Designing Signalised Intersections for Cyclists

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August 2000
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Glossary of Terms

ASB	**A**dvanced **S**top **B**ox. This is an area (minimum length 3m) between the limit lines of a traffic lane and the pedestrian crosswalk lines designated for cycle storage at traffic signals, with a cycle symbol indicating this designation. This treatment formalises the common practise adopted by cyclists at signals where they are more visible to turning vehicles. The pavement surfacing is often coloured.
ASL	**A**dvanced **S**top **L**ines. Cycle lane limit lines (usually at pedestrian crosswalk lines), with limit lines in adjacent traffic lanes set back by a minimum of 2m.
Cycle Facilities	A general term denoting provisions made to accommodate or to encourage cycling. This can include both on and off road and end of journey facilities.
Cycle Lane	A portion of the carriageway that has been designated by road markings, signs or pavement surfacing for the preferential or exclusive use of cyclists. Always on-street, as opposed to off-street cycle paths.
Cycle Logo	A road marking symbolic cycle used to show a cycle lane.
Stress Point	Any area that causes stress to a cyclist. This can be pinch points, merge and diverge areas and any number of physical or perceived barriers to cycling.

1 Introduction

It is a challenging task to design signalised intersections for cyclists. According to data recorded by LTSA (Land Transport Safety Authority), cyclists have most of their crashes at intersections (Transit New Zealand, 1991, page 4).[1] Thus, this seems to be the most important area for the need of dedicated cycle facilities. However, road space at traffic signals is at a premium. Furthermore, it seems that the needs of cyclists are not well understood within the traffic engineering profession in New Zealand, resulting in cyclists being critical of designs that have been implemented.

This paper will discuss the various design elements needed for achieving continuous on-street cycle facilities at signalised intersections. Supporting criteria for so called 'Stress Point' treatments will be presented and the detection of bicycles by detector loops will be mentioned.

NZ design guidelines for cycle facilities will be compared to their overseas equivalents. The state of best practice in traffic engineering has evolved steadily and the NZ guidelines no longer represent European best practice codes.

2 Discussion of Design Principles

When the speed differential between cyclists and motorists becomes too large, the Dutch design manual recommends separation rather than lane sharing (CROW, 1993, Figure 4.3).[2] Through lanes at urban signalised intersections generally have higher speed differentials, suggesting that providing separate facilities for cyclists is preferable. These separated facilities would usually be on-street in an urban environment.

2.1 Facility Continuity

Probably the most important design principle that the author recommends to adopt is facility continuity. Cyclists need to be continuously guided at each individual facility, including signalised intersections. Continuous facilities, e.g. a cycle lane leading through a diverge area for motorists, result in lanes that can

[1] This Christchurch study found that 66% of crashes involving cyclists occurred at, or within 20m of, an intersection.

[2] Separation between cyclists and motorists is recommended for 85%ile speeds of motorised traffic above 30 km/h.

be used intuitively by cyclists. Perhaps even more important is that continuous facilities make the likely path that a cyclist is going to take more predictable for motorists.

Many crashes result from cyclists acting irrationally because they do not know how to use demanding areas (e.g. diverge areas) or from motorists misinterpreting cyclists' intentions. European experience clearly shows that continuous facilities result in road safety benefits for both cyclists and motorists.

2.2 Route Continuity

A cycle route can be compared to a chain: it is only as strong as its weakest link. An otherwise good route can be diminished by a missing link or a link perceived as unsafe, thus deterring possible users. Parents who might otherwise be happy for their children to cycle to school might be reluctant for them to do so because of a section of road or intersection that is lacking safe facilities.

As with each individual facility, a route should be continuous, too. Only complete routes can eventually form a safe cycle network that encourages people to use this mode of transport. For this reason, special emphasis should be put on the projects that are in the 'too hard basket', as they can be real deterrents to cycle use. These projects are often signalised intersections.

