PLANNING AND DESIGN FOR CYCLING:

A FRAMEWORK OF BEST PRACTICE GUIDANCE

Megan Fowler, MET, BE(Hons), GIPENZ
(Presenter)
Traffic Engineer, ViaStrada, Christchurch
Megan@ViaStrada.nz

Jeanette Ward, MET, BE(Civil), NZCE, CPEng, MIPENZ
Associate
Abley Transportation Consultants Ltd., Christchurch
Jeanette.Ward@Abley.com

Gerry Dance BPR&TM
Principal Advisor, National Cycling Team,
NZ Transport Agency
Gerry.Dance@nzta.govt.nz

ABSTRACT

The NZ Cycling Safety Panel recently identified the need for further guidance in cycle design; industry feedback accords with this, which shows that this project is of national significance.

Consequently, the NZ Transport Agency ('the Agency') initiated the 'National Cycle Network Design Guidance' project, to develop a framework of nationally consistent guidance for planning and designing for cycling.

The framework will not produce a full suite of new guidance, rather it aims to update existing guidance to reflect best practice. This will be supplemented with other international guidance sources or interim technical notes to be developed where no suitable guidance is available. The framework structure is presented in this paper. The framework will be on-line and link these various sources, giving practitioners a structured way of identifying the appropriate guidance.

Stage 1 involved identifying gaps in the current guidance and rating the level of difficulty to address them. Working with practitioners was critical throughout this project to ensure the delivered framework best suits industry needs. Stakeholders indicated a high level of support for the proposed framework.

Overall, 68 gaps were identified, of which 50 were identified as 'Quick Wins' to be addressed in Stage 2. Some of these are presented in this paper. The remaining, more substantial, gaps will be progressed by the Agency over time.

1 INTRODUCTION

1.1 Context

It is becoming increasingly recognised in New Zealand and abroad that cycling benefits society. Groundwater (2014) shows that significant benefits to the general transport network can be expected as a result of people walking and cycling and that these benefits would become costs to the network if people who currently choose to walk and cycle chose to revert to other modes. The benefits arising from increased walking and cycling include improved travel time and lower congestion (due to fewer motor vehicles on the road network), improved health (including mortality and morbidity), reduced vehicle operating costs (related to efficiency in conditions of lower congestion) and reduced pollution (since active transport modes involve no emissions).

The NZ Transport Agency has recognised the benefits of cycling by including "make urban cycling a safer and more attractive transport choice" as one of six priorities for 2015-2019. It aims to achieve a 30% increase in the number of cycling trips by 2019.

The Government's Urban Cycleways Programme is designed to combine a range of funding sources to build the best possible cycling network that benefits all New Zealanders. Over the next three years $333 million from the Urban Cycleways Fund, the National Land Transport Fund and local government will be invested in 54 new cycleway projects.

Many overseas cities have identified that providing for people who cycle with a greater degree of separation from high-volume and high-speed motor traffic will help entice more people to choose to cycle, and cycle more often. However, in some cases there may be a discrepancy between what people *perceive* to be safe and what is *actually* safe. In other words, the facilities that encourage people to get on their bikes may also lead these people into dangerous situations. There may well be localised areas where the disbenefits increase, for example at intersections; careful planning and design are required to avoid such issues.

A Coroner's recommendation after an investigation into on-road cycling casualties (Matenga, 2013) led the NZ Transport Agency to commission the NZ Cycling Safety Panel. The panel identified 15 high priority recommendations (Leggat, 2014) and warned that if the country fails to adopt these "we will see increases in cycling deaths and injuries as more people choose to cycle." In particular, the recommendation to "develop and promote nationally applicable design guidelines for cyclist infrastructure" is directly related to the theme of planning and designing for cycling guidance. Many of the other recommendations also pertain to elements that must be reflected in guidance.

In response to this, the NZ Transport Agency ('the Agency') initiated the National Cycle Design Guidance Project, which seeks to improve the quality and coverage guidance for both planning cycle networks and designing facilities. Abley Transportation Consultants and ViaStrada have been commissioned to undertake this project, overseen by the Agency's Cycle Steering Group. The Active Modes Infrastructure Group (AMIG)[1], a working group of the Road Controlling Authorities Forum, was considered the key stakeholder group for this project. The project was still in progress at the time this paper was written and presented.

