BIKEWAY TRAFFIC CONTROL GUIDELINES

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INTRODUCTION

Public interest in cycling has grown substantially throughout Canada in the past few years. Much of this is in direct response to the quality of life and environmentally based public expectations that are now part of the planning process. Many communities have witnessed the growth of grass roots support for cycling transportation systems and facilities.

In the early 1990's, several communities across Canada were in the process of developing cycling master plans plus on- and off-road cycling systems. At that time, there were several guidelines for designers to use regarding the issues of signing, marking and designing bicycle facilities in North America. Included in these were design manuals such as the existing Transportation Association of Canada (TAC) "Guidelines for the Design of Bikeways," The Canadian Institute of Planners (CIP) Design Manual, and the American Association of State Highway Transportation Officials (AASHTO) Guidelines. However, these manuals did not deal specifically with signs and markings. Other manuals, such as the Quebec and U.S. Manuals of Uniform Traffic Control Devices (MUTCD) do include specific sections on signs and markings.

Project Description

Clearly there were inconsistent and incomplete standards available, and there was a need to update them in light of recent developments in the planning, design and operation of cycling facilities across the nation. Accordingly, TAC's National Committee on Uniform Traffic Control (NCUTC) determined that updated guidelines for bicycle facilities needed to be developed. The NCUTC initiated Project 209 in September 1993 to develop these guidelines.

A Steering Committee consisting of representatives from both provincial and municipal agencies across the country, and the Canadian Cycling Association was formed to oversee the development of the guidelines. A Project Working Group was assembled in December 1993 to undertake the necessary work to develop the

guidelines. It consisted of representatives from the Regions of Waterloo, Hamilton-Wentworth, Metro Toronto and Ottawa-Carleton, the Cities of Hamilton and Mississauga, the Ontario Ministry of Transportation (MTO), TAC and two local consultants actively involved in the design and operation of on-road and off-road cycling facilities.

Scope and Objectives

At the initial Working Group meetings, the scope and objectives were established for the project. Based on existing guidelines, user experience and available reports, all current information about bicycle facilities was to be reviewed, including regulations and pertinent legislation. The information was to be used to formulate guidelines, including devices and systems, for the operation and design of bicycle facilities. The information was then to be used to identify those areas that were in need of new guidelines.

After due consideration, it was decided by the Working Group that the focus was to deal primarily with on-road facilities. Off-road situations would only be addressed where there was a direct linkage between on- and off-road facilities. This would include intersections with off-road facilities, or off-road facilities within the road right-of-way.

Key considerations included:

- Available guidelines and standards;
- Existing Legislation;
- Need for special treatments; and
- Testing of devices and guidelines.

Final documentation was to be presented in a format for integrating the materials into the Manual of Uniform Traffic Control Devices for Canada (MUTCDC), or as a stand-alone document.

Preliminary Documentation Review

The Working Group was divided into four subgroups, with each being responsible for a specific area. The four areas were:

i. signs;

ii. markings;

iii. special treatments; and

iv. regulations.

Groups (i) to (iii) each identified the needs in their area, and reviewed existing manuals and other sources, including research papers and web sites. Group (iv) identified the existing legislation and regulations regarding bicycle facilities.

The subgroups found that there was a proliferation of signs and markings in the reference documents. Also, any new signs and markings would have to be tested prior to inclusion in the MUTCDC. Due to the urgency to produce a manual, the Working Group felt that to address all issues properly, a consultant should be retained to undertake the major tasks of the project such as sign testing.

Consultant Selection

In September 1995, the consultant selection process took place. Five letters of interest were received by the Working Group. After due deliberation, the consulting firm of Marshall Macklin Monaghan (MMM) of Thornhill, Ontario was selected to undertake the work. Behavioural Team of Toronto was retained by MMM to undertake any testing that was to be done.

The major tasks for the consultant were as follows:

a. Devices and Regulations

i. Develop or modify devices and regulations as required;

ii. Test the array of devices;

iii. Recommend the most appropriate devices and regulations; and

iv. Document the process.

a. Usage Guidelines

i. Develop methods of evaluating the usage guidelines;

ii. Evaluate existing guidelines;

iii. Develop new guidelines as required; and

iv. Document the process.

a. Final Report

A final report was to be prepared for presentation to the NCUTC. Also, the guidelines were to be produced in English and French in a manner compatible with the MUTCDC.

