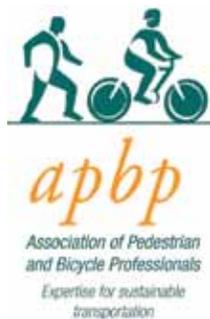


Better Bikeways— Innovative Facilities For Safer Bicycling in California



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Better Bikeways—

Innovative Facilities For Safer Bicycling in California

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Introduction

Bicycling has exploded around California as people rediscover this enjoyable, healthy, convenient, environmentally friendly and inexpensive way to get around. Many communities are working to create bicycle networks to encourage further increases in bicycling and attract new riders, especially in urban areas. Toward that end, some cities—drawing from successful international models—have experimented with a variety of innovative bicycle facilities not even imagined a decade ago.



Market Street cycle track in San Francisco.



Berkeley bicycle boulevard.

This report discusses four innovative bicycle facility designs being implemented in California, along with additional intersection and marking treatments that can help improve safety and increase ridership. These innovative facilities increase the perception of safety that is a key component to attract more Americans to ride bikes.¹ They achieve a greater perception of safety by physically separating bicyclists from motor vehicle traffic or calming the traffic to reduce the threat of a collision. The innovations can be implemented within existing street rights-of-way and have been pioneered in Europe, Portland, New York and various California cities. Connecting these facilities to existing shared-use paths can create a huge boost in ridership and have the additional benefits of calming traffic through neighborhoods and improving traffic flow in business districts.²

The compelling reasons for increasing the rates of bicycling continue to mount. Rails-to-Trails Conservancy (RTC) champions advocacy for increased investment in walking and bicycling to create interconnected active transportation networks as part of our Campaign for Active

NACTO Cities for Cycling

Cities for Cycling, an initiative of the National Association of City Transportation Officials (NACTO), is cataloging, promoting and implementing the world's best bicycle transportation practices and design innovations in American communities. NACTO's newly released *Cities for Cycling Urban Bikeway Design Guide* gives planners and engineers guidance on implementing many of these new concepts in their communities. Planners and engineers can check the status of many of these innovations for adoption into the Manual on Uniform Traffic Control Devices (MUTCD) on the Federal Highway Administration (FHWA) website at www.fhwa.dot.gov/environment/bikeped/mutcd_bike.htm.

The *Urban Bikeway Design Guide* is available online at <http://nacto.org/cities-for-cycling/design-guide>.



Two-way cycle track on 15th Street in Washington, D.C.

Transportation Campaign (see www.railstotrails.org/2010). Active transportation encompasses walking and biking (non-motorized transportation modes) and is ideally linked with transit (e.g., bus, rail, ferry) networks. According to the American Public Health Association, “Making active transportation a realistic, affordable and convenient option for all transportation users would help reduce health impacts and also promote physical activity, recreation and environmental preservation. Well-connected streets with safe pedestrian and bicyclist paths and infrastructure can promote a healthy and active lifestyle for everyone.”³

In California, the Healthy Transportation Network (HTN), a statewide program funded

by the California Department of Transportation (Caltrans) Transportation Enhancements program, is implementing a statewide bicycle and pedestrian safety education program. RTC, as a member of the HTN, prepared this report as a survey of innovative bicycle designs with lessons learned from communities in California.

A balanced network composed of shared-use paths, cycle tracks, bike lanes and bicycle boulevards will appeal to a large cross-section of the population and help increase cycling rates in your community.^{4,5,6} RTC encourages you to utilize this report and associated resources to integrate your paved trails and on-street facilities into a safe and convenient interconnected network.



The Pennsylvania Avenue cycle track in Washington, D.C. leads to the Capitol and demonstrates the emphasis cities are placing on innovative bikeways.

RTC's Urban Pathways Initiative

While many people associate shared-use paths with more rural or suburban settings, these trails play an important role in heavily urbanized communities. For example, Los Angeles County's extensive Class I system is primarily comprised of shared-use paths along active railroad rights-of-way, converted floodway maintenance roads, and beach paths. These shared-use paths form the backbone of the bicycling network, with bike lanes and routes feeding from neighborhoods into the popular paths that offer access to active transportation destinations, open space, scenic vistas and park systems along the waterways and railroad tracks. They integrate physical activity into daily routines and effect positive change in neighborhoods where the demand for improved health and community empowerment is greatest. Riders of all ages and skill levels feel comfortable on these shared-use paths since they are completely separated from traffic.

To this end, RTC's national Urban Pathways Initiative promotes the health, transportation and environmental benefits of trail use in underserved communities and work with local partners to produce events and encouragement programs that increase trail use and deliver maximum community benefit. Find out more at www.railstotrails.org/urbanpathways.



Family riding the San Gabriel River Bike Path in California.



The new Cal Park Tunnel path in Marin, Calif., forms a convenient connection.

Innovative Bicycle Facilities

Cycle Tracks



One-way cycle track in Long Beach includes curb separation.



Two-way cycle track in Washington, D.C.

Cycle tracks are exclusive on-street bicycle facilities physically separated from motorized vehicles and pedestrians. They have been used in a variety of different designs including two-way in the center or on the side of the street (similar to a shared-use path), or one-way on the side of the street that may include lanes against vehicle traffic. Cycle tracks usually employ bicycle-only signal phases at intersections or methods to control the merging of bicycle and motor vehicle traffic. Various designs for physical separation include a raised curb, safe-hit posts, low-growing planting strips, or on-street parking between the cycle track and motor vehicle lane. This innovation combines the user experience of a separated shared-use path (with dedicated bicycle use) and the on-street infrastructure of a bike lane.

