Advisory Bicycle Lane Design Guide

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INTRODUCTION

This guide addresses facility selection and design issues for Advisory Bike Lanes (ABLs) in the North American context.

This guide is organized as a series of questions one might ask when considering an ABL as a potential design solution.

I reference information primarily from the following sources:

- 2017 Alta white paper titled Lessons Learned: Advisory Bike Lanes in North America co-authored by me,
- English translation of the 2016 Dutch CROW bicycle design manual,
- 2016 FHWA Small Town and Rural Multimodal Networks guide (AKA the FHWA Small Town guide), and
- 2015 Danish Report #543, “2-minus-1 roads, Collection of Experiences”.

This document has been created without a large time investment on my part. No attempt is made to create a graphically-stunning guide or to communicate with a lay audience.

JARGON

I dislike the name “Advisory Bike Lane”. It refers only to the edge lanes and implies this road format is just a bike lane, tacked onto an otherwise normal road. This is wholly inaccurate as the entire road is a new type of road with unique expectations, behaviors, and geometric requirements. This name also ignores the capacity of this road format to support all types of vulnerable road users, e.g. pedestrians, equestrians, personal mobility devices, etc.

I prefer a name that omits any mention of bicycles and one which refers to the entire road. Denmark and New Zealand call them 2-minus-1 roads. I like this name but without the context of those countries, it makes less sense in the North American conversation.

For these reasons, I use the acronym “ABL” to refer to the entire road. The lanes on either side of the road are the edge lanes and the remainder of the road is the center lane. There are places where I use the terms “bike lane” or “cyclists” to refer to the edge lane and its occupants. No specificity is implied by that use.

A SPECTRUM OF ABLS

ABLs come in all shapes and sizes. Different designs achieve different goals. One way of looking at ABLs is via a design spectrum in which center lane width is the governing factor.

ABLs with narrow center lanes provide room for wider edge lanes, prioritize traffic calming, encourage lower speeds and are comfortable only with lower vehicular volumes. These narrow center lane ABLs are likely viewed as more comfortable by vulnerable road users. This style of ABL is the one preferred in Denmark.

At the other end of the spectrum, ABLs with wide center lanes place more emphasis on vehicular throughput, can support higher vehicular speeds, but are likely to be perceived as more intimidating to vulnerable road users. This style of ABL is often used in Britain.

The Dutch recognize both styles and address both in their design guidance. More importantly, they have different recommendations for these two styles.

What appears to be occurring in North America is that most ABLs are being implemented as wide center lane ABLs when a narrow center lane would better fit their road volumes and design goals.

There are questions in this area that require research to answer, but in the absence of those answers, I suggest that people use the wide center lane only when absolutely necessary. Narrow center lanes provide room for wider edge lanes, perform a traffic calming function and discourage drivers from passing another vehicle when vulnerable road users are nearby.

Center lane width is an important aspect of ABL design which is easily overlooked. This short discussion is intended to raise the awareness of this issue before tackling the remainder of this guide.

WHAT STREET ENVIRONMENT IS APPROPRIATE FOR AN ABL?

Figure 1 Dutch ABL with Horse

The first decision one needs to make is whether the candidate street is appropriate for an ABL installation. For obvious reasons, a candidate street is assumed to be a two-lane street with vehicular travel in both directions.

In the Netherlands, ABLs are used in both rural and urban settings. All of the facilities surveyed in my white paper were in an urban or suburban setting. Since the release of that paper, more facilities have been built or have been brought to my attention. Some of those are in rural settings.

Of more importance than land use setting are the traffic characteristics, primarily vehicle volume and speed.

GUIDANCE

FHWA Small Town and Rural Multimodal Networks Guide Recommendations

The FHWA Small Town and Rural Multimodal Networks guide provides recommendations for both traffic volume and speed for candidate ABL streets.

With respect to volume, it recommends a preferred ADT of less than 3,000 and a maximum ADT of 6,000. The MUTCD requires a centerline on streets over 6,000 ADT precluding use of ABLs on those streets.

This guide recommends a preferred speed of 25 MPH or less and a potential maximum speed of 35 MPH.

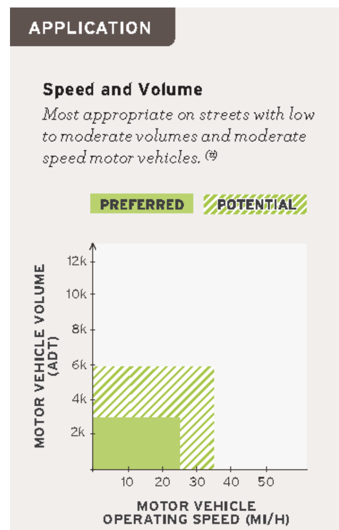


Figure 2 FHWA Small Town and Rural Multimodal Networks Guide

2016 CROW Recommendations

Dutch guidance provides three sets of conditions for ABL placement. One is for the rural context and two are for an urban context.

1. An ABL can be placed on rural residential streets with 30 or 60 KPH (~20 or ~35 MPH) speed limits but this placement is limited to streets with vehicle volumes ranging from 2,000 to 3,000 ADT. The lower volumes were selected in recognition of the higher vehicles speeds observed in rural areas. In addition, only narrow center lanes are allowed on rural streets.

2. An ABL can be placed on urban streets with 30 KPH (~20 MPH) speed limits, more than 500 bikes/day, and 2–5,000 ADT. Above 4,000 ADT, exploration of a separate cycle path is recommended.
3. An ABL can be placed on urban streets with speed limits of 50 KPH (~30 MPH) if the center lane is large enough to allow two passenger vehicles to pass without entering the cycle lanes (4.8–6 m / 15.75–20 ft.). In the North American context, a roadway wide enough to support two vehicles side-by-side without use of the bike lanes would likely be striped with a normal configuration of two travel lanes and two bike lanes so this configuration may be inapplicable or only marginally applicable. In recognition of the higher vehicle speeds, this configuration is only recommended for streets with less than 750 bikes/day.

When viewed from a speed perspective, ABLs are only allowed at 35 MPH on rural roads with 2-3,000 ADT using a narrow center lane. At 30 MPH, ABLs are only allowed on urban roads with 2-4/5,000 ADT and less than 750 bikes/day using a wide center lane. Below 30 MPH, higher bike volumes are allowed on urban streets.

Danish Recommendations

Current Danish guidance differentiates between rural and urban installations, as the Dutch do.