RESEARCH AND DOCUMENTATION REVIEW

The consultant team undertook an extensive review of existing documentation. This included a complete review of over 20 Manuals of Uniform Traffic Control from around the world. These were available to the team by virtue of the rewrite of the MUTCDC that was already underway in the MMM office. In addition, a number of cycling manuals were reviewed such as those produced by the Québec Ministère des Transports and by Vélo Québec, as well as by a number of cities across Canada, the U.S., Britain and Europe. The group responsible for the development of bicycle

facility guidelines for AASHTO was also consulted.

The research also included an open forum discussion with Australia's Mr. Andrew O'Brien to discuss the cycling related traffic control devices in that country. Mr. O'Brien outlined his experience in reviewing the AustRoads *Guide to Traffic Engineering Practice - Part 14, Bicycles,* as part of his assignment for a State Bicycle Committee. The open forum discussion also included representation from the Toronto City Cycling Committee.

Finally, access to a bulk e-mail users group provided the team with a wealth of current opinion and relevant information on a wide range of cycling design and operational issues. This, together with searches of a number of Web sites, resulted in a comprehensive base of information from which to formulate these Canadian guidelines.

QUESTIONNAIRES/VIDEOS/DISCUSSIONS

The next step in the process was to augment the available supply of international bicycle related documents with a representative array of domestic bicycle traffic control practice, to ensure that a comprehensive library of cycling related signage and pavement markings was assembled for review. Accordingly, a questionnaire was distributed to all ten provinces, one regional and one national parks authority, as well as numerous cycling-supportive municipal level jurisdictions in every province of Canada. In total, 43 survey forms were distributed.

The survey was general in scope, requesting information about the extent of bicycle facilities in their jurisdiction, bicycle policy and Master Plan provisions, cycling infrastructure, historical and forecasted funding, education programs, and an emphasis on signing and pavement markings. The specific traffic control related questions were:

> *2c In your jurisdiction, do you use any specific design guidelines and signing/pavement marking standards?*
>
> *2f If a bicycle policy/master plan does not exist, and if design guidelines are not currently being used, are there plans in the future*

to either develop a policy/master plan or adopt currently available design guidelines?

2g In your jurisdiction, would a Canadian Standard for bicycle signing and pavement markings be used?

3a Do you have any critical needs related to on-street cycling that are not addressed with existing signing and pavement markings? If yes, please describe and attach any photographs or sketches, if available.

3b How have these situations been addressed?

3c How effective was your treatment?

3d Has your jurisdiction created or modified any bicycle related signs or pavement markings? If yes, please explain why, and attach a photograph, plan or illustration.

Completed questionnaires were received from all provinces, Parks Canada, and 17 municipalities.

Of the municipal and provincial respondents that answered question "2f", all indicated that there are no plans in the future to either develop a bicycle policy/master plan or adopt currently available design guidelines. This is not surprising for the municipal respondents, since the overwhelming majority (94%) currently use specific design guidelines and signing/pavement marking standards. However, this is surprising at the provincial level, since only 44 percent of the provinces currently use existing design guidelines. This response confirmed the need for the development of Canadian guidelines.

This was further proven by the response to question "2g", to which 92 percent of respondents indicated that a Canadian standard for bicycle signing and pavement markings would be used.

The questions related to the development of new signing and pavement marking treatments (3a, 3b, 3c and 3d) were primarily limited to responses from municipal jurisdictions. Of these respondents, 92 percent found that there are critical needs related to on-street cycling that are not addressed with existing signing and

pavement markings, and that 88 percent have created or modified existing traffic control devices to satisfy their needs. The effectiveness of treatments for situations that are not addressed by typical guidelines varied from poor to okay.

