causation models and methods



A range of incident causation methods that might be applicable to road safety and more specifically cycling casualties have emerged over time and, although not always specific to the road safety domain, some authors have described and compared the various methods (Larsson et al 2010; Salmon et al 2012; Toft et al 2012; Stanton et al 2013). All but one of the incident causation models (the Haddon matrix, which was developed partly within the road safety domain) originated from areas outside road safety. For some of these methods, there has been discussion of the potential applicability to road safety (Salmon and Lenné 2009). Lack of consistent, routinely collected data for various levels of a chosen taxonomy is one barrier to the widespread adoption of systematic incident causation methods, and it appears the research effort in this area has not yet transferred into normal practice for road safety practitioners (Salmon and Lenné 2015), except for some recent examples such as the 'UPLOADS' initiative (www.uploadsproject.org) in the outdoor education sector.

The following sections outline some of the key incident analysis models and methods that have been proposed in recent years, and consider their applicability to cycling safety. This is not an exhaustive analysis of all possible methods but rather a brief selection of those that might offer the most potential, given their attention in recent studies. A more comprehensive explanation of a wider range of human factors and incident analysis methods is provided by Salmon et al (2011) and Stanton et al (2013).

3.2.1 The Haddon matrix

One of the most commonly recognised approaches to injury prevention is the Haddon matrix (Haddon 1970; 1980), which has also been routinely applied in the road safety domain (Peden et al 2004; Murray et al 2014). A typical version of the Haddon matrix, as applied to road safety is presented in figure 3.2.

Figure 3.2 The Haddon matrix

Phases	**Factors**			
	Person	**Vehicle**	**Physical environment**	**Social environment**
Pre-crash				
During crash				
Post-crash				

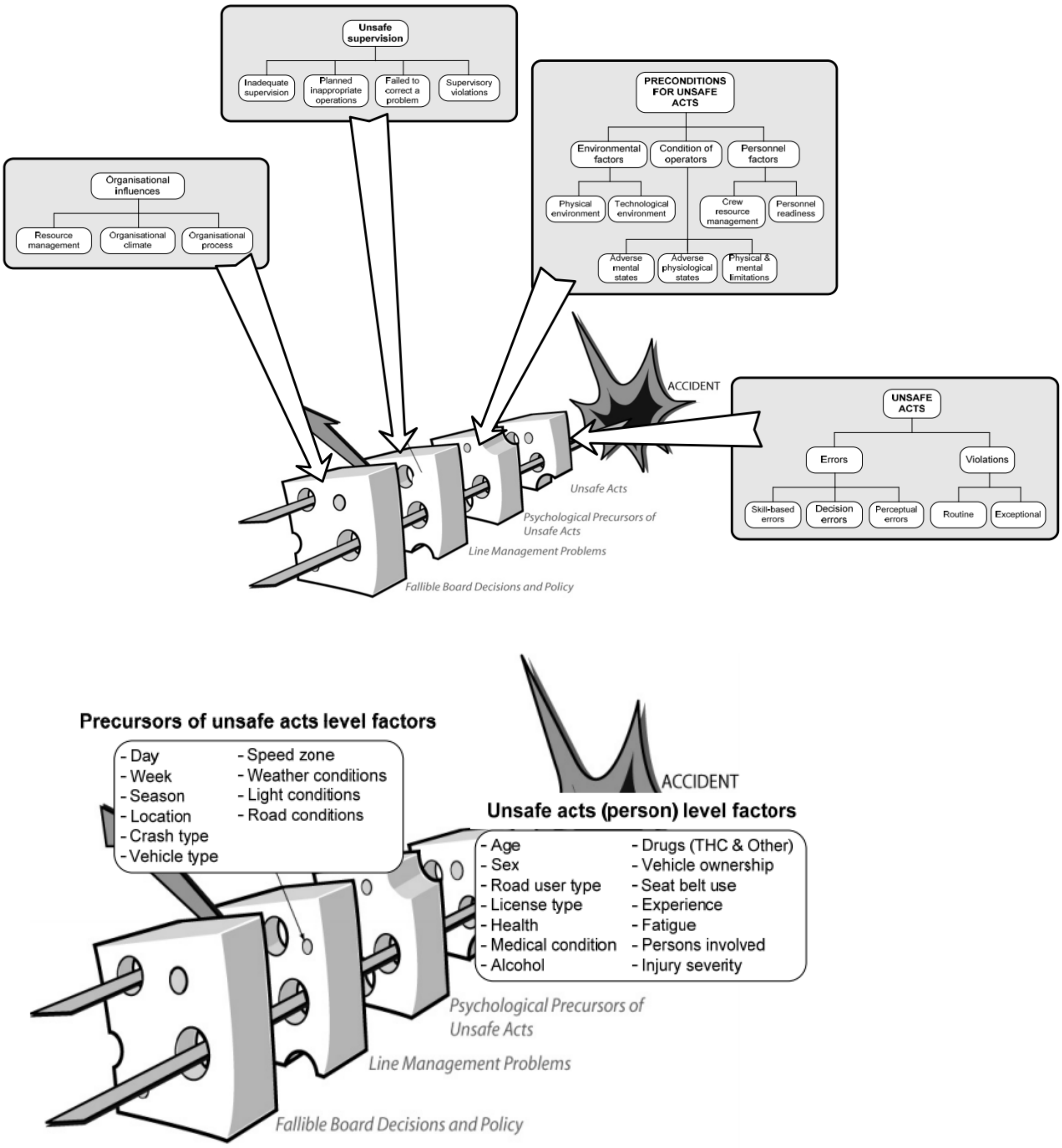
Importantly, the Haddon matrix provides an opportunity to consider a broad range of influences that may apply both before and after a crash. This enables a more holistic account of factors that may contribute to crashes rather than focusing only on situational factors such as speed, individual behaviour and road conditions at the time of a crash. For example, a broader societal culture of under-valuing cyclists as legitimate road users may be an important pre-crash/social environment condition, as defined by the Haddon matrix. A third dimension to the Haddon matrix has been proposed (Runyan 1998) to include 'decision' factors to facilitate its application in decision making including criteria effectiveness, cost, freedom, equity, stigmatisation, preferences, feasibility and other identified criteria. Another advantage is the categorisation of pre, during and post-crash elements. This means that not only are the various factors contributing to a crash considered, but also the events that happen after a crash that may ultimately affect the crash outcome (for example emergency response).

A limitation of the Haddon matrix is that there is no provision for interactions between various factors and actors in a crash system, even though these interactions are considered to be an important characteristic of complex systems. Also, higher level factors such as societal and government culture and processes do not feature explicitly in the Haddon matrix.

3.2.2 Human factors analysis classification system (HFACS)

HFACS (Shappell and Wiegmann 2000) was originally designed for the analysis of military aviation accidents and is based on Reason's (1990) Swiss cheese model. HFACS has been successfully applied in many new areas, eg mining (Lenné et al 2012), maritime (Chauvin et al 2013), rail (Baysari et al 2008) and healthcare (El Bardissi et al 2007; Mosaly et al 2014). With a focus on human error, Reason's model and the HFACS framework identify four system layers: unsafe acts, pre-conditions for unsafe acts, unsafe supervision and organisational influences (figure 3.3). For an incident to happen, failings at each of these must occur at the same time, otherwise various system factors act as a 'backstop'. Recent adaptations have extended the levels to incorporate an 'external influences' level. This level considers failures outside organisations such as legislation gaps, design flaws and administration oversights (Chen et al 2013).

Figure 3.3 HFACS and fatal road crash data mapped onto Reason's Swiss cheese model



Source: Salmon and Lenné (2009)

Potential issues related to the application of HFACS to the road safety domain have been raised (Salmon and Lenné 2009) and include the road safety sector's lack of uptake of the theory underpinning the methods used and issues related to the quality of the data obtained and its subsequent use. Further, HFACS does not contribute much to identifying key actors in a system and the inter-relationships between actors, which are key to more contemporary methods.

Considering how HFACS might apply to road safety and more specifically cycle crashes, it seems the categories 'unsafe acts', 'pre-conditions for unsafe acts' and 'organisational influences' could be applied to the road safety domain with minor modifications, building on the example shown above in figure 3.3, although the category of 'unsafe supervision' seems unrelated to the road safety sector. Alternatively, 'policies, procedures and training' might be a suitable replacement at this level of the HFACS hierarchy if it were to be applied to cycling safety. In identifying the error types that individuals might make, care is needed to make sure that this is not translated into blame for individuals. Higher level factors also need to be clearly identified.

3.2.3 DREAM/SNACS

The SafetyNet Accident Causation System (SNACS) is an in-depth crash causation method that has been specifically developed in Europe for the road safety domain. SNACS is based on the existing Driving Reliability and Error Analysis Method (DREAM). DREAM, in turn, is based on a model called the Cognitive Reliability and Error Analysis Method (CREAM) (Hollnagel 1998). DREAM has a human-technology-organisation perspective, which implies crashes happen when the dynamic interaction between people, technologies and organisations fails in one way or another, and there are a variety of interacting causes creating the crash.

A detailed methodology has been developed for DREAM and it has been applied to road safety contexts (Habibovic et al 2013). However, many of the categories would seem irrelevant to cyclists and it has only been used in Europe to date. The system also appears to be very complicated with specialist expertise needed to use it effectively.

3.2.4 Function resonance accident model (FRAM)

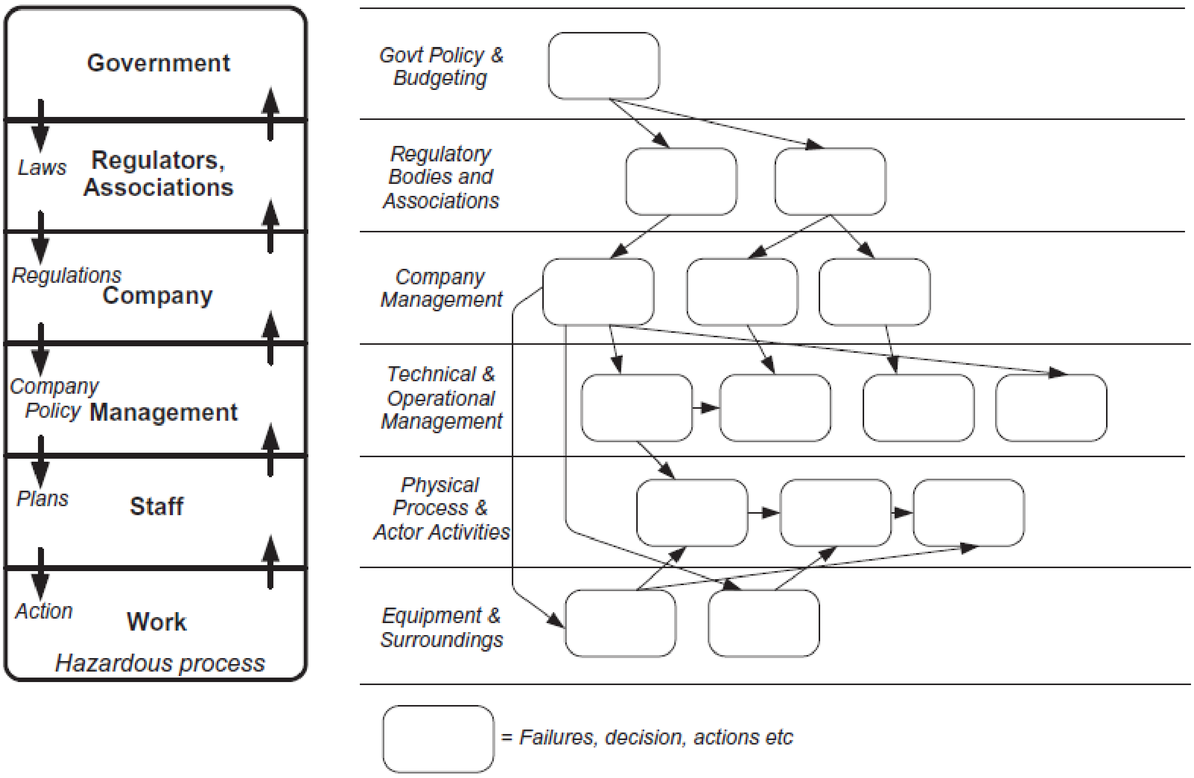
FRAM has an underlying philosophy that sometimes things happen without clearly recognised causes. The relationships between causal factors are important and it is argued that incidents can be the outcome of unexpected combinations of normal performance variability (Hollnagel et al 2008). FRAM requires that normal system operation is first defined, then followed by an analysis procedure to understand the variations from normal system function. Finally, the identification of countermeasures is carried out. Differently from other methods, FRAM does not have an underlying model to guide a proposed system structure and it does not presuppose that events happen in a certain way.

An attractive attribute of FRAM is the description of how a system *should* work up front. This takes a positive view which could be useful in setting a vision for cycling safety. However, many aspects of the FRAM parameters seem unrelated to cycling safety and significant modification of the approach may be needed to usefully apply it to the cycling safety domain. Further, the full procedure is quite detailed and time consuming.

3.2.5 AcciMaps

Originally designed for use in workplace settings, the AcciMaps method is based on Rasmussen's model of risk management (Rasmussen 1997). In a similar way to Reason's Swiss cheese model, Rasmussen's model involves hierarchical levels where failings may occur, but the differing characteristic is the focus on the causal relationships between these levels and less on the errors of individuals. The six levels of socio-technical complex systems as described by Rasmussen are: government, regulators/associations, company, management, staff, work. The AcciMaps method, used to apply Rasmussen's framework to incident examples, maps the failures, decisions or actions that link together, within the context of Rasmussen's model to explain the different levels of incident causation (figure 3.4).

Figure 3.4 Rasmussen's model of socio- technical complex systems and associated AcciMaps method



Source: Salmon et al (2012)

Although this method was not developed for the road safety domain, it has been applied to road safety in recent times including level crossing safety (Salmon et al 2013), road freight (Newman and Goode 2015) and beach driving (Stevens et al 2015). In another road safety application an 'actor map' is included – a process by which the actors in the system are identified. The actors involved in all levels of the young driver safety system in Australia were identified via an actor map as part of an AcciMaps analysis (Scott-Parker et al 2015). This step is taken before turning to relationships, actions and influencers. For cycling safety it is very important to be explicit about the actors, especially if a subsequent analysis of errors in the system is to be carried out, and so this approach could be useful.

The levels used in AcciMaps seem generally appropriate for the latent or less direct influences that need to be considered for cycling safety (eg local area government planning and budgeting). When the more detailed situational factors are considered, other methods such as HFACS may capture more detail and therefore enable a greater understanding of the error types at play. However, an advantage of AcciMaps is that it is very flexible so it could be tailored to fit cycle safety and link to other error-focused methods such as HFACS. Certainly, recent applications to the outdoor education sector are proving the versatility of AcciMaps (Salmon et al 2014).

3.2.6 System-theoretic accident model and processes (STAMP)

In the STAMP approach, it is proposed that incidents occur when external disturbances or dysfunctional interactions among system components are not adequately handled by the control system. Incidents therefore are not caused by a series of events but by inappropriate or inadequate control or enforcement of safety-related constraints on the development, design, and operation of the system.

Safety then can be viewed as a control problem, and safety is managed by a control structure embedded in an adaptive socio-technical system (Leveson 2004).

An example of a STAMP control diagram, as applied to the Mangatepopo Gorge incident (Salmon et al 2012), is presented below in figure 3.5.

An important component of the STAMP approach is the initial process of defining the system including all the associated actors, as well as the interactions between various components. Recently the STAMP methodology was used to create a model for the road transport system in Queensland (Salmon et al 2015). Although this exercise demonstrated how complex and large such models can become, it did provide a comprehensive map of the system, from which areas of system failure can be identified.

Figure 3.5 Control structure diagram for Mangatepopo incident

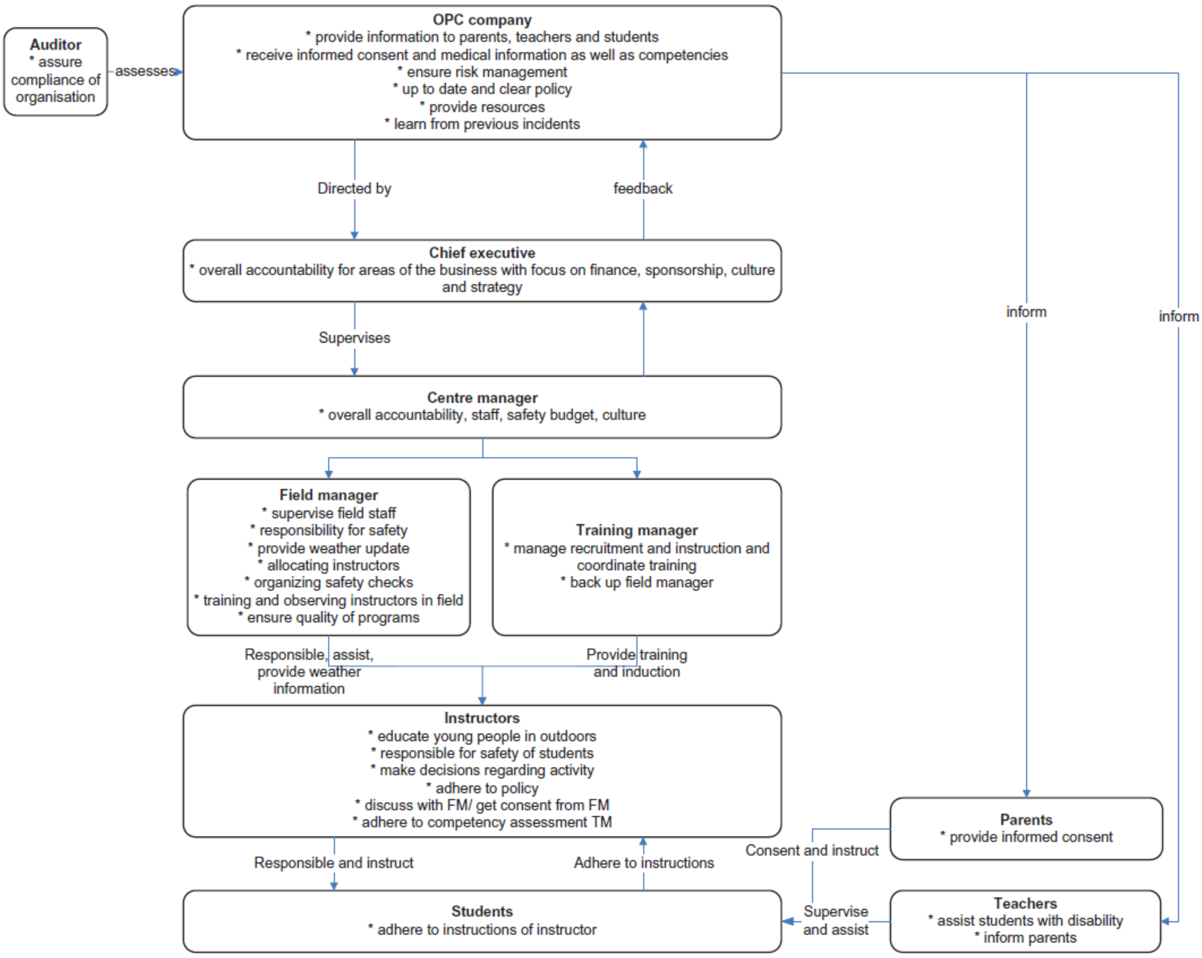


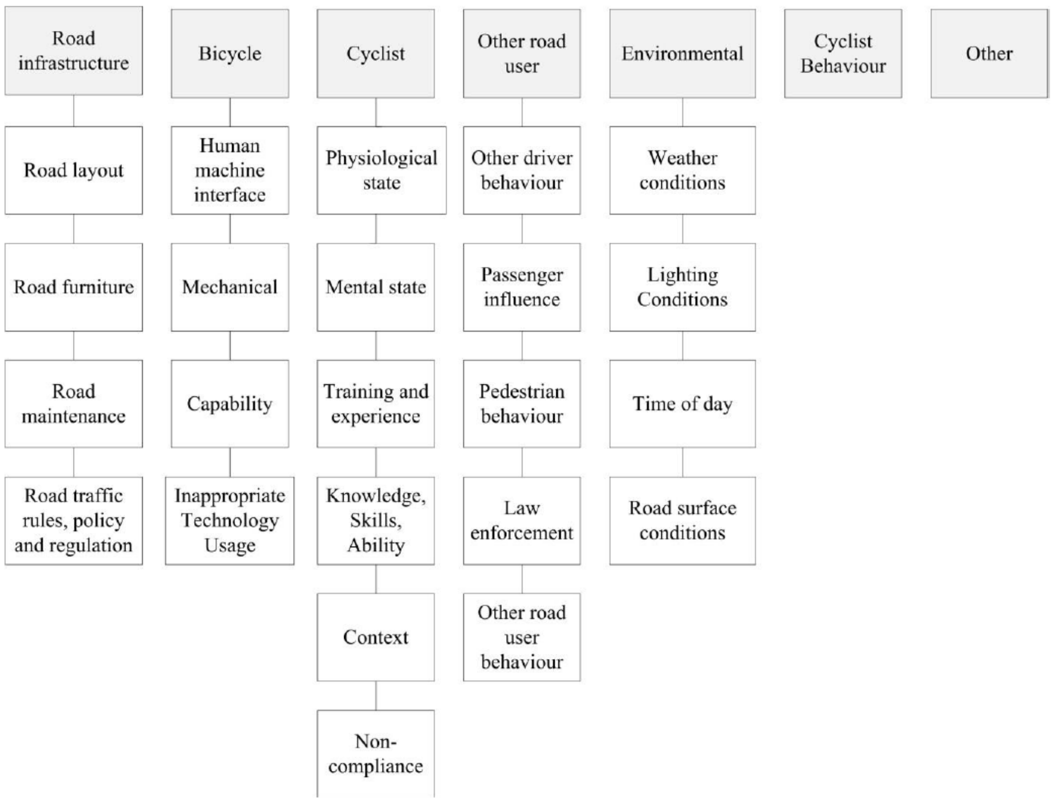
Fig. 6. Mangatepopo incident: basic control structure diagram.

Source: Salmon et al (2012)

3.2.7 Applications of systems thinking to cycling safety

There have been some attempts to apply systems thinking to cycling safety. The factors associated with near misses between cyclists and motorists have been analysed from naturalistic cycling data (Dozza and Werneke 2014; Goode et al 2014). Stanton et al (2013) driver error and contributory factors taxonomy (figure 3.6) was applied by Goode et al (2014) to identify road design, road layout, pedestrian behaviour and road infrastructure as contributory factors to near misses. This study represents a breakthrough in understanding cyclist near miss causal factors as a much broader set of contributing factors were considered within the analysis, than is usually attributed to cycling or other road safety crashes. The authors found that road layout, driver behaviour and road rules, bicycle capabilities, cyclist behaviour, road furniture and pedestrian behaviour were identified as contributing factors in some near collisions.

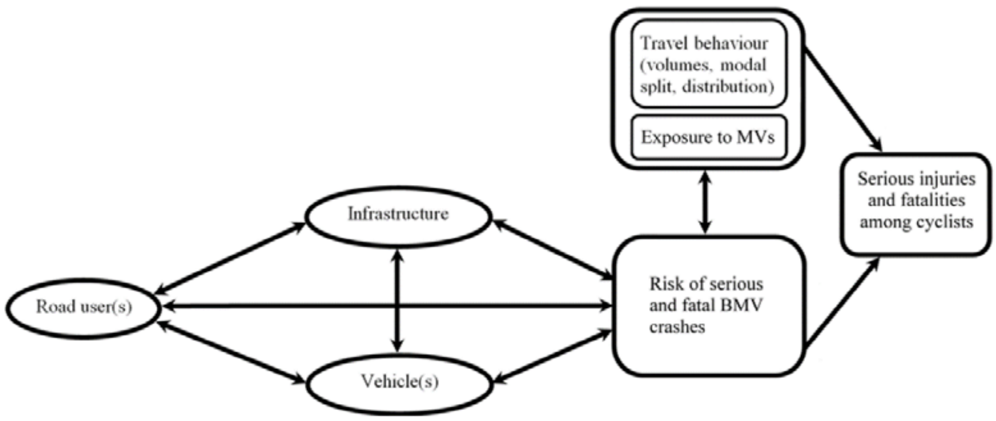
Figure 3.6 Taxonomy of contributing factors in cyclist near collisions



Source: Goode et al (2014)

In Europe, a conceptual framework for factors influencing road safety was adapted to explain the risk of serious and fatal bicycle/motor vehicle crashes (figure 3.7) in the Netherlands (Sherpers et al 2014).

Figure 3.7 Conceptual framework for bicycle safety.

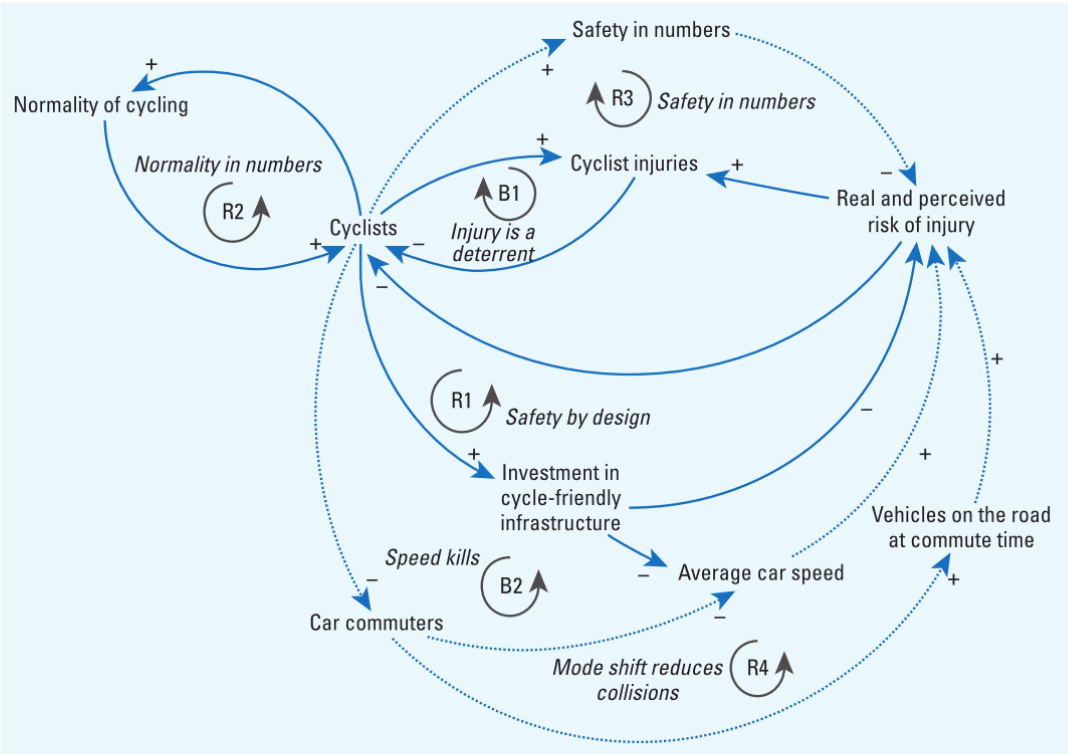


Source: Sherpers et al (2014)

Conceptual frameworks like this are deliberately simple so most people can easily understand the broad structure of how the system works. In this case the key initial components are the interactions between road users, vehicles and infrastructure, which is very similar to the safe system approach (without speed). For a cycling safety system model, a conceptual framework may be useful at some levels, but for an in-depth understanding of how crashes happen, a more detailed approach is needed.

System dynamics modelling has been used to investigate factors responsible for trends in commuter cycling in Auckland as well as assist with identifying policy levers to reverse a trend of decreasing cycling (Macmillan et al 2014). One of the causal loop diagrams used in the study by Macmillan et al (2014) is reproduced in figure 3.8. Although this research focused on cycling participation, again, the strong link between risk of injury (real and perceived) and cycling participation is evident. If there are problems with injury risk then attention must be paid first to cycling safety to unlock all the benefits that higher levels of cycling participation would bring. Again, while diagrams like this are very useful for policy discussions, for in-depth analyses of cycling casualties, other system mapping methods, described earlier, are likely to be more useful.

Figure 3.8 Causal loop diagram explaining cycling participation in Auckland



3.3 Implications for a cycling safety system model and analysis method

The incident causation models outlined above provide useful theory that can be used to underpin a cycling safety model as well as associated interventions to prevent cycle casualties. However, to date there is limited evidence of these models being practically applied within the road safety, let alone the cycling safety, domains. Part of the reason for this is that the taxonomies from each method may not be transferable or relevant with other domains, such as road safety.

Whereas many applications of incident causation methods tend to involve single large-scale events which have been the subject of significant scrutiny, for cycling safety, a hybrid approach may be needed and various aspects of different methods may be assembled to create a cycling safety system and associated analysis method. A distinction between single large-scale and multiple smaller incidents is very important. A large-scale incident (such as an airline crash) is likely to justify a large amount of time and effort to elucidate the causes of the crash, whereas for cycle safely it is more likely that a number of crashes would be aggregated to provide a robust analysis.

The following attributes from the incident causation methods are summarised below in table 3.2. Consideration of these factors helps identify the method that might work best for a cycling safety system analysis, even if it borrows from various methods.

Table 3.2 Summary of advantages and disadvantages of incident causation methods

Model/method	Advantage	Disadvantage
Haddon matrix	Simple, has been used for road safety, post-crash considerations acknowledges the role of emergency response.	Does not consider influences between factors and some important factors may be missed with simplistic approach (eg policy).
HFACS	Seeks to identify error types for unsafe acts, which is useful in determining correct interventions. A well-defined taxonomy which is easy to use.	Focus on errors can lead to over-emphasis on individual's behaviours and less on higher order factors.
DREAM/SNACS	Developed for road safety application. People, technology, organisation interactions seem well suited to road safety.	Quite complicated and many categories do not seem relevant to cycling safety.
FRAM	First defines functional system as it exists.	Many aspects of method look unrelated to cycling safety so significant modification would be required. Full procedure is quite detailed and time consuming.
AcciMaps/actor map	First defines functional system as it exists. Causal relationships between sociotechnical levels is useful for explaining the story of causative factors. Process of identifying actors, or those with responsibility in the system is useful.	Rasmussen's model was originally designed for workplace settings so some modification needed (although AcciMaps categories look more useful).
STAMP	First defines functional system as it exists (control structure).	Large and complicated control structure models could be hard to interpret, understand or use by sector.

Giving further consideration to an accepted and usable cycling safety system model, it may be that a mixture of theory and pragmatism needs to be adopted. A theoretically underpinned approach is important but it is unlikely that the wider transport sector will adopt a method if it is too complex, onerous or does not match the structure of the sector. Key researchers in this field have admitted that most of the methods have not yet been widely adopted by the road safety sector (Salmon and Lenné 2015). Although issues such as lack of data are given as key barriers, it may also be that the prospect of attempting to use complex systems approaches just seems too difficult for those in applied roles, who would prefer to apply simpler frameworks to understand real-world crashes in a relatively efficient way.

