# Low-Stress Bicycling and Network Connectivity

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In one sense, a city's or region's bicycling network includes all of its roads and paths on which bicycling is permitted. However, some streets provide such a poor level of safety and comfort for bicycling that the majority of the population considers them unsuitable for bicycling. This research had two primary objectives:

> *For a bicycling network to attract the widest possible segment of the population, its most fundamental attribute should be low-stress connectivity.*

1. Propose and test the practicality of a new way to define the bicycle network – that is, as the set of streets and paths that people consider acceptably safe for bicycling.
2. Develop metrics for low-stress connectivity, or the ability of a network to connect travelers' origins to their destinations without subjecting them to unacceptably stressful links.

## Study Methods

*1. A User-Oriented Bicycling Network Definition*

To make bicycling safer and more appealing, cities often make bicycle-related improvements to certain streets. However, the improvements do not necessarily represent the network of paths and streets that people deem safe enough to use. This research proposes a new scheme for classifying road segments by one of four levels of traffic stress:

> **Level of traffic stress 1 (LTS 1):** the level that most children can tolerate.
> **LTS 2:** the level that will be tolerated by the mainstream adult population.
> **LTS 3:** the level tolerated by American cyclists who are "enthused and confident" but still prefer having their own dedicated space for riding.
> **LTS 4:** a level tolerated only by those characterized as "strong and fearless."

For each type of roadway condition (e.g., lanes, speed, existing bicycling infrastructure configuration, intersection design features, etc.), we applied our classification scheme. Table 1 presents an example of how our classification scheme would be applied to an unsignalized crossing without a median refuge.

| | Width of Street Being Crossed | | |
|---|---|---|---|
| Speed Limit of Street Being Crossed | Up to 3 lanes | 4 - 5 lanes | 6+ lanes |
| Up to 25 mph | LTS 1 | LTS 2 | LTS 4 |
| 30 mph | LTS 1 | LTS 2 | LTS 4 |
| 35 mph | LTS 2 | LTS 3 | LTS 4 |
| 40+ | LTS 3 | LTS 4 | LTS 4 |

*2. A Network Connectivity Metric*

Connectivity is perhaps the most critical aspect of a bicycling network and should feature prominently in network planning. In contrast to a normatively defined network, the user-perspective-based network may be incoherent – that is, it has some areas not connected to others, or the connecting route is so circuitous that most people would consider them

effectively unconnected. Our research focuses on connectivity to include a maximum acceptable level of detour, and we use graphical displays, such as stress maps and shortest-path "trees" (connectivity graphs) to demonstrate how these powerful tools can be used to identify the links to be added to the network to improve connectivity. The figure shows an example of a shortest-path tree rooted at San Jose State University showing everywhere a bicyclist can travel at LTS 2 or lower.
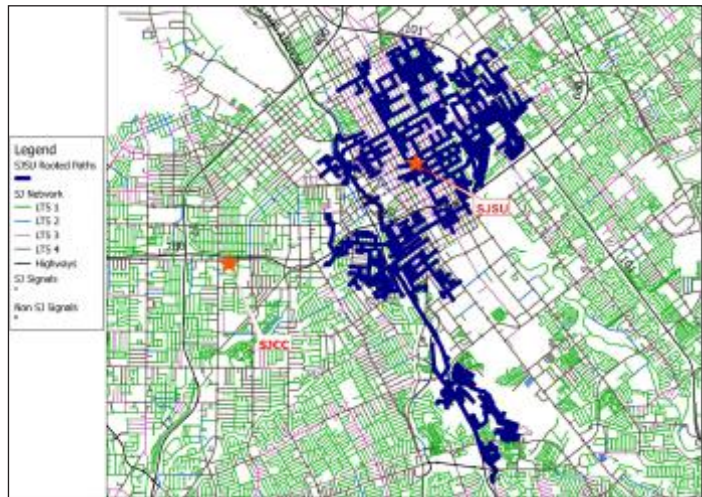


## Findings

Using San Jose, CA as our case study, we applied our classification scheme to the overall road and path network. Total centerline miles in San Jose by level of traffic stress are: **LTS 1:** 2,131 Miles, 64% of total; **LTS 2:** 115 Miles, 3% of total; **LTS 3:** 276 Miles, 8% of total; **LTS 4:** 678 Miles, 20% of total; **Freeways (Bicycles Prohibited):** 134 Miles, 4% of total.

We examined stress maps and shortest-tree paths rooted at key destinations in San Jose in order to propose a sample slate of improvements to the network based on current work trips within the city. This was designed to show how a relatively modest set of improvements could bring about substantial gains in connectivity. Our analysis was able to show an overall level of improvement in the fraction of work trips connected at LTS 2 or lower from 4.7% to 12.7% of all work trips (for trip lengths less than 6 miles) and a 5.8 times (580%) increase in node-to-node connectivity for the same LTS.

## Policy Recommendations

The LTS criteria developed and applied can distinguish four levels of a street network's stressfulness, corresponding to identified user profiles, and it offers cities a way to map their bicycling networks according to which populations they serve rather than according to facility types. Our research highlights the importance of intersection approaches and street crossings in network connectivity. We also developed several analysis tools for visualizing connectivity, including stress maps, shortest-path trees, and maps highlighting barriers and islands. Our case study in San Jose demonstrated how a modest slate of network improvements targeted at providing critical, low-stress links can dramatically increase connectivity.

## About the Authors

Maaza Mekuria is founder and principal of ADEC, Peter Furth is a professor of civil and environmental engineering at Northeastern University, and Hilary Nixon, is an associate professor in the Department of Urban & Regional Planning at San José State University.

## To Learn More

For more details about the study, download the full report at *transweb.sjsu.edu/project/1005.html*