Urban Bikeway Design Guide

WORKING PAPER

Material Success

Designing Durable Bikeways | March 2023

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Updating the *Urban Bikeway Design Guide*

Material Succes: Designing Durable Bikeways, is one of seven Working Papers being released by NACTO as part of the ongoing update to the NACTO *Urban Bikeway Design Guide*. The working papers will cover topics related to equitable planning, engagement, and implementation. The papers will help inform project delivery concerns and policy considerations that should accompany the design updates in the guide. NACTO will develop a complete update to the *Urban Bikeway Design Guide* in 2023 by synthesizing these working papers with state-of-the-practice design guidance.


GO TO PDF

Making Bikes Count: Effective Data Collection, Metrics, & Storytelling

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Breaking the Cycle: Reevaluating the Laws that Prevent Safe & Inclusive Biking


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Shared Micromobility Permitting, Process, and Participation


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Moving Together: Collaborating with Communities for More Equitable Outcomes


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Designing for Small Things With Wheels


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Material Success: Designing Durable Bikeways


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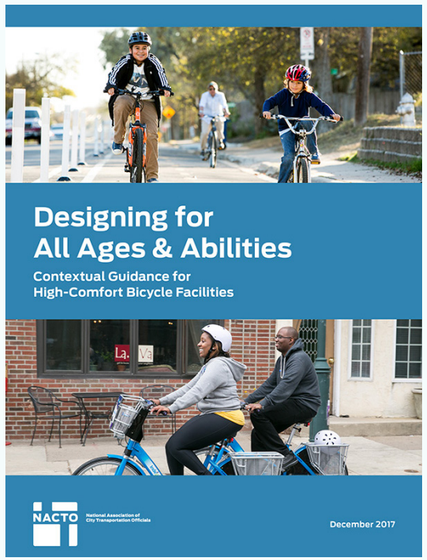
Complete Connections: Building Equitable Bike Networks

Introduction

Over the past decade, cities have built hundreds of miles of protected bike lanes between the curbs of existing streets. This proliferation of higher-comfort designs has driven a massive increase in cycling and helped significantly increase the mileage of All Ages & Abilities bikeways in North America. Now, after years of using flexible materials that can be easily installed, removed, replaced, and relocated, many cities are changing their approach–switching to more durable solutions to reduce the increasing maintenance costs caused by widespread use of temporary, flexible materials.

While there is no magic answer–all roads require maintenance, and streets with street-level protected bikeways require more attention than streets without–cities have found strategies to expand the palette of materials used for street-level protected bikeways while also accelerating project delivery by reducing implementation complexity.

While a complete street reconstruction provides opportunities to invest in raised and median-separated bikeways, these larger projects are not feasible at the speed that bikeway projects must be installed. This paper therefore explores strategies cities can use to select, install, and maintain more permanent *means of separation*–vertical elements that delineate a street-level protected bike lane. Instead of typical flexible delineators, cities are integrating new materials like doweled-in medians or modular concrete barriers. These more durable materials will entail more complex installations but then they require less frequent maintenance, allowing cities to reconfigure more streets as safe places to bike for everyone.



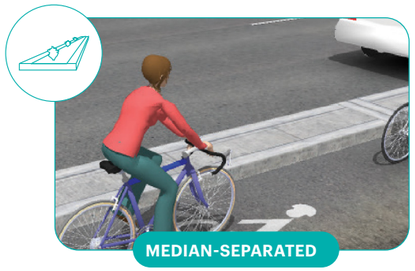
All Ages & Abilities

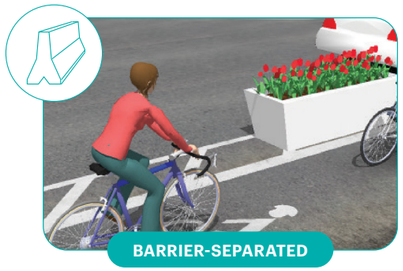
All Ages & Abilities bikeways are bikeways that are truly safe and inviting for bicyclists of All Ages & Abilities and attract wide ridership. Detailed guidance available: *Designing for All Ages & Abilities: Contextual Guidance for High-Comfort Bicycle Facilities*[1].

