Developing a cycling facility selection tool: Some observations

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ABSTRACT

While it is necessary to ensure that existing cycling facilities perform appropriately from a safety standpoint, cycling facility planners and designers also need to provide additional routes and facilities that encourage new or less experienced cyclists. This can only be accomplished if new cyclists feel comfortable and “safe” using these facilities. An emerging option that is becoming increasingly important in this respect is the appropriate deployment of segregated cycle facilities.

One of the significant challenges designers and road safety evaluators face when dealing with cycling safety issues is the sparseness of collision data. This leads to an inability to develop statistically reliable tools that quantify the specific safety benefits for one facility type relative to another (i.e. comparing a segregated facility to a non-segregated facility). In the absence of these tools, practitioners are faced with using other safety-related proxy measures to determine the most appropriate facility type for the cycle route under review. This paper examines recent research findings in this area, methods currently being used to select facility types elsewhere in the world, and the development of a preferred technique for the City of Ottawa, in the Province of Ontario.

The facility selection tool represents a significant departure from the practical experimentation that has taken place across North America with respect to the issue of segregated cycling facilities and changes how we look at facility selection and the principles behind our decisions. It provides guidance on the use of a mixture of cycling facility types. Having a mixture of facility types that can be deployed using a consistent methodology is necessary to improving the safety and comfort of our cycling routes.

1 INTRODUCTION

1.1 Some background

Research clearly shows that one of the most effective measures for improving overall cyclist safety within a road network is increasing the number of cyclists using the system. Therefore, it is necessary that cycling facilities perform appropriately from the safety standpoint. To accomplish this goal cycling facility planners and designers also need to provide additional routes and facilities that encourage new or less experienced cyclists. This can only be achieved if new cyclists feel comfortable using the facilities, and an emerging option that is becoming increasingly important in this respect is the use of segregated cycle facilities.

1.2 Project overview

In September 2010, the City of Ottawa engaged Delphi-MRC to research the issue of relative safety performance of various types of cycling facilities and develop application criteria to identify opportunities and requirements for the use of cycle facilities that segregate cyclists from motor vehicle traffic. This project was successfully completed and an overview of our approach and salient findings are the provided in the Sections that follow.

2 WHY SEGREGATED FACILITIES?

2.1 Segregated versus non-segregated facilities

Direct comparison of the relative safety of bicycle facilities proves to be a difficult task. Separate bicycle paths may appear to be "safer" than bicycle lanes but may result in more conflicts at intersection and driveway locations, especially if the path is physically removed from the roadway in such a way that motorists may not be expecting cyclists at the junction of the path with the driveway or intersection.

Similarly, bicycle lanes may result in more orderly and predictable behavior between motorists and cyclists along a road segment, but may lead to conflicts at intersections if cycle lane traffic must re-integrate with motorized vehicles as they jointly traverse the intersection and its influence area. Much of the safety performance seems to depend on the design of bicycle facilities and the context of the road environment on which they are applied. The New Zealand Land Transport Safety Authority makes note of this in their Cycle Network and Route Planning Guide as a general consideration for providing either roads or paths:

> *One choice is not inherently safer than another; both can be hazardous and both require high-quality design to achieve safety.*[1]

Research on this issue is far from conclusive. Findings can be contradictory and many studies seem to exhibit shortcomings in data analysis, basic definitions, (i.e. what are considered on-road and off-road facilities) statistical robustness, and often - a preconceived bias that seemingly favors one type of facility over another. Further, much of the research has been conducted outside of North America where the rules of the road and the nature of transportation systems and policies are substantially different than those experienced on this continent.

2.2 Difficulties in quantifying bicycle safety

The National Cooperative Highway Research Program (NCHRP) Report 552: Guidelines for Analysis of Investments in Bicycle Facilities[2] provides an excellent discussion regarding the challenges associated with evaluating and comparing studies that attempt to determine relative safety levels of various bicycle facilities:

[1] Land Transport Safety Authority, New Zealand. "Cycle Network and Route Planning Guide." Wellington, New Zealand, 2004.

[2] Transportation Research Board (TRB), National Cooperative Highway Research Program (NCHRP). *Guidelines for Analysis of Investments in Bicycle Facilities*, Report 552. Washington. 2006.

The prevailing argument is that enhanced facilities – bike lanes, bikeways and special intersection modifications – improve cyclist safety. This claim, however, is the source of a rich controversy within the literature as evidenced by the debate between Forester[3] and Pucher[4]. Part of the controversy around this topic is fueled by differences between what cyclists state they prefer (i.e. their perception) and what studies with collision data actually reveal.

