CYCLE TRACKS:
Lessons Learned






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February 4, 2009

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This report summarizes information and experience gained through an October 2008 research tour to Amsterdam and Copenhagen. The research tour was sponsored by Portland's regional government (Metro)'s Blue Ribbon Committee on Trails, and supported by the German Marshall Fund, Oregon Community Foundation, Keen Footwear, Bike Gallery, and City of Portland.

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Introduction

A cycle track is an exclusive bicycle facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane (Figure 1). Cycle tracks have different forms, but all share common elements. Cycle tracks provide space that is intended to be exclusively or primarily for bicycles, and are separated from vehicle travel lanes, parking lanes and sidewalks. Cycle tracks can be either one-way or two-way, on one or both sides of a street, and are separated from vehicles and pedestrians by pavement markings or coloring, bollards, curbs/medians or a combination of these elements.

There is much to be learned from the experience of bicycle planning in European cities, particularly about facilities for bicyclists that separate them from automobile and pedestrian traffic. This document describes the lessons learned from the European experience with cycle tracks, regarding implementation, concerns and design features of cycle tracks in Europe. Further refinement of these design standards will be required to accommodate cycle tracks in American cities.

Figure 1. Cycle track in Amsterdam with on-street parking and planted curb extensions

Advantages and Disadvantages of Cycle Tracks

Cycle tracks provide increased comfort for bicyclists and greater clarity about expected behavior on the part of both cyclists and motorists. Properly designed cycle tracks eliminate conflicts between bicycles and parking cars by placing the cycle track on the inside of the parking lane. They also provide adequate space to remove the danger of "car dooring." Danish research has shown that cycle tracks can increase bicycle ridership 18 to 20 percent, compared with the five to seven percent increase found resulting from bicycle lanes.[1] The same study also found that fewer cyclists were hit or run over from behind, were hit when turning left, or ran into a parked car.

On the other hand, there also a number of cycle track design issues. As bicyclists are not traveling directly alongside automobiles, motorists may not be aware of their presence, leading to increased vulnerability at intersections. In addition, regular street sweeping trucks cannot maintain the cycle track; however, smaller street sweepers can accommodate the narrower roadway. Finally, conflicts with pedestrians and boarding or deboarding bus passengers can occur, particularly on cycle tracks that are less well-differentiated from the sidewalk, or that are between the sidewalk and a transit stop. These concerns will be addressed below, and should be incorporated into the planning process when cycle tracks are being considered.

[1] Jensen, Søren Underlien, Claus Rosenkilde and Niels Jensen. Road safety and perceived risk of cycle facilities in Copenhagen. *Available at:* http://www.ecf.com/files/2/12/16/070503_Cycle_Tracks_Copenhagen.pdf

Where are Cycle Tracks Appropriate?

Because of the difficulty and danger of allowing other traffic to cross the cycle track, they are not recommended on streets where there are many major and closely spaced intersections. Conversely, cycle tracks work well on streets with signalized intersections and minor side roads, as the crossing roads can be given speed-reducing regulations. Cycle tracks are particularly appropriate on roads that have fewer cross-streets and longer blocks, which often allow higher vehicle speeds.

Cycle tracks should only be constructed along corridors with adequate right-of-way. Sidewalks or other pedestrian facilities should not be narrowed as pedestrians will likely walk on the cycle track if sidewalk capacity is reduced.

International Best Practices

Cycle track design guidelines were determined through staff visits to cities in the Netherlands (primarily Amsterdam), Denmark (Copenhagen), and Germany. One-way cycle tracks are provided on each side of the street (two-way cycle tracks are discussed later in this document). They are physically separated from both motor vehicles and pedestrians. Cycle tracks should be wide enough to accommodate two bicyclists passing each other.

A major concern with cycle tracks is providing visibility at crossings and enabling turning movements for bicyclists. All design elements of the cycle track should continue through crossings of minor streets and driveways, including the grade-separation. The physical barrier is dropped at crossings, and crossing motorists and bicyclists must be made aware of the cycle track and reminded to yield to bicyclists in it. At larger intersections, bicycle movements should be clearly delineated, and movements for bicyclists and motorists separated by different signal phases. Right-turns on red should be prohibited by automobiles, while bicyclists in the cycle track turn left via protected left-turn movements (the "Copenhagen Left"), or signalization.

Additional considerations for cycle tracks include: maintenance, interactions with transit, signage, connections to the rest of the bicycle network, and two-way cycle tracks.

