Designing for All Ages & Abilities

Contextual Guidance for High-Comfort Bicycle Facilities

NACTO
National Association of City Transportation Officials

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Streets that are safe and comfortable for All Ages & Abilities bicycling are critical for urban mobility.

NACTO cities are leading the way in designing streets that are truly safe and inviting for bicyclists of All Ages & Abilities and attract wide ridership. This guidance—developed by practitioners from cities across North America—builds on NACTO's *Urban Bikeway Design Guide* and sets an **All Ages & Abilities** criteria for selecting and implementing bike facilities. Building bicycle infrastructure that meets this criteria is an essential strategy for cities seeking to improve traffic safety,[1] reduce congestion,[2] improve air quality and public health,[3] provide better and more equitable access to jobs and opportunities,[4] and bolster local economies.[5]

This All Ages & Abilities facility selection guidance is designed to be used in a wide variety of urban street types. It considers contextual factors such as vehicular speeds and volumes, operational uses, and observed sources of bicycling stress. In doing so, it allows planners and engineers to determine when, where, and how to best combine traffic calming tools, like speed reduction and volume management, with roadway design changes, like full lane separation, to reduce traffic fatalities and increase cycling rates and rider comfort.

The All Ages & Abilities criteria is a national and international best practice that should be adopted for all bicycle facility design and network implementation; lesser accommodation should require additional justification. Along with a problem-solving approach to street design, the All Ages & Abilities benchmark should be applied across a city's entire bicycle network to grow bicycling as a safe, equitable mode for the majority of people.

All Ages & Abilities Bike Facilities are ...

Safe

More people will bicycle when they have safe places to ride, and more riders mean safer streets. Among 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.[6] Better bicycle facilities are directly correlated with increased safety for people walking and driving as well. Data from New York City showed that adding protected bike lanes to streets reduced injury crashes for all road users by 40% over four years.[7]

Comfortable

Bikeways that provide comfortable, low-stress bicycling conditions can achieve widespread growth in mode share. Among adults in the US, only 6–10% of people generally feel comfortable riding in mixed traffic or painted bike lanes.[8] However, nearly two-thirds of the adult population may be interested in riding more often, given better places to ride, and as many as 81% of those would ride in protected bike lanes.[9] Bikeways that eliminate stress will attract traditionally under-represented bicyclists, including women, children, and seniors.

Equitable

High-quality bikeways expand opportunities to ride and encourage safe riding. Poor or inadequate infrastructure—which has disproportionately impacted low-income communities and communities of color—forces people bicycling to choose between feeling safe and following the rules of the road, and induces wrong-way and sidewalk riding. Where street design provides safe places to ride and manages motor vehicle driver behavior, unsafe bicycling decisions disappear,[11] making ordinary riding safe and legal and reaching more riders.

SE Mill Street, PORTLAND
(photo credit: Portland Bureau of Transportation)

Who is the "All Ages & Abilities" User?

To achieve growth in bicycling, bikeway design needs to meet the needs of a broader set of potential bicyclists. Many existing bicycle facility designs exclude most people who might otherwise ride, traditionally favoring very confident riders, who tend to be adult men. When selecting a bikeway design strategy, identify potential design users in keeping with both network goals and the potential to broaden the bicycling user base of a specific street.

Children

School-age children are an essential cycling demographic but face unique risks because they are smaller and thus less visible from the driver's seat than adults, and often have less ability to detect risks or negotiate conflicts.

Seniors

People aged 65 and over are the fastest growing population group in the US, and the only group with a growing number of car-free households.[12] Seniors can make more trips and have increased mobility if safe riding networks are available. Bikeways need to serve people with lower visual acuity and slower riding speeds.

Women

Women are consistently under-represented as a share of total bicyclists, but the share of women riding increases in correlation to better riding facilities.[13] Concerns about personal safety including and beyond traffic stress are often relevant. Safety in numbers has additional significance for female bicyclists.

People Riding Bike Share

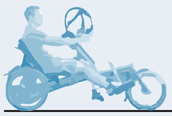
Bike share systems have greatly expanded the number and diversity of urban bicycle trips, with over 28 million US trips in 2016.[14] Riders often use bike share to link to other transit, or make spontaneous or one-way trips, placing a premium on comfortable and easily understandable bike infrastructure. Bike share users range widely in stress tolerance, but overwhelmingly prefer to ride in high-quality bikeways. All Ages & Abilities networks are essential to bike share system viability.

People of Color

While Black and Latinx bicyclists make up a rapidly growing segment of the riding population, a recent study found that fewer than 20% of adult Black and Latinx bicyclists and non-bicyclists feel comfortable in conventional bicycle lanes; fear of exposure to theft or assault or being a target for enforcement were cited as barriers to bicycling.[15] Long-standing dis-investment in street infrastructure means that these riders are disproportionately likely to be killed by a car than their white counterparts.[16]

Low-Income Riders

Low-income bicyclists make up half of all Census-reported commuter bicyclists, relying extensively on bicycles for basic transportation needs like getting to work.[17] In addition, basic infrastructure is often deficient in low-income neighborhoods, exacerbating safety concerns. An All Ages & Abilities bikeway is often needed to bring safe conditions to the major streets these bicyclists already use on a daily basis.