It is widely acknowledged that increased perception of safety is important to encourage cycling as a means of transportation and recreation. Subsequently, providing separated bicycle facilities along roadways is mentioned as a key ingredient to increased perception of safety…

Existing literature on the safety of bicycle facilities usually considers one of three outcome measures: the number of fatalities, the number of crashes, and perceived levels of comfort for the cyclists. Key explanatory variables behind these measures are myriad and complex to identify. For example, the overwhelming majority of bicycle crashes resulting in fatalities are caused by collisions with motor vehicles. Less severe crashes tend to occur at intersections or at locations where motor vehicles and bicycles come in contact with each other; it is further suggested that crashes are caused by differing expectations between auto drivers and bicyclists. However, there is increasing evidence to suggest that some bicycle crashes do not involve any other party; this is especially true for children.

The degree to which perception of safety translates into actual increased safety however is still debated. It proves difficult to translate perceived measures of safety into quantifiable or economic estimates. Additional confounding factors are that prevailing guidelines recommend a variety of solutions.

[3] Forester, John. "The Bicycle Transportation Controversy." Transportation Quarterly, Vol. 55, No. 2, Spring 2001. Eno Transportation Foundation Inc., Washington, DC, 2001.

[4] Pucher, John. "Cycling Safety on Bikeways vs. Roads." Transportation Quarterly, Vol. 55, No. 4, Fall 2001 (pp 9-22). Eno Transportation Foundation Inc., Washington, DC, 2001.

> *In the end, bicycle safety data are difficult to analyze, mostly because bicycle trip data (and thus accident probability per trip) are hard to uncover. As more research and conclusive findings become available, it will likely be possible to understand the safety benefits of bicycle facilities in more detail – at such time, a model could then be developed and incorporated into the guidelines[5].*

The NCHRP report touches on the fact that comprehensive bicycle trip data is very difficult to determine; one must have an accurate estimate of the volume of cyclists on each route/facility in order to determine exposure (cyclist kilometers travelled) and subsequently cyclist collision rates. Furthermore, many cyclist collisions go unreported. This is particularly true for "single bicycle" collisions and those that do not result in significant injury or property damage. The rate of unreported bicycle collisions may vary significantly between different types of bicycle facilities, again making it difficult to compare "safety" directly.

2.3 **Accommodating different types of cyclists**

In addition to safety considerations, the level of comfort is an important component to the success of a cycling network[6]. Every cyclist possesses a different level of skill, confidence, and experience. As a result, many cyclists have different needs and often prefer different types of facilities.

This need to provide a variety of bicycle facilities on a variety of types of roads in order to provide an effective cycling network appealing to all users is reflected in the AASHTO Guide for the Development of Bicycle Facilities:

> No one type of bicycle facility or highway design suits every bicyclist and no designated bicycle facility can overcome a lack of bicycle operator skill. Within any given transportation corridor, bicyclists may be provided with more than one option to meet the travel and access needs of all potential users.[7]

Below, we discuss typical breakdowns of skill level and trip purpose used to help designers address the distinct needs of cyclists within their network environment.

2.3.1 Cycling skill levels

Most literature classifies cyclists into one of three distinct skill categories. The following definitions are presented in the AASHTO Guide for the Development of

[5] Transportation Research Board (TRB), National Cooperative Highway Research Program (NCHRP). *Guidelines for Analysis of Investments in Bicycle Facilities*, Report 552. Washington. 2006.
[6] Information Technology Centre for Transport and Infrastructure (CROW). *Traffic Engineering Design Manual for Bicycle Traffic*. The Netherlands. June 2007 (English version).
[7] American Association of State Highway and Transportation Officials (AASHTO). *Guide for the Development of Bicycle Facilities*. Washington. 1999.

Bicycle Facilities[8] and is generally representative of the types of skill stratification considered in the design of such facilities:

1. Child cyclists – they do not travel as fast as adult cyclists but still require access to key destinations within their community such as schools and recreational facilities. Residential streets with low motor vehicle speeds and separate paths are preferred as children tend not to recognize risk in the same way most adults do. In addition, children have a limited understanding of the rules of the road and how best to interact safely with motor vehicle traffic.

2. Basic/novice cyclists – less confident adult riders using their bicycles for transportation purposes but prefer to avoid roads with fast and busy motor vehicle traffic unless there is ample roadway width to allow easy passing. They consider riding on neighborhood streets and separate paths to be more comfortable and prefer designated facilities such as bike lanes or wide shoulder lanes when riding on busier streets.

