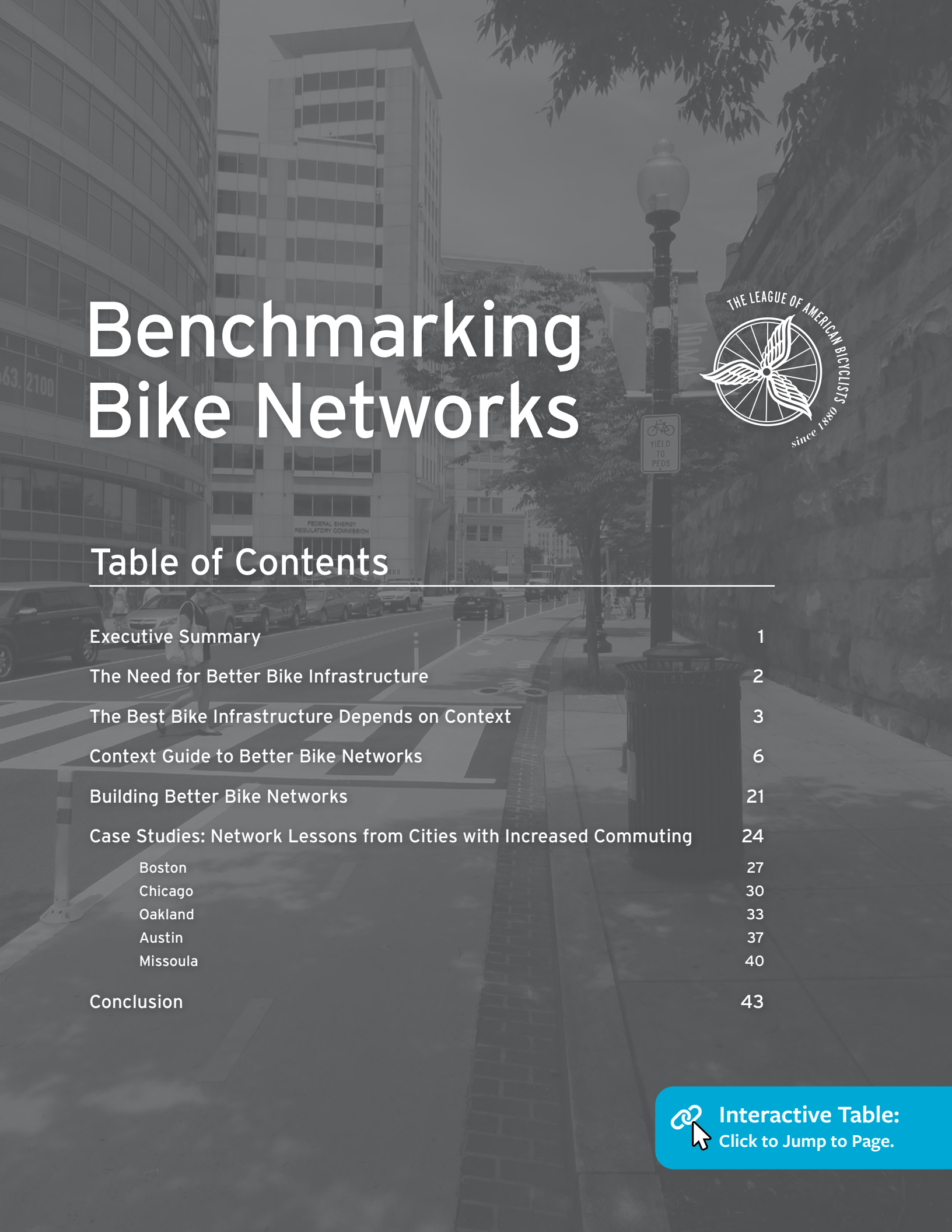
Benchmarking Bike Networks

THE LEAGUE OF AMERICAN BICYCLISTS since 1880

Benchmarking Bike Networks



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Executive Summary

The last decade has seen a rapid change in best practices for improved bicycle infrastructure and policies to promote bicycling. However, many places still lack connected bicycle networks. By talking to officials in some of the cities where bicycle commuting has increased the most over the last decade and identifying areas where they have built connected networks, this report will help other communities and advocates understand the many approaches to bicycle network development.

THE LEAGUE OF AMERICAN BICYCLISTS developed this report to articulate our priorities around bicycle infrastructure and to encourage individuals who bike, cycling clubs, state and local bicycle advocacy organizations, and communities that participate in our Bicycle Friendly Community program to use these lessons learned as they seek to improve conditions for people who bike.

To improve the safety of people who bike, walk, use a wheelchair, and drive, it is necessary for transportation agencies to prioritize safety in their road designs using a Safe System Approach. The Safe System Approach proactively uses road design to change human behavior so that dangers in our transportation system are minimized and human errors are anticipated and their impact minimized. Two principle techniques of the Safe System Approach are slowing people down to reduce kinetic energy and separating people to reduce conflicts.

In the United States, speeding is a factor in about 30 percent of all traffic deaths and the majority of bicyclist and pedestrian fatalities occur on roadways with speed limits over 35 mph. The most common speed limit on roadways where people biking and walking are killed is **45 mph**. Building roadways with a Safe System Approach to lower speeds and deter speeding pairs well with improved bicycle and pedestrian infrastructure, which provides defined spaces for those road users and can provide traffic calming for roadways.

While there have been rapid changes in best practices for bicycle infrastructure in the last decade, current and proposed guidance shows a clear consensus that separated bike lanes are needed in situations with higher vehicle speeds or higher vehicle volumes. These safer bike facilities remain rare in most communities and it is even rarer for them to form a connected network that embodies best practices of network development.

This report:

Summarizes guidance and best practices to create safer bicycle facilities and connect them into networks that allow more people to safely bike to more places within and throughout communities.
Provides a 'Context Guide' to better bike facilities with definitions and examples.
Stresses the importance of building a connected network, not individual facilities, and the methods commonly used for network development.
Compiles case studies of cities that have improved their networks and seen bicycle mode share growth in the last decade. These case studies focus on network data and development, providing benchmarks for other communities.

The Need for Better Bike Infrastructure

Historically, the League of American Bicyclists and other bike advocates who educated cyclists have endorsed vehicular cycling—the idea that people biking are safest when they behave like motor vehicles and share infrastructure designed for cars and trucks. While safely operating in mixed vehicle traffic is an essential skill for people who bike in the United States where separate bicycle infrastructure is uncommon, development of these skills is best coupled with bicycling infrastructure improvements to make bicycling comfortable for everyday trips for the majority of people. **Over the last decade, research about people's preferences, and research about bicycle infrastructure, have mutually reinforced the demand and need for separated bicycle infrastructure that does not depend upon perfect human behavior to provide safety.**

Providing bicycle infrastructure that maximizes the safety of people biking is an important part of creating great bicycle networks. Fear for personal safety due to the potential of being hit by a motor vehicle is a major concern for people considering bicycling. A close call with a car can often precipitate a person choosing not to use a bicycle for even short trips. Current best practices for providing safe infrastructure focus on reducing the risk of severe injury and death by managing speed, separating users in time or place, and designing infrastructure based on human limitations.

The National Association of City Transportation Officials (NACTO) publication of several bicycle infrastructure design guides over the last decade helped communities seeking to build bicycle networks suitable for people of all ages and abilities. These guidelines stress safety based on the experience of NACTO cities, where "[a]mong seven NACTO cities that grew the lane mileage of their bikeway networks 50% between 2007–2014, ridership more than doubled, while risk of death and serious injury to people biking was halved. Better bicycle facilities are directly correlated with increased safety for people walking and driving as well.[1]"

Infrastructure shown to increase bicycling levels includes bicycle boulevards, speed humps, curb extensions, pedestrian crossways, and separated bike lanes. Studies in Copenhagen; London; Washington, DC; and Montreal have all found that cycle tracks or protected bicycle lanes attract more bicyclists than similar streets without such infrastructure. Bicyclists were willing to reroute their paths to use specialized infrastructure in Portland, OR, and go the furthest out of their way to cycle on off-street bike paths followed by bicycle boulevards.

Buffered bike lane on Ravenna Blvd in Seattle, WA.

> ***Building a Bicycle Friendly America for everyone*** means building and maintaining safe and connected bike networks with bicycle infrastructure that is appropriate to the street context and the needs of the people living in the community. The communities making improvements in bicycle safety are seeing increases in rates of bicycling, showing they are meeting the demand and need for bicycle networks built to provide safe travel for people of all ages and abilities. Just as the League of American Bicyclists led a movement for paved roads to improve the cycling experience more than 100 years ago, we are now committed to building a movement for great bike networks.

1. Designing for All Ages and Abilities at p. 2. Available at https://nacto.org/wp-content/uploads/2017/12/NACTO_Designing-for-All-Ages-Abilities.pdf.

The Best Bike Infrastructure Depends on Context

The following discussion of bicycle infrastructure is a summary of some best practices for different street contexts as part of larger bike networks. **Guidance about the safest bicycle facilities for a roadway historically have used two measures to select an appropriate facility:**

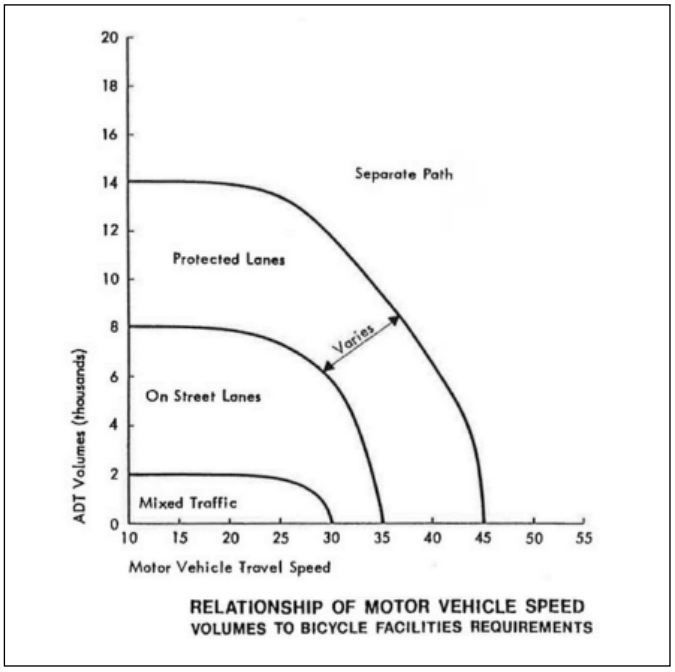
1. **Traffic Speed**—typically the posted speed limit, but if speeding is a regular issue on a roadway then observed speed may be more appropriate to consider. Posted speed limits are usually easily observed during a site visit or through an online map. Observed speeds may not be readily available.
2. **Traffic Volume**—typically measured in vehicles per day (Average Daily Travel or Annual Average Daily Travel). Not every locality will have this data for all roadways.

Guidance based on speed and volume was first developed in the 1970s ahead of a long period where the League of American Bicyclists[2] and most transportation agencies focused on vehicular cycling as a strategy for infrastructure development—focusing on shared lanes, faster bicyclist speeds, and improved human behavior primarily through bicyclist and, less often, driver education to increase the safety of people bicycling.[3]

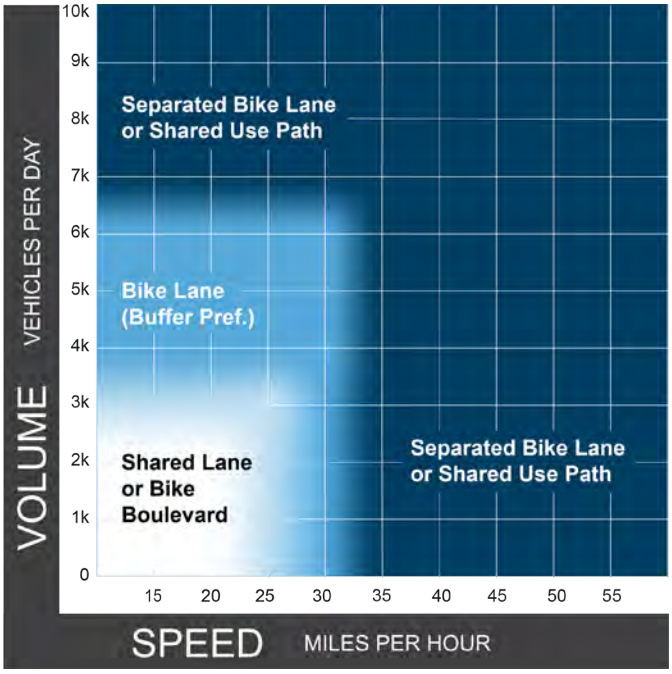
During this same time period, some US cities and places throughout the world, predominantly in northern Europe,[4] experimented with bicycle infrastructure development focused heavily on separated facilities.

> After more than 40 years, places that embraced vehicular cycling—the idea that people biking are safest when they behave like vehicles and share vehicle infrastructure—in their infrastructure development philosophy had lower rates of bicycling and higher rates of bicyclist deaths.[5] This real-world experience reinforces the need to build appropriate and safe bicycling facilities, including separated facilities that do not rely on human behavior for safety.

Figure 1: Bike Facility Guidance in 1972 and 2019



Bikeway selection graph for City of Davis, CA (1972). *Source:* *FHWA Literature Review – Resource Guide for Separating Bicyclists from Traffic*



Preferred Bikeway Type for Urban, Urban Core, Suburban and Rural Town Contexts (2019). *Source:* *FHWA Bikeway Selection Guide*

2. Then named the League of American Wheelmen. The name was changed in 1994.

3. https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18030.pdf ("bikeway design guides began to incorporate vehicular cycling ideas, treating bicyclists as motor vehicles in road design, beginning with the 1978 CalTrans Bicycle Design Guide...The Guide prohibited physical separation of bike lanes and did not provide guidance for specific motor vehicle volume and speed thresholds which would warrant separation.")

4. See https://www.vtpi.org/puchertq.pdf at p. 19.

5. https://www.tandfonline.com/doi/abs/10.1080/01441647.2020.1823521?journalCode=ttrv20 ("In 2018, pedestrian fatality rates per km in the USA were 5–10 times higher than in the other four countries; cyclist fatality rates per km in the USA were 4–7 times higher.")

Comparing guidance on bike infrastructure from the 1970s to today in the United States, it is remarkable how little has changed[6] (See Figure 1 on page 3).

For shared lanes and shared lane markings, modern guidance is more likely to allow their use on roads with higher volumes, but less likely to allow their use on roads with higher speeds.
For conventional bike lanes, modern guidance is less permissive and more likely to say that additional features, such as traffic calming, physical barriers, or buffered space, are needed for safety at lower speeds and volumes compared to older guidance.
For protected, buffered, or separated bike lanes; modern guidance is more permissive, allowing them as a solution on higher volume and higher speed roads, and on streets with multiple road users.

The United States is 40 years behind when it comes to developing bike networks. The experience of others can help us catch up. In the last decade, organizations such as National Association of City Transportation Officials (NACTO) and the Federal Highway Administration (FHWA) have published influential guidance on bicycle facility selection. While not every state or local jurisdiction has followed these guides, NACTO and FHWA guidance are reasonable starting places for any community or advocate interested in taking stock of existing bicycle facilities or the needs of bicyclists on existing streets. Use **Figure 2** below to find helpful guidance based on your needs and use case.

