STEP 3

ASSEMBLE THE DATA

Once the purpose of the analysis is clarified and the method is selected, it is time to assemble data, which includes spatial definitions of the bicycle and pedestrian network(s) as well as the data required to rate the components of the network using one or more measures (Step 4), and then to aggregate, summarize, and visualize the results (Step 5), potentially overlaying other data, in order to inform the key planning questions and analysis goals (Step 5).

The process illustrated in Figure 4 and in the following discussion represents a simplified, linear version of Steps 3 to 5. In practice, the process will be iterative, and multiple metrics may be applied in the same analysis. The Fort Collins case study example started with a broad network of all links open to bicycling, measured connectivity at the link level using a measure of traffic stress, and then used the results to narrow the analysis network to only those segments meeting a minimum quality threshold. The reduced network was then used in three additional steps to identify gaps (via map visualization), access to schools (via route directness scores), and link importance (via a link centrality metric). The Fort Collins example highlights the way that a single metric (level of traffic stress) can be summarized and overlaid in different ways to address planning questions in a larger connectivity analysis framework.

NETWORK DATA

Central to every connectivity analysis is the mapping of the network. The output of this step is a defined network consisting of a set of links and nodes as well as data on the attributes required by the selected technique. The building blocks of connectivity are the links (street or trail segments) and nodes (intersections or junctions) that define the bicycle and pedestrian network, as well as attributes that describe the facilities on and characteristics of each link and node.

Key considerations when defining the network include the following:

- Results are only informative to the extent that they measure the "right" network—the one that bicyclists and pedestrians are likely to use in real life
- Defining the network can be challenging because agencies often have only limited data on bicycle and pedestrian facilities. Developing the necessary data is a key step to defining the network.
- Often, this will be an iterative process, and either analysis goals, network definitions, or methods may need to be modified to fit available data and resources

The choice of which links, nodes, and attributes to include is jointly determined by a selected measure's requirements and the planning question or application at hand. In some cases, an agency might choose to include only links within its jurisdiction or planning process (e.g. only state-owned roadways for a state DOT, or bicycle facilities in the Regional Transportation Plan); however, depending on the question, other facilities may need to be considered where they interact with the selected system. For example, an analysis of state highways might consider where local bikeways and walkways interact with state highways. Similarly, a local analysis might consider where state-owned highways present barriers to connectivity. In the Portland Metro

SMALL CONNECTORS CAN MAKE A BIG DIFFERENCE

Networks based on designated facility types might seem simple on paper, but complications arise in practice. For example, different ways of classifying certain facilities can make a difference in the final assessment of connectivity. Portland Metro evaluated questions such as the following when deciding which facilities to include in its base network for the connectivity analysis conducted as part of the research for this guidebook:

- Should some or all off-street trails be included when calculating network completeness or density metrics?
- What about unimproved alleyways that add many miles of network but are unlikely to have designated bicycle or pedestrian facilities?

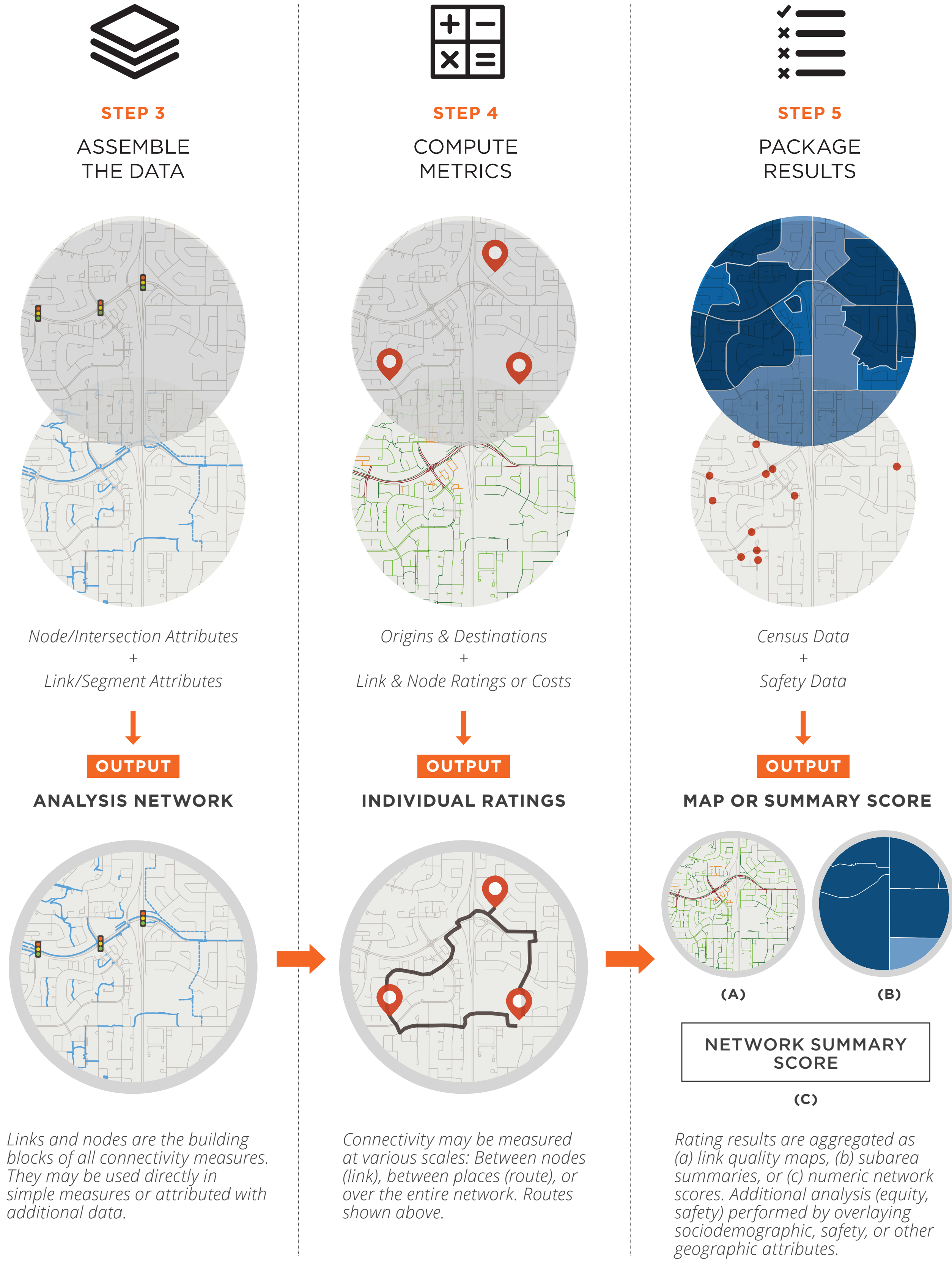
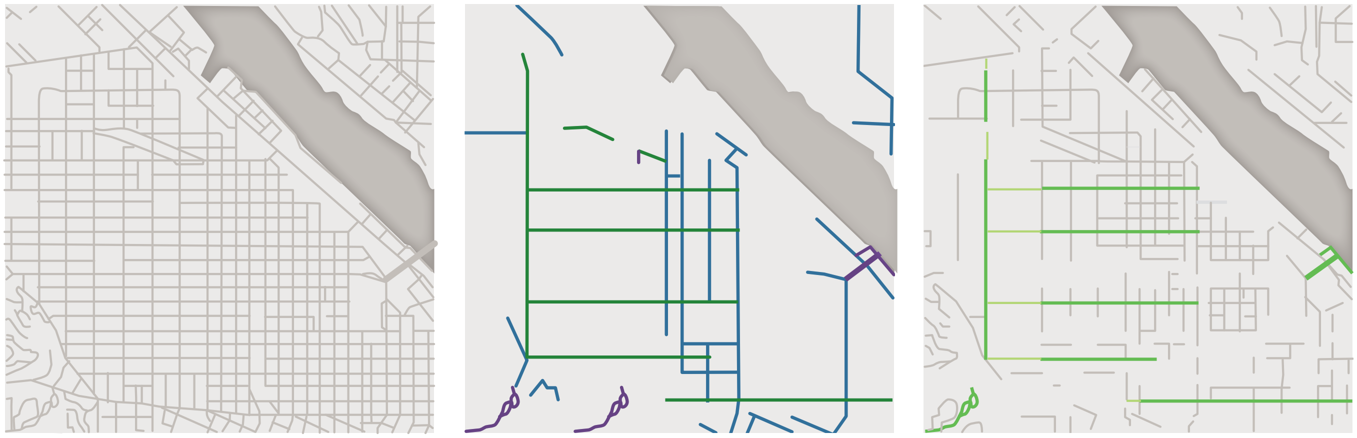