A common theme among the above issues was centred around interchanges and arterial crossings. The City of Richmond, B.C. for example, indicated that activating signals without the use of a push button was an issue. This city has implemented a bike lane merge sign where a right turn lane merges into a bicycle lane. In Vancouver, B.C., a push button activated signal allows cyclists in a contra flow lane to cross an arterial. Vancouver also stated that signs need to be made more specific, catering to the needs of cyclists. These signs could act as "information" tabs. The City of Red Deer, Alberta stated that visibility with bike offset gates, as recommended by the TAC guidelines, was a problem. They also commented on the fact that bike symbol pavement markings need to be simplified because of the detail and complexity required to develop a template. In Mississauga, Ontario, cyclists must stop and dismount at intersections along boulevard pathways on arterial roads. Finally in Regina, Saskatchewan, Cyclists Yield to Pedestrians signs are used where cyclists are permitted on sidewalks along subways.

With each questionnaire that was sent out, a request was also made to submit any videos that had been made or that could be produced to document any special bikeway treatments or unique cycling requirements in their jurisdiction. Unfortunately, presumably due to the level of effort required to comply with this request, videos were only received from a few municipalities in the Ottawa-Carleton and Hamilton-Wentworth Regions.

SIGN DEVELOPMENT

Through the efforts of the Working Group, a long list of signs and pavement marking schemes were developed. This list was then reviewed by the Consultant Team and distilled to a manageable length. Based on the extensive knowledge and experience of the Working Group members, it was possible to compile a final list which was used for the testing component by applying the following criteria:

1. Legibility;

2. Ease of comprehension;

3. Appropriateness to the needs of all road users; and

4. Ability to be understood in both official languages, or to be readily translated.

TESTING SIGN COMPREHENSION

Users do not always comprehend communications in the manner intended by those who originate the message. This is true in all media of communications but becomes especially critical when:

- The message relates to life safety and property damage;
- It must be understood quickly and accurately;
- It is a message to which the user has not previously been exposed; or
- For whatever reasons, it is conveyed by pictures.

Since all these issues exist in the present development program, it was essential to confirm the effectiveness for communication of the proposed signs. This included messages which were already in use in some jurisdictions.

While comprehension effectiveness does not guarantee behavioural effectiveness, there certainly cannot be much compliance unless the message is widely understood. Moreover, those most in need of comprehension and compliance are likely to be those weakest in their roadway intelligence. For example, if 20% of a sample fails to understand a sign, they are likely to be drawn, in a statistical sense, from the population most needing to understand the message.

More specifically, it is clear that child cyclists, those old enough to be on the street without adult supervision yet those lacking the perceptions of a licenced driver, are a group of special interest to comprehension testing. This generalization holds true both for signs directed at cyclists and signs directed at motorists of which cyclists also

need to be cognizant.

There are a number of methods of gauging comprehension. The most direct and logically defensible procedure, direct unprompted paraphrasing of the sign content, was employed in this study. Because it was developmental, an iterative sequence was used. Messages which failed to show acceptable comprehension in the original round of testing were replaced by new versions in later rounds. To ensure that the use of school children did not bias the results, a sample of licenced adult drivers was also tested. Results matched closely, being slightly better in some cases and slightly worse in others.

Children in grades 6 through 12 were tested. No trend with age was detected within this range. As a control for geographic bias, students were tested in two urban neighbourhoods, a suburban setting, and a rural setting.

Test subjects indicated their level of experience as riders in terms of their length of time owning a bicycle as well as recent trip experience. Neither factor particularly influenced comprehension scores.

In light of these comparisons, it can be stated with some confidence that these tests reflect the effectiveness of the signs as communication media. The tests are not a reflection of any road experience, developmental or other experiential process.

Method

Proposed signs were presented to the test subjects in booklets. Blank lines next to each image were provided for entering the meaning of the sign. Written definitions of signs were developed and reviewed by the study team. The reliability among the various team members who rated the tests was high when a response was subjected to multiple scoring.

Answers were scored as correct or incorrect. In the first round of testing, errors were also scrutinized to see if there were any dominant patterns as to the source of errors and to help improve the signs. A number of signs had answers which appeared to interpret the message in a manner inconsistent with safety, given the intention of the sign. These were, of course, singled out for revision.

Early on in the process, it became clear that certain effects were evident:

    - Words are better understood than pictures;

- Representative images are better understood than stylized or iconic representations;

- Abstractions are not readily expressed in pictures; and

- Painting a square sign yellow and turning it 45° does little to convey a message of warning to children or even licenced drivers.