Furthermore, personnel within the sector may have their own views about the components of a cycling safety system model, given their experience and ‘coalface’ view of the system. Therefore, a participatory design process to arrive at a suitable cycling safety system model for New Zealand is suggested, mixing key aspects of established incident causation methods with the views of the cycling safety sector. Based on the learnings from this literature review, chapter 4 presents the method used to develop a cycling safety system for New Zealand and its application to real-world crashes.

4 Method for developing a cycling safety system and analysing crashes

The process to develop the cycling safety system model and analysis method is outlined in this chapter. The goal was to develop a model of the cycling safety system so system designers could understand the relevant components and appreciate the direct and indirect factors that apply. It would also be important to understand the common pathways that bring various factors together. This would provide an evidence platform, against which different efforts to improve cycle safety could be tested. In this way we aimed to ensure that cycle safety activities would be positioned within a wider world view of safety – and therefore more likely to be effective.

Using the model, the secondary goal was to analyse the conditions surrounding common cycling crash types. This would result in a broader view of contributing factors to cycling fatalities, more in line with the safe system approach, and more useful for identifying improvements in the system that could make a difference. The methods proposed are not meant to undermine existing crash analysis efforts, but rather build on existing reports and analyses.

4.1 Cycling safety system model

The literature review highlighted the importance of defining the system as it currently operates, before focusing on failures. It was also determined that the best model and analysis method was one that achieved a balance between theoretical robustness and user accessibility. The focus should first be on achieving buy-in to the fundamentals of this approach – multiple system levels and identified pathways between system factors.

A draft cycling safety model was developed by the project team and then circulated to 27 key cycling safety stakeholders (including project steering group members), with an invitation to distribute it more widely as required. Ten stakeholders responded with comments about the model and in-depth discussions were continued with two stakeholders.

There was general acceptance of the draft model presented to stakeholders, although there were a number of suggestions that were of relevance to a further version. Some of the key points from the feedback included:

> *A need to define the scope of the model – does it include fatal as other injury crashes or even near misses? The mechanisms for these crash severities might be different. Does it include elements that might relate more to cycling uptake (which would ultimately influence safety)?*

Response: It was agreed that learning from all crash severities, including near misses is important. The cycling system model was adjusted to account for crash severities. We chose to focus on cycle safety (crashes) as opposed to a more comprehensive model including participation as the methods used are derived from the safety domain. Also, if cycling is safe then more people are likely to participate.

> *Some felt the diagram was complex, but others pointed out the need for extra components and pathways. It was noted that it is important to define the purpose and intended use of the model to understand whether a complex or simple model is appropriate.*

Response: It was determined that the model needed to be complete enough to include the key actors, non-person factors and links, but it also needed to fit onto one page so that users could get a general overall picture relatively quickly. This position then determined the complexity and form of the cycling safety system model.

> *Those actors with immediate responsibility in cycle/vehicle interactions, namely people who cycle, people who drive (public and professional) and road designers need to be identified. It was noted that a cyclist, a driver and a road design that allows interaction between these road users are all needed for a fatal crash to occur. Take either road user or incompatible road design out of the system and a high severity crash cannot occur.*

Response: This seemed like an important point as the actions of these three actors in the system should be of primary interest. There was some concern that this would lead to blaming of road users, but the role of responsible road use was considered important, alongside emphasis on other system components.

4.2 Data collection and causal pathway analysis method

Following the development of the cycling safety system model, the next stage involved the collection of cycling fatality data, grouping fatal cases into crash types and then using the cycling safety system model to analyse typical examples of crash types. The output from this process was crash causation pathway diagrams to show the lower parts (road users and environmental context) of the cycling safety system that have failed, the connections between factors and ultimately the resulting collision.

Only fatal cycle crashes within the road reserve were included in the analysis. For fatal crashes, crash investigation reports and coroners' findings are available, which gives a much richer picture of contributing factors than simply relying on traffic crash reports, which is normally the main information available for non-fatal crashes. Further, the established methods from which the cycling safety system is derived are usually used where catastrophic system failures are evident (usually including multiple fatalities, such as an airline crash). We are proposing that an on-road cycle fatality represents a catastrophic system failure, albeit on a smaller scale than an airline crash. However, it is acknowledged that non-fatal crashes and even near misses would provide a useful area of focus in the future and the cycling safety system model could easily be used for these crashes.

Using the cycling safety system model, 30 individual fatal crash cases were chosen by matching crash characteristics against the 94 crashes used by Koorey (2014), so that a generally representative sample of crashes was used. For each of the crashes, the categories and key components of the cycling safety system were used to describe the various aspects of each crash. The crashes were then aggregated into crash types to create typical crash scenarios drawing on the information from the individual crashes. Causal pathway analysis diagrams were then created to provide a fictitious crash, built from actual crash information. This aggregation of crash information within types was necessary as the identity of individuals needed to be protected.

Invariably, with the data available, lower level factors (such as road users and environmental context) were identifiable through the crash and coroners' reports and then links to higher level factors were achieved via focus groups with cycling experts, many of whom were very familiar with the nature of the fatal cases, and related documents. For example, the sudden termination of a cycle lane may have been a relevant contextual factor in some crashes, which triggered higher level enquiry about design practices, standards or higher still, funding priorities. These higher level factors were interrogated in-depth via three workshops with a total of 16 key experts in transport planning, cycling safety/promotion, traffic engineering, automobile/cycle advocacy, transport policy and cycling infrastructure and promotion delivery. The focus of these workshops was to:

1 Confirm the structure of the cycling safety system.

2 Explain how societal, organisational, policy and practice system failures influence failures in road environments within the context of cycling crashes.

The key themes from these workshops were distilled from the transcripts and then mapped using the cycling safety system as a guide. This process resulted in the contributing upper level system failures being identified for the causal pathway diagrams, which were then linked to the lower level factors determined from the crash reports.

The last phase of data collection was to review key documents that have influenced cycling priority, investment and action. This helped to paint a picture of the strategic importance given to cycling, along with associated initiatives, at the time of the cycling fatalities. The documents that were reviewed included:

- *Safer journeys, and associated action plans* (MoT 2010)
- *Connecting New Zealand* (MoT 2011b)
- *Government Policy Statement for Land Transport (GPS 2009/10 – 2018/19, GPS 2012/13 – 2021/22 and GPS 2015/16 – 2024/25*) (MoT 2009; 2011a; 2015d)
- *Getting there – on foot, by cycle* (MoT 2005)
- *The cycle network and route planning guide* (Land Transport Safety Authority 2004).

Three cycling fatality scenarios were developed: the first two were the most common crash types from the 30 crashes, and the third was a crash type that had many different system aspects to it, with more than the usual information available for the analysis.

Following each causal pathway diagram, a modified version of the HFACS method was used to identify errors (if they existed) for the categories: unsafe acts, preconditions for unsafe acts, practices and standards and organisational influences. This stage was considered important to show that the higher level failings are just as important as the slips and lapses, mistakes and violations by road users in the system. This also allows interventions for different crash types to be matched to the error types involved. For example, a deliberate decision to retain parking or terminate a cycle lane at a known cyclist crash site would have different practical implications than inadvertently arriving at poor road design through inadequate design capability.

For each of the three crash scenarios the variation in circumstances from the crash data was described. For example, for ‘Cyclist hit by overtaking vehicle’ crashes, although the chosen scenario involved a motorist who failed in their attempt to safely overtake, other similar crashes involved trucks leaving their lane for no apparent reason, before hitting the cyclist from behind. This variation among crash types helps to identify the different initiatives to improve safety that are likely to be needed for the different crash types (eg established protocols for overtaking cyclists vs fatigue and distraction countermeasures for truck drivers).

Finally, key themes from the entire analysis exercise were identified, which helped arrive at more general recommendations for the future.

5 Analysis outcomes

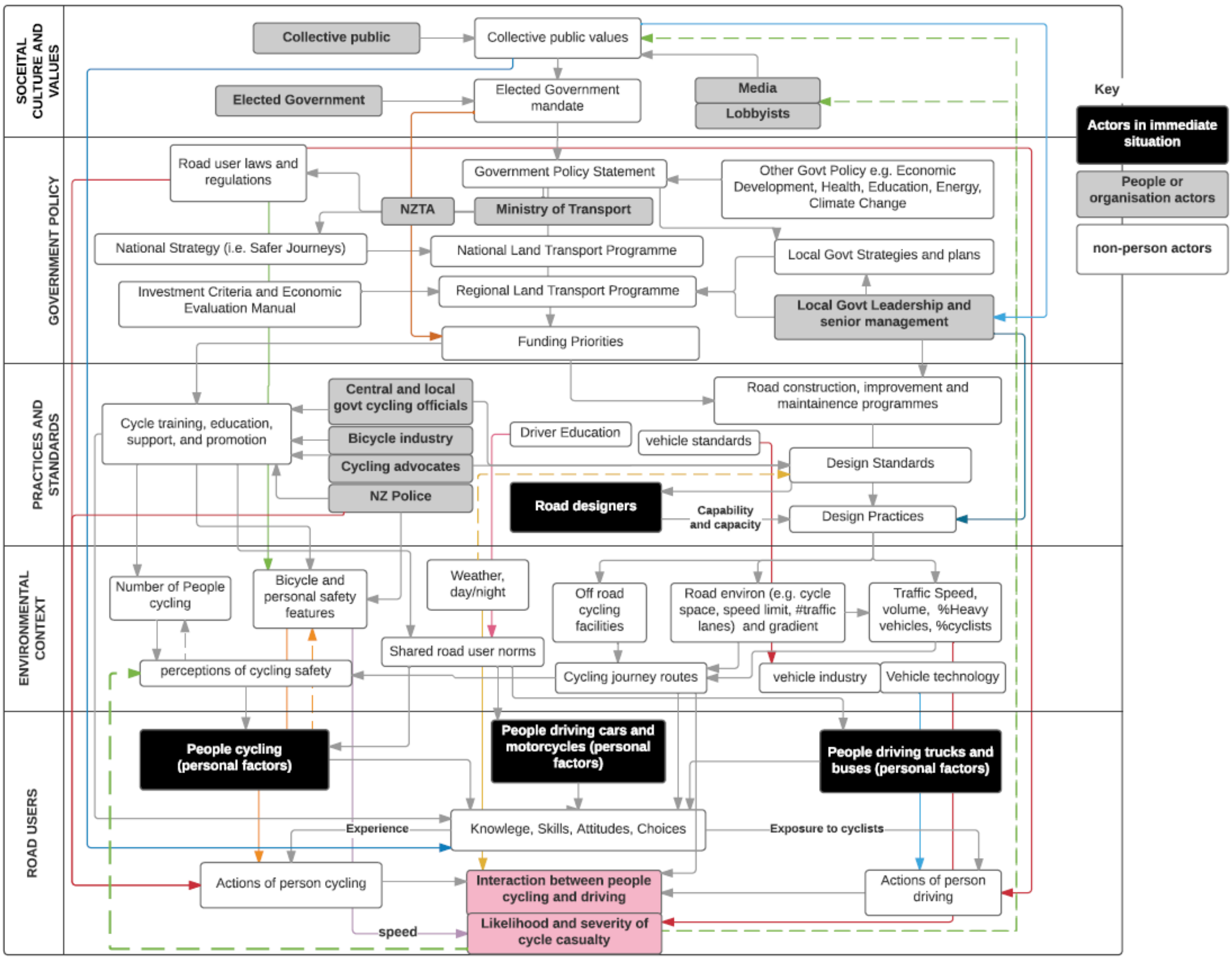
5.1 A cycling safety system model

The cycling safety system ‘control structure’ model, developed through the method outlined earlier, is shown in figure 5.1. The model shows how the current system operates, for better or worse and the people, organisations or actors involved in the system. It has endeavoured to be complete enough to describe the essential components of the cycling safety system, while hopefully not so complex that it is incomprehensible. For real applications, aspects of the model, rather than all of it, may be used to identify system failings, therefore it should not matter that the model is relatively complex.

A key feature of the model is the categories (on the left): road users, environmental context, practices and standards, government policy, and societal culture and values. Basically, the model shows there are important factors within each of these categories that influence other factors and ultimately come together to allow cycling crashes and casualties to happen or not. The boxes in the model represent non-person factors and people/organisations who have responsibility within the system. The black boxes, based on stakeholder feedback, show the actors who have immediate responsibility. Road designers might not ordinarily be considered as having immediate responsibility, but since their work has such significant influence on the way motorists and cyclists interact, it was decided to allocate immediate responsibility status. The arrows linking these items indicate influence and feedback. In places, coloured lines add legibility where large jumps across factors or categories were required and dashed lines indicate feedback influences within the system.

As highlighted above, some stakeholders felt it was important to identify those actors who have immediate responsibility within the system (coloured black) but it is acknowledged that this should not dilute the importance of considering the potentially large influence of other factors in the system.

Figure 5.1 Cycling safety system model



The cycling safety system diagram can be used as a template to analyse actual or typical cycling casualties. Using the model to analyse crashes would ensure all the potential factors are considered.

5.2 Applying the cycling safety system model to cycling crash scenarios

5.2.1 Cyclist fatality data

The description of the patterns of cycling fatalities in New Zealand (Koorey 2014) and cycle crashes in New Zealand (MoT 2015a) provides guidance for the crash types which should be analysed in more depth. A sample of 30 cycling fatalities between 2006 and 2015 was deliberately manipulated so the characteristics of the crashes broadly reflected the cycle crash patterns previously reported. Table 5.1 shows the level of match between these data sets.

Table 5.1 Comparison between sample used by Koorey (2014) and 30 crashes selected for use in this study

Crash characteristics	Koorey %	Sample %
Older than 65 years	26%	23%
Younger than 15 years	12%	7%
Female	25%	30%
Collision with truck	29%	37%
Speed limit greater than 80km/h	50%	33%
State highway location	30%	27%
Intersection	28%	33%

With a sample of cycling fatalities broadly matching a high proportion of all cycling casualties, the crashes in our sample were then categorised by crash typology. Table 5.2 shows the crash types present within our sample in order of the most common crash types. The purpose of this exercise is not to provide an accurate representation of the proportion of various cycle crash types (which is the focus of many other studies), but rather to identify fatal cycle crash types that are clearly an issue for New Zealand, and therefore warrant further and deeper investigation. The crash types are categorised by movement types or by the primary road user error as deduced from the description of the crash.

Table 5.2 Crash types of sample

Crash typology	Number	% of total
Cyclist moves into path of vehicle	9	30%
Cyclist hit from behind	6	20%
Driver failure to give way	5	17%
Cyclist loses control down hill	5	17%
Driver loses control	2	7%
Car door/under truck	2	7%
Cyclist loses control braking	1	3%
Total	**30**	

A surprising feature of the crash types is the high proportion of ‘cyclist moves into the path of vehicle’ crashes. These are not necessarily the most common type of fatal cycling crashes in New Zealand, but these crashes clearly happen relatively frequently. This is supported by Koorey (2014) who found that cyclists turning, moving over to the right or crossing, who failed to give way to passing or through motorists accounted for approximately 24% of the cycling fatalities studied. This is also consistent with 22% of cyclists being ‘primarily responsible’ for cycle/motor vehicle crashes (MoT 2015a). It may seem to be blaming cyclist behaviour by focusing on these crashes, but alternatively a key point of this study was to understand the broader factors that might lead to cyclists making errors such as not checking before turning.

The next step in the analysis was to understand the characteristics of the most common crash types in our sample, create ‘scenarios’ for typical crashes within each crash type, identify system failures in these scenarios, explain the variations that exist for these crash types and finally suggest initiatives that might supplement existing effort to improve cyclist safety.

5.2.2 Expert workshop information for higher level causal factors

In the expert workshops, participants were encouraged to consider the higher level factors that ultimately influence more direct factors in the system, and the likelihood of cyclist casualties. The key themes that emerged from the expert workshops are listed below:

- Poor infrastructure design, including cyclist exposure to high-speed and high-volume traffic, is linked to cycling casualties.
- Design guidance, practice and auditing for cycling is poor. Roads normally get re-built as they are, even if they are functioning poorly (for anyone not just cyclists).
- Connections and area-wide approaches need emphasis and not just corridors.
- A lack of overall national strategy for cycling and integration into wider urban form and the development of towns and cities.
- Implementation of the Local Government Management Act, in conjunction with a lack of strategic positioning of transport cycling, often allows poor cycling outcomes and yet land use planning is crucial.
- Targets are very important as they drive action and change.
- Trade-off between safety and economics is leading to poor safety outcomes. Philosophically, safety needs to come first and should not be traded off against economic gain.
- Broader road safety education, including cycling is missing (values, shared understanding).
- Cycling is not well integrated into wider planning tools such as the One Network Road Classification (ONRC) system and the speed management programme.
- A lack of cycling exposure in driver training is a problem.
- Often motorists and cyclists do not have shared expectations of how to behave. There is a need for better ‘scripts’ for what is normal and expected.
- Heavy vehicle side under-run is important.
- Funding priorities within land transport do not support cycling.

In addition to the higher level system factors, it was mentioned by many that pedestrian safety is also important and there should be a more integrated view of the strategic importance of active modes.

5.2.3 Key themes from document analysis

In considering the relevant documents, some patterns emerged that are likely to have impacted on cycling investment over the period of the fatal crashes analysed. These themes are listed below:

- The earlier national walking and cycling strategy (MoT 2005) along with sound guidance via the cycle network and route planning guide provides strong strategic support for cycling and guidance that should have resulted in reasonable cycling outcomes. However, there is no evidence of this translating into ‘on the ground’ investment in cycling. This may indicate that various other governance, planning and funding mechanisms did not support the central strategic emphasis on walking and cycling.
- Later documents, such as MoT (2009; 2011b) only address cycling in a very minor way, suggesting relatively low priority for cycling as a component of the transport system. However, associated investments such as model communities were funded through this period, which, with very limited funding achieved some cycling benefits in Hastings and New Plymouth (Keall et al 2015). During this period, *Safer journeys* (MoT 2010) and the initial action plan (National Road Safety Committee 2011)

were also launched, but cycling did not feature strongly, probably due to the relatively low number of fatal and serious crashes compared with other vehicle crash types.

- As time progressed, the subsequent government policy statements (MoT 2011a; 2015d) have given more weight to cycling and the goal of increased safe cycling through improvement of cycle networks is clearly stated. This paved the way for the Urban Cycleway Programme – a total package of $333 million to expand and improve New Zealand's cycling network. Around this time the Cycling Safety Panel was also appointed by the Minister of Transport to make recommendations for cycling safety. Cycling was also made one of the Transport Agency's top six priorities for 2015–2019.

In summary, the document analysis reveals that during the period over which the cycling fatalities analysed in this study occurred (and by Koorey 2014), there was little strategic emphasis on cycling, little investment and therefore little by way of meaningful infrastructure or other measures to safely promote cycling. This does not necessarily mean that this has caused the fatalities, but rather that the fatalities happened within a context that was not supportive of cycling. The documents also tell us that recent efforts to promote safe cycling have greatly improved. This may mean that the causal pathways for future cycling fatalities will be different, especially if investment and priority is maintained.

5.2.4 Cycling fatality analyses

In the next three sections, three typical cycling fatality scenarios have been identified and analysed from the fatal crash cases. For each of them a basic description of the scenario is followed by a 'causation pathway analysis', using the cycling safety system model as a guide. For each of the analyses, information from the fatal crash cases, expert workshops and document analyses have been brought together to create the system failure pathways. The crash data has contributed to the road user and environmental context categories, while the content of the higher categories is mostly determined through the stakeholder workshops and document analysis (shaded in blue). The diagrams have been deliberately kept as simple as possible, only drawing on the key relevant elements from the cycling safety system model.

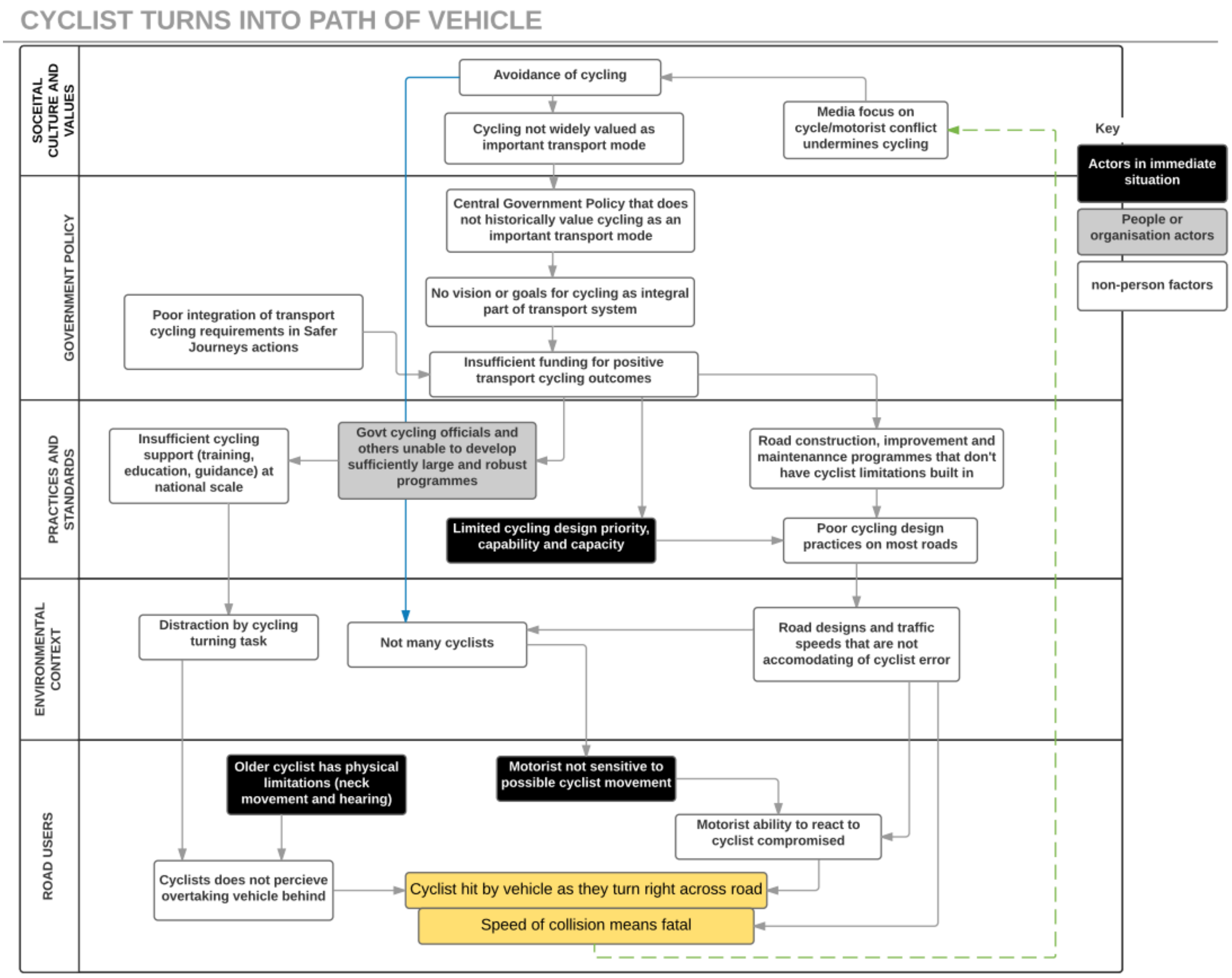
5.2.5 Scenario 1: Cyclist turns into path of vehicle

5.2.5.1 Description of crash scenario

This fatality happened when a cyclist on an urban collector road turned suddenly in front of a passing vehicle with little warning. The older cyclist (75 years) was travelling to a friend's place and in attempting to move to the middle of the road to turn right into a side road, did not check over his shoulder for passing traffic. As he moved to the centre of the road a passing vehicle, travelling at approximately 50km/h and with very little time to react, struck the cyclist. Sadly, the cyclist died at the scene.

Summarising the analysis in figure 5.2, the cyclist was killed when he attempted to turn right across the road. The physical limitations of the cyclist may have contributed to his lack of awareness of the passing vehicle and focusing on the turning task manoeuvre may have distracted him. Checking before proceeding to the right may not have been habitualised which may have been exacerbated by a lack of support, training, education or understanding of the risks of doing this. For the driver, although there was little they could do at the time, a lower impact speed may have resulted in the collision being avoided or at least survivable. The design of the road permitted and supported a 50km/h travelling speed and so the vulnerability of cyclists (or pedestrians) was not reflected in the street design or design guidance. A lack of road safety education and cyclist friendly design guidance was a natural consequence of a lack of funding and strategic support for cycling.

Figure 5.2 Causal pathway diagram for 'cyclist turns into path of vehicle'



Following the above description of the factors contributing to the crash, the system failures are summarised into categories modified from the HFACS framework. A contemporary perspective is that the term 'unsafe acts' focuses too much on the behaviours of individuals (whereas equal focus across the system is preferred) and so this term has been changed to 'road user actions' and the next level is defined as 'pre-conditions for event'.

5.2.5.2 Summary of system failures

Road user actions	• Cyclist lapse (skill-based error). Likely not perceiving nearby vehicle before turning across traffic • Motorist not adjusting speed or distance as they approached cyclist
Pre-conditions for event	• Speed environment and road design does not accommodate cyclist error • Motorist not ready to react to cyclist movement • Older cyclist who is more vulnerable to crash forces
Practices and standards	• Road design standards do not accommodate cyclists error • Insufficient cycling competency support • Road design practices and standards that are not sensitive to cyclists
Organisational influences	• Little strategic support and therefore funding for cycling design, promotion and education

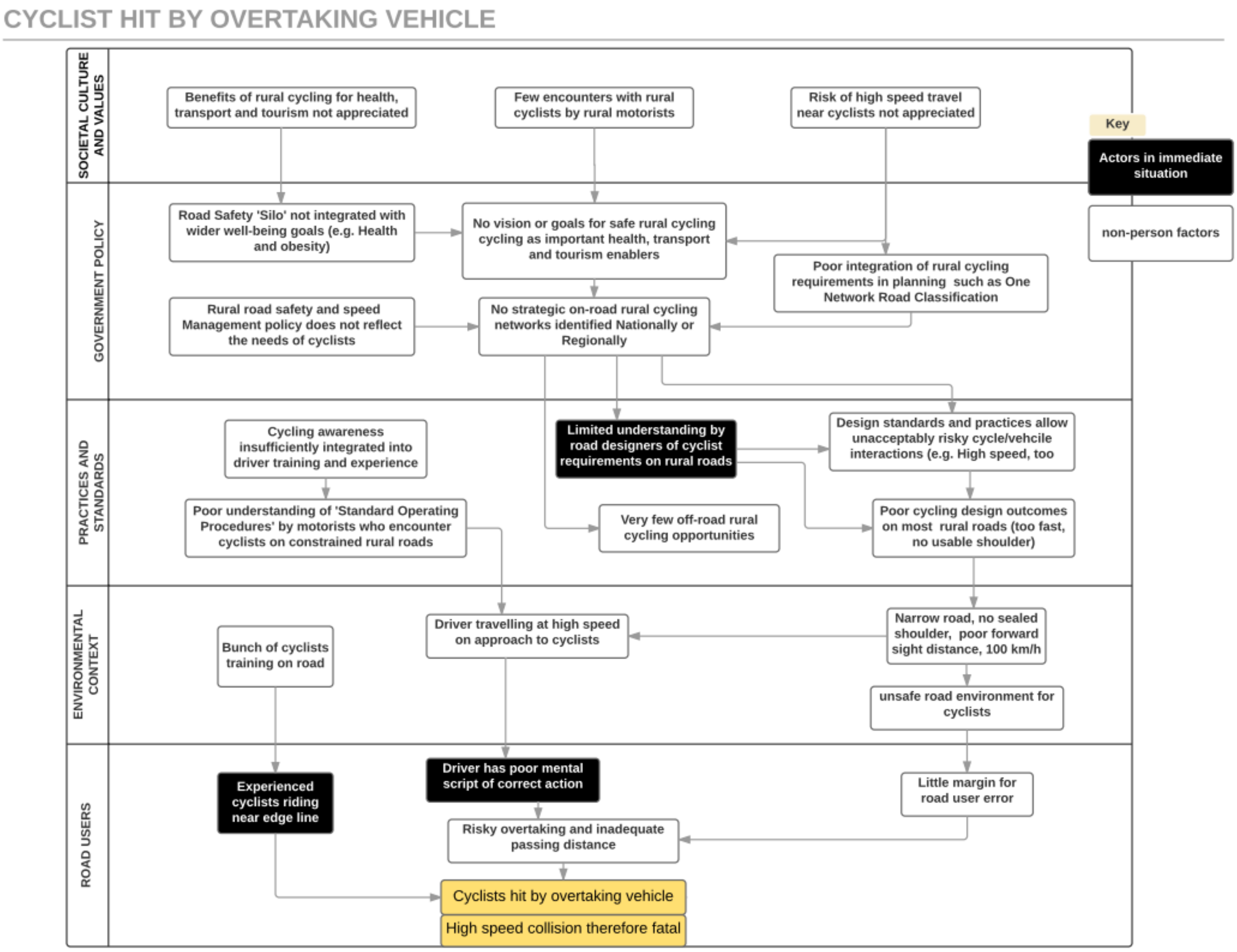
5.2.5.3 Variations of 'cyclist turns into path of vehicle'

There are a number of variations on the 'cyclist turns into path of vehicle' crash type. In some instances younger cyclists are following others across the road and are possibly distracted by this goal. In others, middle aged cyclists turn or u-turn, presumably without checking properly, and it is not clear why this might have happened. Remarkably, other examples include cyclists turning right across the path of an oncoming vehicle. In these cases, perceptual errors, distraction and individual factors are all potential factors depending on the circumstance. Often the 'looked but didn't see' phenomenon is attributed to motorist errors in cycle vs vehicle crashes. However, in many cases, either failing to check properly or cyclist 'looked but didn't see' errors might also be key factors.

5.2.5.4 Existing and suggested initiatives to mitigate 'cyclist failure to check'

Cycling competency is an area that requires, and is receiving, further development. The goal of making a habit of proper checks before turning, through training and reinforcement, should be included in cycle skills training and supporting activities. Checklists, and triggers for using them, can be effective tools for preventing lapses such as inadvertently failing to check. For situations where younger cyclists follow others across the road without checking properly, road safety education based in the school curriculum and surrounding community, to reinforce correct attitudes, perhaps while addressing wider risk-taking issues, consequences and also peer pressure, may be useful.