Figure 4. *Illustration of Steps 3-5*

***Figure 5.** Network Representation*



From left to right: All streets network; Facility-based (line color showing different facility designations); Quality-weighted (line color showing different quality levels for links meeting some minimum quality/ maximum stress threshold)

case study example, the lack of future local facilities that were not in the RTP network was identified as a limitation of the resulting analysis. Ideally, the analysis network will closely match the one actually considered by pedestrians and bicyclists.

Some measures are only defined or suited for a specific subset of links, such as arterial streets (e.g. Bicycle Level of Service), links with sidewalks (e.g. Sidewalk Density or Completeness), links with designated bicycle facilities (Bicycle Network Density or Completeness), or links where walking or cycling is permitted (Route Directness Index). Other measures, particularly simple, form-based measures such as intersection or link density, connected node ratio, or similar, can be applied to all streets. While it is unreasonable to assume that all streets are equally suitable for bicycle and pedestrian travel, it is also important to note that cyclists and pedestrians are not limited to streets with designated facilities. Fifty to ninety percent of cycling in the U.S. has been found to take place on streets without separate space for cycling; that is, in mixed traffic (Buehler and Dill 2016). Priority or low-stress networks often include both links with facilities and links with low traffic or slower vehicle speeds.

To date, node (intersection) attributes have been applied less frequently to bicycle and pedestrian network analyses, but their importance to connectivity is increasingly recognized (Buehler and Dill 2016). An otherwise high-quality bicycle or walking facility will be of limited use if there is a major barrier along the route, such as an unsignalized crossing of a high traffic volume street.

As noted in the call-out box on network data sources on the following page, some information, such as crowdsourced data or commercially produced inventories, change rapidly, so practitioners should check them frequently for updated content and availability.

NETWORK TYPES

Analysis networks are typically defined as either facility-based or quality-weighted networks:

- **Facility-based networks** are defined as networks that typically consist of designated bicycle and pedestrian facilities but may sometimes include all streets open to walking and bicycling. These may be separated facilities for nonmotorized users, or shared facilities that have been designed to accommodate pedestrians and/or bicyclist as well as other users.
- **Quality-weighted networks** are defined using an objective rating system for links and nodes that accounts for the quality of the facility. After scoring, the rated network can be used in further analysis, or a minimum rating threshold can be applied to create a restricted network for analysis. For example, a low-stress network might include only segments assumed to be safe and comfortable for bicyclists of a certain ability level or age, based on a maximum Level of Traffic Stress (LTS) rating or similar.

Figure 5 illustrates three representations of the same underlying network: an all-streets network that only omits facilities where walking and cycling are prohibited; a facility-based network of designated multimodal systems; and a quality-based network of facilities that exhibit certain desired characteristics such as low Level of Traffic Stress ratings. The connectivity within a given study area appears quite different depending on the decision of which networks to include in the assessment.

NETWORK DATA SOURCES

Publicly available data: Most of the data required for bicycle facilities analysis must be collected by transportation agencies. However, the following data sources can be used to supplement agency data, subject to coverage and availability:

- **OpenStreetMap (OSM):** A crowd-sourced map that includes some information on bicycle facilities and street characteristics. Coverage may be limited, and most attributes are not required. Data completeness and quality will depend to a large degree on the extent to which local agencies and community members provide data and updates.
- **Census TIGER/Line:** Generally, the most complete publicly-available source of street network data.
- **Highway Performance Monitoring System/All Roads Network of Linear Referenced Data (HPMS/ARNOLD):** Supported by state DOTs, FHWA maintains geographic databases of all state and federally owned roads (HPMS) and is developing a standard submission and update process for all public roads (ARNOLD). HPMS data includes traffic volume and number of lanes, among other items.
- **State DOT data:** In addition to submissions to ARNOLD, most states maintain additional attributes on roads within their jurisdiction and sometimes local roads as well.
- **Privately developed data from proprietary sources (e.g. HERE/TomTom, NAVTEQ):** Can provide additional data on roadway characteristics such as number of lanes, traffic volumes, and speeds, but proprietary algorithms and rapidly evolving data and practices can make it challenging to know what data can support analysis.