Separation

By definition, cycle tracks are separated from travel lanes and pedestrians by a physical barrier, such as on-street parking or a curb, or are grade-separated. Shy-distances increase the perception of separation and of wider lanes by providing additional clear space through pavement markings or low barriers. Cycle tracks using a barrier separation can be at-grade, or either above or below the level of the travel lanes and cross-streets. Visual and physical cues should be present that show where bicyclists and pedestrians should travel. This can be done through grade separation, pavement coloration or surfacing. Whatever form of separation is used, openings in the barrier or curb are necessary for driveway and minor street access, becoming potential conflict points between bicyclists, pedestrians and motorists.

Choices regarding cycle track width and type are dependent on road safety and costs, as well as ease of passage, perceived risk, comfort, and experience of the route. Types of cycle track separation are shown in the photographs and descriptions following.

Parking Placement

Where on-street parking exists, the cycle track should be placed between the parking and the sidewalk. Drainage inlets should be provided adjacent to the sidewalk curb to facilitate run-off. This technique is common in Copenhagen, as pictured left.

Channelization

Cycle tracks can be at street-level, provided that there is a physical separation. The curb creates the separated space, as well as preventing passengers from opening doors into the cycle track and discouraging pedestrians from walking on the facility.

Mountable Curb

Cycle tracks can be grade-separated from the roadway. The cycle track should be two or three inches above street-level, and the sidewalk should be an additional two to three inches above that. Where cyclists may enter or leave the cycle track, or where motorists cross at a driveway, the curb should be mountable with a small ramp, allowing cyclist turning movements.

Bollards and Pavement Markings

In addition to grade separation or channelization, the cycle track should have signage, pavement markings and/or different coloration or texture, to indicate that the facility is provided for bicycle use. Signage, in addition to bollards, can add to the physical separation of the facility, shown in this example from Melbourne, Australia.

Source: http://flickr.com/photos/avlxyz/2270515901/

In many existing cycle track applications, on-street parking has been removed to accommodate the track adjacent to the travel lanes without roadway widening.

The buffer between the cycle track and the vehicle or parking lane provides safety and comfort for bicyclists in the cycle track. A buffer is not required of a cycle track wider than seven feet, but is recommended where possible.

The CROW *Design Manual for Bicycle Traffic* provides guidance in the Netherlands for the width of the buffer area, including the barrier between the cycle track and the automobile travel lanes. These buffer areas should be suitable for street furniture, low vegetation, and/or trees. According to these guidelines, inside built-up areas, the buffer area should be a minimum of 1.1 feet (0.35 meters). Table 1 shows the guidelines for buffer width depending on type of barrier.

Table 1. Guidelines for Barrier Width in Built-up Areas

Barrier Type	Buffer Width (feet)
Lamp posts	3.2
Vegetation	7.5
Fence	2.3
Physical barrier	3.6

Source: CROW *Design Manual for Bicycle Traffic, p.177*

For a two-way cycle track, the minimum buffer width is 3.2', according to the *CROW* guide. In rural areas, barrier with should be dependent on the speed of the main road, as shown in Table 2.

Table 2. Guidelines for Barrier Width in Rural Areas

MPH	Barrier Width (feet)
40	5 - 8
50	15 - 20

Source: CROW *Design Manual for Bicycle Traffic*

If a road in a built-up area does not have space to accommodate a physical barrier, a narrow paved separation can be acceptable. On asphalt-paved cycle tracks, an asphalt ridge or concrete curb can be appropriate. It should have a height of four- to five-inches from the travel lane and two- to three-inches above the cycle track, to not conflict with pedals.

Width

Cycle tracks should have a minimum width of six and a half feet clear to provide safe passing for bicyclists. At constrained intersections, the cycle track can be narrowed to five feet. In the Netherlands, cycle tracks are typically seven feet wide, although eight feet is desirable for new

construction. In higher demand situations, each lane can be as wide as ten feet.[2] Figure 2 and Figure 3 show example cross sections of cycle track with and without on-street parking, respectively.