Figure 2: Finding the Right Design Guide for Your Need

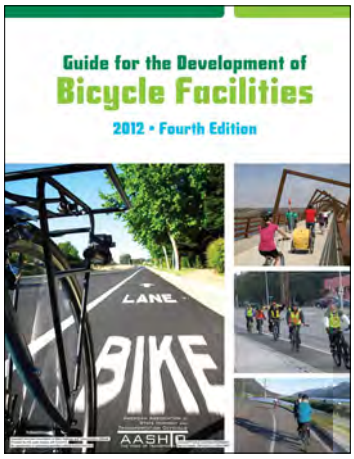
Guide	Use Case
NACTO Urban Streets Design Guide	Broad guidance on better streets for cities
NACTO Urban Bikeways Design Guide	Bicycle-specific guidance for bike facilities
NACTO Designing for All Ages and Abilities	Stronger support for safer facilities, with a focus on more vulnerable users
NACTO Don't Give Up at the Intersection	Intersection-specific guidance for bike facilities
FHWA Bikeway Selection Guide	Selecting bicycle facilities based on traffic speed and volume, this Guide is the basis for recommendations in this report
FHWA Separated Bike Lane Planning and Design Guide	Guidance on separated bike lanes from a federal agency
MassDOT Separated Bike Lane Planning and Design Guide	Guidance on separated bike lanes from a state agency
FHWA Small Town and Rural Design Guide	Broad guidance on better streets for rural areas
New for 2021 MNDOT Guidance for Separated/Buffered Bike Lanes with Delineators	Supplemental guidance from a state agency, with a focus on delineator separation and winter maintenance
New for 2021 Portland Protected Bicycle Lane Design Guide	Guidance for how America's largest Platinum Bicycle Friendly Community will design protected bike lanes

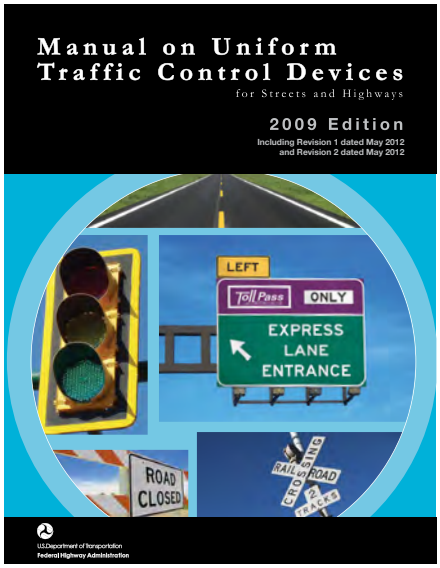
6. Compare Figure 5 – Bikeway Selection Graph for City of Davis, CA from 1972 on page 5 of https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18030.pdf and FHWA Bikeway Selection Guide graph.

What about AASHTO and the MUTCD?

As of 2021, two important documents relied upon by traffic engineers have yet to incorporate standards or guidance specific to bicycle facilities popularized during the last decade, such as separated bike lanes. This does not mean designs found in the guides listed in **Figure 2** are not allowed. Each guide listed puts considerable effort into showing the ways in which its guidance is compliant with the requirements of the Manual on Uniform Traffic Control Devices (MUTCD) and allowed under guidance from the American Association of State Highway and Transportation Officials (AASHTO).

The highly influential AASHTO Guide to the Development of Bicycle Facilities was last updated in 2012. Several sections of the next edition have been circulated online, and the next edition is expected to include separated bike lane guidance.





The Manual on Uniform Traffic Control Devices (MUTCD) does not prevent separated bike lane deployments. In 2013, a FHWA memo noted that "the vast majority of treatments illustrated in the NACTO [Urban Bikeway Design] Guide," first published in 2010, are "either allowed or not precluded" by the MUTCD. The proposed update to the 2009 MUTCD published in 2020 included illustrations and guidance on separated bike lanes.

> For places that feel constrained to conform to what these documents explicitly allow when developing new bicycle facilities, the anticipated updates of the MUTCD and AASHTO Bike Guide are likely to provide significant reassurance that separated bike facilities are safe and accepted by all national standard setting bodies. Until these documents align with modern standards, advocates should use the guides in **Figure 2** and plan on addressing questions using existing published guidance.

Context Guide to Better Bike Networks

This Context Guide is intended to summarize current guidance for better bike facilities. The appropriate design of a bike facility should be based upon practices discussed more fully in the Design Guides found in Figure 2, and may include facilities not mentioned in this guide. For the sake of brevity, bicycle facility types are only described once even if they may be appropriate in more than one context.

The Context Guide looks at six important contexts to consider, primarily based on the speed and volume of vehicle traffic. The speed and volume of vehicle traffic was chosen because it is the most commonly available data used by design guidance to determine appropriate bicycle facilities. The CDC's Active Communities Tool suggests the number of lanes on a road and pedestrian volumes are other important considerations.

For each context, the relevant speed and volume is highlighted based on FHWA's Bikeway Selection Guide.

- **Speed:** Posted speed or observed speed may be used. If speeding is prevalent, then observed speed is important as traffic calming or other design changes may be needed to promote speed compliance.
- **Volume:** Traffic volume may be available through a public agency, such as a Department of Transportation or Metropolitan Planning Organization, but you can also observe it based on the number of vehicles passing a point during a high-volume hour. Volume can be estimated based on observation and if there are enough potential passing events to make the road uncomfortable for a person biking.[7]

7. https://nacto.org/wp-content/uploads/2017/12/NACTO_Designing-for-All-Ages-Abilities.pdf (see chart on page 5 and surrounding explanations).

Wayfinding for the Context Guide

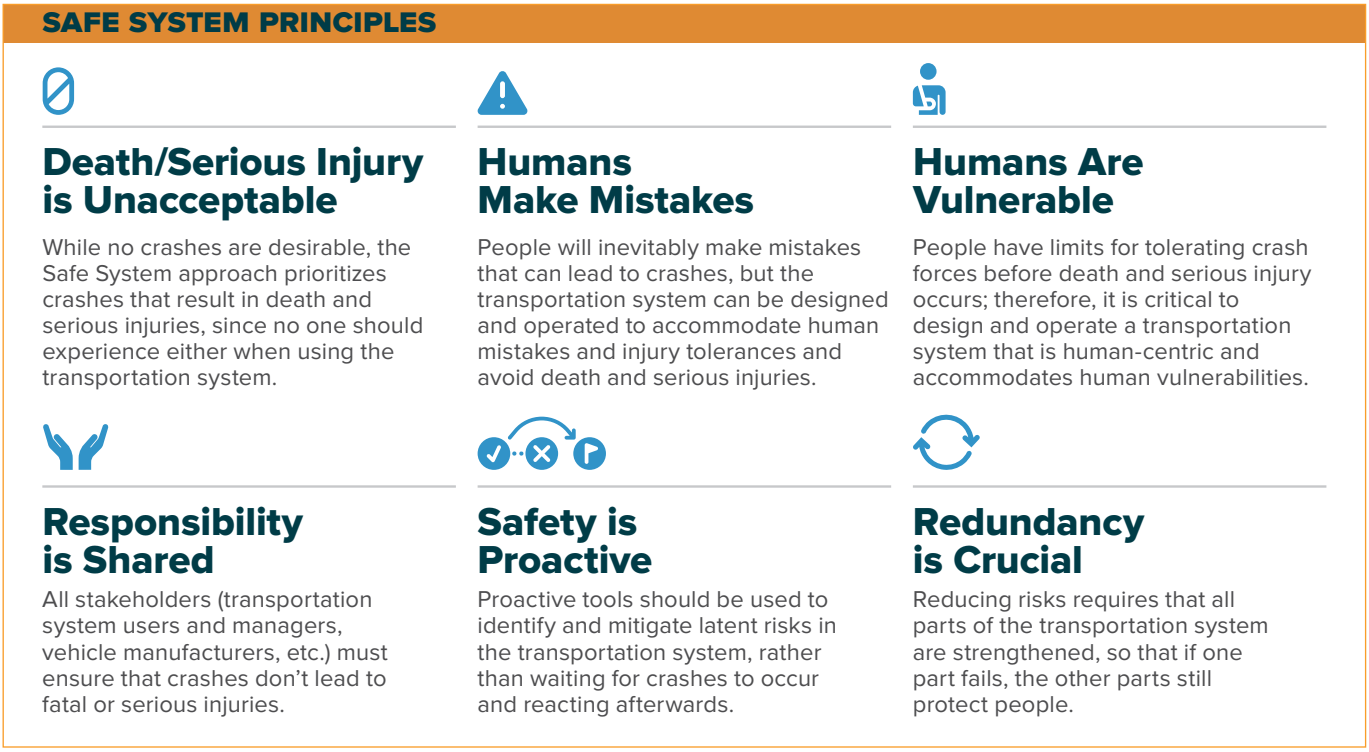
The Context Guide is organized so that contexts and suggested facilities build upon each other, mostly going from the least dangerous/least protective to the most dangerous/most protective. The three goals listed below should serve as reference points for why a more protective bike network is preferable and whether a selected bicycle facility is likely to accomplish one or more of the goals.

Goal 1. Adopting a Safe System Approach

The Safe System Approach (Figure 3) recognizes the ethical imperative of creating a transportation system that does not kill or seriously injure people. To accomplish that goal the Safe System Approach to safer roads stresses that humans are vulnerable, and that a roadway should be designed to be proactive in preventing crashes and with redundancy in the design so that if a crash does happen, it is not fatal.

The Safe System Approach can be applied to bicycle facility design by eliminating or mitigating conflicts between road users and reducing the force of a motor vehicle's impact in any crashes that might occur. Separating users in a manner that reduces conflicts between motor vehicles and people bicycling and walking are critical factors to consider in bike facility planning and design through the Safe System Approach. This report uses guidance based on vehicle speed and volume, because reducing speeds reduces the potential force of a motor vehicle's impact and lower volumes mean fewer potential conflicts between users.

Figure 3: Safe System Principles According to FHWA



Source: FHWA

Goal 2. Increasing Physical Activity

The Community Preventive Services Task Force recommends combining built environment approaches with land use and environmental design interventions to increase physical activity. Examples include combining changes to street pattern design and connectivity or changes to improve bicycle and pedestrian infrastructure with mixed land use, increased residential density, or improved parks and recreational facility access. Street pattern and connectivity changes can be critical to separating people in time and place to reduce conflicts and reduce the exposure of people biking to high speed vehicles.

Goal 3. Lowering Level of Traffic Stress

Level of Traffic Stress (LTS) is an objective, data-driven approach to understanding perceptions of bicyclist comfort and a willingness to travel based on bicycle facility characteristics. LTS is measured based on factors like vehicle speeds, on-street parking presence, bikeway design, road user separation, intersection approach and control, bicycle facility obstructions, and bike network gaps. LTS corresponds with research on types of bicyclists so that "the most desirable bicycling score, LTS 1, is assigned to roads that would be suitable for most children to ride or suitable for inexperienced adults riding bicycles or families with small children."

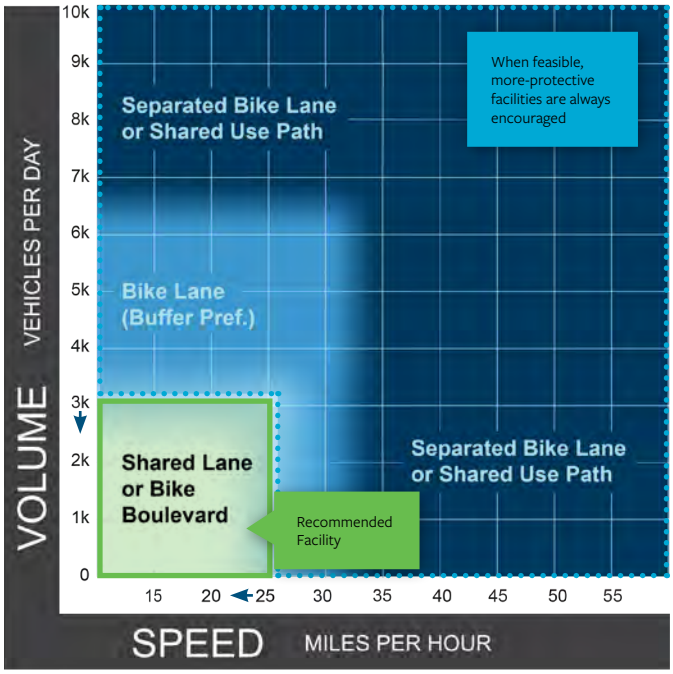
A separated bike lane using a concrete curb in Austin, TX, USA that considers context in selection of facility type. *Source: City of Austin.*

Low Speed / Low Volume Streets

Posted speed limit 25 mph or less • Volume of 3K ADT or less

GOALS:

- **Promote compliance with low speed limit through traffic calming**
- **Provide cohesive biking experience through paint and/or signs**



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* Facilities "Not Recommended" may be allowable under local rules and regulations, but they are not recommended by the League as good bike facilities in this context.

SUGGESTED BIKE FACILITIES

Neighborhood Greenways / Bike Boulevards are a corridor design strategy that prioritizes bike traffic by minimizing stops along the corridor and having features that discourage vehicle-through-traffic.

Advisory bike lanes are painted bike lanes on narrower roads that facilitate slow two-way motor vehicle travel by creating a shared two-way center lane for motor vehicles and permitting motor vehicles to enter the bike lane when needed to pass.

Shared lane markings (sharrows) are a painted marking with a bicycle and chevron to indicate direction of travel. They can increase attractiveness, and promote bicycle flow, but do not provide protection.

Signs may provide directions, identify destinations, and brand the corridor to make it more attractive to people biking.

SUGGESTED CHANGES TO STREET PATTERN DESIGN AND CONNECTIVITY

Motor Vehicle diverters can be any materials that prevent through-vehicle-traffic, but allow through bicycle traffic. Plastic bollards and concrete curbs or planters are common materials.

Bicycle cut-thrus are paved shortcuts for people biking and walking through curbs, parking lots, cul-de-sacs, or other places to connect low speed-low volume areas.

Low Speed / Low Volume Streets

Posted speed limit 25 mph or less • Volume of 6K ADT or less

Good bike facilities for Low Speed / Low Volume Streets

Shared lane markings on a neighborhood greenway

Source: Seattle DOT, Flickr

Bike boulevard with horizontal deflection traffic calming

Source: Payton Chung, Flickr

Shared lane markings with vertical deflection traffic calming

Source: Walkandia, Flickr

Plastic bollards diverting vehicle traffic from bike route

Source: M Canzi, Flickr

Advisory bike lane with center median traffic calming

Source: District of Columbia Department of Transportation

Bicycle cut-thru in Norman, OK

Source: Norman, OK Bicycle Friendly Community application

Mixed facilities with a sharrow and bike lane on the same street.

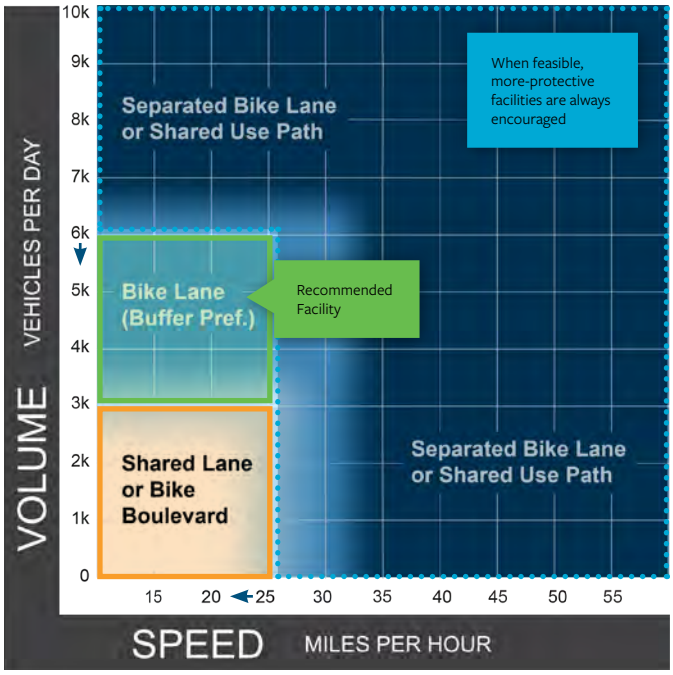
Source: Airbus777, Flickr

Low Speed / High Volume Streets

Posted speed limit 25 mph or less • Volume of 6K ADT or less

GOALS:

- **Promote compliance with low speed limit through traffic calming**
- **Provide comfortable biking experience through facilities**



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SUGGESTED BIKE FACILITIES

A standard **painted bike lane** should be at least four feet wide and marked with a bicycle symbol. Some jurisdictions make them considerably wider to increase bicycle operating space or to provide space for safety from opening vehicle doors. The measured width should not include the gutter pan that extends from a curb. The presence of motor vehicle parking should be considered in determining space for a bike lane so as to allow bicyclists to ride outside the path of an opening door.