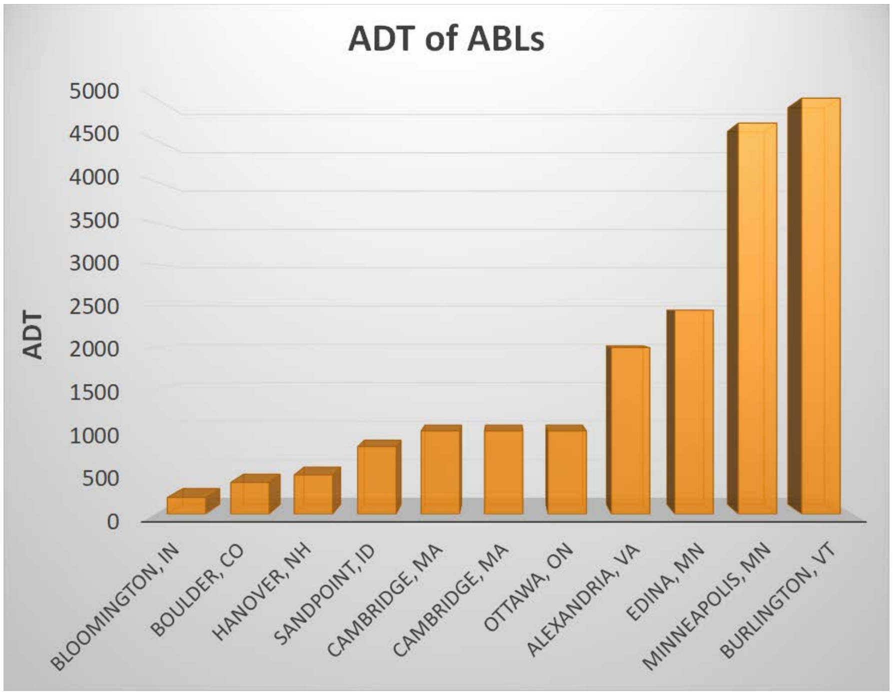
Rural: Speeds up to 60 KPH/37 MPH and volumes less than 300 VPH/3000 ADT.

Urban: Speeds up to 50 KPH/31 MPH and volumes less than 300 VPH/3000 ADT.

Some of their existing installations do not adhere to this guidance.

FINDINGS

The graph below shows reported ADT levels of the eleven existing ABLs surveyed for the white paper. Seven (64%) had ADTs of 1,000 or less. The median value was 1,000 ADT, the average was 1,728 ADT and only two facilities had ADTs above 2,500 (one at 4,700 and one at 5,000).



Five of the installations were posted at 25 MPH, one used both 15 and 25 MPH and five were posted at 30 MPH.

My recommendations in this area are also informed by personal observations of Dutch ABLs at varying volume levels. During one such observation period, I was struck by the uncharacteristic hesitation that I observed from Dutch motorists and cyclists at a T-intersection of two ABL-equipped roads. Given that traffic flow in the Netherlands is normally free of such uncertainty, this indicated to me that the volumes were high enough to push the limits of the facility type. My estimate of volumes on those roads were approximately 2-3,000 ADT on one and 3-4,000 ADT on the other. Admittedly, the intersection was a worst-case scenario which combined those flows.

No data exists to support the difference between American and Dutch guidance at higher volumes. The MUTCD requirement that streets with volumes above 6,000 ADT are required to have a centerline (which precludes use of an ABL) played a role in the choice of the upper volume limit adopted in the FHWA guide.

Unlike the American guidance, the Dutch temper their allowed volumes with vehicle speed, i.e. as speeds go up, allowed volumes go down. American guidance does not include any similar tempering.

RECOMMENDATION

Until more drivers become acquainted with this facility and until good data is available, I consider 3,000 - 4,000 to be close to the maximum ADT for a street in the US and 30

MPH a maximum posted speed. This is opinion is based on information from both Dutch and American ABLs – no real data supports this position.

Street context, vehicle mix and other relevant conditions must also be weighed when making this decision but consideration of all possible factors isn't possible in this guide.

Until data from good research is available, I have to wonder why we are choosing more dangerous settings for North America than the Dutch have chosen. The Dutch have decades of experience with thousands of road-kilometers of ABLs and their drivers are well-acquainted with this roadway configuration. It seems wise to use their guidance as our starting point until we have more information on which to base any differences.

WHAT WIDTH OF ROAD IS APPROPRIATE FOR AN ABL?

For many, ABLs are considered to be the facility one looks to when insufficient width is available for standard bicycle lanes on a 2 lane street. This is a misconception which results in dangerous door zone bike lanes being installed when better alternatives exist.

On appropriate streets, ABLs can provide much greater horizontal separation between vulnerable road users and parked or moving vehicles. Most engineers will choose a standard two lane configuration with dedicated bike lanes if sufficient width is available. The choice to place bike lanes on roads between on-street parking and travel lanes provides little to no margin for error when vehicle doors, pedestrians, poorly parked vehicles, etc occlude the bike lane and force cyclists toward the travel lane. The narrower the parking lane, the greater the problem.

Take, as an example, a road with parking lanes on both sides and 32 feet of available width between parking lanes. This road will normally be configured with 11' travel and 5' bike lanes or 10' travel and 6' bike lanes. If the street was configured as an ABL, 3' of hatched width could be provided next to the parking lanes (to mark the door zone and reserve a place for people accessing their cars) and 10-11' could be allocated to the center lane. This permits 7-1/2' to 8' wide edge lanes. Edge lanes of this width provide significant lateral clearance between cars and bikes and allow cyclists to safely ride side-by-side. Additional clearance is created when vehicles choose to move into the opposite edge lane when passing cyclists.

The key to evaluating this trade-off is horizontal separation. In many cases, an ABL can provide more separation and lower vehicular speeds when compared to standard bike lanes.

Even the Dutch have chosen to replace a 2 lane road plus bike lanes with an ABL in at least one instance. See https://bicycledutch.wordpress.com/2018/12/04/from-main-road-to-attractive-peoples-space/ for a description of a street in Utrecht which was changed from standard bike lanes to an ABL.

So what available pavement widths are appropriate for the ABL format, ignoring other areas, such as the hatched pedestrian area described above? The following discussion assumes that bike lanes of 6’ width or more are being created.

As available width shrinks to less than 20 feet, center lane width approaches edge lane width and may start to look too narrow to some drivers to be considered a travel lane. Bike lane or pedestrian lane symbols may need to be repeated more frequently on an ABL with a narrow center lane.

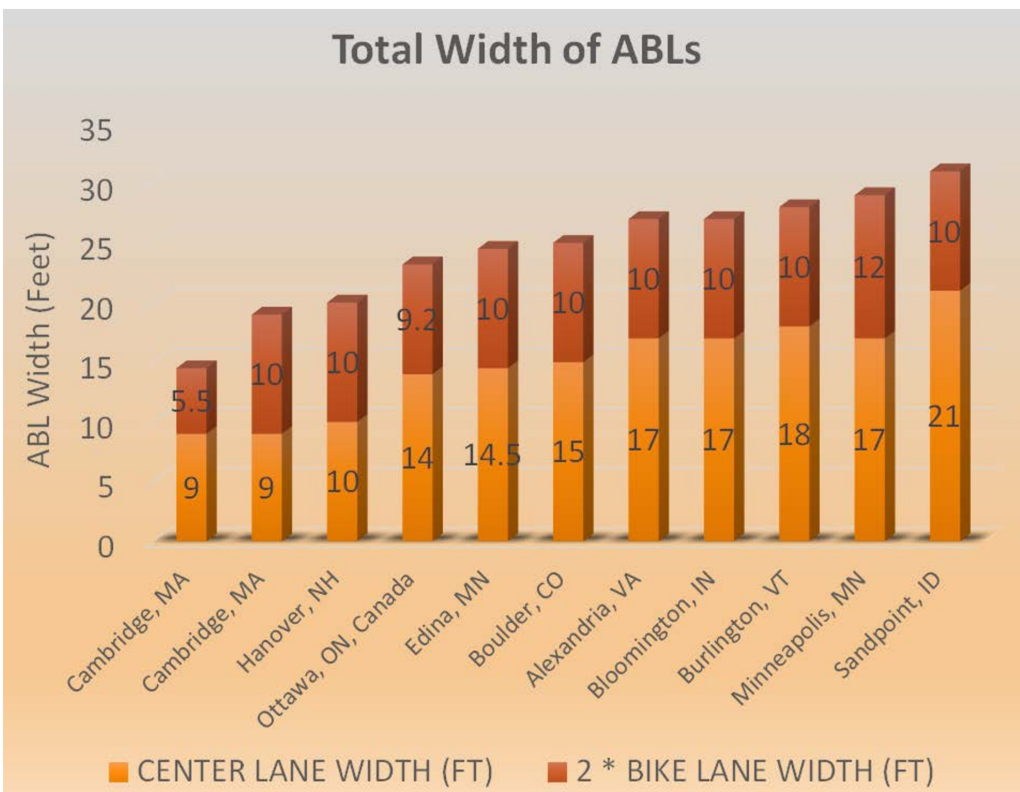
As available width falls well below 20 feet, some drivers may have issues physically passing other vehicles depending on roadside environment, vehicle size, chosen speed, etc. though this is commonly done on narrow, rural roads. Widths below 20 feet will likely experience problems with higher traffic volumes, oncoming traffic being uncomfortable with passing maneuvers and center lane widths too narrow for driver acceptance. But this discomfort is not an altogether bad thing since it normally results in lower speeds. There may be concerns with larger vehicles, however.