Figure 5.3 Causal pathway diagram for 'cyclist hit by overtaking vehicle'



Summarising the contributing factors outlined in figure 5.3 above, the driver of the over-taking vehicle misjudged the safety of overtaking in this constrained situation and possibly did not have a strong mental script or 'standard operating procedure' for how to behave in this situation. Because there was no usable shoulder and the travelling speed of the vehicle was high, there was exposure of the cyclists to a high severity collision situation. The cyclist was on this road as it was commonly understood to be a well-known training route, despite the dangerous environment for cyclists. There is little understanding of the requirements of cyclists in these situations by road controlling authorities and therefore design and maintenance practices do not reflect cyclists' needs. This may stem from a lack of any strategic guidance for rural cycling on higher speed roads.

Table 5.3 Error analysis

Road user actions	Motorist makes mistake of thinking they can overtake safely
Pre-conditions for event	• High speed road and high closing speed means little time to make decision • No shoulder space for cyclist • Popular cycling route
Practices and standards	• Road design practices and standards that are not sensitive to cyclists • Limited on-road training opportunities • No 'standard operating procedures' for drivers encountering cyclists when insufficient space
Organisational influences	• Little strategic support for rural on road cycling routes with good level of service.

5.2.5.5 Variations of 'cyclist hit by overtaking vehicle'

There are two other mechanisms by which cyclists have been hit from behind by an overtaking vehicle. In two crashes, trucks have left their lane and hit the cyclist, even when plenty of shoulder space is available and the cyclists were riding correctly in the shoulder. In two further cases, impairment of drivers (sun glare and alcohol) have been factors leading to collisions with cyclists from behind, on high-speed roads with little shoulder space. In the case of trucks leaving their lane, fatigue or distraction are likely to be involved. For the sun glare and alcohol examples, the driver has committed violations (in the sun glare case, the driver failed to drive to the conditions and continued at high speed).

5.2.5.6 Existing and suggested initiatives to mitigate 'cyclist hit from behind'

For the various 'cyclist hit from behind' examples there are range of initiatives that may mitigate this crash type. The Cycling Safety Panel (2014) recommended that on rural roads, usable shoulder space is likely to significantly help cycling safety. Therefore any shoulder widening with ongoing clean shoulders is likely to be an improvement for cyclists. However, this still leaves a system that is not safe, where 100km/h traffic is passing close to cyclists.

A solution could be to create iconic and very recognisable rural cycling routes for training cyclists, tourists and recreational cyclists where relatively large numbers of cyclists are expected. Early testing of rural road cycling solutions have been carried out (Trotter et al 2016), borrowing from Dutch '2-1' road designs, but the trial outcomes were unsuccessful. However, further work, liaising closely with rural cyclists, could lead to effective cycling solutions that are acceptable. Design elements could include plentiful smooth shoulder (sometimes via traffic lane narrowing), lower speed limits (60–80km/h), signage, sharrows and perhaps even strategic use of road marking colours other than white (eg green).

Training and other work to reinforce 'standard operating procedures' for motorists encountering cyclists may help. While the road code has clear guidance for safe driving around cyclists (eg 'Wait for a clear space before passing a cyclist on a narrow road') (NZ Transport Agency 2015) an automatic checklist of actions for drivers could be reinforced. It seems some drivers are simply not clear on how they should act when encountering cyclists on high-speed roads in constrained conditions.

For the two cyclists who were hit from behind by trucks that left their lane, initiatives need to be aimed at truck driver fatigue and distraction to address such cases. There have been various efforts to investigate this, but to date there appears to be no satisfactory solution to the inherently risky situation truck drivers find themselves in. Spending up to 14–15 hours per day on work-related duties, often starting in the early hours of the morning breaks many fundamental rules of good fatigue management. Until this is addressed, trucks leaving their lane and some of them colliding with cyclists, is likely to continue in the future.

5.2.6 Scenario 3 – Cyclist hit by car door and falls under truck

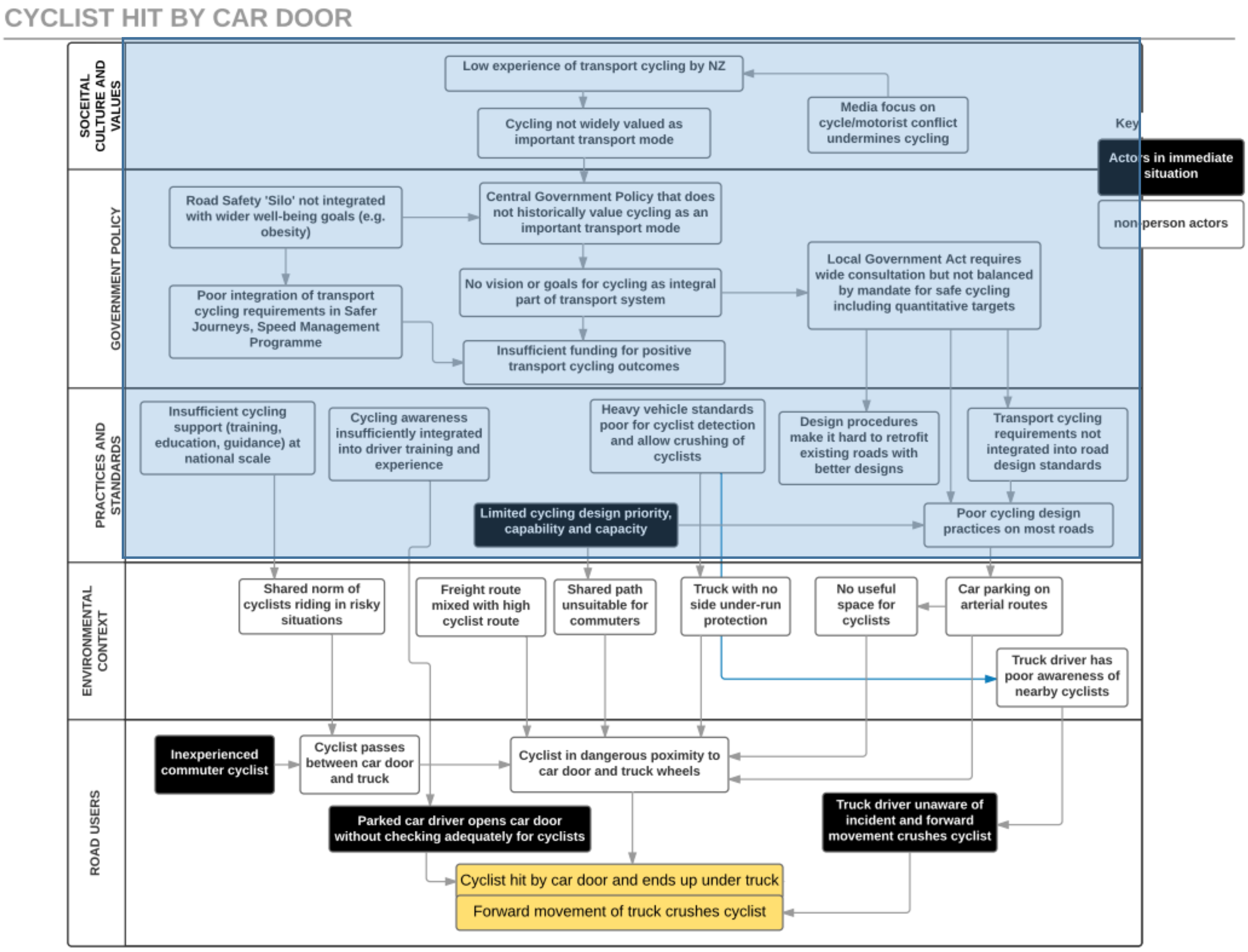
The third chosen crash type, 'cyclist hit by car door and falling under truck', was chosen for analysis, despite being relatively less common, because this situation has so many different system elements to it. Individually these are important cycling system considerations. Also, this scenario relates to car parking in urban areas, which is one of the greatest obstacles for urban transport planners in trying to create safe and user-friendly cycling networks. There is also an interwoven connection between actual and perceived safety, with the latter crucially important for attracting more cycle trips in towns and cities. This crash type, 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 for fear of their safety. There was also a considerable amount of information and expertise available for this crash type, which helped to make the analysis more robust.

5.2.6.1 Description of crash scenario

> A cyclist was riding to work along a busy arterial road with car parking and a general traffic lane next to it. A painted cycle lane is provided for some parts of this route, but not where the collision occurred. A driver in a parked car opened his door without checking properly and the passing cyclist, travelling relatively quickly and squeezed for space between the general traffic and the parked cars hit the car door. At the same time, a truck was moving slowly responding to a green traffic light ahead and the cyclist fell underneath the truck. The slow-moving truck's rear wheels crushed the cyclist who then died at the scene.

In figure 5.4, the key actors are the cyclist, the driver of the parked car, the truck driver and those who were responsible for designing the road. While the central event was the car driver opening their car door, the cyclist hitting it and then falling under the truck, there are many other important aspects to this crash. First, the road design was clearly inadequate for cyclists and yet there was no other feasible option for the cyclist. The reason for this design was due to ongoing tension between those who wanted to retain parking at this location and those who viewed it as a safety hazard. Because there was no national mandate to improve road conditions for cyclists, and with local government requirements to consult with all involved, those who preferred to retain the parking won the battle. The proximity of cyclists to trucks with no side under-run protection is also a key consideration with massive cyclist consequences from road user errors in this situation. Last, the parked driver's lapse of not checking properly before opening her door was linked to a lack of cycling awareness, exposure and therefore consciousness of cyclists. Checking for cyclists was not a habit for the driver. The last point, but not the central one, is that the cyclist failed to see the risk of passing close to the car door and did not act defensively by riding slowly or riding further out in the lane, in the traffic stream, although there are very reasonable reasons why this did not happen.

Figure 5.4 Causal pathway diagram for 'cyclist hit by car door and falls under truck'



5.2.6.2 Error analysis

Road user actions	• Motorist opens car door without checking (lapse) • Cyclist rides at speed between parked car and traffic (mistake) • Truck driver does not detect cyclist and continues over the cyclist (slip)
Pre-conditions for event	• Poor road design for cyclist and no feasible alternative route • Close proximity of cyclists and truck with no under-run protection or sensors • Lack of cyclist awareness by car and truck drivers • Cyclist insensitive to dangerous situation
Practices and standards	• Road design standards that are unwilling to place safety first and practices that are insensitive to potentially dangerous situations • Lack of cycling promotion, awareness, training among motorists
Organisational influences	• Little strategic local and central government leadership to prioritise cycling safety and communicate the many benefits of urban transport cycling

5.2.6.3 Variations of 'cyclist hit by car door and falls under truck'

There were no other variations of this crash type. At least one other earlier fatality is known of (in very similar circumstances). There are likely to be a large number of serious and minor injury crashes where a cyclist has hit the car door, but not fallen under a truck.

5.2.6.4 Existing and suggested initiatives to mitigate 'cyclist hit by car door and falls under truck'

A number of high-priority Cycling Safety Panel (2014) recommendations apply to this scenario:

- Accelerate the provision of completed, fit-for-purpose, connected cycle networks.
- Separate cyclists from high-speed and high-volume or high freight density traffic.
- Progressively remove parking from arterial roads where it is a safety risk.
- Develop and promote nationally applicable design guidelines for cycling infrastructure.
- Increase and incentivise training for commercial drivers about driving safely near cyclists AND raise cyclist awareness of the risks of riding near heavy vehicles.
- Investigate the costs and benefits of introducing mandatory truck side under-run protection and other vehicle safety features.

These recommendations would go a long way to addressing the 'cyclist hit by car door' crash type including the 'falls under truck' component. However, an issue that came through strongly from the stakeholder meetings was the barriers to implementing changes such as those outlined above. There is enormous inertia when it comes to changing the way of building roads, and dealing with the number of political, regulatory, consultation and design barriers to safer and more user-friendly arterial roads for cyclists. All of this comes back to the lack of strategic importance given to cycling, despite the many congestion, health, environmental and economic benefits that cycling brings. There is still some way to go before road design systems are likely to accommodate safe and user-friendly cycle routes.

5.2.7 Other cyclist crash types

The analysis in this report has focused on some common cycling crash types to demonstrate the application of contemporary crash analysis methods. Other crash types have been identified but have not been addressed in depth here. In particular, 'driver failed to give way' is a very important crash type that could be analysed later in more depth. Central to 'driver failed to give way' is inattention blindness (looked but did not see) and/or the conspicuity of cyclists. Another important crash type is 'cyclist loses control downhill'. This has not been given much attention in New Zealand to date, and yet cyclist speed has been identified as a safety issue (Shepers et al 2014; G Wijlhuizen, pers comms 2016). There have clearly been cyclist fatalities and serious injuries where gradient and/or speed has been a contributing factor in the severity and possibly the likelihood of cyclist crashes. It may be that cyclist decision making and also the error tolerance of road infrastructure are important elements that could be explored further.

5.2.8 Themes from the analysis of cycling casualties

The influence of road design on cyclist and motorist behaviour was the strongest theme emerging from the analysis. It was a central discussion point in the expert workshops with clear links to how road design has resulted in poor safety for cyclists. From the crash analyses, in most cases, the design of the road was clearly a causal factor in the cycling fatalities. It should be noted that this conclusion is derived from expert conversations and our own interpretation of the crash information. Often in fatal crash and coroners' reports, road design is not mentioned as a causal factor, possibly because the road met design standards. This raises questions about the scope of crash reporting, but also the extent to which road design standards are fit for purpose.

Another common trend that emerged from the analyses was clear errors by motorists and cyclists, often reflecting a lack of basic skill or decision making. Care is needed to understand the limitations of people and also the environment which may or may not afford safe behaviour. Nevertheless, it does seem that reinforcement of some basic safe behaviours or ‘standard operating procedures’ for motorists and cyclists would go some way to improving cyclist safety outcomes.

Considering that road designers, motorists and cyclists are all likely to have a major role to play in cycling safety, a model of shared responsibility, in line with the safe system approach emerges.

6 Discussion

6.1 The application of contemporary incident analysis methods to cycle casualties

The analysis in this study applied a cycling safety system model, derived from contemporary crash analysis methods, to cycling fatality crash types. Fatal crash information along with themes gathered from key cycling documents and cycling safety experts were used to create causal pathway diagrams to explain how various parts of the cycling safety system have failed. The analysis has shown how failures at various levels of the cycling safety system influence each other to result in cycling fatalities. The key learning is that failures at all levels of the system can contribute to high severity crashes and road users are often the recipients of bad system design. For example, it seems clear that national strategic leadership for cycling would help facilitate better consultation outcomes, design standards, more training, education and support; and would also make the case for a greater proportion of transport spending on cycling provision. In turn, this would lead to better cycling environments, more cyclists, more competent drivers and cyclists, and relatively fewer cycling casualties.

The main difficulty with the analysis, as has been mentioned by other authors, is the lack of high quality data to apply the cycling safety system model to individual cases. A pragmatic approach has been taken to use available crash data at the lower levels (road users and environmental context) and then rely on documents and workshops with experts to populate the higher levels (practices and standards, government policy, and societal culture and values). Consequently, caution is needed in interpreting the interface between these levels of the system and their different methods. This has been mitigated as much as possible by interrogating how higher levels of the system have actually impacted on lower levels in some cases and likewise for individual crash cases, effort has been made to understand the broader context whenever information is available (usually in higher profile cases).

It is hoped that future investigations of cycling casualties will not only describe the various conditions surrounding crashes, but will actually dig deeper into the range of system factors, including organisational ones, that may have a strong influence on casualty likelihood.

6.2 Next steps for the safe system approach?

Next steps following this report should be to refine the cycling safety system method and, alongside road safety officials, discuss ways in which the principles could be integrated into cycling and other casualty analyses. Although the focus has been on cycling casualties, the methods have origins in broader applications including general road safety. There is potential application of the safe system approach which is now relatively well accepted and understood in New Zealand, but not always well implemented. The cycling safety system model emphasises joint responsibility and a whole of system approach, and reflects the fact that people make mistakes and other aspects of the system need to accommodate these errors. These are also key principles within New Zealand's version of the safe system approach and so the cycling safety system and its application to road safety may provide a useful method for 'how to apply the safe system'.

A challenge in attempting to apply this approach to road safety is that insufficient data may be available to robustly interrogate all levels of the system. Further effort is needed to develop an analysis method that is workable enough, alongside better data to feed into the analysis. Options for this may include extending the scope of crash reporting (such as the crash analysis system or fatal crash reports). Alternatively, it may be that the analysis is not carried out for every crash, but only as a special exercise when needing to understand clusters of crashes. This may make the system more workable, while still giving a level of insight much deeper than the current system, which almost never gets past users and immediate environmental factors.

A precedence for applying this approach to real-world contexts does exist in the outdoor education sector, where a systems approach to incident reporting has been developed. See the UPLOADS project (University of Sunshine Coast www.uploadsproject.org).

6.3 Integration of contemporary incident analysis methods into New Zealand's transport planning system

Taking a step further than just identifying the causes of crashes, the cycling safety system method could also be used to help map interventions that are likely to have the greatest impact on cycling safety and participation outcomes. By setting out the logic of how societal and organisational influences flow down to practices/standards and ultimately the transport environment and people's behaviour, investment could be more robustly planned. For example, the analysis in this report has shown how the lack of an overall strategy for cycling affects many elements, such as the ability to remove parking, and providing safe rural cycling opportunities for tourists, training cyclists and commuters. This process could link into the Transport Agency's business case and investment logic mapping approach to provide a logical rationale for cycling investment.

6.4 Limitations of this research

A key limitation of this research is that the analysis has focused on fatal crashes only. Serious and minor injury crashes, and even near misses are also important to consider; however, information about these crash types is much more limited. Typically a police crash report will only be carried out for fatal (or very serious) crashes. Coroners' reports also often have useful information that considers broader issues, but these only exist for fatalities. Further work should explore how less severe crashes and near misses can feed into an analysis system such as that proposed in this report. This could include more reporting of near-misses, uncomfortable situations and interviewing techniques to access the rich information from those involved in crashes or near misses, but also those who are responsible for implementing the system. A key advantage of utilising non-fatal crash or incident data is that a living person can give a detailed account of the various individual and background factors that would otherwise not be possible. For example, asking about distractions, cycling experience and events leading up to an incident could yield important contributing information. This level of interrogation is common in safety critical domains such as aviation and in road transport fuel haulage.

Another important limitation was the lack of available information to create the crash causation diagrams. The expert workshops and document analyses, along with fatal crash and coroners' reports were certainly useful, however, a deeper understanding would be possible if all of those involved in the management of individual crash cases could be interviewed. To some extent this is already done, but with more information available, a systematic process of asking *why* starting from the crash itself and working up to organisational and societal factors would be useful. The methods for actually applying crash analysis frameworks would clearly need refinement if they were to be used in future, although simplified approaches could still be useful in the shorter term.

6.5 Recommendations

6.5.1 Recommendations for cycling safety and promotion

The study has identified some key areas to support cycle safety and cycling promotion.

- A more constructive public conversation about transport cycling is needed, starting with an accurate understanding of what the general public's values are now. Collective public values are at the very top of the cycling safety system model, and this has remained so, following scrutiny by a number of transport experts. Shortly, a national cycling perceptions survey will help with this, but the next step will be to form and communicate an accurate picture of the general public's mandate for cycling, moving beyond political rhetoric. This will help politicians and transport officials make informed decisions about the extent to which cycling should exist as part of the transport system. Within this conversation, the wider benefits and costs and potential scenarios of choosing more cycling investment or not, need to be clearly laid out. There are potentially enormous economic opportunities to be gained from safe cycling in future cities (Mason et al 2015), and these conversations, along with any other implications, need to take place in a balanced and constructive way.
- A more strategic approach to active travel modes within New Zealand's future transport system, would make the many benefits of active modes clear to all, explain what is needed to realise these benefits, provide a case for a step change in active modes and ultimately help to integrate better active travel environments into goals for future towns and cities. Strong active transport signals within transport policy would help to ensure a more systematic, consistent and lasting approach to integrated active travel provision and therefore increase the likelihood of congestion, health and environmental benefits being realised.
- Prioritising road infrastructure and focusing on the behaviour of motorists and cyclists are both key to cycling safety. While almost all crashes are the direct result of human error, it is the environment within which road users must operate that largely dictates their behaviour. Road design systems should facilitate best practice during greenfields projects and the re-design of roads at cost-effective opportunities such as during re-builds, re-seals and footpath renewals in particular. The inertia of the current roading system is still producing poor outcomes for cycling.
- Design standards, capability, capacity and behaviour need to be improved. New Zealand will shortly have much better design guidance for cycling (through the Transport Agency's cycling network design guidance project), but this does not mean that actual design practices will be achieved throughout the country. A sustained effort to upskill, recruit and incentivise road designers so that actual design behaviour follows latest practice is needed.
- Standard operating procedures for motorists and cyclists should be reinforced. Until infrastructure provision for cyclists can be dramatically improved, some very clear expectations could be clarified, reinforced and enforced to create safer driver/cyclist interactions. In other countries, such as the USA, even when cycling infrastructure is poor, there is often much more considered driver behaviour around cyclists. For example, when a driver approaches a cyclist from behind on a narrow high-speed road, it should be absolutely clear what the correct driver response should be, the response should be automatic and the consequences of behaving incorrectly should be clearly understood.
- The Cycling Safety Panel (2014) recommendations cover many issues for cycling safety, but some specific safe system design considerations either introduced or reinforced through the present project are:

- more emphasis on speed management in providing for safe cycling, linking in with existing road classification and operating tools such as the ONRC system, the speed management programme and network operating frameworks
- more area-wide and connection approaches to cycling network development (as opposed to only easy-wins)
- re-design key rural cycling routes in a participatory way to provide very recognisable cues to motorists and an acceptable level of service for cyclists

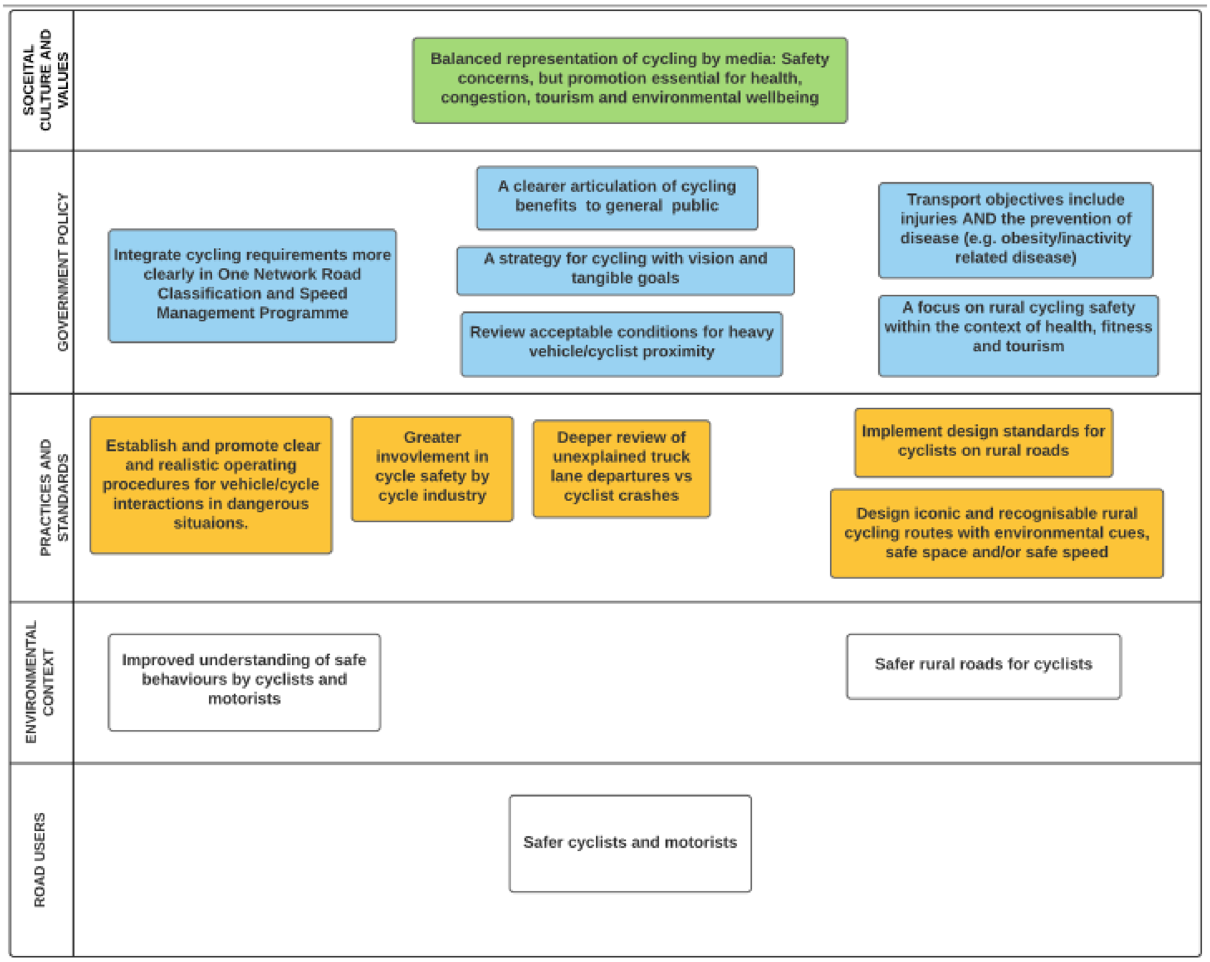
- A set of safe riding behaviours, and standard operating procedures reinforced through best practice road safety education, cycle training and repeated awareness, would go some way towards cyclists keeping themselves safe. Information exists for this, but road users often do not understand or exhibit these behaviours.
- Road design guidelines should be strengthened to reflect cyclist speed, control and errors.
- Closer engagement with the bicycle industry would be helpful. Forgetting or not understanding how to secure a front wheel after re-assembling (perhaps after transporting the bike in a car) has had fatal consequences.
- There should be a comprehensive focus on heavy vehicle/cyclist interactions. This relates not only to side under-run protection and/or sensors, but also to driver fatigue/distraction and clearly understood safe behaviour around cyclists.

6.5.2 Recommendations for applying contemporary incident analysis methods to cycling safety and road safety in general

- Start simple. Use the cycling safety system, or at least the five system categories, to identify system failures in road safety workshops or other projects to address cycling safety. For example, the next time a problematic intersection for cyclists is analysed, apply the framework to interrogate the whole system, and map the influences of higher level factors on more direct road user and environmental factors. Formally record these causal pathways.
- Establish a user-friendly cycling safety system (or road safety system) analysis tool. This could involve the development of a simple reporting tool that requires information to be entered about crashes or groups of crashes either soon after a crash or at periodic occasions. The tool would prompt information to be entered about road users, vehicles, environmental context as would normally be collected, but also connected higher level practices and standards and even policies. An example of this approach in practice is the Australian UPLOADS project as mentioned earlier, which uses a socio-technical systems approach to better understand outdoor education incidents. Reporting tools and an analysis framework have been established and 'whole of system' causal factors have been identified.
- Carry out a participatory process to design a 'safe system road safety analysis tool'. With the above goal in mind, utilise sector experts to identify the most efficient and effective way of establishing a data collection and analysis process that identifies both immediate and higher level factors for explaining crashes and associated solutions.
- Carry out a review of the information that is currently collected through various sources and the information that would ultimately lead to a safe system understanding of cycling and other crashes. Without being too complicated, the goal should be to identify new data that is needed and the methods that could be employed to collect it, so that safe system analyses of crashes can be carried out.

A hypothetical example is the investigation of cycle crashes and/or near misses on rural roads. A data collection tool would interrogate existing crash data, and a supplementary survey tool would ask questions about potential causal factors (providing a menu on the range of possible causal factors from all levels of the cycling safety system, including design standards, cycling strategy etc. The analyst (eg an appropriately trained road safety professional) would then identify the factors and the links between them that are contributing to the cycling crashes, using the framework provided. Example outputs might include inadequate design standards, unsafe speed on popular cycling routes, or a lack of understanding of safe behaviours around cyclists by motorists. Solutions could then be mapped onto the same framework so that a logical sequence of higher and lower level initiatives emerge (figure 6.1). This approach is much more likely to lead to nationwide safety improvements than simply focusing on the behaviour of road users at a location who may have made an error of some description.

Figure 6.1 Hypothetical solutions to address 'cyclist hit by overtaking vehicle' crashes on rural roads



6.6 Conclusion

Proactive effort is needed to reduce the likelihood of cycling casualties alongside current cycling promotion activities. Building on the recommendations of the Cycling Safety Panel, this study takes the next steps in applying the safe system approach to cycling casualties. With some modification, application of contemporary incident analysis methods to cycling fatalities has shown to be useful in moving beyond simply describing the characteristics of crashes, to obtaining a deeper and broader understanding of causal factors. Many factors within all levels of the cycling safety system have been identified as problematic by the sector and so this approach could play a role in identifying system failures and ultimately mapping investments that have evidence-based and logical pathways to preventing cycling casualties. There is currently work underway to address some of these system factors through the National Cycling Programme, but gaps remain. The method could work well alongside existing investment logic mapping approaches and could also be applied to the broader road safety domain.

PART B: PREPARING NEW ZEALANDERS FOR UTILITY CYCLING

7 Introduction to Part B

The Transport Agency's programme of work to make urban cycling 'a safer and more attractive choice' is multi-faceted, encompassing investment in cycling infrastructure, the promotion of cycling, changes to legislation and education components, such as cycle skills training.

For many, cycling is an enjoyable activity and learning to ride a bike a key life milestone; however, being able to confidently and competently ride a bike on the network is not something all New Zealanders currently have access to or want to participate in. In alignment with the safe system approach, the Cycling Safety Panel's highest priority recommendations were the development of connected and completed urban networks and safer motorist speeds (Cycling Safety Panel 2014). However, the panel also recognised the need to facilitate a major culture shift across all road users so that sharing the road safely was an embedded norm (Cycling Safety Panel 2014). While improved infrastructure, speed management and greater numbers of people cycling, will play a role in this culture shift, a mix of legislation, advertising and training approaches were also recommended as part of the overall suite of initiatives. Specifically, in terms of training for cyclists, the Cycling Safety Panel recommended: improved access to cycle skills training for children as part of a comprehensive package of safer routes; safer speeds and school travel planning initiatives; and the creation of cycle training opportunities for adults.

As highlighted above and discussed throughout Part A of this report, it is unlikely that any one initiative (eg cycle training) in isolation will contribute to tangible improvements in cycle safety or cycling participation, and overall, a package of safe system measures will be needed. However, it remains important that each component is playing its part and is functioning as effectively as possible. Thus, the Transport Agency has sought guidance on a best practice cycle skills training system that can develop confident, competent bike riders, and contribute to the goal of increasing cycling for transport trips.

Although this work focuses on cycle training approaches and cyclist competencies, the authors do not seek to 'blame the cyclist' in anyway or dilute the importance of road design, motor vehicle speeds, driver behaviour and wider social norms around cycling.

