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BICYCLE PLANNING GIS TOOL

Final Report

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by

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16. Abstract

Although currently only about 1 percent of U.S. trips are done by bicycle, there is significant geographic variation. Differences across communities, along with much higher cycling rates observed in other places around the world, indicates large potential bicycling demand for daily travel in the U.S. In response, many communities are developing and implementing bicycle master plans that include a range of bikeway infrastructure aimed at making riding more appealing, including separated paths, protected (or separated) bike lanes, striped bike lanes, bicycle boulevards, sharrows, route signage, and intersection crossing aids. Given limited resources, planners and engineers need tools to estimate the effects of new infrastructure on behavior. How many more people will ride a bike if a city builds out their planned bicycle network? Which competing project options provide the most bang for the buck? Those are the questions communities are asking, but that our current tools do a poor job of answering.

Recent research has sharply advanced our understanding of bicyclist—and potential bicyclist—preferences for different types of bikeways. This project translates that emerging research into a GIS planning tool that is relatively simple and quick to apply but also powerful enough to answer questions about how specific bicycle network changes might impact ridership. Inputs are data on bicycle networks, such as bikeway types, slope, and intersection features, along with local data on origins and destinations and/or widely available Census data. Outputs are quality of connections and predicted bicycle commute rates at the Census Tract level under different planning scenario conditions. Scenarios can be compared by incorporating planned bikeway networks, population, or land-use changes. The methods allow side-by-side analysis of both the overall impact of a project or plan and the geographic distribution of impacts on connectivity and bicycle commute rates.

This project extends existing sketch tools by improving sensitivity to specific bicycle infrastructure changes and by explicitly linking network connectivity changes to bicycle use outcomes. The GIS tools developed seek to make available to a wider audience analysis methods formerly only available in complex regional travel demand models in a handful of regions.

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EXECUTIVE SUMMARY

There is a growing demand among practitioners for bicycle planning tools sensitive to network quality and connectivity. This project adapted recent research on bicyclist route preference and mode choice into a package of GIS sketch planning tools. The resulting software and guided tutorials allow planners to:

- Identify key bicycle infrastructure and potential network gaps.
- Calculate a standardized bicycling accessibility index score (Route Quality Index, or RQI) between sets of location points or zones.
- Estimate predicted changes in bicycle commute mode share under different network and land-use scenarios down to the Census Tract level.

The software tools and instructions are released and maintained in open source repositories and are freely available. The modular nature of the tools encourages further development and adaptation to fit specific planning needs. The project also developed a catalog of existing sketch planning tools for transportation and related planning efforts.

1.0 BACKGROUND AND OBJECTIVES

Currently, only about 1 percent of personal trips made in the U.S. are on a bicycle, though there is significant geographic variation.[1] The variation within the U.S., as well as much higher cycling rates in cities around the world, indicates a large potential latent demand for bicycling for transportation. In response, many cities are developing and implementing bicycle master plans that include a range of bikeway infrastructure, including separated paths, protected (or separated) bike lanes, striped bike lanes, bicycle boulevards, sharrows, and route signage. How many more people will ride a bike if a city builds out its planned bicycle network? That's the question cities are asking that our current tools do a poor job of answering. In contrast, most metropolitan areas have a travel demand model that will answer that question for motor vehicles and transit. This project synthesizes emerging behavioral research into a relatively simple but powerful planning tool to help answer the question for bicycling that could eventually be used in a range of cities using readily available data.