As available width increases above 30 feet, it becomes possible to transition to a street configuration with two travel lanes and two dedicated bike lanes (two 10' travel lanes plus two bike lanes of 5+' width). As illustrated above, one should not jump to the standard configuration once sufficient width becomes available without considering horizontal separation. If an ABL is chosen for a street at this upper end, center lane width may be increased which could lead to higher vehicle speeds. Additional traffic calming features may be necessary in that case.

FINDINGS

One may ask what current practitioners are doing. Adding center lane width to twice the bike lane width for all of the existing ABLs which I surveyed in the white paper shows the total width of those ABLs.

The following graphic shows the distribution of total width for those ABLs. With the exception of the outlier in Cambridge, MA which uses 2.75 feet as bike lane width, all of the ABLs have a total width falling between 19 and 31 feet.



RECOMMENDATION

As a rule of thumb, when available road width falls between twenty and thirty feet, an ABL is likely the preferred choice to provide bicycle or pedestrian facilities. Widths outside this range may benefit from other treatments. The presence of a parking lane and center lane width falling into the ambiguous zone are important factors which need to be considered and/or addressed in this decision.

Expansion of this range into narrower widths, with center lanes narrower than 7-9 feet, should be explored as drivers become more familiar with ABLs.

FACILITY SELECTION: WHERE DOES AN ABL BEST FIT?

When considering an ABL, one may be considering other facility types as well. What criteria does one use to select between facilities suitable for low-volume, low-speed streets?

First, the desire or need for a centerline precludes an ABL. If the street will have a centerline, an ABL is not appropriate.

Figure 3 Dutch ABL on Narrow Roadway

Streets much below 20 feet in available width will likely be better configured as a true shared street. Once ABLs become familiar to American drivers, it may be possible to create ABLs with center travel lanes narrower than 9-10 feet which would allow them to be placed on streets narrower than 20 feet. European countries already create ABLs on streets narrower than 20 feet but this occurs where drivers are familiar with ABLs. Whether this could be done successfully in North America without familiarity is open to debate.

On streets with 20-30 feet of width and without a centerline, it is possible to implement a bike boulevard as well as an ABL. Both facilities receive the same LTS scores but the ABL maintains its LTS level at higher volumes while a bike boulevard does not. (A draft of a paper illustrating this effect is available here https://www.advisorybikelanes.com/uploads/1/0/5/7/105743465/an_application_of_lts_to_abls.docx).

The key to choosing between an ABL, bike boulevard, or standard bike lanes is the lateral separation between bicycles and cars.

Bike boulevards are true mixed traffic facilities (cyclists and vehicles are sharing the street) while an ABL provides a level of separation due to its preferential channelization of road users. ABLs can safely support operation with higher vehicular speeds and/or higher volumes than a bike boulevard. The key differences to be considered is the amount of vehicle-bicycle passing “pressure”, distance from on-street parking activities and relative speeds.

Standard bike lanes provide dedicated space but may create little true horizontal separation, especially when doors, pedestrians, and poorly parked vehicles occlude the bike lane.

FINDINGS

North American guidance is silent on this issue.

Some Dutch studies have shown a small reduction in lateral separation during vehicle-cyclist passing maneuvers following installation of an ABL on an unmarked road but a Canadian study from Ottawa shows a large increase. *add citations here* The Dutch reductions in separation were in the realm of single digits of centimeters.

RECOMMENDATION

This is a context-sensitive decision. I recommend lateral separation and speed differential as the guiding considerations here.

Also of concern are:

- the presence of on-street parking (which reduces lateral separation),
- resources available for traffic calming, and
- the proposed lane widths.

If bicycle boulevard is the alternate of choice, speeds above 25 MPH should strongly lean toward an ABL.

Streets with on-street parking may benefit from a bike boulevard unless the ABL bike lanes are of sufficient width to preclude dooring problems or a buffer between the parking lane and the edge lane is added.

If sufficient traffic calming and diversion measures are not available to create a well-designed, low-volume bike boulevard, then an ABL is likely a better choice.

Unless the usable portion of ABL edge lanes are in the six foot and wider range, one should lean toward bike boulevards which normally accommodate side-by-side riding.

WHAT ARE THE APPROPRIATE LANE WIDTHS FOR AN ABL?

One goal of the ABL design is to exert a traffic calming effect via a narrow center lane. In addition, narrowing of the center lane allows creation of wider, more comfortable bike lanes. Choosing a wide center lane undermines both of these goals.

In general, current North American ABLs have chosen poorly with respect to lane widths. Virtually all installations have adopted wider center lanes and standard bike lane widths thereby missing the opportunity to create a safer, more comfortable facility.

The enormous advantage of the ABL design is the removal of the win-lose situation that usually exists when one is attempting to add bicycle or pedestrian facilities to existing roads. Often, any right of way consumed by non-motorized facilities is forever lost to motorized vehicles. This is often the root cause of the political and engineering resistance to active transportation projects. ABLs offer a win-win dynamic where wider bike lanes don't require motorists to give up space. This aspect is often ignored or under-appreciated by agencies which choose to implement ABLs.

GUIDANCE

FHWA Experimentation web page recommendations

The FHWA dashed bike lane experimentation web page suggests a center travel lane width of 16 feet or greater. Because this recommendation is significantly older, it is assumed to be superseded by the FHWA Small Town guide. Despite this suggestion being part of the experimentation webpage, the FHWA has approved ABLs with narrower center lanes.

This resource makes no recommendation on bicycle lane width.

FHWA Small Town and Rural Multimodal Networks guide recommendations

The FHWA Small Town Guide gives four recommendations for center travel lane width. It recommends a minimum width of 10 feet, a preferred minimum width of 13.5 feet, a preferred maximum width of 16 feet, and an absolute maximum width of 18 feet.

