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Prioritizing new bicycle facilities to improve low-stress network connectivity

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ABSTRACT

This paper introduces a new method to prioritize bicycle improvement projects based on accessibility to important destinations, such as grocery stores, banks, and restaurants. Central to the method is a new way to classify "bicycling stress" using marginal rates of substitution which are commonly developed through empirical behavioral research on bicyclist route choice. MRS values are input parameters representing bicycling stress associated with the number of lanes and speed limit of a street. The method was programmed as a geographic information system tool and requires commonly available data. The tool is demonstrated on three improvement scenarios that were recently proposed for Seattle, Washington. The full build-out scenario consists of 771 projects that include various new bike lanes, protected bike lanes, and multi-use trails. The tool produces priority rankings based on a project's ability to improve low-stress connectivity between homes and important destinations. The analysis identifies specific areas and neighborhoods that can be expected to exhibit better bikeability. Transportation planners can use the tool to help communicate anticipated project impacts to decision-makers and the public.

1. Introduction

Many cities are currently trying to expand their bicycle network (Buehler and Pucher, 2012). They are devising Bicycle Master Plans that enumerate a wish list of improvement projects such as bicycle boulevards, bike boxes, buffered bike lanes, and cycle tracks (NACTO, 2014). American cities are way behind their European peers in terms of expansive infrastructure for mass bicycling, but there is evidence change is underway (Furth, 2012). In 2010, USDOT Secretary Ray LaHood signed a policy declaring "The establishment of *well-connected* walking and bicycling networks is an important component for livable communities, and their design should be part of Federal-aid project development" (LaHood, 2010 emphasis added). Four years later, his successor, Secretary Anthony Foxx, launched a new initiative to increase federal funding for bicycle improvement projects, which he called "the most innovative, forward-leaning, biking-walking safety initiative ever" (Foxx, 2014). Over the next few decades, cities will need to make strategic capital investment decisions as the federal government, state departments of transportation, local governments, and non-profit organizations such as the Rails-to-Trails Conservancy direct more funding toward bicycle infrastructure.

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Capital investment decisions usually involve two key steps: project appraisal and project prioritization. Project appraisal determines whether there is economic justification for the project based on expected benefits and costs. One approach is to monetize expected impacts over a particular time period in terms of present-value dollars and calculate the benefit–cost ratio to confirm that benefits outweigh costs. It can be fairly easy to estimate costs (Krizek et al., 2006); but, monetizing benefits can be quite difficult. Most benefits from bicycle improvement projects are non-market benefits, meaning the dollar value is not readily apparent. Such benefits are typically indirect or ancillary, meaning the benefit is not directly due to the project, but rather due to incidental impacts from a change in society's behavior. For example, if a community improves their bicycle network, more people might choose to ride their bike rather than drive, which in turn might improve health, reduce emissions, and decrease traffic congestion. Likewise, improvement projects might increase home values or increase community attractiveness. These types of benefits are very difficult to quantify and monetize. Even direct benefits, such as reduced bicycle crashes, can be difficult to quantify (Nordback et al., 2014). Consequently, decision-makers often use professional judgment and the intensity of public opinion to justify bicycle facility improvement projects.

Once projects have been economically justified, the next step is to prioritize them for implementation. There are various prioritization techniques available, and the information used during project appraisal can often be used for prioritization as well. For example, through a process called Incremental Analysis projects can be rank-ordered based on benefit–cost ratios. However, once again, decision-makers face the challenge of monetizing non-market benefits. An alternative approach is to identify performance indicators (also called measures of effectiveness or project selection criteria) to evaluate how well a project is expected to perform with regard to specific goals and objectives. For example, the Seattle Department of Transportation (SDOT) identified five goals and corresponding performance indicators to prioritize candidate bicycle improvement projects. The goals are to increase (1) ridership, (2) safety, (3) connectivity, (4) equity, and (5) livability. They were developed through public involvement activities, stakeholder focus groups, assessment of data availability, review of the literature, and other activities (SDOT, 2013a). Prioritization can be achieved by rank-ordering a single performance indicator, a composite indicator, or through some deliberative process that takes into consideration all the performance indicators simultaneously.

Preferably, the evaluation of performance indicators should involve quantitative analysis. The USDOT notes, "Quantitative information lends objectivity to a decision-making process which might otherwise be dominated by subjective judgment or political considerations" (FHWA, 2011). Quantitative analysis is more likely to be repeatable and transparent. Nevertheless, as already discussed, the benefits associated with bicycle improvement projects are often very difficult to quantify, in which case, qualitative indicators may be the only viable alternative. Qualitative evaluation might consist entirely of narrative description. For example, the City of Portland's bicycle implementation plan involves a series of yes/no and open-ended questions to evaluate seven performance indicators. A quasi-qualitative evaluation might involve subjectively assigning a score to some or all of the performance indicators on a scale of 1–10. SDOT's bicycle master plan notes that project prioritization should use "a variety of qualitative and quantitative methods, recognizing that prioritizing bicycle projects is not a science but rather an art" (SDOT, 2013a, pg. 8).

This paper introduces a new method to objectively analyze "connectivity", a performance indicator commonly used to prioritize bicycle improvement projects. According to a review conducted by SDOT, the cities of Portland, Minneapolis, and Vancouver all include connectivity as one of their prioritization criteria (SDOT, 2013a). A recent USDOT Roundtable called for "more standardized tools…to measure connectivity." (Foxx, 2015).

The new method described in this paper uses network analysis and geographic information system (GIS) software to produce project priority rankings based on a project's ability to connect homes with destinations via low-stress bicycling. The method was programmed as an ArcGIS tool and requires commonly available GIS data: (1) street and trail network, (2) residential land use parcels, and (3) points-of-interest destinations. Transportation engineers and planners can use the tool to help communicate expected project impacts to the public and decision-makers.

The next section of this paper provides background on assessing bicycling stress and measuring connectivity. This is followed by a description of the new method and a case study example involving the Bicycle Master Plan for Seattle, Washington in which the full build-out includes 771 projects.

2. Background

Assessing the stress associated with a bicycle facility can be accomplished through various *bicycle suitability assessment* methods. Callister and Lowry (2013) provide a summary of more than a dozen methods that have been developed since 1987, starting with Davis's pioneering Bicycle Safety Index Rating (BSIR). Each method calculates a *suitability rating* based on different roadway attributes. For example, the method developed by Sorton and Walsh (1994) called Bicycle Stress Level (BSL) calculates five stress ratings from "Very Low Stress" to "Very High Stress" based on three roadway attributes: (1) width of outside lane, (2) vehicle traffic volume, and (3) vehicle speeds. The 2010 Highway Capacity Manual presents a method called Bicycle Level of Service (BLOS) based on ten roadway attributes and produces a letter grade rating from "A" through "F" (TRB, 2011). Mekuria et al. (2012) developed a method called Level of Traffic Stress (LTS) which produces four ratings ranging from LTS 1 to LTS 4 based on three key roadway attributes: (1) number of vehicle lanes, (2) speed limit, and (3) bike lane width (other attributes included in the method are bike lane blockage, parallel parking, and presence of traffic signal).