Cycle training can be defined as 'preparing people to confidently and safely ride on the road' (NZ Transport Agency 2012a). Various types of cycle training are delivered around the world to various age-groups, with the aim of contributing to broader goals of reducing cycling injuries and increasing the frequency of cycling (Johnson and Margolis 2013; NZ Transport Agency 2012a; Richmond et al 2014; Goodman et al 2016; Beca 2013; Hawley and Mackie 2015a; 2015b; Hooshmand et al 2014; Pucher and Buehler 2008). The Transport Agency has guidelines for the set-up and delivery of training schemes, which include training content, recommendations for age-groups, health and safety procedures and evaluation activities (NZ Transport Agency 2012a). There is also a qualification framework, which enables cycle instructors to become nationally accredited. As well as considering areas for development within these existing processes and guidelines, this work also considers the role and importance of additional 'actors', initiatives and conditions that may support the development of confident, competent cyclists and more cycling.

First, this work comprises a literature review covering: the rationale for cycle training; the skills, knowledge and attitudes children and adults need to ride on the network (including on cycle facilities, such as shared paths); the effectiveness of cycle training on cycle skills, knowledge, road use and cycling participation; good practice recommendations for cycle training approaches; and the current reach and approach to cycle training in New Zealand. This work initially focuses on formal cycle training (ie training delivered by an instructor to an individual or a group). However, as this is not the only way for individuals to develop the competencies required to ride on the network, other activities, referred to as 'informal training' are also discussed (eg training or supervision from friends or family, recreational cycling, online resources, the code for cyclists and experience).

Building on the literature review, a qualitative research process was undertaken with a range of stakeholders and end users. Overall, the purpose of this work was to provide guidance on a best practice cycle skills training system that would be most likely to result in the outcomes below for bike riders of all ages (these outcomes were provided by the Transport Agency):

- confident and skilled riders of bikes on the road, and on other shared spaces
- riders of bikes who know the road user rules and use techniques to keep themselves and others safer on the roads
- riders of bikes who behave courteously to other road users, including on shared spaces
- significantly increased numbers of people cycling to school (under 18 component)
- increased numbers of people cycling for utility purposes (18+ component).

8 Literature review

The literature review focused on the areas below, as proposed in the initial scoping of this research.

- the rationale for cycle training
- the skills, knowledge and attitudes children and adults need to ride on the network (including on cycle facilities, such as shared paths)
- the effectiveness of cycle training on cycle skills, knowledge, road use and cycling participation
- good practice recommendations for cycle training and road safety education
- the current reach and approach to cycle training in New Zealand.

Both peer-reviewed and grey literature is included. In terms of examining the effectiveness of cycle training approaches, peer-reviewed literature with stronger study designs, such as control or comparison groups, was focused on; however, this was supplemented by other evaluation studies if limited research was evident (eg adult cycling training). Similarly, international and national guidelines and research summaries were also included.

8.1 The rationale for cycle training

8.1.1 Cycle training not in isolation

Cycle training falls within the 'road user education' pillar of the safe system approach (MoT 2010) and is only one part of a safe system for cyclists. A focus on shared responsibility and coordinated action within the four pillars of safe speeds, safe vehicles (including bikes), safe roads and roadsides and safe road use are needed to ultimately ensure the safety of cyclists on a population level (Cycle Safety Panel 2014). Correspondingly, the Cycling Safety Panel (2014) recommends a package of safe system measures to increase the safety of cycling to school, and suggests that education and training around the key risks for cyclists combined with improvements to cycle routes will be needed to increase safety outcomes.

International reviews suggest that the development of separated cycling facilities, speed management and intersection treatments, are the most important approaches for improving cyclist safety while also increasing the uptake of cycling (Pucher and Buehler 2008; OECD/ITF 2013). However, other components of a coordinated and multi-faceted approach are also important, such as bike parking, end of trip facilities, legislation to protect cyclists, integration with public transport, promotion of cycling, and education and training for motorists and cyclists (Pucher and Buehler 2008; Schepers et al 2013). The impacts of coordinated implementation, while making it difficult to attribute changes to any one policy or approach, is considered more beneficial than any one initiative in isolation and more beneficial than simply the sum of each part (Pucher and Buehler 2008).

Similarly, intervention studies have demonstrated that the provision of cycling infrastructure alone may not lead to the expected increase in cycling volumes; other approaches over time, such as the promotion of cycling, development of cycling competencies and removal of other barriers, are likely to be needed to receive a meaningful return on investment in infrastructure (Rissel et al 2015; Goodman et al 2014; Goodman et al 2010). The relative success of New Zealand's investment in model communities, on reported transport cycling, also points to the benefit of a comprehensive approach (Keall et al 2015). Delivering cycle training and developing cyclists' competencies, in conjunction with infrastructure that supports safety is also suggested as good practice in other reviews (Mackay et al 2011; Raftery and Wundersitz 2011).

As well as coordinated action within the other pillars of a safe system, cycle training as a tool to facilitate *more* cycling may need to be embedded within a wider behaviour change strategy that supports the uptake of cycling.

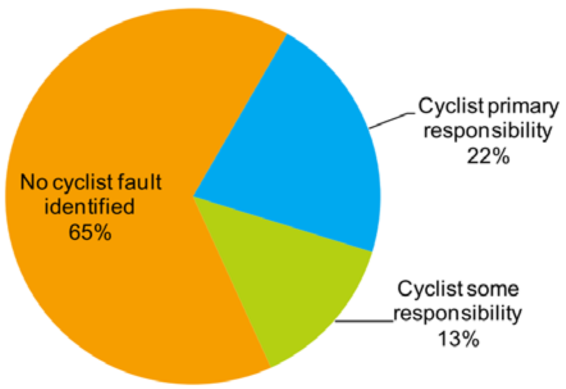
8.1.2 Cycle training from a theoretical basis

First, it important to understand the underlying mechanism by which cycle training could contribute to safer road use and increased cycling participation. Examining this underlying logic helps to clarify the rationale for cycle training and other strategies over and above traditional forms of training, that could also support cycling competency and contribute to longer-term outcomes of safety and participation.

Cycle training is based on the logic that, through facilitating good basic skills, habitual safety behaviours and defensive cycling, it can have a positive effect on safe road use. Many countries with high volumes of cyclists ensure both cyclists and motor vehicle drivers are provided with training related to cyclist skills, in order to create widespread understanding and expectation in terms of behaviour (OECD/ITF 2013).

In New Zealand, between 2010 and 2014, cyclists were primarily or partially 'at-fault' in 35% of fatal and injury crashes involving a vehicle (figure 9.1) (MoT 2015a). Failing to see the other party and failing to give-way were common crash factors. It can be hypothesised that sufficient training could reduce the likelihood of a cyclist 'at-fault' crash by trained bike riders. Although, purely focusing on a cyclist's skills may be insufficient.

Figure 8.1 Cycling crash fault for fatal and injury crashes (2010–2014)



Source: MoT (2015a)

Cyclists were not 'at fault' in 65% of fatal and injury crashes on roads – common crash factors were drivers failing to give way or stop and failing to see the cyclist (MoT, 2015a). It can also be hypothesised that if people are trained to ride where they are most likely to be seen, to be constantly aware of vehicles and to choose their routes wisely, these defensive cycling behaviours could have some impact on the likelihood of a 'non-cyclist fault' crash in trained individuals. However, a key point is that training may need to have sufficient reach and 'dose' (total time of training) in order to have a noticeable effect on these injury outcomes, and other safe system approaches may ultimately have a greater net safety benefit.

A large proportion of cycling casualties are due to non-collision crashes; it has been estimated that 33.6% of cyclists' serious injuries and deaths between 2003 and 2007 were as a result of non-collision transport crashes (Tin Tin et al 2010). Hospitalisation data from 2014 shows that 117 cyclists were hospitalised (for more than 24 hours) due to collision with a motor vehicle, 328 due to a non-collision crash on the road and a further 393 from non-traffic (or off-road) incidents (MoT 2015a). The development of good cycling skills through training, on-going practice and reinforcement has the potential to reduce non-collision or off-road injuries. Similarly, a recent New Zealand study found that poor helmet condition and inaccurate fitting, and poorly maintained bikes, such as worn brake pads, were common (approximately 40% of a sample of 215 students aged 8–12) (Bromwell 2016), highlighting the potential role of training and education approaches in addressing these ‘safe vehicle’ components.

As outlined in Part A (section 3.1) older adults and males of all ages are over-represented in fatal cycling crashes. Heavy vehicles, urban intersections and higher speed roads are also risk factors for cyclists (Koorey 2014; Boufous et al 2012; De Rome et al 2012). It is important that these groups and risky situations are considered in the targeting and content of training approaches (Cycling Safety Panel 2014).

Approaches based on training generally assume there is a knowledge and skill deficit (Christie 2001) and that improvements in this deficit will result in positive behavioural and injury outcomes. The field of road safety and human factors describes the different types of error that contribute to incidents or crashes (Reason 1990). On a simplistic level, errors can be classified into:

- inadvertent slips or lapses, which result from road design factors or road user alertness
- mistakes or violations, which are more conscious and result from a lack of knowledge, skills or poor attitude.

Cycle training approaches have the potential to address conscious mistakes, enable cyclists to be aware of the situations that present the most risk, and create good habits that can be performed ‘unconsciously’. An example would be to teach individuals to position themselves where heavy vehicle drivers can see them, or to confidently and habitually check behind for on-coming traffic before making a manoeuvre. It is important that training initiatives have clear objectives regarding the type of error they aim to influence, the knowledge or skill deficit they are trying to address, and that this content aligns with common causal factors.

8.1.3 Cycling participation

Consistent with the goals of the Transport Agency, this review also focuses on how training can influence participation in cycling for transport, specifically cycling to school for those under 18 and cycling for utility (ie to work or other transport trips) for adults. Key barriers and enablers of cycling participation are summarised below.

Safety concerns and the perception that cycling is unsafe, are consistently reported as a major barrier to cycling participation both internationally (Christmas et al 2010; Lowe 2013) and in New Zealand (Horspool 2006; Mackie 2009; Cycling Safety Panel 2014; Mason et al 2015). Other barriers include perceived inconvenience, lack of confidence, weather, personal security, the amount of physical effort involved (Christmas et al 2010; Carver et al 2014) and even more simply no access to a bike.

There is some evidence that safety concerns may be more of a barrier to cycling for females, parents and children (Mackie 2009, Lowe 2013; Horspool, 2006). Qualitative research involving New Zealand primary school students and their parents showed that safety concerns arising from traffic speeds, traffic volumes and busy intersections are a significant barrier to cycling participation (Mackie 2009). Concern about the risk of injury, neighbourhood safety and social trust are factors associated with parents driving their children to school and to other local destinations in Australia (Carver et al 2014). An in-depth qualitative analysis of 33 women in Australia revealed that a lack of confidence, skills and knowledge were key barriers to cycling, as well as safety concerns, weather and terrain. Motivations for attending cycling courses were to improve knowledge and skills, learning to manage risks and increase enjoyment (Lowe 2013).

8.1.4 How could cycle training lead to increased cycling?

A significant amount of research has sought to understand the individual, social and environmental factors associated with active transport, termed a socio-ecological approach (Sallis et al 2006). Given the complexity of influences on travel behaviour, it is may be unrealistic to expect that two to five cycle training sessions will lead to noticeable changes in cycling participation given the range of barriers described above. An individual's choice to cycle for transport is likely to be influenced by a myriad of interlinking factors across the three layers of the socio-ecological model outlined below (Sallis et al 2006; 2012; Trapp et al 2011).

1 Individual factors: personal skills and knowledge, confidence, individual values related to cycling as a transport mode

2 Social factors: attitudes of peers to cycling as a transport mode, parental concerns, wider societal attitudes to cyclists

3 Environmental factors: cycling infrastructure, distance from home to school, distance from home to work, end of trip facilities, availability of appropriate routes.

The key question is how can a cycle training system be designed and delivered in a way that reduces barriers and simultaneously promotes and optimises the relevant enabling factors? While cycle training may not be able to remove all barriers to cycling, it has the potential, in conjunction with other initiatives, to play a role in bringing individuals and communities a step closer to regular cycling participation. Similarly, as the primary barriers and influencing factors are likely to be different for different groups and contexts, training may play a role in influencing some groups more than others.

Australian cross-sectional studies have shown that, as well as aspects of the physical environment, such as low traffic volumes and high connectivity, factors such as parent/caregiver confidence in their child's cycling ability (Carver 2015), and the child perceiving cycling as 'cool' are positively associated with cycling to school (Trapp et al 2011). Cycle training as a strategy to mitigate some of these parental concerns has been suggested as a way to support cycling participation (Trapp et al 2011). However, researchers have cautioned against simply providing training to reduce perceptions of risk, without also modifying the road environment to improve actual safety (Kerr et al 2006; Schepers 2013). Similarly, this research highlights the potential for cycle training and/or education approaches to portray cycling as a 'cool' or a socially positive behaviour.

Studies in both New Zealand and America have indicated that attitudes to cycling may be different in different age groups (Horspool 2006; Underwood et al 2014); with cycling going from 'fun' and 'cool' in younger years to being perceived more negatively at high school, particularly for females (Underwood et al 2014). This again highlights the importance of social norms and peer approval of cycling and the potential role of these factors in cycling participation.

As part of a Transport Agency project, Smith et al (2011) examined encouraging cycling for utility travel using a 'product design' methodology and incorporating aspects of two behaviour change theories: the stages of change and diffusions of innovations theory. The central question for this work was 'who would the next 1% of cyclists be?' and the main output was a proposed conceptual model, based on systems thinking that would encourage cycling for transport (Smith et al 2011). This model took a holistic perspective and emphasised the need for any one solution to encompass the criteria below:

1 Plant the seed: cycling for transport is portrayed as a normal, positive activity that is visible in the community

2 Make it easy to choose to ride a bicycle: tools are readily available, including appropriate bikes, access to training, access to resources

3 Create a pleasurable experience: the first experience (and on-going experience) of practical cycling is perfect, expectations are exceeded and negative perceptions are removed (Smith et al 2011).

These criteria provide some guidance on how to design a cycle skills training system that also supports cycling participation and is consistent with other promotional messaging related to cycling.

From an individual behaviour change perspective, Prochaska's trans-theoretical model proposes that behaviour change is a process rather than something that occurs instantly. According to this model, people progress through six stages of change, and as they progress, the benefits or positives of a behaviour start to outweigh the negatives, barriers and risks (Prochaska et al 2008).

The six stages of change are summarised below:

1 Pre-contemplation: people are not intending to change

2 Contemplation: people are intending to change within the next six months, but may not yet be convinced by the benefits of the behaviour in relation to the costs.

3 Preparation: people are intending to change in the next month; they understand the costs and benefits of changing their behaviour and some behaviour change may already have taken place, including developing a goal or plan.

4 Action: people have made changes to their behaviour, usually within the last six months.

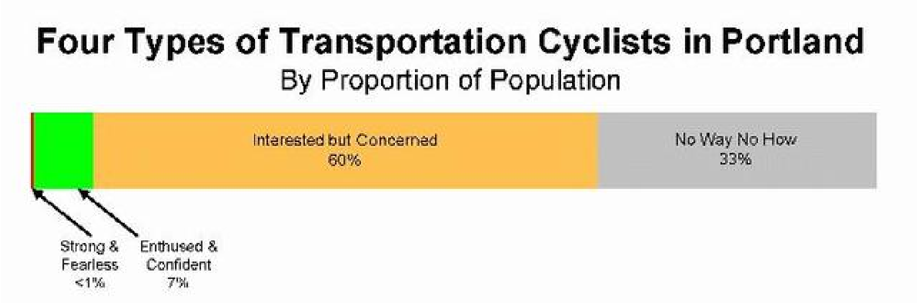
5 Maintenance: actively working to maintain the behaviour

6 Termination: the new behaviour has become habitual or 'normal'. (Department for Transport 2011).

While shifting those who are in 'pre-contemplation' may require other methods that are probably beyond the scope of a cycle training system, appropriately targeted training approaches may act as an enabler for someone in the 'contemplation' and 'preparation stages' (Gatersleben and Appleton 2007). A sample of 1,048 adult Aucklanders were segmented into five categories of cycling readiness, 70% were pre-primed (have never or will never consider cycling), 19% were primed or preparing (thinking about starting to cycle or starting to seek more information), 5% had recently changed and 6% were normalised or regular cyclists (Dodd and Jackson 2014). For this sample, the 24% in the 'primed' or 'recently changed' group may benefit the most from training or competency development approaches in adults.

Corresponding to this concept of different stages of readiness to change, cyclists have also been segmented into different types of transportation cyclists: 'strong & fearless', 'enthused & confident' 'interested but concerned' and 'no way no how' (Geller 2009; Wilke et al 2014) (figure 9.2). Cycling network designers are beginning to incorporate these principles of cyclist typologies within infrastructure design and planning, with particular focus on those in the most common category of 'interested but concerned' (Wilke et al 2014). Similar to infrastructure planning, different types of cyclists are likely to require different types of training approaches, thus, as well as distinguishing between the needs of children and adults it is likely that training approaches will also need to consider these cyclist typologies.

Figure 8.2 Types of transport cyclists



Source: Geller (2009)

8.2 What competencies do children and adults need to ride on the network safely?

8.2.1 Defining skills and competencies

Competency can be defined as the capacity to apply a set of knowledge, skills and abilities to perform a task (Fernandez et al 2012). For example, the New Zealand Education Curriculum is based on a set of five key competencies, which is described as a combination of skills, attitudes and values that lead to action in various contexts (Ministry of Education 2007). The desired outcomes of a cycle training system (see five bullet points at end of chapter 7) are not solely related to skills; 'using techniques to keep themselves and other safe', 'behave courteously to other road users' and an individual's travel behaviour are outcomes that may also be influenced by attitudes, habits, deeper held beliefs and the social context. Therefore, examining the motor skills, knowledge, attitudes and values that children and adults need to cycle safely on the network can start to build a picture of the 'set' of requirements or overall 'competence'. In this way we aim to provide a platform for determining the type and extent of cycle training and education needed at various life stages and for cycling in different environments.

Ellis (2014) reviewed the literature of bicycle education programmes from a developmental and learning perspective and highlights the importance of considering a child's physical development, perceptual development and cognitive development in relation to riding in traffic. While this developmental perspective may be most relevant for children, the underlying skills required for riding on the road are thought to be the same for adults. In order to ride a bike on the road there are knowledge requirements, as well as motor skills, cognitive skills and perceptual skills.

8.2.1.1 Knowledge

The knowledge requirements for riding on the network are:

- knowledge of the road rules and the expected behaviour of cyclists on shared paths
- knowledge of the key elements of a bike safety check and the characteristics of a safe and appropriately fitted helmet
- knowledge of the hazards and the situations that are particularly risky for cyclists
- knowledge of cycling routes in the local area.

8.2.1.2 Motor skills

Motor skills are developed through frequent practice in order to become automatic. There are two types of motor skills required to ride on the road in traffic:

1 Basic bicycle riding skills: balance, pedalling, braking, bike control

2 Traffic safety skills: skills needed to correctly and safely manoeuvre through traffic – moving head to search for traffic, signalling/one-handed riding, slowing down to give-way or stop. Sufficient bike control to efficiently avoid hazards and respond quickly (Ellis 2014).

8.2.1.3 Cognitive and perceptual skills

The cognitive skills needed to ride safely in traffic are:

- Learning, remembering and applying the rules of the road.
- Remembering potential hazards and where they are likely to be, and searching for these hazards while riding
- Selecting safe gaps to cross or turn lanes of traffic
- Reacting quickly in emergency a situation
- Using visual and peripheral cues for balance and estimating speed and distance (Ellis 2014; Hodgson et al 2014).

8.2.2 Practice and reinforcement

Riding a bicycle requires a cyclist to multi-task – perform a motor task and a cognitive task at the same time. There is some evidence that children can be trained to multi-task and practice may make it easier to combine these skills (Ellis 2014), therefore regular and frequent practice of cognitive and motor skills is a consistent recommendation from learning and development point of view.

> *It requires at least 100 hours of learning and practice to acquire any significant cognitive skill to a reasonable degree of proficiency* (Anderson 1982, p369).

This emphasis on on-going practice and parental involvement is also present in guidelines for cycle training; the Royal Society for the Prevention of Accidents (2000) summarises this point well

> *Most importantly, parents need to understand that training provides only the basics of safe road use and recognise the need to provide constant guidance, supervision and help to their children during and after the course.* (Royal Society for the Prevention of Accidents 2000, p5).

Corresponding with this emphasis on frequent practice is the concept *of transfer appropriate processing*, whereby information is best learned in an environment similar to where it will be remembered (ie class-room based for conceptual knowledge and on-road for actual skills and behaviour) (Ellis 2014). This has implications for training that occurs in mock road settings, as opposed to learning, practising and applying skills in road environments with other road users. Children are also slower to process information, and while there is likely to be individual variation, children younger than 12 years may take longer to react to a situation or emergency. This has implications for the types of road environments they should ideally be exposed to below this age (Ellis 2014).

An epidemiological study in the Netherlands (Twisk et al 2013) examined the mobility patterns and fatality risks of 10 to 17 year olds and specifically examined the transition from being driven in a car or being supervised while walking and cycling, to more independent travel by modes such as cycling and moped riding. It was hypothesised that males would experience greater cycling crash risk, compared with females, due to greater risk-taking and sensation seeking tendencies in males, and that an initial spike in fatalities around the age of 10 to 12 would be seen for cycling due to inexperience. However these hypotheses were not supported, and cycling fatalities were in fact mainly associated with cycling exposure. Interestingly, early cycling experience prior to entering adolescence (for example cycling with parents/caregivers) was suggested as protective factor for crash risk during adolescence, the proposed mechanism being that this experience while supervised enables cyclists to develop the competencies that prepare them for cycling when solo (Twisk et al 2013).

In New Zealand, adolescents between 13 and 19 years are a high-risk group for serious injuries and deaths for cycle vs motor vehicle crashes (after controlling for the number of kilometres cycled) (MoT 2015a). Hospitalisation data also shows that those under 15 years may be at greater risk for non-collision crashes (Tin Tin et al 2010). Compared with the Netherlands, New Zealand children may not receive the amount of early experience on a bike, particularly while being accompanied by an adult in environments with traffic. In the driver education space, the emphasis on supervised practice is built into the design of the graduated driver licensing system, and there is good evidence that this system leads to reduced crash risks (Begg et al 2001). On this basis, a cycle training system that also facilitates and maximises supervised practice and experience may be indicated.

8.2.3 Attitudes and values that underpin safe cycling.

Within the field of road safety education, it is acknowledged that a person's behaviour on and around the road environment is not solely determined by their technical ability to execute skills or their knowledge of risks; a person's risk tendencies, ability to self-assess, attitudes to complying with rules, attitudes to role-modelling safe behaviour, normative beliefs and habits, and the road environment itself are also important determinants of behaviour (Royal Society for the Prevention of Accidents 2000; Christie 2001; Dragutinovic and Twisk 2006). Similarly, attitudinal and emotional elements are constructs within many behavioural theories (Rimer 2008). This suggests that approaches which go beyond the skill-development of cyclists are needed as part of an overall system (Ellis 2014). However, while the skill requirements of cyclists are largely well documented, specific underpinning attitudes for cyclists are not well defined, and may more appropriately relate to the attitudes and values required of all road users, as opposed to just cyclists. The concept that all road users need to value the road as a shared space and view road sharing behaviour as an act of 'citizenship' underpins good practice road safety education (NZ Transport Agency 2015b) (see section 8.4).

Individual characteristics, such as the temperament of children, may affect their level of risk-taking behaviours (Stevens 2012). Ellis (2014) specifically examined risk-taking by children and adolescents in order to understand how cycle training programmes could be tailored to promote safer behaviours. It was recommended that training be delivered to groups of peers to ensure role-modelling as well as involve parents/caregivers to enable them to model and reinforce learning. This need to identify who 'risk-takers' are and tailor education approaches accordingly, has also been highlighted in pedestrian safety literature (Hoffrage et al 2003). It is important that a child's level of competence and progress be explained and understood by parents in order to facilitate on-going skill development, and also prevent over confidence or children riding in road environments beyond their skill level (Royal Society for the Prevention of Accidents 2000).

8.3 Cycle skills training effectiveness

Quantifying the effect of cycle training programmes on the longer-term outcomes of injury risk and cycling participation is inherently difficult, requiring long-term studies that control for factors, such as the road environment and cycling exposure. Correspondingly, systematic reviews have highlighted the lack of well-designed studies in this area (Richmond et al 2014). There is also variability across type of training offered, target group, 'dose' (total training time) and context in which training is delivered, making comparison across studies difficult.

Despite these challenges, there have been a variety of efforts to determine the effectiveness of cycle skills training for children and adults. And while overall results are mixed, there is some evidence that some training 'models' can have an effect on intermediate outcomes, such improved cycle skills and confidence in children, and cycling participation in specific sub groups of adults. The following discussion summarises the evidence that exists related to cycle training effectiveness and points to the factors that are considered 'good practice' and most likely to maximise outcomes of training approaches.

8.3.1 Cycle training effectiveness for children and youth (under 18)

Some studies that have compared trained and untrained individuals have demonstrated significant improvements in cycling knowledge (eg traffic rules, road markings and general safety (McClaughlin and Glang 2010; Saville et al 1996) after training. However, other studies have demonstrated no effect (van Schagen and Brookhuis 1994) or limited retainment of knowledge beyond three months after training (Macarthur et al 1998). The effect of cycle training on children's attitudes towards safe cycling and cycling participation has not been well studied. Those that have examined attitudes as an outcome variable have shown no effect of training on attitudes such as 'cars have more of a right to be on the road' (presented as a negative attitude) or 'the importance of concentrating properly when riding' (presented as a positive attitude) (Macarthur et al 1998; Colwell and Culverwell 2002).

This suggests there may be a 'dose' or amount of training needed in order to have tangible improvements in knowledge as well as reinforcement of key messages over time (Macarthur et al 1998). While knowledge of road rules and cycle safety is a key part of the cycling competency, improvements in knowledge are not necessarily retained, and do not automatically translate into safe behaviours (Richmond 2014; McGlaughlin and Glang 2010). Similarly, it may be that the intervention 'time' (ie dose) and approach to cycle training may be insufficient in influencing lasting attitude change (see section 8.4).

Studies have shown that training can improve basic cycling skills measured by a practical cycling test or assessment (van Schagen and Brookhuis 1994; Saville et al 1996; Ducheyne et al 2014). An intervention study (Ducheyne et al 2014) involving five schools in Belgium showed that four sessions of playground-based cycle training improved the basic cycling skills of 9 and 10-year olds (eg mounting the bike, riding one-handed, looking behind). Cycle skill test scores were significantly better than the control group immediately after training and five months on. However, not all studies have shown an effect on basic cycling skills (Richmond et al 2014), and the concept of dose also appears important; a 90-minute session was not enough to demonstrate significant improvements in basic bike skills (Macarthur et al 1998). Similar to the concept of multi-tasking, the development and automation of basic cycling skills is suggested as important for being able to concentrate more on environmental factors when cycling on the road, rather than on the execution of the basic skills (Ducheyne et al 2014; Ellis 2014).

The effectiveness of on-road training versus playground-based training has important implications for the logistics of cycle training delivery and the level of investment required. An older, yet well-designed, experimental study (Wells et al 1979) compared playground-based training with on-road training and an untrained control group. Both types of training resulted in significant improvements in children's ability to perform key skills (eg left and right turns, starting and stopping) after the training as well as eight months on (Wells et al 1979). However, the students who received on-road training made fewer errors than playground trained children, particularly in tasks related to intersections (eg left turn into a side road, right turn out of a side road), and playground trained children tended to make more errors related to observation and looking for traffic (Wells et al 1979). The enhanced effectiveness of on-road training has also been observed in a large retrospective UK-based study (Saville et al 1996) and is also supported from a learning perspective (Ellis 2014).

There are few studies of the effect of education approaches on skills and behaviour related to high-risk situations. Twisk et al (2013) conducted a trial comparing two types of education approaches (both half-day interventions) for adolescent cyclists and pedestrians aiming to improve their behaviour around heavy vehicle blind spots. Results showed no effect on their simulated behaviour post-training, although the approach based on 'competencies' as opposed to 'knowledge of risks' was marginally more effective. Authors highlighted the need to extend learning beyond school-based initiatives in order to sufficiently affect behaviour in various traffic scenarios (Twisk et al 2013).

Few studies have also investigated the maintenance of training effects over time, with the follow-up periods ranging mostly from immediately post-training to three to eight months on. One retrospective study in 12 to 13 year olds demonstrated that cycle training effects on safety behaviours were maintained for up to two years (Saville et al 1996), whereas other studies have indicated that while improvements in knowledge may be maintained (Hodgson et al 2015), improvements in practical skills seen immediately post-training may diminish if they are not continued to be applied and practised (Wells et al 1979; Hodgson et al 2015). An example is a study which examined the effect of the UK's Bikeability programme on students' ability to perceive and respond to hazards (n = 517) (Hodgson et al 2015). Students who had received Bikeability level 2 training (eight hours of instruction with six hours on the road) had significantly better hazard perception and response scores (measured through an online quiz) compared with those who had not received training. Knowledge of hazards and how to respond was maintained two months after the training; however, students' motor skills (measured through a practical test) diminished over time, again suggesting the need for consistent practice and reinforcement.

8.3.2 Effect of cycle training on injury and crash outcomes

While the majority of studies in this area have examined intermediate factors such as safety knowledge and cycle skills, some have sought to measure the effect of cycle training on injury or cycle crash outcomes (Richmond et al 2014). The review by Richmond et al (2014) concluded there was no convincing evidence that cycle training reduced injury rates, injury severity or collision type, with the majority of studies showing either minimal or no effect on injury outcomes. An Australian cross-sectional study that specifically examined collisions with a motor vehicle, found no differences in collision rates between 10 and 11 year olds who had been trained and passed a cycling proficiency test, and those who had not (Preston 1980). In contrast, other reviews in this area have concluded that several hours of classroom-based teaching, combined with several hours of training in on-road environments is likely to be the most effective in terms of actual behaviour and crash outcome (Ellis 2014).

A case-control study in Australia compared 9 to 14 year olds presenting at emergency departments as a result of a bicycle injury, with randomly selected controls from the population (Carlin et al 1998). There was an increase in bicycle-related injury associated with participation in the Bike education programme (adjusted odds ratio of 1.57, 95% confidence interval 0.91 to 2.71), and this effect was maintained after adjusting for exposure, sex and age. The bike education programme was three tiered, combining theory, off-road and on-road training. Sixty-six percent of accidents were 'cycle only' crashes, with 42% of injuries occurring while a child was using the bike for play rather than transport. The majority were also minor injuries (16% required hospitalisation). The association of bike education training with increased injury appeared to be stronger for boys, those of lower socio-economic status and for children whose families did not cycle. While this study on its own is not sufficient to indicate that training promotes increased risk, particularly for collision crashes, it does highlight the potential for unintended effects and that population subgroups may respond to training differently. It is also important that parents/caregivers do not view cycle training as a 'licence' or approval for unsupervised cycling.