1.2 Project description

The project involves developing an on-line 'framework' that identifies and consolidates the appropriate guidance into a resource that is fit for purpose for the sector, can be aligned with the One Network Road Classification (ONRC) and the Transport Agency's Business Case Approach, and will assist in achieving better value for money for cycling provision. The framework is not

[1] See http://rcaforum.org.nz/working-groups/active-modes-infrastructure

intended solely for 'cycle-specific' projects, and it will add value to planning and design of general transport projects. The framework will also alert users involved in cycle-specific projects to consider the wider transport planning and design context.

2 PROJECT DEVELOPMENT

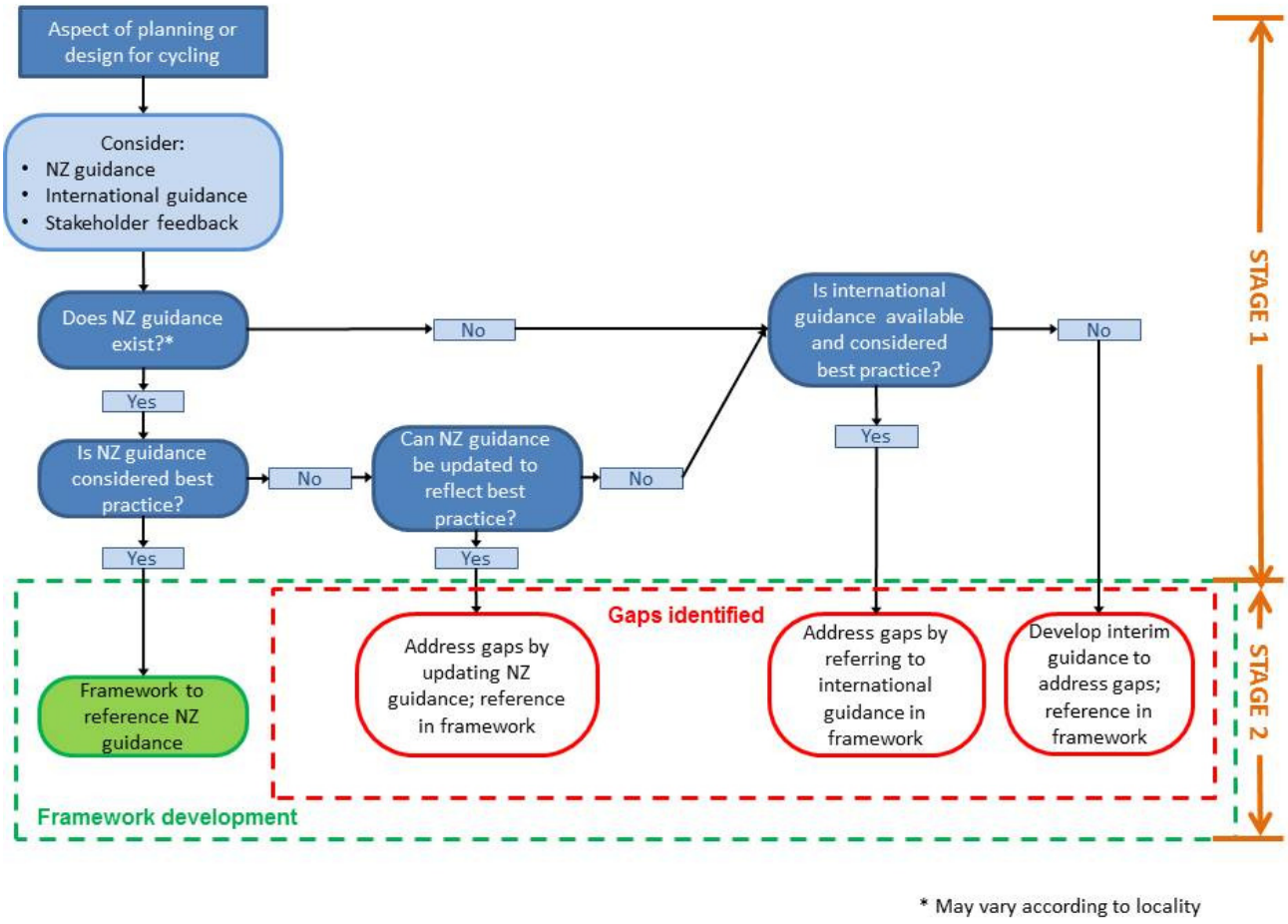

Figure 1: Flow chart showing simplified[2] process to determine gaps

Figure 1 indicates the process that has been followed. This includes two distinct stages:

Stage 1 involved identifying the important elements relating to planning and designing for cycling that should be included in the framework, and how well the guidance currently available provides for these elements.