[1] Pucher, J., R. Buehler, and M. Seinen. Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation research part A: policy and practice, Vol. 45, No. 6, 2011, pp. 451–475. https://doi.org/10.1016/j.tra.2011.03.001

2.0 PROJECT DESCRIPTION

The Federal Highway Administration's (FHWA) recently released *Guidebook for Measuring Multimodal Network Connectivity* provided a scan of best practices among agencies that were attempting to measure how well existing and future facilities served bicyclists and pedestrians. The guidebook noted a disconnect between the complex planning questions agencies needed to answer and the limited tools they were able to access for network analysis. The guidebook also pointed to recent research on quality-based network connectivity that showed potential to bridge that gap. This project focused on porting one piece of that emerging research into a practice-ready tool that would allow for more complex analysis of bicycle networks (and network changes) on accessibility and bicycle use.[2]

The resulting GIS-based toolkit was envisioned as a combination of detailed tutorials, scripts, and suggested guidance that would allow users to apply the research to their locality with relatively low data and technical requirements. The project was broken into four components: 1) desk scan of related sketch planning tools; 2) coding the core of the existing research project into modular software scripts; 3) developing documentation, tutorials, and guidance for acquiring and wrangling the necessary input data as well as visualizing and interpreting outputs; and 4) a plan for implementation and dissemination of the toolkit. The first three are described here in turn. The final component is described in Chapter 5 of this report.

2.1 RELATED SKETCH PLANNING TOOLS

A graduate research assistant (GRA) completed a desk scan of similar sketch planning tools. Sources included: NCHRP 08-36 Task 117 *Sketch Planning Tools for Regional Sustainability*, TRID, and general internet searches for "sketch planning tool," "bicycle planning tool," and "GIS planning tool."

For each tool identified, the GRA attempted to install and use the tool to better understand how an outside user might fare if they encountered our own tool without additional knowledge. She recorded her experiences, and summarized them to help us design our own toolkit.

2.2 CODING EXISTING RESEARCH

The original research (Broach & Dill, 2017) that formed the toolkit's basis was completed, as are most GIS studies, in an *ad hoc* way using a mix of desktop GIS tools (ArcMap, QGIS), database tools (PostgreSQL), scripting languages (Python), and statistical software (R, SPSS). Standardizing and documenting the analysis steps comprised a key project task. We considered both a standalone graphical user interface and development of toolboxes or plugins that would

[2] Broach, J., and J. Dill. Bridging the Gap: Using Network Connectivity and Quality Measures to Predict Bicycle Commuting. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington, D.C, January 2017.

work graphically within a desktop GIS. Our poor experience with several existing tools that had taken this route including version incompatibilities, required licenses and lack of flexibility, led us toward a simpler, non-graphical interface with rich documentation.

2.3 DOCUMENTATION, TUTORIALS, AND GUIDANCE

Thoroughly documenting the toolkit, providing step-by-step tutorials for a range of use cases ("vignettes"), and drafting guidance for preferred data standards and acceptable substitutions formed a final project task. We elected to create online documentation embedded in the project's GitHub code repository. This would allow for documenting additional uses and features over time, as well as correcting inevitable errors and omissions in a central, authoritative location.

3.0 OUTCOME AND RESULTS

3.1 CATALOG OF RELATED SKETCH PLANNING TOOLS

More than 50 sketch planning tools were identified and reviewed. Most tools identified were related to transportation, land use or environmental planning, and include examples from government agencies, academia, and private firms. An annotated catalog is available as a Google Sheet at https://tinyurl.com/y38pgom7.

3.2 CODE AND DOCUMENTATION

Up-to-date code and documentation will be available via the project's GitHub page at https://jbroach.github.io/bike-planning-tools/. Feedback received during the project indicated many potential users were unsure on how to access tools via GitHub. We provide several options for direct download of the tools for those unfamiliar with version control systems. Included are sample data for the Portland metropolitan region to allow potential users to explore the toolkit before committing resources to local data collection and assembly. We also include suggestions on reasonable substitutions for data that can be difficult to obtain or process, particularly detailed bicycle network data. A summary of data requirements for different uses of the toolkit are provided in this report as an appendix.

4.0 FURTHER ACTIVITIES

A research proposal that included this toolkit as a candidate method was recently submitted with funding commitments from the Oregon Department of Transportation (ODOT) and Portland Metro, and formal support from the FHWA. The toolkit will be considered for enhancements to regional strategic planning framework VisonEval as well as the Portland Metro regional bicycle model.