Best Suited For

Cycle tracks are best suited for high-volume streets in downtowns and busy neighborhood thoroughfares where heavy traffic creates a daunting environment for bicycling. Cycle tracks perform best where motor vehicle turns are limited and the path is not crossed by multiple driveways. For cities with a commitment to more livable, healthy and active communities, cycle tracks can be part of an overall strategy to increase bicycle usage.

Cycle tracks are also known in various places as “protected bikeways,” “protected on-street paths,” “separated bikeway” or “physically separated bike lanes.” For the purposes of this paper we are using the term “cycle track.”



Advantages

- The use of cycle tracks is believed to provide an incentive for everyday bicycle transportation for those who are reluctant to ride in traffic or even in Class II bike lanes.⁷
- Cycle tracks provide a more comfortable and safer environment than riding on sidewalks that may endanger pedestrians. Streets with cycle tracks change intimidating fast-moving thoroughfares into streets moving vehicles, bicyclists and pedestrians at a comfortable pace that allows them to stop and patronize adjoining businesses.
- One-way cycle tracks are often 7 to 10-feet wide, allowing adequate space for passing, though when there is less bicycle traffic, bicyclists can ride side by side.
- Cycle tracks with a minimum 3-foot buffer from parallel parked vehicles prevent collisions in the door zone. Cycle tracks are commonly constructed on the passenger side of parked vehicles, which are opened less frequently than driver's side doors (where Class II bike lanes are typically located).

Formal studies to determine whether cycle tracks increase bicycle riding, encourage local business and reduce bicycle-related injuries are in their early stages. One such study by researchers from McGill University, Harvard School of Public Health and Northeastern University regarding multiple cycle tracks in Montreal found that 2.5 times as many bicyclists used the cycle tracks compared to the streets, and the cycle tracks had a 28 percent lower injury rate compared to bicycling in the street.⁸

Disadvantages

- Cycle tracks may involve more upfront costs and ongoing maintenance than regular Class II bike lanes or shared roadway markings. However, they can be created at minimal cost by removing a travel lane, moving the parallel parking over and painting lines for the outside edge of the cycle track and buffer area.
- Cycle tracks often require more space than Class II bike lanes or shared roadway markings and may require the removal of a travel lane or parking.
- While bicycle-only signal phases at major intersections provide a means to address those interactions between motor vehicles, pedestrians and bicycles, solutions for driveway crossings and less-busy intersections are more difficult and generally involve users learning new practices and behaviors. Of note, the European standard is to use yield control pavement markings, such as color or textures, at low-volume intersections and for motor vehicles to yield to the cycle track.
- Since the cycle track is offset from the street, measures must be taken to improve visibility for bicyclists at intersections and prevent collisions with turning motorists. While some practitioners propose making the cycle track become a bike lane at the intersection, The Netherlands and Washington, D.C. have been developing alternate designs that improve safety.

Cycle Tracks



Long Beach cycle track separated with parked vehicles and potted plants.



Bicycle signals have separate phase for bicyclists on the Long Beach cycle track.



Market Street cycle track adjacent to transit vehicles in center lane and separated from traffic with safe-hit posts.

Specific Applications

Long Beach, Calif.— Broadway and 3rd Streets (see <http://bikelong-beach.org/Planning/Read.aspx?ArticleId=19>).

- The cycle track has the physical barrier of parked vehicles and a curb between bicyclists and moving vehicles, with buffer space for those exiting parked vehicles to check for passing bicyclists before crossing to the sidewalk. The project is 1.1 miles long from Golden Avenue to Alamitos Avenue and consists of a westbound cycle track on 3rd Street and an eastbound cycle track on Broadway. Both cycle tracks are on the left side of the street. This project is in a trial phase with FHWA and the California Traffic Control Devices Committee (CTCDC).
- Bike signals are coordinated with new left turn signals for vehicle traffic. Motor vehicles turn left on the green arrow only while bicyclists have a red bike signal to stop and vice versa. Driveways, alleys and left turns at uncontrolled intersections are marked by green paint in the cycle track to alert bicyclists and vehicles of the potential conflict point and that all users must share the road safely.

San Francisco, Calif.— Market Street from 8th to Octavia Boulevard (see www.sfmta.com/cms/bproj/27370.html).

- The green painted cycle track ranges between 7 and 10 feet in width, with a physical barrier of safe-hit or delineator posts between the path and motor vehicles. This implementation is undergoing evaluation before the method is expanded by the San Francisco Municipal Transit Agency (SFMTA). The current cycle track is 0.6 miles in length. Public buses and trolleys use the center lane with island loading platforms at intersections, so the protected bike lane does not interfere with transit vehicles.
- The solution is well-suited to the section of Market Street where there is little or no motor vehicle parking. Safe-hit posts have also been implemented for short distances on Division Street and Laguna Honda Boulevard.



Cost, Approval Process and Length of Operation (as of 2011)

Long Beach

The cycle track cost \$700,000, which includes replacing the 30-year-old traffic signal system. This is a Federal Highway Administration (FHWA) demonstration project and is also approved by California Traffic Control Devices Commission.

San Francisco

Because the Market Street cycle track was completed in stages, there is no total cost information for the entire project. The cost for purchase and installation of each safe-hit post is approximately \$90. The cost of the green paint used to raise awareness of the cycle track is \$3.25 per square foot for paint and installation. The posts and green paint were installed in 2010 and 2011. The project was approved internally and required the city traffic engineer to write a justification.