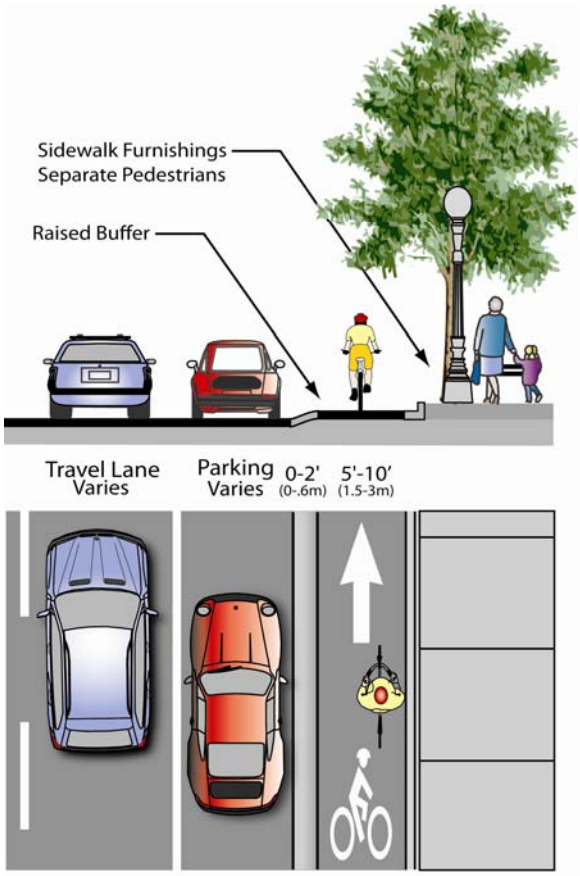

Figure 2. Example Section Design for Cycle track with On-Street Parking

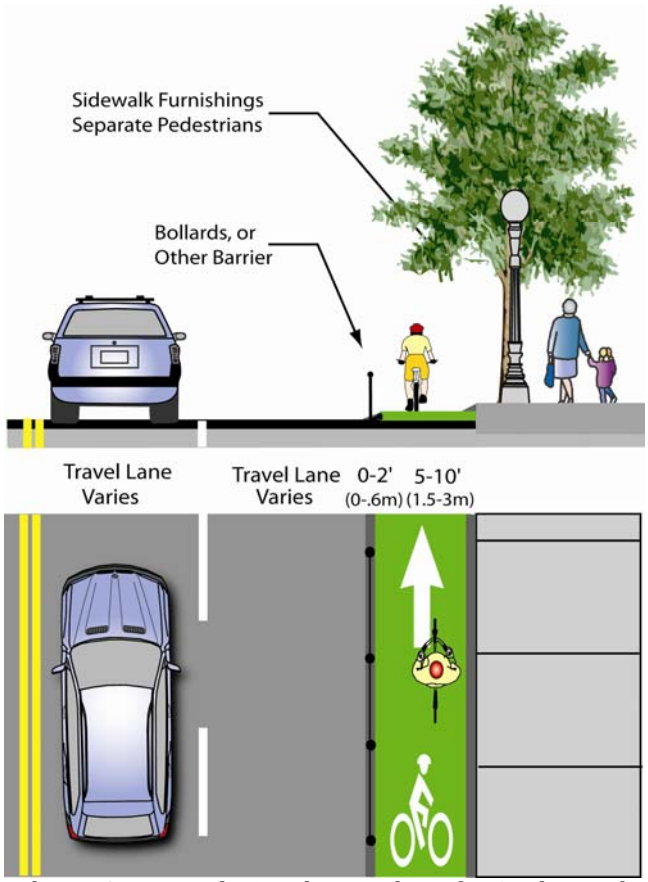

Figure 3. Example Section Design of a Cycle track without Parking

In locations where there is substantial parking and pedestrian traffic, such as at a shopping area, pedestrian islands can be offered on the street-side of the cycle track. This increases pedestrians' visibility to passing cars as they wait to cross the street, and provides pedestrians a safe place to wait outside of the cycle track.

The CROW *Design Manual for Bicycle Traffic* from the Netherlands standardizes cycle track width based on usage as shown in Table 3. This is based on a design speed of approximately 18.5 mph for main cycle routes.

Table 3. Cycle Track Width Guidelines in The Netherlands

Rush hour intensities (two directions, bikes per hour)	Cycle Track Width (feet)
0 – 150	6.5
150 - 750	10
> 750	13

Source: CROW *Design Manual for Bicycle Traffic*

[2] Niels Jensen, Copenhagen Traffic Department

Intersections

Cycle tracks separate cyclists and motor vehicles to a greater degree than a bicycle lane. This increases comfort for cyclists on the cycle track, but it creates additional considerations at intersections, which must be addressed through design. All roadway users have to expand their visual scanning to see potential conflicts.