A buffered bike lane is a painted bike lane supplemented by a painted buffer that is typically two feet wide. The buffer area may contain additional markings such as diagonal cross hatching or chevron markings, and those markings are required if the buffer is three feet or wider.

A delineator separated bike lane is a painted bike lane supplemented by flexible delineator posts placed on the bike lane stripe or in a painted buffer. Posts should not be placed in the bike lane.

SUGGESTED CHANGES TO STREET PATTERN DESIGN AND CONNECTIVITY

Road reconfiguration, such as a 4-to-3 lane conversion: The Federal Highway Administration's research says that four lane roads with less than 10,000 ADT are a "great candidate" for a redesign that provides two travel lanes, a center-turn lane, and often bike lanes, and that "capacity will most likely not be affected."

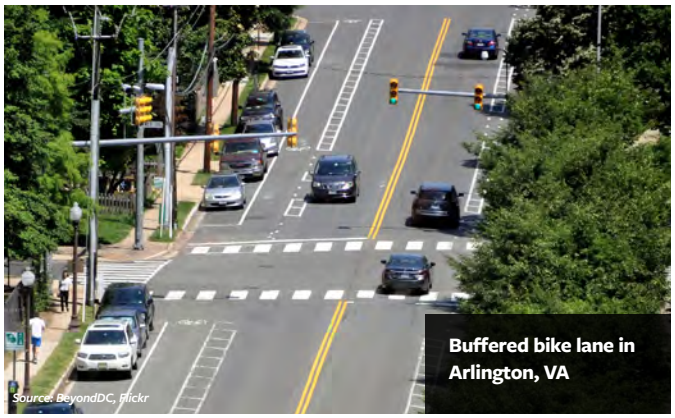
Improved bicycle and pedestrian crossings: Medians, pedestrian crossing islands, pedestrian leading intervals, and pedestrian hybrid beacons are Proven Safety Countermeasures for pedestrian safety that may also benefit people biking on trails or sidewalks.

Bicycle signals are traffic control devices that can improve safety and operation of bicycle facilities and provide guidance for bicyclists at intersections. Bicycle signals were granted interim approval under the MUTCD in 2013.

Low Speed / High Volume Streets

Posted speed limit 25 mph or less • Volume of 6K ADT or less

Good bike facilities for Low Speed / High Volume Streets



Buffered bike lane in Arlington, VA

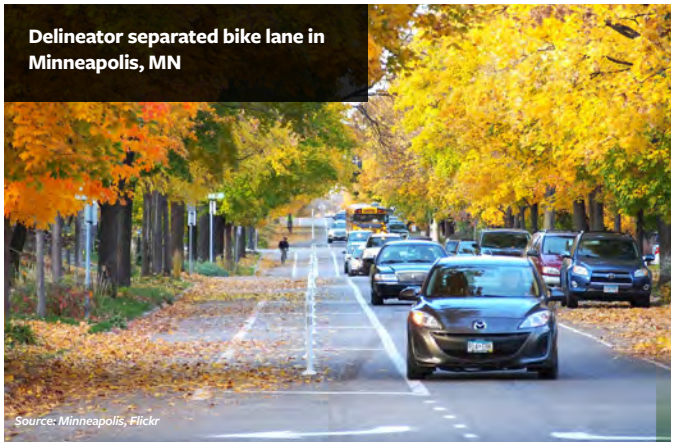
Source: BeyondDC, Flickr

Buffered bike lane on high volume street in Chicago, IL

Source: Places for Bikes, Flickr

Delineator separated bike lane with intersection markings in Washington, DC

Source: Toole Design Group



Delineator separated bike lane in Minneapolis, MN

Source: Minneapolis, Flickr

Delineator separated bike lane on Ravenna Blvd. in Seattle, WA

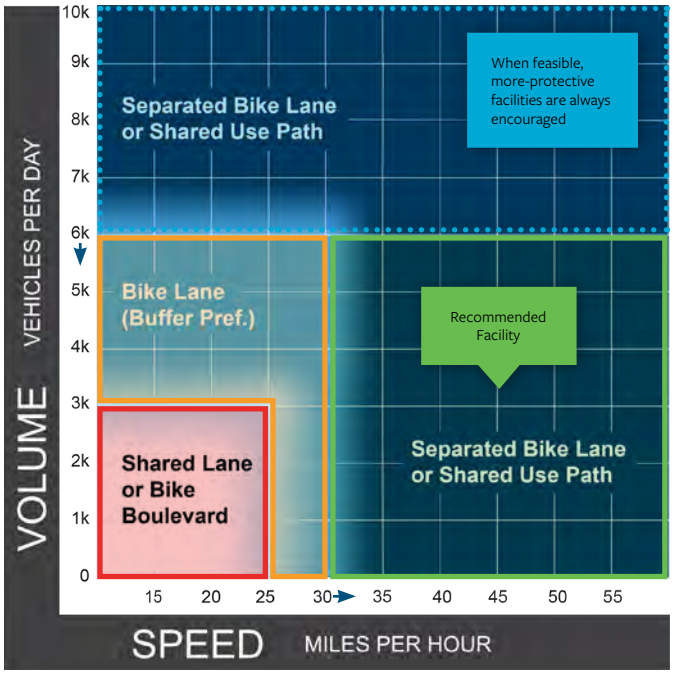
Source: Seattle DOT, Flickr

High Speed / Low Volume Streets

Posted speed limit 30 mph or more • Volume of 6K ADT or less

GOALS:

- **Promote compliance with speed limit through traffic calming**
- **Provide a comfortable and cohesive biking experience through facilities**



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SUGGESTED BIKE FACILITIES

Parking separated bike lane: A parking separated bike lane is a painted bike lane supplemented by a painted buffer that is marked to provide vehicle parking spaces between the bike lane and the travel lane. Parking demand, turnover, and the potential for doors opening into the bike lane should be considered.

Improved shoulders An improved shoulder suitable for bicycling provides at least five feet of clear shoulder. If a rumble strip is placed, it should be placed to provide at least four feet of clear shoulder and have a pattern that allows a bicyclist to leave the shoulder without crossing the rumble.

SUGGESTED CHANGES TO STREET PATTERN DESIGN AND CONNECTIVITY

Horizontal deflection devices for traffic calming: On higher speed roadways, horizontal deflection devices encourage drivers to slow down by introducing an obstacle which drivers must safely and comfortably navigate around. The horizontal shift in roadway geometry due to physical devices may also introduce an optical narrowing of the road.

Narrow lanes for traffic calming: AASHTO recommends a lane width of 10 feet for most travel lanes. NACTO recommends 10-foot lane widths in urban areas. According to FHWA, "narrowed lanes can accommodate bicycle lanes or parking, and provide some traffic calming benefit."

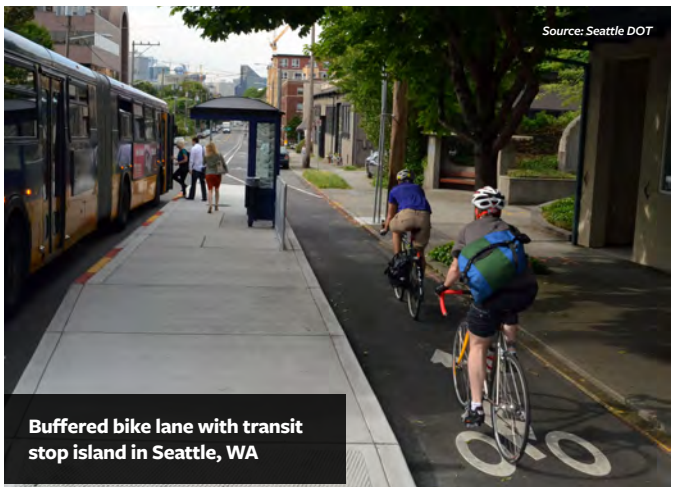
High Speed / Low Volume Streets

Posted speed limit 30 mph or more • Volume of 6K ADT or less

Good bike facilities for High Speed / Low Volume Streets

Source: Kristin Langford, PBIC

Sidewalk-level vertically separated bike lane.

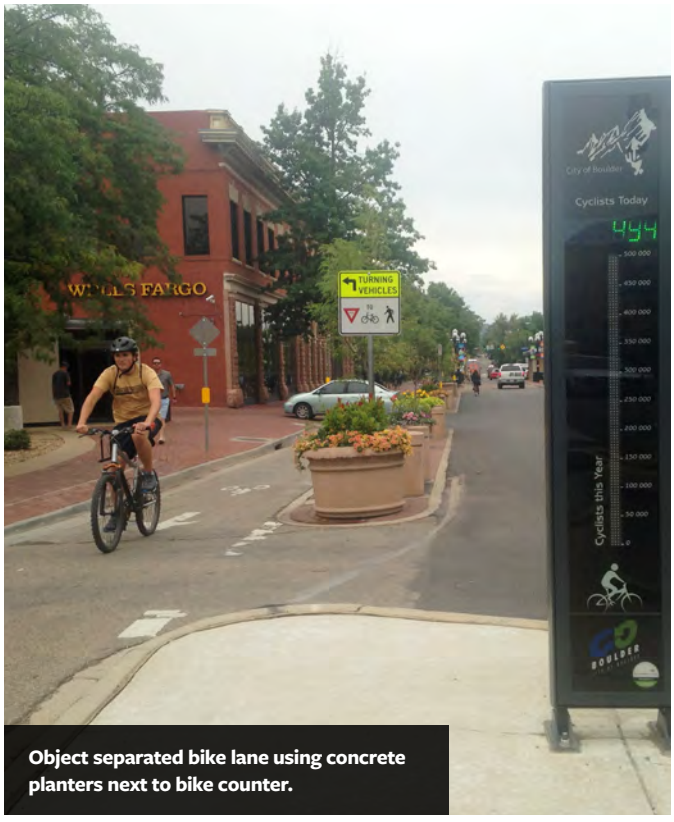


Source: Seattle DOT

Buffered bike lane with transit stop island in Seattle, WA

Source: Chicago BikeWalk

Two-way delineator separated bike lane on a one-way street in Chicago, IL



Object separated bike lane using concrete planters next to bike counter.

High Speed / High Volume Streets

Posted speed limit 30 mph or more • Volume of 6K ADT or more

GOALS:

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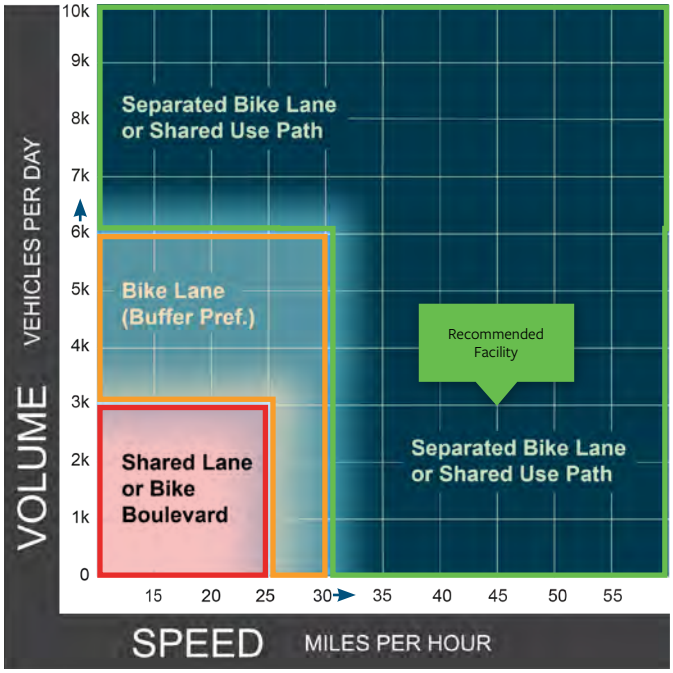
- **Provide a comfortable and cohesive biking experience through facilities**



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SUGGESTED BIKE FACILITIES

Object separated bike lane: An object separated bike lane is a bike lane separated from travel lanes by a solid object, such as a traffic separator, concrete island, or concrete planter that is intended for permanent placement.

Vertically separated bike lane: A vertically separated bike lane is a bike lane vertically separated from travel lanes, often adjacent to and at the same height as a sidewalk. Materials should be used to differentiate the bike lane area from the sidewalk and buffer zones.

Shared use path: A shared use path is a paved path at least ten feet wide shared by people biking and walking that is separated from a roadway. The minimum width to enable side-by-side travel and passing is 11 feet. In areas without comfortable bike facilities, sidewalks adjacent to high speed-high volume streets may function as de facto shared use paths because of the perceived danger of riding with motor vehicles.

SUGGESTED CHANGES TO STREET PATTERN DESIGN AND CONNECTIVITY

Improved access management: Corridor access management is a Proven Safety Countermeasure that manages potential conflicts created by intersections and driveways. Driveway closure, consolidation, or relocation can be particularly important to manage conflicts with shared use paths or separated bike lanes, especially when there is two-way bicycle traffic.

Protected intersections and other intersection treatments: A protected intersection is a design that keeps bicycles physically separate from motor vehicles up until the intersection to minimize exposure to conflicts. Features like setbacks, corner islands, waiting zones, and bicycle signals can be integrated into a complete protected intersection or deployed separately.

High Speed / High Volume Streets

Posted speed limit 30 mph or more • Volume of 6K ADT or more

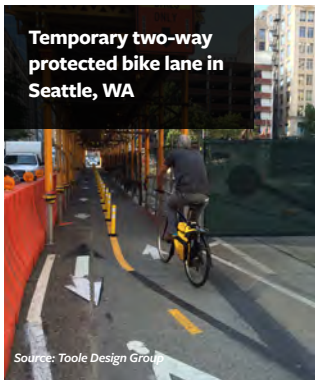
Good bike facilities for High Speed / High Volume Streets

Concrete island separated bike lane on former stroad in Decatur, GA

Source: PBIC image library, Cheryl Burnette

Source: Toole Design Group

Bike signal in Portland, OR



Temporary two-way protected bike lane in Seattle, WA

Source: Toole Design Group

Protected intersection with bike signal in Chicago, IL

Source: Sarah Abel, ITE

Vertically separated bike lane at sidewalk level in Washington, DC

Source: Sarah Abel, ITE

Shared use path in Austin, TX

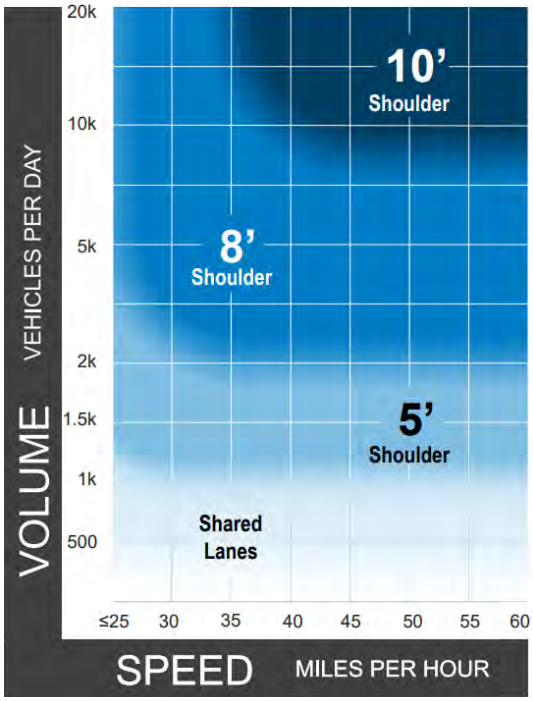
Source: Adam Coppola

Rural Roads

Special matrix for rural roadways

GOALS:

- **Promote compliance with speed limit**
- **Separate users by space and time to reduce conflict**



SUGGESTED BIKE FACILITIES

Improved shoulders: An improved shoulder suitable for bicycling provides at least five feet of clear shoulder. If a rumble strip is placed, it should be placed to provide at least four feet of clear shoulder and have a pattern that allows a bicyclist to leave the shoulder without crossing the rumble. A recent review of state rumble strip policies by the Adventure Cycling Association found that only four states followed their minimum model design standards.