2.3 Stress Point Treatment

The successful treatment of stress points can make the difference between a good and a poor cycle network. Design emphasis should be used in places where cyclists feel most vulnerable (e.g. at intersection diverge areas) to make their journey safer and less stressful. One key to stress point treatment is facility continuity, while another tool is to raise motorists' level of alertness to the possible presence of cyclists, hence trying to achieve considerate behaviour. Using coloured surfaces through stress points and a deliberate placement of cycle logos can do this.

An informal recommendation was made by a group of about 30 transportation practitioners (staffs from local authorities, TNZ, LTSA, road marking companies, Transfund and private consultancies) at the 1999 Traffic Management Workshop to use green for colouring of cycle lanes (Roundabout, April 2000). This needs to be formalised in NZ publications such as MOTSAM (Transit NZ / LTSA, 1997) or any new cycling guideline.

3 Signalised Intersection Design

3.1 Data Requirements

Due to space restraints, it will generally not be possible to provide for all movements of cyclists, requiring compromises as to which movement(s) to cater for. However, the highest demands should be supported by dedicated facilities. Often, the straight through movement will have the highest demand. The situation may be different near high cycle traffic generators (e.g. schools, universities), where turning proportions for motorists and cyclists can be markedly different from each other. For good design of cycle facilities, it is necessary to survey movement data of cyclists, as motor vehicle movement data can give a misleading picture. It is also important to consider that peak count periods for cyclists may not be the same as those of motor vehicles (e.g. after school).

3.2 Six Intersection Elements

As outlined in section 2.1, cycle lanes should be continuous at signalised intersections. Cumming et al (1999) have suggested analysing or designing signalised intersections using the following breakdown (see Figure 1):

(1) Approaching mid-block cycle lane.
(2) Cycle lane in transition area.
(3) Intersection approach lane.
(4) Storage area for cyclists at limit lines.
(5) Guidance through intersection.
(6) Cycle lane on intersection departure side.

MOTSAM (Transit / LTSA, 1997) only knows elements (1) and (3), whereas no useful detail is given in the other New Zealand guideline (NRB, 1985) about these elements.

The importance of element (2) – cycle lane through the transition area – has already been discussed in section 2.1. Advantages result from motorists knowing what to expect from cyclists.