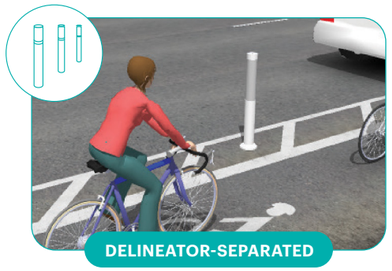
Principles of selecting means of separation for street-level protected bikeways

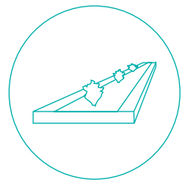
Categories of means of separation for street- level protected bikeways

Street-level protected bikeways (also referred to as protected bike lanes, separated bike lanes, and protected cycle tracks) are buffered bikeways with a 3-dimensional means-of-separation installed in the buffer to separate bikeway users from motor vehicles. In this paper, street-level protected bikeways are categorized based on the installation complexity of the means of separation.







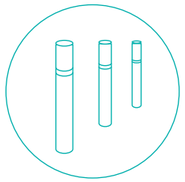


Median-separated bikeways use construct-in-place concrete curbs and medians, offer robust protection, and are very durable. Medians require more intensive planning, design, and implementation tasks than modular elements. To provide additional comfort, medians can be landscaped or planters can be installed on hardscape medians.

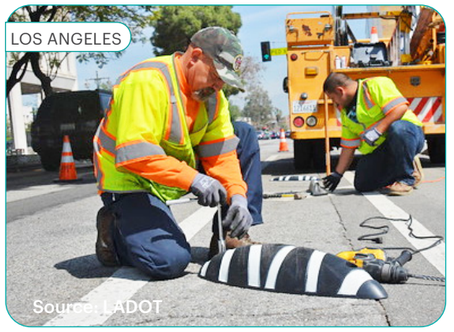
Median-separated bikeways require the most complex design and installation and can be the most robust and attractive means of separation. Standardizing design details and incorporating sufficient gaps for drainage can make construct-in-place concrete medians a feasible option for separating on-street bikeways from motor vehicles.

Barrier-separated bikeways use custom and off-the-shelf precast concrete or other durable barriers to offer bikeway protection and comfort. These items can be installed or removed quickly with crews and equipment. They range from curb-height (e.g. precast medians) to mid-height (e.g. Jersey Barriers and self-watering planters) with a wide range in cost and anchoring techniques. Place barriers in continuous patterns to maximize comfort and work with local artists to improve the overall attractiveness of concrete barriers.

Purchasing off-the-shelf durable items like Jersey Barriers or heavy duty planters can simplify design and procurement; using standardized custom forms can provide a more attractive, cost effective alternative. Large modular concrete materials are extremely heavy and require specialized equipment to transport and install. Smaller concrete materials cannot be placed by hand, but they may require more modest equipment than large concrete objects.



Delineator-separated bikeways use flexible delineators or other flexible or mountable off-the-shelf items like rubber parking stops or armadillos. They offer fast implementation and replacement with minimal disruptions, lots of flexibility for later design changes, and little to no effect on drainage. They discourage incursions into the bikeway but do not block them, and need to be replaced more frequently than concrete.



Although installation complexity varies, delineators can be transported and installed by staff or contractors with standard trucks and tools. On larger projects, a forklift is useful for loading pallets of materials.

Source: Toronto Transportation Services

Pick materials that meet design needs —not the other way around

The comfort of the bikeway and the performance of the means of separation depends on the street context. Streets with higher motor vehicle volume or speed, more truck traffic, or a higher level of curbside activity and likelihood of motor vehicle drivers entering the bikeway often call for more robust means of separation than flexible delineators alone. Different street contexts—and stressors—call for different separation materials in different layouts. Cities can combine materials and design solutions to create the best possible All Ages & Abilities bikeway solution for the given context.