Bicycle Community Response and Impact on Bicycle Ridership

Long Beach

The cycle track opened in April 2011. Later in 2011 there should be some additional information available at <http://bikelongbeach.org>.

San Francisco

The cycle track on Market Street is very popular with the bicycle community, though some experienced bicyclists prefer riding in the regular flow of street traffic. For a perspective on the Market cycle track from the San Francisco Bicycle Coalition, see www.sfbike.org/?market. SFMTA citywide bicycle counts indicate that between 2006 and 2010, bicycle use on Market Street increased 61 percent. The current number of bicyclists using Market Street during the morning rush hour averages 600 per hour.



Long Beach cycle track wide enough for two and the dog.



Market Street cycle track adjacent to curb.

Cycle Tracks

Surrounding Community Response

Long Beach

The cycle track is in the commercial downtown, surrounded primarily by businesses. Prior to and during implementation, Long Beach has been working with local businesses to answer questions about the project. While the project reduced parking for motor vehicles by 13 percent in this corridor, the goal is that both bike traffic and foot traffic will increase for the local businesses.

San Francisco

When the Market Street cycle track was originally implemented, there was community concern about the elimination of on-street parking on Market Street. At that time, vehicles serving businesses often parked in the bike lane and now cannot due to the safe-hit posts. As a result, some businesses have ongoing concerns about vehicle access. Also, the safe-hit posts mean that taxis and paratransit vehicles that serve the surrounding community cannot easily pickup and dropoff passengers mid-block.

Impact on Safety

Long Beach

There is no safety evaluation data available at this time. Long Beach planners believe bicycle safety will be enhanced by the improved coordination of traffic and bike signals provided by the project, the protected left turn areas for bicyclists, and the green paint treatment at driveways.

San Francisco

With the implementation of the safe-hit posts to create the cycle track on a portion of Market, instances of vehicles blocking the cycle track have decreased 84 percent and instances of vehicles driving in the cycle track have decreased 96 percent.⁹ There is no data on collision occurrences available at this time.



Market Street cycle track.



Lessons Learned and Future Plans

Long Beach

If the cycle track is deemed successful, landscaping will be added. Long Beach hopes to implement more cycle tracks where possible to serve bicyclists not comfortable in mixed traffic and the city will use the experience with Broadway and 3rd Street to guide implementation.

San Francisco

- Extensive dialog with the surrounding community is key to planning and implementation, particularly where curb access issues are involved.
- The green paint treatment may be replaced by a colored slurry seal and used in future implementations.
- Mechanical street sweepers cannot fit in the cycle track area and an agreement was made between the SFMTA and the San Francisco Department of Public Works to manually sweep the cycle track. This issue may present a challenge for future expansion of the cycle track network.

Additional Cycle Track Resources

NACTO Urban Bikeway Design Guide

Cycle Tracks: <http://nacto.org/cities-for-cycling/design-guide/cycle-tracks/>

Alta Planning + Design Cycletracks Lessons Learned Report:

www.altaplanning.com/App_Content/files/pres_stud_docs/Cycle%20Track%20lessons%20learned.pdf

Presentation: www.portlandonline.com/Transportation/index.cfm?a=228196&c=34816

SW Broadway Cycle Track & SW Stark/Oak Street Portland Buffered Bike Lanes:

www.ibpi.usp.pdx.edu/media/PSU%20Cycle%20Track%20BBL%20Report%20FINAL.pdf

Long Beach Separate Bikeway Fact Sheet:

<http://admin.longbeach.gov/civica/filebank/blobdload.asp?BlobID=27126>

Risk of injury for bicycling on cycle tracks versus in the street:

http://injuryprevention.bmj.com/content/early/2011/02/02/ip.2010.028696.short?q=w_injuryprevention_ahead_tab

CROW Design Manual for Bicycle

Traffic: www.crow.nl/nl/Publicaties/publicatiedetail?code=REC25

Bicycle Boulevards



Traffic circles and other traffic-calming elements are common on bicycle boulevards.



Street closures and diverters allow through bicycle traffic and reduce motor vehicle volumes and speeds.

Bicycle boulevards are Class III bicycle routes that feature additional treatments to favor cycling. The additional treatments often include restricted access for motor vehicles, signage and wayfinding, pavement markings and preferential right-of-way with limited stops for the bicyclists. These treatments ensure slower motor vehicle speeds and lower volumes that allow slower and less experienced bicyclists to feel comfortable taking the lane and mixing with the limited traffic on the street. In a survey of residents who live along a bicycle boulevard in Portland, Ore., 42 percent of residents said living on a bicycle boulevard made them more likely to bicycle while 4 percent said it make them less likely to bicycle.¹⁰

Best Suited For

Bicycle boulevards are best suited for two-lane residential streets where vehicle traffic can be restricted to low volumes and slow speeds. Ideally they are parallel to major streets and provide an alternative without lengthy deviation. Streets chosen as bicycle boulevards should be reasonably continuous with limited jogs, and crossing of major street intersections should be accommodated through adequate gaps in traffic for bicyclists to cross or installation of traffic control devices. Treatments commonly used for bicycle boulevards are also traffic-calming treatments. Bicycle boulevard design must also take into consideration access for emergency vehicles to reach homes and businesses along the street.



Advantages

- Bicycle boulevards are effective at increasing cycling levels and perceptions of safety and can be accomplished with minor changes to street configuration.
- Slower vehicle speeds accomplished with traffic-calming measures reduce risk of serious collisions.
- Since they are shared facilities, no additional street width is needed.
- With fairly inexpensive signage, a few street closures and reconfiguration of stop signs, a bicycle boulevard can create an attractive route connecting neighborhoods.
- Bicycle boulevards can be combined with neighborhood greening efforts to enhance street closures and traffic circles with trees and landscaping.

