
STOP
LANE
RIGHT
ONE WAY
EXCEPT BICYCLES

Source: FHWA

FACT SHEETS ON CONNECTIVITY ANALYSIS METHODS AND MEASURES

Chapters 1 and 2 defined multimodal connectivity analysis, described its importance in general terms and outlined a process for measurement. This chapter provides summaries of technical information about commonly applied connectivity analysis methods and measures, with references to more materials that can help practitioners to assemble data and calculate results. Detailed descriptions of many of the methods and measures presented here, along with other analysis measures and tools, can be found in the *FHWA Guidebook for Developing Bicycle and Pedestrian Performance Measures* (2016).

CONNECTIVITY ANALYSIS METHODS

The first part of this chapter consists of a set of fact sheets about each of the five types of analysis methods described in Chapters 1 and 2, as follows:

- Network completeness
- Network density
- Route directness
- Access to destinations
- Network quality

Each fact sheet describes the following information:

- **Key Question(s):** Which specific question(s) is the analysis method best suited to answer?
- **Description:** What core concept is measured and what are some key characteristics of this type of analysis?
- **Example Planning Application(s):** What types of policies or decisions can this analysis inform?
- **Example Measures:** What are some specific metrics associated with this type of analysis? Footnotes in these sections provide references to guidebooks and articles on how to compute key measures.
- **Typical Data:** What types of data are typically required to support this analysis method?
- **Advantages:** What makes this analysis method useful and/or relatively easy to conduct?
- **Considerations:** What are some important things to be aware of when conducting this type of analysis?
- **Peer Applications:** Where has this type of analysis been applied? The fact sheets provide a few selected examples from agencies that have conducted the analysis method.

CONNECTIVITY MEASURES

The second part of this chapter consists of a set of fact sheets about the following measures that can inform one or more of the connectivity analysis methods listed above:

- Bicycle Level of Service
- Bicycle Level of Traffic Stress
- Bicycle Low Stress Connectivity
- Bicycle Route Quality Index
- Pedestrian Index of the Environment
- Pedestrian Level of Service
- Pedestrian Level of Traffic Stress

All of the selected measures described in the fact sheets are fundamental to network quality assessments. The other types of connectivity analyses (network density, completeness, route directness, and access to destinations) can be conducted by assessing existing or planned network conditions without developing the quality-related measures presented in these fact sheets. The data collected and analyzed for these measures can, however, significantly enrich an agency's ability to make fully informed transportation investment decisions.

The connectivity measure fact sheets are organized similarly to the connectivity analysis method fact sheets, with slight variations to incorporate more in-depth discussions of elements such as inputs, outputs, and relevant research. Topics addressed in each fact sheet include the following:

- **Key Question(s):** Which specific question(s) does this measure address?
- **Description:** What are some key characteristics of this measure?
- **Example Planning Application(s):** What types of planning exercises and scales are best suited to this measure?
- **Typical Data:** What types of data are typically required to develop this measure?
- **Advantages:** What makes this measure useful and/or relatively easy to conduct?
- **Considerations:** What are some important things to be aware of when developing and applying this measure to an analysis?
- **Peer Applications:** Where has this measure been applied? The fact sheets provide a few selected examples from the array of agencies that have computed the measure.

CONNECTIVITY ANALYSIS METHOD

NETWORK COMPLETENESS

How complete is the planned bicycle and pedestrian network?

DESCRIPTION

A network completeness analysis reveals either the proportion of the network with designated bicycle or pedestrian facilities, or the extent to which the planned bicycle or pedestrian network has been built out. In the first case, it captures the availability of the street network for bicycling and walking. Completeness may be usefully compared between stages of build out. When measuring only the percent of a planned network that is built, this method assumes that the design of the planned network is built on robust community and stakeholder input and analyses of existing conditions.

EXAMPLE MEASURES

- Percent of planned nonmotorized facility-miles that are complete
- Percent of street-miles with designated nonmotorized facilities
- Percent of street-miles that meet level of service, low-stress, or accessibility thresholds

EXAMPLE PLANNING APPLICATION(S)

- A planned nonmotorized network designed with a high level of consensus-building and rigorous analysis. These measures are most meaningful when they are tracking the completion of a system that represents all stakeholders' vision and closes key gaps in connectivity.
- Details on what type of facilities are planned in each location (and the data to track whether those facilities are being built). It is best if agencies track not only whether they are building facilities in planned locations, but also whether these facilities meet the standards in the plan. This helps avoid questions such as "does it count if we put shared lane markings in a location where the plan calls for a separated bike lane?"

TYPICAL DATA

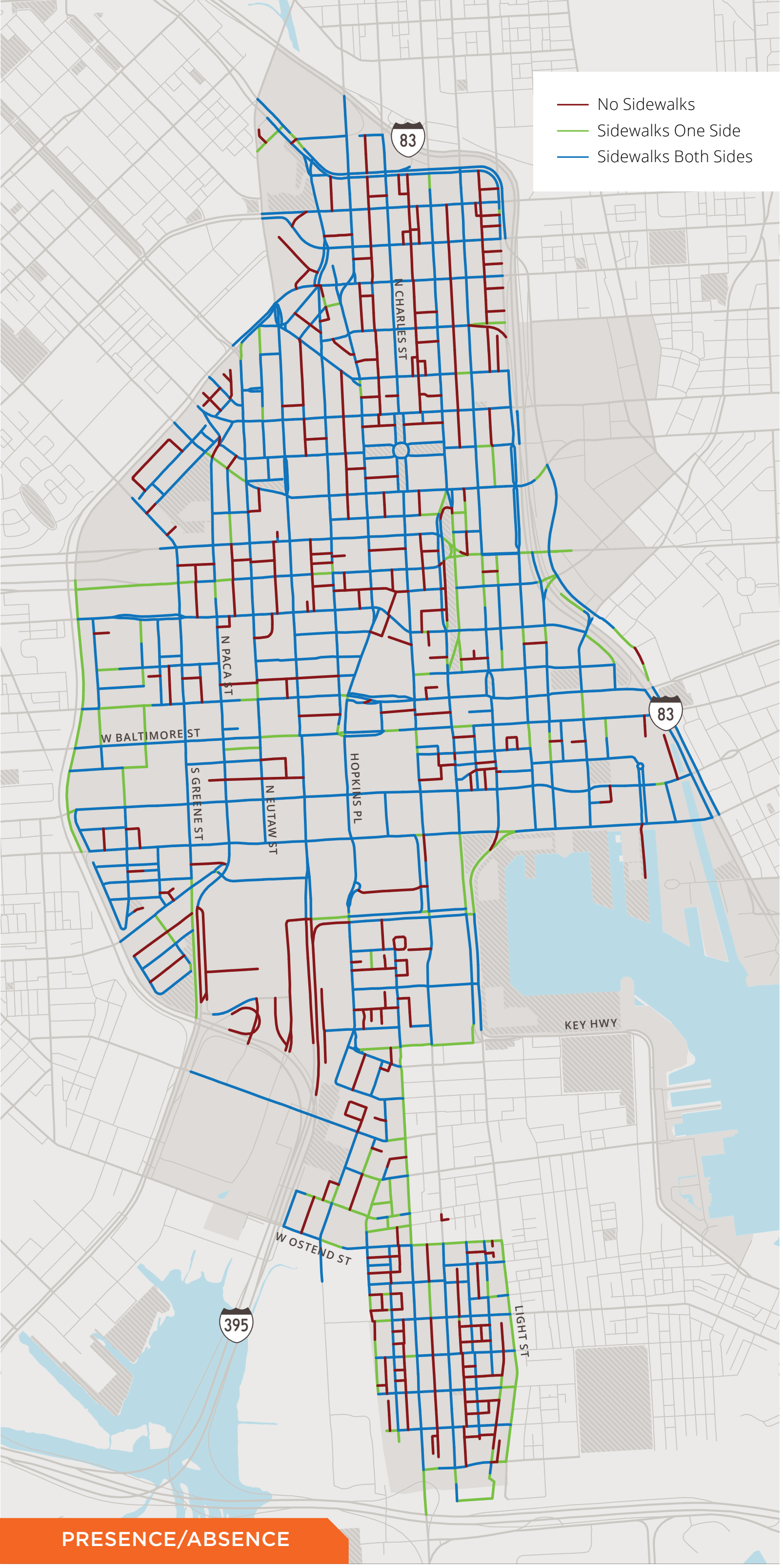
- Shapefile of planned nonmotorized facilities
- Shapefile of current nonmotorized facilities
- Centerline street network