The FHWA Small Town Guide describes the bike lanes as having an absolute minimum width of 4 feet and a preferred width of 6 feet. This is presumed to be drawn from earlier design guidance which was based on a zero-sum game where an increase in bike lane width required a reduction in the width available for vehicles.

2016 CROW Recommendations

The 2016 CROW manual contains more detailed guidance on this issue. It prohibits center lanes less than 2.2 m/7.2 ft though existing ABLs with narrower center lanes can be found. A maximum center lane width is specified as 6 m/20 ft.

CROW also prohibits center lane widths between 3.8 m/12.5 ft and 4.8 m/15.8 ft. I call this the ambiguous zone. This width range is prohibited because it can produce uncertainty in the mind of the driver about whether opposing traffic can bypass without use of the bike lanes. This uncertainty may lead to a poor decision in the face of oncoming traffic, resulting in a conflict and possible collision. Their approach is to either make the center lane so narrow that a driver knows they will have to use the bike lanes when faced with oncoming traffic or so wide that they are sure they can bypass oncoming traffic without resorting to the bike lanes.

Application of the ambiguous zone concept to North America may require the size limits be increased to account for our larger vehicles.

For bike lanes, the Dutch recommend widths which support side-by-side riding and bicycle-bicycle passing. The basic assumption is a bike lane of 1.7-2.25 m (5.6-7.4 ft) width with a preferred width of 2.0-2.25 m. These dimensions are for useable width only; they do not include any portion of pavement markings or areas of shy distance from fixed objects as is done in North America.

Danish Recommendations

Current Danish guidance recommends a center lane width of 3-3.5 m/9.8-11.5 ft. They limit the maximum width of their center lane based on studies of shared lanes in worksites. Similar to the Dutch experience, they found that shared lanes wider than 3.5 m caused drivers to misjudge the available width at times. Results from these studies included smashing of mirrors by passing traffic. I am unaware of any Danish research which evaluated lane widths much wider than the 3.5 m ceiling.

The Danish guidance recommends bike lane widths from .9 m - 1.5 m/3-4.9 ft. Their reason for the relatively narrow 1.5 m upper width limit is that bike lanes wider than this invite drivers to drive in them. From my research, I believe that their bike lanes are not marked in any way, other than with the broken line (I have not confirmed this yet). I have seen evidence in their literature of a sizeable public education effort to teach drivers to stay out of the bike lanes. The lack of any markings or color in the bike lanes may be partially responsible for their problem with drivers in those lanes.

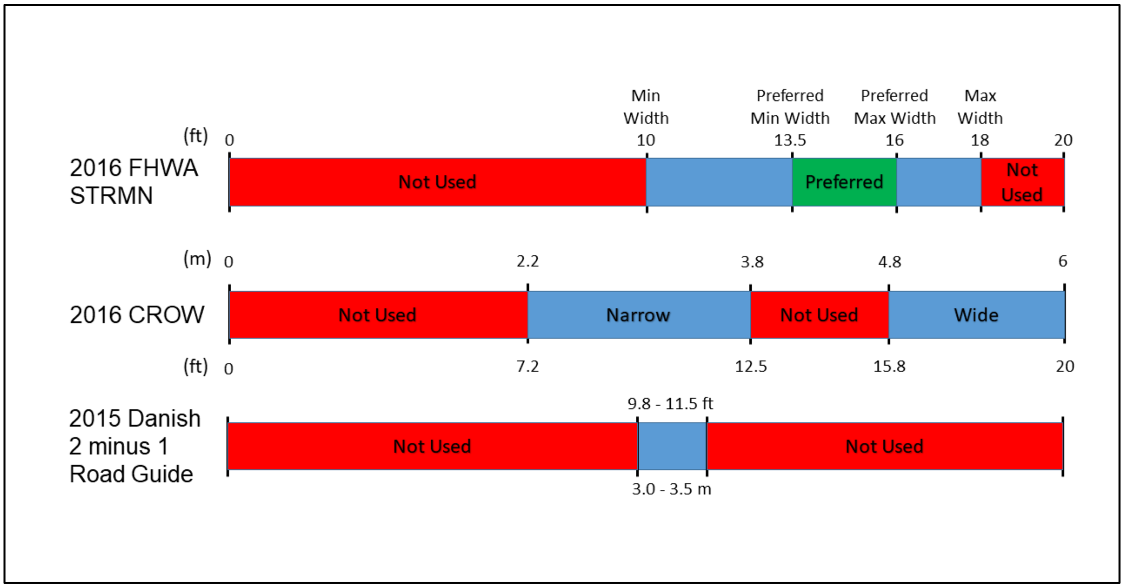
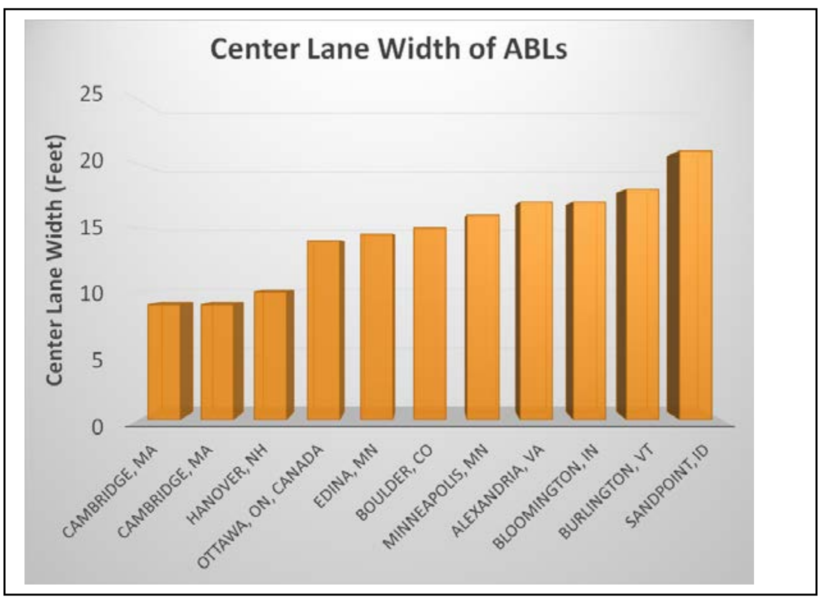


Figure 4 Center Lane Width Recommendations

FINDINGS

With regard to center lane widths, my survey found values ranging from 9 to 21 feet. The graph below shows the center lane widths of the eleven existing ABLs.



Five of the twelve ABLs surveyed in the white paper possess center lane widths in the ambiguous zone, between 12.5 feet and 15.8 feet. These installations may face problems. Already, Burlington, VT, has received complaints from bicyclists about unsafe passing events on their ABL which has an 18' wide center lane and a higher proportion of heavy vehicles.

In the survey of installed ABLs, eight of the twelve installations used five foot wide bike lanes, two used narrower bike lanes, and one used six foot wide bike lanes. Many of these installations were located on streets with parking lanes.