Side path: A side path is distinguished from a shared use path by being immediately adjacent and parallel to a roadway rather than in its own alignment. The preferred minimum separation from the roadway is 6.5 feet.

Separated bike lane: Vertical or object separation may be preferred to parking separation due to low parking demand in rural areas.

Advisory bike lane: Advisory bike lanes are similar in function to yield roadways which are roadways too narrow for two-way travel without people yielding to pass, and may also be referred to as advisory shoulders to recognize that they may also be used by people walking.

SUGGESTED CHANGES TO STREET PATTERN DESIGN AND CONNECTIVITY

2+1 roadways and passing lanes: A 2+1 road design has a continuous three-lane cross section with alternating passing lanes. Research generally shows safety and operational improvements. As passing maneuvers or lack of passing opportunities are major sources of conflict between people driving and biking, more safe passing opportunities may mitigate that conflict.

Rural Roads

Special matrix for rural roadways

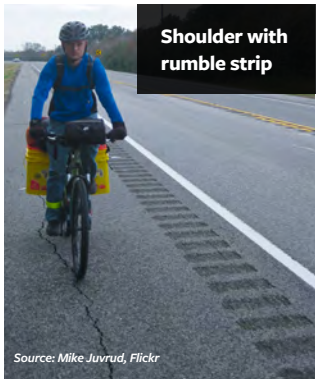
Good bike facilities for Rural Roads

Source: League of American Bicyclists

League Cycling Instructors using a side path in Fort Collins, CO

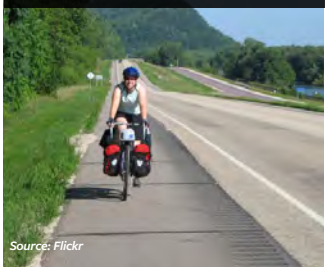
Source: Bicycle Friendly Community application

Advisory bike lanes/shoulders in Hanover, NH



Source: Mike Juvrud, Flickr

Shoulder with rumble strip



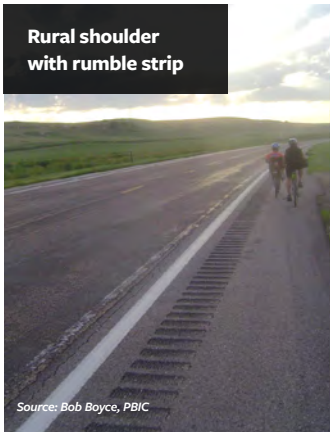
Source: Flickr

Bicyclist on shoulder with rumble strips that could be moved closer to travel lane

Source: Gene Bisbee, Flickr

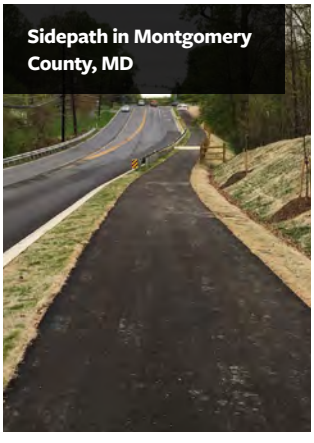
Green bike lane on 30mph road

Two-lane road before-and-after addition of bikeable shoulders in Minnesota



Source: Bob Boyce, PBIC

Rural shoulder with rumble strip



Sidepath in Montgomery County, MD

Recreational & Fast Cycling

People bike for many reasons and when they do they may have different needs. So far, we have discussed safety treatments that are applicable for all people who bike, especially those using bicycles for transportation. Some other people who bike may ride faster, ride in groups, and ride longer than other people. To address those differences, this page is about the users of bike facilities and roadways, rather than the context of the roadways based upon speed, volume, or rural nature. Recreational or sports cyclists are typically not discussed in engineering and planning as users, and engineering guidance for accommodating them specifically does not exist. This page describes some considerations for bike networks specific to recreational or sports cyclists. These are to be considered in addition to previous guidance already discussed, not as a replacement for that guidance.

GOALS

Allow performance criteria for higher bicycle speeds (15 mph or greater) - The 2012 American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities suggests **speed performance criteria** for bike facilities with a 15-mph average operational speed. Recreational cyclists, especially in groups, can regularly operate at higher speeds, with **professional riders** averaging 25-28 mph on flat terrain, and e-bike users can reach speeds over 15 mph regularly. Bicycle facilities designed for lower speeds may be incompatible with these faster speeds, creating conflicts and dangers not apparent at lower speeds.

Accommodate group riding dynamics - **Riding in a group is a skill** and affects the behaviors of people riding together. People ride in a group to gain an **aerodynamic advantage**, so they ride close together to maximize that advantage. Riding close together and taking turns at the front create the need for occasionally riding two abreast and **avoiding rapid braking** without warning. Groups often also **choose to ride two abreast** for better communication and to provide a shorter overtaking distance for motor vehicles. These group riding dynamics often require more space and better pavement conditions than are available at the edge of a road.

Design for different routes - Recreational riders often ride long distances, with 100-mile rides being a goal of many people who ride for fun and fitness. These longer rides are likely to be in suburban or rural places, and may prioritize unbroken flow or natural beauty over directness. While sports-oriented apps may not provide data on all bicycling, data like Strava's **heatmap** or **metro** are likely to show popular recreational routes.

SUGGESTED BIKE FACILITIES

Bike lanes: May be a good redundant facility adjacent to shared use path or side path.

Signed bike routes and sharrows: Promotes unbroken flow and may improve comfort and attractiveness when used alone. Can also reinforce the right to the road when placed adjacent to a separated bike lane, side path, or shared use path.

Improved shoulders: Shoulders are a common bike facility in rural areas. A wider clear distance and a pattern that allows a bicyclist to leave the shoulder without crossing the rumble strip can be important for group dynamics.

Shared use paths: Probably the most commonly used recreational bicycling facility.

SUGGESTED CHANGES TO STREET PATTERN DESIGN AND CONNECTIVITY

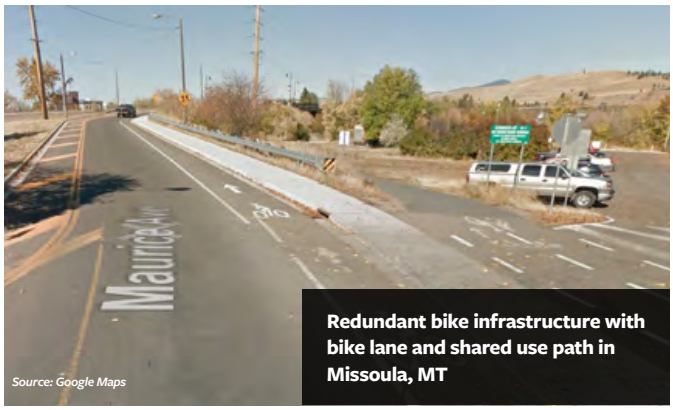
The Right to the Road: People who ride need the ability to choose whether to ride in the roadway or in a bicycle facility. Historically, separated bike lanes, side paths, and shared use paths have often been accompanied by laws requiring their use, disregarding the needs of people who ride at faster speeds than those facilities are designed for or who ride in groups that do not fit in those facilities. The right to the road allows cyclists to use the facility that best meets their needs.

Redundancy of bike facilities: Providing multiple bike facilities that can serve different people with different needs provides options that prevent conflicts. Even the "strong and fearless" may choose to use a shared use path if the alternative is a high speed-high volume road with no bike facility. Group rides often consist of people of varying comfort levels and providing redundant bike facilities allows people to meet their needs without causing conflict.

Separated biking and walking paths: In places with high pedestrian or bicycle volumes, a shared use path may create conflict between users. Several formerly shared use paths have been separated into paths for biking and walking to mitigate that conflict and provide a better experience based on high use.

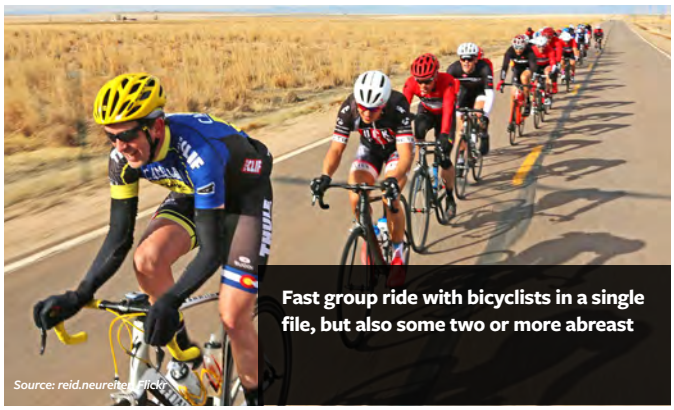
Recreational & Fast Cycling

Good bike facilities for Recreational and Fast Cycling



Redundant bike infrastructure with bike lane and shared use path in Missoula, MT

Source: Google Maps



Fast group ride with bicyclists in a single file, but also some two or more abreast

Source: reid.neureiter, Flickr

Mayor-led group bike ride in Sitka, AK using their right to use the road

Source: Bicycle Friendly Community application

W&OD trail in Falls Church, VA has bicycle and pedestrian dual trails

Source: NOVA Parks

Multi-use trail in Denver, CO

Source: Toole Design Group

Building **Better Bike Networks**

There may be nothing more frustrating for a bike rider or bike advocate than a bike lane to nowhere—one that ends in a dangerous roadway, one that disappears at an intimidating intersection, or one that only exists for a block or two. When a bike lane does not connect to other bicycle infrastructure, or does not connect to destinations, it often fails to provide a useful place to ride, and can become a flash point for people who do not believe that bicycle infrastructure should be built. While each bike facility is a win to celebrate, incomplete networks create confusion and danger for people biking and driving. To fully realize the safety benefits of bicycling facilities, they need to connect to each other in networks. With connected bicycling facilities, more people can access the benefits of bicycling and as more people bike, the roads become a safer place for even more people to bike. It all starts with safe networks.

The best way to avoid a contested "bike lane to nowhere" is to think in terms of networks—and have a plan for building networks, not just single lanes. Having a clear network vision places currently unconnected bike lane into a context of a connected future. This helps counter the "bike lanes to nowhere" argument and can help advocates, policymakers, and citizens understand why bike lanes are built where they are and the benefits they provide.

The CDC's Active People, Healthy Nation℠ initiative prioritizes creating "activity-friendly routes to everyday destinations" in order to incorporate physical activity into everyday activities. This is an evidence-based strategy to improve public health through increased physical activity based on a review of 90 studies that found the built environment—such as the presence or absence of bicycle infrastructure—influences rates of physical activity.

The strategy of creating "activity-friendly routes to everyday destinations" also recognizes that trips are caused by human needs. Understanding everyday destinations and providing appropriate infrastructure so that people can access them with active modes of transportation such as bicycling and walking is critical to allowing more people to choose physically active modes. Understanding the trips that matter to a community is best accomplished through engaging the local community in the area where a network is needed. Starting with an important or popular everyday destination—such as a bus stop, grocery store, park, or place where people gather—may help define your network area and reach people who will be served by the creation of a bike network.

In many places in the United States, the best routes for bicycling are learned through trial-and-error, local knowledge from experienced bicyclists, and piecing together sections of bike lanes, side streets, and other adaptations to places not originally built for physical activity. A great bicycle network is made up of great bicycle routes. When bicycle routes connect together to form bicycle networks they open up more places in a community to more people, support people who may be unfamiliar with the network, and allow more people to feel safe cycling. FHWA's Bikeway Selection Guide reinforces this by including principles of connectivity, cohesion, and unbroken flow in developing a bicycle network.

Principles and Language for Better Bike Networks

Most places in the United States do not have well developed bicycle networks. It is common for shared use paths, paved trails, painted bike lanes, and low speed streets without any signs or improvements to make up most of a community's *de facto* bicycle network, regardless of gaps or discontinuities. A well-developed bike network will provide both access and coverage so that people biking can get where they need to go in a consistent, safe, convenient, efficient, reliable, and comfortable way. According to the Pedestrian and Bicycle Information Center, access reflects the degree to which people can get to key destinations on the network, and coverage reflects ease with which all destinations can be accessed on the network.

Bicycle network principles do not follow the functional classification system of roadway networks with highways, arterials, collectors, and local streets. Bicycle network principles are based upon building a bicycle network into an existing system of roadways and other right of ways, rather than a wholesale reshaping of roadway systems as was done through the functional classification system that prioritized non-grid street patterns. Bicycle network principles can be applied regardless of existing street pattern.

Bicycle network principles help advocates, agency staff, and others talk about a shared vision for a future bicycle network and why some routes might be preferable or necessary for a well-functioning bicycle network. The Federal Highway Administration (FHWA) articulates seven principles of bicycle network design that are significantly influenced by Dutch network principles.[8]

8. The principles of Safety, Comfort, Directness, Attractiveness, and Cohesion were articulated in the CROW Design Manual for Bicycle Traffic in 2016: https://dutchcycling.nl/en/news/blog/5-design-principles-for-successful-bicycle-infrastructure

Figure 4: Seven Principles of Bicycle Network Design According to FHWA

The FHWA's Bicycle Network Principles are:

SAFETY

With the transportation sector shifting toward a Safe System Approach, now more than ever, safety is a principle for all network development. Choosing good routes and ensuring appropriate infrastructure on network segments is a major part of limiting the frequency and severity of crashes on the bike network.

COMFORT

Comfort can be a qualitative supplement to safety. Even if data does not show a history of crashes, places can be uncomfortable in ways that deter people from bicycling. Comfort can also capture safety concerns that are not vehicle traffic-related such as high noise, high pollution, personal safety from violence or harassment, and discrimination.

CONNECTIVITY

The principle of connectivity is that people should be able to access destinations without leaving the network and are not subjected to gaps in the network. The FHWA says that Safety, Comfort, and Connectivity are particularly important for bikeway selection.

DIRECTNESS

Directness captures the distance and trip times of routes in a bicycle network. While people will go out of their way to use high-quality bicycle infrastructure, the directness of a network affects bicycling's ability to compete with other modes of travel when people are choosing whether to ride or not. According to a 2012 NHTSA survey, the number one reason that people do not use bicycle paths or bicycle lanes is that they "don't go where I need to go." [9]

ATTRACTIVENESS

Attractiveness captures the look and feel of a route. For the CDC's Activity-Friendly Routes to Everyday Destinations strategy, this may include whether the route has interesting and engaging places along the route. The appropriate design and operation of bicycle infrastructure should also reflect the principle of creating an attractive environment.

COHESION

Cohesion captures whether most people can reach the network within a short distance. According to the Dutch CROW Manual, "people should not have to travel more than about 250 metres (~820 feet or .15 of a mile) to reach the bicycle network." According to a 2012 survey by the National Highway Traffic Safety Administration (NHTSA), less than 40% of respondents lived within a quarter mile of a bike lane.[10]

UNBROKEN FLOW

Unbroken flow speaks to paying attention to barriers and transitions that can break the flow of a person using a bicycle network. An example given by the FHWA is a long stop at a traffic light, where an otherwise safe, comfortable, and even attractive section of a bike network nevertheless creates a bad experience for the person using it. Making clear transitions from one bike facility to another or providing clear signs or markings for non-intuitive routing can also contribute to unbroken flow.