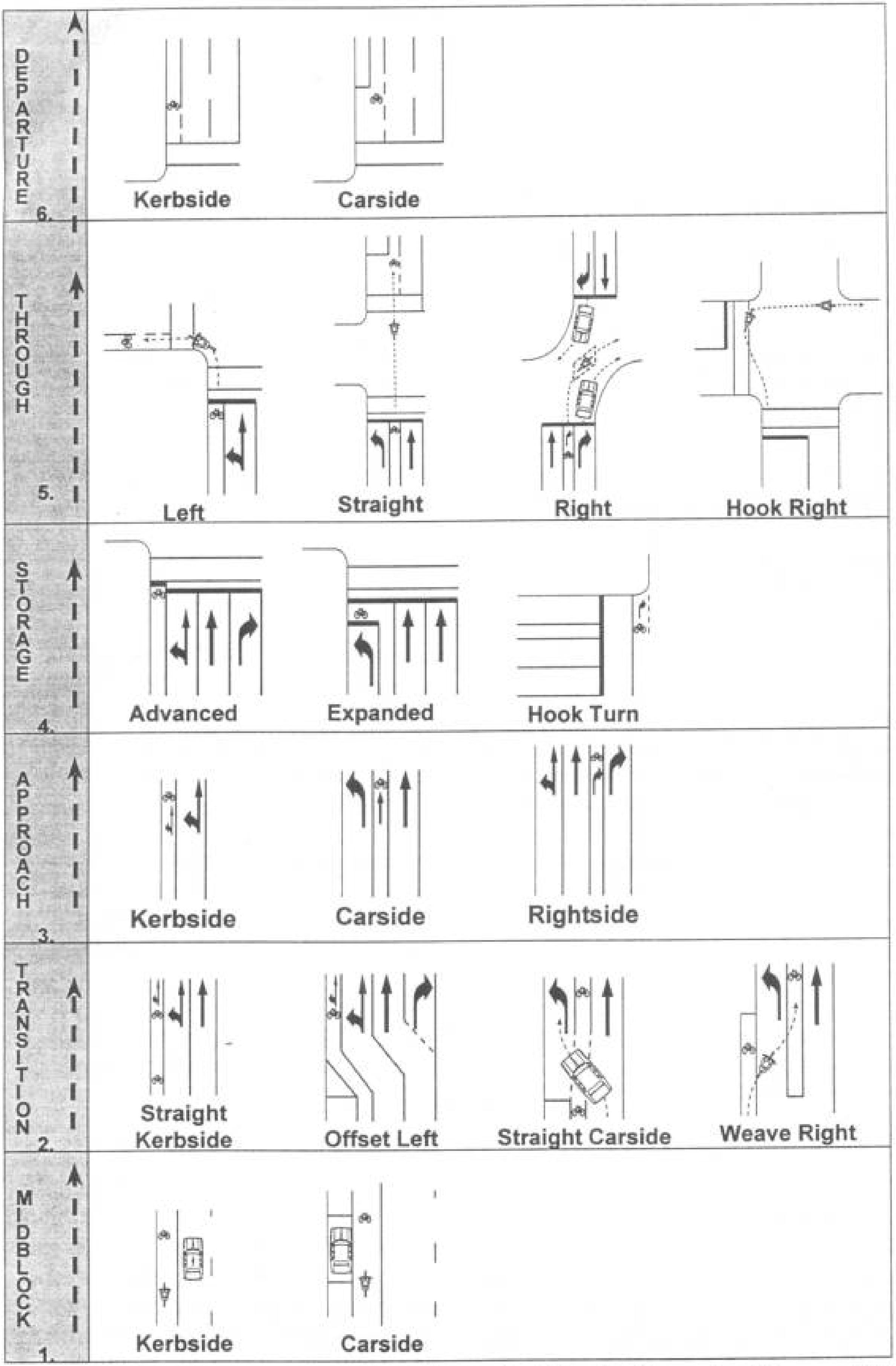

Figure 1: Intersection Model for Cycle Design (reproduced from Cumming et al, 1999)

Possible safety disbenefits from cyclists being less cautious in such a layout are more than outweighed by the fact that checking behind by looking over the shoulder may result in the cyclists starting to wobble. It is evident that it is far easier for motorists to check their path ahead than for cyclists to check behind. NZ law generally places the vehicle behind at fault in a collision where the front vehicle follows a consistent route. Therefore, provision of clearly marked paths/lanes for cyclists to approach the intersection would help both motorists and cyclists be aware of their respective rights and minimise the need for cyclists to check behind.

Element (3) - an intersection approach lane - is the element that is provided if provisions have been made for cyclists.

Element (4) – a storage area for cyclists at the limit lines – can be achieved using either Advanced Stop Lines (ASL) or Advanced Stop Boxes (ASB). Both these stop line treatments achieve increasing motorists' awareness of cyclists being present, reducing the likelihood of driver error that may result in crashes with cyclists. ASBs can cater for higher volumes of cyclists, for example near schools. The effectiveness of these treatments has been shown all over Europe, with LTSA approved trials currently being undertaken in Christchurch (ASL and ASB) and Hamilton (ASB with coloured pavement).

Element (5) – guidance through the intersection – is common Australian practice (for both motorists and cyclists), but is uncommon in New Zealand and in the author's opinion usually not necessary. The Traffic Regulations (1976) define that drivers are deemed to be not turning when following lane markings.[3] Thus, only turns always protected by signal turn aspects can be marked through an intersection. In certain cases, however, cycle lanes should be marked through intersections. This is recommended when the far side cycle facility is offset to the right, or when the road follows a bend.

This treatment is usually more significant for priority-controlled intersections (incl. roundabouts), where side road traffic may need the cue to remind them to check for cyclists also.