People with Disabilities

People with disabilities may use adaptive bicycles including tricycles and recumbent handcycles, which often operate at lower speeds, are lower to the ground, or have a wider envelope than other bicycles. High-comfort bicycling conditions provide mobility, health, and independence, often with a higher standard for bike infrastructure needed.

People Moving Goods or Cargo

Bicycles and tricycles outfitted to carry multiple passengers or cargo, or bicycles pulling trailers, increase the types of trips that can be made by bike, and are not well accommodated by bicycle facilities designed to minimal standards.

Confident Cyclists

The small percentage of the bicycling population who are very experienced and comfortable riding in mixed motor vehicle traffic conditions are also accommodated by, and often prefer, All Ages & Abilities facilities, though they may still choose to ride in mixed traffic.

Choosing an All Ages & Abilities Bicycle Facility

This chart provides guidance in choosing a bikeway design that can create an All Ages & Abilities bicycling environment, based on a street's basic design and motor vehicle traffic conditions such as vehicle speed and volume. This chart should be applied as part of a flexible, results-oriented design process on each street, alongside robust analysis of local bicycling conditions as discussed in the remainder of this document.

Users of this guidance should recognize that, in some cases, a bicycle facility may fall short of the All Ages & Abilities criteria but still substantively reduce traffic stress. Jurisdictions should not use an inability to meet the All Ages & Abilities criteria as reason to avoid implementing a bikeway, and should not prohibit the construction of facilities that do not meet the criteria.

Contextual Guidance for Selecting All Ages & Abilities Bikeways

Roadway Context				All Ages & Abilities Bicycle Facility
Target Motor Vehicle Speed*	**Target Max. Motor Vehicle Volume (ADT)**	**Motor Vehicle Lanes**	**Key Operational Considerations**	
Any		*Any*	*Any of the following:* high curbside activity, frequent buses, motor vehicle congestion, or turning conflicts‡	**Protected Bicycle Lane**
< 10 mph	Less relevant	No centerline, or single lane one-way	Pedestrians share the roadway	**Shared Street**
≤ 20 mph	≤ 1,000 – 2,000		< 50 motor vehicles per hour in the peak direction at peak hour	**Bicycle Boulevard**
≤ 25 mph	≤ 500 – 1,500			
	≤ 1,500 – 3,000	Single lane each direction, or single lane one-way	Low curbside activity, or low congestion pressure	**Conventional or Buffered Bicycle Lane, or Protected Bicycle Lane**
	≤ 3,000 – 6,000			**Buffered or Protected Bicycle Lane**
	Greater than 6,000			**Protected Bicycle Lane**
	Any	Multiple lanes per direction		
Greater than 26 mph†	≤ 6,000	Single lane each direction	Low curbside activity, or low congestion pressure	**Protected Bicycle Lane, or Reduce Speed**
		Multiple lanes per direction		**Protected Bicycle Lane, or Reduce to Single Lane & Reduce Speed**
	Greater than 6,000	*Any*	*Any*	**Protected Bicycle Lane, or Bicycle Path**
High-speed limited access roadways, natural corridors, or geographic edge conditions with limited conflicts		*Any*	High pedestrian volume	**Bike Path with Separate Walkway or Protected Bicycle Lane**
			Low pedestrian volume	**Shared-Use Path or Protected Bicycle Lane**

* While posted or 85th percentile motor vehicle speed are commonly used design speed targets, 95th percentile speed captures high-end speeding, which causes greater stress to bicyclists and more frequent passing events. Setting target speed based on this threshold results in a higher level of bicycling comfort for the full range of riders.

† Setting 25 mph as a motor vehicle speed threshold for providing protected bikeways is consistent with many cities' traffic safety and Vision Zero policies. However, some cities use a 30 mph posted speed as a threshold for protected bikeways, consistent with providing Level of Traffic Stress level 2 (LTS 2) that can effectively reduce stress and accommodate more types of riders.[18]

‡ Operational factors that lead to bikeway conflicts are reasons to provide protected bike lanes regardless of motor vehicle speed and volume.

The All Ages & Abilities Design Toolbox

Five major types of bikeway provide for most bike network needs, based on the contextual guidance on page 4. This list is organized from more to less shared operation with automobiles. Each facility type is appropriate as an All Ages & Abilities bikeway in relevant street contexts. The NACTO *Urban Bikeway Design Guide* provides detailed guidance on bikeway facilities.

Argyle Street, CHICAGO
(photo credit: Chicago DOT)

Low-Speed Shared Streets allow bicyclists to comfortably operate across the entire roadway. Shared streets target very low operating speeds for all users, typically no greater than 10 mph. The volume of people walking and bicycling should be much greater than vehicle volume to maintain comfort. Issues for bicycling in shared environments arise from conflicts with people walking, who may be expected at any point across the street's width. Materials and street edges must be appropriate for bicycling; materials are often varied to delineate road space, but any seams or low mountable curbs must be designed to avoid creating fall hazards for bicyclists.