Disadvantages

- Because bicycle boulevards are on quieter neighborhoods streets, bicyclists may not feel comfortable accessing the “last block,” or getting to the commercial destinations on busier streets once leaving the bicycle boulevard.
- As shared facilities, some bicyclists may not feel comfortable riding with traffic.
- Where they cross major arterials, bicycle boulevards may require the installation of additional signals or traffic control devices.
- Bicycle boulevards can be costly if the traffic-calming measures include large numbers of bulb-outs, chicanes, traffic circles and islands.
- The street closures and preferential treatments for successful bicycle boulevards may be controversial. Opposition may come from within the neighborhood that is resistant to change or from drivers who will need to use alternate (and often more congested) routes.



Half-street closures on Berkeley bicycle boulevards restrict traffic to bicyclists and emergency vehicles.



Bicycle boulevards in Berkeley primarily utilize quiet neighborhood streets.

Bicycle Boulevards



Top: Enhanced wayfinding signage used in Berkeley.
Middle: Berkeley bicycle boulevards get distinctive colored street signs.



Vista Street bicycle boulevard includes traffic circles and yield markings at intersections.

Specific Applications

Berkeley Bicycle Boulevard Network

- Extensive set of street closures to ensure light traffic and slow speeds.
- Enhanced signage makes wayfinding easy and promotes the network to all residents and visitors.
- Limited reconfiguration of stop signs to allow preferential bicyclist travel, future steps to be made in Phase II.
- Some major streets are difficult to cross where traffic controls are not present.

Long Beach Vista Street

- Removal of all stop signs along Vista Street allows for uninterrupted travel.
- Use of traffic circles at intersections slows traffic by breaking the visual horizon.
- Enhanced wayfinding and signage is currently being installed.

Cost, Approval Process and Length of Operation (as of 2011)

Berkeley

Approximately \$4.5 million has been spent to date, most of which (just over \$4 million) was spent acquiring railroad right-of-way to build a pathway connection between bicycle boulevards in Berkeley and Emeryville. The total bicycle boulevard network is about 15 miles in length. The bicycle boulevards were included in the 2000 Bicycle Plan approved by the city council.

Long Beach

The implementation cost of the project is \$750,000 and includes a new traffic signal with a traffic diverter at Redondo Avenue, two roundabouts, six small traffic circles and enhanced signage and markings along 1.5 miles of Vista Street. The project is completing construction as of May 2011.



Bicycle Community Response and Impact on Bicycle Ridership

Berkeley

The bicycling community has been positive and supportive, especially of improvements to arterial roadway crossings. Surveys conducted during the development of the 1971 Bicycle Plan and again in the 1990s for the development of the 2000 Bicycle Plan showed that bicyclists were uncomfortable sharing the roadway with high-volume auto traffic. Since opportunities were physically and politically limited for removing vehicle parking to install bike lanes or separated bikeways, the bicycle boulevard strategy was chosen. This network, predominantly on low-volume, quiet residential streets, aims to provide a biking environment suitable for all ages and ability levels of bicyclist, which could not be delivered on arterial roadways.

Long Beach

The bicycling community has enthusiastically received the Vista Street Bicycle Boulevard. According to Bike Long Beach Year in Review 2010, children and parents now consider Vista Street a safe route for bicycling to two elementary schools and one middle school.

Surrounding Community Response

Berkeley

The community response to the bicycle boulevards has been generally positive. The network builds on diversion and traffic calming done in the mid-1970s, which at that time was very controversial. Not much controversy has occurred since, although one arterial crossing signal had to be abandoned due to public misunderstanding/opposition.

Long Beach

The surrounding community has varying reception to the bicycle boulevard. Concerns were raised over the cost of the project, and the city emphasized that the project was not funded from local tax dollars. Long Beach connected with residents interested in traffic calming to gather increased support.



Vista Street improvements.



Clear street markings emphasize sharing the road and increase awareness of the bicycle boulevards.

Bicycle Boulevards



Berkeley bicycle boulevard.



Markings show bicyclists where to stop to actuate traffic signals.

Impact on Safety

Berkeley

Overall bicycle collisions (both absolute numbers and rates) have declined in Berkeley since implementation began in 2000. A study of bicycle boulevards compared to parallel arterial routes found that collision rates were two to eight times lower on the bicycle boulevards.¹¹ *Berkeley Bicycle Boulevard Design Tools and Guidelines* asserts that bicycle boulevards “improve the safety of bicyclists in the following ways:

- The low volume of traffic, compared to a collector or arterial, reduces the potential for conflicts between motorists and bicyclists.
- Traffic controls that give right-of-way to the bicycle boulevard reduce the potential for conflicts with traffic entering or crossing the bicycle boulevard from side streets.
- Bicyclists can cross collectors and arterials more safely at four-way stop signs or signals than at gaps in traffic at uncontrolled crossings.
- Slower traffic, compared to a collector or arterial, makes it easier for both motorists and bicyclists to avoid collisions, and reduces their severity if they occur.”¹²

Long Beach

There were collisions in the neighborhood before implementation of the bicycle boulevard, but construction is not yet complete so new data is not available.