There are well-established cycle skills programmes in various regions in New Zealand (Spence et al 2006; Cycling NZ 2014). However, currently there is no standardised way of evaluating these programmes that allows comparison of outcomes across regions. An evaluation of Christchurch's Cycle Safe programme, in five intermediate and high schools, reported that training improved students' reported ability to cycle safely, parents' perceptions of their child's ability to cycle safely and parents' confidence in allowing their child cycle to school (Beca 2013). Self-reported increases in cycling to school increased immediately after the programme; however it appears that these changes were generally not maintained over time. Parental concerns about the behaviour of other road users were also commonly reported in qualitative results. Across Christchurch as a whole, this evaluation reported significant reductions in fatal and serious cycle crashes for 10 to 17 year olds since the introduction of Cycle Safe in 1998 (Beca 2013). However, school bike shed counts also showed a reduction in cycling to school over this time and therefore this reduction in crashes cannot be directly attributed to cycle safety training.

8.3.3 The effect of cycle training and on cycling participation

A causal link between formal cycle training delivered to children or youth, and subsequent cycling participation, is unsubstantiated in the literature; some studies have shown no effect on levels of cycling to school (Ducheyne et al 2014), or studies have been of cross-sectional nature or lacking a comparison or control group (Beca 2013; Goodman et al 2016). However, as discussed earlier, evidence does point to the role of cycle training, as part of a suite of activities to facilitate cycling participation (Pucher and Buehler 2008; Rissel 2015; Goodman et al 2013), and the experience of the UK's Bikeability training scheme also provides some important learnings for New Zealand (Steer Davies Gleave 2016).

A large cross-sectional study comparing schools that offered Bikeability and those that had not, showed no effect on the frequency of children cycling overall (not just to school) and did not increase the frequency of cycling independent of an adult (Goodman et al 2016). Similarly, UK school census data has also shown that since the introduction of Bikeability (level 1 and 2 for 9 to 11 year olds) cycling to school levels have generally remained stable (Steer Davies Gleave 2012). However, it is somewhat encouraging that cycling rates in certain secondary schools marginally increased when Bikeability training was delivered in a high proportion of 'feeder' primary schools for two years or more (Steer Davies Gleave 2012). This indicates the potential importance of consistency and continuing to offer cycle training in schools over time. Participation benefits may not be seen immediately and only become evident as children develop independence.

As opposed to comparing outcomes across schools, cross-sectional studies have shown significantly higher cycling participation levels in trained children, compared with untrained children (Goodman et al 2016). However, this relationship is not necessarily causal as those who already cycle, or who are already interested in cycling may be more likely to complete a cycle training course (Frearson 2013). Cycle training may be sought out by children/families for whom it is most relevant; thus, while it may be valuable for this particular group, in order to facilitate wider effectiveness other approaches to improve relevance and reduce other barriers to cycling may need to precede (or be delivered in conjunction with) any offer of training. Overall, as a tool to facilitate more cycling, cycle training alone may not be enough, without being part of wider environmental, promotional and educational intervention (Goodman et al 2016).

In response to these learnings, Bikeability PLUS, is the UK's latest focus, which aims to couple traditional Bikeability training (predominantly levels 1 and 2) with other initiatives that reduce identified barriers to cycling and facilitate enablers (Steer Davies Gleave 2016). Examples of the Bikeability PLUS modules include improving access to bikes, engaging with parents, led rides and promotional events. While still in the 'pilot' phase there is emerging initial evidence that this combination of activities (and certain modules in particular) is starting to have a positive impact on cycling to school (Steer Davies Gleave 2016).

The problem of focusing solely on cycling to school as an outcome has also been acknowledged in the literature, given that children, particularly in younger age groups, may be more likely to cycle for recreation (Goodman et al 2016). Other researchers have highlighted the need to distinguish between training interventions that primarily aim to improve cyclists' competencies for greater safety, and strategies that seek to encourage cycling (Ducheyne et al 2014).

The Cycle Safe programme in Christchurch, introduced above, has achieved significant reach since 1998, being delivered to approximately 86% of year 6 students and supported by other school travel planning initiatives. While causal claims of increased participation cannot be made, the large reach of Cycle Safe may have contributed to slowing the decline of cycling in Christchurch in comparison with other New Zealand cities (Beca 2013). Cycle Safe and school travel planning initiatives may not be enough to overcome other forces of traffic volumes, speeds and safety concerns; however, the large reach in Christchurch does create a solid base of children who have had some exposure to on-road riding. Therefore, a larger effect may be observed when coupled with infrastructure that supports cycling, promotion of cycling and further reinforcement of skills from parents or further cycling education.

8.3.4 Parent and family involvement

Parents, caregivers (and in some cases schools) are likely to play a significant role in determining whether or not a child rides, and can actively encourage or discourage cycling for transport trips. While parental involvement in cycling initiatives, active transport to school programmes and cycle training is emphasised as important and recommended in good practice guidelines, limited research has tested the effect of parental involvement. Ducheyne et al (2014) compared three intervention groups of 9 to 10 year olds: cycle training for students, cycle training with parental involvement and a control group. No differences between groups in cycling to school or on parental attitudes to cycling were reported, although the extent of the parental involvement (five homework tasks with the child) may have been insufficient. No known studies have investigated the effect of cycle training aimed specifically at parents/caregivers, or the effectiveness of more family-based approaches, and this area is a current research gap. As discussed in section 8.2.2 the role of parents in enabling supervised practice and reinforcing training messages is important.

8.3.5 Cycle training for adults (18 and over)

Cycle training programmes for adults are less widespread than for children; however, there are training programmes for beginner adult cyclists, novice on-road cyclists and initiatives aiming to teach adults how to ride safely in groups (eg Cycling New Zealand's Ride Leader programme) (Cycling New Zealand 2014).

Impact evaluations of adult training programmes have shown they can improve adults' cycling skills (Rissel and Watkins 2013; Hawley and Mackie 2015a) confidence to ride in traffic (Rissel and Watkins 2013; Hawley and Mackie 2015a) and confidence in their place as a legitimate road user (Hawley and Mackie 2015a). An in-depth study of a small group of novice on-road cyclists in Auckland showed that attendance at an on-road training course resulted in competent riding on local and urban collector roads and participants attributed much of their ability to the training course. These participants also reported improvements in key safety behaviours, such as positioning themselves at intersections where they would most likely be seen by drivers (Hawley and Mackie 2015a). Even after the training, these cyclists were generally less confident negotiating busier urban roads and intersections, and managed their own risk in these environments through using pedestrian crossing facilities, riding on the footpath, route planning and riding in quieter periods of the day.

An evaluation of Tauranga's Ride Leader programme also showed there are elements of cycle safety knowledge that some existing adult cyclists are not aware of (eg intersection positioning and safety around heavy vehicles). Training approaches may reduce this gap and encourage attendees to share new knowledge with other cyclists (Hawley and Mackie 2015b).

There is stronger evidence of a link between cycle training and subsequent cycling participation amongst adults. Evaluations of adult cycle training programmes in Australia and the UK have demonstrated statistically significant increases in cycling participation three months after the training (Johnson and Margolis 2013; Rissel and Watkins 2013) as well as 12 months on (Rissel and Watkins 2013). Similarly, the evaluation of Auckland Transport's adult cycle training programme showed for those who attended the training with a specific goal to ride on the road, the training had a large impact on the amount they cycled, and participants attributed this change in travel behaviour to the skills and confidence they attained from the training (Hawley and Mackie 2015a). Evaluations of these types of courses have generally relied on self-reported data, with no comparison group, and the number of adults being trained is relatively small with limited reach; however, despite these limitations there is some evidence that for individuals who are motivated to cycle and want to learn to cycle safely, professional training can improve their skills, confidence levels and safety behaviour, and facilitate cycling participation (Johnson and Margolis 2013; Rissel and Watkins 2013; Hawley and Mackie 2015a). This ability to 'self-select' into a training programme is a key point of difference between traditional formats of cycle training for children/youth and adults. Similarly, cycle training as part of community-wide approaches to encourage cycling in adults, has demonstrated some success (Goodman et al 2013).

However, there may be a large group of adults who would never attend any kind of training course. A survey of 1,048 Aucklanders over 15 years old in 2014 showed that 85% were unaware of any training courses offered, and more than half would be unlikely to attend any type of formal training (Dodd and Jackson 2014). Maps and friends or family were the most commonly reported information sources. A cycle skills system may need to consider approaches to facilitate skill development and participation in this large portion of the population.

8.3.6 The effect of other types of 'training'

Specific research on the effectiveness of 'online' cycling training approaches was not able to be identified. However, online computer-based programmes for young drivers have shown some improvements in hazard perception and risk awareness (Fisher et al 2002; Isler 2011). These training methods may be more likely to attract participants given the legal requirement for driver licence testing, and may need to be coupled with intensive promotion or incentive if applied to cycling. The Netherlands has a cycling test, in which students are required to demonstrate their competency in traffic scenarios. There is a mobile app which accompanies this test that allows students to practise knowledge of road rules and best practice cycling (NL Cycling 2016). While it is difficult to determine the effectiveness of these tools in isolation, they may make learning accessible and complement more practical types of training.

New Zealand currently has a *Road code for cyclists* (NZ Transport Agency 2015b), which describes the legal requirements, expected behaviour and key safety recommendations for cyclists. Over and above practical cycle training, initiatives that promote the key messages of the *Road code for cyclists*, for example, internet-based resources, may also contribute to cycling competence. There are mobile applications that aim to promote cycling, such as Auckland's *Love to ride* app (Love to Ride 2016), which could also provide opportunities to spread key cycle training messages.

8.4 Cycle training as road safety education

8.4.1 What is road safety education?

Resources provided through the Transport Agency's education portal, describes the purpose of road safety education as:

- to assist young people to acquire the competencies to be responsible, safer citizens
- to help young people take steps to improve road safety in their community, and to demand and expect safety improvements at a system level.

The New Zealand curriculum (Ministry of Education 2007) outlines the vision, values, principles, pedagogy and key competencies that underpin teaching and learning in New Zealand schools.

The curriculum states that students learn best when teachers:

- create a supportive learning environment
- encourage reflective thought and action
- enhance the relevance of new learning
- facilitate shared learning
- make connections to prior learning and experience
- provide sufficient opportunities to learn
- inquire into the teaching–learning relationship.

The New Zealand curriculum also presents future-focused concepts such as:

- sustainability – exploring the long-term impact of social, cultural, scientific, technological, economic, or political practices on society and the environment
- citizenship – exploring what it means to be a citizen and to contribute to the development and well-being of society.

Previous reviews and recent guidance in road safety, as well as sexuality, physical education and health, highight the need for programmes delivered in school time to align with the principles, values and key competencies that underpin the curriculum (Ministry of Education 2013; NZ Transport Agency 2015a; UNESCO 2015). Similarly, guidelines written by the Transport Agency, encourage schools to assess the quality and value of external road safety providers (NZ Transport Agency 2012b).

Road safety education guidelines strongly outline the importance of basing road safety education on effective teaching and learning, ensuring relevance to the individual's learning needs and linking content with students' prior knowledge and experiences (NZ Transport Agency 2015a). This aims to ensure that learning is authentic, relevant, extended beyond one-off approaches and can lead to deeper learning. Good practice road safety education guidelines, based on summaries of the literature in this area, highlight the need for comprehensive approaches reinforced throughout each school year (NZ Transport Agency 2015a). One-off approaches are highlighted as ineffective in leading to any knowledge, attitudinal or behaviour change. Collaborative and interactive approaches that involve discussion and an exchange of ideas are also highlighted as more effective than didactic approaches that focus on knowledge or skill transfer (NZ Transport Agency 2015a; Dumont et al 2010).

To support this approach, there are unit plans available based on the underlying values of sharing the road and the broader concept of 'citizenship'. An example is the unit plan 'Everyone is a road user', which requires students to identify, discuss and develop solutions to problems for pedestrians, cyclists and passengers (NZ Transport Agency 2012)

The Transport Agency's education portal (NZ Transport Agency 2012b) outlines that road safety in school settings should support a 'whole school approach', which is based on the premise that actions are needed within the school curriculum, school ethos and organisation and with community partners (parents, whanau and the wider community). School travel planning initiatives around the country are also based on this model.

Cycle training can be thought of as a component of road safety education, and exposure to road or pathway environments has the potential to be an authentic learning experience (Cognition Education 2010). However, it may need to be underpinned by a more formal education framework in order to lead to outcomes that go beyond immediate cycle skill improvements and to be considered good practice education. There is a need to investigate how pedagogical approaches (such as inquiry learning, service learning and collaborative learning) (Dumont et al 2010), existing school travel planning initiatives, as well as more traditional types of cycle training can be integrated into a comprehensive, yet workable, system that results in competent cyclists. A combination of approaches is more likely to result in cyclists with the knowledge, skills and attitudes needed to ride for transport, and is particularly important given the lack of evidence regarding the effectiveness of cycle training in isolation on injury risks (Richmond et al 2014).

8.4.2 What can we learn from driver education systems?

The Graduated Driver Licensing System is based on the idea of facilitating experience while under supervision and reducing exposure to risky situations in the learning phase (such as driving at night and driving with other young passengers). There is a considerable body of evidence that suggests this type of system reduces young driver crash risks in those that comply (Begg and Stephenson 2003).

A review of literature related to pre-driver and young driver attitudes towards safety, highlighted the inherent difficulty in changing attitudes, and the complex relationship between attitude and behaviour. Peer-led initiatives, active participation and discussion in learning sessions, and initiatives that also aim to influence the attitudes of parents were recommended as good practice (Deighton and Luther 2007).

8.4.2.1 The Goals for Driver Education Matrix

A key concept in New Zealand's current guidelines for young driver education as well as within international best practice describes the competencies required for young people to become safe drivers: vehicle handling and manoeuvring, mastery of traffic situations, goals and context of driving, personal goals for life and the social environment (Schulte 2012). The matrix is based on the premise that a young driver's safety is affected by their technical driving knowledge and skill, as well as their personal tendencies for risk, their values, culture and social environment. Driver education should therefore aim to influence competencies across all five levels. This concept may prove useful in the design of a cycle training system and contributes to the idea of educating the 'whole cyclist' to result in overall competence, as opposed to solely aiming to influence knowledge or skills. It is important to note, however, that there are legal requirements for getting a driver licence that may encourage participation in training and education initiatives for novice drivers, and therefore these concepts may not be directly transferable to cycling.

In the driving world, there is also a distinction between approaches that aim to facilitate skill acquisition, often referred to as 'training', and broader education that seeks to influence knowledge, understandings, underlying attitudes and decision making (Keskinen and Hernetkoski 2011).

8.4.3 ‘Cross mode’ training

There may also be a future role for cycle training, or more emphasis on how to drive safely around cyclists, in the driver training system. As recommended in Part A (section 6.5.1) clearer, and more widespread understanding of expected driver behaviour around cyclists is needed. The idea of ‘cross-mode training’, ie providing drivers with cycle training or motorcycling training is highlighted as a potential safety countermeasure in the literature (Salmon et al 2014; Walker et al 2011; Magazzu et al 2006).

Human factors research suggests that when in the same road environment, vulnerable road users (eg cyclists and motorcyclists) may have different situational awareness and mental schemata (representations) to motorists, particularly at intersections. A simple example being that at a signalised intersection, the key focus for cyclists may be on the traffic around them, whereas the driver focus tends to be on the traffic lights themselves (Salmon et al 2014). Thus, this incompatible situational awareness and mental schemata is thought to lead to conflicts. While altering the road design is highlighted as the key countermeasure to reduce conflicts, education, training and experience for both drivers and cyclists are also suggested as a possible strategies to facilitate more compatible situational awareness and expectation of other road user movements (Salmon et al 2014).

Interestingly, those who have a motorcycle are less likely to be responsible for a collision involving a motorcycle, than those who do not have motorcycle licences (Magazzu et al 2006), the ability to predict motorcyclist movements identified as a key explanation. While the concept that ‘cyclists will be better drivers’ is a common belief, this evidence suggests there may be some benefit in exposing drivers (new and experienced) to cycling in order to facilitate expectancy and an overall understanding of how to drive safely around cyclists. This may be particularly relevant given the common casual factor in cycling crashes is motorists failing to give way or ‘look properly’ (OECD/ITF 2013). This concept underpins the current ‘road user workshops’, delivered in New Zealand by the Cycling Advocates Network, aimed at heavy vehicle drivers and cyclists (Hawley and Mackie 2015b). Similarly, although cyclist-specific questions are in the learner licence theory test, and information about driving near cyclists is in the New Zealand road code (NZ Transport Agency 2016), the amount of exposure to driving near cyclists in the learning phase is likely to be highly varied.

8.4.4 The life course approach and systems thinking

A life course approach to disease prevention aims to understand the causes of disease from a long-term, intergenerational perspective and this approach has also been used in the injury prevention field (Hosking et al 2011). In a similar way to the systems approaches focused on accident causation, discussed in Part A, the life course approach examines more distal factors related to disease and injury risk (eg early life factors, social determinants), as opposed to solely focussing on the immediate (or proximal) factors (Hosking 2011). For example, there is good evidence that physically active children are more likely to be physically active adults, and this may then reduce the level of falls in older adulthood, highlighting benefits of injury prevention approaches that can extend across the life course (Hosking 2011). A highly relevant example being that improvements to the road environment, making it safer for active road users, have the potential to improve levels of physical activity and thus further potential health benefits over the life course.

In terms of cycling competencies and participation, while environments that support cycling are important (from both a safety and participation point of view), family-focused interventions that can influence a child’s competency and travel behaviours from a young age, have the potential to increase cycling in adulthood and into the next generation.

Traditional intervention models may assume a linear relationship, between inputs and outputs, and that increases in knowledge and changes to attitudes will translate into behaviour change (Resnicow and Page 2008). 'Complex systems' frame inputs and outputs in a non-liner fashion, in which multiple components interact to create change and the presence of positive or negative feedback loops either reinforces or inhibits other factors (Resnicow and Page 2008; Diez Roux 2011). In terms of individual behaviour change, the timing of the intervention as well as the initial conditions are important principles, as opposed to intensity alone. The outcome/benefit of a given input is conditional on other conditions in the system and the focus is on the functioning of the system as a whole, rather than individual components (Resnicow and Page 2008).

Systems dynamics modelling has been used to explain the multiple factors that interact to influence cycling participation levels (Macmillan et al 2014). The idea that an individual's attendance at a training session will lead to safer or more cycling, fails to consider all the other components of the 'system' and the various other influencers on both competency, safety and participation. Correspondingly, although the outcomes achieved through cycle training or education (eg perhaps perceiving cycling as less dangerous), may not have a detectable effect on the longer-term outcomes, they may flow on to positively influence other parts of the system. In terms of participation, cycle training has been most effective so far for adults who are already motivated to cycle but want to improve their 'skills' (Johnson and Margolis 2013; Rissel and Watkins 2013); in this example the other conditions or components may already be present, and therefore training provides another positive contribution, to result in a meaningful outcome.

This thinking implies there may be specific contexts/conditions in which cycle training is most effective, or put differently, while training may have a linear effect on immediate outcomes, it may need to be combined with other factors to result in overall change in participation levels. The 'timing' of training may also be important, particularly for children, and points to the need to consider 'life stages' in the planning of cycle training and education.

8.5 The current state of cycle training in New Zealand

8.5.1 Cycle training in New Zealand

A review of New Zealand cycle skills training programmes was undertaken in 2014 by Cycling New Zealand to ascertain the quantity and reach of cycle training programmes and to identify gaps in the delivery system (Cycling New Zealand 2014). This review built on work completed by Spence et al (2006) and key findings are summarised below.

For the 2012−2013 year:

- Twenty-nine stakeholders/agencies were involved in the delivery of cycle training, including those who facilitate training through funding other organisations or individuals.
- There were 23 delivery channels (10 from the sport sector – primarily through Kiwi Sport funding, seven from the transport sector, six transport/sport sector collaborations).
- All organisations reported basing the course content on the core skills outlined in the Transport Agency's cycle skills guidelines (NZ Transport Agency 2012a), although there were varied models of delivery.
- A total of 475 instructors were actively delivering cycle skills training courses. Thirty-three of these had achieved a National Certificate in Recreation and Sport – Coaching and Instruction (Cycle Skills Instructor). This qualification is on the New Zealand Qualification Framework and is administered by Skills Active, the industry training organisation for sport and recreation (Skills Active Aotearoa 2016).

- Significant barriers related to becoming a qualified cycle skills instructor were identified.

The reach of cycle skills training in 2012/2013 was as follows:

- In the financial year 2012/2013, 27,935 children received training (4.9% of New Zealand children aged between 5 and 14 years, based on census data).
- Of this total, 68% of students aged between 5 and 12 received Grade 1 only (training off the road) and 32% between the ages of 9 and 14 years received Grade 2 training (introductory on-road training); 30% received both Grade 1 and Grade 2.The review highlighted that this focus on Grade 1 in younger children is not consistent with the greater proportion of cycling injuries seen in the 10 to 14 and 15 to 19 year old age groups and barriers to on-road delivery such as costs, time, instructor ratios and school demand were highlighted as issues.
- Christchurch's Cycle Safe and the Bay of Plenty's Kids Can Ride are delivering significantly more Grade 2 cycle training than other areas, with numbers of around 3,000 students in the 2012/2013 year.
- Training based on Grade 3 core skills is generally not being delivered to under 15 year olds; although, Kids Can Ride in Tauranga has recently starting trialling training in Grade 3 traffic environments (meeting minutes Cycle Skills Working Group, 22 July 2015).
- A total of 589 adults were reported to have received cycle training in the 2012/2013 financial year: 63% of adults received Grade 2 and 11% received Grade 3.
- The New Zealand Police has been involved in the delivery of cycle skills training and cycling education for many years, through their programmes 'Riding By' (Grade 1) and 'Out and About' (Grade 2). In the 2012/2013 financial year, the police delivered 16,663 sessions across New Zealand although it is unknown what proportion of these were Grade 1 and Grade 2.

There are some good examples of training providers and territorial local authorities attempting to build on cycle skills training, integrate skills training into other programmes and deliver a base level of learning approaches. For example:

- Cycle skills training in Auckland and Tauranga is delivered in conjunction with school travel planning programmes.
- Cycling New Zealand integrates skills training with upcoming events and/or offers a 'celebration ride' at the end of the training that involves parents, teachers and the community.
- Cycling NZ's Learn to Ride programme is based on a 'teaching games for understanding' approach, which includes 5–7 modules (delivered over time as opposed to one session of three hours) designed to maximise learning, enjoyment and problem-solving (Cycling New Zealand 2014).
- The South Dunedin Cycling Project aims to improve the safety of cycling and increase the uptake of cycling. Despite some problems, the project aims to improve the infrastructure in conjunction with skills training for all students, and includes a model whereby high school students are trained as cycling leaders.
- In combination with the model communities project in the New Plymouth, a progression model of training has been established with opportunities provided to early childhood centres, primary schools and intermediate schools.

These reviews do not include more informal approaches that may develop cycle skills, such as those delivered by schools themselves, parents training their own children, and services that may be offered by bike shops and recreation providers.

A review of cycle skills training schemes in New Zealand in 2006 shows that access to cycle skills training has increased over time (16,000 children in 2006 to 27,935 in 2013), with greater consistency in the set of core skills taught; however, the varying models of the delivery, the limited link with parents/caregivers, the few training opportunities for adults and secondary school age students, and the low levels of practical on-road training, remain largely unchanged. This review highlighted that age 10 was the most appropriate age to start on-road training (developmentally and socially) as well as the need for clear, measurable objectives and practical learning undertaken in the environment where the skills are likely to be applied (Spence et al 2006).

Despite the current low levels of formal training for secondary school students, a recent study in Dunedin has indicated there may be some demand for training in this age group. A cross-sectional survey of 1,464 adolescents showed that 38.5% perceived cycle training would make them safer in traffic and 42.3% would enrol in training if it was offered at their school. Half the students perceived themselves as confident and capable to cycle to school, with only 1.4% of the sample currently cycling to school and a further 8.5% wanting to cycle to school (Flaherty and Mandic 2015). Further work investigating cycling and cycle training in a high school context is needed.

8.5.2 Innovative approaches to cycling competencies

There has recently been a move towards more innovative approaches that encourage cycling competencies, without being a ‘formally delivered’ cycle training course. An example is Auckland Transport’s Guided Rides, which introduce people to key cycling infrastructure routes while also providing safety messages and a socially pleasant experience. This approach has also been extended to E-bikes, which were recognised as a growing mode; (Auckland Transport 2016). Cycling New Zealand’s Ride Leader programme is another example, members of the public are trained to ‘lead by example’ and ‘share their love of cycling’ while facilitating a strong culture of safety and courtesy within group rides (Hawley and Mackie 2015b). Community cycling champions, for example, Mr Tee in Mangere (Manukau Courier 2016) are also more organic examples of individuals spreading cycle safety and promotion messages.

Another key initiative that falls outside the traditional cycle training approach is ‘Bikes in Schools’ developed by the BikeOn New Zealand Charitable Trust. Bikes in Schools aims to give equal access to bicycles and the opportunity to learn and practice riding in a safe environment. The Bikes in Schools package includes a fleet of bikes, a helmet for every child, a combination of riding, pump and bike skills tracks, a bike storage facility and project coordinators to deliver the programme and teach basic riding skills (Bike On New Zealand Charitable Trust 2015). Some areas have also included professional development or cycle training for teachers as part of the overall package. Bikes in Schools has been implemented in approximately 50 schools in New Zealand with many more in the ‘pipeline’ as a result of recent investment by the Accident Compensation Corporation and the Transport Agency.

To date, two key external evaluations of Bikes in Schools have been conducted. Mackie and Gascoigne (2012) focused on the implementation and immediate qualitative outcomes of the programme in Nga Iwi primary school in Mangere, Auckland. Evaluation findings showed that the bike track and corresponding equipment were implemented successfully. Students, teachers and families perceived the programme positively and there were reported health, confidence and various other benefits for students. However, a key consideration was the need for on-going support and the integration of the programme within wider system enablers in order maximise outcomes.

Maclaren et al (2013) evaluated Bikes in Schools in three schools in Hawke’s Bay and compared outcomes to a ‘control’ school. The programme was perceived positively and overall cycling was viewed as a healthy and fun activity within school grounds. There was some evidence of improvements in indicators of fitness and of a slower rate of weight gain in students in intervention schools. Concerns regarding the safety of the roads around the school were expressed by both parents and teachers and the number of students who biked to school remained low across all intervention schools (Maclaren et al 2013). The combination of infrastructure that supports cycling around a school, Bikes in Schools and on-road cycle training, has the potential to overcome some of the limitations of current 'formal cycling training', and there is current research evaluating the effectiveness of this combination.

Given the range of individual, social and environmental factors that influence a person's cycling competency, perception of cycling and the evidence that one-off cycle training approaches or limited 'dose' are not always effective, innovative approaches that aim to influence individuals through a range of settings over time, are likely to be an important part of a cycle training system (Trapp et al 2011; Richmond et al 2014; NZ Transport Agency 2015a).

8.6 Summary of key learnings from the literature

Cycle training is defined as 'preparing people to confidently and safely ride on the road' (NZ Transport Agency 2012a). There are various types of formal cycle training being offered internationally and in New Zealand; examples include school-based training schemes, elective training for adults and initiatives targeted at high-risk groups or situations (OECD/ITF 2013; Cycling New Zealand 2014, Goodman et al 2016; Richmond et al 2014, Hawley and Mackie 2015a; 2015b; Twisk et al 2013).

Riding a bike in environments with traffic (and other road users), requires the ability to multi-task – execute motor skills, cognitive skills and perceptual skills at the same time (Ellis 2014; Hodgson et al 2015). Frequent practice and experience is required to develop and apply these skills in various environments (Ellis 2014). However, although skills are necessary to ride on the network, behaving safely on the road is not solely determined by a person's ability to execute technical skills or their knowledge of risks. Risk tendencies, attitudes to safety, social norms and the physical environment are also important determinants of behaviour (Royal Society for the Prevention of Accidents 2000; Christie 2001; Dragutinovic and Twisk 2006). Therefore, the term 'cycling competency' may be more appropriate, as opposed to referring to 'cyclist skills'.

Motorists are reported to be 'at-fault' in the majority of motor vehicle vs cyclist crashes in New Zealand, and therefore improvements to road design and speed management (Cycling Safety Panel 2014) as well as driver education, may have the largest impact on cyclist safety (Schepers et al 2014). However, cycle training, alongside other safe system measures, is delivered in many countries to develop widespread understanding of expected road user behaviour (OECD/ITF 2013). Also, a large proportion of cycling casualties are due to non-collision crashes; and therefore the development of sound cycling competencies, including bike maintenance skills, has the potential to reduce these types of crashes (Tin Tin et al 2010).

In children, while results are mixed, there is some evidence of a positive effect of training on cycle safety knowledge (Mclaughlin and Glang 2010), skills and confidence (Ducheyne et al 2014; Hodgson et al 2015; Beca 2013) and the perception of and response to hazards (Hodgson et al 2015). The concept of 'dose' appears important; more comprehensive approaches delivered over time, with a significant amount of classroom time and on-road time, are thought to be more effective than one or two sessions of one to three hours. It is also important that skills are learnt in environments similar to those that the participant will be riding in and that participants are supervised while gaining confidence (Ellis 2014). Therefore, while formal training programmes need to ensure sufficient time in 'real' or on-road environments (at least six hours of 'on-road time' is suggested as the more effective) (Hodgson et al 2015; Ellis 2014), there is also a need to encourage more 'informal training' to increase children's experience in a range of environments (eg encouraging parents to continually reinforce training messages and to ride with their children) (Royal Society for the Prevention of Accidents 2000; Mackay et al 2011; Trapp et al 2011; Ellis 2014).

In children and adolescence, no known studies have been able to demonstrate the link between cycle training and reduced injury risk (Richmond et al 2014). Therefore, delivering cycle training in conjunction with infrastructure that supports safety is recommended as good practice (Mackay et al 2011; Raftery and Wundersitz 2011; Kerr et al 2006). The Cycling Safety Panel (2014) recommended a package of safe system measures to increase the safety of cycling to school and suggested that education around the key risks for cyclists combined with improvements to cycle routes would be needed to increase safety outcomes. Also, although not a consistent finding, one study has demonstrated negative effects of cycle training on injury risk in children, the possible explanation being training facilitated over confidence and reduced parental supervision (Carlin et al 1998). This again demonstrates the need for encouraging parent involvement pre and post training and clear communication about training being part of the process of learning, in combination with parents/families, as opposed to being the sole activity. The need for robust and consistent evaluation is also indicated by this finding.