Following the testing, each participant was given an illustrative set of signs showing the correct interpretations for their debriefing.

In the first round, 101 students were tested. In the second round, 30 licenced adult drivers were tested. In the third round, 130 students were tested, for a sample grand total of 261.

Results

Some might argue that anything less than 100% comprehension would be unsatisfactory. However, no measurement process is perfect, and some number of persons will never answer correctly, or for that matter, behave properly on the street. Therefore, a practical criterion of success needs to be established, recognizing that the role of the transportation professional is to achieve high performance even when complete effectiveness is not realistically achievable.

The presentation of results for the final phase of testing is shown below. A total of 28 signs were tested in this round. The table divides sign comprehension into three classes of performance:

- It was felt that 80% or better comprehension was a reasonable target for performance;

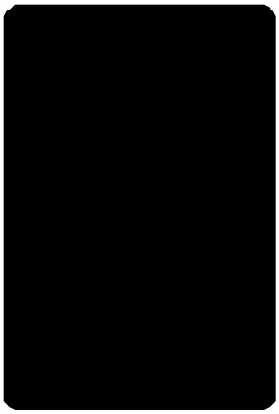
- Falling in the range of 51% to 79% represented a compromised sign, not achieving a reasonable level of safety comprehension, but acceptable for use in the absence of anything better; and

- A score below 50% could not be considered acceptable, but again, in the absence of a better sign, could be considered for inclusion.

Percent Correct Responses	Number Of Signs At That Level
80% or more	11
51% to 79%	7
50% or less	11

The specific signs are shown on the accompanying pages of illustration.

Effective (80% Or More)



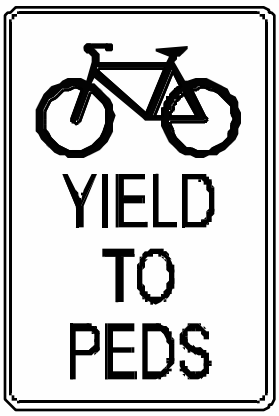

KEEP
LEFT
RIGHT

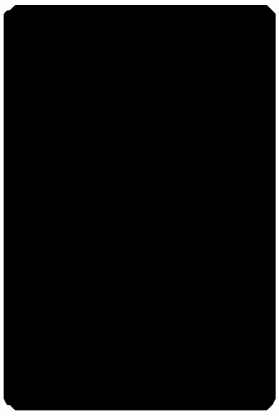

ON
SIDEWALK

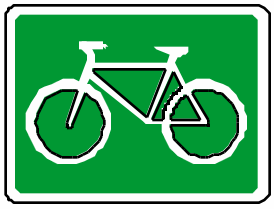

WALK
YOUR
BIKE

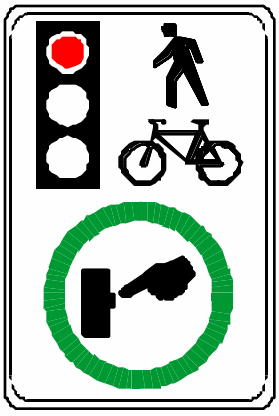

ROUTE

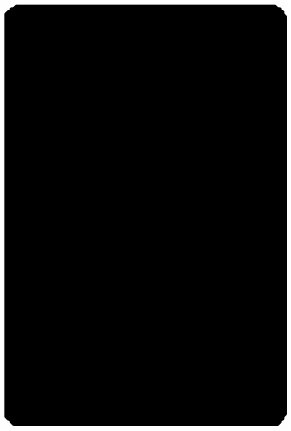
Intermediate (51% to 79%)


YIELD
TO
PEDS

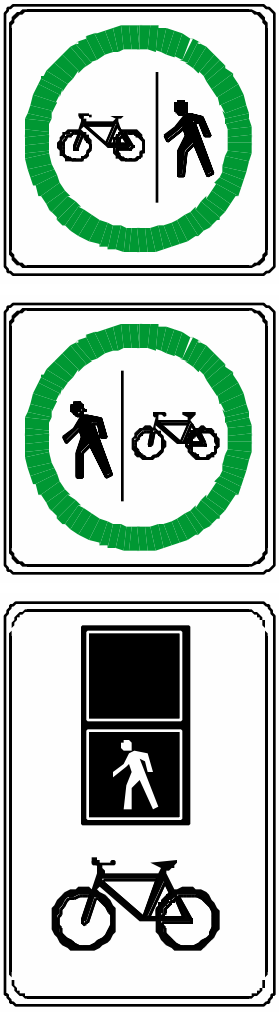








Ineffective (50% Or Less)