	OSM	TIGER/LINE
Nonmotorized facility location and type	(✓)	
Basic street network centerlines	✓	✓
Roadway functional classification	✓	✓
Traffic speeds	(✓)	
Number of lanes	(✓)	
Shared Use Paths	✓	
Intersection attributes	(✓)	

(✓) *Indicates attributes that are not required or less likely to be available*

The table above summarizes the data that may be included in two of the sources with greatest coverage and availability. As noted above, attributes from state DOT databases may help to enrich the national data sets. Data from all of these sources typically require additional processing to support network routing.

DATA STANDARDIZATION

To allow for application of connectivity measures, agencies should use consistent standards for all bicycle and pedestrian network data, including:

- Consistent facility types and attributes
- Consistent reference geographies

Agencies do not always use the same detailed standards to map and classify planned bicycle and pedestrian facilities that they use when mapping the current network, because projects may not be planned to a high level of detail. Promoting consistent standards can be especially challenging for regional and state agencies, which often rely on local agencies to supply data on planned bicycle and pedestrian projects.

Facility-based Networks

Defining networks by facility type is a common approach. For some simple, form-based measures, it may be appropriate to include all parts of a network that allow bicycling and walking. Distinguishing facility types in more detail gives agencies the ability to exclude inadequate facilities from their networks and conduct more meaningful connectivity analyses. For example, shared lane markings or even conventional bike lanes on higher speed or higher volume streets may be considered inadequate for most bicyclists. Table 4 provides a list of facility types and definitions that can be used to help define network elements and characteristics.

Quality-Weighted Networks

Quality-weighted network definitions, such as Level of Service (LOS) or Level of Traffic Stress (LTS), rate or quantify the quality of links and intersections based on separation from motor vehicle traffic and other attributes by applying standardized weighting schemes.

- **Level of Service models** have been developed primarily from stated preferences for different facility configurations (Landis, Vattikuti, and Brannick 1997; Landis et al. 2001; Petritsch et al. 2008; Foster et al. 2015). Mirroring motor vehicle LOS ratings, bicycle and pedestrian LOS ratings generally apply to major streets (arterials and above) and rate

Table 4: *Bicycle and Pedestrian Network Facility Types*

FACILITY TYPE	DEFINITION
Sidewalk	That portion of a street or highway right-of-way, beyond the curb or edge of roadway pavement, which is intended for use by pedestrians*
Sidepath	A shared use path located immediately adjacent and parallel to a roadway*
Shared Use Path	A bikeway physically separated from motor vehicle traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way*
Bike Lane	A portion of roadway that has been designated for preferential or exclusive use by bicyclists by pavement markings and, if used, signs*
Buffered Bike Lane	Conventional bicycle lanes paired with a buffer space designated by markings that separates the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane
One-Way Separated Bike Lane / One-Way Protected Bike Lane / One-Way Cycle Track	An exclusive one-way facility for bicyclists that is located within or directly adjacent to the roadway and that is physically separated from motor vehicle traffic with a vertical element
Contraflow Bike Lane	A portion of the roadway that has been designated to allow for bicyclists to travel in the opposite direction from traffic on a roadway that allows traffic to travel in only one direction
Contraflow Buffered Bike Lane	A buffered bike lane that has been designated to allow for bicyclists to travel in the opposite direction from traffic on a roadway that allows traffic to travel in only one direction
Contraflow Separated Bike Lane / Protected Bike Lane / Cycle Track	A separated bike lane that has been designated to allow for bicyclists to travel in the opposite direction from traffic on a roadway that allows traffic to travel in only one direction
Two-Way Separated Bike Lane / Two-Way Protected Bike Lane / Two-Way Cycle Track	An exclusive two-way facility for bicyclists that is located within or directly adjacent to the roadway and that is physically separated from motor vehicle traffic with a vertical element
Bike Boulevard / Neighborhood Greenway	A street segment, or series of contiguous street segments, that has been modified to accommodate through bicycle traffic and minimize through motor vehicle traffic*
Paved Shoulder	The portion of the roadway contiguous with the traveled way that accommodates stopped vehicles, emergency use, and lateral support of subbase, base, and surface courses. Shoulders, where paved, are often used by bicyclists*

** American Association of State Highway and Transportation Officials, 2012, Guide for the Development of Bicycle Facilities, 4th ed.*

at the segment level without regard to intersection or midblock crossing features.

- **Level of Traffic Stress ratings** are subjective scales based on different classes of potential users. Lower stress categories represent facilities that would be comfortable for a wider range of users, including less experienced users, children, and older adults. While numerous versions and adaptations have been applied in planning and research settings, all draw from original work on bicycling by Mekuria, Furth, and Nixon (2012). Subsequent work has expanded the original model to apply to walking, including accessibility attributes (e.g. Baltimore case study).
- **Preference models** developed from observed behavior have mainly been used in academic research applications to date. Their direct link to observed behavior is potentially useful. MPOs including Portland Metro (Oregon), San Francisco County Transportation Authority (California), Los Angeles County Metropolitan Transportation Authority (California), Lane Council of Governments (Oregon), and Puget Sound Regional Council (Washington) have either applied or are working toward applying these more complex connectivity models within their planning processes. Models of bicyclist route choice in Portland and San Francisco have served as the basis for most of these efforts (Broach, Dill, and Gliebe 2012; Hood, Sall, and Charlton 2011). Route choice findings have been further validated against bicycle use data (Broach and Dill 2016; Broach and Dill 2017).

Defining a quality-weighted network is considerably more data-intensive than defining a facility-based network.