Right-of-Way at Driveways and Low-Volume Cross-Streets

A cycle track retains priority at low-volume intersections and driveways. As shown in Figure 4, bicyclists in the cycle track should clearly have the right-of-way over other vehicles at driveway crossings and crossings of low-volume streets, which need to be clearly marked to indicate right-of-way.

In order to indicate to motorists and bicyclists in driveways and low volume side streets that they are expected to yield to bicyclists in the cycle track, the crossings could have pavement markings of bicycles, as shown in Figure 6. The surface of the cycle track could alternatively change through marking, coloration, or texture. The cycle track should not change grade; rather, motorists are required to mount the curb to cross, thereby slowing down and recognizing a change (Figure 7). Maintaining grade-separation between the cycle track and crossing streets is particularly important when the main street is very busy, as drivers may be liable to pull up through the cycle track to improve their visibility when merging onto the street.

Figure 6. Bicycle markings at a driveway crossing clearly designate that bicyclists have right-of-way

The CROW guide states that, if the speed of the main street is 45 mph or less, the cycle track should turn inwards prior to crossing a side street. This is to improve visibility of cyclists to motorists in the main road turning right. If the speed is greater, the cycle

Figure 4. Cycle track is unbroken at driveway crossing

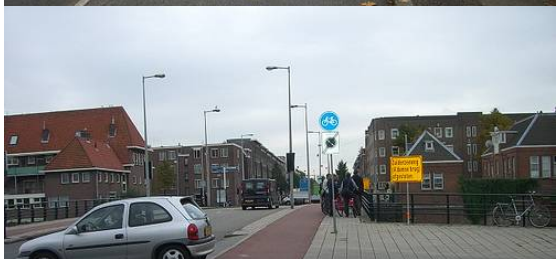

Figure 5. At this unsignallized right turn, the cycle track has dropped to a bike lane with blue coloration and pavement markings through the conflict area.

track should bend away from the main road at intersections, so that vehicles leaving the main road can stack up on the cross street, between the cycle track and the main road. Signage should also warn motorists of the crossing.

To minimize conflicts associated with motor vehicles crossing the cycle track, such facilities are more appropriate to areas which have longer block lengths and fewer driveways, rather than in the conditions of most CBDs. Cycle tracks located on one-way streets will have fewer potential driveway conflicts than those on two-way streets.

Signalized Intersections

Particular concerns associated with cycle tracks at signalized intersections include a lack of visibility for bicyclists in the cycle track, the right hook danger (right turning vehicles not seeing bicyclists in the cycle track and turning through the bicycle's forward movement), and the difficulty of left-turn movements from the cycle track. At signalized intersections along cycle tracks where cyclists are provided a protected phase for the through movement, right-turns on red by vehicles should be prohibited. To mitigate these issues, the following treatments can be applied at intersections.

Increased Visibility

To increase drivers' awareness of bicyclists in the cycle track, the stop line is usually moved back about 16 feet, while allowing cyclists to wait as far up on the intersection as possible. In addition, the cycle track can be dropped into a bicycle lane about 16 feet prior to the intersection, as shown in Figure 8. This technique can incorporate a bike box in addition to the pulled-back stop line for added protection. The bike lane should be colored starting 16 feet prior to the intersection, and in certain locations, the bike lane markings can be extended through the intersection (Figure 9). If colored pavement markings indicate the crossing, the width should be eight feet, according to the CROW design guide. Finally, removing parking from intersections 16 feet prior to the intersection increases the visibility of cyclists in cycle tracks.

Figure 8. Cycle track dropping to bike lane before an intersection

Figure 9. Bike lane marking continues through the intersection

Another aspect of increasing cyclist visibility in the cycle track is to reduce curb radii at a turn, which increases predictability by ensuring that automobiles will cross in a smaller area.

Protected Phases at Signals

With this treatment, left and right turning vehicle movements are separated from conflicting through bicycle-movements. In some cases, the signal phases for motorists should be completely separated from bicycle phases. In other scenarios, an advanced warning allows bicyclists to prepare to move forward through the intersection. This warning can be accomplished through a pre-green interval, a yellow warning display two seconds before the green, or a bicycle countdown signal. The bicycle countdown signal shown in Figure 10. Bike countdown signalFigure 10 counts down to the green, so that waiting bicyclists can mount onto their bicycles and prepare to move forward. During the green signal, the countdown indicates how much longer the light will remain green, enabling cyclists to determine if they have time to cross. This amenity is particularly effective in locations with less-experienced riders, cyclists who may require a longer time to cross the street, or at crossings of a particularly wide road.