FINAL REPORT

The style and format of the final report were established based on the principles laid down by the team who were rewriting the MUTCDC. A style guide had been prepared for the Canadian Manual, and all page layouts, headers, footers, fonts and rules of grammar utilized were consistent with this guide. Initially, there was a plan to incorporate the Bikeway Guidelines as a chapter in the MUTCDC. Thus, the format had to be consistent with this national standard. Despite the fact that the Guidelines are now being published as a stand alone document, the use of the same style guide has prevailed, which gives the final product a consistent “look”.

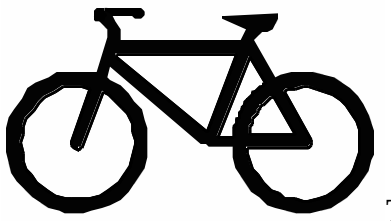
The contents in the final edition are guidelines for use throughout Canada, strictly for signing and pavement marking. None of the background research, testing, theory, rationale for recommended selections, Committee deliberations or alternative practices are included in the Guidelines. This paper, together with the minutes of Steering and Working Committee meetings, fully document the process. For further information on the above issues, the reader is asked to contact the Transportation Association of Canada or any of the four co-authors directly.

KEY FINDINGS AND RECOMMENDATIONS

As a final component of the project, several key findings and recommendations were developed. These included changes to some of the fundamental traffic control principles related to bikeway traffic control devices, development of signs, review of acceptable pavement markings and identification of signing and pavement marking plans for common situations. Several other cycling instances and treatments that are found to occur in Canada were reviewed, but not documented in the final report of the Bikeway Traffic Control Guidelines due to the preliminary (and often controversial) nature of the treatment.

The practices which were reviewed are discussed below.

New Bicycle Symbol



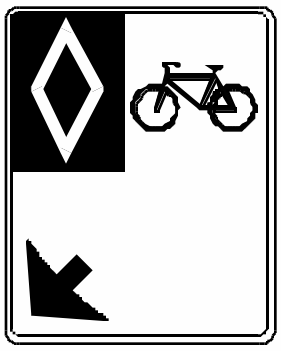
The first and most important component of bikeway related traffic control devices to be scrutinized was the bicycle symbol. It was determined that the bikeway symbol that forms the basis for reserved bicycle lane pavement markings, as well as such signs as the Bicycle Route Marker and the

Bicycle Crossing Signs, should reflect current bicycle geometry, contain a simpler design and provide for easier visual interpretation. The final symbol design is a refinement of the existing version illustrated in the MUTCDC, and is similar to the design currently being used in the province of Québec. These changes include modification to the handlebars, hubs, pedals, chainrings, seat and the frame thickness. The revised bicycle symbol is illustrated in Figure 1.

Reduced Size Signage

Although it was not the direct mandate of this particular project, the utilization of reduced-size signing was reviewed. It was determined that for signs that are installed on non-motorized vehicle paths, signs in the MUTCDC may be reduced in size. Reduced-size signs are appropriate for this type of vehicular and pedestrian traffic due to slower travel speeds. An example of an acceptable reduced -size sign is the traditional Stop sign, which is normally 600 x 600 mm (24" x 24"). A 450 x 450 mm (18" x 18") sign may be installed to regulate the movements of bicycles on bicycle and multi-use paths.

Bikeway Marker Signs



An essential component of any on-street bikeway is to identify the facility through the installation of adequate signing, whether it be a reserved bicycle lane or a bicycle route. Signs depicting these bikeways are illustrated in Figures 2 and 3.

The Reserved Bicycle Lane sign is used where a lane is reserved for the exclusive use of bicycles. The Reserved Bicycle Lane sign is consistent with the Reserved Lane signs in the MUTCDC. Generally, the sign should be installed at the beginning of each block, and at 200 metre (650 foot) intervals thereafter.