Element (6) – the continuation of the cycle lane on the far side of the intersection – is about picking up the cycle lane immediately past the pedestrian crosswalk lines. In most cases, this will require a kerbside taper (usually a solid edge line) from the kerb to the commencement of parking as a definition of the inside to the cycle lane.

Using the simple breakdown as outlined above, good design can be benchmarked against the completeness of the five (or six, if element (5) is to be included) design elements.

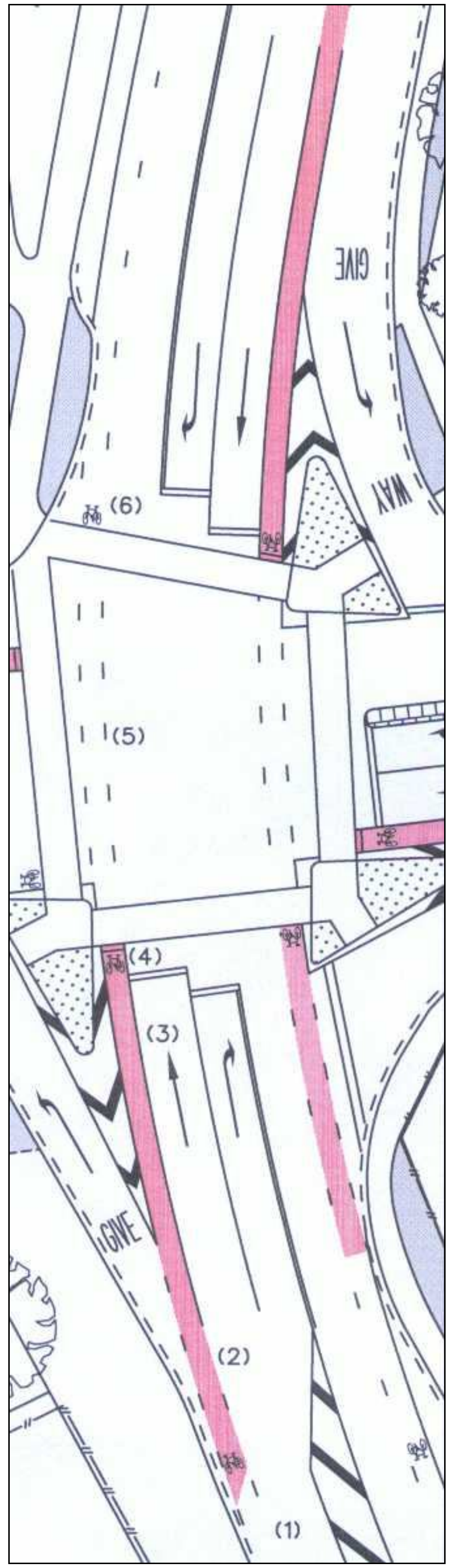

Figure 2: Example of the six elements at a State Highway intersection.[4]

[3] A turn is defined in the Interpretation of the Traffic Regulations as follows: "Turn means to change direction; provided that if a roadway is marked with a centre line or lane line to show the normal path of vehicles, (a) a vehicle shall be deemed to turn if it leaves that path … (b) a vehicle following the markings shall be deemed not to turn, even through an intersection or curve at a point where the markings are laid out in a curve."

[4] Proposed layout for traffic signals at Halswell (SH75) / Halswell Junction / Sparks Roads in Halswell near Christchurch.

3.3 Coloured Surface

As indicated earlier, the use of coloured cycle lane surfaces can greatly enhance motorists' level of alertness. It is recommended to use colour from some distance prior (15m, say) to the commencement of element (2) to the limit lines, i.e. to the end of element (4). Sometimes, it might be necessary to use colour for elements (5) and (6), too.

Areas with high speed differential, weaving of motorists over cycle lanes (i.e. the path of cyclists) at diverge areas, the inside of bends, storage areas, offsets over intersections, left turning motorists over cyclists' paths, and merge areas are all stress points that should potentially be treated with coloured surfaces.

3.4 Marking of Detector Loops

In some cases, vehicles that trigger detector loops call traffic signal phases. As these loops detect ferrous objects, the vast majority of cyclists can be detected if the loops are tuned to detect the relatively small amount of metal that a bicycle contains. However, detection will usually not occur if for example cyclists ride along lane lines.