Figure 10. Bike countdown signal

Figure 11. Bicyclist-actuated signal button

Figure 12. Bike-specific signals are small and placed on the near-side of traffic

The use of a bicycle signal head (Figure 10) is required for separated bicycle phases to ensure that all users know which signals to follow. Signals guiding bicycle traffic should be clearly identified to distinguish from those for motorist travel. Several methods have been employed to distinguish bicycle signals from general traffic signals. One method is to use a bicycle emblem within the signal lens display. The emblem is then lit with the appropriate color for the signal phase. Another method is to place a bicycle emblem at the top of the signal head above the signal lenses, and use a smaller signal head and lens (approximately four inches wide). A third method that has been used is to place a regulatory sign with the message "Bicycle Signal" adjacent to a conventional signal head. In cases where there is less bicycle traffic, or usually at certain times of the day, a demand-only bicycle signal can be used to reduce vehicle delay. This technique would prevent an empty signal phase from regularly occurring. For the demand-responsive signal, a push button or imbedded loop within the cycle track should be available to actuate the bicycle phase (Figure 11). A protected bicycle signal phase will likely require an additional signal phase within the signal cycle and will potentially increase delay to all users.

Bicycle signals should be clearly differentiated from other traffic control signals. As shown in Figure 12, they can have smaller signal heads, use bicycle logos in the light itself, and can be installed on the near-side of the intersection to improve visibility for bicyclists.

The CROW design guide outlines the following menu of bicycle-friendly options at traffic lights, and the Netherlands' experience with measures that can be combined:

Table 4. Possible Combinations of Bicycle-Friendly Measures at Signals

Number	Measure	Can be combined with:
1	Shorten cycle time	2 - 16
2	Include additional green light options for cyclists	1, 3, 4, 7 - 9, 11 - 16
3	Permit right turn through red (for bicycles)	1, 2, 4 - 11, 14 - 16
4	Give all cycling directions a green light at the same time(1)	1 – 3, 10 - 13, 15
5	Accept motorized vehicle/bicycle sub-conflicts	1, 3, 7 - 9, 11 - 13
6	Ser favorable standby time for cyclists	1, 3, 4, 9, 11 - 13, 15, 16
7	Increase cycling directions with priority along with public transit	1 - 3, 5, 8, 9, 11 - 16
8	Increase cycling directions with priority along with other directions	1 - 3, 5, 7, 9, 11 - 13
9	Set favorable phase sequence for cyclists turning left	1, 2, 3, 5, 7, 8, 10 - 13, 15, 16
10	Set green wave for bicycle traffic(2)	1, 3, 4, 5, 9, 11 - 16
11	Keep mutual conflicts between slop traffic outside of the control	All measures
12	Implement right turn through red (for bicycles)	All measures, except 3
13	Introduce long distance detection/pre-request for cycle traffic	All measures
14	Introduce expanded cycle stacking lane(3)	All measures, except 6 - 8
15	Increase flow capacity for motorized traffic	All measures, except 5
16	Set two-way green light	All measures, except 4, 5, 14

Source: CROW *Design Manual for Bicycle Traffic*

(1) Also called a "scramble signal"

(2) A facility in Copenhagen where signal timing is designed to allow cyclists traveling at 12mph to not encounter red lights.

(3) This facility allows cyclists continuing straight to pass those waiting to turn right, as shown in Figure 13

Right Turning Movements

At intersections where a substantial proportion of bicycle traffic makes a right-hand turn, while other bicycle traffic continues forward from the cycle track, an additional right-hand turn lane should be provided within the track (see Figure 13). This allows right-turning cyclists to slow down for the turning movement, while cyclists continuing straight can do so freely. It is very important that cars

Figure 13. Straight and right turn (extended cycle stacking lane) at intersection, Copenhagen

cannot make right turns on red if the through bicycle movement occurs on a separate signal phase from automobile traffic or if there is a bicycle box present where cyclists may be queuing ahead of stopped vehicles.

If there is a cycle track on the street a cyclist would make a right turn onto, a slip lane can be provided to allow cyclists to make the turning movement past the red light.