Lessons Learned and Future Plans

Berkeley

The network is being implemented in two Phases. Phase I, which is complete, involved the installation of wayfinding signs and pavement markings. Phase II, which is being implemented incrementally, involves the removal or turning of stop signs along the bicycle boulevard routes, as well as arterial intersection crossing improvements and additional diversion and traffic calming. There has been opposition to new traffic signals in some cases, and the city is working to address concerns and bolster community support.

Long Beach

- Bicycle boulevard projects need to have political support and long-term commitment in place from the beginning. The Long Beach city council unanimously supported setting the goal of becoming the top bicycling city in the United States, which aided implementing bicycle boulevard and cycle tracks. The City Council sees their bicycling improvements as an economic development strategy that will increase tourism and support local business.
- Traffic engineers need to have experience in traffic circles to create a successful design.

Additional Bicycle Boulevard Resources:

Bicycle Boulevard Planning & Design Guidebook: www.ibpi.usp.pdx.edu/guidebook.php

NACTO Urban Bikeway Design Guide: Bicycle Boulevard components include signage and shared-use markings: <http://nacto.org/cities-for-cycling/design-guide/bikeway-signing-marking/>

Berkeley Bicycle Boulevard Design Tools and Guidelines: www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6652

Resident Perceptions of Bicycle Boulevards: A SE Salmon Street Case Study: www.ibpi.usp.pdx.edu/boulevardperceptions.php

Long Beach Vista Street Bike Boulevard Fact Sheet: www.longbeach.gov/civica/filebank/blobdload.asp?BlobID=29497

Long Beach Bike Boulevard Presentation: <http://admin.longbeach.gov/civica/filebank/blobdload.asp?BlobID=27126>

Green Sharrow Lane



The green sharrow lane consists of roadway markings used to indicate a shared lane environment for bicycles and motor vehicles. It is a combination of standard sharrow markings with a continuous green stripe to emphasize the legal right of bicyclists to take the lane. The green sharrow lane is an excellent educational tool that defines the proper location for bicyclists to ride in a shared lane and alerts roadway users to the presence of bicyclists.

Best Suited For

The green sharrow lane is useful for streets where traffic speeds are slow, allowing for a comfortable mixing of bicycle and motor vehicle traffic. Business districts with space constraints that do not allow for bike lanes or cycle track facilities are candidates for this treatment. The paint on the shared lane emphasizes the bike space and can be especially effective in conflict zones at intersections, driveways or shared turn lanes. They inform bicyclists where to ride clear of the door zone when placed adjacent to parallel motor vehicle parking.



Advantages

- A green sharrow lane can help bicyclists position themselves more safely in a designated area where space is limited, and move bicyclists outside of the door zone of parked vehicles. The markings need to be painted in the proper location and some education provided for bicyclists and drivers.
- This application can mitigate conflict areas between vehicles, bikes and pedestrians.
- The green lane can provide a reminder to use environmentally friendly transportation methods.
- No removal of traffic lanes is required for this solution.

Disadvantages

- The green sharrow lane is not separated, so those riders who are not comfortable sharing the lane with motorists are unlikely to use it.
- The green sharrow lane requires periodic maintenance to renew paint, and use of paint materials that are not slippery.
- There may be some confusion over whether the green sharrow lane is a bike-only lane or a shared lane, due to unfamiliarity with this treatment in the United States.
- Applications of the green sharrow lane may be limited to locations where the speed differential between bicyclists and motor vehicles is low, such as commercial corridors with regular traffic signals timed for bicycling travel speed.

Green Sharrow Lane



A bicyclist riding in the proper position on the green sharrow lane (but without a helmet!).



The 15 traffic lights in the business district are timed to slow traffic to 6 mph.

Specific Application

Long Beach

- The green sharrow lane extends for 0.7 miles on 2nd Street in Belmont Shores (a busy commercial thoroughfare) with approximately 35,000 motorists per day and more than 400 bicyclists, many of whom were riding on the sidewalk. This prompted businesses to request a solution from Long Beach to reduce the hazard to pedestrians.
- The solution employs a 6-foot green stripe with sharrows for bicyclists to avoid pedestrians and the parked vehicle door zone. The solution is coupled with enforcement fines of \$170 for bicycle riding on the sidewalk.

Cost, Approval Process and Length of Operation (as of 2011)

The cost of the green sharrow lane was \$10,000 for paint and two days staff time for a public works crew to complete the project spanning 15 blocks. The project was approved by the Long Beach City Council, the Belmont Shores business association and as an experiment by the Federal Highway Administration (FHWA). The green sharrow lane has been in place since 2009.

Bicycle Community Response and Impact on Bicycle Ridership

A 12-month progress report showed an increase in bicycle ridership from 414 per day to 809 per day, with a reduction of sidewalk riders from 42 percent to 21 percent. Bike riders have expressed the view that the green sharrow lane articulates the law of sharing the road. Long Beach received an Institute of Traffic Engineers award for this solution.

Surrounding Community Response

Businesses on the affected street are experiencing more business from the increased bicycle ridership. This has led to an increase of business requests to the city for bike racks and corrals at their location. In addition, some businesses are using bicycles to do some of their deliveries to customers.



Impact on Safety

The green sharrow lane has improved safety for bicyclists in the corridor. The one-year report to FHWA shows that while the overall number of bicyclists using this corridor has doubled to average 809 daily, the rate of vehicle/bike collisions has dropped by half (i.e., the absolute number of collisions remained the same with double the cyclists). Rates of bicyclists using the sidewalk have dropped from 42 percent to 21 percent. Rates of bicyclists riding in the door zone have dropped from 48 percent to 36 percent. And perhaps most dramatically, rates of bicyclists using the travel lane have tripled from 12 percent to 39 percent.