Source: FHWA

9. See Figure 3.10: https://one.nhtsa.gov/Driving-Safety/Research-&-Evaluation/2012-National-Survey-of-Bicyclist-and-Pedestrian-Attitudes-and-Behavior

10. https://one.nhtsa.gov/Driving-Safety/Research-&-Evaluation/2012-National-Survey-of-Bicyclist-and-Pedestrian-Attitudes-and-Behavior (survey was first done in 2002, repeated in 2012, and will likely be repeated again soon).

From Network Principles to Activity-Friendly Routes to Everyday Destinations

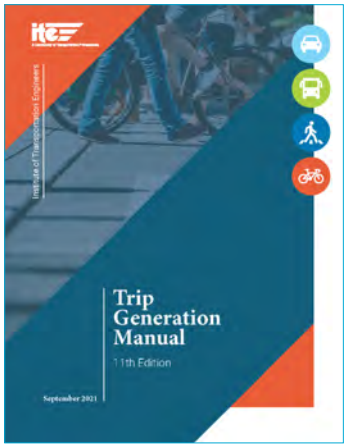
The CDC's strategy of providing Activity-Friendly Routes to Everyday Destinations is a great way to focus on creating bicycle networks based upon good principles. To be activity-friendly means a route should be safe, comfortable, and attractive.

Focusing on routes to everyday destinations helps apply the principles of directness, cohesion, connectivity, and unbroken flow to where people are and the places they want to go. The CDC's Active Communities Tool explicitly asks about policies to connect bike networks in its bicycle infrastructure assessment module.

When and How Bike Networks get Built

Turning a bicycle network plan into a reality is usually done through three main methods: capital projects, repaving, and site development improvements.

Capital projects, repaving, and site development improvements are usually the outcome of transportation planning or private initiative. Transportation planning has made several improvements that prioritize metrics for people getting around without a private vehicle. The following approaches provide helpful metrics in bicycle network planning, capital projects, as well as multimodal transportation impact analysis for site development reviews within agencies. If your community already uses one or more, that's great! If your community doesn't use any, then find the one that decisionmakers are interested in to begin the process of shifting what counts as success.



Cover of ITE Trip Generation Manual, 11th Edition. *Source: ITE*

Selected metrics or processes to improve transportation planning:

Measuring Person Trips – a trip made by any mode of travel by an individual person from an origin to a destination.

Every trip made anywhere by a person is a person trip. Person trips for certain land uses, including specific data on bicycle trips, can be found in the 10th edition or later of the Trip Generation Manual by the Institute of Transportation Engineers.

Shifting from Level of Service to Quality of Service: measures effectiveness of roadways for all users beyond the traditional auto-oriented Level of Service (LOS).

This is a trend reflected in many emerging federal, regional, state, and local policies that expand LOS to all modes of travel and recognize that the Quality of Service (QOS) may also be relevant to defining system adequacy.

Using Transportation Demand Management (TDM): a set of strategies aimed at maximizing traveler choices.

TDM is a planning application to consider efforts to increase multi-modalism in transportation plans and congestion mitigation, as well as other options such as air quality improvements. In 2020, the Mobility Options, Resiliency, and Efficiency (MORE) Through TDM Act was introduced for the first time to define TDM in federal transportation law and expand its use.

Road Safety Audits: a proactive, formal safety performance examination of an existing roadway or future project area.

This formal audit structures data collection and conversation about roadway conditions and deficiencies. Road safety audits can be a great way to bring people together across agencies and departments, or structure input from citizens. While the audit is of a specific place, the audit process may provide insight into systemic issues.

Context Sensitive Design: a collaborative, multidisciplinary process that involves all interested parties in planning and designing transportation facilities.

Context sensitive design helps facilities meet the needs of users and collaborators, be compatible with their settings and minimize environmental impacts, are designed for safety, efficiency, multimodal mobility, capacity and maintenance; and integrate community objectives and values relating to livability and sense of place.

Case Studies: Network Lessons from Cities with Increased Commuting

For this report, we chose communities for case studies based on cities with data showing improvements in the rate of bicycling to work over the last decade. Each city selected for an interview and network study has a bicycle commute to work rate of more than twice the national average and each had a positive growth rate over the last decade.

Figure 5: Bicycle Mode Share and Growth of Case Study Communities

Communities Selected for Case Study

Community	Biking Mode Share	Percent Change 2000-2019
Boston, MA	2.3%	59%
Chicago, IL	1.7%	53%
Oakland, CA	2.7%	40%
Austin, TX	1.3%	19%
Missoula, MT	6.2%	7%

Source: American Community Survey data on ***data.bikeleague.org***

What We Found is Critical to Network Growth

In conversations with leading Bicycle Friendly Communities about their bike network development and growth, the following themes, further discussed in the case studies, emerged when talking about what has been critical to their recent bike network growth.

YOU NEED A BIKE PLAN

No city successfully developed a network without a bike plan.

Most cities had multiple plans (2-4), but not all facilities built had been included in plans, and plans before 2012 typically did not include separated bike lanes

REPAVING IS CRITICAL

Every city implemented multiple projects through repaving.

Repaving is usually on a 10 to 20-year cycle and based upon maintaining a certain pavement quality standard or citizen complaints. Citizen complaint-driven repaving can prioritize wealthier, more politically empowered, residents at the expense of people with lower incomes and less time for proactive agency engagement.

CULTURE CHANGE WAS TYPICAL

Many cities pointed to staffing or political changes as a catalyst for new and improved bike facilities.

Getting city council members, mayors, and top staff to clarify goals and endorse plans can be an important part of building a network. Publicly authorized bonds or taxes can show citizen support for institutional changes.

NETWORK DATA COLLECTION IS HELPFUL, BUT COSTLY, AND NETWORKS ARE COMPLICATED

Data on existing bike networks was not uniform between cities or over-time. This reflects both the evolution of bicycle facilities over time and the complexity of facilities that vary between directions on some streets and vary over the course of a route.

Lack of existing bike network data rarely stopped bike network developments, but better data provided more context to inform the public during community engagement.

THE REASON FOR DEVELOPING THE NETWORK IS IMPORTANT, BECAUSE IT REFLECTS THE PEOPLE SERVED

Every city had a reason for bicycle network development that was specific to its needs and its residents. Citywide bicycle plans generally set the tone of more local conversations while allowing space for a collaborative engagement process.

Transportation equity is a consideration for each community, but is not yet driving network developments.

What We Found About Benchmarking Bike Networks

Benchmarking bike networks is difficult. AASHTO's Council on Active Transportation's Research Roadmap states that "there is also no agreed-upon 'best' measure for bicycle infrastructure networks." Bicycle facilities have evolved rapidly in the last decade and standards for inventorying facilities have not been widely adopted to facilitate cross-jurisdiction comparisons. The following list is based on conversations with our case study cities and our experience with the Bicycle Friendly Community program.

1. DATA INVOLVES A COMMITMENT

Austin, Boston, Chicago, and Oakland had data on bike facilities available in a Geographic Information System (GIS).

- GIS allows for easier mapping and combining of data.
- Equity analyses often use GIS data to overlay bike facilities and demographic characteristics.
- Most GIS data allows for the export of data into a spreadsheet format, which is helpful for showing changes over time.

GIS is a specialized data skill requiring a qualified employee or consultant for setup and maintenance.

The League's Bicycle Friendly Community application does not require GIS data. GIS software can be a financial investment for public agencies. Not every city has made this investment yet, and some have partnered with academics or other community partners to work around the lack of software and/or qualified employees to do GIS analysis.

2. DATA PRACTICES ARE NOT UNIFORM

Most cities reviewed use centerline miles in their data.

- Centerline miles count one mile of length as one centerline mile.
- Centerline miles recordkeeping creates conditions where a city can have mixed bike facilities on one centerline mile, such as a painted bike lane going uphill and a shared lane marking going downhill.
- The League's Bicycle Friendly Community application asks for bicycle facility data in centerline miles.

The other common form of recordkeeping is "lane miles" which count one mile of length as two "lane miles" if there are two travel lanes, and four "lane miles" if there are four travel lanes.

3. BIKE INFRASTRUCTURE PRACTICES CHANGE

Bike facilities have grown in complexity over the last decade and the many types of buffering and separation now used create more complex data which may be more difficult to communicate to the public.

- While we tried to keep our Context Guide to Bike Facilities high-level and simplified, it nevertheless describes 19 types of bike facilities that could be mapped.
- California has formalized four classes of bike facilities to aid mutual understanding of bike facilities in the state, but this approach is not common.

4. INCORPORATING LEVEL OF TRAFFIC STRESS AND EQUITY IS STILL NEW

Sometimes facility types are presented as high or low stress to counter the complexity of describing and/or labeling many different types of facilities.

Equity analyses were typically done as part of a planning process.

5. WHERE DATA EXISTS, IT IS HELPFUL IN COMMUNICATIONS AND TRUST BUILDING

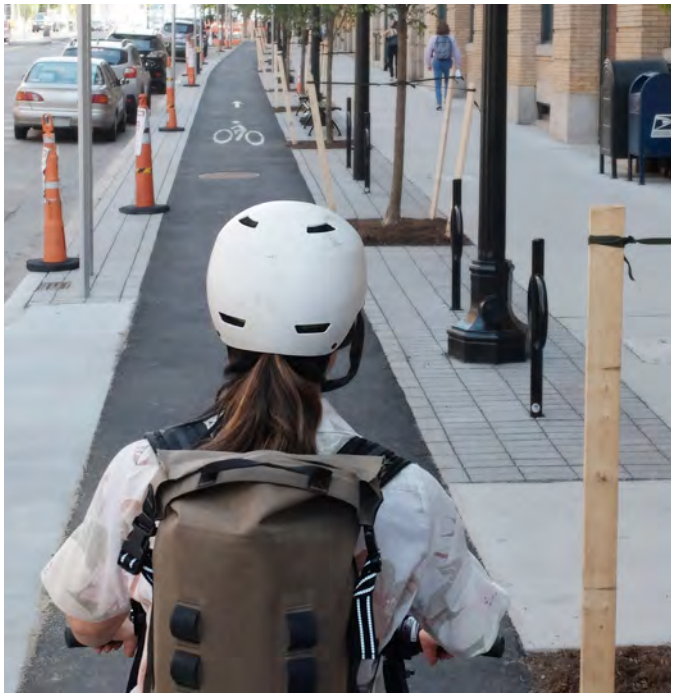
It is fairly common for investments in transportation to be unequal and complete data on bike facilities collected over time provides a solid history of investments so that discussions about equity and investment can be informed by that history.

Boston

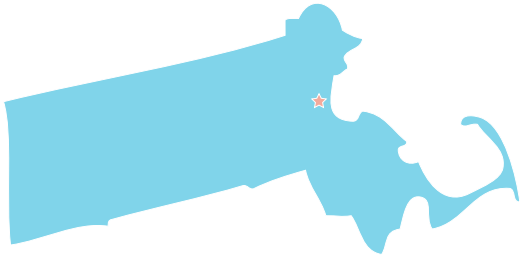
Making Health Connections with an Evolving Bike Network

The City of Boston's bike network has strong ties to public health and opposition to highway building. A backbone of the network is the Paul Dudley White Path, created in the 1970s and named after President Eisenhower's physician who advocated for bicycling and walking as preventative medicine. Other major pieces of the network use corridors reserved for highways that were not built, such as the Southwest Corridor Park, or highways that were capped as part of the Big Dig.

At least four transportation plans have helped Boston create its current network, and showcase the evolution of bicycle facility practices over the last quarter century. The Access Boston Plan in 2001 included a bike plan that identified existing facilities, proposed facilities, and corridors for evaluation, with a heavy emphasis on shared use paths and shoreline paths in its proposed facilities. In 2007, the Boston Bikes program created by Mayor Thomas Menino allowed the City to quickly build more than 40 miles of bike lanes as part of repaving and other projects funded in part by the American Recovery and Reinvestment Act. In 2013, the City adopted its first standalone bike plan and its first plan to include separated bike facilities. This was published in the fall around the time that NACTO released its highly influential Urban Street Design Guide, and two years before the Massachusetts Department of Transportation (MassDOT) published its Separated Bike Lane Guide. Most recently, in 2018, GO Boston 2030 was published with a further emphasis on separated bike lanes and traffic-calmed routes, and with zero standard painted bike lanes as priority projects (see **Figure 6** on next page for changes in facilities built over time).



Vertically separated cycletrack in south Boston, MA, USA on Summer Street.
Source: City of Boston



Lack of Grid Network Makes Connections Difficult

Our discussion focused on downtown Boston, where there is an emphasis on getting people to and from bridges and the shoreline Paul Dudley White bike path, and a recently developed network of protected bike lanes that use Boston Common and a "box" of one-way streets as critical hubs in the network (see **Figure 7** on page 29 for a map of area). While the network around Boston Common is found in the five-year action plan of the 2013 bike plan, the "box" of one-way streets around LaGrange is not.

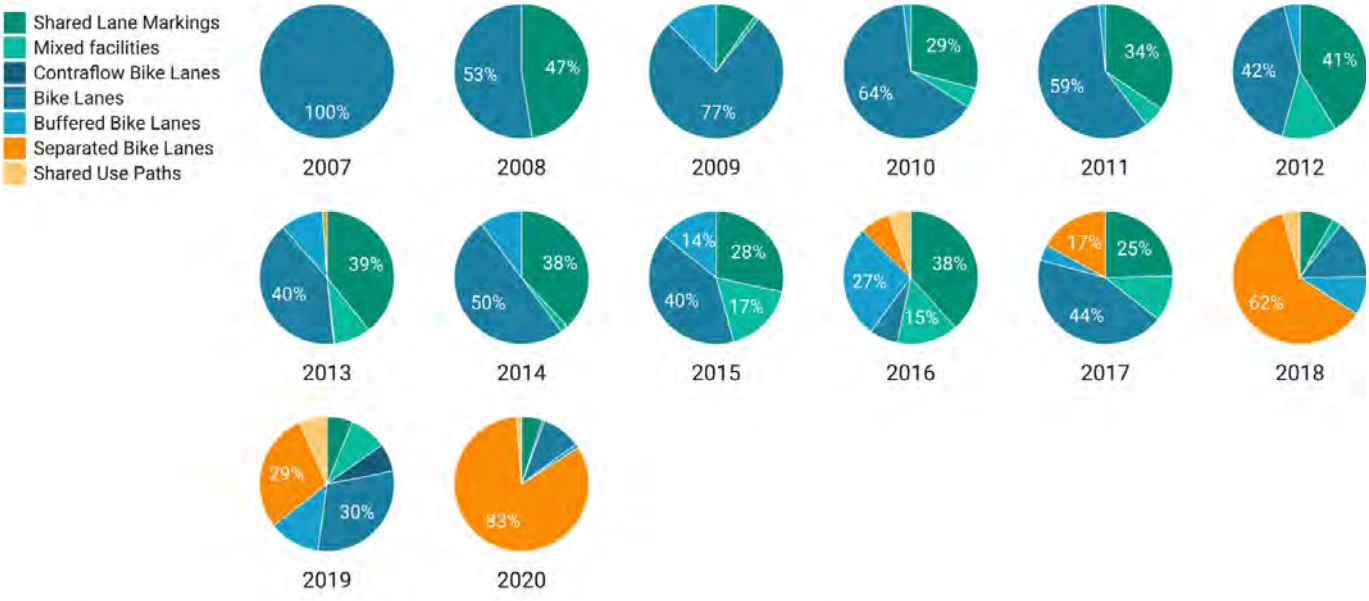
Boston relies on many traffic-calmed streets in its bike network. The connection between Boston Common and the Harvard Bridge currently relies on a multi-year pilot project creating a parking protected bike lane on Beacon Street and a one-way couplet with shared lane markings (a couplet is two parallel one-way streets that "couple" to provide a two-way corridor, in this case both are named Commonwealth Ave). Massachusetts Avenue becomes Harvard Bridge and was the first project where vehicle parking was repurposed to bicycle lanes, eventually becoming protected bike lanes around 2017.