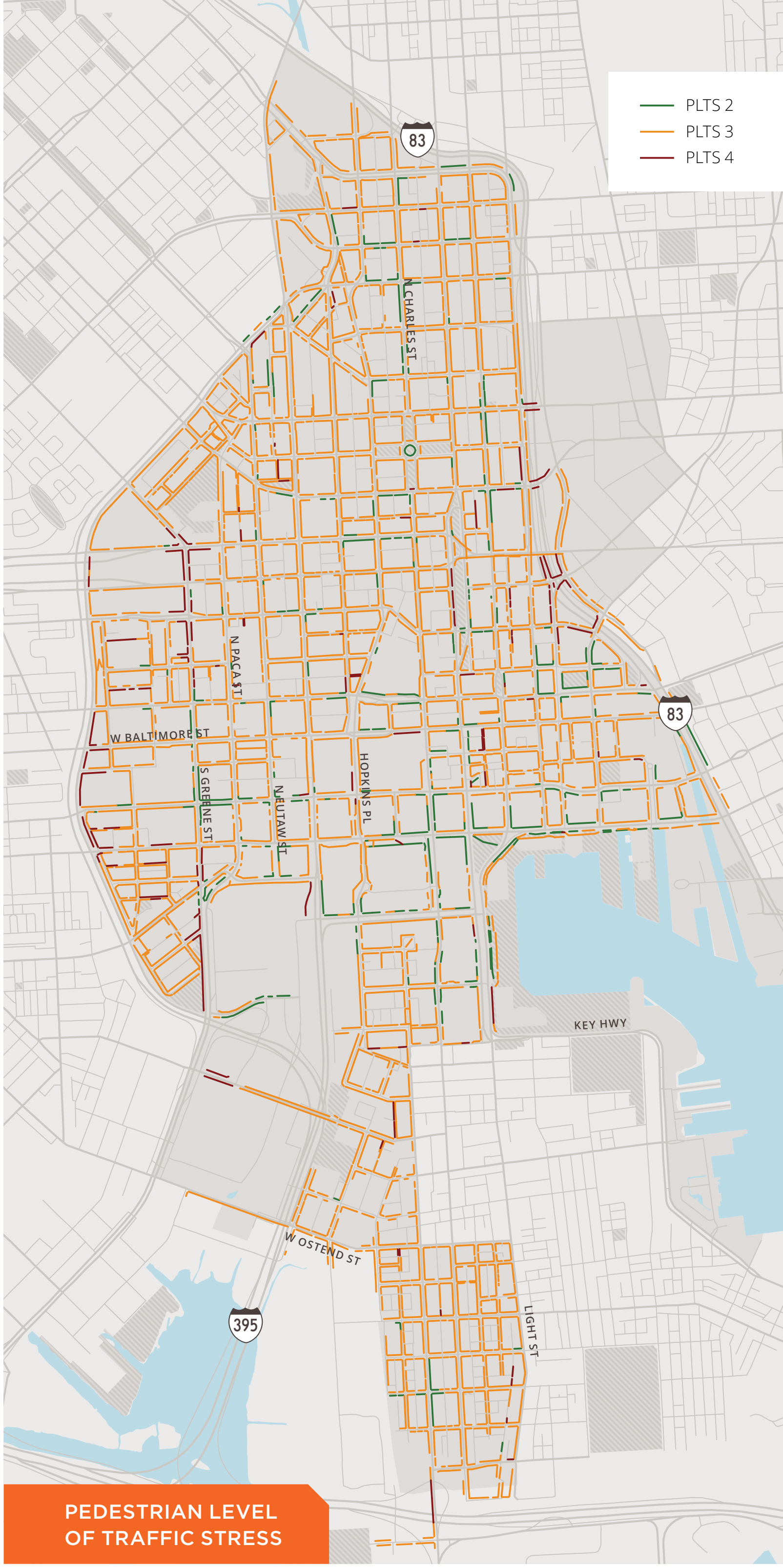
ADVANTAGES

- The data are relatively available or easy to collect
- The metrics are easy to communicate
- Tracking metrics over time can illustrate progress towards a goal

CONSIDERATIONS

- The value of the analysis for identifying gaps increases as network completion approaches 100 percent; results may not be as meaningful for sparse networks that have more gaps than facilities
- The apparent level of network completeness may decrease if the definition of "network" changes or if the analysis compares current conditions to a newly expanded planned network
- Network completeness is not easily comparable from one area to the next, as there is no standard definition of a bicycle or pedestrian network





PEER APPLICATION: **BALTIMORE, MD**

The Baltimore case study assessed the level of completeness for sidewalks within the downtown area based on several different metrics. The analysis first considers presence or absence of sidewalks, regardless of quality, based on neighborhoods and roadway type. However, in areas with built-out networks, completeness can be measured instead based on the completeness of high-quality (or low-stress) facilities.

CONNECTIVITY ANALYSIS METHOD

NETWORK DENSITY

Does the multimodal network provide a variety of direct route options for those who travel by bike or on foot?

DESCRIPTION

Network density measures assess whether the street grid provides options for travel between locations for people who walk and bike. Research shows that areas with high street density have higher rates of walking and lower rates of driving. More dense networks are also more resilient – a closure of one street will be less likely to inhibit travel.