North American research has generally shown a linkage between increased lane width and higher speeds though some studies have shown no relationship. The consensus is that wider lanes encourage higher vehicle speeds. *Need to add citations here*

International research shows a near-universal consensus that a decline in vehicle speeds occurs when centerlines are removed. *Need to add citations here*

It is my opinion that Dutch widths for support of side-by-side riding are narrower than those needed in the American context. The geometry of Dutch bikes allow for riding closer to other cyclists because they are more stable. I once watched a mother ride next to her young daughter (7-10 years old) with her hand on her daughter's back for approximately 1/8 mile. This was not an uncommon practice in the Netherlands. I do not believe this is possible for an average rider, much less a young child, on a commonly available bicycle in the US. Bicycles common in the US do not use frame geometries which support such stable riding. My opinion is that bike lanes intended to support side-by-side riding in the U.S. need a minimum width of 7 feet. I recognize that this is wider than some existing American guidance recommends.

RECOMMENDATION

ABLs are meant to provide a narrow center lane for two-way traffic in order to reduce speeds. To provide wide center lanes in the interests of providing more room for vehicle-vehicle passing maneuvers is a common mistake which eliminates some of the advantages offered by an ABL.

In order to realize all of the safety benefits possible with an ABL design, it is essential to allocate width for the bike lanes first and use the remaining width for the center travel lane.

I recommend allocating a minimum of six to seven feet for each of the bike lanes and the remainder for the center travel lane to allow for a comfortable riding experience. If this results in a travel lane of unacceptably narrow width, the bike lanes may be reduced to five or six feet but it must be recognized that this change precludes comfortable side-by-side riding (such as a parent riding next to a child) and safe cyclist-cyclist passing maneuvers within the bike lane. If on-street parking exists alongside the bike lanes, add a buffer to the parking lane or hatch the bike lane areas which present a dooring hazard and widen the bike lanes to maintain the desired width.

If the center travel lane width exceeds 10 to 12 feet, consider widening the bike lanes to maintain the visual narrowness of the center travel lane. More frequent bike lane symbol placement may be required on ABLs with wide bike lanes.

If a wide center travel lane is unavoidable, the addition of traffic calming measures should be considered to keep speeds low.

The Dutch and Danish recommendations against center lane widths which produce uncertainty in the mind of the driver about whether two vehicles can fit without entering the bike lanes is sound. This width range may need to be up-sized for larger vehicles in the American context. The prohibited range of 12.5-15.8 feet found in Dutch guidance might be adjusted to 13.5-17 feet for North American application. I have not examined Dutch and North American vehicle sizes for data to characterize this possibility.

Wide center lanes can engender higher vehicle speeds which are incompatible with an ABL. ABLs with higher speeds may produce unfavorable safety outcomes. These outcomes could be interpreted as showing ABLs to be unsafe when the root cause is poor design. FHWA recommendations on center lane width should be modified to encourage the use of narrow center lanes.

ABLs present a fundamentally different choice from all other previous facilities. Other facilities require road width to be removed from vehicular use when allocated to bicycle use. This has tended to keep bike lanes to minimum widths in practice. By allowing vehicles to use the bike lanes, ABLs replace that win-lose choice with a win-win choice. ABLs allow bike lanes to be made as wide as desired without robbing width from vehicular use.

Video footage is available on my website which shows examples of Dutch ABLs and a mix of vehicles using them. These may be useful for public education around the use of narrow center lanes.

WHAT HAPPENS AT INTERSECTIONS?

Current practice for treatment at intersections varies considerably. When surveying ABL installations across North America in 2016/2017, I found that ABL markings at intersections differed within facilities as well as between agencies. This is a surprisingly nuanced issue and interacts with other aspects of ABL design.

Feel free to call me at 530-859-3468 about this design problem.

WHAT HAPPENS AT ROUNDABOUTS?

As of this writing, at least two American ABLs include a roundabout – Potomac Greens Drive in Alexandria, VA and Eastern Road in Scarborough, ME.

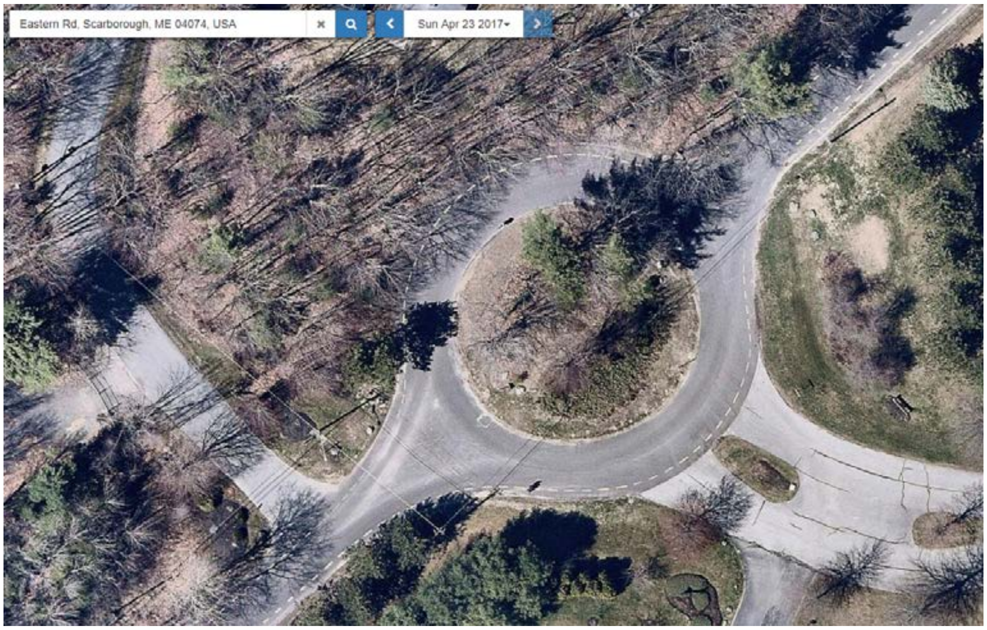


Figure 8 Roundabout on Eastern Road ABL, Scarborough, ME (Courtesy nearmap.com)

GUIDANCE

FHWA Small Town and Rural Multimodal Networks guide recommendations

The FHWA has no recommendations for ABLs at roundabouts.

2016 CROW Recommendations

There appears to be no specific guidance from the Dutch on ABLs and roundabouts though general guidance likely exists.

2009 MUTCD

Paragraph 12 of MUTCD Section 9C.04 states:

"Bicycle lanes shall not be provided on the circular roadway of a roundabout."

This standard is based on published research. *Need to insert citations here*

FINDINGS

My experience with ABLs in the Netherlands is that they are terminated at the circulatory roadway of a roundabout but my experience was not extensive. Without published guidance, it is not possible to know if this condition is representative. I am unsure if this treatment is common on higher volume streets, especially those in urban areas. I suspect not.

With those caveats, I present Google Streetview pictures of one roundabout at the intersection of Westplantsoen, Hof van Delftlaan, and Adriaan Pauwstraat in Delft where all of the approaches are ABL-equipped.


Westplantsoen
Delft, South Holland
Google, Inc.
Street View - Jul 2016
HOF VAN DELFT
Google


Delft, South Holland
Google, Inc.
Street View - Jul 2016
HOF VAN DELFT
Google

RECOMMENDATION

The bike lanes of an ABL should not be continued into the circulatory lane of the roundabout. In my opinion, the presence of permeable bike lanes within a roundabout is contrary to MUTCD Section 9C.04 and would likely lead to the same problems described in the findings of published studies of bike facilities on roundabouts.

There are generally three options for an on-street bike lane, whether part of an ABL or not, at a roundabout.