This section presents common assemblies of materials separating street-level protected bikeways based on three mid-block street contexts:

Context 1: High speed streets

Context 2: Streets without on-street parking

Context 3: Streets with on-street parking

For all contexts:

Use materials that prevent drivers from encroaching on the bikeway. In places with low parking demand, flexible delineators and markings are sometimes enough to keep drivers out of the bikeway. In others, curbs or high barriers are necessary to make the bikeway usable.

Make it visible and detectable. Add flexible delineators or other retroreflective elements on top of or in line with an otherwise less-visible object such as a curb or concrete barrier. Keeping barrier elements close together and in line with one another makes them more legible to pedestrians with visual impairments.

Let water cross the buffer. Check that stormwater can flow under or between the separation materials. Some barriers have built-in channels but still may need to be spaced apart at high-flow areas.

Test new configurations and upgrade materials over time. It can be helpful to use temporary or less durable materials to make the case for a new design and to allow engineers to make modifications to improve the design. Over time, upgrade to more durable materials instead of replacing temporary materials again and again.

Context 1: High speed streets

Description: Streets with prevailing speeds of 30 mph or higher.

Example streets: Multilane thoroughfares, arterial streets, and other streets where speed management is difficult.

Purpose of means of separation: Provide a high level of separation that minimizes the potential of vehicle incursion and crash severity.

High speed and multilane contexts are the least comfortable streets for people biking, and call for investment in a durable means of separation. Medians and high concrete barriers provide the greatest protection and comfort to riders. The wider and more durable the means of separation, the more comfortable the bikeway. Alternative designs that work well on high speed streets are raised bikeways and, in contexts with low pedestrian activity, shared-use paths.

Refer to City Limits[2] for NACTO guidance on setting safe speed limits on urban streets to further improve the level of comfort for all roadway users.

Median-separated options

Means of separation: Constructed median.

Configuration and spacing: For improved comfort, a 4 foot (1.2 meter) or wider median supports built-in landscaping or planters placed on top of the median. Curbs or medians less than 3 feet (1 meter) wide are usually not preferred, but are better than delineator options like flex posts. Design continuous medians with gaps as needed to create bike-access points and allow for drainage.

Source: Alta Planning + Design, Inc

Source: Alta Planning + Design, Inc

Barrier-separated options

Means of separation: Custom or off-the shelf mid-height concrete barriers like a concrete Jersey Barrier.

Configuration and spacing: Continuous with gaps as needed to create bike-access points or allow for drainage. Built-in drainage channels can minimize the size and frequency of gaps required for drainage.

Source: Portland Bureau of Transportation

Source: City of Jersey City

Context 2: Streets without on-street parking

Description: Streets or specific locations where parking is prohibited along the bikeway and there is high potential for motor vehicle incursion during freight loading, passenger drop-off or pick-up, or from illegally parked vehicles.

Example streets: Downtown streets and neighborhood commercial zones, where parking is prohibited along the bikeway. See *Context 3: Streets with on-street parking,* for locations where parking is allowed along the bikeway.

Purpose of means of separation: Robust and continuous separation to fully block or strongly discourage motor vehicle entry.

Construct medians or place concrete barriers, planters, and other heavy objects in on-street buffers to block drivers from entering the bikeway. Delineator-protected bikeways with closely placed delineators also deter vehicle entry, but over time, especially in areas with high frequency of motor vehicle strikes, the maintenance costs may become unsustainable.

Median-separated options

Means of separation: Constructed curb or median.

Configuration and spacing: Continuous with gaps as needed to create bike-access points or allow for drainage. Gaps should be no greater than 10 feet (3 meters) long to minimize likelihood of vehicle incursion. Medians typically have vertical curbs, but can have mountable or chamfered curbs on the bike side to increase the effective width of the bikeway[3]. If a fire department or other entity requires mountable curbs on the bikeway for emergency access, install flexible delineators along the median to deter regular vehicle incursion.