A challenge for Boston is its historical development without a strong grid street pattern. While there are areas with gridded networks, the overall street development pattern is a hub and spoke system. Major spokes can be some of the only through streets, creating pressure to accommodate private vehicles, public transit, bicycling, and walking adequately within one corridor and limiting lower-traffic street alternatives.

Other network challenges include several localities that share borders with Boston, including some—like Brookline—that have parts of Boston on multiple sides, and bridges that are owned by MassDOT. Luckily, many of these localities have similar goals to improve bicycling and walking and MassDOT has taken steps to provide a shared framework for Complete Streets improvements. Notable policies in neighboring localities include Cambridge's Bicycle Safety Ordinance that requires implementation of its bike plan's separated bike lane network.

Notable MassDOT policies include alignment with NACTO on the City Limits speed limit setting guide, the 2015 Separated Bike Lane Guide, and a statewide program that provides incentive grants based upon Complete Streets policies.

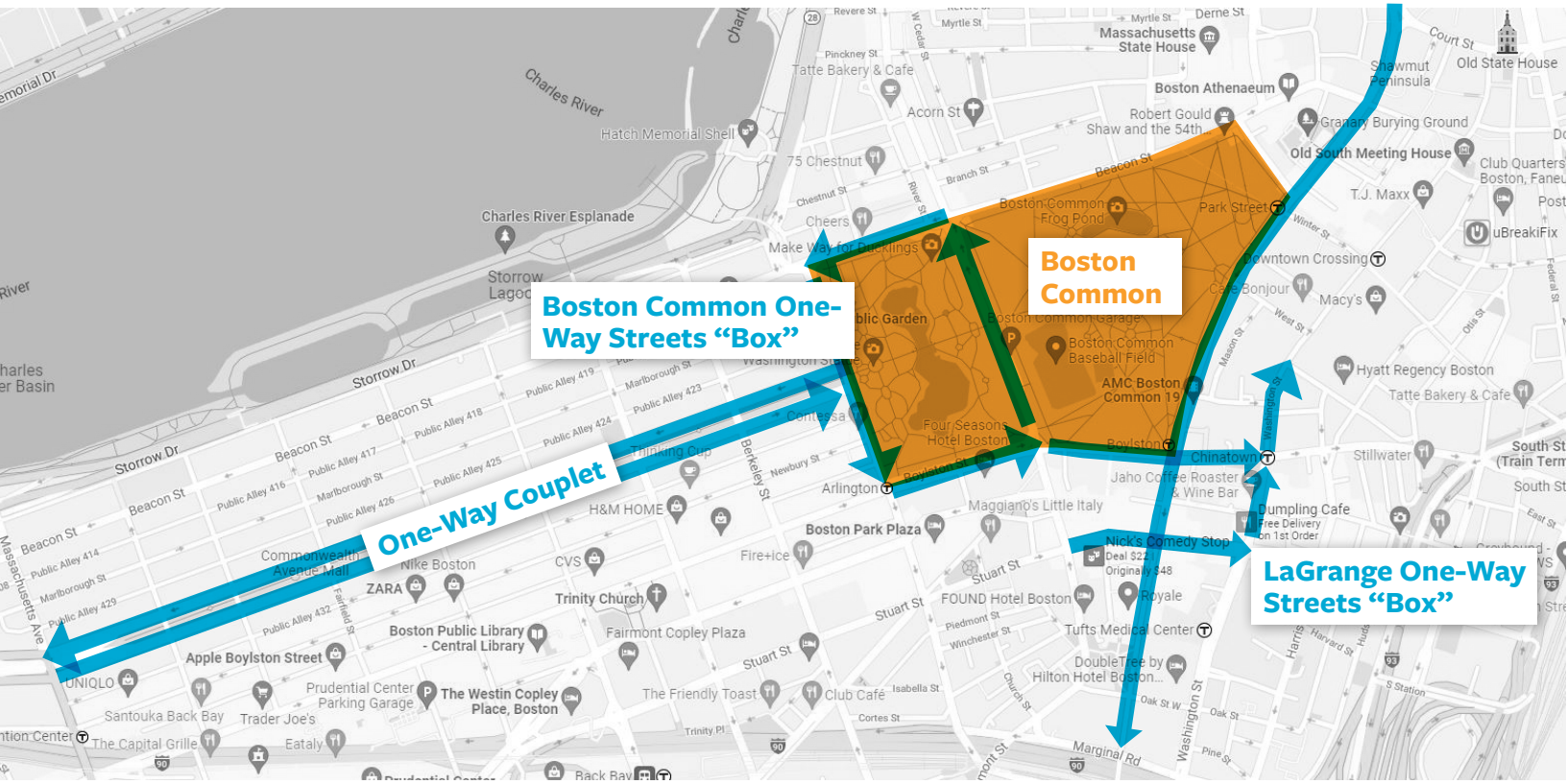
Figure 6: Change in Bike Facilities Built in Boston



Bike facility types were grouped from 13 types in the initial data into the 7 presented here. Mixed facilities are streets where different types of bike facilities co-exist on either side of a street and includes bike lanes, shared lane markings, and separated bike lanes.

A strong shift to separated bike lanes is apparent in Boston's data on network growth over time. Data was simplified to show changes in infrastructure types over time. *Source: City of Boston*

Figure 7: Annotated Map of Boston's Bike Network



Source: City of Boston

Other Policies of Note in Boston:

1. Boston successfully advocated for a change to statutory speed limits in order to establish 20 mph safety zones. City staff credits this change with enabling traffic calming based on a 20-mph target speed, which is now accomplished through the Neighborhood Slow Streets program.

2. Massachusetts, like most states, is considered a "Dillon's Rule" state—meaning that cities only have the powers delegated to them by the state legislature. This can limit city initiative and remains an issue for speed limit setting and e-bike regulation.

3. In 2016, FHWA changed its "controlling criteria"—geometric standards that must be met or have a justified exception—for projects on the National Highway System (NHS), which covers about 230,000 miles of roadways in the United States. The 2012 federal transportation law known as "MAP-21" made principal arterial roadways that connect to the NHS part of the NHS. Principal arterials in urban areas are often part of High Injury Networks and disproportionately the type of streets where people biking and walking are killed. While MassDOT has incorporated Complete Streets into its controlling criteria, city staff said designs including narrow travel lanes of 10 feet or less required an exception, creating a barrier to implementation.

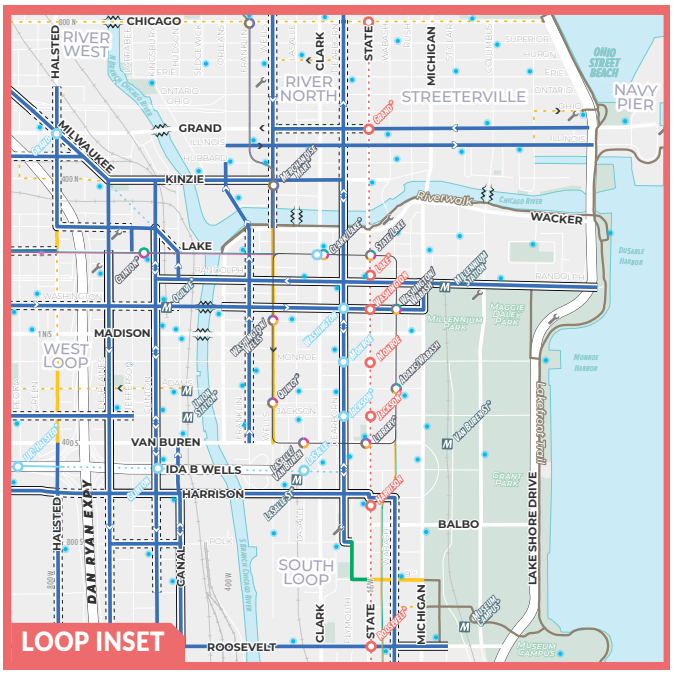
Chicago

Grid It to Win It

Chicago is a city with deep ties to transportation as a hub for railroad and other traffic. Unlike Boston, with its narrow pre-car streets, or Austin, with its post-World War II car-oriented streets, Chicago has an extensive grid of streets that developed over time to accommodate various forms of travel. This gridded network of streets is an asset when building a bike network and grids of bike facilities of varying quality appeared to be more common than in other cities reviewed for this report.

Thanks to its extensive grid network and publicly accessible GIS data, Chicago's bike network has been the subject of many studies and map-making activities, including many that emphasize disparities in bike infrastructure for different geographic regions of the city or for different demographic groups. In 2015, the League of American Bicyclists used Chicago for its report on using GIS methods for assessing equitable access to bike infrastructure. Chicago's data uses centerline miles for bike facilities.

Chicago's recent bike network development is heavily influenced by the 2012 Streets for Cycling Plan which outlined a 640-mile network and has helped the city double the length of its bike network in the last decade. The Streets for Cycling Plan is a vision plan, meaning that specifics of routes are not discussed, rather the goal is to provide a roadmap for network development. This approach is now being carried forward in the City's Neighborhood Bike Networks Process and its goal to make 100 miles of network improvements by the end of 2022.



Example of grid of bike facilities in the "Loop" in downtown Chicago.
Source: City of Chicago Bike Map

Neighborhood Bike Networks Process Leads with Collaboration

Our discussion focused on the Belmont Cragin neighborhood, where Chicago is currently implementing approximately 15 miles of bike network improvements as part of its effort to make 100 miles of network improvements by the end of 2022, with a focus on improving equity. According to city staff, the Belmont Cragin neighborhood is primarily single-family homes in Chicago's "bungalow belt" and has higher than average populations of young and Latino people.

To lead with collaboration, the city formed a community task force with the Northwest Side Housing Center (now rebranded Northwest Center) as a lead partner. Activities of the community task force included working with a local bike shop on youth-oriented workshops, regularly meeting with the Northwest Center's youth council, and doing walkability assessments with the Consortium to Lower Obesity in Chicago's Children. This community task force approach focused on identifying issues that mattered to the community and how biking can contribute to addressing those issues (see **Figure 9** on next page for data on bike facilities in Chicago).

Leading with community collaboration and a hyper-local approach to understanding community needs led to a larger network than the city planned for previously. The process, which focused on building a bike network for a neighborhood all at once, rather than over-time through repaving and corridor-by-corridor planning is seen as a success to replicate. In most cities, it would be time to update the 2012 citywide bike plan to reflect changes and experience over the last decade, but city staff told us that continuous neighborhood network planning in Chicago may remove the need for such a large formal update.

Figure 8: Comparison of Belmont Cragin Bike Network Planned Over Time

Belmont Cragin network map from 2012 Streets for Cycling Plan.

Belmont Cragin network map planned for 2021-2022 implementation.

Source: City of Chicago & City of Chicago

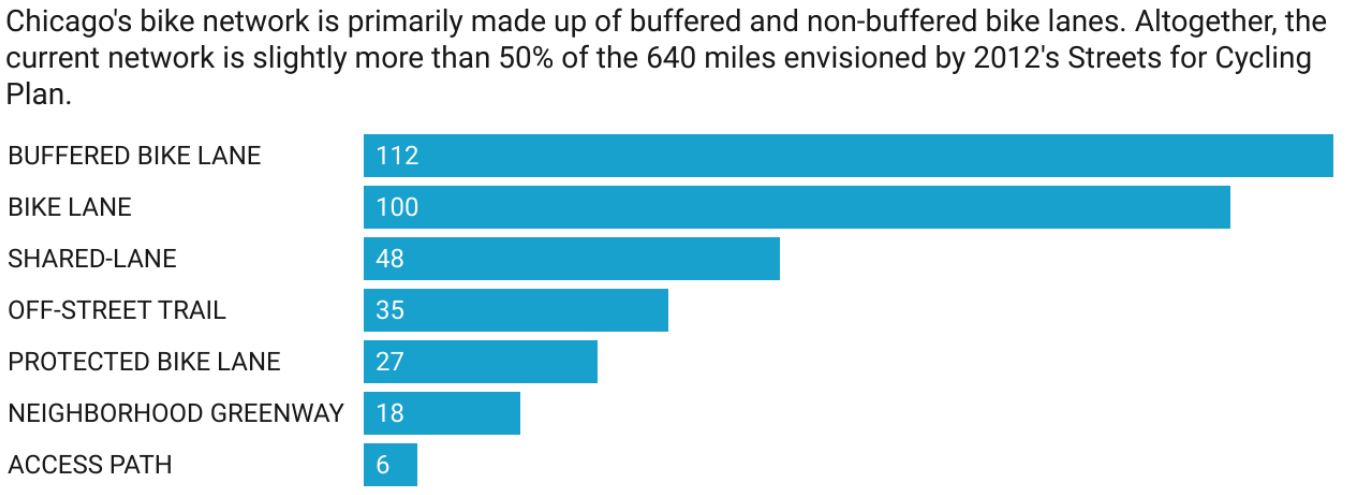
Other Policies of Note in Chicago:

» A key recommendation of the city of Chicago's Vision Zero downtown action plan is to "lower the speed limit to 20 mph across downtown." The action plan cites several cities that have taken similar steps, including Seattle, which saw a 20% decrease in severe crashes after lower speed limits in its city center. According to the National Conference of State Legislatures, Illinois is not one of at least 10 states that have increased flexibility to lower speed limits over the past decade. According to state law, the speed limit in an urban district is 30 mph unless it is altered by a locality.

» The League of American Bicyclists generally recommends that cities and states update their bicycle or active transportation plan every 10 years. The city of Chicago last adopted a citywide bike plan in 2012 and has no update scheduled. The hyper-local planning efforts described in the Belmont Cragin neighborhood and the Chicago Community Cycling Network Update are seen by city staff as removing the need for a citywide plan at this time.

» Chicago has an established bikeshare system in Divvy bikes, which is a program of the Chicago Department of Transportation, and has managed micro mobility through e-scooter pilots. These efforts have provided the city a larger degree of control over shared bikes and scooters than some cities, and also made those efforts more integrated in the city's planning.

Figure 9: Centerline Miles of Bike Facilities in Chicago.