The first option is to terminate the bike lane markings at least 100 feet prior to the roundabout entry and provide markings letting bicyclists and drivers know that bicyclists belong in the travel lane. This is often done for single lane roundabouts with low circulating speeds but is less feasible with higher speeds and volumes.

The second option is to provide a connection to an off-street facility (either shared use path or dedicated bike path) from the street. Connections back to an on-street facility should be provided as well as crossings of the roundabout approaches.

A third option is to combine the first two options to support different bicyclist preferences.

Signage may be necessary to inform drivers that they are on an ABL as they exit a roundabout (they may have entered the roundabout from a non-ABL-equipped street).

WHAT SIGHT DISTANCE IS NEEDED FOR AN ABL?

Most ABLs are installed on existing streets which were converted from a two lane configuration. A street configured with two lanes has different sight distance requirements than an ABL. Sight distance requirements are critical on ABLs when visual obstructions, vertical curves, or horizontal curves may prevent drivers from seeing oncoming traffic. Current domestic guidance on sight distance is incorrect.

Feel free to call me at 530-859-3468 about this design problem.

HOW DOES ONE TRANSITION INTO AND OUT OF AN ABL?

All ABLs have a beginning and an ending. Some ABLs may need to transition to and from another treatment in sight-constrained situations. Some ABLs may need to change form at intersections. All of these situations require transitions into or out of an ABL.

Feel free to call me at 530-859-3468 about this design problem.

DOES ON-STREET PARKING WORK WITH AN ABL?

When surveying ABL installations in North America, I found ABLs were sometimes selected because removal of on-street parking was politically infeasible and insufficient room existed to install standard bike lanes.

The existence of parking lanes on an ABL-equipped street can produce problems. Some of those problems are:

- Unfamiliar drivers can find the pavement markings confusing, especially when the parking lanes are lightly used,
- Vehicular movements into or out of the parking lane can create conflicts with vehicles attempting to bypass oncoming traffic or with bicyclists in the bike lane,
- High turnover in the parking lanes can produce vehicle/bicycle conflict and pedestrian/bicycle conflict as drivers access their vehicles, and
- Increased incidence of vehicle doors opening and conflicting with a cyclist (a problem known as dooring).

Figure 10 Ottawa ABL with hatched door zones

Despite these problems, ABLs with parking lanes do exist and appear to work. One method of mitigating the dooring problem has been used by the City of Ottawa in their installation. They have added a hatched buffer in the bike lane next to parking spaces. This provides awareness and guidance to the cyclist to ride outside the door zone. In order to implement this well, a wider bike lane will be required.

GUIDANCE

FHWA Small Town and Rural Multimodal Networks guide recommendations

The FHWA Small Town guide recommends against use of ABLs on streets with lightly-used on-street parking. This direction is to help eliminate possible driver confusion when faced with a wide street hosting a myriad of novel pavement markings.

2016 CROW Recommendations

The Dutch prohibit the combination of ABLs and on-street parking on roads of 50 KPH/30 MPH or greater in urban areas. In situations where on-street parking lies next to bike lanes, a buffer space is recommended.

RECOMMENDATION

My primary recommendation is to not place ABLs on streets with parking lanes due to the conflicts this configuration creates. These conflicts become more problematic as vehicle volume and parking turnover rates increase.

This configuration is not uncommon in earlier installations and the use of ABLs on streets with parking lanes is expected to continue.

For parking lanes with high turnover rates, no North American guidance exists but common sense should cause one to look for better options, especially if higher vehicle volumes exist.

Per FHWA guidance, ABLs should not be implemented on streets with lightly-used parking lanes. Instead, remove or relocate the parking lanes and install more protected facilities.

When an ABL is installed next to a parking lane, the use of a hatched buffer to visually communicate the door zone is intuitive and inexpensive. A wider bike lane should be created in these areas to preserve the useable width available to cyclists. Other forms of communicating the door zone area or separating the parking lane from the bike lane are possible, e.g. parking lane buffer.

WHAT PAVEMENT MARKINGS ARE USED ON AN ABL?

Because ABLs preclude the use of a centerline, design guidance for ABL pavement markings concentrates on the lines separating the center travel lane from the bike lanes and the symbols inside the bike lanes. If the outer edge of the bike lanes are marked, edge lines or parking lane lines should follow MUTCD standards.

For pavement markings at intersections, see the intersection treatments section of this guide.

GUIDANCE

Color

MUTCD Section 3A.05 calls out white as the color to use when delineating traffic flows in the same direction and yellow for delineation of traffic flows in the opposite directions. One could argue that, due to the bi-directional nature of the center travel lane, the bike lane lines separate both directions of traffic flows and technically qualify for both colors. Given the importance of the yielding behaviors on this facility, white is the appropriate color to use.

Line Width

Because this facility is unfamiliar to many drivers and because the default behavior is to channelize road users into their respective lanes when yielding behaviors are not required, the delineation should emphasize separation. Ideally, the delineation should be dissimilar to the delineation used to separate same-direction traffic flow lanes to avoid having the bike lane look like a travel lane and to highlight the special nature of this configuration. The Support provided in MUTCD Section 3A.06 links line width to emphasis. For these reasons, I believe a “wide line” which is defined in Section 3A.06 as “at least twice the width or a normal line” should be used. Specifically, a line width of at least 8” (or something of noticeably greater width than what is normally used for separation). This communicates that the facility is different from a normal road and emphasizes the separation.

Line Pattern

MUTCD Section 3A.06 provides guidance on the pattern of line to be used. A broken line is used to indicate a permissive condition which is exactly the intent of this delineation.

Broken lines are defined as consisting of "10-foot line segments and 30-foot gaps, or dimensions in a similar ratio of line segments to gaps as appropriate for traffic speeds and need for delineation".

The FHWA Small Town and Rural Multimodal Networks guide recommends 3 foot segments separated by 6 foot gaps. The basis for this recommendation is not clear.

I believe the FHWA Small Town recommendation is the better of the two. My personal favorite is a pattern I've seen used in Portland for bike lane delineation through intersections which consists of 8 inch line width with 3 foot segments interspersed with 4 foot gaps. This pattern emphasizes separation and visually differs from a normal lane line. There is no data to support my preference – it just looks "right" for a 25-30 MPH roadway.

Bike Lane Markings

The FHWA Small Town guide makes no explicit recommendation on bike symbol markings within the bike lane.

On its dashed bike lane experimentation web page, the FHWA requires use of bike lane markings in accordance "with Item C of Paragraph 6 in Section 3D.01 in the MUTCD" which refers to the use of the bicycle symbol or the words "Bike Lane".

In the 2016/2017 survey of existing installations, there was a variety of treatments used in the bike lane. Nine facilities used standard bike lane markings, two used shared lane markings and one facility had no markings on their bike lane.

RECOMMENDATION

ABL striping should emphasize separation and be dissimilar to normal vehicle lane delineation to help unfamiliar drivers interpret the intent of the street.

Given that many drivers may be unfamiliar with this facility, marking the bike lanes with bike lane symbols is important to communicate intended use. If these symbols are likely to be covered with snow, signage may be needed as well.