EXAMPLE MEASURES [1]

- Intersection density
- Connected node ratio
- Block length
- Network density (street-miles per square mile)

1 *https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/*

EXAMPLE PLANNING APPLICATION(S)

- To evaluate minimum intersection density standards for new development
- To consider access management standards for spacing of local streets or limitations on cul-de-sacs

TYPICAL DATA

- Centerline street network

ADVANTAGES

- The data required to measure network density can be simple and can consider presence or absence of facilities
- Network density is widely applied in research to measure how the built environment supports bicycling and walking
- This method is particularly appropriate to walking. Agencies are less likely to have detailed data on the pedestrian network than on the bicycle network, and pedestrian trips are shorter than bicycle trips and more likely to make use of all streets as opposed to streets with designated facilities.
- Density is a useful measure of the potential of the street network to support biking and walking

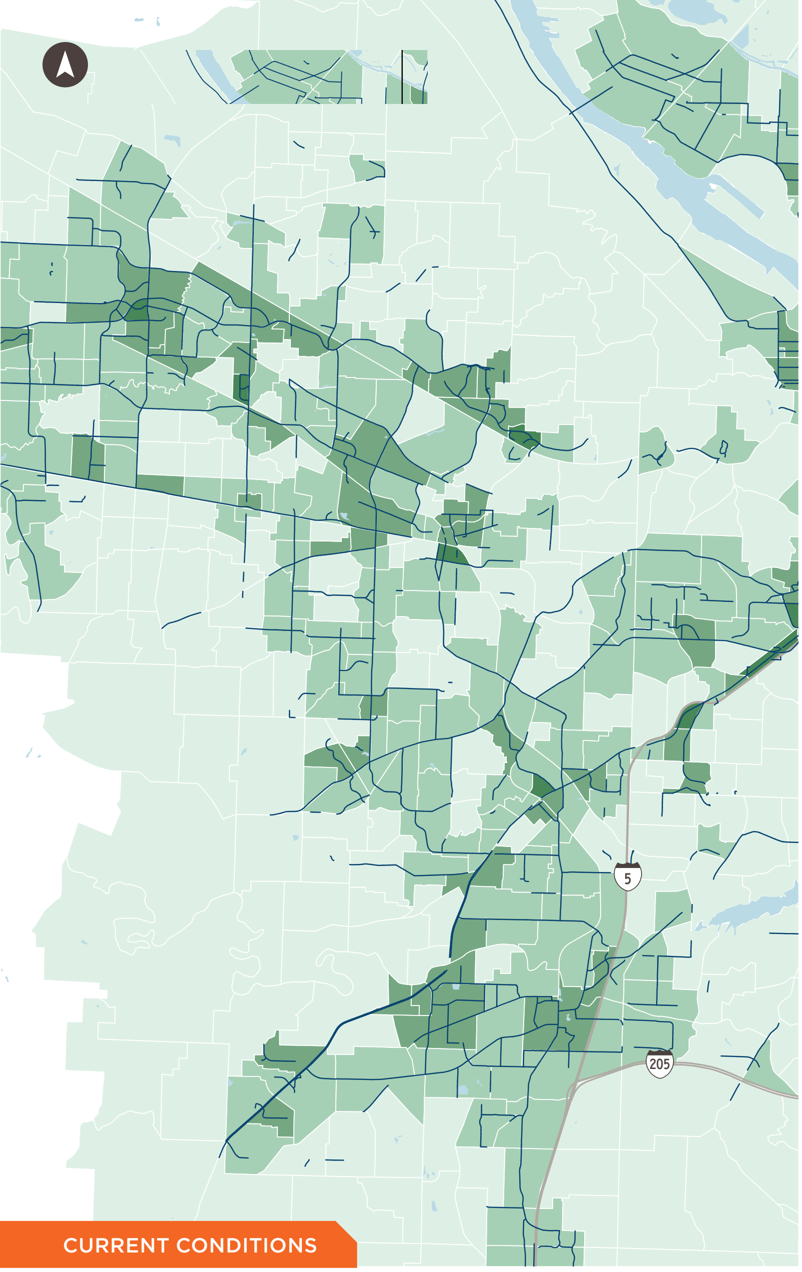
CONSIDERATIONS

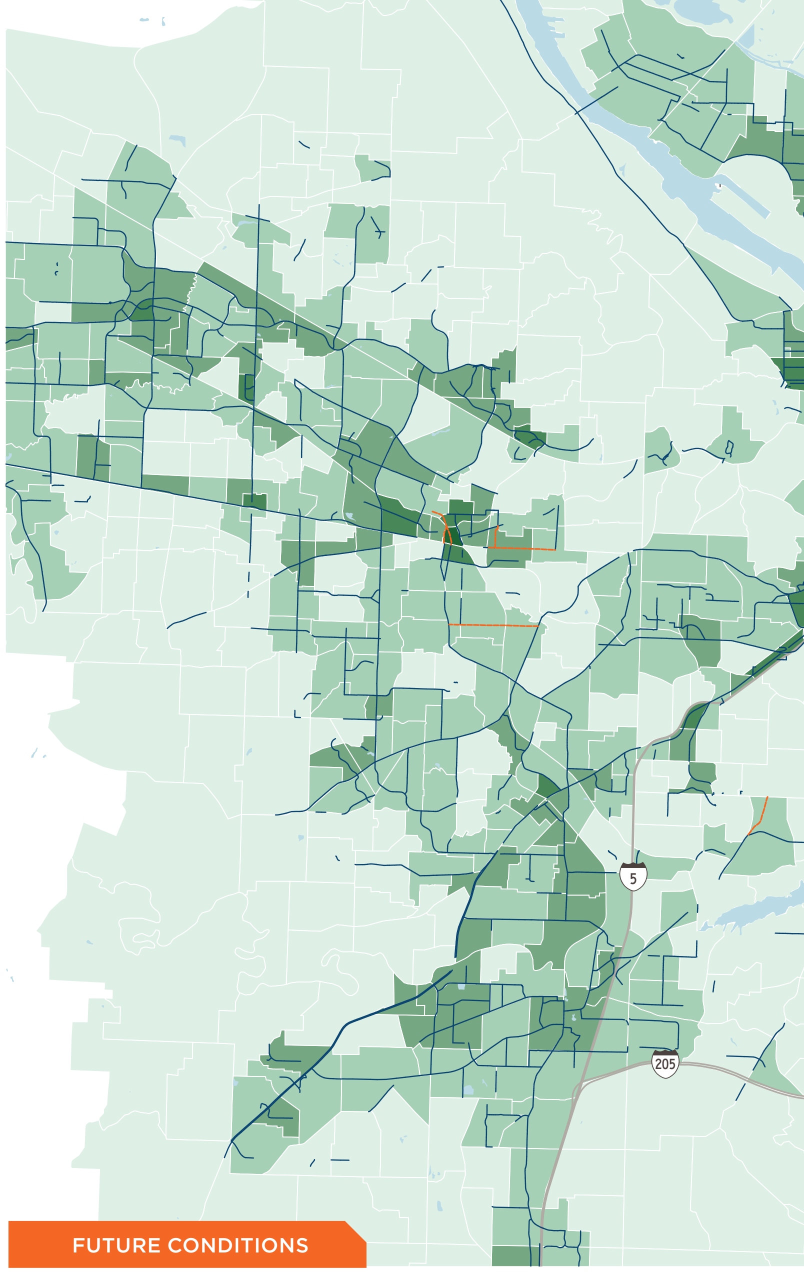
- If network quality is not considered, the density metrics reported assume that all network links are of adequate and equal quality, which can produce false assumptions about how well people that walk and bike are accommodated
- Using a density method without other metrics can report in resulting of false need. For example, parks may be reported as areas of high potential demand and low network density.

