Case Studies for a CycleTrack
On the East Side of Herndon Parkway for 2,000 Feet South of the Washington & Old Dominion Railroad Regional Park Trail

September 20, 2016
# Table of Contents

**Introduction** 3

**Intersections** 4
- Mixing Zone 4
- Straight Crossing 5
- Bend-In 7
- Bend-Out 8
- Protected Intersection 10

**Bus Stops** 13
- Mixing Zone 13
- Bus Passengers Crossing Cycle Track 14
- Bus Stop on Island 15

**Access Roads and Private Driveways** 16
- Pavement Treatments and Signage 16
- Removed Obstructions 17
- Recessed Crossing 18
Introduction

This document explores examples of cycle track practices studies in 11 U. S. cities, 2 cities in the Netherlands, and 3 cities in Canada. The examples can inform Herndon of ways to evolve from an auto-oriented street design to a multi-modal street design with increased safety for pedestrians and cyclists in an emerging transit-oriented context.

In 2012, the Town Council amended the Herndon 2030 Comprehensive Plan to embrace transit-oriented development at the Herndon Metrorail Station. Transit, pedestrian and bicycle needs now are emphasized due to the presence of Metrorail, the Town’s commitment to reduce single occupant vehicle (SOV) travel, and the proximity to two nearby regional trails.

According to the Pedestrian and Bicycle Information Center, a joint effort of the U.S. Department of Transportation Federal Highway Administration and the Pedestrian and Bicycle Information Center within the University of North Carolina Highway Safety Research Center:

“Cycle tracks are separated bicycle facilities that run alongside a roadway. Unlike bike lanes, cycle tracks are typically separated from automobile traffic by a physical barrier, such as parked cars, bollards, a landscaped buffer, or a curb. Cycle tracks may be one-way running with traffic, one-way running against traffic, two-way on the same side of the road, or two-way on both sides of the road. . . . Cycle tracks should be at least wide enough to allow cyclists to pass one another - usually about 6.5 or 7 feet - but may be wider in areas with high bicycle traffic volume and narrower at intersections to slow bicycle traffic. . Options that may help address safety concerns at intersections include advanced stop lines or bike boxes, colored bike lanes, and traffic signals designated for bicyclists.”

According to the Federal Highway Administration’s Separated Bike Lane Planning and Design Guide:

“a separated bike lane is an exclusive facility for bicyclists that is located within or directly adjacent to the roadway and that is physically separated from motor vehicle traffic with a vertical element. Separated bike lanes are differentiated from standard and buffered bike lanes by the vertical element. They are differentiated from shared use paths (and sidepaths) by their more proximate relationship to the adjacent roadway and the fact that they are bike-only facilities. Separated bike lanes are also sometimes called ‘cycle tracks’ or ‘protected bike lanes.’”

In 2014, and with participation by a committee of community members, the Fairfax County Department of Transportation conducted and published the Herndon Metrorail Stations Access Management Study (HMSAMS). Public input obtained for the report found that the planned Sugarland Run Regional Trail from the Washington and Old Dominion Railroad Regional Park (W&OD Trail) to the Herndon Metro station is a top priority for bicyclists and a high priority for pedestrians. As a “shared use path,” the HMSAMS study calls for: a 10-foot wide multiuse path extension to transition to a shared use path in a 20 foot right of way with crosswalk enhancements on the east side of the intersection of Herndon Parkway at Spring Street.

If the link is planned as a cycle track along the south and east side of Herndon Parkway, there are five existing private driveway curb cuts that are not likely to be remedied in the near future by redevelopment, and there are an additional seven private curb cuts that likely will still be in place after anticipated redevelopment in the Herndon Transit-Oriented Core closest to the Metrorail station. Consequently, this document also examines ways to minimize conflicts between bicyclists and motorists at private driveway curb cuts.

1 Pedestrian and Bicycle Information Center at www.pedbikeinfo.org/data/faq_details.cfm?id=3962
Intersections

Intersection designs vary based on the level of interaction among bicyclists, pedestrians, and vehicles and strategies for improving visibility of bicyclists prior to and during the crossing of intersections. The following sections describe typical design treatments at intersections and provide examples of how these treatments have been implemented in the United States and abroad. This research on case studies will be used to help develop relevant guidelines for Herndon Parkway.