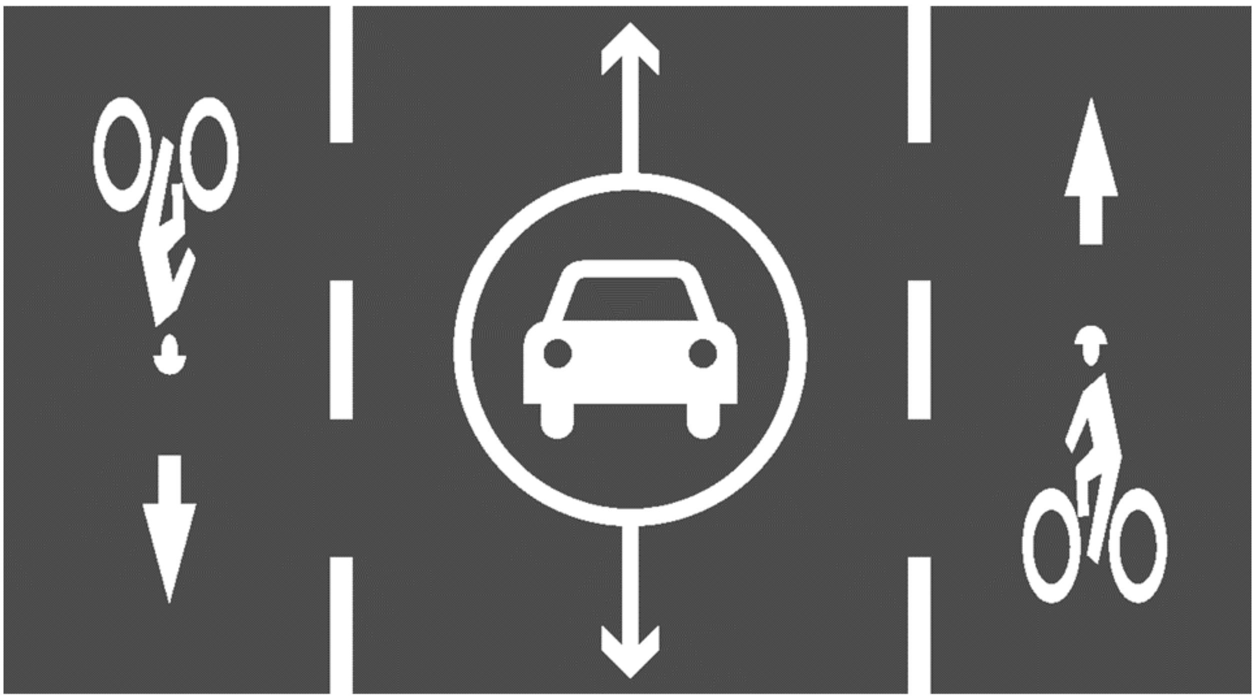
The lines separating the center travel lane from the bike lane should be white and of good size. A minimum of 8 inches wide, composed of 3 foot stripes and 4 foot gaps.

In order to reduce confusion for unfamiliar users and to reaffirm the intended use of the lanes, use of standard bike lane markings within the bike lanes is recommended. It may be appropriate to adjust markings for a road's context. For example, low-volume roads, those dominated by local drivers, or those on which the bike lane also functions as a sidewalk may be fine without bike lane markings.

Use of standard bike lane markings versus the use of shared lane markings is a debate which has yet to occur. The shared lane markings make more sense since vehicles and bicycles share the space. It is likely that the choice between the two has little impact on most drivers. The nine surveyed facilities which used standard bike lane markings did not find these to preclude proper use of their ABLs.

ABLs which support pedestrian use may also want to include pedestrian symbols in the bike lanes. This communicates to all users that pedestrians are allowed and expected there.

I have a personal recommendation that I would like to see tried. It is a pavement marking which better communicates expected road use and, as such, it may be beneficial on streets which have a higher proportion of new drivers. The marking is shown below. Where snow is expected to cover these markings a sign adopted from this graphic may be needed.



WHAT SIGNAGE IS USED ON AN ABL?

Appropriate signage for an ABL is an interesting question with several answers at the moment. Of the twelve North American installations surveyed in early 2017, signage included the following:

- Some communities use no signage whatsoever.
- Some communities use Bike Lane (R3-17) signs.
- Some communities use Two Way Traffic (W6-3) signs.
- Some communities created their own signs which attempt to diagram use of the street.
- If on-street parking is prohibited, applicable No Parking (e.g. R7-1, R8-1, and R8.3a) or No Parking Bike Lane (R7-9, R7-9A) signs may be necessary.

Figure 11 Hanover Diagrammatic Sign

GUIDANCE

FHWA Small Town and Rural Multimodal Networks Guide recommendations

The FHWA Small Town guide does not provide explicit direction on signage but lists three signs one should consider for an ABL:

W6-3 Two-Way Traffic

W8-12 No Center Line

R8-1 No Parking on Pavement


Figure 12 MUTCD W6-3

Figure 13 MUTCD W8-12

Figure 14 MUTCD R8-1

The W6-3 sign is technically problematic because MUTCD Sections 2C.23 and 2C.44 describe its use as communicating an upcoming two-way, *two-lane* condition. However, most motorists are likely to interpret it as meaning only that two-way traffic exists.

At transitions into an ABL, one might consider use of the W5-1 Road Narrows or W20-4 One Lane Road signs.

Figure 15 MUTCD W5-1

With regard to the W5-1, MUTCD Section 2C.19 guidance states "…*a Road Narrows (W5-1) sign (see Figure 2C-5) should be used in advance of a transition on two-lane roads where the pavement width is reduced abruptly to a width such that vehicles traveling in opposite directions cannot simultaneously travel* *through the narrow portion of the roadway without reducing speed*". With the exception of the pavement width condition, this is highly descriptive of a transition into an ABL. The same section provides an option to omit the sign on low-volume local streets with speed limits of 30 MPH or less.

The MUTCD appears to target use of the W20-4, "One Lane Road Ahead", for temporary traffic control or for low-volume roads (< 400 ADT). For unfamiliar drivers, this message may be the most helpful in terms of eliciting the correct behavior.

Recommendations from the FHWA Experimentation web page

On its dashed bike lane experimentation web page, the FHWA requires use of the bike lane sign, R3-17.

On its dashed bike lane experimentation web page, the FHWA recommends use of the two-way traffic sign, W6-3.

Figure 16 MUTCD R3-17

FINDINGS

Despite the requirement on the FHWA webpage, only six of the twelve facilities surveyed used the MUTCD R3-17, Bike Lane sign.

Despite the recommendation on the FHWA webpage, only two of the twelve facilities surveyed used the MUTCD W6-3, Two-Way Traffic sign. Since most installations included well-used, on-street parking, the information provided by this sign could be considered redundant at those locations.

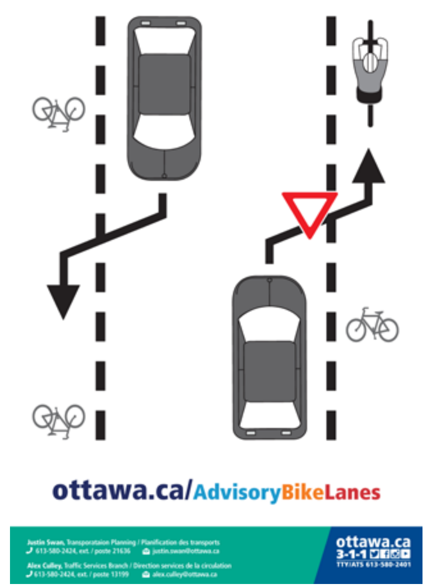


Figure 17 Large format, instructional sign used by Ottawa

RECOMMENDATION

One of the important issues with ABLs is proper use by unfamiliar drivers. Signage can help solve this problem.