BICYCLE AND PEDESTRIAN NETWORK DENSITY

Another way to calculate this measure is to examine only the available bicycle and pedestrian network. This requires some additional data on the bicycle and pedestrian network, but shares the same features as the broader street density measure.

One additional advantage of this measure is the ability to compare the density of bicycle and pedestrian facilities to the broader street network (e.g. for comparison across travel modes) and to examine how the network varies over space (i.e. do some areas have more network available than others).





PEER APPLICATION: **PORTLAND METRO**

The Portland Metro case study assessed system density for sidewalk, bicycle, and trail networks. This application considered the difference in density between the current network and the future network based on the current ATP for both the regional scale and Historically Marginalized Communities. This assessment found that at the regional level, the impact of projects appears to be minimal, while at a more focused neighborhood level, this metric reveals greater changes.

Current Bike Facilities

Planned Bike Facilities

Greater Bike Density

Less Bike Density

CONNECTIVITY ANALYSIS METHOD

ROUTE DIRECTNESS

Do bicycle and pedestrian facilities allow users to travel throughout a community via direct routes?

DESCRIPTION

Route directness considers the variation in trip distance between the route a bicyclist or pedestrian will actually travel versus the shortest available path. Directness may be used to characterize the network in terms of obstacles impeding direct travel. This method is often used for specific destinations but can be used on a network level by computing an average score across a set of generalized origins and destinations.

EXAMPLE PLANNING APPLICATION(S)

- To develop standards for network spacing that reduce required out of direction travel

EXAMPLE MEASURES

- Out of direction travel required as a percentage of shortest path route
- Crossing opportunities[1]

TYPICAL DATA

- Shapefile of current/planned nonmotorized facilities, including a roadway network suitable for routing (i.e. topologically correct)
- Origins and destinations, including schools, residential dwellings, employment centers, recreation destinations, health facilities, and others
- Detailed network data, if stress or quality metrics are used

ADVANTAGES

- Route directness provides a more detailed analysis of connectivity for areas with more advanced bicycle and pedestrian networks
- Results can demonstrate the level of connectivity among destinations
- Results can be communicated in terms of time or distance

CONSIDERATIONS

- Network analysis may require significant data preparation and can be labor intensive, especially when completed at a large scale

1 *https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/*

PEER APPLICATION:
CALIFORNIA (CALTRANS DISTRICT 4)

Straight Line Distance

High Connectivity

Medium Connectivity

Low Connectivity

Crossing not accessible without using low quality network

The Caltrans District 4 Case Study assesses network permeability along state highways to understand the barrier that major highways may create. Permeability was assessed considering both the entire roadway network and only a low-stress network (determined by LTS) to determine the level of out-of-direction travel required to cross the highway via low-stress crossings.

CONNECTIVITY ANALYSIS METHOD

ACCESS TO DESTINATIONS

Do bicycle and pedestrian facilities connect people to key destinations?

DESCRIPTION

This measure addresses whether people can use the bicycle and pedestrian network to reach important destinations like jobs, training, shopping, or transit stations.

EXAMPLE PLANNING APPLICATION(S)

- To inform plans or policies calling for bikeable/walkable development around designated centers or transit stations. For example, the City of Portland has a policy calling for 20-minute neighborhoods in which residents can walk to grocery stores and other commercial services via high-quality pedestrian facilities. Some transit agencies have policies to prioritize bicycle and pedestrian projects within a certain distance of stations.

EXAMPLE MEASURES

- Area around specific point that nonmotorized users can access (travelshed)
- Number or percent of jobs accessible by bike/foot
- Access to community destinations[1]

TYPICAL DATA

- Shapefile of current/planned nonmotorized facilities or of high-quality routes
- Fine-scale land use data such as points, parcels, or Census blocks