The Bicycle Route Marker sign provides guidance for cyclists, and indicates those

streets, highways and separate facilities which form part of a bicycle route system. The sign should be placed at intervals frequent enough to keep cyclists aware of the changes in route direction, and to remind motorists of the presence of cyclists. The sign is similar to that which is illustrated in the MUTCDC, however with the incorporation of the revised bicycle symbol and the word “ROUTE” to clearly identify the nature of the facility. The necessity of integrating this word into the sign was identified during the sign comprehension testing programme, in which it was found to improve the overall comprehension of the sign from approximately 40 percent to 85 percent.

During the course of the study, in addition to the various bicycle route type signs that were tested, several other route signs were reviewed. These included the often used bicycle symbol inside a green annular ring, and the white bicycle symbol on a blue round sign, as used in the City of Toronto. The former route sign was deemed unsuitable since it was not in the existing MUTCDC, and also due to the state of flux over the mandatory / permissive nature of the green annular ring. The latter sign was not accepted since it would be difficult to integrate the word “ROUTE” which was identified as a necessary and integral component during the testing phase. Furthermore, blue is not a typical colour for wayfinding, and round signs do not constitute a typical shape for information signs.

Bicycle Crossing Ahead Sign

The Bicycle Crossing Ahead sign is used to indicate to

motorists that they are approaching a location where a bicycle path crosses the road. The sign is illustrated in Figure 4.

Various versions of the sign were developed, similar to that which is pictured in Figure 4, with additions such as “speed lines” after the bicycle to indicate motion, and a horizontal bar under the bicycle to indicate a road. Through Committee discussion and comprehension testing, the optimum configuration of the sign was identified, which included a bicycle symbol on traditional yellow, with a “Crossing” tab that **must** be used to support the meaning of the sign. In some cases during the testing phase, the addition of the tab was found to result in an increase in comprehension of 40 percent.

“Horizontal” Signing

Horizontal signing is the process by which the image of a sign is painted on the road or bikeway. An example of this would be the Québec practice of painting a Yield sign in a Reserved Bicycle Lane in advance of a bus stop. This particular treatment may be used to convey a message to a cyclist in a bicycle lane to yield the right-of-way to transit vehicles stopped in the bicycle lane. In this example, a painted Yield sign is unnecessary. Overall, horizontal signing is costly, often redundant, requires increased maintenance, may confuse motorists, can be slippery, and can be obscured by snow or other debris. In addition, the legality of a painted sign such as the example above is questionable. In general, a standard sign correctly installed should be sufficient to communicate any necessary regulatory or warning message.

Lane Delineation

Lane delineation for reserved bicycle lanes is used to identify that portion of the road that is dedicated for the exclusive use of bicycles, where vehicle travel is in the same direction on both sides of the line. The lines also direct motorized vehicles and bicycle traffic into appropriate lanes, providing for efficient and safe use of the road.

Reserved bicycle lanes are delineated by a white line, 100 mm (4") in width. This line width actually contradicts the 200 mm (8") width minimum requirement for full-time with-flow reserved lanes in the MUTCDC, however, the wider lane lines may present a less safe situation for cyclists during wet conditions. The line is solid, except at the end of a block where right turns are permitted. In this case, the bicycle lane line is dashed with a 1.0 metre (3.3 foot) on/off skip for a

minimum of 15 metres (50 feet). This dashed component of the lane line is meant to encourage right turning traffic to start their manoeuvre directly adjacent to the curb, rather than forcing motorists to stay in their lane up to the intersection and then turn across a cyclist's path.

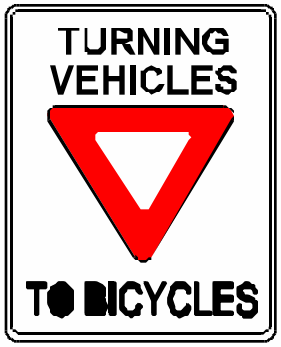
Some theory suggests that a dashed component of the line should also be provided in advance of an intersection to indicate a weaving section. This weaving section would permit bicycle traffic to cross the bicycle lane line in order to proceed to a left turn lane at an intersection. However, this additional dashed segment is not desirable since a defined weaving section may restrict the cyclist's opportunity to change lanes, instead of allowing the cyclist to select an appropriate gap based on traffic conditions. As such, implicit in the definition of a bicycle lane line is that motorists may not longitudinally cross the line unless it is dashed, or they may cross in a transverse manner. Further, bicycles are permitted to cross the line longitudinally at any time.