ODOT staff have also provided a list of potential tool testers at regional and local planning agencies around the state. These locations already maintain local bicycle networks in the preferred Portland Metro format.

The GitHub project website and code repository is set up to track issues and release fixes and enhancements to both code and documentation.

A webinar or other training session will be considered if there is sufficient interest.

5.0 IMPLEMENTATION PLAN

Reason for and benefits of research: Make recent research on bicycle network connectivity impacts available for sketch planning/scenario testing by a broad range of practitioners.	**Possible applications of research and specific examples of how a practitioner would use the results:** Identify key bicycle infrastructure and potential network gaps, calculate a standardized bicycling accessibility index score (Route Quality Index, or RQI) between sets of location points or zones, and estimate predicted changes in bicycle commute mode share under different network and land-use scenarios down to the Census Tract level
Engaging stakeholders (adopters, research directors, technical experts, stakeholders, champions): NITC will host an informational website where users can learn about and download the tool. Solicit tool "beta" testers from a list of those expressing interest over the course of the project. Expand invitation via planning mailing lists and other venues.	**Resources needed (funding, engineering support, trainings, software, etc.):** Will need to fix bugs as the software tool is deployed more widely, as well as maintain repository and respond to issues and feature requests.
Barriers to adoption (institutional policies, regulations, legal requirements, societal constraints, market considerations): Lack of GIS/technical expertise; lack of local network data.	**Planned activities to facilitate implementation and current status:** ODOT to reach out to regions that already maintain Portland Metro-style bike networks. The tool is included as a candidate in proposed enhancement to the VisionEval strategic planning framework backed by FHWA and ODOT and Portland regional bicycle model update (project proposed spring 2019, with funding commitments from ODOT and Portland Metro, and FHWA support).
Methods of tracking and measuring the impacts of implementation: Users will be asked via a website portal to provide initial and follow-up information on planned/actual use of the toolkit. GitHub also	**Schedule:** June 2019 – solicit initial testers via ODOT, interest list Late summer/early fall 2019 – solicit additional testers via email, publicity,

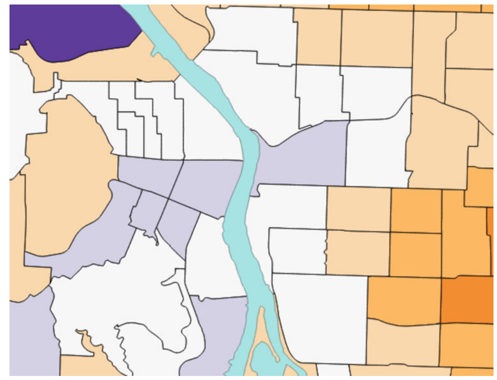
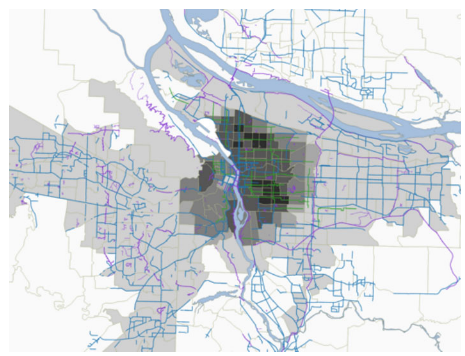
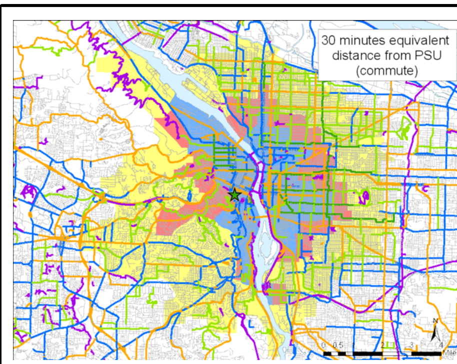
provides tracking of where the project is “watched,” “starred,” or “forked.”	TCS2019 Fall/winter 2019 – tentatively plan a webinar or training around the toolkit’s application