The Cycle Network and Route Planning Guide (CNRPG) (LTSA, 2004) formed the backbone of the investigations with respect to planning. It also informed the design investigations as it outlines the types of provisions available for cycle networks, which must therefore be covered in design guidance. The Manual of Traffic Signs and Markings (MOTSAM) (NZTA, 2010a-b), Austroads guidance, and the historic NZ Supplement to Austroads Part 14 (Transit, 2008), were the major New Zealand guidance sources reviewed. The project team reviewed current NZ guidance with respects to research (both from NZ and overseas) and international guidance.

[2] This process is termed 'simplified' because it does not reflect the fact that some gaps cannot be completely addressed through changes to guidance. Some gaps involve legal aspects require rule / law changes.

In parallel to this review, the project team also sought initial feedback from technical stakeholders regarding the strengths and weaknesses of current guidance, current issues encountered in the planning and design for cycling, and the intended purpose and content of the framework. In total, 160 responses were received. The respondents were primarily from the consulting sector (46%), then local government (39%) and central government (13%).

The key messages obtained from the stakeholder survey were:

- The framework will add value to the industry: the majority of respondents (80%) stated that the potential framework would capture the subjects that would be of value to their organisation. The remaining 20% either offered suggestions on how to improve it or sought clarification on the content.
- In terms of planning, there is need for more guidance to assess demand for cycling and integrate provision for a cycle network within wider transport policy. 'Insufficient or inadequate guidance on how to assess demand for the network' and 'insufficient or inadequate wider transport policy to support development of a cycle network' were the two most commonly raised planning issues.
- In terms of design, 'road space allocation' was the most commonly raised issue and 'insufficient or inadequate guidance on intersections' was second.
- Comments showed that there is a need for more guidance on designing protected cycleways in particular.
- Only a small proportion of respondents stated that there was guidance that they disregarded because it wasn't considered best practice.
- Respondents suggested that whatever form the framework takes it needs to be simple to use, flexible, not be too restrictive, not exclude engineering judgement and not inhibit innovation.

Informed by the guidance review and stakeholder feedback, the project team identified the various gaps, each of which was assigned one of five possible classifications:

1. *No or minimal guidance exists* – this particular aspect of planning or design for cycling is not covered in current NZ guidance.
2. *Lack of clarity* – guidance exists but is ambiguous, vague, or poorly presented and may be difficult for users to correctly interpret.
3. *Inconsistency* – multiple sources of guidance exist and contradict each other.
4. *Not considered best practice* – NZ guidance (note this includes Austroads guidance where it is not superseded by NZ-specific guidance) is not consistent with what is considered best practice.
5. *Overly onerous requirement* – it takes too much effort to follow the guidance, or doing so results in excessive designs that exceed the requirements.

In addition, it was identified for each gap:

- Whether further research is required;
- Whether approved trials are required;
- Whether legislative changes are required (note that this is not included in Figure 1, hence why it is termed 'simplified');
- Whether the gap can be classified as a '*quick win*' i.e. it can be easily addressed within a suitable timeframe, without requiring legislative changes and is unlikely to be controversial within the industry or in the public sphere.

The project team issued their findings, in the form of a draft Stage 1 report (Ward *et al*, 2015), for review by technical stakeholders. The revised report was made available to the stakeholders and 17 further responses were received and incorporated into the gap evaluation.

Overall, 68 gaps were identified, of which 50 were termed quick wins. Figure 2 shows the gap types for the 50 quick wins and whether they were related to the planning stage or design of midblock sections, intersections or crossings.