Table 5: *Examples of Network Quality Analysis Methods and Associated Data*

	LEVEL OF SERVICE MODELS	TRAFFIC STRESS RATINGS	PREFERENCE MODELS
Bicycle and pedestrian facility data			
Bike lanes	✓	✓	✓
Shared-use paths	✓	✓	✓
Bicycle boulevards			(✓)
Sidewalks	✓		✓
Signed routes		(✓)	(✓)
Intersection features	✓	✓	✓
Slope		(✓)	✓
Supporting data			
Number of lanes	✓	✓	
Traffic volume	✓	✓	(✓)
Traffic speed	✓	✓	
Functional class			(✓)
Street / lane widths	✓	✓	✓
Presence of on-street parking	✓	✓	
Heavy vehicle traffic	✓		
Potential obstacles (driveways, blockages, right turn lanes, bridge crossings)		✓	

(✓) *For each type of quality rating scheme, a number of specific measures have been developed. Parentheses around a data item indicate that a particular attribute is not required by all measures in a class. In other words, agencies lacking such data might still find a measure of this type that can be applied.*

In addition to data on the location and type of bicycle facilities, such methods may require additional facility attributes (e.g. width/position of facilities and frequency of blockage) and data on other roadway characteristics that may affect bicyclists' and pedestrians' perceptions of safety or facility attractiveness (e.g. traffic volume, traffic speed, road slope, or intersection controls).

Quality Data Challenges

Agencies often lack the data needed to analyze network quality according to research-based methods. In some cases, agencies customize these rating systems to the data that are available. Table 5 provides a snapshot of typical pedestrian and bicycle network facility data that support the most common types of network quality assessments.

DATA ON ACCESS TO DESTINATIONS

Connectivity is ultimately about enabling travel between places, not just around a network, and adding place data to network scoring metrics can add valuable information to an analysis. Place data can be as simple as calculating population (see Atlanta case study) or employment within areas scored differently by a connectivity metric (e.g. all those within a certain [weighted] distance of a destination, or all those within an area in a given connectivity score range).

Quality-weighted network measures lend themselves to route scoring, or estimating the relative connection quality between sets of origin-destination pairs. Route scoring is explained in more detail in subsequent sections. This additional analysis can provide a better idea of the effectiveness of network connections. Table 6 provides examples of place data that have been used to measure network connectivity between sets of locations.

Table 6: *Connectivity Measures and Data Sources for Analyzing Access to Destinations*

ANALYSIS PURPOSE	PRIMARY MEASURE	ORIGIN DATA (PEOPLE)	DESTINATION DATA (PLACES)
Assessing community-wide bikeability*	Community-wide access to destinations	Census Blocks	Census/LEHD: Population, employment OpenStreetMap: Education, health/medical, recreation/community, retail, transit
Assessing community wide bikeability (M. Lowry et al. 2012)	Community-wide access to destinations	Regularly spaced points representing residential origins	Commercial parcels (weighted by square footage and distance from origin)
Predicting bicycle commuting patterns (Broach and Dill 2017)	Connectivity to employment	Census Block Group centroids (weighted by population)	Census Block centroids (weighted by number of jobs)
Identifying low-stress streets (Mekuria, Furth, and Nixon 2012)	Overall connectivity	Census Block vertices	Census Block vertices
Prioritizing bicycle network improvements (M. B. Lowry, Furth, and Hadden-Loh 2016)	Home-based access to destinations	Residential parcels	Selected groups or "baskets" of important and/or desirable types of destinations (21 types)
Quantifying local access to destinations (Kuzmyak, Baber, and Savory 2007)	Home-based access to destinations	Traffic Analysis Zones (TAZs, weighted by number of households)	TAZs (weighted by jobs and distance)
Assessing bicycle access to regional centers**	Home-based access to destinations	Census Blocks	Centers designated by the community, such as Livable Centers Initiative communities in the Atlanta region
Assessing bicycle access to local K-12 schools ***	Home-based school access	Census Block centroids	K-12 Schools

** https://bna.peopleforbikes.org/#/methodology*
*** Atlanta case study*
**** Ft. Collins case study*

STEP 4

COMPUTE THE METRICS

Once the network is defined and links and nodes are assigned attributes, connectivity is scored at one (or more) of three scales: link, route, or area/ network, as shown in Figure 6.

LINK

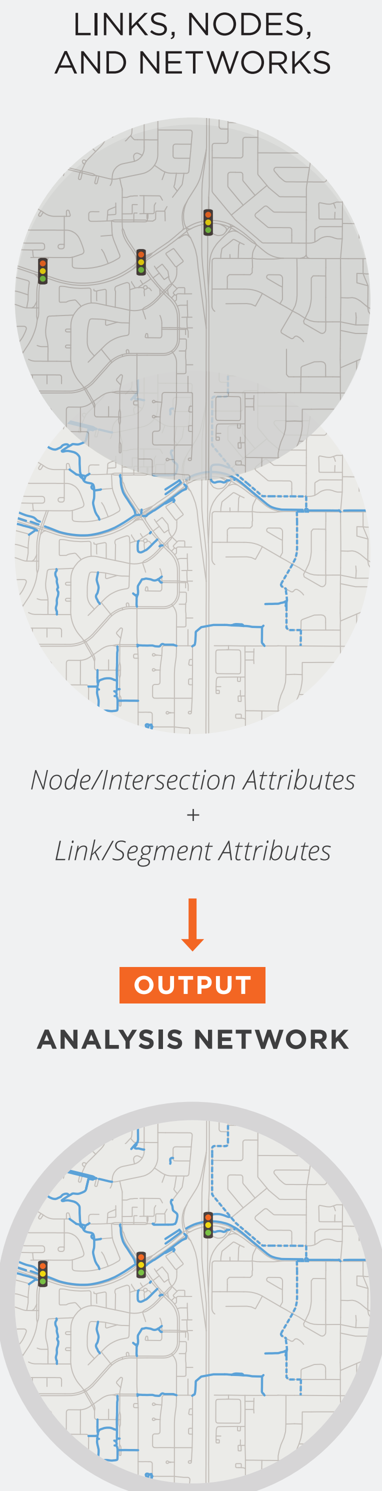
The smallest unit of analysis is the connection between two nodes along a single link. The quality of the connection provided by a link is defined by attributes of the link, and, possibly, the approach to the end node or intersection. A numeric score or derived rating is assigned to the link by weighting the attributes relative to one another or by applying a classification scheme. In this case, the output is a single score for each link in the analysis network (sometimes a score for each direction of travel).

Common examples of metrics that score at link-level are Bicycle/Pedestrian Level of Service (BLOS/PLOS) and Level of Traffic Stress (LTS).