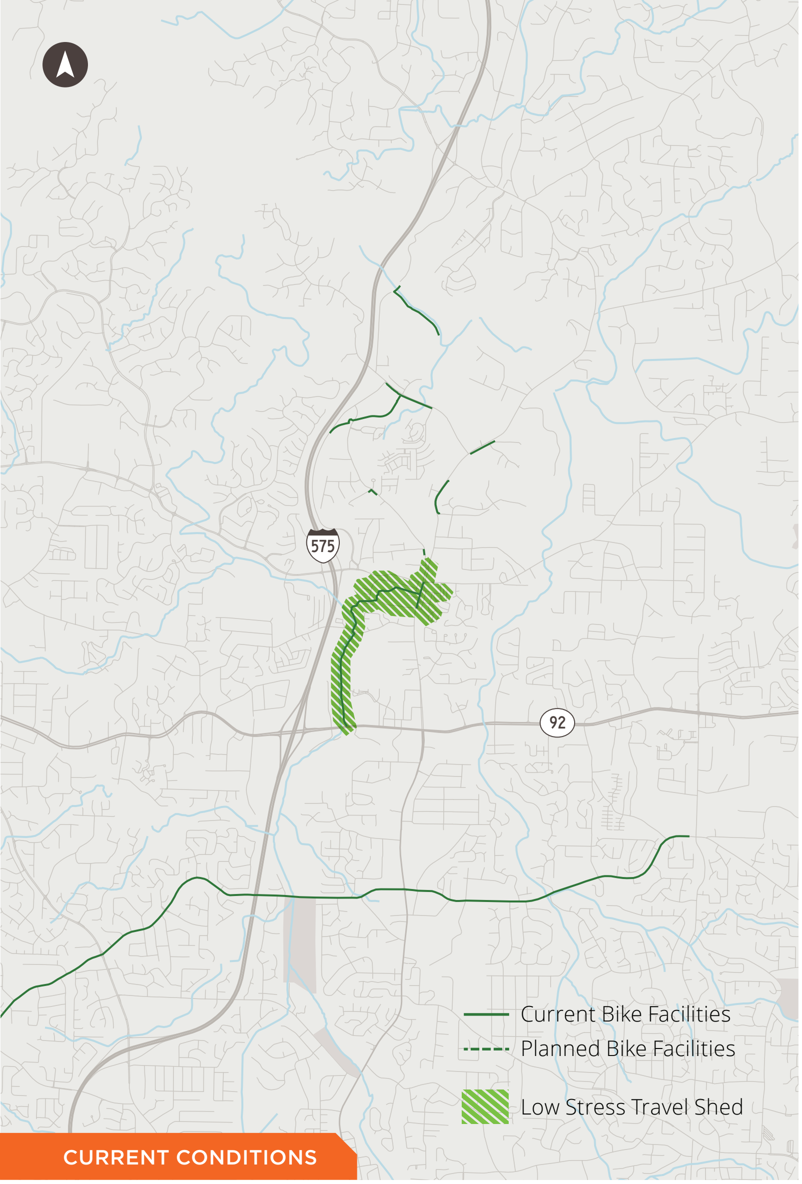
ADVANTAGES

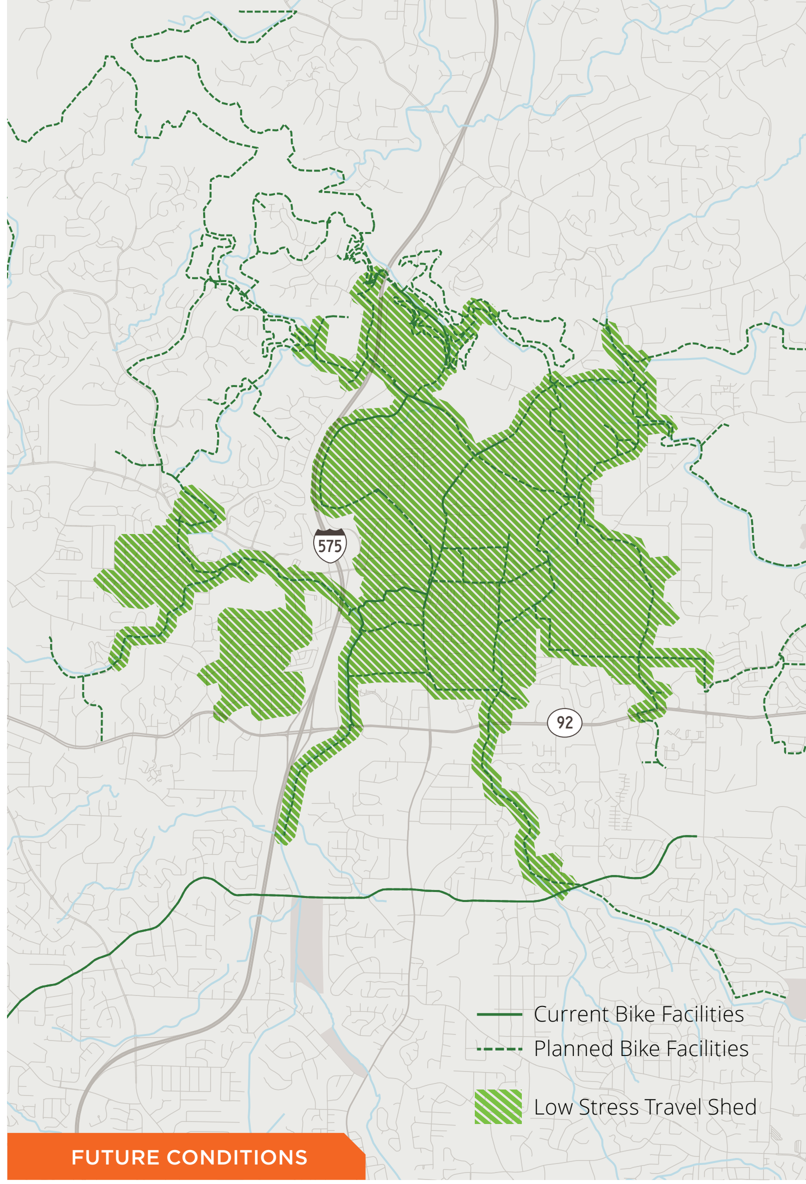
- Access to destination measures are particularly well-suited for identifying and prioritizing projects that connect to important destinations such as transit stations, because they can capture the benefits of connectivity projects at a fine scale
- While other connectivity measures focus solely on the characteristics of the network, access-related measures capture whether the network connects people to the places that they want to travel. Projects that are useful to people walking or bicycling for transportation are likely to have a greater impact on mode shift than those likely to be used only for recreation.

1 *https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/*

CONSIDERATIONS

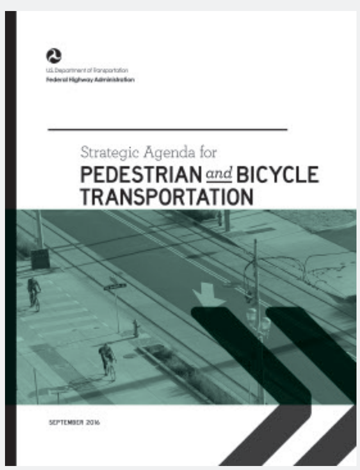
- Access to destination measures are data- and labor-intensive, requiring fine-scale land use data and sophisticated network analysis
- Careful thought must be given to the type of destinations in order to create impactful metrics
- Summarizing origins is equally important and can be just as challenging as destinations. Due to shorter average trip lengths, understanding the location and demographics of the target population is critical.
- Results can be hard for transportation agencies to interpret and act upon. There is little research on how many destinations should be accessible by bike or on foot, and relatively few examples of agencies that have conducted detailed access analyses or set access-related policies that can help agencies benchmark results. Furthermore, land use patterns have a significant impact on destination access, which tends to be higher in more compact neighborhoods with diverse uses, but transportation agencies often do not have authority over land-use decisions.





PEER
APPLICATION:
ATLANTA

The Atlanta Regional Council (ARC) case study assesses access to destinations by calculating the number of homes and jobs accessible near existing and planned low-stress networks. Travelsheds were created for each network scenario using a three-mile distance threshold and overlaid with Census Data to calculate the number of households and jobs within the travelshed.



U.S. Department of Transportation. 2016. "Strategic Agenda for Pedestrian and Bicycle Transportation." https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/strategic_agenda/fhwahep16086.pdf.

FOCUSING MULTIMODAL ANALYSES AND STRATEGIES ON THE FIRST-AND-LAST MILE

In September 2016, FHWA released the *Strategic Agenda for Pedestrian and Bicycle Transportation*. The plan sets an aspirational goal of "increasing the percentage of short trips represented by bicycling and walking to 30 percent by 2025." A short trip is defined as one mile on foot and five miles by bike. Focusing analyses and investments on the quality, density, and completeness of walking and bicycling infrastructure within walking or cycling distance of destinations can help communities achieve this goal.

NETWORK QUALITY AS A MULTIFACETED CONNECTIVITY INDICATOR

Network quality analyses enrich the other four types of analyses (network completeness, network density, route directness, and access to destinations) by enabling a more nuanced understanding of the ways in which users may experience existing and proposed networks.

Narrowing the focus of assessments of completeness, density, directness, and access to destinations to low-stress networks can reveal gaps and issues that might not be apparent when looking at the network without applying the filter of quality.

CONNECTIVITY ANALYSIS METHOD

NETWORK QUALITY

What is the quality of the users' experience provided by an existing or planned network?

DESCRIPTION

Research shows that people walking or biking are more sensitive to the physical attributes of a facility than a person driving a motor vehicle. Assessing the physical qualities of bicycle and pedestrian facilities and providing a score for each roadway and intersection (or route) can provide robust information about the user experience provided and capture the types of users that feel comfortable on specific facility types.