In order to cater for cyclists during periods of low traffic demand, cyclists will need to know how they can call a green light. It is therefore required to tune all detector loops on non-arterial intersection approaches (i.e. approaches that only get a green light when a vehicle is present) to detect bicycles. Furthermore, the loops need to be marked according to AUSTROADS (1999, figure 5-9), with Figure 3 showing an example. As the markings can be applied in three different locations (on the centre, the far left or the far right side of the detector loop), it is necessary that an engineer who is used to biking in an urban environment specifies the position to be marked. If cycle-tuned detector loops are not possible, then provision of a push-button at the side of the road is an alternative solution. In both cases, some education of cyclists may be necessary to explain how to use the intersections.

Figure 3: Loop Marking

3.5 New Zealand Example

Figure 2 shows a proposal for a State Highway intersection that uses all six elements and a coloured surface for stress point treatments.

The approaching mid-block cycle lane, as seen from the bottom of this figure, is on the kerbside (1). The coloured surface starts in this mid-block area before the commencement of the slip lane, which is the transition area (2) and in this case a stress point as left turners cross the cycle lane. The approach cycle lane (3) to the right of the chevron markings connects to an Advanced Stop Line (4). The through cycle lane is marked through the intersection (5) delineating the bend in the road, which helps both motorists and cyclists in their alignment. The cycle lane is commenced again on the far side of the intersection (6), this time next to a parking lane.

4 Discussion of NZ and Overseas Design Guidelines

MOTSAM (Transit / LTSA, 1997) asks for facility discontinuity[5] and only knows two design elements of the six as discussed in section 3.2 (three elements if the mid-block cycle lane starts immediately after the pedestrian cross-walk lines). In contrast, European guidelines[6] and the Australian AUSTROADS (1999) are based on facility continuity, with special emphasis in the European guides put on stress point treatment. The NRB *Guide to Cycle Facilities* (1985) guide does not make any useful reference to traffic management at signalised intersections and does not show any example, yet is still one of the official document according to Transfund's *Standards and Guidelines Manual*.

[5] *MOTSAM* specifies that "Cycle lane lines should terminate at the end of the parking zones or at least 7m ahead of the formation of the turning lanes." (section 3.18.03 (b) second sentence)

[6] The Dutch guide CROW (1993) is a very useful document that has been published in English. The British SUSTRANS (1996) manual is very design orientated, with good examples for stress point treatment and facility continuity, but does not reflect much on underlying design philosophy. The German guide (FGSV, 1995) is another good source, but unfortunately not available in English.

No professional would probably dispute that the NZ guidelines are out of date. However, it is of concern to the author that local guidelines are making recommendations that are not just different to overseas standards, but contrary. Since the European countries referred to can be seen as world leaders in their field, New Zealand practitioners applying local guides in good faith may be designing facilities that are considered overseas as not meeting the needs of cyclists and perhaps even unsafe.

The author would like to encourage the Transportation Group to work towards or support the urgent adoption of a suitable overseas design guideline and to initiate an urgent review of cycle design guidelines that will result in a New Zealand addendum to the guideline adopted.

5 Recommendations

(1) To aim for facility (section 2.1) and route continuity (section 2.2) when designing cycle facilities at signalised intersections.

(2) To put particular emphasis on Stress Point treatment (section 2.3).

(3) To base design for cyclists on proper data collection (section 3.1).

(4) To benchmark signalised intersection design against the provision of the six design elements, bearing in mind that element (5) is only sometimes required / appropriate (section 3.2).

(5) To use coloured surfaces for stress point treatment (section 3.3).

(6) To mark detector loops that call traffic signal phases with markings according to AUSTROADS (section 3.4).

(7) To adopt a suitable overseas cycle design guideline (section 4).

(8) To initiate a working group for the review of cycle design guidelines that will result in a New Zealand addendum to the overseas guideline adopted (section 4).

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