Left Turning Movements – the "Copenhagen Left"

The "Copenhagen Left" (also known as the "Melbourne Left," the "jug-handle turn," and the "two-stage left") is a way of enabling a safe left-turn movement by bicyclists in a cycle track. Bicyclists should not be allowed to make left-turn movements from the cycle track and are often physically barred from moving into the roadway by the cycle track barrier.

Figure 14. Left-turn from a cycle track on the right via bicycle-signal phase in Winterthur, Switzerland

Instead, bicyclists approaching an intersection can make a right into the intersecting street from the cycle track, to position themselves in front of cars. Bicyclists can go straight across the road they were on during next signal phase. All movements in this process are guided by separate traffic signals – motorists are not allowed to make right turns on red signals. In addition, motorists have an exclusive left-turn phase, in order to make their movements distinct from the bicyclists'.

Figure 15. "Copenhagen Left" application

Figure 16. "Box left" turn in Troisdorf, Germany

Figure 17. A Three-Step Demonstration of the "Copenhagen Left" in Amsterdam

The cycle track drops to a bike lane

A channelized right turn puts the cyclist onto the cross-street

Bicyclists can proceed through the intersection

Two-way Cycle Tracks

Two-way cycle tracks have many similar design characteristics as one-way tracks. They are physically divided from cars and pedestrians, and require similar amenities at driveway and side-street crossings. Two-way cycle tracks require a higher level of control at intersections, to allow for a variety of turning movements. These movements should be guided by a separated signal for bicycles and for motor vehicles. A two-way cycle track is desirable when more destinations are on one side of a street (therefore preventing additional crossings), if the facility connects to a path or other bicycle facility on one side of the street, or if there is not enough room for a cycle track on both sides of the road.

Figure 18. Two-way cycle track with dividing line

Figure 19. Directional markings on cycle track

To allow cyclists to comfortably pass each other, the cycle track should be a minimum of 12-feet wide. The CROW *Design Manual for Bicycle Traffic* provides guidance on proper width of a two-way cycle track based on usage, shown in Table 5.

Table 5. Two-Way Cycle Track Width Guidelines in The Netherlands

Rush hour intensities (two directions, bikes per hour)	Cycle Track Width (feet)
0 – 50	8
50 - 150	10
> 750	13

Source: CROW *Design Manual for Bicycle Traffic*

Pavement markings indicate where bicyclists heading in either direction should be (Figure 18). The CROW guidelines also specify that two-way cycle tracks wider than 6.5' should have a four-inch painted center line. This is particularly important at bends in the cycle track, to prevent a head-on collision with an additional (thicker) warning stripe, as well as signage.

Cycle Track and Transit Interactions

When cycle tracks cross streetcar or other transit tracks in the pavement, they should cross at as close to a ninety-degree angle as possible. The *Edinburgh Tram Design Manual* states that, "Cycle tracks should be well defined and aligned with the tram track, only merging with each other at tram stops if no other design solution can be implemented." [3] Pavement markings, such as the 'yield' chevrons shown in Figure 20, can designate the right-of-way and caution bicyclists about areas of potential conflicts with transit vehicles.

Figure 20. Cycle track crossing streetcar tracks, with pavement yield markings

In the Netherlands and Copenhagen, bus stops are located on the outside of cycle tracks, and de-boarding passengers are often required to cross a cycle track (Figure 21). Sometimes, they provide an adequate stopping area for transit riders, so that they do not walk directly off the bus and into the cycle track, and often they do not. If a bus-boarding area is not possible, a zebra-striped area can indicate where pedestrians will board or disembark from transit vehicles.

Figure 21. Cycle track passing between bus stop and sidewalk

In addition, there should be adequate visibility for pedestrians to safely cross the cycle path. Signage or markings should instruct bicyclists to yield to disembarking passengers. Buses should not stop closer than 16 feet before an intersection, to promote visibility for cyclists in the cycle track.

[3] Available at: http://www.tramtime.com/newdownloads06/TDM_Intro.pdf

U.S. Experience

Cycle tracks are beginning to be implemented in the United States, in Cambridge, MA, New York, NY, and in Portland, OR. This section outlines some of the implementation strategies and experiences U.S. cities have had in developing cycle track facilities.

Vasser Street – Cambridge, MA

In Cambridge, the cycle track on MIT campus is raised above street-level and differentiated with pavement markings and a street furniture zone. In conjunction with the construction of the facility, MIT has produced a brochure outlining how different street users should and should not use the cycle track. It instructs pedestrians to walk on the sidewalk, drivers to not park on the cycle track, and cyclists to ride in the direction of traffic.