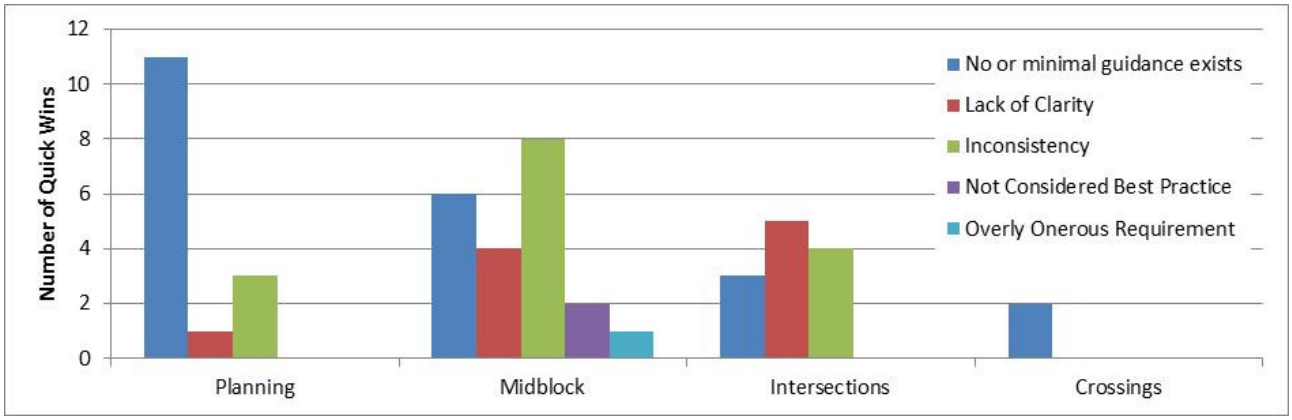

Figure 2: Gap types for Quick Wins

Stage 2, which is still underway at the time of writing this paper, consists of two components:

1. Addressing 43 selected quick wins, plus 2 additional gaps relating to protected cycleway design, and incorporating these into existing guidance where possible:
    a. With appropriate sign-off / review as necessary
    b. Some gaps cannot be accommodated within existing guidance, and will be introduced as interim guidance notes.
2. Developing the on-line framework:
    a. Technical aspects (web page design etc)
    b. Linking the relevant guidance
    c. Developing methods of guiding users through the relevant planning and design processes, or helping them access specific content directly
    d. Sourcing case studies and up-to-date information on trials that are currently underway
    e. Testing the framework on users, and refining it according to results / feedback

3 ON-LINE FRAMEWORK

3.1 Intent and structure

The online framework is intended to be more than just a design manual available online, such as the Irish Cycle Design Manual (NTA, 2011), for example. The framework will be a portal for the sector to use as their 'go-to' source that links all relevant and appropriate guidance. Currently, relevant guidance is provided through numerous documents, with limited linking between sources, and, as discussed in Section 2, the current guidance sources are not always consistent or even best practice. As mentioned earlier, the framework is not intended solely for 'cycle-specific' projects, but will also add value to planning and design of general transport projects. Conversely, the framework will alert users involved in cycle-specific projects to consider the wider transport planning and design context.

The site map (to third-level headings) of the framework is shown in Figure 3.

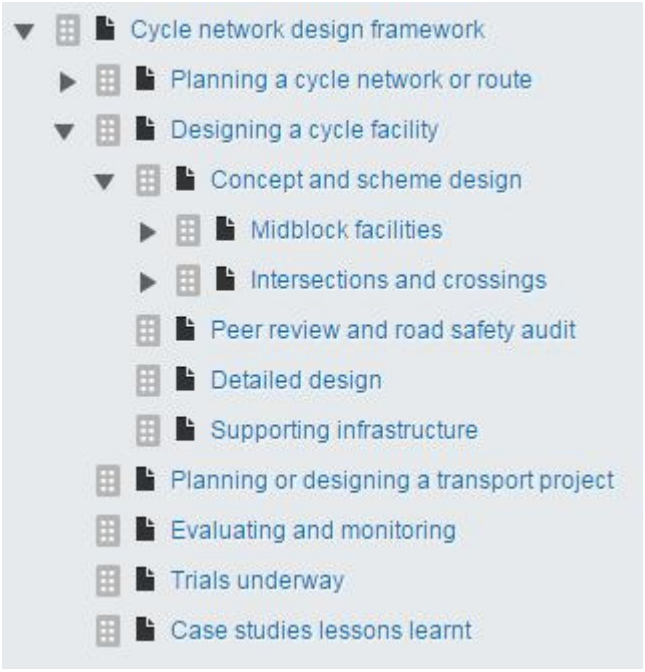

Figure 3: Site Map

The framework steps users through the planning and design process, with the option of being able to go directly to the relevant section if they know specifically what they require.