3. Advanced/experienced cyclists – generally use their bicycles as they would a motor vehicle. They are riding for convenience and speed and want direct access to destinations with a minimal detour and delay.

2.3.2 Cycling trip purpose

Although less of a factor in the decision process to determine if a facility should be segregated or not, some level of consideration should still be given to the reason for the cycling trip. Typically, the trip purpose is related to the characteristics of the route (i.e. is it close by, comfortable to use, direct/indirect), and is a function of how well the route links land uses or trip generators / attractors (i.e. a residential area and an employment area).

The literature stratifies cycling trip purpose in several ways. The City of Ottawa[9] uses two categories: utilitarian (i.e. commuting or school trips) and recreational. Other agencies typically have more categories and an example is provided in the following:

Commuting/utilitarian – getting to a destination efficiently

Neighborhood – leisurely riding to shops, school, or near home

Recreation/touring – for enjoyment, sightseeing, and exercise

Sport – for competition and training

Generally speaking, we would expect that a cyclist making a trip to work (utilitarian) and having more advanced skill, will be more likely to use a more

[8] Ibid.

[9] City of Ottawa Cycling Plan. Bikeway Planning and Design Guidelines: Technical Appendix No. 1. Ottawa. January 2008.

direct on-road facility. Conversely, we would expect a recreational or neighbourhood trip made by a less experienced cyclist to feel more comfortable on a segregated facility or on a low volume, low speed roadway.

2.4 **Facility segregation: a key factor**

Although safety is an important component to measuring the performance of a cycling facility system the level of comfort of a range of users is also important. Creating cycling facility designs that balance the competing needs of these two components is further complicated by the requirement to accommodate both differing user skill levels and trip purposes.

One important design option that can help achieve the necessary balance is the separation of cycle facilities from those of motorized traffic – a technique referred to in this report as segregation. A variety of segregation alternatives exist, ranging from separate cycle lanes delineated by typical lane separator pavement markings, to similar facilities with varying widths of painted buffer, through to cycle lanes that are separated from the motor vehicle lanes with a physical, non-mountable structure of some kind (i.e. raised curb, concrete barrier, etc.).

We begin our exploration of the segregation of cycle facilities from motor vehicle traffic with a review of what is currently being done in other jurisdictions both in North America, Europe and Australasia.

3 LITERATURE REVIEW

3.1 Overview

A carefully focused literature and research-in-progress review was carried out to provide an examination of the current state of practice with respect to cycling facility segregation. Recent research on cycling safety and implementation guidance was reviewed from the following jurisdictions:

- Netherlands
- United States
- Australia
- New Zealand
- Denmark
- United Kingdom
- Germany

The majority of these countries are considered to be progressive cycling nations and have a wealth of experience with respect to cycling facilities and cycling safety. As such, our literature review was deep and broad and numerous details and research findings were incorporated into our work. However, at a summary level, the information gleaned from this process could be summarized into three key principles that must be clearly understood:

1. The choice to provide a segregated versus non-segregated facility is not a simple “yes” or “no” decision;

2. The criteria or thresholds used to select one cycling facility type over another needs to be flexible and be able to accommodate each unique set of site characteristics that will exist for each design situation; and

3. The final decision to segregate or not to segregate, and the choice of the specific facility type to be deployed, will always be the responsibility of the designer. No quantitative algorithm, warrant, or other selection tool can substitute for the experience and judgement of a qualified engineering designer in such situations. To help designers to properly exercise their judgement, any facility type selection tool must also provide supplementary technical guidance appropriate to a full range of likely design situations.

4 DEVELOPING THE TOOL

4.1 Background

Through the use of a facility selection tool, such as those reviewed in our literature review, a practitioner can identify a preferred cycling facility type with relative ease. Several international jurisdictions have based this decision on two key risk factors: vehicle operating speed and vehicle volumes. Through the experiences of these jurisdictions the relative risk levels have been quantified and summarized in nomographs to aid practitioners. However, implementing a result produced from these nomographs may not be possible in all situations due to such issues as physical constraints, environmental or neighbourhood impacts, or significant costs. In making their final choice of facility type, designers must also consider the site-specific characteristics (i.e. lane widths, access density, etc.) and how they relate to cycling safety and comfort. Based on this challenge it was determined that any facility selection process required a multi-step procedure.