Mixing Zone

This design addresses:
• Right-of-way constraints

A mixing zone removes the protective buffer from the cycle track and merges bicycle traffic with either pedestrian traffic or turning vehicular traffic. Various treatments can be applied to this design to enhance safety, including green paint for the bike lane, yield markings for vehicular traffic entering the turn lane, and signalization specifically for bicycle traffic; however, the lack of protection or specifically-delineated space for bicyclists makes this design less desirable and should only be recommended in situations where right-of-way is constrained.

Mixing zones within vehicle turn lanes are not recommended for two-way cycle tracks due to potential conflicts with contraflow bicycle traffic. For example, on 2nd Avenue in New York City, contraflow bicycle traffic would need to travel directly against vehicular and bicycle traffic to access the protected cycle track, causing confusion and extreme safety concerns for all traffic.

Mixing zones with pedestrian traffic can accommodate two-way cycle tracks, placing bicyclists on the sidewalk in the same space as pedestrians waiting to cross the street. On 10th Street Northeast in Atlanta, Georgia, bicycle traffic...
from the cycle track merges with pedestrian traffic and also crosses the intersection with the pedestrian signal. Pedestrian and bicycle traffic continue to merge onto a shared-use path found on the other side of the intersection, the Atlanta Beltline; however, this mixing of travelers at different speeds paired with high volumes of pedestrians and bicyclists has resulted in travelers of both modes to move erratically to avoid each other. This design has also caused long lines of crossing bicycle and pedestrian traffic in the intersection, creating delays for turning vehicular traffic.

The pedestrian and bicyclist mixing zone found on Mercer Street in Seattle, Washington addresses issues found in the Atlanta, Georgia example by providing separate crossing lanes and signals for pedestrians and bicyclists. The mixing zone is ahead of the stop bar for vehicles, providing an unobstructed view of waiting pedestrians and bicyclists. Separate crossing lanes and signals allow a more synchronized crossing for pedestrians and bicyclists, limiting the amount of time these crossings block vehicular movements; however, the mixing zone slows down bicycle traffic that may have a through signal by intermingling it with pedestrian traffic that may be crossing in any direction. As there are no specific bicycle amenities to cross Mercer Street itself, bicycle traffic waiting to cross Mercer Street may also be waiting in the mixing zone along with pedestrians. These conflicts in the mixing zone between pedestrians and bicyclists can cause similar erratic movements to those found in the Atlanta, Georgia example, despite the use of separate crossing lanes and signalization.

### Straight Crossing

**This design addresses:**
- **Visibility of bicyclists waiting at intersection**
- **Bicyclist-Pedestrian conflicts**
- **Right-of-way constraints**
- **Accommodation of two-way cycle tracks**

When adequate space is available, cycle tracks can also maintain their protected, exclusive space in the approach to an intersection. Signalization, visibility, and lane marking are the most significant design considerations in areas where cycle tracks continue straight across an intersection. These straight crossings can also accommodate two-way cycle tracks more easily than mixing zones.

While the two-way cycle track on 2nd Avenue in Seattle, Washington does not have visibility issues, the cycle track does have a conflict with vehicular traffic making a left onto a one-way street; to address this issue, it uses signalization and highly-visible, green-painted crossing lanes, rather than a bike box. Bicycle traffic has its own signal, separate
from both pedestrian and vehicular traffic, and vehicular traffic is barred from making turns on a red light. 2nd Avenue’s striping is highly visible, employing bright green paint in the lanes for crossing cycle track traffic. Additionally, 2nd Avenue’s striping features a “slow” warning at the pedestrian crosswalk to minimize conflicts between bicyclists and pedestrians who might be crossing across 2nd Avenue against the signal or waiting along the sidewalk in the path of the bicyclists.