Overall, the framework will provide the essential ingredients of good planning and design but also encourage innovation and sharing of professional experiences.

3.2 Content

The development of the Traffic Control Devices (TCD) Manual Parts 4 (intersections) and 5 (between intersections) were underway at the time of this project. These documents will replace the MOTSAM Part 1 (signs) and 2 (markings). Given that these projects were running in parallel, it was possible to update guidance that had been transferred from MOTSAM into the relevant parts of the TCD Manual. It should also be noted that the TCD Manual and the framework content will contain the relevant content from the NZ Supplement to Austroads Part 14 (Transit NZ, 2008), meaning this document will no longer be required.

The framework links to the following guidance, context and procedural documents, some of which have been updated as part of the quick wins process:

Existing content (unmodified):

- Transport Agency:
    - Road Safety Audit Procedures
    - One Network Road Classification (ONRC)
    - Business Case Approach
    - Pedestrian Planning and Design Guide
- Local Authority design guidance, e.g. CCC Major Cycleway Design Guide
- Austroads guides and tools (e.g. pedestrian crossing selection)
- International guides such as NACTO Bike Design Guide.

Updated content:

- Revised CNRPG
- Traffic Control Devices (TCD) Manual content

New content developed for framework:

- Interim guidance notes (e.g. design of protected cycleways at driveways)
- Compilation of case studies

The inclusion of case studies within the framework will be an important contribution to the learning needs of the sector. Practitioners will be strongly encouraged to share case studies for the benefit of others in the industry. The framework will also provide updates on the status of any relevant trials (e.g. sharrows) and research currently underway.

The framework website will need to be well maintained to ensure that the information is current. There is potential to extend the website functionalities to include aspects such as self-assessment check sheets in the future.

4 SOME INTERESTING QUICK WINS

4.1 A new approach to classifying people who cycle

The framework incorporates a new way of describing different groups of people who cycle. To best understand this it helps to first consider the approach taken by the current guidance:

4.1.1 Current guidance

The current CNRPG discusses various principles of cycle planning, including defining 'types of cyclists' according to three broad skill levels: child / novice, beginner and experienced. These levels are based on peoples' level of training or experience with respect to cycling in a traditional road environment i.e. where cycle lanes or, in some locations, off-road paths shared with pedestrians may be provided but these generally do not cover the entire length of most people's cycle trip and so most people who currently cycle must also be prepared to cycle in general traffic lanes for at least part of their journey. Improving cyclist skills through training may increase cycling numbers somewhat, but it has been identified that many people still consider themselves to be competent enough to use cycle lanes whilst remaining unwilling to actually do so (Dill and McNeil, 2012).

The current CNRPG subsequently presents five cycling *trip types*: neighbourhood, commuting, sports, recreation and touring. The CNRPG also recognises that depending on the wider context (traffic environment, alternative route provisions etc.) different types of infrastructure will be more or less appealing to different types of people who cycle.

Another important principle presented in the current CNRPG is the five main requirements for cycling: safety, comfort, directness, coherence and attractiveness. The current CNRPG applies these to all types of cyclist, but makes no distinction between the level of importance that different types of cyclist may place on a certain number of the factors. The fact that some people remain unwilling to cycle because they perceive it to be unsafe illustrates that people perceive safety and risk differently. The relative importance of the other criteria also differs – e.g. some people may be more willing to accept a less direct cycling route if they perceive it to be safer to travel on.

4.1.2 A new approach

The preceding discussion suggests that it would be advantageous to not only classify people according to their level of skill, but to also consider their willingness to cycle or risk tolerance. This can then be used to define the intended 'target audience' for a particular route or network, and thus determine the appropriate style of provision required to attract these people.

The typology developed by Geller (2009) is a useful example because it focusses on people's

willingness to cycle for transportation as a function of perceived safety of varying cycling conditions. Geller's typology is not fool-proof and it is not the only possible classification that can be used. Geller's typology will be presented in the revised CNRPG as one possible classification of people who cycle that is useful in determining a target audience and enables use of a consistent terminology throughout the guidance. Planners and designers will be free to adopt or develop a different typology. For example, the cyclist types and trip types used in the current CNRPG or the typology developed by Pettit and Dodge (2014) for Wellington City. The key point, whatever the typology used, is to identify the intended target audience of people who will be cycling on the route or network.