SE Taylor Street, PORTLAND
(photo credit: Greg Raisman)

Bicycle Boulevards (or neighborhood greenways) provide continuous comfortable bicycle routes through the local street network. Bike Boulevards are characterized by slow motor vehicle speeds and low volumes. Sometimes these are present by the very nature of the street and its function (e.g. narrow streets with no major destinations), but sometimes design work is needed, such as adding traffic calming elements, filtering most motor vehicle traffic off, and/or prioritizing bicycles at major and minor street intersections. In this way, bicycling is made comfortable across the entire roadway. Directional markings and wayfinding signage provide riders with intuitive, coherent routing.

Laurier Avenue E, MONTRÉAL
(photo credit: Dylan Passmore)

Buffered & Conventional Bicycle Lanes provide organized space for bicycling, and are often part of street reconfiguration projects that improve safety and comfort for all users. Bicycle lanes are an important tool to improve comfort and safety on streets where the number of passing events is too high for comfortable mixed-traffic bicycling, but where curbside activity, heavy vehicles, and lane invasion are not significant sources of conflict. Buffered bike lanes are almost always higher comfort than conventional bike lanes. In many cases, cross-sections with room for buffered bicycle lanes also have room for protected bicycle lanes.

Dunsmuir Street, VANCOUVER
(photo credit: Paul Kreuger via Flickr)

Protected Bicycle Lanes (also known as Separated Bike Lanes or Cycle Tracks) use a combination of horizontal separation (buffer distance) and vertical separation (e.g. flex posts, parked cars, or curbs) to protect people bicycling from motor vehicle traffic. The combination of lateral buffer distance and vertical separation elements (such as flexible delineators, curbs or height differences, or vehicle parking) can ameliorate most of the stressors of on-street bicycling. The robustness of bikeway separation often scales relative to adjacent traffic stress.

Cultural Trail, INDIANAPOLIS
(photo credit: Green Lanes Project)

Shared-Use & Bicycle Paths have in many cities served as the early spines of an All Ages & Abilities network. Paths can provide a continuous corridor, but usually do not take riders to their destinations. High pedestrian volumes, driveways, obtrusive bollards, sharp geometry, and crossings all degrade bicycling comfort, but often require long project timelines to eliminate. To become useful for transportation, paths work best when connected to an on-street network that meets the same high benchmark of rider comfort, and design provides bicycle-friendly geometry. Ideally, bicycles should be separated from pedestrians where significant volume of either mode is present, but where space limitations exist, multi-use paths are still valuable.

Motor Vehicle Speed & Volume Increase Stress

Whether or not people will bicycle is heavily influenced by the stresses they encounter on their trip. These stressors impact their actual physical safety and their perceived comfort level.

For all roadways and bike facilities, two of the biggest causes of stress are vehicular traffic speed and volume. These factors are inversely related to comfort and safety; even small increases in either factor can quickly increase stress and potentially increase injury risk.[19] The stresses created by speed are compounded by vehicular volume, and vice versa.

Slower or less confident bicyclists experience "near misses"—or non-injury incidents that cause stress—much more frequently per trip than faster riders, which can contribute to discouraging people from riding who would otherwise do so.[20]

SPEED

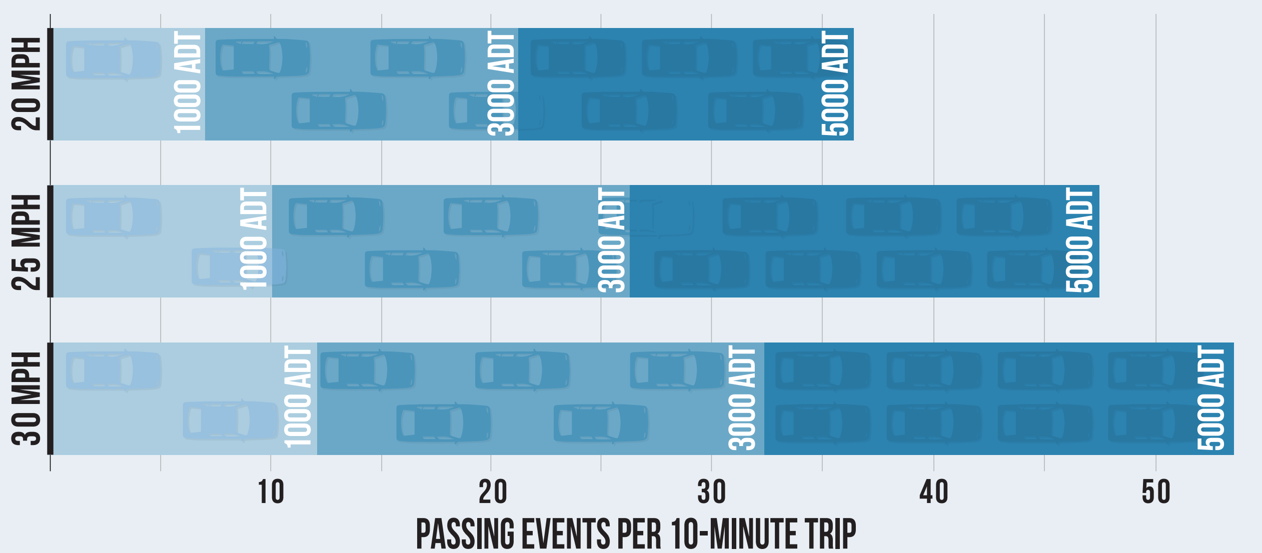
High motor vehicle speeds and speeding introduce significant risk to all road users, narrowing driver sight cones, increasing stopping distance, and increasing injury severity and likelihood of fatality when crashes occur.[21] Most people are not comfortable riding a bicycle immediately next to motor vehicles driving at speeds over 25 mph. Conventional bike lanes are almost always (with rare exceptions) inadequate to provide an All Ages & Abilities facility in such conditions.