The two-way cycle track on Boul de Maisonneuve in Montreal, Quebec, addresses similar issues to the cycle track on Seattle’s 2nd Avenue, but does not use the same elements to address them. Though conflict with vehicular traffic making a left turn onto a one-way street is present, similar to Seattle’s 2nd Avenue, vehicular traffic is able to make the turn on red. Rather than addressing the conflict with separate signalization for each mode, only a caution sign indicating that turning vehicular traffic should yield to bicycle traffic is present. Roadway markers for crossing cycle track traffic are more minimal than the green paint used in Seattle. Boul de Maisonneuvre provides half of the amount of vehicular travel lanes of Seattle’s 2nd Avenue. The intersecting road, Sanguinet Street, also has half of the amount of vehicular travel lanes as the intersecting road in Seattle, Marion Street. This difference in vehicular lanes suggests that the need for bans on turns through red lights, separate signalization, and higher visibility cycle track crossings is likely related to higher volumes of vehicles.
Bend-In

This design addresses:
- Visibility of bicyclists waiting at intersection
- Bicyclist-Pedestrian conflicts
- Accommodation of two-way cycle tracks

Bending the cycle track in toward vehicular traffic, while maintaining a protective buffer, is another way of improving visibility of bicyclists, especially for vehicles waiting at a stop sign or red light. By bending the cycle track, bicycle traffic is slowed slightly, providing bicyclists with more time to react to pedestrians or vehicles crossing the cycle track at the intersection. This design also provides more space for pedestrians crossing the cycle track and clarifies right-of-way conflicts for all modes. The Urban Bikeway Design Guide (2014) published by the National Association of City Transportation Officials and the Design Manual for Bicycle Traffic (2007) published by the Dutch Center for Research and Contract Standardization in Civil and Traffic Engineering (CROW), recommend this design on Indianapolis, Indiana: Alabama Street

On Alabama Street in Indianapolis, Indiana, the bend-in design was implemented on a sidewalk-level cycle track, with additional features to demarcate pedestrian, bicycle and vehicular spaces. Approaching the intersection at East Ohio Street, the Alabama Street cycle track bends in slightly, while maintaining its planted buffer. Bicyclists use the same signal as pedestrians; however, bicycle traffic is separated from pedestrians with a cycle track yield sign placed parallel to the vehicular stop bar, as well as signs and road markings pointing out the appropriate paths for each mode of travel.

Source: Google Streetview, Bing Maps
The cycle track on Saint Petersburg, Florida’s 1st Avenue South has similar features to Alabama Street in Indianapolis. While bicycle traffic is brought closer to vehicular traffic for enhanced visibility, the planted buffer is maintained. The cycle track features a stop bar that is parallel to the vehicular stop bar, separating the waiting and crossing space for pedestrians and bicyclists. The crossing in the direction of the cycle track does not provide separate markings for the pedestrian and bicyclist paths; however, bicyclists are given a separate signal and a pylon sign at the entrance to the protected cycle track indicates that the space is for bicycles only.

Bend-Out

This design addresses:

- Visibility of bicyclists crossing intersection
- Bicyclist-Pedestrian conflicts
- Turning vehicle conflicts
- Accommodation of two-way cycle tracks

While bending toward vehicular traffic at an intersection can improve visibility of bicyclists waiting at or approaching the intersection, bending the cycle track away from vehicular traffic improves the visibility of cyclists in the process of crossing the intersection, especially for turning vehicles. Having the crossing located away from the intersection places bicyclists prominently within the field of vision for a driver of a turning vehicle, instead of alongside or behind the vehicle; this minimizes the risk of “right hook” crashes.

The cycle track on Churchill Avenue North in Ottawa, Ontario has a slight bend-out for the intersection crossing paired with a stop bar parallel to the
vehicular stop bar, which is found at the closest point that the cycle track comes to the side of the vehicular lane. This approach couples the benefits of the bend-in design, making approaching or stopped bicyclists more visible to vehicular traffic, with the benefits of the bend-out, minimizing risk for bicyclists in the process of crossing the intersection. Though sharing a signal with pedestrians, bicyclists are separated from pedestrian traffic by the stop bar and clearly marked paths for each mode. The bend-out also provides a space closer to vehicular traffic for pedestrians waiting to cross Churchill Avenue North, which minimizes the distance required to reach the other side of the street.