Geller's method, unlike most traditional methods which focus on people who currently cycle, is based on an entire population (e.g. the inhabitants of a particular city) i.e. it includes people who don't currently choose to cycle. Geller divides the general population into four types of people who cycle (or don't) for transportation (the authors assume that this concept can extend to other trip purposes). An adaptation of Geller's typology, which uses the proportions determined by Dill and McNeil (2012) is given in Figure 4.

Figure 4: adaptation of Geller (2009) classification of transportation cyclists, based on values from Dill and McNeil (2012)

Note that, whilst Geller's original chart has defined boundaries between the four categories, Figure 4 uses gradual transitions between the colours of the different categories to reflect the fact that boundaries are not necessarily fixed; the model should be seen as a way of drawing lines to define groups within a continuum. Proportions might vary according to local culture and other demographic factors. An individual may change over time, through training or experience. Alternatively, an individual having or hearing about a bad cycling experience may become more risk-averse (i.e. move rightwards on the chart).

The four types of people identified in Figure 4 are described as follows:

Strong and fearless people will choose to cycle regardless of the road and traffic conditions. They have usually learnt by long experience how best to interact with traffic and have a low level of risk-aversion.

Enthused and confident people require some space on the roadway when roads are busy, either informally (e.g. wide kerbside lanes) or formally (e.g. painted cycle lanes) to choose to cycle. They place a high importance on directness and will therefore not generally divert far to choose a more attractive route such as an off-road path. This is the group that most encompasses the traditional "cyclist" stereotype and the people who currently cycle on cycle networks that provide little physical separation from motor traffic. This may be a reasonable target audience for some routes or networks.

Interested but concerned people are, in principle, willing to cycle but wary of doing so in certain circumstances. According to Dill and McNeil (2012) a large majority in this group consider that they know how to cycle in traffic, yet these people often do not feel comfortable doing so. Some (Dill (2012) suggests about 40%) may be comfortable using on-road cycle lanes but in general they prefer not to interact with motor traffic, apart from on roads with lower traffic volumes and speeds. They prefer full separation from motor vehicles if travelling along busier roads and grade separation or traffic signals for crossing them. If it is desired to increase cycling numbers, this would be the most appropriate target audience to focus on. As this group includes a large

proportion of the general population and covers a range of people, it may be suitable to focus on a subset of the *interested but concerned* group.

No way, no how people won't choose to cycle for transport, regardless of infrastructure type, the road environment, or training provided. This choice could be due to practical constraints (such as long distances, luggage or passengers), physical limitations, or simply a personal dislike of cycling that cannot be influenced. Understanding the opinions of people classed as 'no way no how' is important when planning for cycling. Whilst they will not personally cycle for transport they are more likely to interact well with cyclists on the network and be more supportive of cycling projects if they think that cycling can benefit the community and has a valid place on the transport network.

4.2 New lexicon for midblock facility types

Planning cycle routes involves considering the most appropriate facility for a given situation. Whilst intersections are critical in terms of safety, the majority of cycling infrastructure is provided between intersections. Thus the CNRPG defines the appropriate types of midblock infrastructure for different cycling target audiences. The new shift towards attracting greater cycling volumes requires new guidance around the facilities suitable for less confident cyclists. Therefore, new facility types have been added to the planning and design guidance, in particular, protected cycleways and neighbourhood greenways. These are included in the updated CNRPG midblock facility type diagram, presented in Figure 5. Note that a detailed explanation of the terminology adopted cannot be provided in this paper. While the meanings of most terms used are obvious, some nuances have been adopted to account for the grey-areas between certain facilities.