Good practice road safety education guidelines highlight the need for comprehensive approaches reinforced throughout each school year; one-off approaches are highlighted as ineffective in leading to any knowledge, attitudinal or behaviour change. Approaches that are consistent with principles of effective teaching and learning, including those that are linked to prior knowledge are recommended. Interactive approaches that involve discussion and an exchange of ideas are also highlighted as more effective than didactic approaches that focus on knowledge transfer (NZ Transport Agency 2015a). Similarly, the need to tailor education approaches to individual characteristics and identify those who may have greater risk-taking tendencies is important (Hoffrage et al 2003; Ellis 2014).

To date, school-based cycle training programmes in children and adolescence have not resulted in significantly increased levels of cycling participation (to school and to other destinations) (Goodman et al 2016; Ducheyne et al 2014). Consistently delivering in the same schools/areas over time is thought to be important (Steer Davies Gleave 2012). These programmes alone may not be enough to overcome the barriers to cycling and increase cycling on a greater population level. Additional initiatives tailored to address 'barriers' to and enablers of cycling (eg bike access, bike maintenance and parental concerns, increasing independence) in combination with formal training (ie the Bikeability Plus Model) are emerging as effective models (Steer Davies Gleave 2016).

For adults, there is some evidence that training can increase participants' skills and confidence to cycle in traffic (Rissel 2013 Hawley and Mackie 2015a) although studies have lacked comparison groups. Similarly, cycle training appears to act as an enabling factor and result in increased cycling participation in the sub-group of adults who are motivated to cycle, but lack confidence in their own ability (Johnson and Margolis 2013; Rissel and Watkins 2013). Cycle training may be most effective at influencing those in the 'primed for cycling'group. Multi-faceted community approaches to encourage cycling, which include cycle skills training, also show promise (Goodman et al 2013). However, there appears to be a large group of adults who may be unlikely to attend a formal training course (Dodd and Jackson 2014) and therefore other approaches beyond 'formal training' may be needed to raise awareness of key behaviours in this group.

The idea that emphasising too heavily on safety may inadvertently discourage cycling has started to be tested in the literature (Gamble et al 2015). While safety may be embedded in the initiatives as core messages and outcomes, portraying cycling as enjoyable, normal and beneficial may be important for both children and adults in order to contribute to participation goals (Smith et al 2011).

9 Method

Qualitative data was collected from cycling stakeholders and end users through a series of interviews, focus groups and an online survey. The purpose of this component was to gather insights from a broad range of stakeholders in order to identify the critical success factors for a cycle training system from a practical and contextual point of view. Overall, the method aims to combine key learnings from the literature with critical factors identified by stakeholders and end users to form a cycling competency system model and accompanying recommendations.

9.1 Interviews and focus groups

Forty-four participants were engaged through interviews and focus groups. Participants were from the three groups below:

Stakeholders in the cycling sector

- Discussions with the Cycle Skills Working Group (October 2015 and May 2016).
- Semi-structured interviews (conducted with an individual or a group):
  - cycle training funders and cycle training providers from around New Zealand (n=12)
  - police (n=1)
  - other experts or stakeholders in cycling sector (n=3).

School representatives and education advisors

- Semi-structured interviews with school representatives (n=4) and stakeholders in the education sector (n=2).

End users

- Focus group with parents/caregivers of primary and intermediate aged-students (n=6), focus groups with students, aged 11–13 (n=17)
- Focus group with adults who cycle or want to cycle (n=5).

The following elements were explored through these qualitative methods: participants' involvement in and experience of cycling and/or cycle training; the key competencies they felt cyclists need to ride on the road safely; the strengths, gaps and challenges of current approaches; and the optimal strategies needed to enable New Zealanders to become confident and competent bike riders (appendix A).

9.2 Online survey

The primary focus of the method was the interviews and focus groups described above. However, an online survey via Survey Monkey (appendix B) was developed to supplement this data, and gain insights from a wider group of end users.

A 'snowball' sampling method was used; the survey was initially circulated through cycling and parent networks. This sample included a total of 262 adults from around the country, including 69 who were parents/caregivers of children younger than 18 years.

This survey was targeted at New Zealanders who were already cycling (for any purpose) or who were contemplating starting. The purpose of this focus was to gather insights on the key competencies they believe cyclists needed to ride on the road and the most effective strategies for developing confident competent bike riders from their perspective. The survey was a mixture of open-ended and rating questions (appendix B). The characteristics of the baseline sample are outlined in table 9.1.

Table 9.1 Characteristics of the online survey sample of adults

Age	% (n)	Gender	% (n)	Residential location	% (n)	Level of on- road cycling experience (self- classified)	% (n)
18–25	7% (19)	Male	44% (116)	Urban	94% (245)	Experienced and confident	54% (128)
26–40	33% (87)	Female	56% (145)	Rural	6% (17)	Confident depending on the route	25% (59)
41–60	49% (127)					New to cycling on the road	7% (16)
61+	11% (29)					Don't cycle on the road/other	14% (32)
Total	262		261		262		235

9.3 Data analysis and integration

Raw data from the interviews, focus groups and open-ended survey responses were manually coded and subsequently grouped into broad themes. Each theme was then analysed for sub-themes. The analysis was structured around the following elements:

- the perceived skills, knowledge and attitudes cyclists need to ride on the road
- perceived strengths, gaps and challenges of current approaches
- the optimal strategies needed to enable New Zealanders to become confident and competent bike riders
- the perceptions of how cycle training could support cycling participation.

Key themes from the data collection phase are summarised in the following section. Proportions for survey responses were calculated and are presented alongside other data in the relevant section.

Key themes from the literature and the qualitative data were combined and summarised into the cycling competency system model. This model was then circulated with 23 stakeholders who had been involved in the data collection process. Feedback was subsequently incorporated into the final model.

10 Results: critical success factors for a cycle training system

10.1 Insights from cycle training funders and providers

The key themes from interviews with cycle training funders, providers and instructors are outlined in table 10.1 below. More detail for the most dominant themes and corresponding quotes is given below the table.

Table 10.1 Summary of key themes from cycle training funders and providers from around New Zealand

Theme	Sub- themes	Description
Opportunities to ride from a young age		The need for more bike exposure from an early age, through the creation of multiple touch-points and opportunities to ride. Sport, community events, formal and informal training were seen as strategies to create these opportunities. Bikes in Schools was perceived as an important approach to achieve this, as was balance bikes in early childhood centres.
Engagement of parents/families		The involvement of families in both formal cycle training and cycling activity in general was seen as a significant gap.
Beyond cycle skills	Enjoyment of cycling	Ensuring that cycle training opportunities are as enjoyable as possible was seen as significantly important for instilling a 'love of biking' and therefore encouraging on-going participation in cycling. This enjoyment element was perceived as being missing from some current training approaches.
	Education framework	Training approaches that are guided by a framework that encompasses developing participants' skills, and also facilitates positive attitudes towards cycling and positive attitudes towards sharing the network with other users. A framework that allows initiatives to be individually and contextually tailored.
	Facilitates decision-making	Training that goes beyond focusing on the execution of core skills towards a focus on decision making in on-road situations and making sound judgements.
Structure and resource	Leadership	Many cycle training providers (both private and those within territorial authorities) felt there needed to be more leadership around cycle training from within the transport sector. A quality assurance process is an example of this leadership.
	Consistency	Consistency in terms of the cycle training approach and consistency in terms of funding and delivery over time.
	Partnerships	Partnerships across sport, health, transport and the recreation sector were viewed as important, particularly (but not solely) in relation to developing basic bike handling skills.

Theme	Sub- themes	Description
	Sufficient resource	Sufficient funding in the system to enable increased reach of training approaches, as well as improved availability of qualified, experienced instructors. This related particularly to instructors who are qualified to teach Grade 3 cycling and those who can assess other instructors.
Delivery model	Progression model	Generally the core components of formal training (Grades 1, 2 and 3) were seen as sound. The need to ensure participants are given guidance on the next step in their competency development and to move towards more delivery in on-road or 'real' environments was highlighted. This included focusing on more complex routes that participants have to negotiate in their local context.
	Wrap-around community approach	There was a strong perception that cycle training needed to be part of a wider strategy to encourage cycling on a local community level. Delivering training in conjunction with infrastructure that supports cycling (either new or existing) was seen as necessary and effective.
Challenges/gaps	High school age students	Uncertainty in the most effective approach for high school aged students.
	School engagement	The perception that schools may not see the value of training until they have experienced it.
Innovation	Reaching adults	The need to be flexible and innovative in the approach to training adults, as well as consider the many adults who may not want to attend a formal course. Tertiary students were raised as a potential gap in current programmes.
	Technology	The need to explore social media and internet-based messages as a way to extend the reach of training messages for adults.

10.1.1 Opportunities to ride

The need to create many opportunities to ride a bike from a young age emerged as a dominant theme from cycle training providers and instructors. Increased bike exposure would facilitate a strong foundation for children with good basic bike skills, and therefore ensure children had the necessary motor skills prior to progressing to on-road riding when appropriate. Cycle instructors also commented that the range of participant abilities at the start of training courses made it difficult to maximise the amount of 'on-road' time during the sessions. Similarly, instructors acknowledged there was often limited follow-up or reinforcement of training content or skills after the training.

> *Some may not have ridden a bike since the last time you were at the school* (cycle instructor)

Partnerships between sport, health, education and transport sectors were viewed as important for facilitating these opportunities. The Bikes in Schools model was explicitly recommended by five of the 11 stakeholders interviewed from the cycling sector. This was seen as a model that enabled students to ride regularly in a safe environment, while removing the obstacle of having to own a bike, and also engaged teachers and families in biking. Similarly, the availability of balance bikes in early childhood centres was recommended as an important and yet achievable approach to create opportunities to bike from a young age. Corresponding to this theme was the view that focusing solely on cycling to school was too narrow, and possibly unrealistic; the focus initially needed to be on getting children, youth and families riding for any purpose. The need to think more broadly than just cycling to school has also been highlighted by Australian researchers (Carver et al 2014).

> *With Bikes in Schools there might not really be a need for Grade 1 training* (cycle instructor)

10.1.2 Engagement of parents and families

Consistent with the literature described in chapter 8, the engagement of parents and families in cycling and cycle training was viewed as a significantly important gap. While some providers were examining ways they could engage with parents as part of their cycle training delivery; many cycle training providers acknowledged the difficulty with this. There are likely to be learnings from the experience of Bikeability Plus (Steer Davies Gleave 2016), in which engagement of parents/caregivers was significantly easier for younger children, compared with adolescents. The engagement of parents and wider communities was also reported as a benefit of the Bikes in Schools model.

10.1.3 Beyond cycle skills

The need to focus beyond cycle skills was also a common theme across stakeholders. Many providers believed that training approaches also needed to be as much fun as possible in order to influence future participation. For example, the idea that 'safety doesn't sell' was highlighted, suggesting careful marketing of cycle training approaches is needed. While this need for training opportunities to be enjoyable was viewed as important by stakeholders, portraying cycling as a normal and everyday transport mode was perceived as equally important.

There was also the perception that focusing on 'sharing the road/pathway' messages were not always a core part of training approaches and needed to be more explicitly defined in guidelines and practice. Particularly for adults, there was a suggestion that participants needed to be able to self-assess their competence level and understand what they should do to develop their competencies further, as well as be provided with the necessary tools to enable this.

Some instructors felt there needed to be more focus on supporting participants to identify and make the right decisions in various road situations, rather than on executing a core set of skills. The often limited amount of 'on-road' time sometimes made it difficult to cover these more advanced skills.

10.1.4 Structure and resource

While the need for a partnership approach was acknowledged, some stakeholders felt there still needed to be greater distinction between the role of sport and transport sectors in cycle training and were uncomfortable that a sports organisation was the agency with a leadership role in the instructor training process. Some providers had experienced problems with the instructor and assessor qualification process and others had not. More leadership in the transport sector was suggested by some stakeholders, including more guidance on how best to deliver cycle training and a quality assurance process. There were mixed views on the value of a 'national brand' for cycle training: some saw it as unnecessary and others viewed it as a chance to create good brand recognition and efficiency in the terms of nationally consistent resources.

Most regions believed there was insufficient funding for cycle training, leading to an inability to ensure that instructors could be employed on an on-going basis and deliver consistently in their communities.

> *A lack of resource in the system in order to have sufficient reach* (cycle training provider)

> *On-going training linked to cycling infrastructure for at least five years, not just once when it's built* (cycle instructor)

10.1.5 Delivery model

Some areas were already delivering in a progression model type manner (in which different approaches were offered to different groups depending on their age) and reported they had started to see the benefits of this approach over time. Similarly, stakeholders acknowledged the need to move towards more training in on-road environments; for example, more led rides where participants could experience the network.

> *While we can't say we have seen an increase in biking to intermediates, there does seem to be more biking and acceptance of biking at high school* (cycle training provider)

Correspondingly, almost all stakeholders viewed the targeting of cycle training to areas with new or existing cycle infrastructure as good practice and essential for achieving cycling participation outcomes. However, others also acknowledged that targeting training to only those with bikes or in areas with 'good' infrastructure created equity issues and was not necessarily future focused. There were two instructors who highlighted that, due to the illegality of riding on the footpath, it was difficult to cover safety and courtesy messages associated with footpath riding in formal training delivery (eg checking at side roads), despite this being the location where students often rode.

10.2 Insights from education advisors and school representatives

The key themes from engagement with education advisors and school representatives are outlined in table 10.2 below, followed by more detail on the most dominant themes.

Table 10.2 Summary of key themes from education advisors and school representatives

Theme	Description
Opportunity for cycle training to be good practice education	The need to ensure that cycle training is consistent with principles of effective teaching and learning, including consistency with road safety education guidelines and the New Zealand curriculum.
Relevance	Ensuring training is *relevant* to students' prior knowledge, experiences and social and environmental context. Cycle training was generally not viewed by schools as a tool to encourage students to cycle more.
Cycle training as an 'extra activity'	School representatives could identify links with the New Zealand curriculum; however, the time and expertise required to influence the curriculum was acknowledged. Thus, cycle training was viewed more as an extra activity. At the appropriate age, training either on the road, or on cycle facilities in the vicinity of the school was perceived as valuable from a road safety perspective as well as a chance for students to experience their community.
Create the foundation with younger age groups	The need to get students interested in biking at primary school rather than wait until students were older and potentially harder to influence.

10.2.1 Opportunity for cycle training to be good practice education

There were strong views from education experts that the current approach to cycle training misses opportunities for students, schools and the cycling sector. For example, the 'one-off' and primarily skill-focused approaches fail to create valuable links with the principles and key competencies of the New Zealand curriculum, and potential link with achievement objectives across a range of learning areas. Thus, the current approach reinforces the perception that cycle skills training is an 'extra' activity, with limited attention, follow-up or reinforcement in schools. Similarly, cycle skills training was seen by education experts as a more superficial form of education with limited alignment to effective teaching and learning and road safety education guidelines. The need for students to be able to understand, articulate and have a role in what they are learning was highlighted as important, as well as the need for cycle training instructors and guidelines/manuals to reflect education language. Given the movement towards encouraging schools to be more discerning about external providers, who offer services to schools, the need to re-examine the overall approach to cycle training was recommended.

Correspondingly, one recommendation was working towards cycling education being a partnership between schools and cycle instructors; this was thought to provide the best balance between teachers who are qualified educators, who understand the needs of their students, and cycle instructors who understand the key cycling competencies and are experienced in exposing students to on-road environments. This co-construction model was also thought to be an effective mechanism to ensure training reflected good practice education and could be tailored to the students, school and the environment.

Similarly, a need to focus on evaluating cycle training from an outcomes perspective was highlighted, ie assessing what participants actually learnt, rather than a focus on outputs or the number of students 'trained'.

10.2.2 Relevance to schools and training as an 'extra' activity

Overall, schools were positive about cycle training, particularly training that was delivered in on-road environments. The dominant theme from school representatives was 'relevance'; ensuring learning was relevant to students' lives, experiences and context.

> *We design the curriculum for the student who is sitting in front of you* (school principal, intermediate)

> *To integrate something into this curriculum [New Zealand curriculum], you have to be smart and find the links* (classroom teacher, primary school)

An example given by a deputy principal was that if a school was near the ski field in Ohakune, then their curriculum would probably use the mountains and snow sports as a context for learning. The physical education and health learning area, and the key competencies of 'managing self' and 'global thinking' were examples of how cycle training content could align with the curriculum. However, school representatives acknowledged that influencing the curriculum took time with many competing priorities.

Thus, although the links with the curriculum appeared obvious to schools, cycle training was mainly seen as a tool to develop the skills and road safety behaviour of students who already cycled, rather than as a tool to encourage cycling or as a context for learning other transferable concepts.

> *We use to have training when we had lots of students who cycled* (head of physical education and health, intermediate)

There was also the perception from one representative that some learning objectives, such as on-road cycle skills, were best taught in a more instructional way rather than through inquiry-based approaches. As it is not compulsory to teach students about cycling or road safety, there is an opportunity to raise awareness amongst schools for how cycling education (including practical cycle training) can align to their educational outcomes.

10.2.3 Create the foundation

Cycle training and engaging students in cycling from a young age (eg primary school) was viewed as important if the aim was to increase participation in cycling.

If students can't ride a bike well by intermediate they probably won't…they'll feel awkward starting to ride at that age (school principal, intermediate)

10.2.4 Other insights

It was also clear that education experts and school representatives had varying personal views of the overall safety of cycling; with some seeing cycling to school as an important opportunity for independent travel, and others viewing cycling as a very risky travel mode.

Comparisons with swimming education were made as a way to demonstrate how external instructors can add-value to the delivery approach; for example, in some schools external providers support swimming education through leading practical lessons, while teachers might cover more theoretical lessons in the classroom.

The practical challenges and emphasis on numeracy and literacy were also highlighted as a barrier to cycling education (including cycle training) being fully integrated into the school.

There can sometimes be a difference between what is good practice education and what a teacher wants and can do (classroom teacher, primary school)

The co-curricular area (lunchtime and after school) was mentioned by some education stakeholders as an opportunity for cycle training and cycling exposure. The involvement of families was highlighted as important; however, the challenges schools face facilitating parent engagement in school life (in general) was also reported by schools, particularly for intermediates.

10.3 Insights from students aged 11 to 13

Students reported riding a bike for multiple reasons: independence, enjoyment, exploring with friends, and getting to places faster than if they were walking. While all students involved in the focus groups said they could ride a bike, not all of them were interested in it and reported doing other activities instead.

*I'm just not that interested in it… I play netball (*female, student, year 8)

Similarly, the decline in cycling to school from primary school was evident for some students.

I used to ride more at primary school, not really sure why I stopped (female, student year 7)

Some students reported they found riding in off-road environments more enjoyable (for example mountain biking) and they spent time identifying the route to school with the most off-road sections (for example, through walkways and parks and on occasion using the footpath).

All students who were occasionally or frequently riding to school had been taught to ride on the road by their parents and sometimes still rode with their families on the weekend. Some of these students had received training at primary school. However, this was mostly recalled as an activity that occurred within the school grounds (ie on the school courts), as opposed to in real on-road environments.

Knowing the road rules and sneaky driveways, having safety equipment (such as bike checks and a helmet) and confidence as well as choosing the best route, were seen as the skills students needed to cycle for a trip in their local neighbourhood.

Students' views on the most effective strategies for developing cycling skills in students their age were:

- kindergarten, pre-school and then school programmes
- riding with an experienced adult or family member

- practice – just by doing and trying.

Key barriers to students cycling more were parental concerns about them riding on their own, lack of time due to other sports and commitments or lack of interest. Students generally felt that learning by 'just doing and trying' was more effective than internet or online resources.

10.4 Insights from parents/caregivers of children under 18 years

Available spaces to learn to ride (eg parks) and off-road routes to develop children's confidence were viewed as extremely valuable by parent focus group participants and survey respondents (figure 11.1).

> *More opportunities to practice in safe environments, eg especially allocated biking areas in school playgrounds and parks* (survey respondent)

Parents of children under 18 also valued on-road training by professionals, rather than solely relying on their own teaching (figure 11.1). Similarly, parents themselves were less confident in certain on-road situations and had questions about the safest way to negotiate certain parts of the network.

> *There are gaps in my knowledge – if I'm not confident then I shouldn't teach them. They need to learn what it feels like when cars go past and what to do when cycle lanes just stop* (female, mother)

> *What do I do at intersections?* (female, mother)

> *Some coaching lessons at school would be good. Mainly to see other kids doing the same thing and not just the same old messages from Mum & Dad* (survey respondent)

> *Would like some formal training, but I will also do a lot of informal training, firstly off-road then on-road* (survey respondent)

In contrast there were some mixed views on whether or not cycle training was a school's core business.

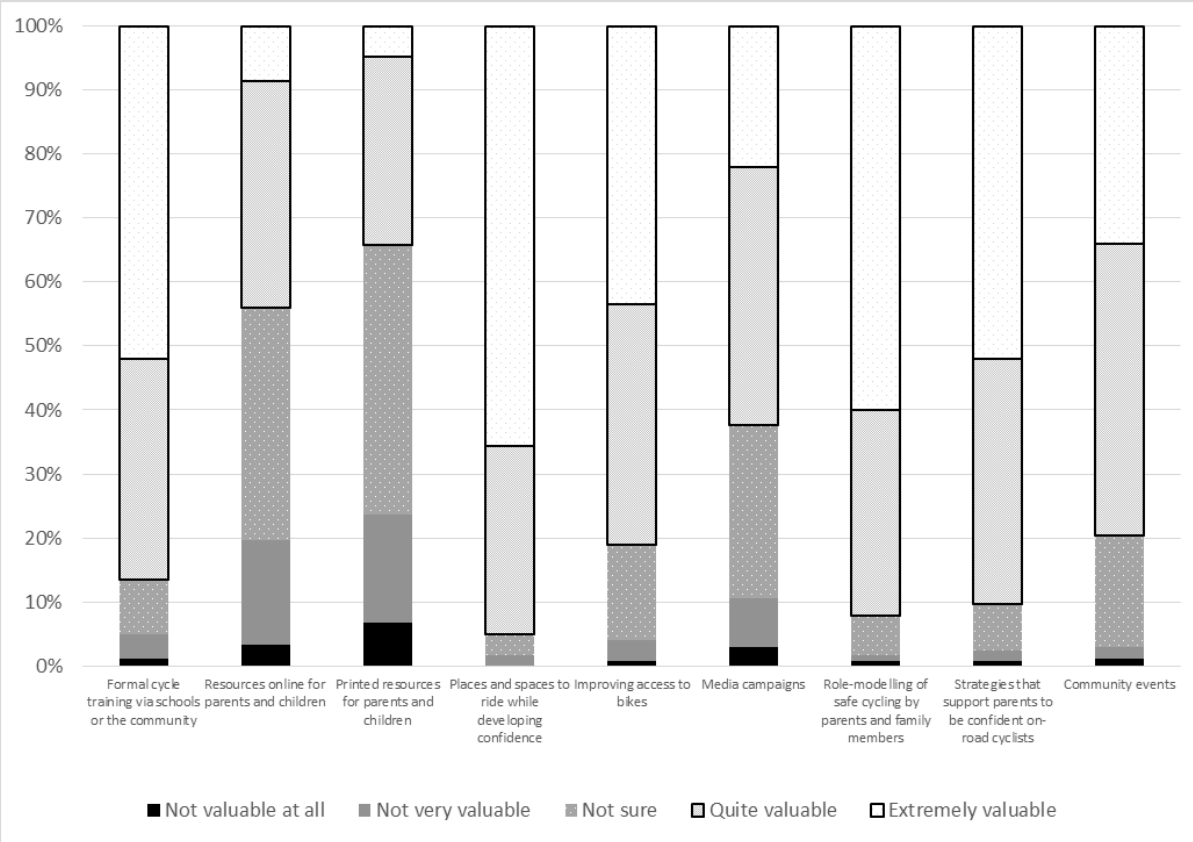
> *Not the teacher's responsibility, use the school as the location, need to learn the safe routes around a school as well so needs to be location specific. Could be externally provided, but at the school* (survey respondent)

> *Course, like we do for swimming we do swimming lessons but there is a gap in education for cycling* (survey respondent)

Survey data showed that 'places and spaces to ride while developing confidence' (95% quite valuable or extremely valuable), formal cycle training (86% quite valuable or extremely valuable), and role-modelling and training opportunities for parents (90–91% quite valuable or extremely valuable) were viewed as the most valuable strategies to develop confident and competent young cyclists. Community events (80%) and improving access to bikes (81%) were also perceived as quite valuable or extremely valuable by the majority of the sample. Printed and online resources were perceived as less valuable for children.

> *Community events are opportunities for skill development, these are activities we can do together… like the harbour bridge bike day* (mother, primary school-aged children)

Figure 10.1 Perceived value of different strategies to support children and young people to become confident and competent to ride a bike (including on the road at the appropriate age)



10.4.1 The role of other factors in the system

Riding on the footpath was viewed as much safer by parents/caregivers, especially for primary school-aged children and generally there were strong concerns about their children riding alone in traffic. Driver behaviour, particularly driving at high speeds, and the lack of separated cycling facilities were viewed as the core problem by many participants, as opposed to a lack of cycling competence. These views are consistent with the need for a cycle training system to be embedded within a broader safe system approach.

> *Unrealistic to expect kids or anyone on a bike to make a right turn on a 6 lane intersection.*
>
> *Clearly identify and signpost safe routes to school. Increase segregated cycleways. Enforce laws relating to poor driver behaviour…*
>
> *My children are both extremely competent riders. It's the people in cars who I worry about.*
>
> *No, their confidence and competence are not the issue, it is the drivers that cause the accidents in most cases.*
>
> *Our teenager never learned to ride a bike and she possibly never will. She has no friends at all who use a bike regularly for pleasure or sport. So there is no motivation. Our 8 year old son is a very reluctant bike rider. What would motivate him more would be riding to school with friends but his friends' parents are too worried about it being too dangerous.*

10.5 Insights from adults who cycle or who are interested in cycling

10.5.1 Advice

Five adults attended an Auckland-based focus group: two were experienced on-road cyclists and three described themselves as novice on-road cyclists.

Overall, the less experienced cyclists wanted more advice on how to keep themselves safe and how to deal with trickier situations, for example how to deal with rows of parked cars, intersections and situations where the road narrows.

> *I want tips on what I should be doing, rather than just looking around – what's the best thing I should be doing?* (male, 20's)

> *Turning right at double-laned intersections, I'm not sure what to do and not confident, so I just use the signals* (female, 30's)

Through the discussion, the more experienced cyclists began offering advice to the less experienced participants.

> *Even just hearing this discussion is helpful* (male, 20's)

New Zealand's current Grade 2 cycle training course (NZ Transport Agency 2012a) covers key behaviours these less experienced cyclists were not aware of. For example, riding slightly out from the kerb as opposed to as far left as possible and road positioning at intersections; they were also unaware there was a 'code' for cyclists. While one of the cyclists was interested in a cycle training course, the others reported they would probably be unlikely to attend; consistent with data from Auckland Transport which indicates there are a large number of adults who are unlikely to attend a formal training course (Dodd and Jackson 2014).

In the online survey, participants were asked to report the most common mistakes and unsafe behaviours they noticed other cyclists doing. The most commonly reported behaviours were (n = 210):

- riding in the door zone, too far left or poor positioning at intersections (19%)
- riding with no lights (10%)
- not signalling their intentions clearly (8%)
- weaving in and out of parked cars (8%)

While these results are based on small numbers and 'reported' data, this suggests there may be a knowledge and skill deficit in less experienced adult cyclists, which could reinforce the need for more widespread approaches that enable skills development and raise awareness of key safety behaviours. This would need to be investigated in a much larger and more representative sample.

10.5.2 Competencies for riding on the network

The online survey also asked adults (both experienced and novice cyclists) what they perceived to be the most important skills, knowledge and attitudes needed to ride on New Zealand roads. The themes reported by 10% or more of the sample are outlined below. As this was an open-ended question, respondents answers could be coded into more than one theme if multiple factors were mentioned (n = 230).

- anticipation of risks and extreme alertness or awareness of surroundings (51%)
- knowing the road code and obeying it (25%)

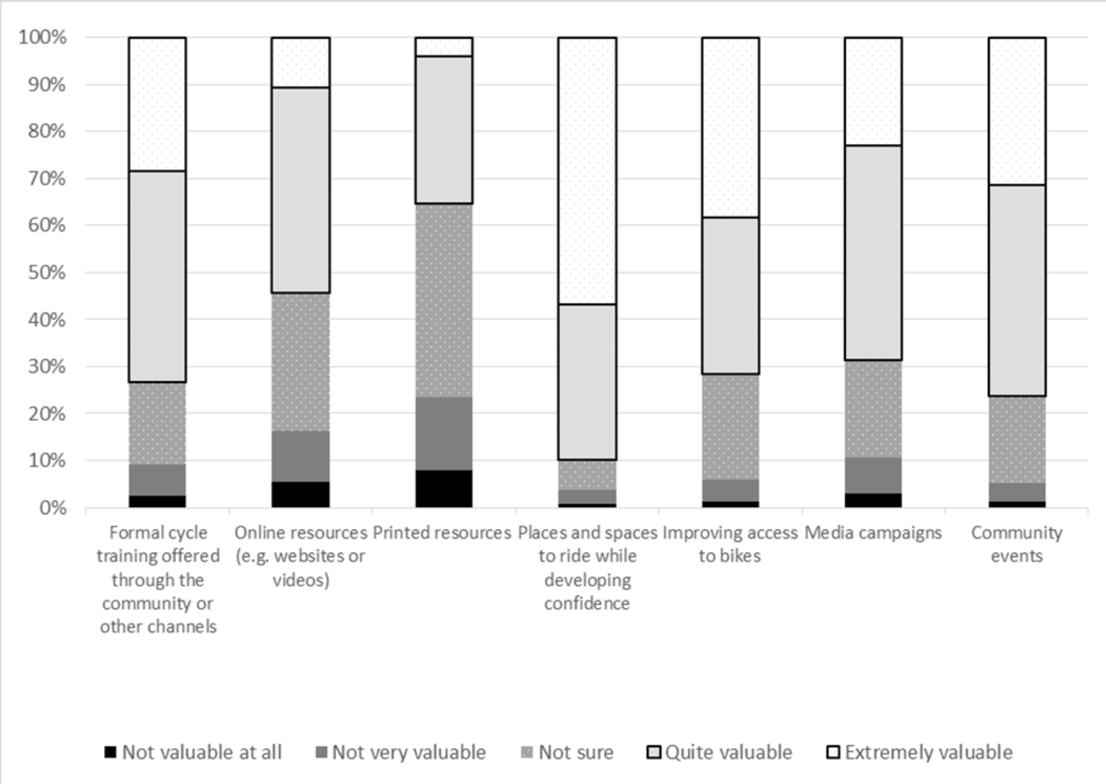
- predictable and confident manoeuvres (22%)
- defensive attitude and the assumption that drivers don't see you (17%)
- assertive riding (15%)
- good bike handling skills (for example being able to look behind confidently)
- knowledge of key risks and how to stay avoid them (eg door zones, intersections, heavy vehicles) (11%)
- road positioning at intersections and around parked cars (10%)
- ability to choose a safe route and when to use the footpath if needed (10%)
- visibility through high vis or lights (10%).