In Gilze, The Netherlands, on Tilburgsebaan, a more pronounced example of a bend-out highlights additional benefits of the design, as well as some drawbacks. The bend-out on Tilburgsebaan does not interact with any pedestrian paths, since much of the surrounding area is farmland. In addition to increasing the visibility of bicyclists as they cross vehicular paths, pushing the cycle track crossing away from the intersection minimizes the distance that bicyclists must travel to cross the vehicular path. Turning vehicles, whether they are turning right or have a permissive left turn, have more reaction time to address bicyclists traveling across the intersection. The additional space between the vehicular through lanes and the cycle track crossing allows turning vehicles to queue after they have passed through the intersection, minimizing the potential for side collisions from oncoming vehicles and reducing congestion in the intersection. While the design used in Gilze would not be ideal for the Herndon Parkway cycle track due to differences in road design and surrounding land uses, the Tilburgsebaan example does highlight several issues related to bend-outs; perhaps the most prominent of these issues is an increased requirement for space. This need for space impacts the amount of right-of-way required, as well as the configuration of vehicular elements at the intersection. Stop bars on the road crossing Tilburgsebaan are pushed back from the intersection, impacting the vehicles’ line of sight. The effect of the reduced line of sight may be mitigated by prohibiting right turns at red lights.
Protected Intersection

The most recent development in intersection design for cycle tracks, especially in the United States, is the protected intersection, sometimes known as a “Dutch junction”. The first protected intersections in the United States opened in 2015 in Davis, California and in Salt Lake City, Utah. The arrangement of the protected intersection limits the number of conflict points between bicyclists and pedestrians by maintaining separate paths, queuing areas and signalization for each mode. Bicyclists and pedestrians are protected from vehicular traffic through the continuation of buffer space, which is extended all the way to the corner of the intersection with a refuge island. This refuge island also provides space in a vehicle’s turn between vehicular through-traffic and crossing bicycle and pedestrian traffic that allows for more reaction time and queuing space, similar to the benefits of the bend-out. In this design, vehicular turning radii are tight, requiring vehicles to slow down significantly in order to turn before encountering the crossing. Placing the pedestrian and bicycle crossings on either side of the refuge island locates them at narrower parts of the vehicular path, making crossings quicker. While this design may require more space than others, it is recommended by the Massachusetts Department of Transportation’s Separated Bike Lane Planning and Design Guide (2015) to be used, where possible.

Protected Intersection Elements

Source: Massachusetts Department of Transportation, Separated Bike Lane Planning and Design Guide (2015), p. 68
An intersection on Blaak, a street in Rotterdam, The Netherlands, shows the features of this design. This design lacks many elements used in other intersection designs to designate separate bicycle and pedestrian paths, such as crosswalks across the cycle track or signs instructing bicyclists to yield to pedestrians; however, the paths for each mode remain evident through the placement of signals and separate grades.

Construction of protected intersections in the United States is currently underway. In the Netherlands, these intersections typically have cycle tracks crossing in every direction of an intersection; few areas in the United States have this level of bicycle infrastructure, but cities are either in the process of incorporating this design in their downtowns or have adapted the elements of the protected intersection design to fit their limited bicycle infrastructure. Salt Lake City, Utah has invested in bicycle infrastructure in its downtown and has also made adjustments to the protected intersection design. While removing separate signalization for pedestrians and bicyclists, the protected intersection on 200 West includes clear markings of separate paths. Additionally, safety of pedestrians and bicyclists is enhanced through the inclusion of a wide median refuge.

On Commonwealth Avenue in Boston, Massachusetts, the cycle track is designed for one side of the street and the amount of connecting bicycle paths is limited. Near Boston University, the protected intersection design has been altered to
accommodate these conditions. The refuge island remains in place, but bicycle traffic crossing Commonwealth Avenue does not have access to bicycle lanes or cycle tracks. Instead, a two-stage turn queuing box is in place. During the crossing phase, bicyclists continue straight into the queuing box and wait for the green light for vehicular traffic on the cross street. The queuing box allows the bicyclists to have more visibility to vehicles on the cross street and affords them a head-start to reach cruising speed as they integrate into vehicular traffic on the lower volume/lower speed street. For bicycle and pedestrian traffic traveling along Commonwealth Avenue, separate paths are maintained and are clearly denoted with pavement marking, though separate signalization is not evident in the current designs.
Bus Stops

Cycle tracks typically separate pedestrian and vehicular traffic; as such, bus stop designs related to cycle tracks vary based on how the connection is made between pedestrians waiting at stops and the buses. The following sections describe typical design treatments at bus stops and provide examples of how these treatments have been implemented in the United States and abroad.