Given this challenge, a customized multi-step process was developed for the City of Ottawa context. This process has three key elements:

1. An initial pre-selection step using a nomograph to guide the practitioner in selecting an initial facility type;

2. A decision tree process in support of the nomograph that guides the practitioner through the decision making process at a more detailed level; and

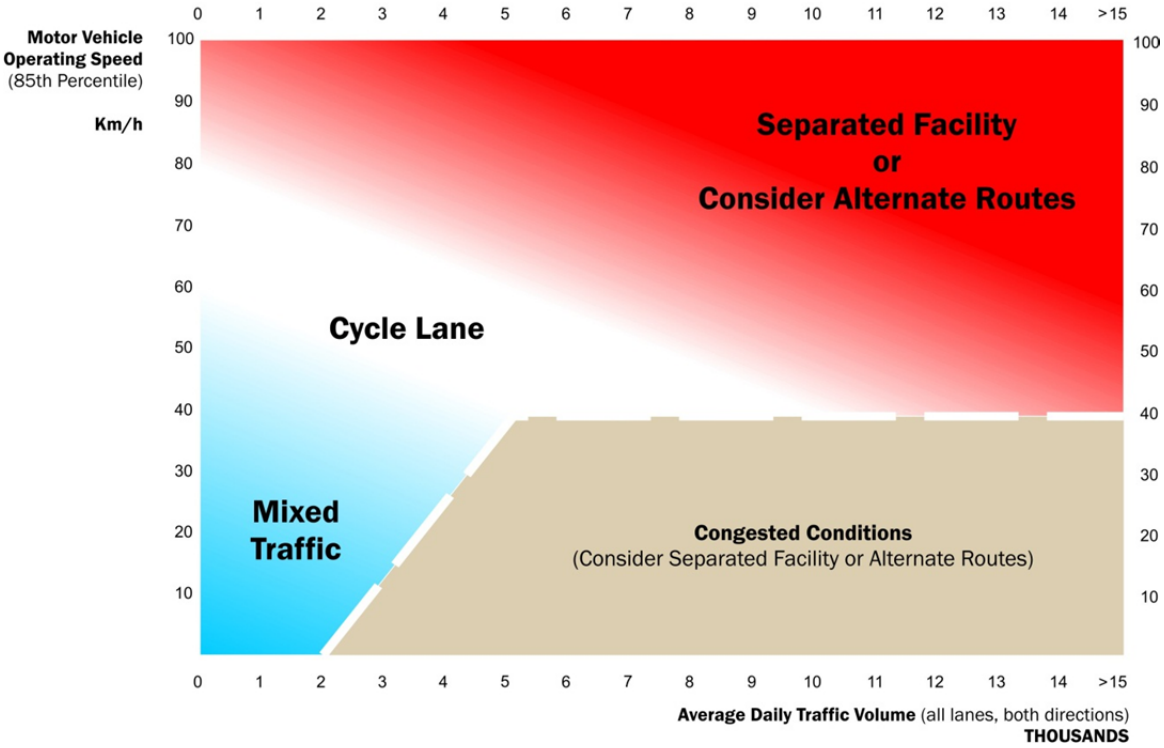
3. A process for summarizing the decision and rationale behind a final facility type.

These steps are discussed in more detail in the Sections that follow.

4.2 The nomograph

It was stated clearly in the literature that the basis for the selection of an appropriate facility type begins with the use of two key cycling safety risk factors: vehicle volume and speed differentials between cyclists and vehicles. As such, our team developed a customized nomograph for the City of Ottawa building on robust information and past knowledge of successful and progressive cycling networks. This is illustrated below.

Cycle Facility
Pre-selection Nomograph



Source: Delphi-MRC, 2011

It is clear from the nomograph above that the decision to provide a segregated cycle facility is not binary. The nomograph actually provides guidance to practitioners on the potential application of other facility types such as cycle lanes, shared facilities and the consideration of alternative routes.

4.3 **The decision tree**

In order to facilitate the secondary step in the process – dealing with site characteristics – we gleaned relevant data from the literature review process and summarized these into a set of design heuristics.