Figure 22. An instructional pamphlet shows proper use of the cycle track on Vasser Street in Cambridge, MA

According to the City of Cambridge, the cycle track on Vasser Street has been very popular, and the facility has been expanded to continue for a mile.

9th Avenue – New York, NY

In New York, the 9th Avenue cycle track is a ten-foot, one-way signalized bike path with an eight-foot buffer. The buffer consists of pavement markings and bollards that prevent cars from entering the facility. Where the physical buffer is dropped to provide access for delivery trucks, the roadway surface is painted green, and the painted buffer narrows considerably.

Figure 23. 9th Avenue, New York cycle track
Source: http://flickr.com/photos/houze/2984838483

Left turns by cars are banned at only one of the four crossings along the facility. Sharrow-type arrows are used to indicate where bicyclists are crossing the intersection to enter the cycle track.

Airport Way and NE Hancock Street – Portland, OR

The two-way cycle track along Airport Way in Portland (Figure 24) is a good example of a facility along a faster road with few crossing streets. The track drops at intersections, which are marked by parallel lines. Portland's other cycle track is a small segment along NE Hancock, a one-way street. The facility allows contra-flow movements with striping on a widened sidewalk (Figure 25).

Figure 24. Two-way cycle track on Airport Way in Portland, OR
(Source: Google Street View)

Figure 25. Contraflow cycle track on NE Hancock Street in Portland, OR
(Source: Google Street View)

The City of Portland is planning several additional cycle track facilities on larger through-streets where automobile traffic is high and few connecting roads or driveways intersect the street. Current plans for the cycle track on Cully Boulevard (Figure 26) include a three-inch curb up to the cycle track, a 8.5 foot cycle track and a three-inch curb from the cycle track to the planter strip and sidewalk. At intersections, the cycle track will drop down to street level and pavement markings will warn drivers about the bicycles crossing.[4]

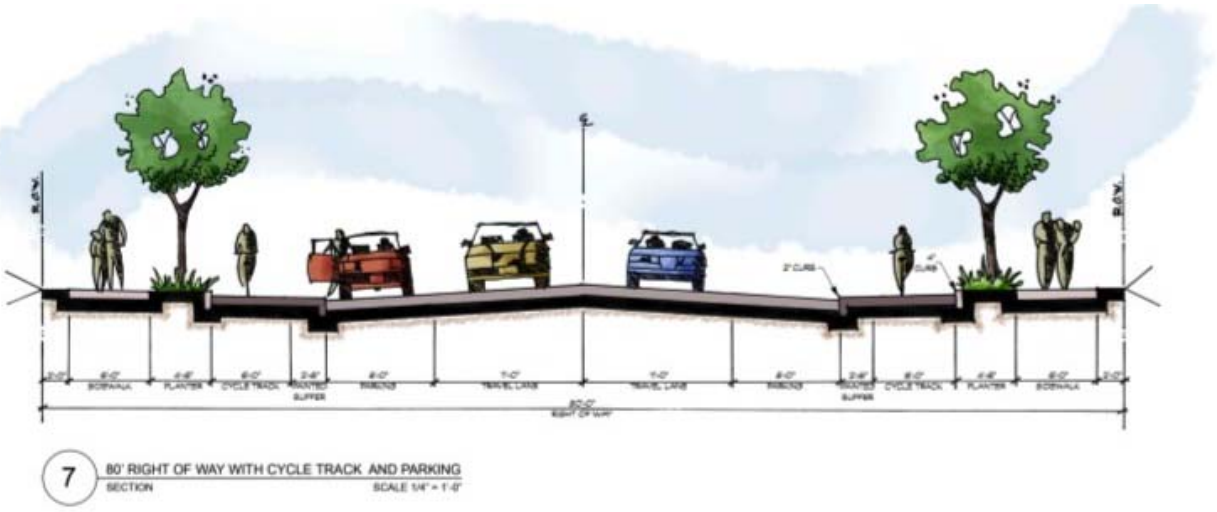

Figure 26. Cross-Section for Cully Boulevard Cycle Track in Portland, OR

Source: City of Portland, http://www.portlandonline.com/transportation/index.cfm?c=46784&a=190086

[4] More information available at: http://bikeportland.org/2008/11/20/portlands-first-cycle-track-proposed-cully/

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