Mixing Zone

This design addresses:

- Right-of-way constraints

A mixing zone removes the protective buffer from a cycle track and merges bicycle traffic with bus traffic at a bus stop. While various treatments can be applied to this design to enhance safety, including bike lane markings, yield signage for bus traffic entering the turn lane, and warning signs and lane markings for bicycle traffic, the lack of protection or specifically-delineated space for bicyclists makes this design less desirable and should only be implemented in situations where bus service is infrequent.

Mixing zones at bus stops are not recommended for two-way cycle tracks due to potential conflicts with contraflow bicycle traffic. For example, on Rosemead Boulevard in Temple City, California, contraflow bicycle traffic would need to travel directly against bus and bicycle traffic to access the protected cycle track, causing confusion and extreme safety concerns for all traffic.

Temple City, California: Rosemead Boulevard (Example Implementation Not Recommended for Herndon Parkway)

Source: Google Streetview
Bus Passengers Crossing Cycle Track

This design addresses:

- Bicyclist-Pedestrian conflicts
- Right-of-way constraints
- Accommodation of two-way cycle tracks

Where the cycle track remains between pedestrian and vehicular spaces, boarding and alighting bus passengers need to cross over the cycle track at bus stops. Bicyclists should yield to passengers crossing the cycle track at the bus stop. To differentiate between pedestrian and bicycle areas, lane markings, yield signs for bicyclists, and crosswalks between the bus passenger waiting area and the areas where the bus doors open can be included. Shelters should be placed behind the sidewalk to avoid interrupting the flow of pedestrian traffic that might lead to through-pedestrian traffic entering the cycle track.

The Massachusetts Department of Transportation’s Separated Bike Lane Planning and Design Guide (2015) recommends this design only in areas where the right-of-way is constricted.

In Cambridge, Massachusetts, the cycle track on Concord Avenue is located between the sidewalk and roadway and is painted green in the areas where passengers may cross to board or alight a bus. The bus shelter, which is behind the sidewalk, is situated in the middle of the crossing zone to provide bicyclists with enough stopping space to avoid crashes involving boarding passengers exiting the shelter. Locations with limited right-of-way, which are so narrow that no buffer exists between the cycle track and sidewalk, require the use of this bus stop design.

Cambridge, Massachusetts: Concord Avenue

Source: Google Streetview
Bus Stop on Island

This design addresses:

- Bicyclist-Pedestrian conflicts
- Accommodation of two-way cycle tracks

Where space is available, the interaction between pedestrians and bicyclists can be controlled by placing the bus stop on an island, also known as a floating bus stop. This design moves the bus stop away from through pedestrian and bicycle travel and channels pedestrians crossing the cycle track into crosswalks, thereby minimizing the area of the conflict zone between the two modes. Channelization of pedestrian cross traffic can be accomplished through crosswalks, barriers, or curb ramps. Painted or textured crosswalks and signage indicate that bicyclists must yield to pedestrians near the bus stop. Bending the cycle track around the bus stop can be helpful in reducing the stopping distance for yielding bicyclists, since the bend in the cycle track will slow the speed of bicyclists.

Indianapolis, Indiana: Massachusetts Avenue

![Indianapolis, Indiana: Massachusetts Avenue](source: Google Streetview)

Austin, Texas: Guadalupe Street

![Austin, Texas: Guadalupe Street](source: Google Streetview)

This design addresses:

- Bicyclist-Pedestrian conflicts
- Accommodation of two-way cycle tracks

However, the bus stop does employ the use of plantings and the positioning of the bus shelter and bike rack to funnel boarding and alighting bus passengers to a single area where they can cross the cycle track. This design highlights the most important consideration when bus stops are placed on islands - minimizing the conflict zone between modes.
Bus stops on Guadalupe Street in Austin, Texas, provide an example of island bus stops that use many of the available treatment options. Painted crosswalks and signs instructing bicyclists to yield to pedestrians are present. Pedestrians are restricted from crossing the cycle track at any point outside of the crosswalk by the presence of fencing. Pedestrian traffic between the bus stop and the adjacent mall has less impact on through pedestrian traffic on the sidewalk because the crosswalk is aligned with the mall entrance. Unlike the Indianapolis, Indiana bus stop, bicycle parking is not integrated into the bus stop itself, but is nearby in a buffer space between the sidewalk and the cycle track, promoting intermodal connections without mixing the pedestrian and bicycle travel space.