Barrier-separated options

Means of separation: Mid-height or curb-height concrete barrier with built-in drainage channels. For mid-height barriers, include periodic retroreflective treatments. For curb-height barriers, install periodic flexible delineators directly on the barrier or on the roadway surface in the buffer.

Configuration and spacing: Continuous with gaps of up to 5-10 feet (1.5-3 meters) to limit vehicle incursion while accommodating existing drainage patterns, bikeway user access, and mid-block pedestrian crossings.

Delineator-separated options

Means of separation: A mix of curb-height objects plus flexible delineators, such as concrete or rubber curbing with posts mounted on them; or parking stops or armadillos intermixed or alternating with flexible delineators. Larger buffers can support planters, stone blocks, and other public space features in addition to or instead of parking stops or armadillos.

Configuration and spacing: Space flexible delineators every 5 feet (1.5 meters), with closer spacing at high-incursion segments. When mixing curb-height objects and flexible delineators, space curb-height objects (like parking stops or armadillos placed) every 5-10 feet (1.5-3 meters) with flexible delineators interspersed at least every 20-30 feet (6-9 meters). Parking stops or armadillos can be placed diagonally in wide buffers or parallel to the bikeway in narrow buffers.

Context 3: Streets with on-street parking

Description: Streets with bikeways along the curb that allow motor vehicle parking between the bikeway buffer and the motor vehicle travel lane.

Example streets: Downtown or other urban streets where parking or vehicle loading is allowed along the bikeway.

Purpose of means of separation: Prevent vehicle incursions, indicate where parking is and is not allowed, maintain pedestrian access without creating tripping hazards.

Parking-protected bikeways take advantage of the space needed for parking and the parked cars themselves as part of the means of separation. Relocating parking from the curb to the buffer area between the bikeway and the motor vehicle lanes changes where people load and unload and how they access the curb. Work with local communities and stakeholders to understand how this change may impact disabled people who are driving or arriving as passengers in cars or vans. Designate parking spaces as accessible on adjacent block faces or include them along the bikeway by narrowing the bikeway to as little as 4 feet (1.2 meter) and expanding the buffer to at least 5 feet (1.5 meters) for accessible loading. An accessible route, such as a crosswalk over the bikeway leading to an ADA-compliant curb ramp, must be provided between any accessible parking spaces and the sidewalk.

The configurations discussed here do not provide design details for designating accessible parking and loading spaces. In the U.S., consult the Americans with Disabilities Act (ADA) Accessibility Guidelines[4] and the Proposed Public Rights-of-Way Accessibility Guidelines[5] (PROWAG) for details and requirements.

Marked buffer options

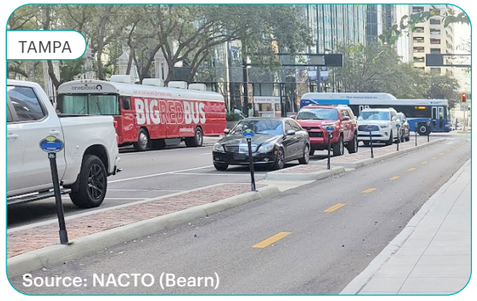
Means of separation: Marked buffer with parked cars.

Configuration and spacing: Marked buffers alone are sufficient for some segments with high parking occupancy and where drivers consistently park within the designated parking spaces. This design allows more resources to be directed to intersections and other hotspots.

Median-separated options

Means of separation: Constructed concrete median.

Configuration and spacing: Medians of at least 3 feet (1 meter) can accommodate a full door swing and medians of 4 feet (1.2 meters) or greater allow pedestrians to navigate around an open door without stepping into the bikeway. Continuous assemblies minimize the potential for tripping and allow pedestrians walking and using mobility devices to continue on a level surface. If street-level gaps are needed to accommodate drainage, it is preferable to design the median to slope down and up compliant with ADA specifications for an accessible path.



Barrier-separated options

Means of separation: Curb-height concrete barriers with delineators.