Through the use of heuristics, the practitioner can identify appropriate facility options as well as design enhancements by reviewing the site-specific characteristics. This ensures compatibility between the preferred facility type (identified using the nomograph) and the site conditions. Two things can happen when this step is carried out:

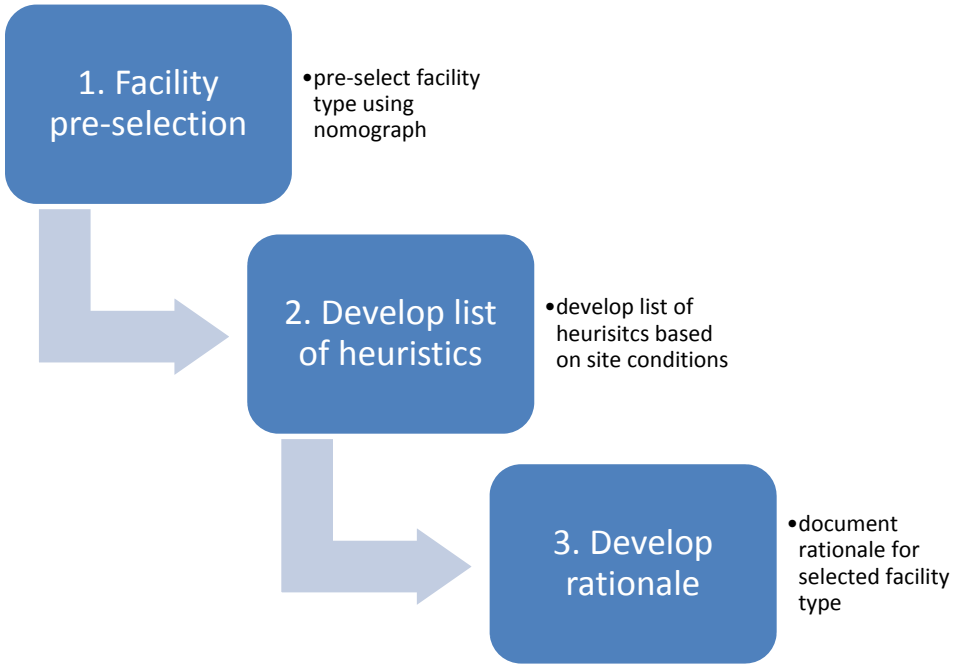
- Other facility types may emerge as being appropriate for the site under review; and
- Specific design considerations will likely be identified to suit the road segment.

The set of heuristics prepared for the City of Ottawa were assembled into categories based on site conditions. This represents a comprehensive set of design heuristics that aid in the decision process. The categories include:

1. Speed;
2. Volume;
3. Roadway function;
4. Vehicle mix;
5. On-street parking;
6. Intersection and access density;
7. Collision history;
8. Available space;
9. User skill level;
10. Cycling demand;
11. Function of cycle route;
12. Type of improvement project; and
13. Project cost/funding.

4.4 **Making a decision**

After the completion of Step 2, the practitioner is left with a customized list of rules for the specific site under review. The practitioner is required to review this list and determine if the rules are compatible with the pre-selected facility type – chosen using the nomograph. For example, if the result of Step 1 is a “cycle lane” facility type, the user must review the list of rules (developed in Step 2) and determine if site conditions support cycle lanes. If not, the practitioner must either consider another facility type that may be more compatible with site conditions, or review parallel routes that are more compatible with the facility type.



Source: Delphi-MRC, 2011

The expectation is that once the user has completed all the steps in the tool, they can make a final decision regarding the appropriateness of the facility type for the specific roadway section being evaluated. In addition to offering guidance relating to a specific facility type, this process also aids designers in determining the need for specific design enhancements such as enhanced buffers, enhanced pavement markings and so forth.

It is imperative that each decision made during the process is documented. In this way, the tool provides a consistent means of defending and documenting planning decisions.

5 CONCLUSION

5.1 Key findings

The facility-type selection tool that was developed for the City of Ottawa is a multi-step process that:

- Addresses the issue of segregated versus non-segregated facilities;
- Is technically reliable and founded on current knowledge and research;
- Provides a consistent framework that is easy to apply and uses readily available data;
- Allows flexibility during the decision process to account for differences in the physical and operational characteristics of the design context; and
- Provides guidance to cycle facility planners and designers

5.2 Concluding thoughts

The technical basis for this tool is extensive and similar tools have been deployed elsewhere in Europe and Australasia with success. As identified above the tool provides the foundation for a consistent framework that can be applied with relative ease and yet provides flexibility to account for the numerous differences in physical and operational characteristics from one site to another. This tool represents a significant departure from the practical experimentation that has taken place across North America with respect to the implementation of segregated cycling facilities and changes how we look at facility selection and the principles behind our decisions.

Finally we note, the selection tool does not tell designers when and when not to provide a segregated facility. Rather it provides guidance on the use of a mixture of cycling facility types. Having a mixture of facility types that can be deployed using a consistent methodology is necessary to achieving both safe and comfortable cycling routes. Again, experiences elsewhere suggest that comfort and safety are key elements to a successful cycling network.

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END NOTES