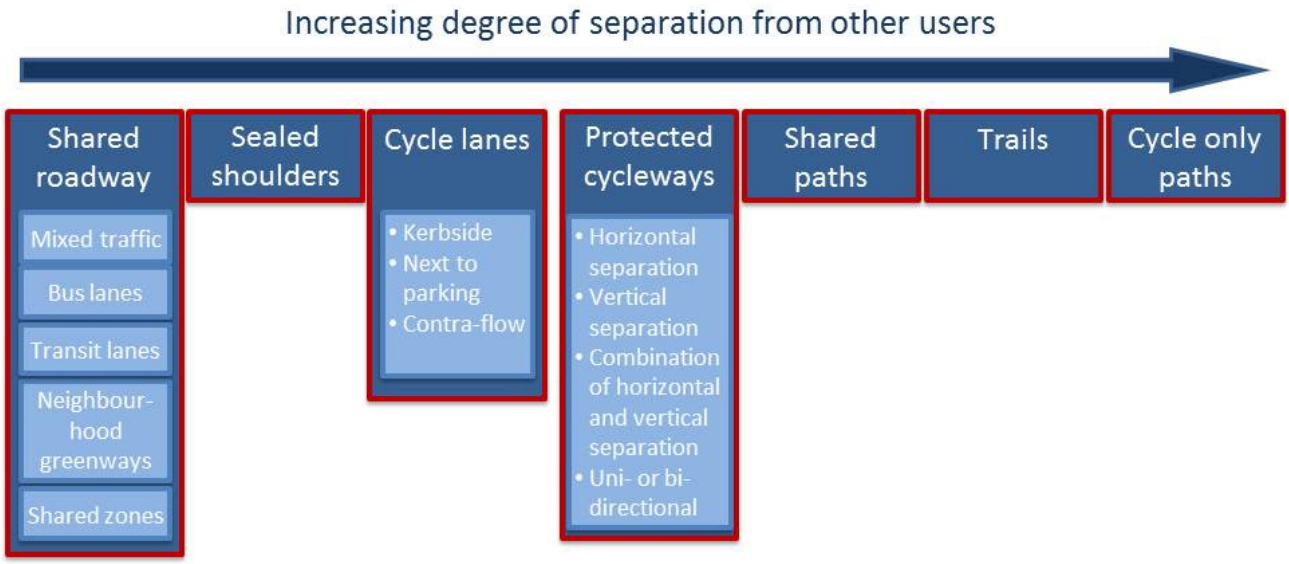

Figure 5: Draft midblock cycling facility type diagram for revised CNRPG

Figure 5 shows the various facilities according to their degree of separation from other modes. The leftmost facilities (shared roadway) involve no separation between people cycling and motor traffic. Moving towards the right involves increasing separation (i.e. defined spaces for cyclists via sealed shoulders or painted cycle lanes) and then separation via physical elements. Shared paths and trails have a high degree of separation from motor traffic but still require cyclists to share facilities with pedestrians. Cycle-only paths (which are defined as being not directly adjacent to the road, as opposed to protected cycleways which are adjacent to the roadway) involve the highest degree of separation from other modes.

The layout of Figure 5 does not directly correspond to appropriateness for a specific target audience. As has been discussed in section 4.1, even people identified as *interested but concerned* will be comfortable cycling in some forms of shared roadway where traffic volumes and speed are lower. Also, some people in the *interested but concerned* group will be comfortable cycling in standard cycle lanes.

The CNRPG, the relevant Traffic Control Devices Manual parts and the framework in general will provide guidance on the design of neighbourhood greenways and protected cycleways through reference to existing national and international guidance and interim guidance notes (see below).

4.3 Interim Guidance on protected cycleway selection

4.3.1 Scope of interim guidance

An interim guidance note with a spreadsheet-based tool has been developed to partially address the identified need for a better method of comparing various protected cycleway options along a corridor. The tool has been developed based on professional judgement by experienced practitioners; the intention is that it will be provided as interim guidance until a full protected cycleway deign guide is developed in the future. It is expected that the tool and the underlying best practice guidance will be improved once more protected cycleways have been constructed and evaluated in New Zealand.

The tool compares two facility type options:

1. Uni-directional protected cycleway. Here it is assumed that cyclists travel in the same direction (with flow) as adjacent motor traffic (i.e. this does not include contraflow uni-directional facilities). A pair of uni-directional cycleways (i.e. one on each side of the road) can be evaluated, with specific inputs for each side.
2. Bi-directional protected cycleway. On these facilities some cyclists will be travelling in the same direction as adjacent motor traffic but others will be travelling in the contraflow direction. Cycling in the contraflow direction has been identified as significantly more dangerous than cycling in the same direction as adjacent traffic at side streets with priority control (i.e. give way or stop) (Foran, 2003).

4.3.2 Factors contributing to risks

Relative risks have been defined for different conflict scenarios which are based on the type of conflict location, cycling direction (with-flow or contraflow), vehicle type (light or heavy) and parking occupancy alongside the cycleway (if applicable). The scenario of a residential driveway with cycling in the same direction as adjacent traffic and no on-street parking has been taken as the base case to which all other scenarios are referenced.