Configuration and spacing: Continuous or with gaps of 5-10 feet (1.5-3 meters) to allow for drainage points and improved pedestrian access to vehicles.

Delineator-separated options

Means of separation: Vertical flexible delineators.

Configuration and spacing: Every 20 feet (6 meters) or approximately the length of one parking space. If the buffer is 5 feet (1.5 meters) or wider, flexible delineators can be offset 3 feet (1 meter) from the parking space and can be placed every 10 feet (3 meters).

Install delineator-separated bikeways with a plan to upgrade

In relatively low speed, low-motor-vehicle-volume settings, **off-the-shelf, modular items like flexible delineators, parking stops or armadillos, used alone or in combination** can be helpful means of separation on streets that need immediate action.

These materials are less durable and require more frequent maintenance (see Maintenance is part of the job, page 21). Typically, delineator-separated bikeways are most appropriate if bikeway upgrades can be guaranteed within a decade.

Design higher-comfort facilities by spacing delineators close together with a delineator every 1-5 feet (0.3-1.5 meters). Regularly including vertical elements in addition to mountable items improves visibility and enhances perceived continuity. If budgets are limited, prioritize the most durable means of separation at intersections, driveways, and locations with higher demand for motor vehicle parking, loading, or driving in the bikeway.

Don't Give Up At The Intersection — Or Driveway!

Apply the principles of protected intersections at all crossings. The above contexts describe common mid-block scenarios, but bikeway separation should also extend as close as possible to an intersection without interfering with pedestrian desire lines.

Prioritize more durable means of separation at intersections with lots of turning movements and where there is a potential for motor vehicles to enter a bikeway to queue-jump or make a right on red.

Protected intersections use the median or curb as part of the intersection design itself. In dedicated intersections, modular, mountable materials at corners reduce motor vehicle turning speed and improve visibility of people in the bikeway.

See Don't Give Up at the Intersection[6] for design guidance on protected and dedicated intersections.

Install mountable means of separation to extend protection across driveways

Mountable means of separation like modular speed bumps, constructed truck aprons, mountable medians, armadillos spaced to allow wheel gaps, or other mountable elements can be installed in the buffer in front of driveways to allow vehicles to cross the bikeway at low speeds.

Source: Central Atlanta Progress

Make barriers visible at intersections

Pay extra attention to the visibility of bikeway users, curbs, and barriers near intersections and major driveways. Place flexible delineators or object markers on top of or in line with barriers and curbs. Check that people walking, biking, and driving can all see the separator.

Use sloping 'nose' sections at the start and end of mid-height barriers to improve visibility among roadway users at intersections and make sure people walking, biking, and driving can see each other.

Source: Toronto Transportation Services

Maintenance is part of the job

All roads require maintenance, and bikeways are no different. As bike networks expand, proactive monitoring for broken components is both important and challenging. To provide equitable service, maintenance efforts cannot rely solely on crowdsourced information such as 3-1-1 or social media reports. There is often a backlog of maintenance needs in neighborhoods where public agencies and big institutions have disinvested in, redlined, or neglected the community. Without proactive maintenance, street elements falling into disrepair can exacerbate a pattern of neglect. Cities should proactively monitor and address maintenance needs along the bikeway network.

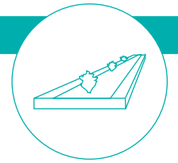
One key strategy for minimizing maintenance needs is upgrading to more durable materials with lower lifecycle costs. City staff should work across divisions to monitor and quantify the need for a bike network's maintenance each budget year. Based on this data, cities can upgrade underperforming materials and rightsize the annual budget for bikeway maintenance.

Cities should maintain a state of good repair by repairing and replacing the means of separation and by clearing bikeways of debris, snow, and ice.

Source: Green Lane Project

Repair and replace the means of separation

Installation and maintenance intensity varies across three different categories of means of separation: medians, barriers, and delineators.



Medians

Over time, locations with frequent incursion by heavy vehicles may need to be reconstructed.