Contra-flow Bicycle Lanes

Contra-flow bicycle lanes are not recommended except in unique cases such as where a contra-flow bicycle lane would comprise a vital link that would not be feasible in an alternate location. The permissible design for this exceptional case would be a one-way street with a contra-flow bicycle lane to the left of one-way flow, with a 200 mm (8") solid yellow dividing line.

A contra-flow bicycle lane is not recommended on one-way or two-way streets to the right of motorized traffic flow. This is poor practice since it is not a standard design, and also since there would be numerous conflicts at intersections.

Right Turns From "General Purpose Lanes" Adjacent To A Parallel Bicycle Lane



One of the most hazardous locations for cyclists travelling in a

reserved bicycle lane is the approach to an intersection. This is due to the action of vehicular traffic turning right from the adjacent general purpose lane. Typical motorist operation requires that when it is clear to do so, the driver should proceed to the rightmost section of the road, including the reserved bicycle lane, and turn from directly adjacent to the curb. This sometimes creates a conflict for users of the reserved bicycle lane.

Although a sign to address this situation would essentially reinforce the rules of the road, it is sometimes necessary to provide a sign to promote safer road operation. The Yield to Bicycles sign illustrated in Figure 5 was developed to aid in this purpose. However, this sign should only be used in exceptional cases at problem intersections where the right-of-way rule does not provide for efficient and safe movement of traffic. This would be especially important for jurisdictions permitting right turns from the general purpose lane, rather than directly adjacent to the curb.

It could also be applied in those cases where a separate bicycle path has been constructed in the boulevard of a roadway. While this form of bicycle facility is **not** recommended for a number of safety, operational and liability reasons, the Yield to Bicycles sign can assist in clarifying the right of way.

Advanced Stop Bars

Advanced stop bars for left and right turning bicycle traffic are used in some jurisdictions to provide for “improved” cycling operations.

These design practices are not recommended since they are deemed to be unnecessary and inappropriate. In other words, a uniform stop bar across an approach leg is the least confusing method to convey the stop message, is easily recognized and is easier to maintain. There are also potential legality issues due to the presence of multiple stop bars on a single approach.

Finally, advanced exclusive left turn stop bars with refuge areas may encourage bicycle traffic to filter through queued traffic on the approach, instead of joining the end of the queue. Advanced exclusive right turn stop bars would not be feasible adjacent to exclusive right turn lanes or where right turns are prohibited, since no conflicts or weaving are introduced.

Two Step Left Turn

Typical operation for a cyclist travelling in a reserved bicycle lane to turn left at an intersection is accomplished by cycling across the bicycle lane line when it is safe to do so, traversing the through traffic lanes, entering the left turn lane or bay, and then undertaking the left turn similar to any other vehicle at the intersection. This is the optimum method of undertaking left turns at intersections.

However, some jurisdictions encourage cyclists turning left at intersections to undertake left turns in an indirect manner. This is done by providing for a left turn refuge area on the far side of the intersection. Thus, cyclists can temporarily pause while waiting for the cross street green signal indication to permit them to complete their “left turn” movement.

The refuge area is usually located directly adjacent to the intersection corner, between the crosswalk and crossing traffic. This is not an ideal location since this potentially exposes the cyclist to crossing traffic, and may require a right-turn-on-red prohibition. Also, since the refuge area is limited in size, the presence of several cyclists may intrude onto the sidewalk, the crosswalk or the adjacent crossing traffic. Locating the refuge area between the crosswalk and the stop bar is also problematic since this would encourage cyclists to ride in the crosswalk.

CONCLUSION

This document is now available through the Transportation Association of Canada. It should be noted that the NCUTC has recently approved a new project to be chaired by Robert Kahle of the City of Montréal, to establish guidelines for signalization schemes for bikeways. Finally, it is acknowledged that the guidelines in this document are expected to evolve over time, depending on prudent engineering judgement, experimentation and testing which are anticipated to take place in an effort to address the future needs of cyclists in Canada.

ABOUT THE AUTHORS

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