VOLUME

When vehicular volumes and speeds are low, most people feel most comfortable bicycling in the shared roadway as they are able to maintain steady paths and riding speeds with limited pressure to move over for passing motor vehicles. However, as motor vehicle volume increases past 1,000 – 2,000 vehicles per day (or roughly 50 vehicles in the peak direction per peak hour), most people biking will only feel comfortable if vehicle speeds are kept below 20 mph.

Conflicts Increase with Speed & Volume

This chart illustrates the number of passing events (at increasing motor vehicle average speed and volume) experienced over a 10-minute period by a bicyclist riding 10 mph. As motor vehicle speed and volume increase, they magnify the frequency of stressful events for people bicycling.



Motor Vehicle Speed and Volume Amplify One Another as They Increase

The frequency at which a person bicycling is passed by motor vehicles is one of the most useful indicators of the level of stress of a roadway or bike facility. Passing events increase with speed and volume, decreasing rider comfort and safety. Where car traffic is routinely above 20 mph, or where traffic volume is higher than 50 vehicles per direction per hour, pressure on bicyclists from motor vehicles attempting to pass degrades comfort for bicycling and increases risk.

» **At speeds of 20 mph,** streets where daily motor vehicle volume exceeds 1,000 – 2,000 vehicles, frequent passing events make shared roadway riding more stressful and will deter many users.

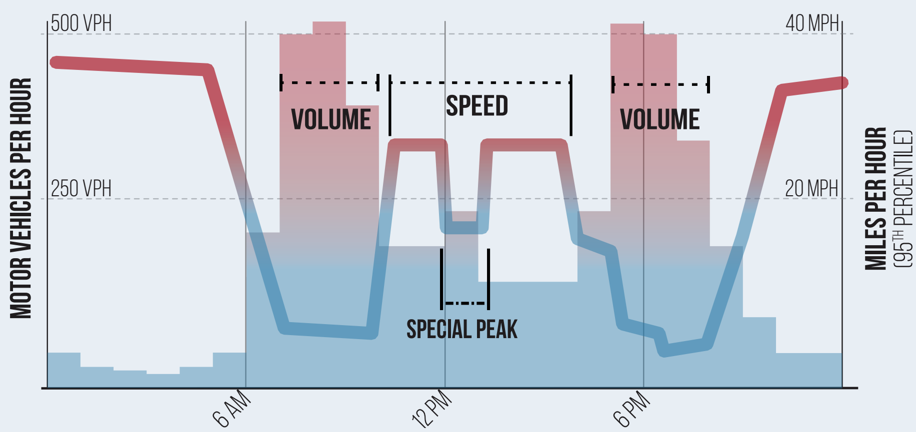
» **Between 20 and 25 mph,** comfort breaks down more quickly, especially when motor vehicle volume exceeds 1,000 – 1,500 ADT. When motor vehicle speeds routinely exceed 25 mph, shared lane markings and signage are not sufficient to create comfortable bicycling conditions.

» **Motor vehicle speeds 30 mph or greater** reduce safety for all street users and are generally not appropriate in places with human activity.

» **Where motor vehicle speeds exceed 35 mph,** it is usually impossible to provide safe or comfortable bicycle conditions without full bikeway separation.

Sources of Stress Change Throughout the Day

Large fluctuations in motor vehicle traffic volume between morning, mid-day, afternoon, and nighttime result in radically different bicycling conditions on the same street throughout the day. The example at right shows a street with roughly 500 vehicles per direction per hour during the peak. While queuing stress occurs at peak times, low off-peak volume results in dangerously high motor vehicle speeds.



Peak vs. Off-Peak

The variation in speed and volume conditions between peak and off-peak hours can manifest as two distinct issues that decrease comfort and safety.

» **During high-volume peak periods,** motor vehicle queuing prevents comfortable mixed-traffic operation and increases the likelihood of bicycle lane incursions, unless physical separation is present.

» **During off-peak periods,** speeds can rise quickly, especially on wide and multi-lane streets, unless the street's design and operations specifically discourage speeding. Streets with very low off-peak volumes that also see little speeding, including many small neighborhood streets, may indicate All Ages & Abilities conditions if peak volumes are managed effectively.