Many of the key themes above are covered in New Zealand's current cycle training guidelines (NZ Transport Agency 2012a) and research has demonstrated that training can have an effect on hazard perception and response skills; however, these skills do need to be reinforced and practised (Hodgson et al 2015). Similarly, as highlighted by cycle training providers, time during cycle training dedicated to hazard perception skills can be reduced if participants have poor bike control skills upon entering the course. The ability to choose a safe route was raised by 10% of adults surveyed, and this could also be included as a 'core skill' necessary for New Zealand's current road environment.

10.5.3 Initiatives for cycle competency development

Online survey results showed that 'places and spaces to ride while developing confidence' (90% quite valuable or extremely valuable), community events (76% quite valuable or extremely valuable) and cycle training (73% quite valuable or extremely valuable) were viewed as the most valuable strategies to develop confident and competent bike riders in those over 18 years. Improving access to bikes was also perceived as valuable by the majority of the sample (71% quite valuable or extremely valuable). While media campaigns and online resources were perceived as less valuable compared with the strategies above, 68% and 54% respectively reported these resources were 'quite' or 'extremely' valuable for adults (figure 10.2).

Figure 10.2 Perceived value of strategies to support adults to become confident and competent to ride a bike on the network (n= 262)



10.5.4 Other insights

On completion of the online survey, participants were invited to offer any further suggestions on how to develop confident, competent bike riders. There was a strong demand for cycling infrastructure, with 35% of the sample recommending separated facilities or better road design. The next strongest theme was the suggestion of better car driver education (6%). There was also the perception by some that by asking questions about the skills of cyclists, the authors were 'blaming the cyclist' and singling out cyclists as a problem group.

> *Better infrastructure – I'm SHOUTING NOW*

> *…knowledge of potentially dangerous situations, a realisation that an accident is 99% of the time because a driver didn't see you*

Participants' own lack of knowledge regarding how to drive around cyclists also arose.

> *How do I pass, how much space do I give?*

Riding on the footpath (14%) and running or pre-empting red lights were also commonly reported 'violations' observed by the survey sample (33%); however, these were viewed more as a strategy for cyclists to manage their own safety as opposed to a deliberate violation. Riding two or three abreast was also reported by 16% of the sample as a common violation.

10.6 Implications of the cycling safety system for the cycle training system

The in-depth analysis of 30 fatal cycling crashes in New Zealand (chapter 5) revealed some important learnings that can be integrated into cycle training content and overall system design.

Surprisingly, nine of the 30 fatal crashes analysed included a ‘cyclist failure to check’ element (although many other causal factors were identified). As highlighted previously, this finding is supported by Koorey (2014) who found that cyclists turning, moving over to the right or crossing (who failed to give way to motorists), accounted for approximately 24% of the cycling fatalities studied. This is also consistent with 22% of cyclists being ‘primarily responsible’ for cycle/motor vehicle crashes (MoT 2015a). While it is difficult to identify if this ‘failing to check’ was the result of cyclist distraction, lack of knowledge or skill, or physical constraints, it does suggest that habitualisation through practical training could be of benefit. Even with fit for purpose cycling infrastructure, people cycling will still need to conduct head checks in a range of situations.

Cyclist speed, particularly losing control while going downhill, was another crash factor that emerged from the in-depth crash analysis. This has y been identified as a factor in the safety of cyclists overseas (Shepers et al 2014) and may be particularly important given New Zealand’s hilly terrain and the increasing popularity of E-bikes. The management of hilly terrain and the appropriate speed in specific scenarios is worthy of inclusion in cycle training content. There are likely to be components of cyclist speed that are ‘skill-related’, such as safe braking; however, there are also factors that may related to a cyclist ‘riding to the conditions and assessing the environment’. This is also relevant for appropriate speeds and courtesy behaviour on shared paths.

Also highlighted by Koorey (2014), heavy vehicles are significantly over represented in fatal cycling crashes and the failure to modify cycling behaviour in the vicinity of heavy vehicles emerged from the analysis of cycling crashes in Part A of this report. There are current approaches to increase the reach of heavy vehicle safety messages for cyclists (both for professional drivers and cyclists) (Hawley and Mackie 2015b) and it is important that these messages continue to be integrated and extended. Cycling safely around heavy vehicles is generally not covered in school-based or introductory on-road training programmes (Hawley and Mackie 2015b). Given that this training may be the only formal cycling education a person receives it is important that heavy vehicle safety is covered. Similarly, although countermeasures, such as separating heavy vehicles and cyclists through road design and vehicle safety features, may ultimately have greater net safety benefit, educating cyclists around key safety behaviours may be an appropriate interim measure.

The issue of properly maintained and fitted bicycles was also a contributing crash factor in some cases. This is consistent with the recent South Island study (Bromwell 2016) discussed earlier, which found that poor helmet condition, helmet-fitting and poorly maintained bikes (such as worn brake pads) were extremely common with student cyclists aged 8 to 12. This has implications for how the bike industry could be involved in supporting bike maintenance and in spreading the reach of safety messages; it does not aim to put unnecessary onus on the bike industry but does include it in the development of a safe system for cyclists. Initiatives such as Bikes in Schools, as well as bike maintenance sessions, may also play a role in habitualising regular bike maintenance and safety checks.

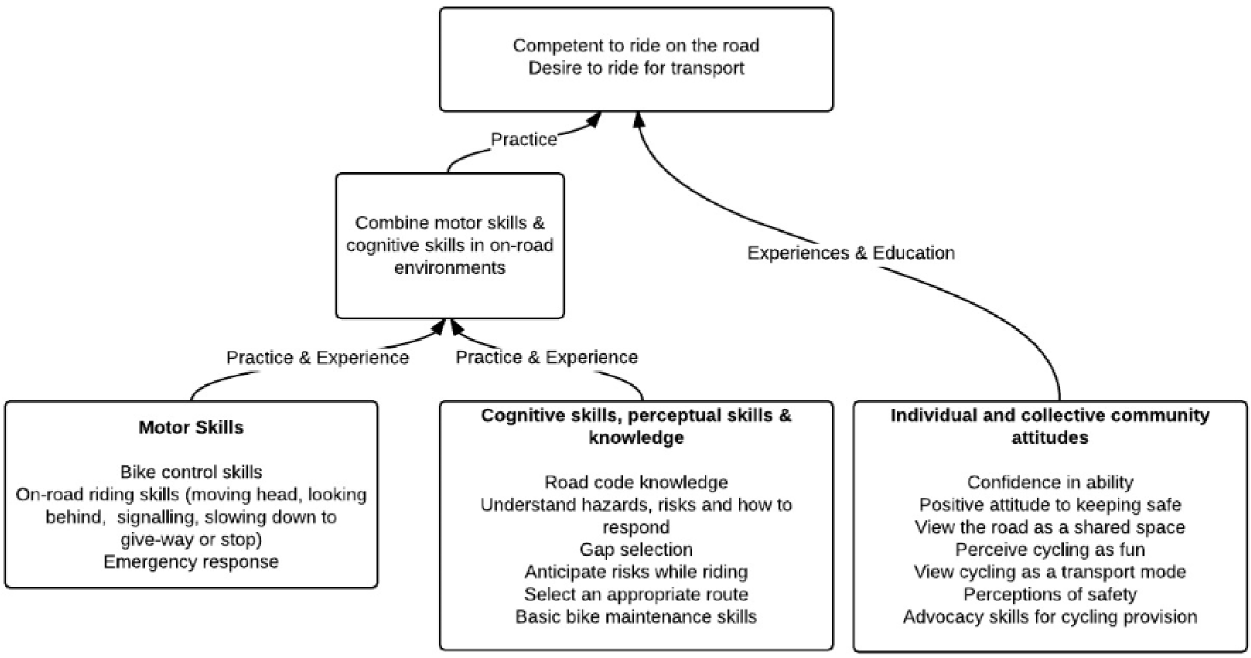
Part A (chapter 6) also highlights the fact that many motorists may have limited exposure to driving near cyclists and therefore have limited ‘mental scripts’ for expected behaviour. Researchers have suggested that riding a bike in on-road environments or education on where cyclists are likely to be, may support the development of the mental schemata for driving safely near cyclists (Salmon et al 2014b), although this remains to be tested in a robust way.

11 Integration of findings and discussion

11.1 A cycling competency system model

Riding a bike on the road and in other shared spaces requires a bike rider to multi-task – perform motor skills and cognitive skills at the same time – which requires a significant amount of practice (Ellis 2014). The need for cycle training initiatives to focus beyond skill and knowledge development, and be more than a 'one-off' intervention was also reflected in the literature and qualitative results. Figure 11.1 summarises this broader view of overall cycling competency, as well as the significant amount of practice, reinforcement and experiences needed for these elements to develop. Similarly, the outcomes required by the Transport Agency (chapter 7) are not solely skill focused; therefore, as opposed to focusing solely on a 'cycle skills system', a cycling competency system is more appropriate. Competence is also context dependant – dependent on the type of environment the individual has to negotiate. It may be that not all cycle education and training approaches target all of these factors; however, it is important that this broader set of competencies is considered in the overall system. Similarly, referring to these factors as 'competencies' does not necessarily mean competency-based training is the most appropriate approach to training delivery.

Figure 11.1 Summary of cycling competencies



Key learnings from the Part B literature review (section 8.6) and qualitative data from stakeholders were combined and summarised in the form of an overall cycling competency system model (figure 11.2) and accompanying critical success factors and recommendations (table 11.1).

The cycling competency system model (figure 11.2) describes how traditional cycle training can be combined with other formal and informal approaches to facilitate the cumulative development of cycling competency (as described in figure 11.1) over the life course. This can be thought of as a 'logic model' which describes the pathway to the intended outcomes through various inputs, outputs, and coupled with consideration of external links, influences and feedback loops. The model can be used on both a national and local level to identify gaps and areas of need, as well as consider how the wider context may inhibit or maximise the success of cycle training approaches.

The model has been influenced by:

- the life course approach to injury prevention (Hosking et al 2011)
- the socio-ecological model of health (Sallis et al 2006)
- the characteristics of complex systems and systems thinking (Diez Roux 2011; Resnicow and Page 2008)
- key findings from the literature review (section 8.6)
- key themes from qualitative data collection (chapter 10).

Specific elements of the model are discussed in further detail below. The numbers link to core elements in the model.

The overall goal of the model is to demonstrate how to best prepare New Zealanders for cycling on the network; that is, to target investment to ensure they have the competencies and desire to ride for transport if their circumstances enable it.

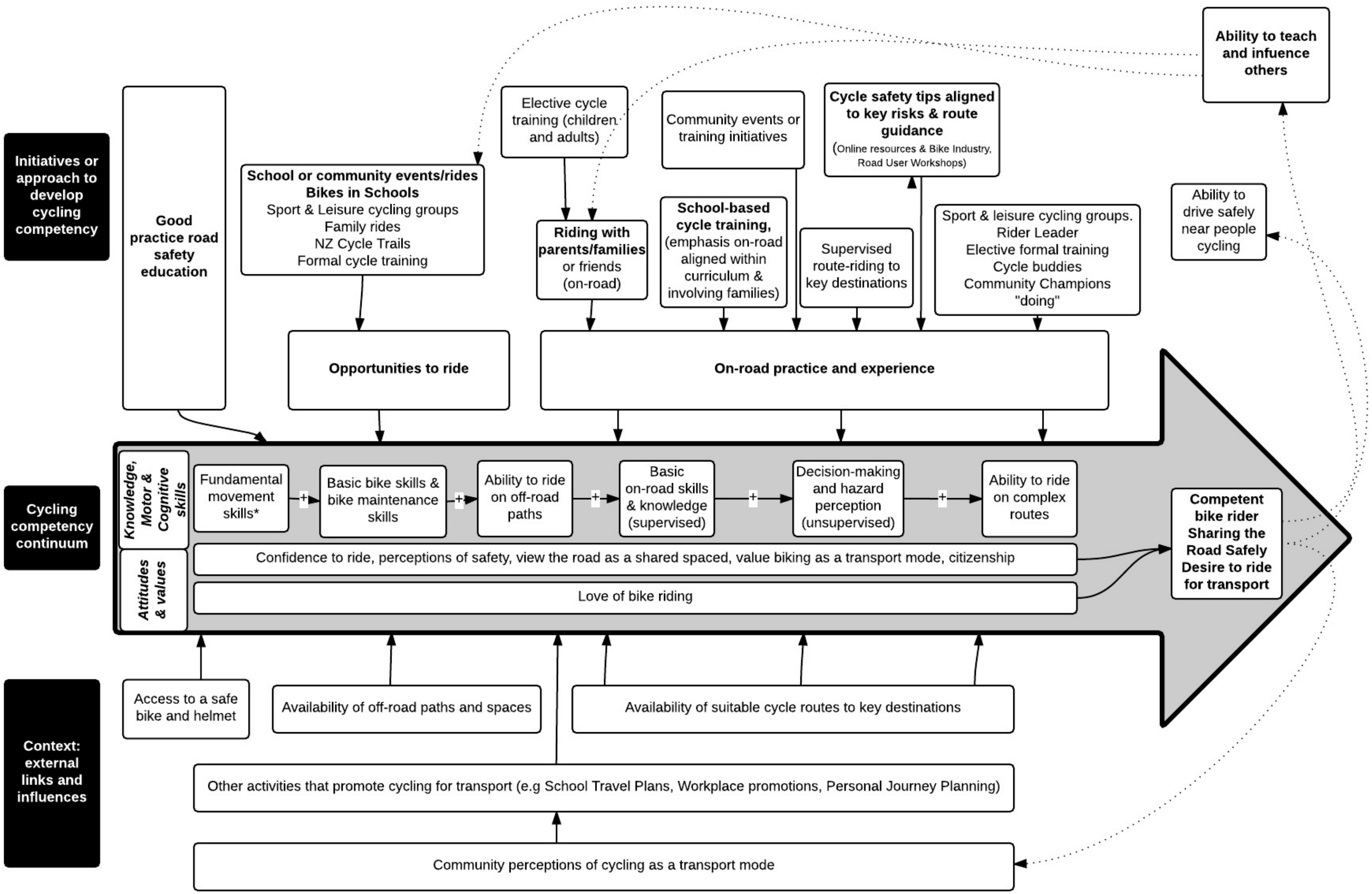
The cycling competency continuum (1) represents the continuum of skills, knowledge and attitudes as described in figure 11.1. The continuum recognises the process by which these competencies can develop over the life course, through a range of opportunities and experiences. Best practice road safety education, which facilitates learning about the road space in a variety of ways and engages participants as ‘active citizens’, is also an integral part of the system.

Multiple touch points, through a range of competency initiatives and approaches (2) means ‘cycle training’ is more of a process than a three-hour ‘event’. Implicit in the model is the partnerships across sport, recreation, transport, tourism, education, the bike industry, communities and families to create these multiple touch points. The importance of parents and peers in supporting others to cycle is also highlighted, as this is important for facilitating on-going supervised practice, experience and reinforcement of messages. While offering formal cycle training (including practical on-road training as part of the curriculum for children/youth) remains a core part of the model, this broader view aims to represent the whole picture of activities likely to be needed to prepare New Zealanders for transport cycling, and ultimately contribute to cycle safety and participation in conjunction with other supporting factors. In this way, the focus on formal training delivered by instructors can be coupled with thinking about how these multiple touch points can be created. Results indicated that many people saw spaces and places to ride while developing confidence, (eg parks and off-road cycleways) as an effective ‘competency development’ initiative, suggesting that the provision of such spaces, perhaps along with initiatives such as bike share schemes, may indirectly support cycling competencies.

As highlighted through the literature review, cycle training in isolation may not be sufficient to overcome barriers to cycling. Similarly, other factors, such as road design and speed management are recommended as higher priorities to improve the safety of cyclists (Cycling Safety Panel 2014). Therefore, as well as reinforcing the need for cycle training to be part of a package of safe system and behaviour change measures (Richmond et al 2014; Goodman et al 2016; Cycling Safety Panel 2014; Pucher and Beuhler 2008), the model aims to encourage consideration of these contextual factors in the targeting and tailoring of cycling competency initiatives (external links and influences (3)). The availability of cycling routes, cycling promotion and community perceptions of cycling is likely to interact with the outcomes of cycle training and education initiatives. For example, delivering Grade 1 cycle training to students with limited bike access may mean that the benefit of that training is not maximised; thus in that context, improving bike access first and foremost may ultimately have more value. Alternatively, offering on-road cycle training and route-riding support to students with Bikes in Schools, some familial support for cycling and some suitable available routes, may maximise the impact of training on safe road use and cycling participation. Similarly, there is emerging evidence of a 'knowledge and skill deficit' in terms of key safety behaviours in novice adult cyclists. However, solely relying on formal training courses for adults, may miss opportunities to engage with the large number of adults who are unlikely to attend an organised course.

Many of the competencies required for transport cycling are the same for recreational or sport cycling taking place on the network. Similarly, fatal and serious injuries are not only experienced by people making utility or commuter trips. These multi-purposes or 'reasons for cycling' enable partnerships to develop to support this overall system model, particularly in younger age groups. However, in order to contribute to the uptake of transport cycling there is a need for specific transport-focused training approaches at certain points in the life course (eg intermediate age) or in certain target groups/settings (through workplace travel plans). There were strong views from some stakeholders that these approaches needed to 'plant the seed' and portray the benefits of and normalisation of transport cycling, and this is supported by a 'product design' point of view (Smith et al 2011).

Figure 11.2 A cycling competency system model



** An individual of any age can enter or leave the continuum from here*

11.2 Critical success factors and recommendations

As described in section 8.5, there are many components of this model (figure 11.2) that are already functioning well in some parts of New Zealand. There is a network of dedicated qualified instructors, and providers are utilising cycle training guidelines to deliver training approaches. There are extensive school-based cycle training programmes in some regions, which are reported to be in high-demand by schools and parents. Similarly, some regions have also developed progression models in particular areas alongside cycling infrastructure. Recently, there has also been a move towards more innovative approaches for adults, such as guided rides and the Ride Leader Programme, which aim to develop skills and safety behaviours as well as promote the enjoyment of cycling. The Bikes in Schools model is also gaining traction around the country.

To accompany this model there are the critical success factors outlined in (table 11.1) below. These factors have been elucidated from the literature and qualitative data, and the comparison of the cycling competency system model with the current state of cycle training and education in New Zealand. Consistent with the principles of the safe system approach, there is a need to strengthen all parts of the system, and therefore the recommendations below are focused on strengthening the approach to cycle training.

The critical success factors and recommendations below are designed to transfer the theoretical model above (figure 11.2) into practical solutions. For transparency, a rating of 'limited', 'some' or 'strong' has been ascribed to each critical success factor. This represents the extent to which this factor was evident as good practice in the literature (chapter 8), present in qualitative results (chapter 10) or a key finding of the crash causation analysis described in Part A. Each critical success factor is relevant for contributing to the Transport Agency's desired outcomes of this work, detailed below:

- confident and skilled riders of bikes on the road, and on other shared spaces
- riders of bikes who know the road user rules and use techniques to keep themselves and others safer on the roads
- riders of bikes who behave courteously to other road users, including on shared spaces
- significantly increased numbers of people cycling to school (under 18 component)
- increased numbers of people cycling for utility purposes (18+ component).

Table 11.1 Critical success factors for working towards a cycling competency system

Critical success factor	Evident in the literature (chapter 8)	Evident in qualitative results (chapter 10 or Part A)	Recommendation
Cycle competency initiatives within a package of safe system measures and as part of a comprehensive behaviour change approach that encourages cycling.	Strong	Strong	1 In the short-term, include cycle training and education as part of a wrap-around behaviour change approach in areas with new or existing cycling routes (for children and adults). This is likely to have the largest impact of cycling participation and safe road use in the immediate future. 2 In the longer-term, work towards increasing the reach of cycling competency approaches, in conjunction with other safe system measures.
Monitoring, evaluation and research Ensuring that sufficient and consistent monitoring and evaluation occurs on local and national levels is a critical success factor. This is an important component of good practice training schemes (Royal Society for the Prevention of Accidents 2000) and will contribute to the 'what works' knowledge base, given the lack of evidence that cycling training leads to safer cycling or 'more' cycling. Monitoring and evaluation will also enable the appropriate targeting and tailoring of education approaches to different audiences and contexts. The need to move beyond reporting 'numbers of participants trained' was recommended by some stakeholders, and cycle training providers also acknowledged the need for user-friendly evaluation and quality assurance tools.	Strong	Some	1 Consider the recommended approach presented in chapter 12)
A cycling education framework To be consistent with road safety education guidelines, formal cycle training needs to be based on principles of effective teaching and learning and aligned with students' prior knowledge, experiences and the New Zealand curriculum. One approach is to develop a 'cycling education' framework, which covers core cycling skills and knowledge, but also links to broader themes of 'citizenship', 'self-assessing one's own competence level' and 'travel behaviours'. This approach will ensure there is national consistency in terms of training content and approach, but also allows for contextually relevant delivery that can be tailored to individuals and groups. This approach is also important for ensuring that training content can be tailored to students (and potentially adults) who	Strong	Strong	1 For children/youth, cycle instructors co-constructing cycle training with teachers is an area to be trialled going forward. It is acknowledged there may be practical barriers to implementing this type of approach, given that instructors already report school time and costs as barriers to delivery. Therefore, trialling this approach in 3 to 4 schools is recommended in the first instance, and then this learning can then feed into the development of a cycling education framework. There is a risk that this broader cycling education approach may reduce access to cycle training (and therefore key cycle safety messages) if it is not practically achievable. Similarly, cycle training instructors may need to be upskilled in specific areas, such as understanding of the

Critical success factor	Evident in the literature (chapter 8)	Evident in qualitative results (chapter 10 or Part A)	Recommendation
demonstrate greater risk-taking tendencies.			curriculum; however, it is important for alignment with good practice and effectiveness that this is developed in the longer-term.
Opportunities to ride from a young age Maximise bike exposure at a young age in off-road environments to ensure children develop good basic bike skills and a love of biking. Good basic bike skills are needed before children can manage the multi-tasking demands of on-road riding (Ducheyne et al 2014; Ellis 2014). Developing stronger basic bike skills may ensure 'formal' training can cover more complex tasks at the appropriate age, and maximise the focus on hazard awareness and response. Facilitating a solid base of New Zealanders who can confidently ride a bike in off-road environments has important implications for future cycling participation.	Some	Strong	1 Consider how more exposure to biking in off-road environments can be facilitated from a young age. A combination of formal training, with more informal activities such as events and community or family rides, are likely to be needed to maximise this bike exposure. Models, such as Bikes in Schools, are likely to have a significant contribution to this success factor.
More training delivered on the network A move towards more cycle training being delivered in on-road environments and on the network, where appropriate. This includes more on-road time and an emphasis on route-planning and route riding to key destinations (eg school, sports and recreation facilities) as part of formal and informal training. This will ensure the training is relevant to the surrounding environment, teaches participants how to use infrastructure and manage difficult situations, as well as raise awareness of new/existing cycling routes. It is acknowledged that training in on-road environments can be dependent on the base skill of the participants, and therefore this factor is also dependent on the other parts of the system working well.	Strong	Strong	1 Increase opportunities for practical cycle training, (focusing on riding on the network), marketed to the 'interested but concerned' group of adults. Many regions in New Zealand are delivering such adult training; however, this is not occurring in all areas. 2 Increase the proportion of 'on-road' or 'on the network' formal training delivered to children/youth (from approximately the age of 11, although this will vary depending on the context) in conjunction with encouraging supervised practice with parents. Utilise key life stages as potential levers, such as the transition from intermediate to high school. 3 Investigate how route-planning and route-riding can be included as core activities, and how this content can be delivered as inquiry-based learning modules and involve parents/families.
Engagement of parents and whanau Engagement of parents/caregivers and families in both formal and informal training approaches is a critical success factor. This is significant for ensuring children continue to practise and gain experience riding on the network, and is an important strategy for reducing the	Strong	Strong	1 The link with parents/families is a critical gap in current cycle training approaches for children and youth. Initiatives and trials to reduce this gap and encourage parents to ride with their children and reinforce training messages are needed. It is also imperative that parents are given feedback about their child's

Critical success factor	Evident in the literature (chapter 8)	Evident in qualitative results (chapter 10 or Part A)	Recommendation
barrier of parental safety concerns. A focus on encouraging 'supervised practice' is needed.			competence level after participating in school-based training and given advice about how to further develop their child's competencies. Elective cycle training, specifically targeted at parents/caregivers and families is worthy of investigation.
Extending the reach of cycle competency messages in innovative ways.	Some	Some	1 Examine ways to extend the reach of cycle safety messages and road sharing messages to adults who are unlikely to attend a formal training course. Cycling New Zealand's 'Rider Leader 'is emerging as an effective way to achieve this. It also important to investigate the potential benefit of well-publicised and targeted online resources particularly for adults. 2 Encouraging the engagement of the bike industry to introduce and reinforce cycle competency messages is an area for investigation. This will be particularly important for emerging technologies, such as E-bikes, where people may need specific advice and training on how to use them safely.
Facilitate a love of biking and normalisation of transport cycling Embed safety and road sharing messages in both formal and informal training approaches, whilst maximising the enjoyment of cycling and the normalisation of cycling as a transport mode.	Some	Strong	1 There are already some innovative approaches that aim to promote the enjoyment of cycling as well as cover key safety messages (eg Auckland's guided rides, Cycling New Zealand's Ride Leader, Bikes in Schools) and it is recommended these kinds of approaches continue to be developed and extended. 2 Ensure all cycle training and other competency development approaches are consistent with broader cycling promotion messages, and reinforce cycling for utility as socially positive and normal behaviour.
Cycle competency approaches that target high- risk situations or groups This is recommended in combination with other Safe System measures or as an interim approach until changes to the road environment/vehicle design can be achieved.	Some	Some	1 Continue to improve knowledge of the effectiveness of cycling training and competency initiatives targeted at high-risk situations or groups (including recreational cyclists). Examples include education around heavy vehicle blind spots, route-selection, how to deal with complex road environments, how to use E-bikes safely and the skill development of older bike riders.

As well as these overarching critical success factors and recommendations, below are some more specific recommendations, considerations and knowledge gaps.

11.2.1 Content for inclusion in cycle skills training guidelines

The actions below have been identified as particularly important in the current New Zealand context. It is recommended they are explicitly included in cycle skills training guidelines (or future education frameworks) and subsequent delivery:

- Choose an appropriate route that matches bike riders' competencies and preferences. This may reduce barriers related to perceived safety and raise awareness of suitable cycling routes.
- Give specific guidance on how to reduce the risks when cycling near heavy vehicles, including the extent of heavy vehicle blind spots.
- Provide on-going reinforcement of the need for head-checks and the opportunity to execute these in a range of environments.
- Explain the role that cyclist speed may have in terms of crash cause and severity, including how and when to manage speeds.
- Give more explicit guidance on cyclists' expected behaviour on shared paths and the opportunity to practise these 'sharing' behaviours.

A process is also needed that enables current and future cycling instructors (and others involved in cycling education) to remain up to date with best practice and emerging knowledge.

11.2.2 Other considerations and areas for development

- Consistency of funding is likely to be needed to allow cycle training providers to offer consistent services to their communities and be embedded as part of wider behaviour change programmes. Some flexibility in the funding approach is also likely to be needed if there is a move towards more co-construction of cycling education with schools (as opposed to standard delivery of Grades 1 and 2).
- Similar to the Ride Leader approach, a mechanism by which support can be provided to community cycling champions is worthy of investigation. Providing these individuals with good knowledge of key safety behaviours, route guidance and bike maintenance training, may help to share these messages as well as a love of biking across the community.
- For road casualties of all types there is evidence that suggests lower socio-economic communities experience greater rates of deaths and series injuries compared with less deprived areas (Hosking et al 2013). It could be hypothesised that cycling may follow a similar trajectory as cycling rates increase. More deprived areas may also, by comparison, lack access to suitable bikes and have generally lower bike competencies. Thus, from an equity perspective tailoring approaches for communities with high road safety risk and traditionally poor access to bicycles may be a necessary approach within the system.
- If cycling competency approaches are only delivered in areas with good bike access, availability of cycling routes and community support for cycling it may fail to address underlying barriers to cycling competency and fail to create a population of New Zealanders who are ready for transport cycling. While initially targeting training to infrastructure/routes that supports cycling (both social and physical infrastructure) may be a sensible approach in the short-term, other more population-based strategies, such as places or spaces to ride, Bikes in Schools and widespread promotion of key safety behaviours, should be considered for other communities.

- Some stakeholders raised the possibility of a national brand for New Zealand cycle training, similar to the UK's Bikeability Scheme, with generally mixed perceptions. Bikeability is reported to be valued by parents in the UK with high demand for the training (Ipsos MORI 2010). However, there are likely to be advantages and disadvantages of such an approach; for example, consistent resources, evaluation and quality assurance processes could be developed; however, the one size fits all approach may not enable opportunities to be flexible to the social and environmental context.
- Continue to work through the reported problems with the cycle training instructor qualification process.

11.2.3 Key knowledge gaps:

Further research is needed to quantify the impact of more comprehensive cycling education approaches, delivered in conjunction with other safe system measures. While the limitations of the traditional approaches to training, namely the 'one-off' nature or small 'dose', may partly explain the lack of evidence on safe road use and participation, this needs to be robustly evaluated.

There is limited understanding of high school students' (and secondary schools') perceptions of cycling, cycling competencies and transport preferences, including the views of adolescent sport cyclists. The University of Otago's Built Environment and Active Transport to School (BEATS) Study, currently underway, is focusing on secondary school students (Mandic 2016). Findings from the BEAT study should be used to inform future work in this area.

The need to create clear behavioural expectations between drivers and cyclists was highlighted in Part A of this report. The idea that a cycling competency system model includes a focus on driver skills was highlighted by some stakeholders, and extremely poor and impatient driving around cyclists was reported by many experienced cyclists in the online survey. 'Cross-training', or facilitating exposure to on-road cycling prior to or linked with driver education is worthy of further research given the potential impacts on cycling competency, driver competency and cycling participation.

As discussed, targeting of cycle training to infrastructure that supports cycling was supported by stakeholders as well as the literature review findings, and is recommended as a sensible approach going forward (as one approach within the wider system). However, there is a need to clearly describe what 'good' cycling infrastructure looks like for particular age groups or competency levels, in order to effectively target training approaches to areas that meet this definition.

11.2.4 Limitations of this approach and the cycling competency system model

This research drew on literature and empirical data to formulate the conceptual model, accompanying critical success factors and recommendations. However, the effectiveness of the model overall, has not as yet been tested, and therefore highlights the need to ensure on-going monitoring and evaluation of both formal and informal training approaches, as well as the system overall. Similarly, the links between model components are not established as definitive causal links.