ROUTE

Measures can also be computed at the route or corridor level, defined as the set of available routes connecting two places along a series of links connecting locations of interest. There are typically multiple routes of travel in a given corridor. The highest quality or least-cost connection can be defined using available data, but for bicycle and pedestrian networks it may be more appropriate to consider a range of routes, given varying user behavior. Different people may take different routes in the same general corridor due to slight variations in origins and destinations, variability in comfort at using different facilities, knowledge of available bicycle and pedestrian facilities, and random chance. Route-based scores reflect both the quality of individual links and how those links fit together. Output in this case is a score or rating representing the quality of connection for each pair of places

Figure 6. *Links, nodes, and networks*



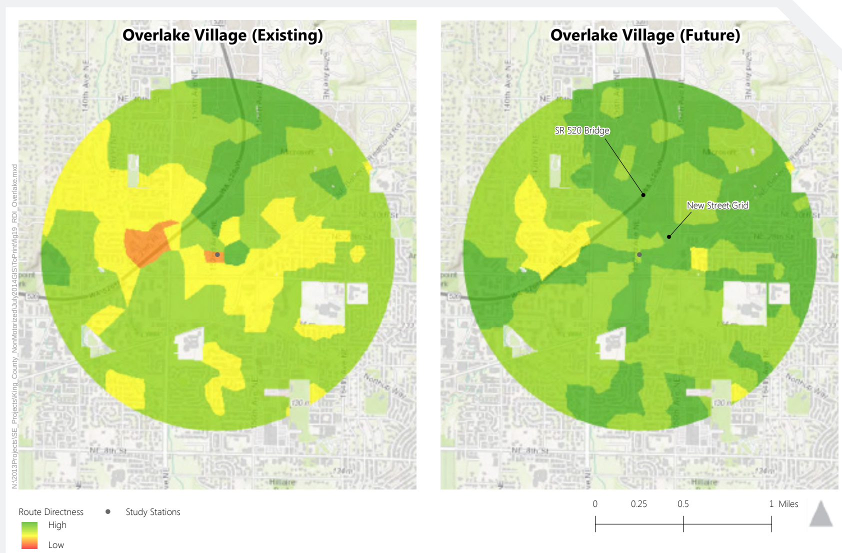
along the "best" route provided by the current or planned network. Any link-based metric can be applied at the route scale as long as routes can be identified.

Measuring quality along the immediate path of a given route is valuable, as it reflects the end goal of connecting people and places. To measure the full connectivity of the area served by the route, however, an analyst needs to identify specific origins and destinations associated with the route. For specific planning applications, such as access to transit stops or schools, it may be enough to specify all points within a reasonable distance of the given destinations (sometimes referred to as travelshed analysis). In other cases, a more varied sample of origins and destinations is required. Table 6 in the previous section provides examples of place data that have been used for route-level connectivity analysis.

AREA/NETWORK

Form-based metrics such as Block Length Analysis, Connected Node Ratio, Sidewalk Density, and Route Directness typically work only at the scale of entire networks or areas. Links and nodes or attributes of interest are counted, or techniques are applied to calculate general measures such as density, directness, or fragmentation of the network. The output in this case is a single area or network-wide score. Subareas or subnetworks can be defined and scored for different areas within the same planning region or locale.

Source: FHWA



King County Metro and Sound Transit. 2014. "Non-Motorized Connectivity Study." http://metro.kingcounty.gov/programs-projects/nmcs/pdf/nmcs-report-091214.pdf

FROM DATA ASSEMBLY TO CONNECTIVITY ANALYSIS

King County Metro (Washington) performed a route directness connectivity analysis by defining the network as all streets (although they could have chosen to include only streets with facilities such as sidewalks and bike lanes); calculating shortest network paths and straight-line distances from transit stations to points within three miles of each station to create route directness scores ranging from 1 to 5; and summarizing the results as route directness maps to identify areas of poor network connectivity around the stations. (King County Metro and Sound Transit 2014)

STEP 5

PACKAGE THE RESULTS

The final step in the process is to relate the results of the analysis to the planning context that was articulated in Step 1. If the purpose of the analysis is to inform regional or subarea plans or project prioritization, for example, data on thousands of individual links and routes must be aggregated into map(s), charts, and other visualization tools that help decisionmakers to understand the results at the scale relevant to their needs. The aggregation process would ideally occur as a result of scaling the analysis to suit the planning context, but planners must often do some post-processing in order to create maps and graphics that summarize the information in an understandable way. In these cases, analysts and planners need to work carefully in order to avoid "burying" essential details or otherwise distorting the results of the analysis.

Overlaying the aggregated results with other maps and data on topics such as equity, safety, or economic growth will help planners and stakeholders prioritize the projects that are going to produce the greatest benefit for bicyclists and pedestrians and help to achieve additional community goals. Again, it is important for planners and analysts to work together in order to ensure that the messages conveyed by overlays help to enrich, rather than skew or obscure, the key points identified in the connectivity analysis.

AGGREGATE

The simplest way to aggregate link scores is to display them on a map, representing quality with colors or symbols to help stakeholders visualize routes of interest, gaps, barriers, and relative connectivity across areas. Figure 7 shows an example of a weighted link/node quality measure displayed as a connectivity map. The map visualizes routes and areas with