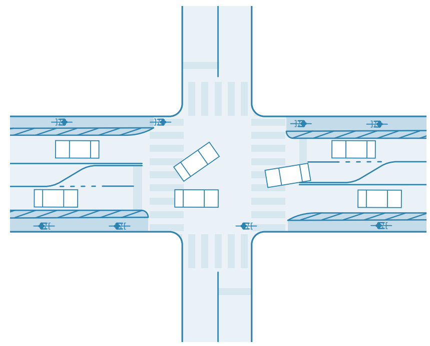
» **Special Peaks** occur on streets that experience intensive peak activity periods. Schools have multiple short windows of time where pedestrian and motor vehicle activity are intense at exactly the time and place where the appeal of All Ages & Abilities bicycling is most sensitive. Downtown cores and retail streets experience intensive commercial freight activity throughout the day including at off-peak times, adding importance to the creation of protected bike lanes.

Changing the Street: Design, Operation, Networks

Not every solution that helps to create safe and comfortable bicycling conditions will be a geometric design. Creating a network of high-comfort bicycle facilities that meet the All Ages & Abilities criteria requires leveraging the full suite of design, operational, and network strategies to transform streets. Strategies can be implemented incrementally to address sources of stress and conflict, change demand for access and movement, and ultimately transform streets for all users by continuously increasing comfort and creating more opportunities to make more trips by bicycle.

Change Design

Design strategies change the cross-section of a street in order to provide bike lanes, buffered bike lanes, protected bike lanes, or other dedicated bicycle infrastructure. Creating dedicated space for bicycling— either by reducing the number of motor vehicle lanes or their width—usually does not involve substantial changes to motor vehicle volume or the types of vehicles that can use a street, and has substantial benefits for the safety of all street users. 4-to-3 and 4-to-2-lane (with left turn pocket) conversions are widely used, and many other street redesigns apply the same basic principle of organizing movements and modes into dedicated space to improve the efficiency of each space.



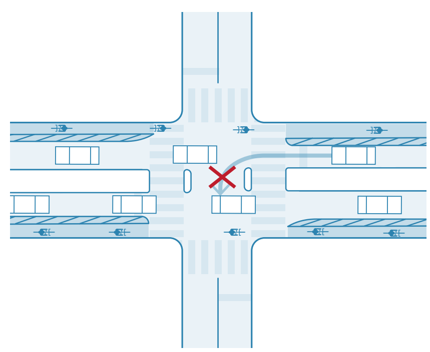
Examples:

- **Repurpose Motor Vehicle Lane**
- **Convert from Buffered to Protected Bike Lane**

Change Operation

Operational changes—such as speed reduction, signalization and other conflict management, and proactive curbside management—improve bicycling conditions by reducing the level of traffic stress on a street. Operational strategies make streets more predictable, efficient, and safe without necessarily changing the street's cross-section or the types of vehicles allowed.

On all facility types, reducing motor vehicle speeds to 20 – 25 mph is a core operational strategy for improving bicycle comfort and meeting the All Ages & Abilities criteria. In addition, reducing speeds can also make it easier to enact other safety changes, such as changes to intersection geometry, signalization, turn lanes, and turn restrictions. Since operational changes do not impact what types of vehicles can use the street, they usually do not require significant planning beyond the street itself, and are often the easiest type of change to implement.



Examples:

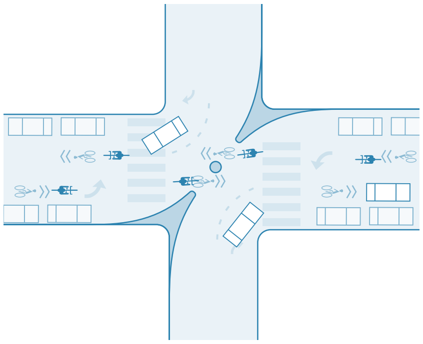
- **Signal Separation of Conflicting Movements**
- **Low-Speed Signal Progression**

Change the Network

Diverting motor vehicle traffic from a street, changing travel direction, (dis)allowing specific types of curbside access, and making other changes to the role of a street in the motor vehicle network are powerful ways to create All Ages & Abilities bicycling conditions. Such network changes allow the street to be transformed into a comfortable bicycling environment without requiring dedicated space.

Bicycle boulevards and shared streets, in particular, often rely on network changes to create the low-speed, very low-volume conditions necessary for cyclists to feel safe and comfortable. Prohibiting through-traffic (requiring all motor vehicles to turn off the street at each intersection), either through physical diverters or signage, is an effective strategy for reducing speed and volume.

Changes to the motor vehicle network can open up opportunities for better bikeway designs. For example, converting a high volume or high speed street from two-way to one-way or removing all curbside parking can provide space for a protected bike lane.



Examples:

- **Bicycle Boulevard**
- **Time-of-Day Regulations**

Ames Street, CAMBRIDGE
(photo credit: People for Bikes)

Low-Speed, Low-Volume Roadways Can Be Shared

See the Urban Bikeway Design Guide *for detailed guidance on Bicycle Boulevards, Conventional Bike Lanes, Buffered Bike Lanes, and Left Side Bike Lanes.*

Bicycle Boulevards & Shared Streets

Bicycle boulevards and shared streets place bicycle and motor vehicle traffic in the same space at the same time. These facilities meet the All Ages & Abilities criteria when motor vehicle volumes and speeds are so low that most people bicycling have few, if any, interactions with passing motor vehicles.