Access Roads and Private Driveways

The use of multiple design treatments in places where cycle tracks cross the entrances of access roads and private driveways can improve visibility for bicyclists and vehicles and minimize conflicts related to vehicular turning movements. The following sections describe typical design treatments at entrances to access roads and private driveways and provide examples of how these treatments have been implemented in the United States and abroad.

Pavement Treatments and Signage

This design addresses:

- Awareness of bicycle traffic for crossing vehicles
- Turning vehicle speed and conflicts

Visibility and awareness of bicyclists are the most important factors for vehicles crossing the cycle track. As is common with other areas where a vehicle might cross the cycle track, vehicles crossing at access roads and private driveways are most commonly made aware of bicycle traffic through the use of markings on the pavement and signage. Both Hornby Street in Vancouver, British Columbia and East 300 South in Salt Lake City, Utah use green paint to alert vehicles that they are crossing a bicycle facility. Hornby Street also includes signage, for vehicles turning off and onto Hornby Street, to inform drivers that they must yield to bicyclists. Additionally, the tight turning radius caused by the location of the sign and the street buffer slows turning vehicular traffic from Hornby Street, providing more reaction time for interactions with bicyclists.
Salt Lake City, Utah: East 300 South

Source: Google Streetview

Removed Obstructions

This design addresses:

- Visibility of through vehicular traffic for turning vehicles
- Visibility of bicycle traffic for crossing vehicles

Vehicles turning out of access roads and private driveways should not need to use the cycle track as an area to view through vehicular traffic. Limited visibility can cause vehicles to pause in the cycle track which can interrupt bicycle traffic. In addition to pavement treatments and signs alerting drivers to the presence of a cycle track, enhanced visibility minimizes the impacts of vehicles crossing the cycle track. The Federal Highway Administration’s *Separated Bike Lane Planning and Design Guide* (2015) recommends that landscaping and street-side elements not be included within 15 feet of the edge of a driveway or access road entrance. Elements located in the buffer between the cycle track and through vehicular traffic, such as floating street parking or bus stop shelters, should not restrict visibility within 20 feet from the edge of a driveway or access road entrance.

At a shopping center on North Broadway Street in Chicago, Illinois, visibility for vehicles leaving the parking lot is aided by the location of street trees and floating parking. The tree to the left of the exit is far enough away from the driveway for vehicles to see bicyclists in the cycle track and through vehicular traffic. The view of vehicular traffic is maintained by parking boundaries being several car-lengths from the driveway. These parking boundaries are ensured by both paint markings and delineator posts.

Chicago, Illinois: North Broadway Street

Source: Google Streetview
Recessed Crossing

This design addresses:

- Visibility of through vehicular traffic for turning vehicles
- Visibility of bicycle traffic for crossing vehicles
- Turning vehicle speed and conflicts

The recessed crossing performs many of the same functions as the bend-out intersection design, but at the scale of a driveway or access road entrance. Bending the cycle track away from vehicular traffic improves visibility of cyclists traveling across the entrance by placing bicyclists prominently within the field of vision for a driver of a turning vehicle; this minimizes the risk of “right hook” crashes. In addition to enhancing safety for bicyclists, the presence of space between the vehicular through lanes and the cycle track crossing provides an area for turning vehicles to queue, reducing congestion for through traffic and improving sight distance for exiting vehicles.

Rotterdam, The Netherlands: Woudspolderstraat

On Woudspolderstraat in Rotterdam in the Netherlands, the recessed crossing is far enough away from the roadway that a whole vehicle, after yielding to any crossing bicycle traffic, can pull into an area between the roadway and the cycle track to wait for a clear break in traffic when exiting the access road. The recessed crossing provides vehicular traffic entering the access road with additional stopping and queuing space to yield to crossing bicyclists. In addition to extra space, vehicular reaction time and bicyclist safety is further improved with a median, which discourages vehicles from making wide, high-speed turns when entering the access road; this also provides bicyclists with a refuge area in the event that vehicles do not yield to them. While this design does afford many safety benefits to all users, the space requirements are much greater in comparison to a more typical straight access road or driveway crossing.