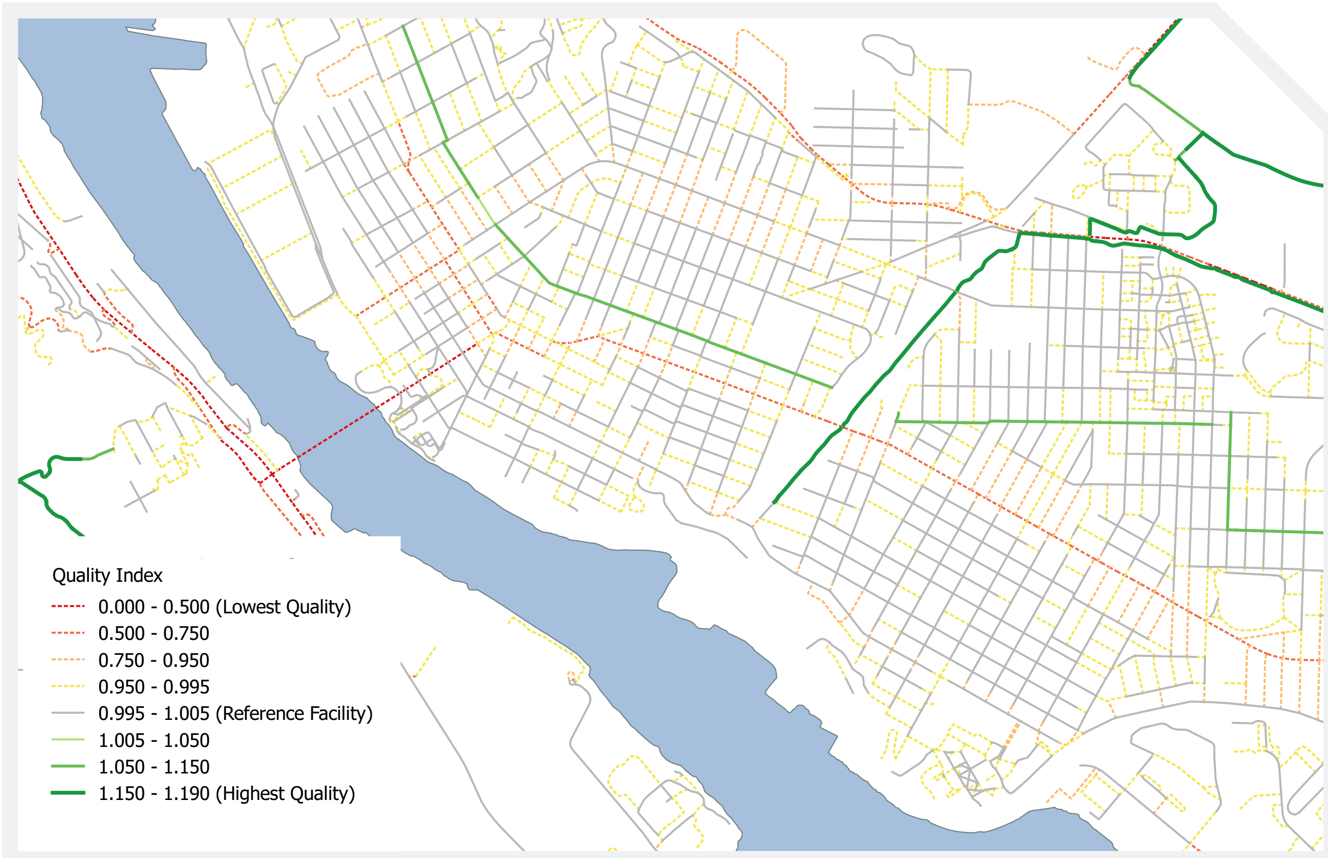


Figure 7. *Link-level Connectivity Map*

In this connectivity map, individual links are weighted by a preference-based model that includes multiple factors. Darker/thicker lines represent better (solid green) or worse (dotted red) connectivity.

higher or lower connectivity, as well as apparent gaps and barriers.

With route-scale outputs, the average route quality score for all origins or destinations in the subarea might be calculated (perhaps weighted by population, jobs, or some other measure of importance). Typically, the aggregate route-based scores take the form of an index, percentage, average, or some other relative indicator. For example, Bicycle Level of Traffic Stress is often summarized as the percent of origin-destination pairs connected at a reference traffic stress level or better (Mekuria, Furth, and Nixon