Source: City of Chicago

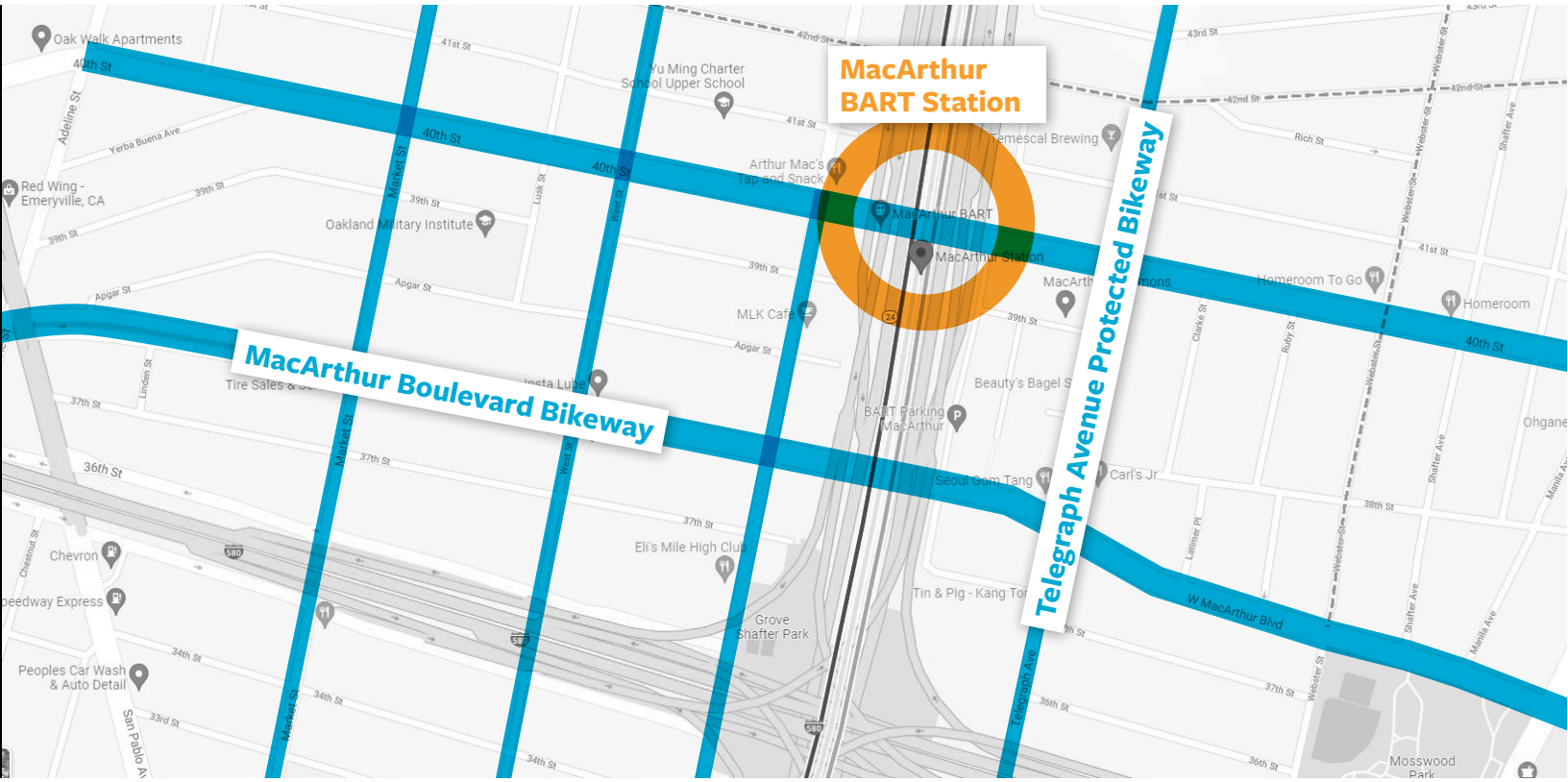
Oakland

Riders using two-way cycletrack in Oakland, CA, USA. *Source: Kyle Ramey of Bikabout*

Built Over Time – The "Value of Every Segment in the Network is Dependent Upon Others"

Oakland has a long history of bicycle planning, with three official bike plans since 1999. Our discussion of Oakland's bike network focused on a "ladder" of two parallel streets connected by seven streets or "rungs" (see **Figure 10** on next page). Of the nine streets that form the "ladder," seven were identified for proposed improvements in the 1999 bike plan. Significant improvements took place in 2003 and then from 2009 until 2020.

Figure 10: Annotated Map of Bike Network Near MacArthur BART Station



Source: *City of Oakland*

The "ladder" exists on either side of the MacArthur Bay Area Rapid Transit (BART) station, which has developed over time into the MacArthur Transit Village. Part of the justification for bicycle network development around the MacArthur BART station was articulated in the 2007 bike plan, finding "18 times as many people live within two miles of the station compared to the number of people who live within one-half mile" to justify prioritizing bike improvements surrounding the station[11] (see **Figure 12** on page 36). Previously, BART developed a "Bicycle Access Growth Potential" tool to rank stations by their likelihood of increasing bicycle mode share (Bay Area Rapid Transit District 2002, Table A-11).[12]

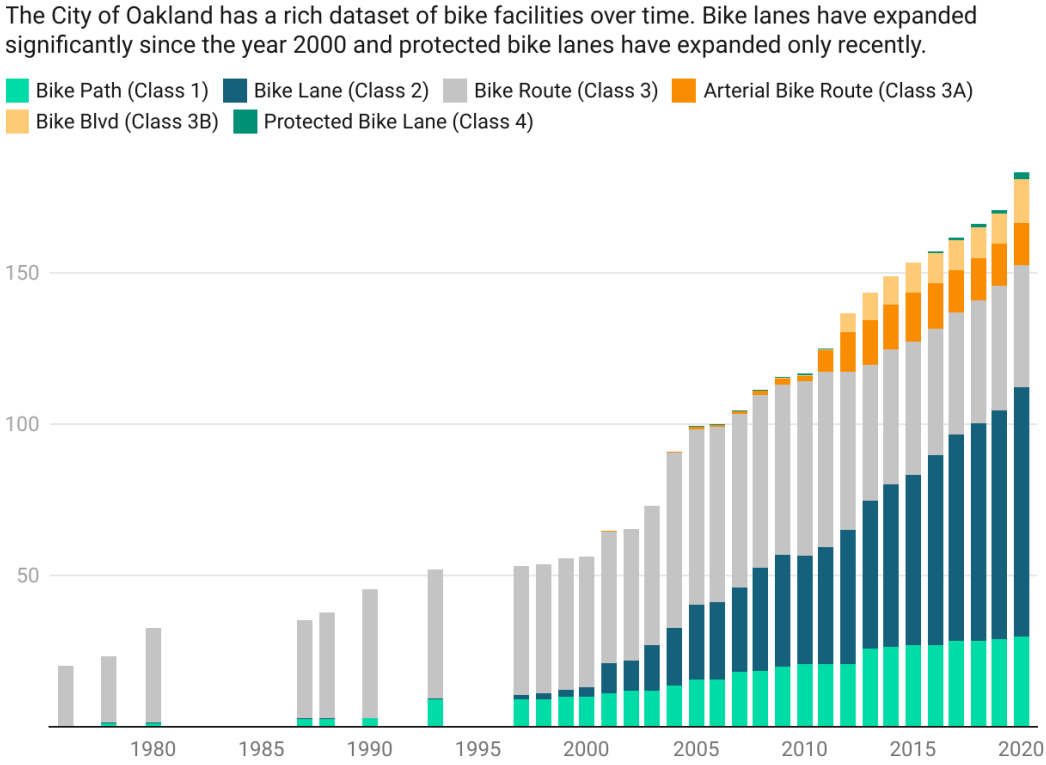
Many of the streets that make up the "ladder" received bike infrastructure as part of a **road reconfiguration**. A critical policy change that enabled these improvements was the 2013 change to the **California Environmental Quality Act (CEQA)**, which removed the requirement to measure environmental impacts based upon auto delay. Before that policy change, potential auto delay led to major difficulties in implementing bicycle infrastructure. For example, 40th Street—the north side of the ladder—was identified for a bike lane improvement in the 1999 bike plan, but that proposal was not implemented due to required modeling of **future auto delay**. MacArthur Boulevard and four of the seven rungs of the "ladder" were improved after the 2013 CEQA reform.

11. The area around a station is sometimes called a "bikeshed" which is the bicycle version of a walkshed, which is common in transit planning. "A walkshed is the area around a station—or any central destination—that is reachable on foot for the average person." https://www.mwcog.org/newsroom/2019/07/16/walksheds-show-planners-how-easily-people-can-walk-to-transit/. The policy of the Federal Transit Administration is that, for the purposes of funding pedestrian and bicycle improvements, the walkshed of any transit stop is 1 mile and the bikeshed for any transit stop is 3 miles.

12. https://oaklandca.s3.us-west-1.amazonaws.com/government/o/PWA/o/EC/s/BicycleandPedestrianProgram/oak024981.pdf at 33

Figure 11: Oakland Bike Network Growth Over Time

Source: City of Oakland



Oakland has done an incredible job of data collection and management. The 2007 bike plan was credited by staff as a milestone for the city as it included:

» A strong data-oriented approach to screening and sorting roadways for potential bicycle improvements.

» The creation of historical data on bicycle network development and the foundation for continued tracking.

Historical data goes back to 1976 when Oakland had 20 miles of bike infrastructure, with over 90% being a designated route in the north of the city. The bike network did not double in size until 1990—24 years later—and it was still over 90% designated routes (routes without improvements other than signs or Class 3 facilities). The bike network doubled in size again by 2004, with designated routes dropping to about two-thirds of the network. By 2020, the bike network doubled again—to 183.1 miles—with less than a quarter being designated routes, 45% being bike lanes, and 17.5% being protected bike lanes or bike paths.

The rich data set created by Oakland, which involved intensive digitization of paper records, provides a large advantage when communicating why projects are happening and how they will connect to the larger network. For communities interested in similar record keeping:

» Bike lane standards and terminology will change, don't let that discourage you.

» Choosing whether to capture centerline or lane miles is an important consideration. Centerline miles describe the mileage of infrastructure based on the centerline of a roadway or path. Lane miles describe the mileage of infrastructure based on the miles of lanes of a roadway or path. A two-way protected bike lane that goes for one longitudinal mile would be counted as one centerline mile of bike infrastructure and two lane miles of bike infrastructure. Oakland uses centerline miles and marks the most protective type of bike infrastructure when there are mixed infrastructure types along a centerline. Bike infrastructure is often mixed where there are width issues, operational issues, or to provide a climbing lane uphill and a shared lane downhill.

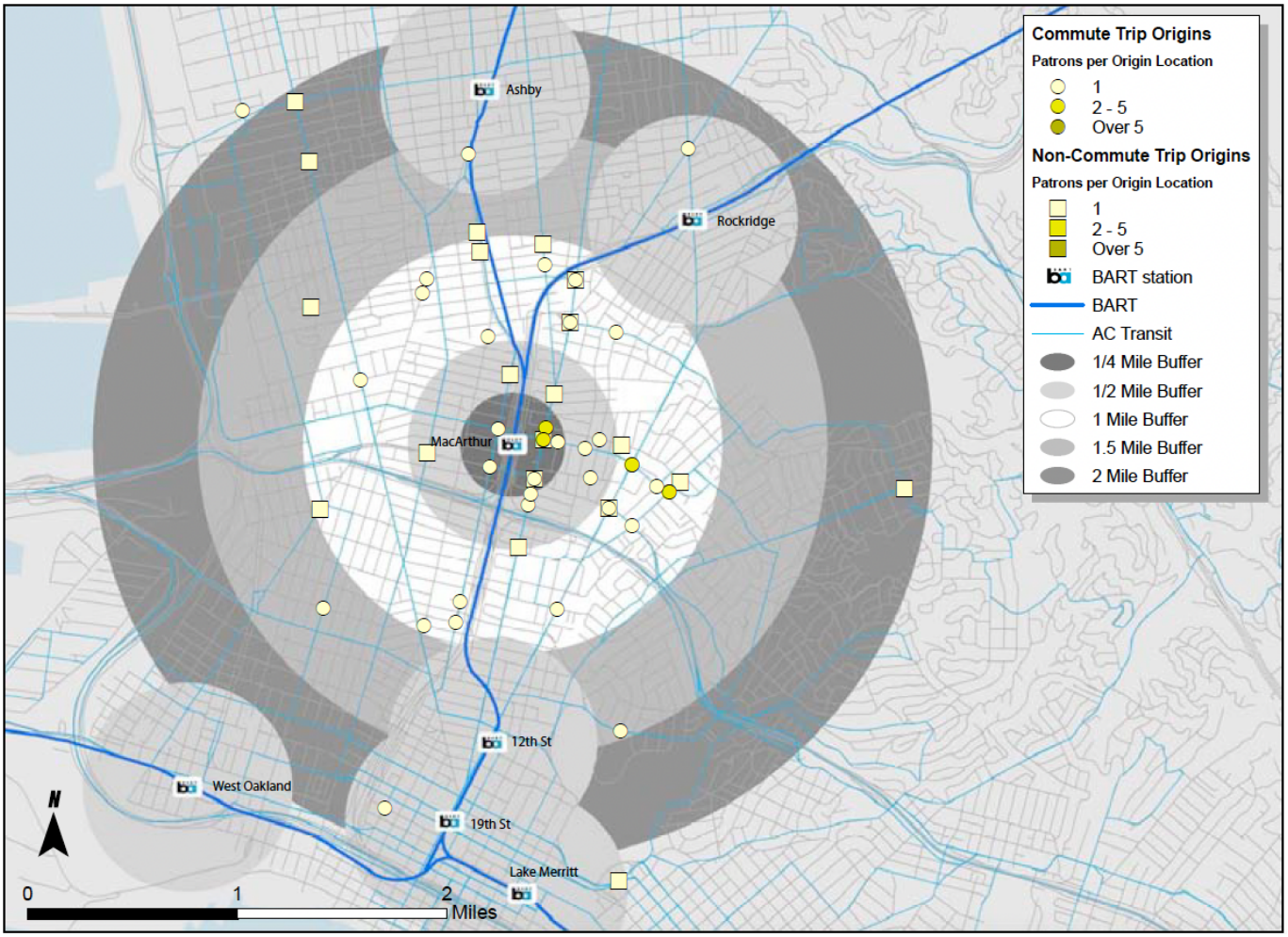
Other Policies of Note in Oakland:

» 2014 Protected Bike Lane legislation was not as impactful as changes in city leadership and involvement with NACTO when it came to shifts towards protected bike lanes.

» Highway encroachment permits are an intergovernmental barrier to infrastructure under urban highways.

» Fire Department street clearance requirements are a barrier to narrower street designs. Typically Fire Departments advocate for street width and operational standards found in the International Fire Code, which requires Fire Apparatus Access Roads to maintain 20 feet of clear width. The conflict between Fire Department access preferences and changes to street design has occurred in several cities, with bike lanes and pedestrian improvements often being the impetus for conflict. Montgomery County, Maryland created a guide to help resolve some of these conflicts and provide both traffic and fire safety through road design.