The conflict locations assessed in the tool are: residential driveways, non-residential driveways, side streets / priority intersections and signalised intersections. Users are required to enter relevant traffic volumes.

Parked cars between cycleways and general traffic restrict intervisibility between cyclists and motorists turning from the road across the cycleway which increases the risk of conflict; therefore a higher risk has been applied for scenarios with adjacent parking. Note that the risk factors have been developed assuming that on-street parking provision complies with the recommended minimum setbacks from driveways which will be specified in the framework.

The consequences of crashes involving heavy vehicles and cyclists are much more severe, therefore the risk factors for scenarios involving heavy vehicles are higher than for the corresponding scenarios involving light vehicles. However, the effects of with-flow versus contraflow cycling and parking occupancy are different for heavy vehicles compared with light vehicles, due to the different physical characteristics of the vehicles. Truck drivers turning left into a driveway are physically restricted by the truck from seeing adjacent cyclists travelling in the same (i.e. with-flow) direction. However, truck drivers can generally see over parked vehicles so the presence of parking does not play as great a role for heavy vehicle conflict scenarios as it does for light vehicle scenarios.

4.3.3 Inclusion of safety in numbers effect

As the volume of cyclists on a cycleway increases, the crash rate per cyclist decreases (Turner *et*

al, 2006). Motorists who see cyclists more often will be more aware of them and more likely to pay more attention. Similarly, an increase in motor vehicle volume will also reduce the likelihood of a crash per vehicle because cyclists will be more aware of the presence of motorists at locations with high vehicle volumes. An exponential formula has been used to include this safety in numbers effect, based on Turner *et al* (2009); the tool assumes that an increase in cyclist numbers has a greater safety in numbers effect than an increase in motor vehicle numbers.

The safety in numbers effect is applied at each conflict location (i.e. each driveway, accessway or intersection) separately, according to the localised user volumes. Next, the risks of each individual location are summed to give an overall facility risk score.

4.3.4 Tool output and application

The tool presents the risk rating for each individual conflict location along a route. A summary table identifies the contributions of the various conflict types along a route to the overall route rating and indicates which option is considered safer, and by what proportion.

The tool is intended to serve as one input towards choosing a facility design. Of course, there will be other factors to consider beyond those considered in the tool, including how a particular section connects to the greater route at each end and the physical constraints of accommodating the cycleways within the existing corridor.

Users should be aware that the lack of empirical data relating to the safety of protected cycleways means that many of the factors used in the model have been determined by professional judgement and there is limited scope to validate the tool. Current models (see for example Turner *et al*, 2006 and Turner *et al*, 2009) focus on on-road cycling environments which differ from protected cycleways in terms of relative position to moving traffic and parked cars, visibility, directional flow and user familiarity. The current models also involve a high degree of aggregation. For example, they consider entire midblock sections without considering the number and type of driveways. Until more protected cycleways are built in New Zealand and evaluated, there is little information available to accurately validate the tool in the local context. In the meantime, it is anticipated that this interim guidance tool will provide practitioners with a useful basis of evaluation.

5 CONCLUSIONS

The benefits of cycling are becoming increasingly acknowledged, both by people wanting to cycle more and authorities wanting to provide for and encourage more cycling. The ‘target audience’ for cycling is broadening. However, to improve both perceived and actual safety for people who cycle, our guidance needs to be updated to better reflect the characteristics and needs of this new, broader target audience, including new types of facility that may be more appropriate and appealing for them. Providing for cycling requires consideration from the earliest planning stages, integration with the wider transport context, and careful consideration of certain design aspects that may seem small but can have great consequences on a project’s success. The industry recognises this and has identified a need for more and improved guidance.

Current guidance with respect to planning and designing is contained in a variety of different sources which are not all linked and do not necessarily reflect accepted best practice. In some cases different sources of guidance contradict each other. Practitioners can be forgiven for not always knowing where to seek guidance from, or what source to choose. Therefore, rather than simply updating existing documents, a more efficacious approach is proposed; an on-line framework that links the appropriate guidance and offers the possibility of guiding users through the stages relevant to planning and designing for cycling.

The framework will also provide the opportunity for more sharing of information within the industry; practitioners will be encouraged to share case studies of projects that have been successful (or otherwise, where lessons have been learnt). It will also serve as a platform for providing up-to-date information on the status of current trials and research relevant to the industry.

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