EXAMPLE PLANNING APPLICATION(S)

- To inform project selection by assessing the impact of different alignments, facility types, and network phasing on the experience of nonmotorized travelers

EXAMPLE MEASURES

- Level of Traffic Stress[1]
- Level of Service[2]
- Preference-based route utility or quality[3]

TYPICAL DATA

- Shapefile of existing/planned nonmotorized facilities
- Detailed roadway network data, including attributes such as number of lanes, posted speed, traffic volume, heavy vehicle use, on-street parking, intersection features, facility type, facility width, slope, pavement quality

ADVANTAGES

- Quality analyses can help to identify routes that may be particularly attractive to pedestrians and bicyclists for whom network qualities are particularly important, such as children or average-skill riders
- Developing a consistent, periodically updated measure of the quality of the network allows municipalities to better understand the impact of planned or implemented improvements
- Findings from quality analyses can be easily applied to facility design and improvement strategies
- Some measures are available that are supported by use and behavior data

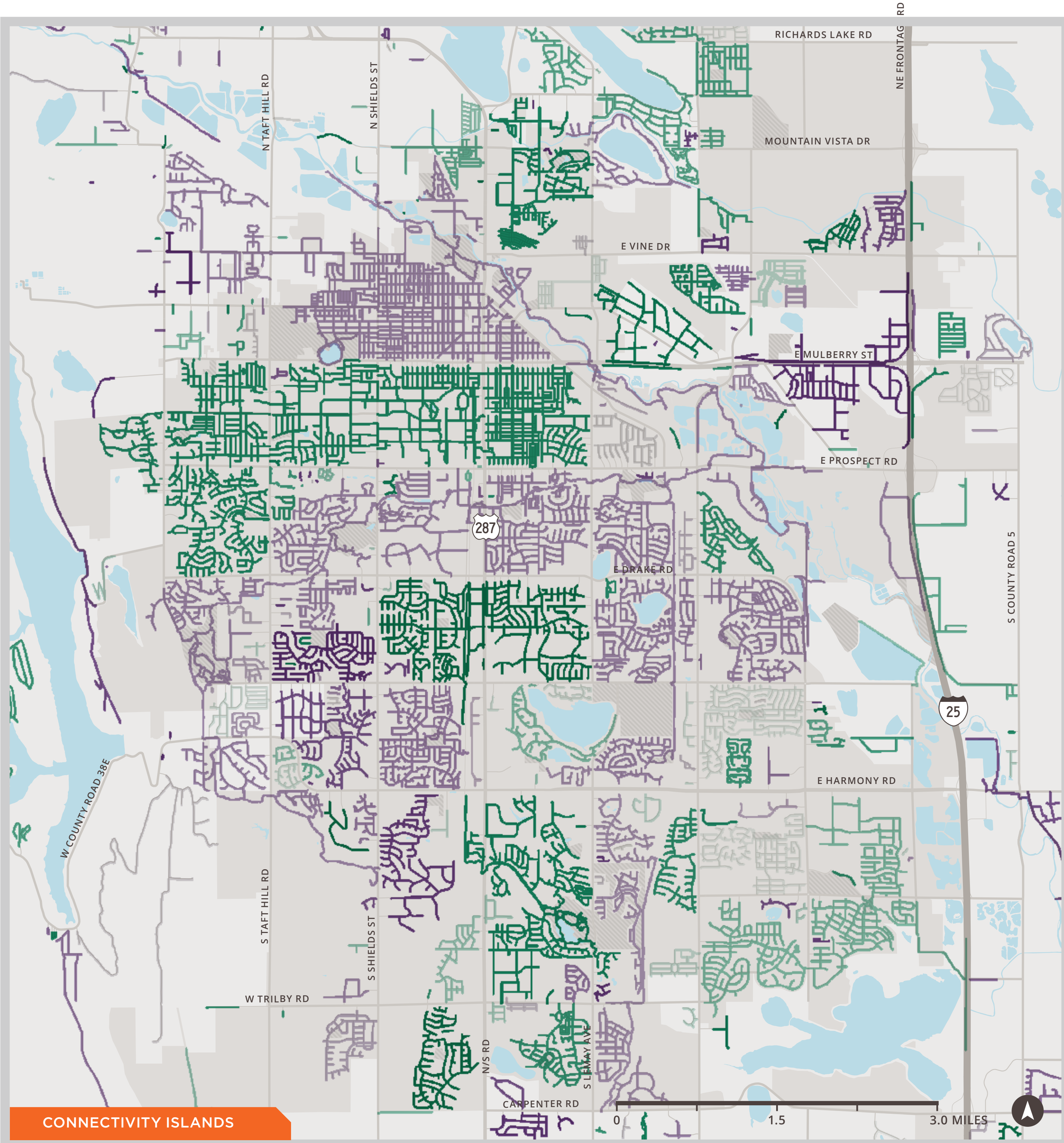
CONSIDERATIONS

- Quality analyses tend to be data intensive. Advanced applications that use measures such as low-stress network ratings are also often labor-intensive.
- Quality analyses are most useful in urban settings where networks are fairly complete and mature; assessments of sparse networks in suburban or rural areas produce less coherent information
- There are questions about the transferability of existing quality measures to different contexts. Quality measures have been developed mainly in urban settings where networks are fairly dense and mature.
- Due to data and technical challenges, quality measures are often modified to adapt to a given analysis context and available resources. While such adapted measures may still be useful, comparability and connections to supporting research will be reduced.

1 *Mekuria, Furth, and Nixon (2012); M. B. Lowry, Furth, and Hadden-Loh (2016)*

2 *Landis, Vattikuti, and Brannick (1997); Landis et al. (2001); Petritsch et al. (2008); M. Lowry et al. 2012; Foster et al. (2015)*

3 *Broach and Dill (2016); Broach and Dill (2017)*



PEER APPLICATION: **FORT COLLINS**

Note: The colors on this map are intended to convey geographic distinctions between various connectivity islands; however, the colors do not have a relative value associated with them.

The Fort Collins case study considers network quality based on both Level of Traffic Stress and Low-Stress Network Connectivity. These measures were then used to define low-stress networks for input in subsequent measures, including route directness considerations. Display methods were also explored to identify gaps in the existing low-stress network.

SPOTLIGHT ON

NATIONAL PRACTICE

The PeopleForBikes Initiative to Measure Bicycle Network Connectivity Nationwide

Table 7: *BNA Data Sources*

DATA	SOURCES
Network	OpenStreetMaps
Population	US Census
Employment	US Census LEHD
Destinations	OpenStreetMaps

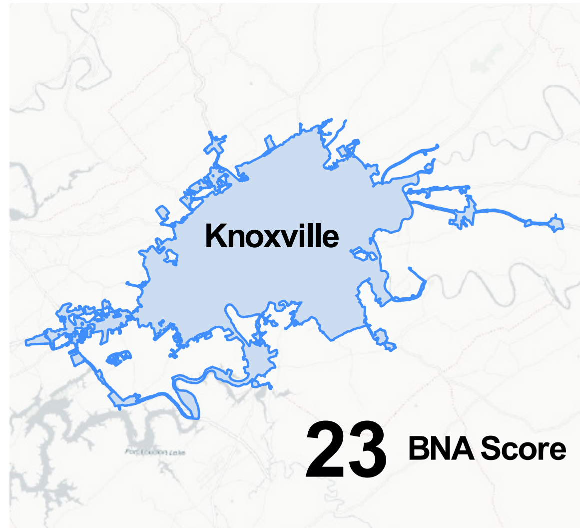


Figure 9. *Example BNA Results*

OVERVIEW

In 2016, PeopleForBikes launched a national effort to measure bicycle network connectivity as part of their PlacesForBikes city ratings. At the core of their approach is a measure of bicycle network quality based on level of traffic stress (Mekuria, Furth, and Nixon 2012). Their Bicycle Network Analysis (BNA) tool applies the stress network to a basket of destinations meant to cover most everyday travel needs. Origins and destinations are considered connected if they are within about 10 minutes by bicycle (one and two-thirds miles) via a low-stress connection requiring at most a 25% detour.[1] The maximum stress level chosen is meant to appeal to a broad range of typical adults.