What to do:

- » **Use both peak-hour volume and off-peak speed** to determine whether a shared roadway can serve as an All Ages & Abilities bike facility. High peak period volumes or high off-peak speeds create a high-stress bicycling environment. These sources of stress can be addressed through speed management or volume management, or may indicate the need for a separated bicycle facility.
- » **Set a 20 – 25 mph target speed (10 mph on shared streets)** for motor vehicles in the majority of urban street contexts. Use the 95th percentile motor vehicle speed, along with the overall speed profile of motor vehicle traffic, to determine whether high outlying speeds exist, since even small numbers of motor vehicles traveling at high speeds can degrade the comfort of people bicycling on shared roadways.
- » **Manage motor vehicle speeds** through operational and network tools such as speed humps, pinchpoints, and neighborhood traffic circles.
- » **Reduce motor vehicle volume** by constructing diverters, prohibiting through traffic, or removing parking. The All Ages & Abilities condition is likely to be reached below approximately 1,000 – 1,500 vehicles per day or approximately 50 vehicles per hour per direction.
- » **Use time-of-day analyses** to match regulations or access restrictions to demand. Commercial setting can also work with bike boulevards if stressors are managed. Prioritize delivery and freight access off-peak, or allow only transit and bikes at peak periods.

SE Ankeny Street Bike Boulevard, PORTLAND
(photo credit: NACTO)

Brookline Street, CAMBRIDGE
(photo credit: City of Cambridge)

Conventional & Buffered Bicycle Lanes

Conventional and buffered bike lanes on urban streets delineate space for bicyclists but provide no physical separation between people bicycling and driving. With on-street parking, they also place the bicycle between parked vehicles and moving motor vehicles. Since bicyclists must enter the motor vehicle lane to avoid conflict with turning vehicles, parking maneuvers, double parking or curbside loading, or open doors, it is important for passing events to be minimized.

What to do:

» **Set target speeds at or below 25 mph.** Speeds of 20 – 25 mph improve comfort and allow drivers to more easily react when bicyclists need to move into the motor vehicle lane. Use strategies such as lower progression speed and shorter signal cycle lengths to reduce the incentive for drivers to speed, and reduce top-end speeding incidents.

» **Discourage motor vehicle through-movement to reduce volumes.** Lower motor vehicle volumes reduce the number of passing events. Depending upon the presence and intensity of other operational stressors, an All Ages & Abilities condition may be reached below approximately 3,000 – 6,000 vehicles per day, or approximately 300 to 400 vehicles per hour.

» **Reduce curbside conflicts**, especially freight, loading, and bus pull-outs (see page 15). Carefully manage loading activity and parking demand. On one-way streets with transit activity, move the bike lane or buffered bike lane to the left side of the street to alleviate intersection and curbside conflicts. On streets with heavy curbside use but low motor vehicle volume, consider moving truck traffic or curbside loading to other streets.

» **Address intersection conflicts** through motor vehicle turn prohibitions, access management, and signal phasing strategies. Due to the likelihood of both left- and right-turning conflicts from bi-directional motor vehicle traffic, use the same motor vehicle volume threshold on two-way streets as on one-way streets.

» **Increase buffer distance** where traffic characteristics adjacent to the bike lane decrease comfort, including large vehicles or curbside parking. Where adjacent sources of stress are present, a buffered bike lane can improve comfort by increasing shy distance between bikes and motor vehicles. Where multiple motor vehicle lanes, moderate truck and large vehicle volumes, or frequent transit indicate that most bicyclists will need more separation to be comfortable.

Separate Bicyclists When Speed & Volume are High

Protected Bicycle Lanes

Protected bike lanes (including raised bikeways) create All Ages & Abilities conditions by using physical separation to create a consistently exclusive, designated bicycling space. The physical protection offered by protected bike lanes means that they can often meet the All Ages & Abilities criteria even in higher speed, high volume, or unpredictable conditions. Protected bike lanes improve the overall organization of the street, and increase safety for people walking, bicycling, and in motor vehicles.

What to do:

» **Build protected bike lanes where motor vehicle speed consistently exceeds 25 mph,** where daily motor vehicle volume is higher than approximately 6,000 vehicles per day, where curbside conflicts are expected, or wherever there is more than one motor vehicle lane per direction.

» **Manage intersection and curbside conflicts** with transit boarding islands, protected (bend-out or offset) intersection designs, signal phasing, and other turn management strategies.

» **Reduce speeds through operational strategies,** such as signal time, lower signal progression, and shorter signal cycles.

» On streets with parking, **reverse the position of the parking and the bike lane to create physical separation** between the bike lane and moving motor vehicle traffic.

» On streets without parking, **add vertical separation elements** (e.g. delineators, barriers, raised curbs) in an existing buffer, or raise existing curbside bike lanes.

» On streets with multiple motor vehicle lanes in each travel direction, **convert one travel lane to a protected bike lane,** better organizing the street and improving safety for people biking, walking and driving.[22]

» **Convert conventional or buffered lanes to protected lanes** if motor vehicle speeds and volumes cannot be otherwise reduced and where there is high curbside activity or peaks of intensive demand such as retail-heavy streets, or around schools, large employers, institutions, and entertainment districts.