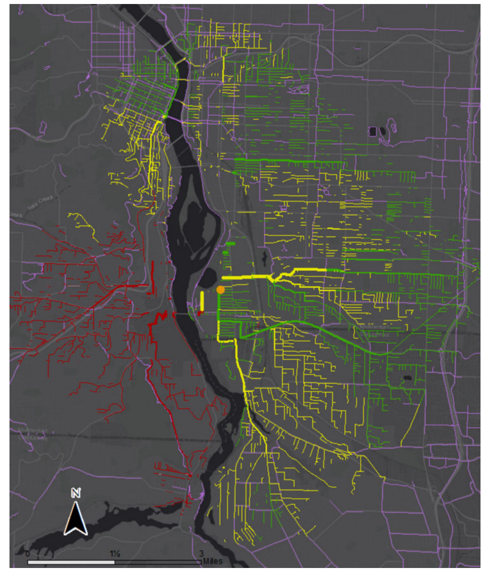
6.0 APPENDIX

6.1 SUMMARY OF TOOLKIT DATA REQUIREMENTS AND CAPABILITIES

Component	Preferred Data	Alternate Data	Output(s)
Route Quality Index calculator	• Origin & Destination Points (any) • Portland Metro-style bicycle network (see docs)	• OpenStreetMap (OSM)-style bicycle network OR other conforming local bike network (see docs)	• Quality-weighted "bikeshed" • Composite bicycle accessibility measure per origin • Critical link analysis
Bicycle Commute Model	• ACS Census Tract spatial • LEHD/LODES employment data • CBD/central city boundary • Base & Future Scenario networks, or two scenario networks (Portland Metro style) • [Optional: land-use employment/pop-ulation scenarios]	• Equivalent data on: # commuters [optional: income, education, age] • Total jobs by zone • Base & Future Scenario networks, or two scenario networks (OSM style OR other conforming local bike network)	• Predicted change in bicycle commute rate at the Census Tract level

6.2 EXAMPLES OF GRAPHICAL OUTPUTS

Description	Parameters	Output
Route Quality Index		
Average route quality from each origin zone	Destination point(s) [weight, e.g. jobs]	
Predicted Bike Commute Share Change		
Change in bike mode share by Census Tract (percentage or number)	Two scenarios/alternatives	
Bikesheds		
Bikeable area within equivalent distance budget	Single origin or destination point distance budget commute/non-commute	
Key links		

Identify links most often associated with poor/high-quality routes	Quality threshold	

6.3 SUMMARY OF UNDERLYING MODELS AND EMPIRICAL SUPPORT

The tools are adapted from several pieces of related research, each with underlying empirical support.

Component	Research	Empirical Support
Commute and non-commute route choice preference	Improving Regional Travel Demand Models for Bicycling[3]	Revealed preference GPS study of 150+ cyclists in Portland, OR (2007)
Route Quality Index	Travel Mode Choice Framework Incorporating Realistic Bike and Walk Routes[4]; Broach & Dill (2016)[5]	Revealed preference GPS study of 300+ Portland residents
Bicycle commute share model	Broach & Dill (2017)[6]	2016 ACS commute data

[3] https://nitc.trec.pdx.edu/research/project/249/Improving_Regional_Travel_Demand_Models_for_Bicycling
[4] https://ppms.trec.pdx.edu/projects/detail/718
[5] Broach, J., & Dill, J. (2016). Using predicted bicyclist and pedestrian route choice to enhance mode choice models. *Transportation Research Record*, *2564*(1), 52-59. https://doi.org/10.3141%2F2564-06
[6] Broach, J., and J. Dill. Bridging the Gap: Using Network Connectivity and Quality Measures to Predict Bicycle Commuting. Presented at the 96th Annual Meeting of the Transportation Research Board, Washington DC, January 2017. https://trid.trb.org/view/1439490