Based on the number of destinations reachable in different categories, scores from 0 to 100 are assigned to each census block origin. The scores have also been aggregated to city level (on the same 0 to 100 scale) by weighting each block score by population. Figure 9 shows examples of network, block, and city level scoring. Scores were initially tabulated for nearly 300 cities.[2] The source code is publicly available.[3]

1 *https://bna.peopleforbikes.org/#/methodology*

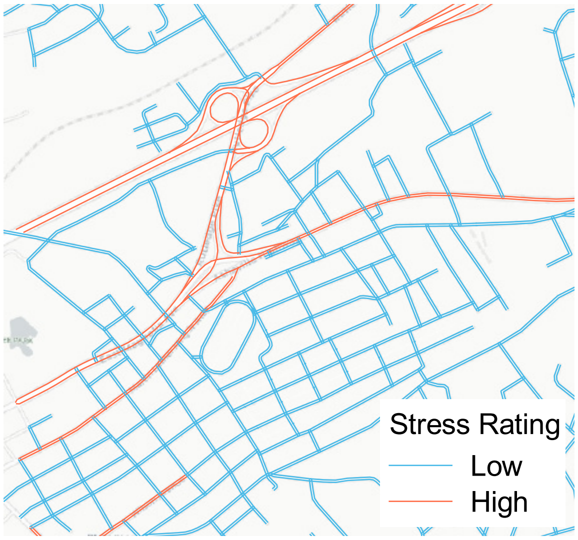
2 *http://peopleforbikes.org/blog/we-scored-the-bike-networks-in-299-u-s-cities-heres-what-we-found/*

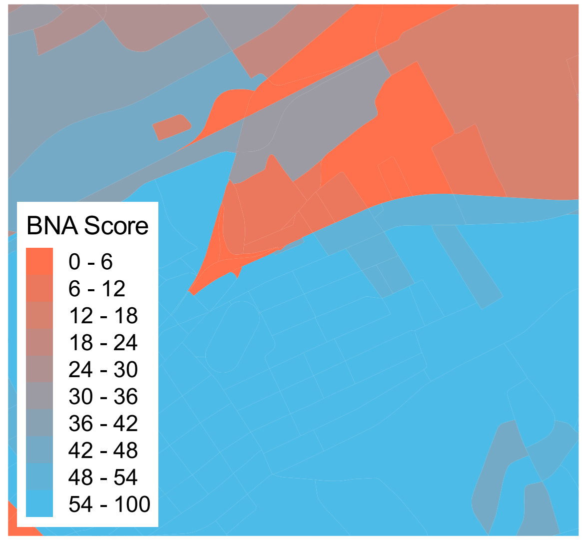
3 *https://github.com/azavea/pfb-network-connectivity*

DATA

The BNA tool relies on network, population, and destination data from OpenStreetMaps (OSM) and the US Census Bureau (Table 7). Specific network data used to calculate stress level include the following attributes:

- Functional class
- Speed limit
- One-way traffic (car and bike)
- Roadway width
- Bike infrastructure (width, direction)
- Number of lanes (by direction)
- Number of intersection crossing lanes (by direction)
- Street parking (by direction)
- Center turn lane presence
- Intersection treatments such as median islands and traffic signals





From left: Network Segments, Census Block, and Citywide

Destinations are measured across six major categories comprised of 16 sub-categories, including indicators such as the following:

- People (population)
- Opportunity (jobs, education)
- Core services (health/medical, grocery)
- Recreation
- Retail
- Transit

Destination access is scored based on both the number of destinations that can be reached in each subcategory, as well as the ratio of places reachable along low- versus high-stress routes.

As shown in Table 7, much of the data comes from OSM, a crowd-sourced, public database of street network and place data. Data quality and coverage varies by location, and PeopleForBikes has encouraged cities to update and improve local data by providing an OSM editing toolbox for commonly used ArcMap GIS software.

RELEVANCE TO THIS GUIDEBOOK

PeopleForBikes' BNA tool represents an important effort to make connectivity analysis available to a wide audience and to simplify and standardize data and measurement. Although PeopleForBikes cautions that the scores and methodology are preliminary and subject to errors and future modifications, the tool is an exciting new option in the connectivity landscape.

This guidebook explains how a measure such as BNA is chosen, constructed, and applied, while situating it within the broader spectrum of techniques available to measure pedestrian and bicycle networks.

CONNECTIVITY MEASURE

BICYCLE LEVEL OF SERVICE (BLOS)

How well does network infrastructure support bicycle travel, including interaction with other modes, based on perceived bicyclist comfort levels?

MODE	METHOD	OUTPUTS	CONNECTIVITY ANALYSIS METHODS	ACCESSIBILITY	USE IN PRACTICE	LEVEL OF EFFORT
Bicycle	Inputs entered into weighted formula; GIS tool available to make calculations easier	Numeric scores converted by formula to a six-point scale (A through F)	Quality	Explicit consideration of accessibility for people with disabilities: **No**	Common among agencies with strong interests in multimodal planning	LOW