Lessons Learned and Future Plans

Educational and police enforcement efforts are planned to reduce bicycle ridership in the door zone and on the sidewalk. Long Beach is considering adding additional green sharrow lanes and may enhance the paint treatment with reflective material and with door zone markings.



Some bicyclists are still riding in the door zone, so education and outreach is ongoing.

Additional Green Sharrow Lane Resources

NACTO Urban Bikeways Design Guide shared roadway markings and colored pavement:
<http://nacto.org/cities-for-cycling/design-guide/bikeway-signing-marking/>

NACTO webpage on the Green Sharrow Lane: http://nacto.org/wpcontent/uploads/2011/02/SecondStreetSharrowsandGreenLane_sharedlanemarking_longbeach.pdf

Neighborhood Traffic Calming



Half-street closures with openings for bicyclists have substantially reduced motor vehicle traffic on neighborhood streets.



The street closures feed into bike lanes that stretch through the neighborhood and connect to major trails and bike routes.

While not strictly a bicycle innovation, **traffic calming** is included here as an effective strategy to improve safety conditions and provide an environment that promotes bicycling.

- Neighborhood traffic calming can transform neighborhood streets from dangerous thoroughfares to pleasant places to ride a bike. When implemented at a neighborhood scale, bicyclists can benefit from a new network of low-volume and slow-speed streets that operate similar to bicycle boulevards.
- To benefit bicyclists, traffic-calming measures can include half-street or full-street closures that prohibit through-vehicle traffic while allowing bicycles. The closures discourage motorists from using the calmed streets as a short-cut and create a street environment that encourages bicycling.
- The replacement of stop signs by traffic circles and yield signs helps keep bicyclists moving with less effort to reach their destinations quickly.

Best Suited For

Traffic calming most commonly occurs in residential neighborhoods with a grid-type street pattern where traffic can be diverted to appropriate collector or arterial streets nearby. Before traffic calming, the neighborhoods commonly suffer from automobile traffic using the neighborhood streets as short cuts or to avoid congestion on the nearby arterials.



Advantages

Neighborhood traffic calming can achieve major changes to the street environment with minor infrastructure investment. Traffic calming is a holistic solution that changes the entire atmosphere of the street, making conditions better not just for bicyclists, but also for pedestrians, motorists and residents. The slower speeds accomplished by traffic calming result in fewer vehicle collisions and increase overall safety. Bicycle boulevards and bike lanes can easily be integrated into a neighborhood traffic-calming project with minimal additional cost and effort.

Disadvantages

Traffic calming shifts traffic patterns and may result in higher traffic levels on adjacent streets. Because traffic shifts are hugely controversial, strong political leadership and an informed and involved populace is critical to successfully implementing a traffic-calming project. Motorists from outside the neighborhood and those accustomed to driving through the neighborhood are likely to have strong complaints when they need to change their driving routes. Based on experience with these controversies, the city of Sacramento is pursuing less drastic measures in most neighborhoods currently implementing traffic calming.

Specific Applications

Sacramento, Calif.—Midtown Neighborhood Preservation Transportation Plan bounded by C, J, 19th and 29th Streets.

- Three-lane one-way streets with high traffic speeds and volumes connecting downtown Sacramento to the Business 80 freeway were converted to two-lane two-way streets.
- Half-street closure traffic diverters were installed to discourage through traffic.
- Traffic circles, islands and bulb-outs were installed at specific locations to decrease traffic speed.
- Bike lanes were installed on E, G, H, I and 28th streets.
- Through traffic is directed to nearby commercial streets, J Street and L Street, which remain three-lane, one-way streets.
- Improves access through midtown to the Sacramento Northern Bike Trail gateway at 20th and C streets with connection to the American River Bike Trail.



Traffic circles add landscaping and slow through traffic.

Neighborhood Traffic Calming



Crossing islands, traffic circles and half-street closures reduce the apparent width of the street and encourage motorists to slow down.

Cost, Approval Process and Length of Operation (as of 2011)

Construction cost was approximately \$1.5 million for the 70-city-block project. The majority of the cost was for traffic signal changes and decorative textured crosswalks to enhance J Street, where traffic was diverted. The project required an Environmental Impact Report, extensive traffic studies and more than 75 public meetings before implementation in 1998.

Bicycle Community Response and Impact on Bicycle Ridership

At the beginning of the process, the traffic-calming project enjoyed broad support from bicycle advocates, but some were skeptical about implementing traffic circles because they redirect motorists from the center of the street to the edge and require sharing space in the intersection. The improvements now enjoy broad acceptance and the traffic circles are regarded as a net positive, since they reduce speeds and beautify the neighborhood. Overall bicycle ridership has steadily increased in Sacramento, but no studies can directly attribute the ridership increase in midtown to traffic calming. Midtown is now regarded as one of the most enjoyable and interesting neighborhoods to ride a bike in the Sacramento region.

Surrounding Community Response

The surrounding community was very concerned about the traffic increasing on their streets, which resulted in additional traffic-calming measures being implemented on neighboring D Street and the neighborhood south of J Street. This concern has resulted in conversions of many of the three-lane one-way streets to two-lane two-way streets with bike lanes and has further improved the cycling network. There were hot spots of opposition from business owners in the area to be traffic calmed, but they were a minority and balanced by businesses on J Street eager for additional traffic.



Impact on Safety

Traffic calming results in slower vehicle speeds and increases safety. In midtown it has resulted in a decrease in vehicle-to-vehicle collisions as well as a decrease in vehicle-to-bicyclist collisions.