Maintenance frequency: LOW

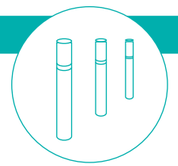
Maintenance intensity: HIGH

Durable barriers

Even durable barriers can get knocked out of place by repeated or high speed motor vehicle strikes. Objects dislodged into the bikeway or travel lane require immediate response.

Maintenance frequency: PERIODIC

Maintenance intensity: MODERATE TO HIGH



Delineators

Replacing broken or missing delineators is a simple but routine need.

Maintenance frequency: HIGH

Maintenance intensity: LOW

Clear bikeways of debris, snow, and ice

Bike networks are core components of the transportation system that need to be accessible year-round. Design and policy decisions make this possible.

Be sure that maintenance crews can physically sweep and plow the bikeway. Design bikeways so they are wide enough to fit sweeping and snow plowing/snow removal equipment, and purchase smaller vehicles[7] to clear an expanding network of physically separated bikeways (both street-level and sidewalk-level). If possible, test new barrier configurations with existing sweepers and plows before implementing.

In cold and snowy places, bikeways need additional attention during snow and ice events.

Establish the bike network as a winter maintenance priority. Winter maintenance involves a combination of snow clearance, snow removal, and deicing. Use a fleet of dedicated, bikeway sized equipment to clear bikeways as a top priority or consider identifying priority tiers within the bikeway network, clearing key bikeways on the same timeline as key roadways.[8,9]

Install vertical objects to find bikeways after snow events. Snow clearance and removal equipment can damage and dislodge nearly any means of separation along a bikeway. Flexible delineators installed at driveways and intersections make it easier for plow drivers to avoid low-profile modular elements. Anticipate some degree of repair in the spring. Work with crews to understand what they can and can't steer around, and modify standard details if it is possible to minimize damage without compromising the bikeway's effectiveness.

Downsize maintenance vehicles to more efficiently, effectively, and safely clear bikeways of debris, snow, and ice. See Optimizing Large Vehicles for Urban Environments and Case studies: Downsized Street Maintenance Vehicles for more details.

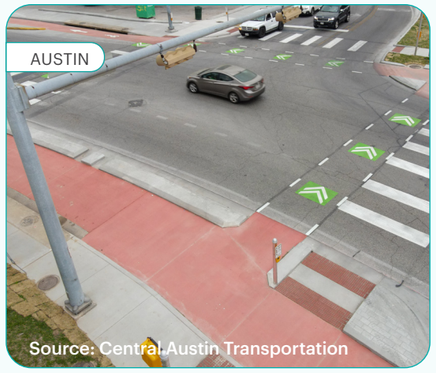
Reduce implementation complexity to build more, faster, and better

Focusing on streamlining procurement and contracting processes can reduce implementation complexity and timelines. Designing a street-level protected bikeway that can be constructed relatively quickly, without drainage work or utility coordination, can accelerate project delivery. However, if procurement and contracting is administratively burdensome, projects can be delayed for months or even years. To accelerate project delivery, focus on streamlining procurement and contracting processes.

In some cases, cities may want to explore structural reorganization or process resets to support better project delivery[10]. Although the best strategy will differ by city, this section presents four successful strategies for accelerating project delivery.

Leverage in-house maintenance and operations capacity

The skills, tasks, and technical expertise required for reconfiguring roadways and installing street-level protected bikeways are similar to citywide operations and maintenance work: signal upgrades, resurfacing, striping, anchoring delineators, and installing concrete islands or curb ramps. Redefined organizational priorities and additional training can refocus a portion of a city's existing capacity on installing bikeways. Larger in-house maintenance crews may be able to dedicate full teams to street-level protected bikeways installation. This method is best suited in cities where design, implementation, and maintenance are consolidated in one department so that a single director can establish performance measures that reflect department-wide goals addressing maintenance, bikeway, and vision zero priorities.