DESCRIPTION

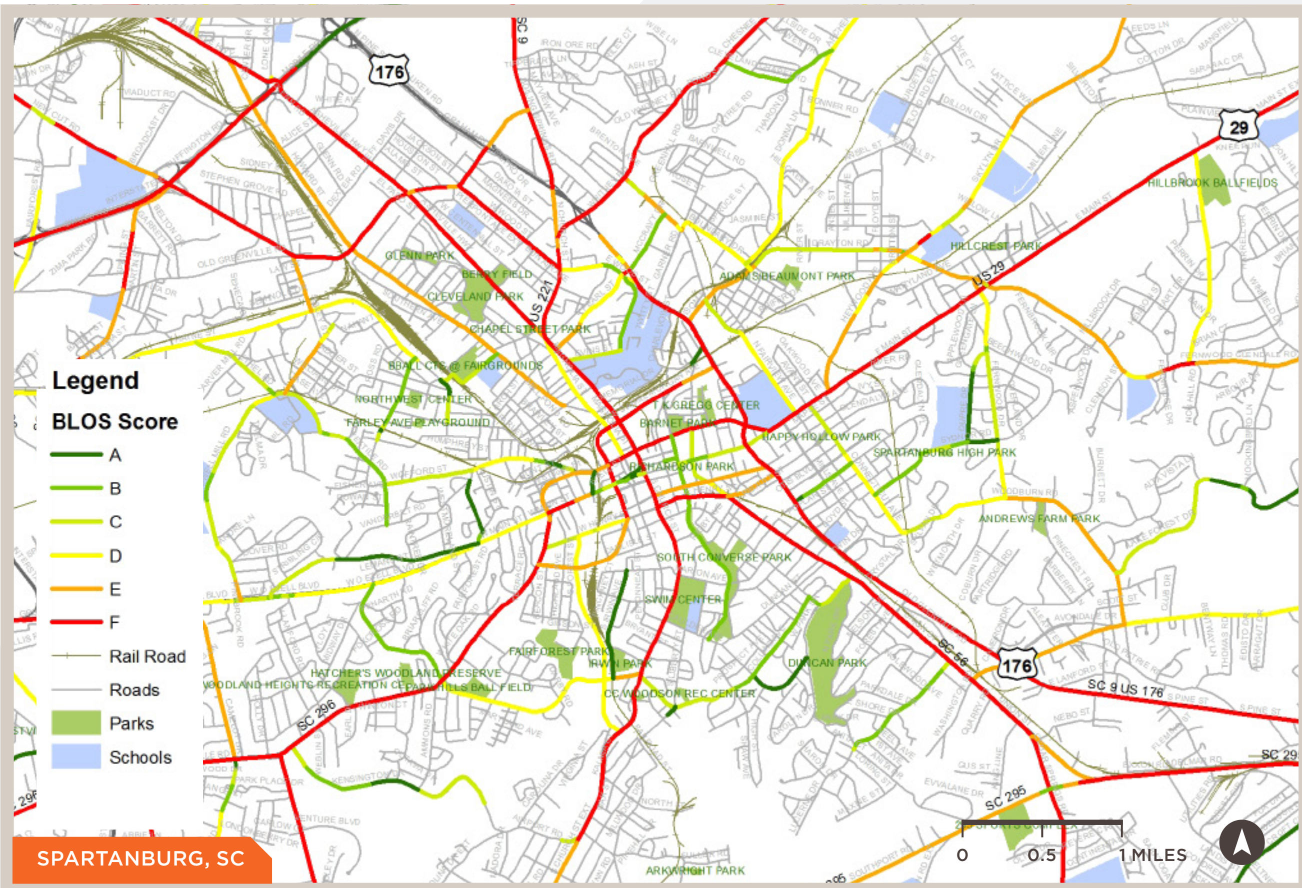
Bicycle LOS (BLOS) indicates the overall quality of the network in terms of bicyclist comfort levels. BLOS is an adaptation of a standard measure of motorized road quality. The initial research was supported by a stated preference study of a broad range of facility attributes (Landis, Vattikuti, and Brannick 1997), with additional stated preference data incorporated into an updated version (Petritsch et al. 2008). Additional research has extended BLOS to include separated (protected) bike lanes (Foster et al. 2015). The original link quality measure has been extended into a measure of connectivity by using BLOS as a link weight in order to solve routes between sets of origins and destinations (Lowry et al. 2012). Bicycle LOS is also referenced in the Highway Capacity Manual (HCM).

EXAMPLE PLANNING APPLICATION(S)

- Can be used to assess the potential impacts of changes such as building or removing a major facility on an area-wide network
- Not generally useful for subarea analyses of specific links or corridors such as local streets, paths, trails, or protected bike lanes, nor for individual project development plans

TYPICAL DATA

- Roadway centerline and characteristics, including number of lanes, shoulder width, outside lane width, posted speeds, pavement condition, presence of curb, on-street parking (including percent occupied)
- Motorized traffic data, including speed, volume, percent heavy vehicles
- Bicycle lanes, including width
- Defined set of destinations or origin/destination zones



Source: City of Spartanburg. 2009. "Spartanburg Bicycle & Pedestrian Master Plan." http://www.cityofspartanburg.org/planning-zoning/bicycle-ped-plan/.

PEER APPLICATION

- Florida Department of Transportation: LOS standards are used in the review of actions that directly impact the State Highway System for all planning and permitting processes; methods are outlined in the Quality/Level of Service Handbook (2013)
- Spartanburg, SC: The City Bicycle & Pedestrian Master Plan (2009) utilizes a Bicycle Level of Service measure to help identify the bicycle network updates
- A variety of large and mid-size agencies assess BLOS, including the Memphis MPO, Community Planning Association of Southern Idaho (COMPASS), City of Winston-Salem, NC, and Omaha-Council Bluffs Metropolitan Area Planning Agency (MAPA)

ADVANTAGES

- The outputs are similar to vehicle LOS, which is widely used and understood
- The tools are endorsed by the Highway Capacity Manual (HCM)
- It captures the quality of facilities, with a strong focus on the extent to which vehicle traffic and parking makes cyclists feel unsafe
- Despite relatively high data requirements, BLOS has been a popular measure in planning practice. It is supported by the original stated preference data and a version has been included in the HCM. A number of versions (many simplified) have been developed across a range of planning applications, mostly related to documenting existing conditions, identifying connectivity gaps, and evaluating network-wide quality.

CONSIDERATIONS

- The tool is data-intensive
- Trails, pathways and separated bike lanes are not assessed
- The standard version of the tool is not designed to be used at corridor-scale
- The letter-grade scale has not been validated with user or behavior data
- Intersection conditions are not evaluated

CONNECTIVITY MEASURE

BICYCLE LEVEL OF TRAFFIC STRESS (BICYCLE LTS)

What is the extent to which bicyclists feel safe and comfortable using the network, particularly on streets where they share space with motorized traffic?

MODE	METHOD	OUTPUTS	CONNECTIVITY ANALYSIS METHODS	ACCESSIBILITY	USE IN PRACTICE	LEVEL OF EFFORT
	Classify roadway links by type by highest stress attribute	Traffic stress rating of 1 through 4 for street segments and intersection	Completeness, Density, Directness, Accessibility to Destination, Quality	Explicit consideration of accessibility for people with disabilities: **No**	Common	MODERATE

DESCRIPTION

Measures and rates traffic stress for street segments and intersections, based on different types of cyclists' presumed comfort level near motor vehicle traffic. The components of the network are scored on a four-point scale relating to user types and confidence levels. Links and intersections are classified based on their most stressful feature, and routes are classified by the most stressful link or intersection between a given origin and destination.

Bicycle Level of Traffic Stress (Bicycle LTS) is based on the concept of the maximum level of traffic stress that will be tolerated by specific groups of existing and potential cyclists (Mekuria, Furth, and Nixon 2012). The classification scheme is loosely based on both the Types of Cyclist (not interested, interested but concerned, enthused and confident, and strong and fearless) line of research from Portland, Oregon (Dill and McNeil 2013), and also on Dutch age-group based bicycle facility planning standards. Most analysis has focused on LTS 2, a level thought to be acceptable to many interested adult cyclists. The Bicycle LTS measure is extended to capture connectivity through route selection and maximum detours using approximations from empirical studies of cyclist route choice.

EXAMPLE PLANNING APPLICATION(S)

- To identify problems and develop strategies to improve the users' perceived and actual experience, particularly in situations where multiple modes share a common facility
- To compare the availability and directness of low-stress routes to all possible routes on the street network

TYPICAL DATA

- Roadway centerline, including number of lanes and posted speed
- Bicycle infrastructure, including type and width
- On-street parking presence, including width
- Signalized intersections
- Turn lane locations and length
- Not recommended for locations with limited, incomplete, or inconsistent data
- Planners should consider adjusting the user type definitions in an LTS model to reflect the demographics of riders relevant to a specific planning context