Figure 12: "Bikeshed" Analysis of Bicycle Trips to MacArthur BART Station



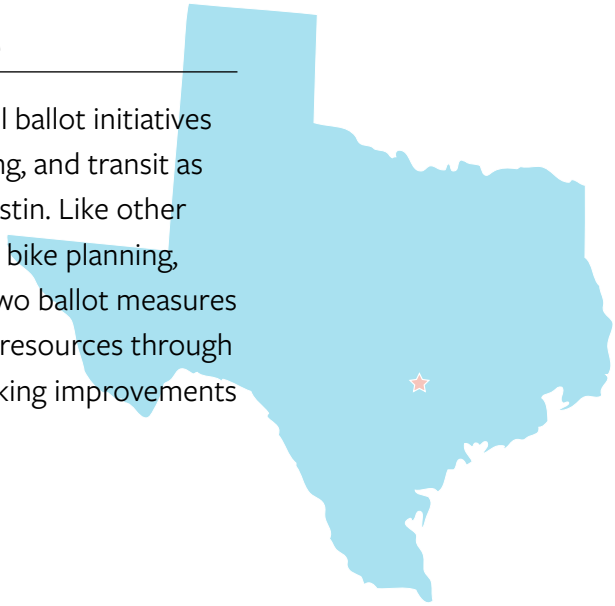
Source: City of Oakland Bicycle Master Plan 2007 [13]

13. https://oaklandca.s3.us-west-1.amazonaws.com/government/o/PWA/o/EC/s/BicycleandPedestrianProgram/oak024981.pdf at p. 34

Austin

Figure 13: Separated bicycle lane in Austin, Texas, USA with increased ridership.
Source: City of Austin

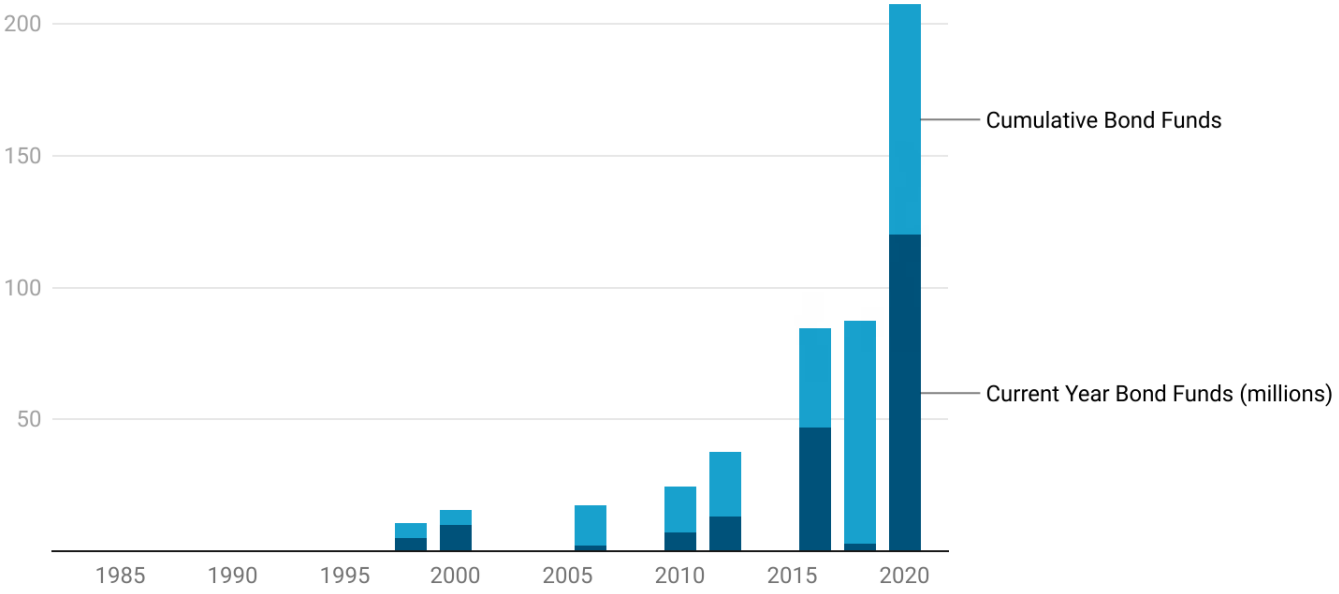
Providing Options is a Successful Message



Austin's bike network has been transformed by successful ballot initiatives that have greatly increased local funding for biking, walking, and transit as part of providing transportation options to citizens of Austin. Like other cities featured in this report, Austin has a good history of bike planning, with bike plans adopted in 1997, 2006, 2009, and 2014. Two ballot measures passed in 2016 and 2019 have greatly increased available resources through mobility bonds with dedicated funding for biking and walking improvements (see **Figure 14** on next page).

Figure 14: Austin Bicycle and Urban Trail Bond Funds by Year

Austin's 2020 Mobility Bond provided $120 million in bond funds for bicycle and urban trails. That amount was more than all previous bonds combined since 1984.



Source: City of Austin 2014 Bicycle Plan at page 171 and email correspondence

Austin's political support for increased investment is bolstered by a series of policy changes and planning documents that all lead towards improving bicycling and walking. In 2014, Austin adopted a **Complete Streets** policy; in 2016, a Vision Zero Action Plan; in 2017, Austin incorporated NACTO's **All Ages and Abilities** network guidance; and in 2019, the **Austin Strategic Mobility Plan** reaffirmed the city's commitments to Complete Streets, zero traffic deaths, and added a new goal of achieving "a 50/50 commute type split by 2039 (50% drive alone, 50% all other modes)."

Austin's messaging and planning stresses the opportunity to **convert short trips** currently made by driving to trips made by biking. Planners in Austin estimate that over 100,000 daily passenger vehicle trips within the "Ring of Congestion" are less than three miles in length—a distance easily biked by most people. According to the most recent **National Household Travel Survey**, more than 45% of vehicle trips nationwide are three miles long or less.

Rapid Progress Through Repaving

Austin has built its bike network more rapidly than many places. Recently, the city announced that it has built 50% of its all ages and abilities bike network. While the infusion of political support and funding from the 2016 and 2019 bond measures are important, Austin is also able to successfully leverage their repaving schedule. While many cities operate with a 20-year repaving schedule to maintain pavement quality, Austin has a 10-year repaving schedule that repaves approximately 300 lane miles each year to keep 85% of roads at an "A" pavement quality.

Officials that we spoke to said that bike facilities typically are implemented through three processes: 1) Opportunity, such as during repaving; 2) Addressing barriers, such as routes around major highways and bridges that require capital investments; and 3) Build out of the All Ages and Abilities network.

Our discussion focused on areas in Austin's bike network with connectivity between bike routes identified as high comfort. One network node discussed is based around Congress Avenue, a one-time six lane road leading to the Texas state capitol. Congress Avenue provides a great connection to Austin's signature riverside bike paths and currently forms a protected intersection at 3rd Street. This prominent connection was implemented on a temporary basis to provide space during Covid-19 and, with City Council support, is now moving forward for permanent installation. As part of the permanent installation, protected intersections will be installed at three more locations on the corridor. The Congress Avenue corridor is significant for Austin, with its commanding view of the Capitol and its use as a canvas for expression, such as its Black Lives Matter mural, and it is exciting to see it turn into a significant spine for Austin's bike network.

Other Policies of Note in Austin:

» Austin's voter approved $7 billion investment in transit expansion includes $300 million specifically dedicated to prevent displacement of residents with lower incomes who live in areas of transit development. Austin has been one of the fastest growing cities in the United States, with nearly 600,000 residents added since 2010. This growth has led to dramatic changes in home prices and rents which have displaced long-time residents. The dedicated anti-displacement funding is a new attempt to address this issue.

» Austin attempted to update its land development code starting in 2012 based on the Imagine Austin comprehensive plan. That initiative, called CodeNEXT, would have wide-ranging effects on where, how, and what could be built throughout the city, potentially allowing more people to access more places by biking, walking, and transit. The CodeNEXT process has been contentious and a lawsuit was filed in 2019. As of this writing, the last update to Austin's land development code occurred in 1984.

Missoula

Big Mode Share Goal in Big Sky Country

Missoula started early in planning for bicycling. In the 1970s it was part of the Bikecentennial bike ride across America and the Adventure Cycling Association is headquartered in Missoula. By 2014, Missoula had the 5th highest bicycle mode share among smaller cities (65,000–100,000 population) with more than 6% of people commuting to work by bike. Missoula's Community Growth Policy, required by Montana law, was adopted in 2015 and included an objective to "Set and then strive to achieve a mode split-goal for the overall transportation system.[13]" That objective led to the city considering three proposed mode split goals and ultimately deciding on the most ambitious—with a goal to triple bike, walk, and transit mode shares by 2045.

Setting an ambitious mode split goal has helped provide a big picture framing for future improvements and further conversations about the importance of building a connected network. While Missoula's long-range transportation was being adopted, the City moved forward on ambitious projects including:

- A 2017 Bicycle Facilities Master Plan using level of traffic stress analysis and calling attention to intersection needs
- Implementation of a TIGER grant, originally secured in 2013, to create an important section of the Bitterroot Trail. TIGER grants were initially created under the American Recovery and Reinvestment Act, but the discretionary grant program has been reauthorized in subsequent transportation bills. Currently called Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grants, the program has awarded over $8.9 billion in grants to projects in all 50 states, the District of Columbia and Puerto Rico since 2009.

13. https://www.ci.missoula.mt.us/DocumentCenter/View/34746/OurMissoulaGP_full?bidId= (at p. 39)

Outside Funding Has Outsized Impact

Collaborating with the Montana Department of Transportation is key for Missoula. A primary example is **Russell Street**, which the 2017 Bicycle Facilities Master Plan identified as a gap and proposed bike facilities as an improvement. The Montana DOT had plans for expanding Russell Street from a two-lane road with no sidewalks to a five-lane road. The over 800-page final **Environmental Impact Study** recommended 5.5-foot painted bike lanes with no vertical separation. By working with the Montana DOT, the city of Missoula and advocates for biking and walking made sure that the roadway expansion also supported biking and walking. Ultimately, a mountable raised bike lane was built on both sides of the expanded roadway and a trail **underpass** was incorporated.

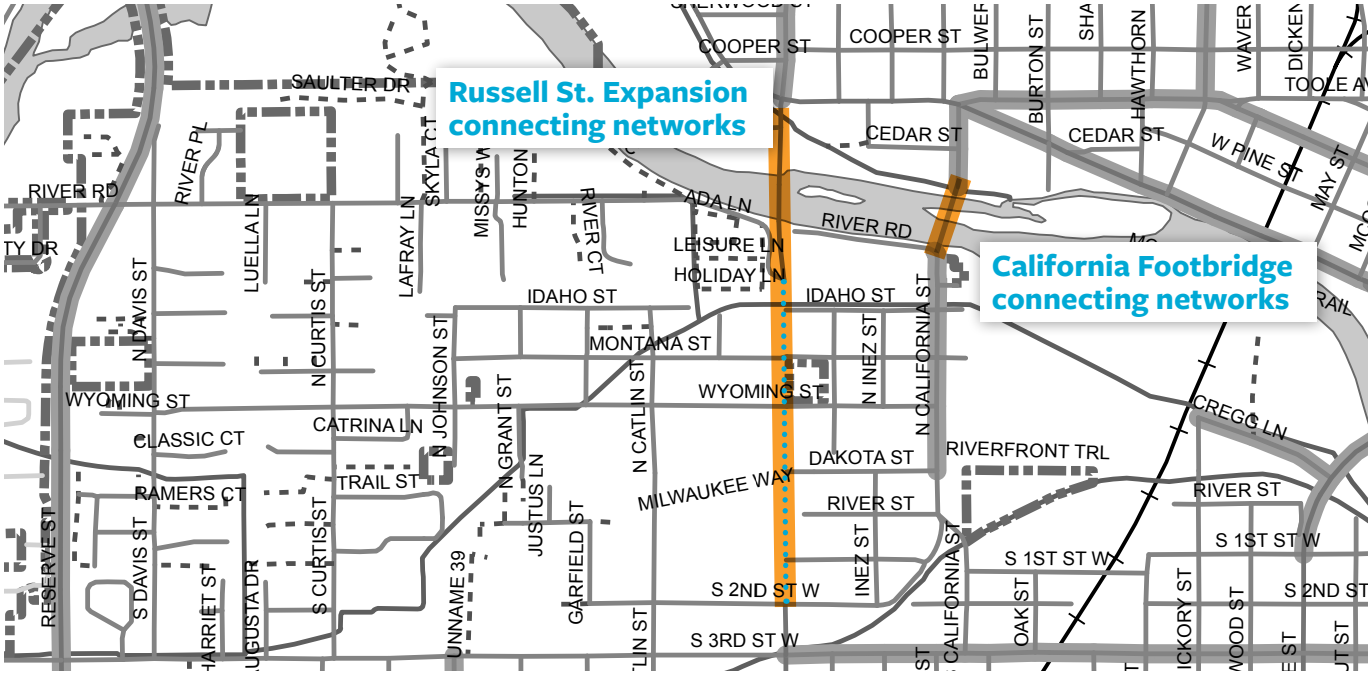
(See **Figure 15** below for before and after photos and **Figure 16** on next page for changes to street connectivity due to project.)

The Russell Street expansion is a major project with potentially large impacts on transportation and housing. As part of the expansion, and consistent with CDC recommendations, zoning was changed to support walkable development along the expanded corridor with a **pedestrian overlay zone** from 3rd Street to the river. The Russell Street expansion has been decades in the making. An **Environmental Impact Study** was initiated in 2000 and work will continue through at least 2025.

Figure 15: Example of Before and After Built Environment on Russell Street

The Russell Street expansion widened the roadway, adding travel lanes, bus stops, and a bike lane with some separated elements. *Source: Google Maps*

Figure 16: Highlighted Street Grid Changes Due to Russell Street Expansion



The Russell Street expansion created a new bridge and through route in northwest Missoula. This route connects to the Bitterroot Branch Trail, a 50-mile paved path that connects Missoula and Hamilton, and is key corridor for biking in the city. *Source: City of Missoula Bicycle Maps in 2010 and 2019*

Other Policies of Note in Missoula:

» The creation of a Neighborhood Traffic Management Program to cultivate citizen involvement in creating slower, safer streets and bicycle connections.

» The state of Montana repealed a law that allowed localities to adopt a local gas tax in 2021. Missoula had used that law to adopted a two cent local gas tax in 2020. According to a 2016 report by the National League of Cities, only 16 states allowed local option gas taxes in 2016.

» The city of Missoula has a limited ability to lower speed limits. Any speed limit lower than 25 mph requires a corridor-specific traffic analysis, which can be a significant burden. In 2020, the Missoula City Council asked staff to investigate the possibility of reducing speed limits on local streets resulting in the report Safe Speeds on City Streets. According to the National Conference of State Legislatures, Montana is one of at least 10 states that have increased flexibility to lower speed limits over the past decade.

Conclusion

Benchmarking bicycle networks in the United States is difficult due to a lack of developed norms and standards for bicycle networks. Key guidance, such as the AASHTO Bike Guide, has yet to catch up to the needs of communities, engineers, and planners. While much progress has been made in the last decade, there is a great need for continued development of bicycle networks and associated practices. The institutionalization of the Safe System Approach is new and promising, with a strong influence on FHWA guidance and incorporation in community Vision Zero efforts.

Communities are encouraged to create and maintain an up-to-date inventory of their bike network data, to aid in the advocacy, planning, and development of future network growth and improvements. Learning from the cities highlighted in this report, other communities should apply the lessons learned:

- Recognizing that every segment of a bicycle network is dependent upon others to achieve true accessibility and connectivity across a community.
- Development partners such as major employers, healthcare providers, and transit can be pivotal in spurring network growth.
- Rapid progress can be achieved by capitalizing on existing repaving and roadway maintenance schedules and standardizing bike facility additions as part of the repaving process.
- Providing safe and accessible transportation options is an important message when advocating for bike network improvements.
- Ambitious and measurable goal-setting, when paired with well-articulated plans, policies, and funding mechanisms, can be an effective way to institutionalize ongoing progress.
- Localized collaboration and engagement to inform neighborhood-scale plans can ensure that the resulting bike facilities fit the vision and needs of the people who live there, and can be just as effective in producing rapid city-wide growth as a singular city-wide plan.
- Identifying and leveraging a variety of funding opportunities, including state and federal transportation funds and local funding through bond measures, is important to supporting the ongoing development and maintenance of high-quality bike networks.

A Safe System approach to building all-ages-and-abilities bike networks can increase ridership, improve safety, and help connect more people to their everyday destinations with accessible and equitable mobility options for all. Given the persistently high level of traffic fatalities in the United States—far higher than similarly wealthy nations—now is the time for changing practices and culture to invest in safety by building bike networks consisting of high-quality bike infrastructure such as separated bike lanes.

THE LEAGUE OF AMERICAN BICYCLISTS since 1880

ABOUT THE LEAGUE

For generations past and to come, THE LEAGUE represents bicyclists in the movement to create safer roads, stronger communities, and a Bicycle Friendly America. Through education, advocacy and promotion, we work to celebrate and preserve the freedom cycling brings to our members everywhere.

WE BELIEVE

— Bicycling brings people together.

— When more people ride bikes:

  — Life is better for everyone;

  — Communities are safer, stronger and better connected;

  — Our nation is healthier, economically stronger, environmentally cleaner and more energy independent.

OUR VISION

is a nation where everyone recognizes and enjoys the many benefits and opportunities of bicycling.

OUR MISSION

is to lead the movement to create a Bicycle Friendly America for everyone. As leaders, our commitment is to listen and learn, define standards and share best practices to engage diverse communities and build a powerful, unified voice for change.

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