While the researchers made every effort to gather a range of insights from around New Zealand, and in fact engaged with many more stakeholders than originally promised, this work does not represent the views of all those in the cycling sector. Similarly, the insights from adults, schools, parents and students are not representative of all end users. The proportion of experienced cyclists (self-reported) in the online survey sample was relatively high (approximately 50%) and although this allowed a good understanding of the perceived skills required to ride on the current network, it is less representative of novice cyclists and those who not currently cycle.

A formal analysis comparing the benefits of investing in cycle training with the benefits of investing in infrastructure, speed management, vehicle safety, driver training or promotional strategies was outside the scope of this study.

12 Evaluation of a cycling competency system

Further evaluation of cycle training and education approaches is needed given the mixed findings to date, particularly for children/youth and the evidence that undesirable outcomes of training in isolation are possible. Currently, there is no nationally consistent way in which providers evaluate their cycle training programmes, making comparisons across regions and delivery models difficult. If further investment in cycling education and training approaches is made, the proposed evaluation activities are recommended. These tools are also designed to capture how the overall cycling competency system is functioning and therefore identify further areas for future focus or development. This chapter is designed to provide guidance going forward; however, the final evaluation activities will need to be revised as the approach to cycle training develops. Tables 12.1, 12.2 and 12.3 outline the proposed evaluation indicators and tools, followed by a more detailed description of particular tools.

Overall, there were two purposes to these evaluation activities:

1 To understand strengths and areas for improvement in order to further develop the cycling competency system. These activities focus on tracking how critical success factors are being embedded into practice. This focus is primarily for sector learning and can include assessment at national and local levels. Draft assessment rubrics that align to the critical success factors identified in chapter 11 are presented in appendix C, with examples shown in table 12.1.

2 To provide evidence of effectiveness and accountability for investment in a nationally consistent way, tables 12.2 and 12.3 outline evaluation indicators, tools and the rationale for each.

Table 12.1 Critical success factors for a cycling competency system: draft rubric for children/youth

Children and youth critical success factors	Assessment criteria			
	Limited	**Developing**	**Good**	**Excellent**
Parent or family engagement in cycling education and parents/ caregivers are riding with their children on the network.	None	Parents/families are informed of training outcomes.	Parents/families are informed of training outcomes and some are actively involved in planning/delivery. Initiatives that create opportunities for parents to ride with their children are developed.	Active parental engagement is an integral part of how we go about training. Initiatives that create opportunities for parents to ride with their children are a central focus.
Development of a cycling education framework, which allows cycle training and education to be developed with schools and tailored to participants.	Cycle training is primarily delivered by instructors with limited engagement from schools/teachers.	Some schools are involved in the planning of training content and/or integrate training into their curriculum units.	Many schools are involved in the planning of training content and/or integrate training into their curriculum units.	The majority of schools are involved in the planning of training content and/or integrate training into their curriculum units. Cycling education is a partner-ship between external providers and schools.

Children and youth critical success factors	Assessment criteria			
	Limited	**Developing**	**Good**	**Excellent**
Integration of cycling competency approaches with cycling infrastructure and cycling behaviour change activities.	Cycle training is only delivered to schools on request and generally not in conjunction with other activities that support cycling.	Cycle training as part of an integrated approach with infrastructure and other behaviour change activities is starting to be developed. Some barriers to this approach remain.	Cycle training is being delivered as part of an integrated approach with infrastructure and other behaviour change activities in some areas/schools. Most barriers to this approach are being addressed.	Key strategic areas have been identified and training is part of an integrated approach delivered consistently over time.

Table 12.2 Proposed cycle competency system evaluation tools: child and youth focused

Children and youth: short-term outcomes	Rationale	Tool or measure
Reported confidence in different types of cycling environments (before and after), key skills they want to learn (before) and reported key learnings (after)	Enable instructors to tailor training to students' previous experience and confidence and involve students in identifying what they need to learn.	National cycle training website or online tool (1), administered in a classroom setting or with parents.
Reported level of and type of bike riding (before and after).	Enable instructors to tailor training to previous cycling experience. Enable monitoring of cycling participation.	National cycle training website or online tool, administered in a classroom setting or with parents.
Instructor assessment of competency level (before and after participation in training).	Enable instructors to tailor training to previous cycling experience and competency level. Provide a database of competency levels per school/area to identify the extent to which students have basic bike skills before training (ie monitor if the initial levels of the system are working well). Evaluate the extent to which training develops cycling competencies and enable individualised reporting to parents.	Competency rubric (2).
Children and youth: medium to long-term outcomes (6-months)	**Rationale**	**Tool or measure**
Reported level of and type of bike riding (including reported level of riding with their families).	Compare to baseline to enable monitoring of change.	National online tool.
Proportion of students cycling to school (including high schools).	On-gong monitoring to determine system level change.	National bike rack counts (3).

Table 12.3 Proposed cycle competency system evaluation tools: adult-focused

Adult – short-term indicators	Rationale	Tool or measure
Self-assessment of competency level (before and after)	Enable instructors to tailor training to students' previous experience and confidence.	National online tool

Adult – short- term indicators	**Rationale**	**Tool or measure**
Perceived safety in various cycling environments (before and after)	Provide a baseline measure of perceived safety to monitor changes as a result of training.	National online tool
Instructor assessment of competency level (before and after)	Enable instructors to tailor training to previous cycling experience and competency level. Assess the extent to which training develops cycling competencies.	Competency rubric
Adult: medium – long- term indicators (>6 months)	**Rationale**	**Tool or measure**
Reported level and type of bike riding	Comparison to baseline to monitor change in trained individuals.	National cycle training website/application

12.1.1 National cycling education online tool

To minimise the burden of evaluation and reporting, we propose the development of a national cycling education website/application serving the dual purpose of capturing evaluation data as well as promoting cycling promotional and safety messages. This can be used for capturing pre-post data on self-reported competency level, perceived safety, attitudes to cycling and cycling participation, as well as provide good information for instructors to tailor training to participants' needs. Borrowing concepts from the 'Love to Ride' (2016) app it could also be used for tracking the routes participants are taking and as a mechanism to continue to promote cycle safety and behaviour change messages.

12.1.1.1 Competency rubric

A competency rubric can be used as a planning tool and an evaluation tool. This would include simple structured statements that represent the key competencies for cycling in various environments as well as perceptions of transport cycling. Instructors can assess a participant's competency level before and after training to monitor changes and provide a base for reporting back to parents (for children/youth). We also recommend involving participants in this assessment process to engage them in identifying areas they need to work on. The existing skill assessment tool developed as part of the current monitoring and evaluation framework is being used in some areas (but not all) (NZ Transport Agency 2010), and it is recommended this tool be further refined.

12.1.1.2 National bike rack counts

As one of the key outcomes desired by the Transport Agency is an increase in cycling to school, we recommend the establishment of an annual national bike rack count. This will provide a good comparison between schools involved in cycle training/education initiatives and those that are not, as well as enable consideration of other contextual factors, such as the road environment. While, as shown in this report, cycle training as a tool in isolation may be unlikely to lead to increased cycling to school, bike rack counts are a simple and relatively robust way of tracking changes over time and for identifying the factors that have led to this change.

The above activities provide a base for on-going monitoring and evaluation. More in-depth evaluation of training approaches (particularly for new initiatives) will be needed. Tools, such as video observation or direct observation of cycling behaviour, before and after training, is one example of a more in-depth approach.

13 Conclusion to Part B

The aim of this work was to provide guidance on a best practice cycle skills training system that results in the following outcomes for cyclists of all ages (outcomes were provided by the Transport Agency):

- confident and skilled riders of bikes on the road, and on other shared spaces
- riders of bikes who know the road user rules and use techniques to keep themselves and others safer on the roads
- riders of bikes who behave courteously to other road users, including on shared spaces
- significantly increased numbers of people cycling to school (under 18 component)
- increased numbers of people cycling for utility purposes (18+ component).

There is some evidence that certain types of cycle training can improve children's cycling confidence, road code knowledge, bike skills and their ability to identify and respond to hazard awareness; however, cycle training, as a strategy on its own, to improve safety and increase cycling participation has not been demonstrated to date. In adults, there is some evidence that cycle training can improve skills and confidence and facilitate 'more' cycling in individuals who are already motivated to cycle.

Currently there is insufficient evidence, particularly concerning children, to understand the effects of more comprehensive approaches. The literature suggests that a mix of factors, with multiple touch points across the life course, based on educational principles and accompanied by infrastructure that supports cycling, may be more effective. It is this 'mix' of activities that needs to be evaluated going forward. Also, cycle training approaches may not always have the outcome expected, and could facilitate over confidence and negative outcomes if not delivered with careful consideration, or with robust evaluation.

There are examples of well-established cycle training approaches being delivered around the country (Taranaki, Tauranga and Christchurch), and examples of innovative approaches to cycle training that facilitate competency development but also promote the enjoyment of cycling (Auckland Transport's Guided Rides, Bikes in Schools, Ride Leader Programme). However, training approaches have generally had a reasonably narrow focus on skills, have not always been coordinated with other activities that support cycling, have not been based on pedagogical principles or linked with parents/caregivers. The balance of delivery has also been in off-road environments which may have limited long-term value in terms of transport cycling.

The cycling competency system model, developed through this work, describes how traditional cycle training can be combined with other formal and informal approaches to prepare New Zealanders for transport cycling and overcome some of the limitations of current approaches. We cannot expect a two to four hour training session to have a direct impact on cycling participation (or safety) in isolation. However, a process of coordinated competency development approaches has the potential to ensure New Zealanders can choose cycling routes that match their needs; reduce individual cycling competencies as a barrier to cycling uptake; and be a channel for promoting the benefits and normalisation of transport cycling. Thus, in combination with other safe system measures, cycling training and other competency development approaches may provide a contribution to safe road use and participation goals.

The need to create clear behavioural expectations between drivers and cyclists was highlighted in Part A of this report. Therefore, while this work has examined how to strengthen education approaches for cyclists, there is a need to understand the most effective approaches for improving driver behaviour around cyclists, particularly in the shorter term until road environment improvements can be made.

The Transport Agency currently has very ambitious goals of increasing the number of trips by bike by 10 million in the next four-years. Targeting cycling competency initiatives (of various forms) to areas with infrastructure that supports cycling and embedding these initiatives in a wider behaviour change programme in these communities, is the approach most likely to support this short-term goal. However, a limitation of this approach is that it may not create a solid foundation of New Zealanders who are prepared for transport cycling and therefore initiatives to increase the reach of cycling competency initiatives, with strong consideration of context and target group, are also recommended. Overall, continued investment in cycling infrastructure should remain a high priority for New Zealand; however, initiatives that develop cycling competency may form an important part of the overall suite of initiatives, and evaluation of more comprehensive approaches are needed to inform practice in the longer term.

14 Overall conclusion

Integrating cycling in New Zealand's transport system as a safe and attractive mode will be a lengthy journey, requiring a multi-faceted programme of work embedded in a safe system approach. An in-depth understanding of the root causes of cycling crash causation, and the most effective cycling education approaches are important facets of this overall journey, where actual and perceived safety, and a life-long norm of transport cycling, are key considerations for the safe promotion of cycling. This research takes a system view to describe a method for identifying system failures and prioritising future action in both cycling safety and road safety more generally. Critical gaps in New Zealand's current approach to cycle training are also presented with recommendations for the development of a more comprehensive and coordinated approach. The research has identified a number of system factors that could improve cyclist safety and has also shown that our current approach to cycle training is too narrow. These two different yet complementary pieces of work are important elements of a proactive and systematic approach to make cycling 'safer and more attractive', and provides future direction for an existing positive programme of work that is underway to improve conditions for cycling.

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Appendix A: Stakeholder interview scripts

A1 Cycle skills training system: Stakeholder interview script – cycle training provider

Name: ________________________

Organisation: ________________________ **Role:** ___________________________

We are working on a project for the NZ Transport Agency that focuses on developing a cycle skills training system for New Zealand that results in:

1. Confident and skilled riders of bikes on the road, and shared spaces
2. Riders of bikes who are knowledgeable of road user rules and use techniques to keep themselves and others safer on the roads
3. Riders of bikes who behave courteously to other road users, including on shared space's
4. Significantly increased numbers of people cycling to school (under 18)
5. Increased numbers of people cycling for utility purposes (18+).

Existing approaches and involvement
• Describe your involvement in cycle training (and or cycling). • What types of training are you involved in delivering? Approximately how much per year? • What are the strengths of the existing training approaches you are involved in? • What doesn't work so well, or what are the limitations or challenges of existing training approaches you are involved in? (prompt: whole process, funding through to delivery)
System development
• What are the most important key skills, knowledge & behaviours people need to cycle on NZ roads and shared spaces? • Are there any special considerations for different age-groups? • Are there any special considerations for different environments? • In your view, what are the critical success factors of a NZ cycle skills training system? i.e. what needs to happen to achieve confident, competent riders and increased participation? • How do you think a training system could facilitate practice and experience, particularly for young cyclists? • How could cyclists (both existing and future) be encouraged to behave courteously to other road users on the road and on shared spaces? • Considering that people cycle for different reasons and in different ways, what groups or audiences' do you think should be directly targeted for training approaches? • Are there any groups that you believe should be supported or targeted for formal training?

- Are there any innovative or new approaches you think would be worthwhile in a cycle training system? (ie strategies that might not be viewed as 'formal' training).
- How could cycle training/education approaches contribute to increased cycling?
- Delivering cycle training in conjunction with infrastructure improvements has been suggested in the literature and by some stakeholders as a good approach. What's your view on this?
- How suitable are the current NZ Transport Agency Cycle Skills Guidelines? Is there anything missing?

A2 Cycle skills training system: Stakeholder interview script – other stakeholder

Name: ________________________

Organisation: ________________________ **Role:** ___________________________

We are working on a project for the NZ Transport Agency that focuses on developing a cycle skills training system for New Zealand that results in:

1. Confident and skilled riders of bikes on the road, and shared spaces
2. Riders of bikes who are knowledgeable of road user rules and use techniques to keep themselves and others safer on the roads
3. Riders of bikes who behave courteously to other road users, including on shared space's
4. Significantly increased numbers of people cycling to school (under 18)
5. Increased numbers of people cycling for utility purposes (18+).

Background and broad feedback on cycling involvement and future cycle skills training system

- Describe your involvement in cycle training (and or cycling).
- What are the strengths of the existing training approaches in your view?
- What doesn't work so well, or what are the limitations or challenges of existing training or education approaches you are involved in?
- What are the most important key skills, knowledge and behaviours people need to cycle on New Zealand roads and shared spaces?
- Are there any special considerations for different age-groups?
- Are there any special considerations for different environments?
- Are you familiar with the current NZ Transport Agency guidelines? Do you have any comments on these?
- In your view, what are the critical success factors of a New Zealand cycle skills training system for the next 5 to 10 years?
- What needs to happen to achieve the outcomes of competent riders and increased cycling?

• Ideally how would you see <u>your organisation</u> being involved in a cycle skills training system going forward?
Specific questions related to a cycle training system
• How do you think a training or education system could facilitate <u>practice</u> and <u>experience</u>, particularly for young cyclists? • How could cyclists (both existing and future) be encouraged to behave courteously to other road users on the road and on shared spaces, and follow road rules? • Are there any innovative or new approaches you think would be worthwhile that can facilitate the development of cycling skills? (ie strategies that might not be viewed as ‘formal’ training). • Are there any groups that you believe should be supported or targeted for formal training? • Delivering cycle training in conjunction with infrastructure improvements has been suggested in the literature and by some stakeholders as a good approach. What’s your view on this?
Final comments
• Do you have any final comments or suggestions?

A3 Cycle skills training system: Stakeholder interview script – adults

Making urban cycling a safer and more attractive transport choice is now one of the NZ Transport Agency’s transport priorities for the next three years. Actions to achieve this includes activities such as, supporting local government to complete urban cycle networks and establish nationally consistent road design guidelines for cycling infrastructure. As part of a more comprehensive approach, initiatives that aim to influence the knowledge, skills and confidence of people who cycle are likely to be needed. As people who cycle or are thinking about cycling we are keen to hear your feedback this issue.

Background and broad feedback on cycling involvement
Tell me about yourselves • What caught your eye about attending this discussion? • Do you currently ride a bike, if so, how often, for what purposes? • If not, why not? What is your perception of riding on the road in Auckland?
• In your opinion, what are the skills, knowledge or attitudes a person must have to ride on the road? • For those of you who currently ride a bike on the road, can you tell us how you developed the skills and confidence to do so (starting from childhood)? • Are there any situations or areas where you feel you lack skills or confidence? • For those of you who are not currently riding on the road, how confident do you feel?

- Would there be any skills or knowledge you feel you need to develop?
- What would need to happen for you to be able to ride to work or ride to the local shops by bike?

Specific questions related to a cycle training system
• What would be the best ways for you to develop those skills? Is there any external or professional support you need? • In your opinion, what would be the best strategies for developing the cycle skills of New Zealand children? • If you could do one or two things, what would it be? • Do any of you have any children? What are your views as a parent/caregiver? • In your opinion, what would be the best strategies for developing the cycle skills of New Zealand adults? • If you could do one or two things, what would it be? • Overall, how important do you think strategies that develop a person's cycling skills are, as part of a wider approach to improve cycle safety and increase cycling participation? • Do you have any final comments?

A4 Cycle skills training system: School representatives and student focus group script

Making urban cycling a safer and more attractive transport choice is now one of the NZ Transport Agency's transport priorities for the next three years. Actions to achieve this includes activities such as, supporting local government to complete urban cycle networks and establish nationally consistent road design guidelines for cycling infrastructure. As part of a more comprehensive approach, initiatives that aim to influence the knowledge, skills and confidence of people who cycle are likely to be needed. As a school we are keen to hear your feedback this issue.

School representatives and students

Cycle training in schools
• Confident and skilled riders is something the NZ Transport Agency wants to see, where would you see a school's role in this? • Broadly, what do you think is the best way for New Zealanders to become confident, skilled bikers? • Has your school ever received cycle training from an outside provider? • How valuable is cycle training that given your schools location, values, ethos? • Would it be something that is integrated into the curriculum or an extra? Where could you see it fitting?
• How would you see practical training and more education approach fitting together in a school?

• Given the environment your school is in – what would your view on on-road cycle training be? Parents/caregivers? • Does your school actively promote cycling to school? • How do your schools' learning outcomes align to cycle training? How would you see it fitting in to your curriculum?
Final comments
• Do you have any final comments or suggestions?
Warm up session
• Warm-up – word association • When I think of the word 'bike' say all the words that come to mind? • When I say the word 'cycle' say all the things that come to mind?
Students cycle training and cycling activity
• How did you learn to ride a bike? • Where do you normally ride now (footpath, cycle paths, road, mountain-biking)? • For those of you who don't ride a bike much, have a think about then explain why that is? • What challenges do you face when riding? • How do you like to learn new skills? If you don't know something where do you go? • Broadly, what do you think is the best way for New Zealanders to become confident enough to ride to school if they wanted to?
Final comments
• Do you have any final comments or suggestions?

Appendix B: Online survey for adults and parents/caregivers

1. Survey background and consent

Hi there,

We are investigating how New Zealanders can be encouraged to become competent, confident and courteous people who ride bikes on the road and shared spaces. ***As someone who rides a bike (or is thinking about giving it a try), your thoughts on the best approaches to achieve this will be extremely valuable.***

The survey will take 5-minutes! **The information you provide will be used to inform a best practice cycle skills system for New Zealand.**

Your participation in this survey is voluntary and you can withdraw at any time without consequence. The information you provide is anonymous and will not be linked to your personal information in reports.

By completing the survey you are agreeing to participate in this research.
Respond by November 20th 2015 and you will go in the draw to win a $100 grocery voucher (there are two up for grabs!).

This work is being conducted on behalf of the New Zealand Transport Agency (NZTA) and is one component of a broader NZTA programme that aims to make cycling a 'Safer and more attractive' transport mode (www.nzta.govt.nz/cycling) . Other components include investment in cycling infrastructure; however, this survey specifically relates to identifying the best strategies for developing the competencies of current and future riders of bikes. Results from the survey will be published into a NZTA report and published on their website in late-2016.

For questions or further comments, please contact: Greer Hawley
Mobile: 022 6018809 Landline: 09 579 2328 Extn 109 Email: greer@mackieresearch.co.nz
www.mackieresearch.co.nz

Thank you for your time.

Kind regards,

Mackie Research & Consulting, in collaboration with the School of Population Health, University of Auckland

2. Demographics

1. How old are you?

- 18-25
- 26-40
- 41-60
- 61+

2. Gender:

- Male
- Female

3. What region of NZ do you live in?

- Northland
- Auckland
- Waikato
- Bay of Plenty
- Taranaki
- Hawke's Bay
- Manawatu-Wanganui
- Wellington
- Tasman
- Nelson
- Marlborough
- West Coast
- Canterbury
- Otago
- Southland

Other:

4. The area I live in is... (choose the answer that best matches your situation)

- urban
- rural

3. Cycling experience and participation

5. Have you ridden a bicycle (for any purpose) in the past 2-years?

- Yes
- No

4. Cycling participation and experience

6. What type of cycling do you participate in (tick all that apply)

- [ ] Mountain-biking or BMX
- [ ] Riding on off-road or shared paths
- [ ] Road cycling as a sport (i.e. as part of a group)
- [ ] Cycling on the road for transport
- [ ] Cycling on the road for leisure or fitness

Other:

7. On average, how often do you ride your bike?

- ◯ Almost everyday
- ◯ 3-5 times per week
- ◯ 1-2 times per week
- ◯ 2-3 times per month
- ◯ About once per month
- ◯ Very occasionally

8. Please tick the statement below that best matches your situation regarding on-road cycling

- ◯ I am an experienced and confident cyclist in most on-road situations
- ◯ I have been cycling on the road for a while, and am confident on the road depending on the route
- ◯ I am relatively new to cycling on the road
- ◯ I don't really cycle on the road
- ◯ Other:

9. In your opinion, what are the most important skills, knowledge or attitudes a person must have to ride on the road safely in NZ?

10. In your opinion, what are the best ways to support children and young people (under 18) to become confident and competent to ride a bike, including having the skills to ride on the road at the appropriate age? (Please rate the items below).

	Not valuable at all	Not very valuable	Neutral	Quite valuable	Extremely valuable
Formal cycle training offered through schools or the community	◯	◯	◯	◯	◯
Online resources for parents and children (e.g. websites & videos)	◯	◯	◯	◯	◯
Printed resources for parents and children	◯	◯	◯	◯	◯
Places and spaces to ride while developing confidence	◯	◯	◯	◯	◯
Improving access to bikes	◯	◯	◯	◯	◯
Media campaigns	◯	◯	◯	◯	◯
Role-modelling of safe cycling by parents and family members	◯	◯	◯	◯	◯
Strategies that support parents to become confident on-road cyclists themselves	◯	◯	◯	◯	◯
Community events	◯	◯	◯	◯	◯

Other (please specify)

11. In your opinion, what are the best ways to support adults (over 18) to become confident and competent to ride a bike on NZ roads and cycle paths?

	Not valuable at all	Not very valuable	Neutral	Quite valuable	Extremely valuable
Formal cycle training offered through the community or other channels	◯	◯	◯	◯	◯
Online resources (e.g. websites & videos)	◯	◯	◯	◯	◯
Printed resources	◯	◯	◯	◯	◯
Places and spaces to ride while developing confidence	◯	◯	◯	◯	◯
Improving access to bikes	◯	◯	◯	◯	◯
Media campaigns	◯	◯	◯	◯	◯
Community events	◯	◯	◯	◯	◯

Other (please specify)

12. Cyclists have to share the road and off-road paths with other users (e.g vehicles, trucks, pedestrians, other cyclists). How could cyclists be encouraged to be courteous to other road users and practice good road-sharing behaviour?

13. When you are riding, are there any common mistakes or deliberate violations you notice other cyclists doing?

14. Do you have any other suggestions for how New Zealanders could become confident and competent to ride on the road?

15. Is there any support or resources you need to become more confident or skilled?

5. Cycling education & training

16. In your opinion, what are the most important skills, knowledge or attitudes a person must have to ride on the road safely?

17. In your opinion, what are the best ways to support children and young people (under 18) to become confident and competent to ride a bike, including having the skills to ride on the road at the appropriate age? (Please rate the items below)

	Not valuable at all	Not very valuable	Not sure	Quite valuable	Extremely valuable	N/A
Formal cycle training offered through schools or the community	○	○	○	○	○	○
Resources online for parents and children (e.g. websites or videos)	○	○	○	○	○	○
Printed resources for parents and children	○	○	○	○	○	○
Places and spaces to ride while developing confidence	○	○	○	○	○	○
Improving access to bikes	○	○	○	○	○	○
Media campaigns	○	○	○	○	○	○
Role-modelling of safe cycling by parents and family members	○	○	○	○	○	○
Strategies that support parents to become confident on-road cyclists themselves	○	○	○	○	○	○
Community events	○	○	○	○	○	○

Other (please specify)

18. In your opinion, what are the best ways to support adults (over 18) to become confident and confident to ride a bike on NZ roads and cycle paths?

	Not valuable at all	Not very valuable	Not sure	Quite valuable	Extremely valuable	N/A
Formal cycle training offered through the community or other channels	◯	◯	◯	◯	◯	◯
Online resources (e.g. websites or videos)	◯	◯	◯	◯	◯	◯
Printed resources	◯	◯	◯	◯	◯	◯
Places and spaces to ride while developing confidence	◯	◯	◯	◯	◯	◯
Improving access to bikes	◯	◯	◯	◯	◯	◯
Media campaigns	◯	◯	◯	◯	◯	◯
Community events	◯	◯	◯	◯	◯	◯

Other (please specify)

19. For adults who are learning to cycle on the road, how valuable is professional training or education in your opinion?

Not valuable at all	Not very valuable	Not sure	Quite valuable	Very valuable
◯	◯	◯	◯	◯

Comments:

20. Would you attend a cycle training course?

◯ Yes

◯ No

◯ Not sure

If yes, what are the key things you would want to learn? If not, why not?

21. Cyclists have to share the road and off-road paths with other users (e.g vehicles, trucks, pedestrians, other cyclists). How could cyclists be encouraged to be courteous to other road users and practice good road-sharing behaviour?

6. Feedback from parents/caregivers

22. Are you a parent or caregiver of a child under 18?

- [ ] No
- [ ] Yes I have children in the 0 to 5 years age-group
- [ ] Yes I have children in the 6 to 10 age-group
- [ ] Yes I have children in the 10 to 14 age-group
- [ ] Yes I have children in the 15 to 18 age-group

7. Feedback from parents/caregivers

23. How comfortable are you at the moment with allowing your child(ren) to cycle to school or for shorter trips?

Not comfortable at all	Not very comfortable	Not sure	Quite Comfortable	Very comfortable	Not applicable (i.e. my child is too young)
○	○	○	○	○	○

Other (please specify)

24. Is there any support you need to enable your child(ren) to be confident, competent bike riders (either now or in the future)?

25. Would any of the items listed below make you more comfortable to allow your child to cycle to school or for shorter transport trips? *Please rate the items below.*

	Less comfortable	No change	More comfortable	A lot more comfortable	N/A
Formal training at school, which includes on-road practical riding	○	○	○	○	○
Resources and programmes that enable you to teach your child safe cycling	○	○	○	○	○
Planning a safe route and riding it with your child	○	○	○	○	○
Routes that mean your child does not have to negotiate busy traffic	○	○	○	○	○
The availability of places and spaces that enable your child to practice and develop their skills off the road (e.g shared paths, off-road paths)	○	○	○	○	○
A cycle buddy programme or other initiatives that mean your child does not have to cycle alone	○	○	○	○	○

Other comments?

8. Contact details

26. If you would like to go in the draw for a one of two $100 grocery vouchers, please write your contact details below (this is voluntary, leave blank if you prefer).

Name

Email Address

Phone Number

Know someone else who might be interested in providing their feedback? Please forward the link on.

Thank you very much for your time. Your comments are greatly appreciated. If you have any further questions or comments please do not hesitate to contact Greer Hawley at Mackie Research.
Phone: 022 601 8809 Email: greer@mackieresearch.co.nz

Appendix C: Draft critical success factor evaluation rubrics

Children and youth – critical success factors	Assessment criteria			
	Limited	**Developing**	**Good**	**Excellent**
Opportunities to ride from a young age	There is large variability across communities, or limited opportunities to ride from a young age generally.	A range of opportunities to ride a bike exist in some regions and communities, with limited opportunities in other.	A range of opportunities to ride a bike exist in most regions and communities	A range of opportunities to ride a bike exist across all regions and communities
Proportion of training delivered on the road, cycling facilities or shared spaces.	< 25% of delivery time	25% to 50%	50% to 75%	> 75%
Parent or family engagement in cycling education and parents/caregivers are riding with their children on the network.	None	Parents/families are informed of training outcomes.	Parents/families are informed of training outcomes and some are actively involved in planning/delivery.	Active parental engagement is an integral part of how we go about training.
Development of a cycling education framework that allows cycle training and education to be developed with schools and tailored to participants.	Cycle training is primarily delivered by instructors with limited engagement from schools/teachers.	Some schools are involved in the planning of training content and/or integrate training into their curriculum units.	Many schools are involved in the planning of training content and/or integrate training into their curriculum units.	The majority of schools are involved in the planning of training content and/or integrate training into their curriculum units. Cycling education is a partnership between external providers and schools.
Integration of cycling competency approaches with infrastructure and cycling behaviour change activities.	Cycle training is only delivered to schools on request and generally not in conjunction with other activities that support cycling.	Cycle training as part of an integrated approach with infrastructure and other behaviour change activities is starting to be developed. Some barriers to this approach remain.	Cycle training is being delivered as part of an integrated approach with infrastructure and other behaviour change activities in some areas/schools. Most barriers to this approach are being addressed.	Key strategic areas have been identified and training is part of an integrated approach delivered consistently over time.

Adult training – critical success factors	Assessment			
	Limited	**Developing**	**Good**	**Excellent**
Adult cycle training approaches are tailored to the individual or group through prior self-assessment (and instructor assessment). Advice/suggestions regarding the next step in competency development are provided as part of the training.	Training is delivered in the same way regardless of the individual or group.	Attempts are being made to link training to participants' needs, with some development required in this area.	Training is sometimes linked to participants learning needs and next steps in competency developed are mostly identified.	Training is linked to participants learning needs and next steps in competency developed are identified.
Communication tools and approaches that increase the reach of key cycle competency messages are developed and marketed well, whilst simultaneously marketing the benefits of cycling (particularly to those that are not involved in formal training)	Not yet developed	These are currently under development.	Some channels for marketing key cycle competency messages have been identified and marketed.	Key channels for marketing key cycle competency messages have been identified and marketed well.
Development of approaches that: embed key cycle safety messages, share the road/pathway behaviours, and promote the enjoyment and benefits of cycling.	Not yet developed.	These are currently under development.	Development and delivery of some approaches that embed these messages and behaviours.	Development and delivery of a number of approaches that embed these messages and behaviours.