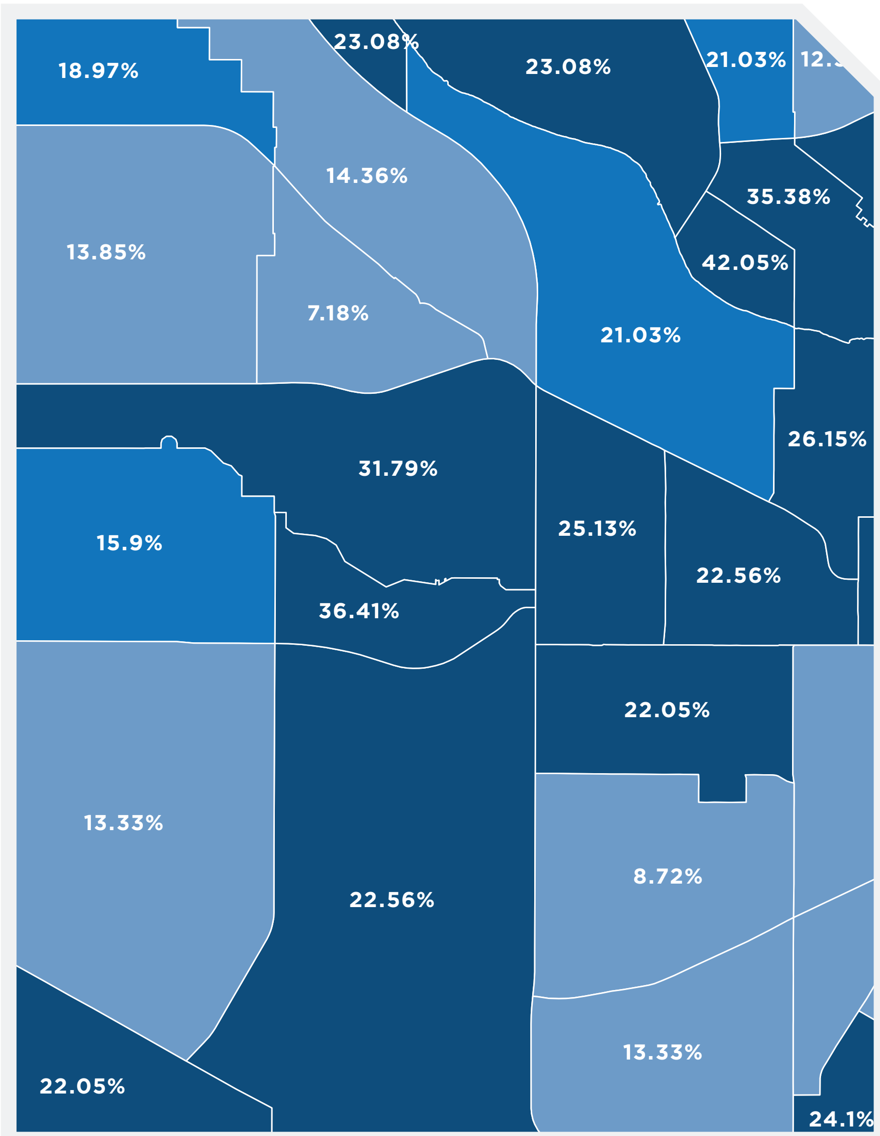


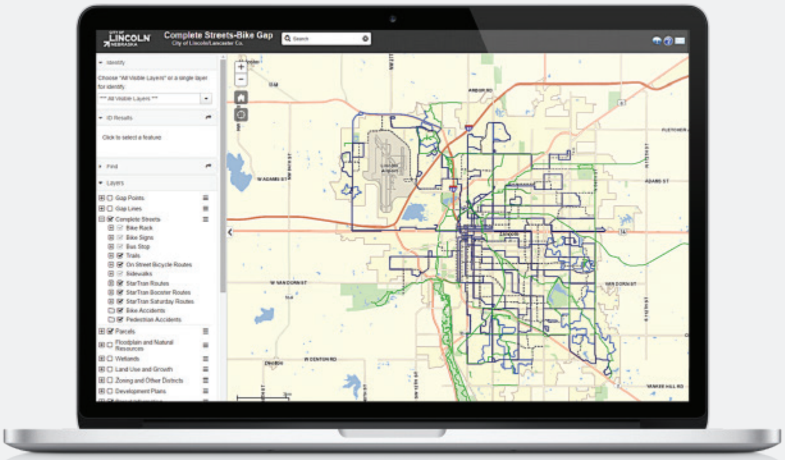
Figure 8. *Connectivity Measures Aggregated to Small Areas*

In this map of sidewalk connectivity analysis results, darker colors show Traffic Analysis Zones (TAZs) with greater sidewalk coverage.

2012). In another example, Bicycle Route Quality Index (RQI) can be normalized by equivalent distance on an "adequate" or "average" facility such as an on-street bike lane (Broach and Dill 2017). These ratings can then be compared with one another to assess the relative level of need in different subareas or measure changes in connectivity over time. As a final example, the PeopleForBikes' Bicycle Network Analysis (BNA) tool is a new connectivity measure based on Bicycle Level of Traffic Stress. It has been applied in a number of cities and small towns throughout the U.S. The BNA score ranges from 0 to 100, based on access to a destination basket along bicycling routes meeting a specific quality and distance threshold.[1] Each of these measures is described in more detail in Chapter 3.

Connectivity ratings can also be aggregated to an entire community, or to subareas within the larger community, using measures such as the average quality of all links or the percentage of links of a given quality. Figure 8 provides an example of a connectivity measure (sidewalk completeness) measured at the link level and aggregated to small areas.

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



Source: Lincoln/Lancaster County Planning Department. 2015. "Complete Streets Gap Analysis and Prioritization Strategy." https://lincoln.ne.gov/city/plan/reports/GapAnalysis.pdf.

ADDING VALUE WITH DATA OVERLAYS

The City of Lincoln (NE) developed an interactive Gap Analysis Tool to support their Complete Streets program (Lincoln/Lancaster County Planning Department 2015). The interactive tool has helped to identify and prioritize projects to receive annual funding. Initial data collection across agencies was aided by Lincoln's Open Data policy. Collaboration with the Public Health Department produced pedestrian/bicycle crash data that can be overlaid with identified connectivity gaps. The system was designed to be relatively easy for staff to update, and features continue to be added over time in response to planning needs.

OVERLAY

Overlaying is an optional step that involves combining connectivity results with data that represent complementary policy goals. Connectivity results are overlaid or joined with other geographic data to support analysis on topics such as equity, safety, and system usage.

Safety analyses can be overlaid with connectivity results. Crash data can be overlaid on connectivity scores to help planners understand the relationship between high-crash locations and poor connectivity. This could be done by area or for specific locations. An area, segment, or node with a low connectivity score and high crash rate might reflect an important gap with high demand and few alternative options. Critical network gaps can be prioritized.

Motor vehicle volume data could be joined to connectivity scores, especially for future scenarios, where bicyclists or pedestrians are likely to come into conflict with other road users. This could help identify areas for proactive treatments to reduce crash risks in those locations.

Equity analyses can be performed to determine how network connectivity is distributed across different parts of a planning region and across different socioeconomic groups. As an example, overlaying income or race/ethnicity data on a connectivity map could be used to identify disadvantaged communities in low connectivity parts of the network and to prioritize projects that will improve conditions for people that may be more likely to rely on bicycling and walking for transportation. In the Portland Metro case study example, connectivity results were overlaid with areas meeting targeted equity criteria in the regional plan to better understand how planned projects were contributing to equity goals.

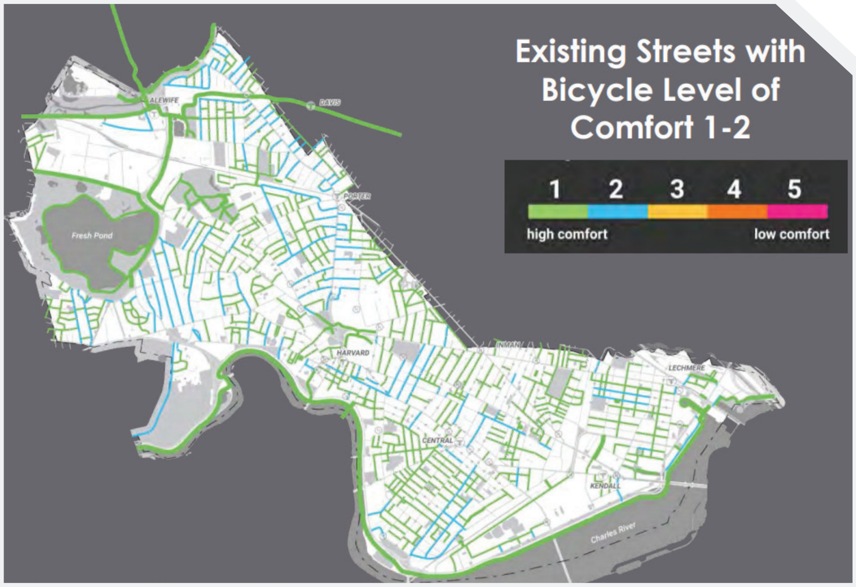
System usage relationships have been validated for a few connectivity measures. Overlaying land-use data with connectivity scores can support prediction of rates or changes in the rate of bicycling and walking. For example, the impact of a new connection or a series of quality improvements could be related to expected increases in use. The overall change could help inform project selection and determine whether existing plans are sufficient to meet targets for walking and cycling.