Lessons Learned and Future Plans

The traffic-calming program has been expanded to other neighborhoods in Sacramento with less drastic measures proposed, but likely with less remarkable results for bicyclists. Street conversions from three-lane one-way to two-lane streets with bike lanes have expanded to the southern portion of midtown, and the city is currently studying downtown streets for similar measures.

One of the lessons learned is that the project was politically controversial and influenced the election of the city councilman who represents the area and supported the plan.



Traffic diverter on H Street in Sacramento allows bicyclists through to the bike lane.

Additional Traffic-Calming Resources

For more information on **Sacramento's Neighborhood Preservation Transportation Plan**: www.ite.org/traffic/documents/AHA97G52.pdf

Fehr&Peers Guide to Traffic Calming: www.trafficcalming.org

Institute of Traffic Engineers Traffic Calming Library: www.ite.org/traffic

Innovative Designs at Intersections

Intersection Crossing Markings

Intersections are where vehicles and bicycles have the most interactions, the most sites of potential conflict and the most accidents.^{13,14} There are a number of innovative designs at intersections that can alleviate some of these conflict points and improve awareness of motorized traffic to bicyclists. Intersection crossing markings, through bike lanes, bike boxes, cycle tracks with small islands at street corners, crossing set backs and bike signals are examples of treatments that have been shown in studies to change driver and bicyclist behavior at intersections and improve safety.

Intersection crossing markings indicate the path of bicycles through an intersection to both motorists and bicyclists. For those intersection markings that show the connection of a bike lane or cycle track across an intersection, the markings extend the outside lines of the bike lane with dashed lines or elephant's feet markings through the intersection. Markings inside the lane may include chevrons, sharrows or colored pavement (usually green and often only for the length of the lane in the intersection where bicyclists are exposed to right turns). The markings also reinforce that through-bicyclists have priority and turning motor vehicles should yield to them. These types of markings are used most often at high-volume intersections or to indicate an unusual path for bicyclists across an intersection (e.g. the bike lane moves from the right side of the road to the left).¹⁵ According to a 2000 Portland study, a colored intersection crossing marking reinforces that through-bicyclists have priority over turning vehicles or vehicles entering the roadway (from driveways or cross streets). The study found that “significantly more motorists yielded to bicyclists after the blue pavement had been installed (92 percent versus 72 percent before installation).”¹⁶



Intersection crossing markings on the cycle track along Pennsylvania Avenue in Washington, D.C.



Another type of intersection crossing marking is a “cross-bike,” a crosswalk for bicycles. Portland is proposing using cross-bikes for bike routes or bicycle boulevards (referred to as neighborhood greenways in Portland) on low-volume streets that cross higher volume collector streets without signals. According to the Portland Bureau of Transportation (PBOT) bicycle coordinator, “one unintended consequence of building curb extensions as crossing treatments on neighborhood greenways was that motorists on the collector street would occasionally stop and yield the right-of-way to a bicyclist waiting to cross. Though that was not the intent of the curb extensions, we considered it a positive benefit and began to consider ways to reinforce these locations

as crossings for bicyclists. We landed on the idea of providing a prominent marking to further alert motorists to the presence of crossing bicyclists.”¹⁷ Portland has not decided on a final design for the markings, but examples are available at <http://bikeportland.org/2011/01/19/cross-bikes-crosswalks-for-bikes-coming-soon-to-portland-46310> and are discussed in a PBOT document, “Enhanced Bicycle Boulevard Markings Demonstration Project,” from 2007 available at http://bikeportland.org/wp-content/uploads/2011/01/Test_New_Bicycle_Boulevard_Marking_Techniques.pdf. Another example comes from Vancouver and can be seen at <http://vancouver.ca/engsvcs/transport/cycling/safety/elephant.htm>



SFMTA has installed “green backed” sharrows through intersections on Market Street that are standard white sharrows on a green box that adds emphasis to the marking. The green backed sharrows assist bicyclists in positioning themselves correctly for the cycle track as it transitions to and from the curb in different segments.

Additional Resources for Intersection Designs

<http://nacto.org/cities-for-cycling/design-guide/intersection-treatments>

Through Bike Lanes



Above and below are two examples of through bike lanes indicating where bicyclists should shift over to allow motor vehicle left turns along the Long Beach cycle track.



When bicyclists riding in a bike lane or in a cycle track approach an intersection with turn lanes, they must carefully position themselves at the intersection to avoid conflicts with turning vehicles.

Through bike lanes indicate to bicyclists where they should travel and make bicyclists more visible to drivers wishing to move into a turning lane. The most common example is with a right-turn lane at an intersection. When the right-turn lane begins, the bike lane lines become dashed with colored pavement in between. The dashed lines indicate to vehicles that they can cross through the bike lane and to bicycles that they are entering a shared space. The paint on the shared lane brings motorists attention to the presence of bicyclists. When Portland installed a through bike lane in 2000, they found that the markings improved safety by making bicyclists and drivers more aware of the conflict area, and drivers more often yielded to bicyclists after the coloring was installed. However, they also found the bicyclists were less likely to use hand signals or turn their head before crossing the lane, perhaps due to a false sense of safety. Through bike lanes can also be used with heavily trafficked driveways or other turns.