SPOTLIGHT: AUSTIN AND NEW YORK CITY

Austin Transportation Department (ATD), the New York City Department of Transportation (NYC DOT), and others have in-house sidewalk repair crews who also build concrete pedestrian islands, construct-in-place concrete medians to protect bikeways, and other 'surface concrete' work.

Create an on-call contract

Procuring an on-call contractor to implement individual street-level bikeways will take significant time and coordination, but a well-funded, flexible on-call contract can be one of the most effective ways to quickly install bikeways. This strategy can also be used to scale up design and engagement capacity to more rapidly expand the bike network.

SPOTLIGHT: DENVER

To achieve the ambitious 5-year implementation goal, Denver's Department of Transportation & Infrastructure (DOTI) established a new neighborhood-based approach to bikeway implementation to accelerate project delivery for quick-build bike projects. DOTI prioritized three neighborhoods (approximately 8 mi² each) for implementation, identifying a set of projects selected from the citywide bike plan. To support this large-scale effort, the City ran concurrent planning and design for all three network areas, established blended project management teams for each neighborhood with a planner, engineer, and construction lead for each area, and hired on-call consultant teams to support the work in each neighborhood.

To ensure projects met All Ages & Abilities standards, to improve consistency across projects and neighborhoods, and to simplify design decisions, DOTI set up regular coordination meetings and adopted interim bikeway design guidance and specifications. In 2023, construction of the first package of projects, totaling 44-miles of bikeways, will be completed.

Bundle multiple projects as a single procurement

Bundling multiple projects for a single procurement is administratively more efficient and can reduce per-item costs by increasing quantities. This method is best suited for a group of projects with similar materials and design treatments. Especially if a set of projects is already funded and designed, one large implementation contract can be an efficient way to build many miles of bikeways relatively quickly.

SPOTLIGHT: HOUSTON

To implement Houston's ambitious 2017 bike plan, the City and Harris County funded a capital project to build dozens of miles of bikeways. To achieve a large network expansion in a short time, many of the bikeway projects were contracted as one large design project and one large construction project.

Take advantage of resurfacing contracts

Resurfacing a street creates a blank canvas and can be the most cost-efficient way to implement a new bikeway. Many cities use on-call markings contracts for routine markings work after resurfacing, paying by the linear foot as needed. These contracts can be written to include additional materials and means of separation, as well as pavement color treatments for bikeways, bus lanes, and pedestrian spaces. This strategy is most effective when the goals of the resurfacing program and the goals of the bikeway program are aligned.

SPOTLIGHT: OAKLAND

In 2019, the Oakland Department of Transportation (OakDOT) adopted a 3-year paving plan using equity, street condition and safety metrics to prioritize projects. OakDOT works across divisions to implement planned bike improvements during the resurfacing effort. In the first two years of the 3-year paving program, the city implemented more than 14 miles of bikeways, including constructed, concrete bus boarding islands along Telegraph Ave.[11]

Source: City of Oakland

REFERENCES AND FURTHER READING

End Notes

[1]NACTO. 2017. *Designing for All Ages & Abilities: Contextual Guidance for High Comfort Bicycle Facilities*. https://nacto.org/wp-content/uploads/2017/12/NACTO_Designing-for-All-Ages-Abilities.pdf

[2]NACTO. 2020. *City Limits: Setting Safe Speed Limits on Urban Streets*. https://nacto.org/safespeeds/

[3]See discussion of bikeable width and shy distance in the NACTO working paper, *Designing for Small Things With Wheels*. https://nacto.org/publication/designing-for-small-things-with-wheels/

[4]U.S. Department of Justice and Civil Rights. 2010 Americans with Disabilities Act (ADA) Standards for Accessible Design. http://www.ada.gov/2010ADAstandards_index.htm

[5]The Access Board. Proposed Public Rights-of-Way Accessibility Guidelines. 2011. https://www.access-board.gov/prowag/

[6]NACTO. 2019. *Don't Give Up at the Intersection*. https://nacto.org/publication/dont-give-up-at-the-intersection/

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