PACKAGE FOR PRESENTATION

Connectivity maps or scores can help planners and stakeholders identify priorities for projects or further study in a variety of ways. Perhaps most importantly, connectivity analysis brings a fresh set of objective information "to the table." For example, during an analysis of bicycle connectivity, transit agency TriMet (Portland, Oregon) realized that prioritizing bicycle access in low-density areas served by transit might be effective because the walk distance to transit stops was too far for many residents. This was challenging to communicate to stakeholders but an important result that guided future planning.

Communicating connectivity effectively involves not only presenting the analysis methods clearly, but also responding to concerns that come up during the planning process. In Seattle, Washington, advocates felt that connectivity was not effectively evident or prioritized in the city's bicycle plan update, partly because evaluation metrics were mileage weighted. Mileage weighting pushed the discussion toward the strategy of adding mileage in outlying locations, where it was cheaper, even if the goal of connectivity might be better served by filling gaps in urban areas.

It is important to not lose sight of the specific analysis purpose defined in Step 1. Results should be summarized at a scale, level of detail, and with overlays appropriate for answering the key questions that drove the connectivity analysis in the first place.



Source: City of Cambridge. 2015. "Cambridge Bicycle Plan." http://www.cambridgema.gov/CDD/Transportation/bikesincambridge/bicyclenetworkplan.

LOCALIZING CONNECTIVITY MEASURES TO IDENTIFY PRIORITY PROJECTS

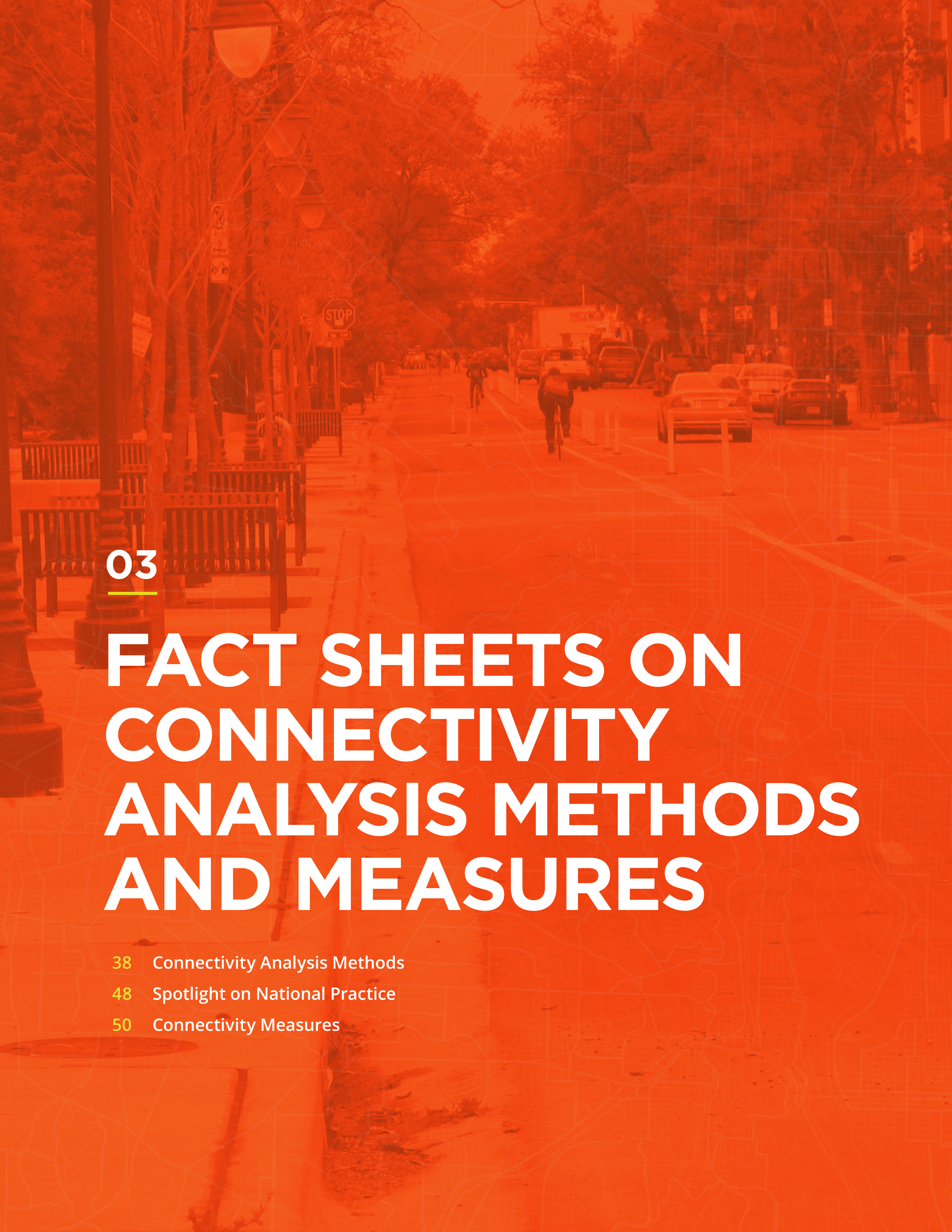
The **Cambridge (MA) Bicycle Plan** (2015) mapped existing conditions using a 1 to 5 Bicycle Comfort Level (BCL) rating. The initial GIS-based ratings of individual segments were refined through public comment, including online map comments. The resulting database and maps were used to prioritize projects and maintenance strategies in the broader plan. Projects that closed gaps in the existing low-stress (BCL 1 or 2) network were ranked highest, followed by individual projects that would shift a street to BCL level 1 or 2. The lowest priority projects improved conditions but resulted in a facility at BCL 3 or worse.

The **Minneapolis, MN Pedestrian Plan** (2009) identified a preferred block size and analyzed block length relative to the preferred size. Areas where larger block sizes indicated lower walk connectivity were mapped and used to identify priority locations for midblock crossings and other improvements.

MAKING DATA-DRIVEN CONNECTIVITY INVESTMENT DECISIONS

The City of Fort Collins wanted to select a bicycle connectivity measure for implementation into its Transportation Master Plan Update. In their experience with previous programs, they found data-supported arguments and the ability to track program impact increased support by elected officials. They focused on metrics that both demonstrate the need for bicycle facilities and that can be easily communicated to city officials and decisionmakers when tracking progress over time.

In the case study example, they selected several measures based on low-stress network analysis.



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FACT SHEETS ON CONNECTIVITY ANALYSIS METHODS AND MEASURES