Additional Resources for Intersection Designs

<http://nacto.org/cities-for-cycling/design-guide/intersection-treatments>



Specific Applications

San Francisco

- Implemented at an intersection of a three-lane, one-way street at the location of a popular gas station with two driveway entrances (on Fell Street at the intersection with Divisadero), where motor vehicles pass through the bike lane, which is on the left, to turn into the gas station (also on the left) and often blocked the bike lane as they waited to enter the gas station.
- The project removed two parking spaces prior to the driveway entrance to the gas stations to provide a queuing lane to the left of the bike lane and then painted the bike lane green with dashed white lane lines.

Impact on Safety

The through bike lane improves safety by keeping turning vehicles from blocking the bike lane and forcing cyclists around them into travel lanes. In 2010, SFMTA staff observed motorist and bicycle behavior over three days at peak travel time between 5 p.m. to 6 p.m. Changes in motorist and bicyclist behavior have occurred at the gas station entrance, mitigating but not eliminating the problem of vehicles blocking the bike lane. Observations from before and after the addition of the colored treatment show that the number of vehicles stopped while blocking the bike lane were reduced by 41 percent after the addition of the colored treatment.

Lessons Learned and Future Plans

The SFMTA impact study did not include an overall analysis of the number of times bicyclists and vehicles crossed paths along the length of the green bike lane. Also, bicyclists sometimes occupied the queuing lane for vehicles rather than the green bike lane, which led some drivers to pass bicyclists using the green bike lane.



Before the bike lane was colored and through bike lane markings were installed. Photo courtesy SFMTA.



Fewer motor vehicles block the bike lane after installation.



Through bike lane on Market Street with bike box.

Bike Boxes



Bike box in San Francisco allows bicyclists to move in front of motor vehicles.



Bike boxes are colored boxes that allow bicyclists to queue in front of motor vehicles at traffic signals, raising visibility and awareness. They prevent conflicts with turning vehicles, particularly dangerous “right-hook” accidents with trucks. The stop bar is moved back and in front is a colored waiting area with a bike symbol in it. The coloring often extends across the entire vehicle lane into the bike lane.

A study in Austin, Texas, found that the bike boxes increased visibility of bicyclists. The study found that, with a bike box, motorists more often yielded right-of-way to bicyclists.¹⁹ Another study in London in 2005²⁰ found that bicyclists were able to position themselves in the bike box, in front of the vehicles, thus reducing the potential for conflicts between bicycles and right-turning vehicles. The same study also found that the bike boxes provided an added benefit. They serve as a buffer for pedestrians and the crosswalk, reducing encroachment into the crosswalk. The study states, “all vehicles that encroached at control sites went into the pedestrian crossing, compared with 12 percent at [bike box] sites, indicating that [a bike box] can provide a buffer zone that discourages vehicles from blocking the pedestrian crossing.”²¹ An additional benefit of bike boxes is that they provide an increased perception of safety among bicyclists. A 2010 study from Oregon found that “77 percent of bicyclists felt bicycling through the intersections was safer with the bike boxes.”²²



Specific Applications

Long Beach

Long Beach has bicycle box treatments on the left-hand turn lane from Marina to 2nd Street and on 2nd Street and Bayshore (for those heading west) near the start of the green sharrow lane. For more information, see <http://bikelongbeach.org/Planning/Read.aspx?ArticleId=16>.

San Francisco

The most successful implementation thus far, according to SFMTA, has been at Scott and Oak streets, a very busy intersection where motorist compliance with the bike box has been good. Five bike boxes were recently installed on Market Street to provide space for multiple bicyclists to wait at signalized intersections. The effectiveness of these implementations will be evaluated in the future.



Market Street bike box.

Additional Resources for Intersection Designs

<http://nacto.org/cities-for-cycling/design-guide/intersection-treatments>



Bike Signals



Bike signal phase in Golden Gate Park.



Bike scramble signal in Portland, Ore. Photo courtesy of John Luton, Capital Bike and Walk, Victoria B.C.

Bicycle signals allow bicycles to proceed through an intersection without vehicular traffic. There are two main types of bike signal phasing: bicycle-only and bicycle scramble. The bicycle-only signal phase allows bicycles to proceed without the presence of motor vehicles in designated directions, similar to signals for vehicles. Bike scramble signals allow all bicycles to proceed through the intersection, from all directions simultaneously. Bicycle signals can also provide a lead time for bicycles at an intersection with a delayed green signal for vehicles.

Bicycle-only signal phase allows bicycles to cross an intersection where there is the potential for conflict with turning vehicles. A study in Davis, Calif., found increased bicycle safety due to a low number of bicycle-vehicle conflicts.²³ The authors also applied a cost-benefit analysis to vehicle delay and emissions and found that the benefits outweigh the cost and disadvantages.²⁴

A bike scramble signal in Portland stops all vehicular traffic and allows bicycles to proceed in any direction, accessing a number of bicycle paths, including a riverfront trail connection. Through observation before and after the signal was installed, a study found that the number of bicyclists using the intersection increased, and the number of illegal crossings (crossing against a signal indication) significantly decreased. Before the signal was installed, 78.1 percent of all bicyclists illegally passed through the intersection, while only 4.2 percent did so after the signal was installed. The study also found 3.3 percent of right-turning vehicles turning during the bicycle scramble.²⁵

Additional Resources

NACTO Urban Bikeway Design Guide: <http://nacto.org/cities-for-cycling/design-guide/bicycle-signals>

Rails-to-Trails Conservancy: our blog has hundreds of bicycle, pedestrian and trail resources [<http://community.railstotrails.org/blogs/trailblog>].

Join our listserv of thousands of bikeway and trail professionals [<http://groups.yahoo.com/group/trailsandgreenways>].

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