Second Avenue, SEATTLE
(photo credit: Adam Coppola for Green Lanes Project)

Strategies to Reduce Other Sources of Stress

In addition to motor vehicle speed and volume, All Ages & Abilities bikeway facility selection should respond to street conditions that increase bicycling stress and often degrade comfort and safety for all people using the street. These sources of stress can be addressed through design, operations, and network solutions that either remove the source of stress or separate it from bicycle traffic.

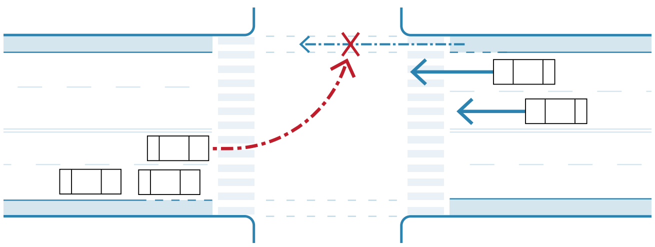
Multiple Motor Vehicle Lanes

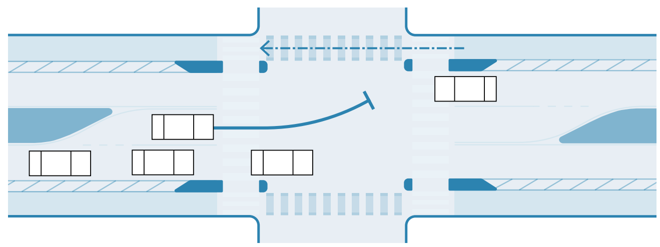
Source of Stress

Motor vehicle traffic on multi-lane streets, whether two-way or one-way, is less predictable than on streets with a single lane per direction of travel. Lane changes, acceleration and passing, and multiple-threat visibility issues degrade both comfort and safety. Corridors with a major through-traffic function and multiple motor vehicle lanes are inherently unpredictable biking environments.

Design Strategy

Reduce the cross-section to one motor vehicle travel lane per direction, where possible. On streets where multiple through lanes in one direction are used to allocate very high motor vehicle traffic capacity, provide physical protection and manage turns across the bikeway. 4-to-3 or 5-to-3 lane conversions paired with protected bikeways are transformative for both bicycling and walking safety and comfort.[23]





A common "multiple threat" conflict, where reduced visibility for motor vehicles turning across multiple travel lanes increase bicyclists' risk at crossings. The 4-to-3 lane conversion is a common technique for managing motor vehicle traffic flow while reducing the multiple threat conflict, though two-way left turn lanes introduce turn conflicts at mid-block locations (e.g. driveways).

Motor Vehicle Queuing

Source of Stress

Motor vehicle congestion presents safety and comfort issues for people bicycling. Queued traffic moves at unpredictable speeds and will often invade conventional or buffered bike lanes.

Design Strategy

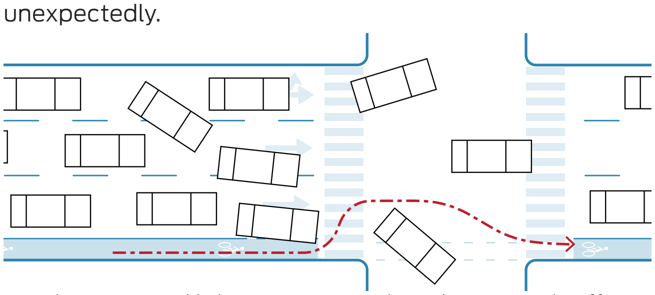
Protected bike lanes should be implemented where motor vehicle invasion of the bike lane is likely to occur otherwise. Visual and physical barriers can prevent encroachment on the bikeway.

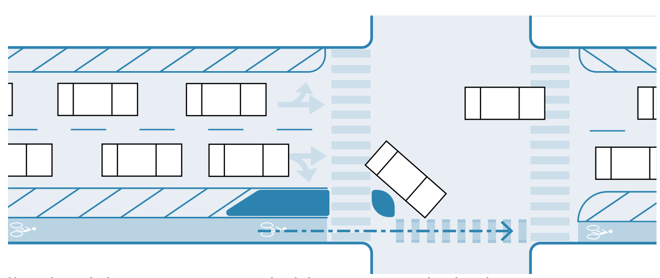
Source of Stress

Queuing encourages both motorists and bicyclists to engage in unpredictable movements. Bicyclists may weave through queued cars when bicycle facilities are obstructed, where motorists are also prone to move unexpectedly.

Design Strategy

Bicycle facilities should be designed with capacity for growing ridership, including passing of slow-moving cargo bicycles.



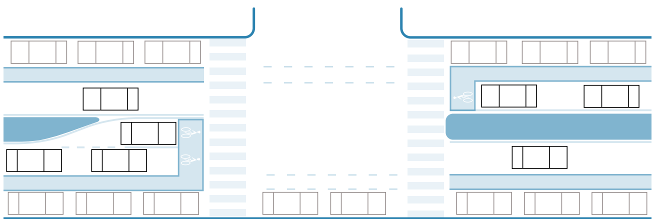


Bicyclists are more likely to try to weave through congested traffic, especially when bikeways are impeded, but motor vehicles become unpredictable. Separation and protection prevent queued vehicles from permeating bicycle space and maintain bikeway integrity throughout the day.

