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The space race: A framework to evaluate the potential travel-time impacts of reallocating road space to bicycle facilities

Charles M. Burke, Darren M. Scott *

TransLAB (Transportation Research Lab), School of Geography and Earth Sciences, McMaster University, 1280 Main Street West, Hamilton, ON L8S 4K1, Canada

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ABSTRACT

When building a cycling network, planners have the option of constructing bicycle facilities at different design widths. However, increasing the width of bicycle facilities reduces lane space for motor vehicles, in turn impacting a road's level of service. Presently, no framework exists to systematically measure the potential travel time consequences of employing wider bicycle facilities on a road network. In this paper, we demonstrate how the Network Robustness Index (NRI) can be used to identify the bicycle facility design that limits traffic disruption for any road link in an urban network. To demonstrate the utility of the new approach, we use a theoretical, generalizable network and compare it against an approach used in current bike lane planning practice. The results show that if a planner is challenged to build a road network of wider bicycle facilities while at the same time minimizing potential impacts on motor vehicle traffic, their decision-making power improves when using the NRI to support this aim. If widely adopted, this new evaluation framework may lead to the development of better urban cycling networks that consist of wider bicycle facilities.

> "Separated bike lanes cannot be planned in a vacuum. Among the primary concerns when planning a separated facility is determining how much, if any, motor vehicle capacity might be removed due to an installation. The reduction could result from removing a lane of vehicular traffic or altering signal timing such that vehicular throughput is impacted. Many municipalities find the subject of reduced capacity politically challenging. Planners should engage in a comprehensive, multi-modal analysis of the costs and benefits of a separated bike lane in terms of mobility for all street users – cyclists, pedestrians, and transit users, in addition to motorists. Planners should take a flexible approach to separated bike lane construction and engage in robust before and after data collection in order to holistically evaluate how separated bike lanes can fit into a roadway network. Evaluation should include performing a traffic volume analysis, determining if a corridor has excess capacity, and evaluating whether a separated bike lane design will require removal of roadway capacity. Planning for high-quality separated bike lanes within a dynamic, constrained environment poses considerable challenges and requires careful consideration and analysis."
>
> [Federal Highway Administration (FHWA, 2015, p. 47)]

1. Introduction

Bicycle lanes come in many different sizes, and the road space required for each design varies. Bike signs and shared lane markings require no specific reallocation of road capacity to bikes while conventional lined bike lanes or wider European style bicycle facilities need some road space to implement. The lowest stress options are bicycle boulevards, buffered lanes, and separated bike lanes or cycle tracks, and these all may need as much as a full lane worth of capacity to employ (see Fig. 1 for examples of various designs). Currently, most North American city cycling networks are made up of bicycle facilities that take up very little road space. Signs, shared markings, and conventional lined bike lanes are employed across Canada and the US, but fewer cities employ wider, buffered, or physically separated bike lanes (NACTO, 2015a).

However, this trend is changing, and as the number of urban cyclists in North America continues to grow, more and more municipalities are adopting wider bike lanes as part of their city cycling networks.[1] To facilitate the transition from the current state of cycling infrastructure to city networks that employ wider bike lanes, planners require some method to evaluate the cost of narrowing or removing lanes to reallocate space to bikes. This need is echoed in the quote from the FHWA that opens this paper, one stating that determining the amount of

* Corresponding author.
E-mail addresses: burkecm@mcmaster.ca (C.M. Burke), scottdm@mcmaster.ca (D.M. Scott).

[1] Over the past decade, at least 17 cities in the United States have incorporated a separated cycle track into their cycling network (NACTO, 2015a).

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Fig. 1. Types of bicycle facilities common in North America: (A) shared markings, (B) conventional bike lane, (C) buffered bike lane, and (D) separated cycle track.

capacity necessary to install a bicycle facility should be one of a planner's primary concerns (FHWA, 2015, p. 47).

One possible approach to assist planners in this regard is to measure the travel time impact a loss of capacity has on the greater road network. Since, for the most part, bicycle facilities are incorporated into rather than added to a road network, a bike lane is in essence a road capacity loss for motor vehicles. Since the network's primary objective is to facilitate operation for the majority of traffic, motor vehicles, the potential travel time impact a bicycle facility may have is a good indicator of the amount of capacity a planner could conceivably reallocate to bikes. The information provided from evaluating the impact of capacity loss can then be used, along with other factors, to help select the bicycle facility design for a particular location, and communicate to the drivers of motor vehicles that their concerns have been addressed in that selection.

Unknown vehicular travel time impacts have limited planned wide bike lanes in the past. Complaints over traffic disruptions have, in at least one case, delayed the installation of wider lanes in a New York City neighborhood (Sadik-Khan, 2016), and in another, forced a separated bike lane's removal in Toronto (Alcoba, 2011). Moreover, these two examples are not likely isolated incidents, as the same FHWA quote above indicates that the need for capacity evaluations stems from many municipalities finding reduced road capacity for cars is politically challenging (FHWA, 2015, p. 47).

This paper proposes a new approach to evaluate the potential impact of reallocating road space to bicycle facilities. This framework is built on a foundation of a critical link analysis method called the Network Robustness Index (NRI), first developed by Scott et al. (2006). The NRI method can be used in conjunction with a software tool called the NRI Calculator to perform a sensitivity analysis of road capacity impacts, measuring each link's ability to accommodate wider cycling facilities without a considerable disruption to vehicular traffic. The following experiment applies this method to a hypothetical, generalizable example road network to test its ability to perform this type of analysis and demonstrate its potential to be applied in cycling network planning.

The remainder of this paper is structured as follows. Section 2 provides some background on cycling in North America and the trends that motivate this research. Section 3 offers a critique of the current framework in place to assist planners in selecting bike lane separation. Section 4 outlines the NRI, the proposed capacity sensitivity analysis framework, and the example network used to demonstrate the approach. Section 5 covers the application of the NRI to the network comparing results against current practice. The paper closes with a brief summary and possible future considerations.

2. Motivation

Regardless of coverage, city cycling networks that consist mainly of road signs, shared markings, recreational paths, and conventional lined bike lanes may soon no longer be considered adequate in North America:

> "Many municipalities may already have a comprehensive network that – when mapped – appears to adequately cover a large area with multiple intersecting on-street bike lanes or sign-posted bike routes. However, if these facilities are inaccessible to cyclists seeking a low-stress experience then the network may not meet the needs of everyone… a [new] network might be overlaid on and around – or even replace – an existing bicycle network."
>
> [Federal Highway Administration (FHWA, 2015, p. 32)]

Shared markings and conventional bicycle lanes may have, in the past, met the needs of the cycling 1% that consider themselves "strong and fearless," but these facilities are viewed by the majority of cyclists as high-stress (Mekuria et al., 2012). Shared markings scored lowest in preference among both surveyed cyclists and drivers, each viewing this design as potentially dangerous to riders (Sanders, 2013). Conventional lined bicycle lanes are the most commonly employed bicycle facility across North America, but survey evidence shows that they fall short of the comfort provided by wider bicycle facility types. Sanders (2013) found that less than 50% of riders found lined lanes to be "moderately or very comfortable when cycling near drivers" on corridors with parking, although that estimate rises significantly on streets where parking is eliminated (p. 69). Broach et al. (2012) collected GPS evidence showing that lined lanes on arterial roads were preferred by cyclists only when no other lower traffic alternative was available (p. 1737). In addition to North American cites heavily relying on these designs in their cycling networks, many municipalities also include