Strategies to Reduce Other Sources of Stress

Intersections

Source of Stress	Design Strategy
Motor vehicles turning across the bikeway typically require people bicycling to negotiate with motor vehicles, a significant stressor at all but the very lowest speed conditions. Bicycle design treatments that require people biking to cross or mix with motor vehicle traffic are stressful at all but low volumes.	Provide separation in space and time between bicycles and vehicles to the extent possible, or reduce speed and maximize visibility between drivers and bicyclists. Tighter effective corner radii, raised crossings, and protected intersection designs are effective in slowing motor vehicle turning speed and placing bicyclists in a priority position.
Bicycle left turns, especially on busy streets, can be very stressful or even dangerous for bicyclists, especially if bikes are expected to merge with fast-moving traffic or turn across multiple lanes.[25]	Provide appropriate intersection treatments to accommodate desired turning movements, including bike boxes, two-stage queue boxes, phase separation, or protected intersections (also known as “offset” or “bend-out” crossings) that organize and give priority to people bicycling.



Source of Stress	Design Strategy
Sharp grade or direction changes, such as sharp lateral transitions approaching the intersection, require people biking to slow down and may increase fall risks. Frequent starts and stops also create instability at intersections.	Reduce or mitigate situations that increase risk of falling and instability. Design intersection approaches and transitions with bicycle-friendly geometry; place bicycle movements first in the signal phase; time signal progressions to bike-friendly speeds; and rotate stop signs to face cross streets.

Trucks & Large Vehicles

Source of Stress	Design Strategy
High volumes of truck traffic degrade adjacent bicycling safety and comfort. This is often the case on major streets, or in commercial or industrial places.	Provide protected bicycle facilities—or, at minimum, buffered bike lanes—on observed or designated trucking routes, regardless of general motor vehicle speed and volume.
Large vehicles have large blind spots, increasing risk of side-swipe and right-hook crashes.	Use buffers to increase the distance between truck and bicycle travel paths. Consider protected intersection geometry (also known as “offset” or “bend-out”).
Large vehicle noise and exhaust increase bicycling stress and present public health issues.	Provide wide lateral separation—such as with wide buffers, planters or planting strips, or parking-protected facilities—to dissipate pollutants entering the bikeway.[26]

Curbside Activity

Source of Stress	Design Strategy
Frequent freight and passenger loading either happens in the bikeway or adjacent in the curbside lane. Loading activities increase conflicts crossing the bike lane, or even blockages by double-parked vehicles that imperil bicyclists and rapidly decrease assurances of safety.	Provide designated truck loading zones and provide space for other curbside uses to prevent blockages of the bicycle lane. Consider restricting freight loading to off-peak periods. If frequent freight or passenger loading is observed, provide protected bicycle facilities regardless of speed and volume, or move passenger and freight loading uses to a cross-street.
High parking turnover results in frequent weaving and door zone conflicts.	Where parking turnover is high, provide protected bikeways regardless of speed to avoid sudden conflicts and reduce injury risk, or remove parking. Cities should establish local guidance on acceptable levels of parking maneuvers across bicycle lanes.
Freight loading is present throughout the day, but motor vehicle speed and volume are consistently low.	Implement a robust bike boulevard or shared street treatment with traffic calming strategies to provide comfort and safety across the entire roadway.
Car doors open into the bicycle travel path during vehicle exit and entry, but parking turnover is low to moderate.	Provide a wide marked buffer adjacent to the vehicle door zone to guide bicyclists clear of dooring conflicts for both buffered and protected bike lanes.

Frequent Transit

Source of Stress	Design Strategy
Buses merge across conventional bike lanes to access curbside stops. At all but the lowest bus frequencies, conventional "pull-out" transit stops degrade comfort and increase transit delay.	Provide spot protection using transit boarding islands, which are compatible with protected, buffered, and conventional bicycle lanes. Boarding islands create in-lane transit stops, which improve bus reliability and travel time.
Bikes and transit travel at similar average speeds but different moving speeds, as buses stop and accelerate frequently. Overtaking buses and bicycle leapfrogging decrease riding comfort in mixed conditions.	Provide dedicated bicycle facilities. On one-way streets, left-side bicycle facilities can be used to separate bikes and transit vehicles.
Core transit routes and trunklines often operate on streets with dense destinations and demand for bicycle access. In some cases, right-of-way width may constrain design decisions and facility types that can be implemented.	On trunkline transit streets, it is even more important to accommodate users in dedicated lanes, since the major streets are where people need to get to their destinations. If the primary demand for the corridor is through travel, it may be possible to consider providing high-quality bike infrastructure on parallel, nearby, and continuous routes, while allowing local bicycle access on the transit street. To improve All Ages & Abilities bicycling conditions, use low-speed signal progressions and other calming measures consistent with transit effectiveness. As on all transit routes, pedestrian safety is the foremost design need.

The NACTO *Transit Street Design Guide* provides detailed guidance for streets with frequent bus transit routes.

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