As a personal opinion, signs which attempt to educate drivers as they pass by are too complex to be comprehended in the time normally available. In a larger format, they can be useful during the familiarization period following installation. Large format signs provide more time for understanding and grab more attention.

I believe the use of large format, diagrammatic signs during the period following installation can speed the familiarization process for this new facility. If possible, these temporary signs should be placed where slowed or stopped cars have more time to view them. The best one I have seen is the Ottawa sign shown here.

For permanent signage, a bike lane sign can be helpful, especially in areas where snowfall may obscure on-street bike lane markings.

As always, local conditions need to be considered, e.g. lack of on-street parking may necessitate use of a two way traffic sign.

HOW IS COLOR USED IN AN ABL?

Figure 18 ABL with contrasting color bike lanes

The Dutch use color very successfully in their ABLs. The bike lanes are colored red and the travel lane is left uncolored (black). Red is associated with bicycle facilities throughout the Netherlands and its presence is a clear signal to drivers that the bike lanes are intended for bicycles. The dashed lines communicate a permeable barrier. This arrangement works well in their context and its use is intuitive for unfamiliar users.

FINDINGS

No use of color in bike lanes was found in the surveyed ABLs. Only one use of color was found and that was application of a skipped green pattern through an intersection on a Minneapolis facility.

GUIDANCE

As of this writing, the use of green for bicycle facilities is governed by the April 15, 2011 FHWA IA-14 interim approval letter. This interim approval describes an allowable use as:

> *"Green colored pavement may be installed within bicycle lanes as a supplement to the other pavement markings that are required for the designation of a bicycle lane."*

This permits the use of green as a contrasting color on ABL bike lanes, assuming one considers the term "bicycle lane" to apply to ABL bike lanes.

However, as of June, 2017, the guidance supplied by the FHWA dashed bike lane experimentation web page appears to oppose this use. It states:

> *"Green-colored pavement can be used, but should be limited to mixing/weaving locations and/or as a background conspicuity enhancement to the bicycle symbol, arrow, and/or pavement word markings used to mark the dashed bike lane."*

Given that the entirety of an ABL bike lane is available for mixing and/or weaving, the use of color in the bike lanes can be argued to comply with this guidance though the intent of this passage appears to be otherwise.

RECOMMENDATION

It is clear to me that the Dutch use of colored pavement does an excellent job communicating the purpose of the road. I believe the colorization of bike lanes in North

America would work equally well. Green is the color selected for bike facilities in the United States and FHWA interim approval has been granted for marking bike lanes with that color.

I believe ABL bike lanes should be colored whenever possible. Marking ABLs in this way provides additional information to road users and, via the experimentation process, will provide needed information on the performance of colored ABLs.

It should be noted that some ABL facilities which are not compliant with experimental FHWA guidelines have been approved. This leaves open the possibility of creating ABLs with colored bike lanes under the FHWA's experimentation process.

HOW IMPORTANT IS PUBLIC OUTREACH?

Because ABLs are new to North American drivers, public education is important. At this time, no content describing ABLs and their operation exists in material for those wishing to obtain their driving licenses. Nor is content available for public safety officers though most would hopefully be informed on a project-by-project basis.

FINDINGS

In the survey of North American ABL installations, I found that many of the successful installations included significant public outreach and education. Conversely, the only facility removed after installation did almost no public outreach.

One of the lessons learned from the survey of existing ABLs was that a strong public outreach effort virtually eliminated negative reactions following installation.

An ABL trial installation in New Zealand which specifically avoided all forms of public education was terminated by the lead engineer less than 24 hours after it was installed. He believed that the unsafe incident(s) he observed were at least partially caused by the lack of public education. These unsafe incidents included speeding and a near-collision.

RECOMMENDATION

This is a new roadway type with a novel mode of operation. Drivers can become confused or frustrated when faced with an unfamiliar street configuration. This can lead to poor reception of a new installation.

Public outreach is important and should be part of any project.

HOW IS A BUS STOP HANDLED ON AN ABL?

Feel free to call me at 530-859-3468 about this design problem.

WHAT IS REQUIRED TO INSTALL AN ABL?

FHWA Request to Experiment

The FHWA currently regards ABLs to be experimental facilities though some entities dispute this assessment. The FHWA wants agencies to follow their request-to-experiment (RTE) process when installing ABLs.

The RTE process confers greater liability protection and allows the industry to gather information on the performance of ABLs. Despite these advantages, approximately half of the current ABLs were installed outside of this process. A number of valid, different reasons for those decisions exist.

If you would like help negotiating this process, feel free to call me at 530-859-3468.

HOW DOES AN ABL IMPACT MAINTENANCE COST?

Because ABLs are new to North America, no long-term data is available on maintenance costs for an ABL. I am unaware of any international studies on this subject.

OPINION

Based upon my experience as a public works contractor, I believe that long-term maintenance costs for an ABL will be lower than a normal two lane road and that this reduction could be significant.

In my experience, the two most common mechanisms of degradation for asphalt roads are edge failure and rutting. Edge failure is the cracking and failure of the edge of the asphalt road due primarily to vehicular loads near an unreinforced edge or an edge reinforced only with a gravel backing. Rutting is the production of ruts in the road due to vehicular loads being concentrated onto two narrow tire tracks.

ABLs can reduce the impact of both of these mechanisms by keeping vehicles away from the vulnerable asphalt edge and encouraging vehicles to vary their path as they travel down the road. What savings are realized from these operational differences is unknown but I expect it to be discernible.

Two aspects where maintenance costs may rise are signage and pavement markings. Depending on road use patterns, the pavement markings may require re-application sooner than on other facilities due to vehicular wear. If additional signs are placed on a road with the installation of an ABL, those signs will have a maintenance cost associated with them.

An issue related to asphalt maintenance is the application of ABLs to degraded roads. If an ABL is placed on a road with poor pavement conditions on its edges, non-motorized road users may choose to travel at the edge of the center lane rather than in the edge lane. This use pattern has been seen at the Burlington, VT ABL.

WHAT CONSIDERATIONS EXIST WHEN PAVING AN ABL?

When a two-lane road is paved, the normal approach is to pave each half of the road at a time. Not only is this a straightforward use of the paving machine, it allows a crown to be easily formed which helps with drainage. As a result, the joint between the two halves lies at the center of the road. This joint can be quite visible. On many roads it acts as a de-facto centerline.

This joint may persuade some drivers to place themselves on the right-hand side of the road, as if a painted centerline existed. If an ABL-equipped road is being re-paved, an alternative approach to paving the road should be considered, e.g. paving the center lane and edge lanes in 3 passes. If the road is paved normally, mitigation should be considered for reducing the visibility of the joint.

WHAT OTHER DESIGN ELEMENTS ARE AVAILABLE FOR AN ABL?

Channelizing Islands

One design element used by the Dutch which has not yet been used in North America is the channelizing island. The usual purpose of these islands is to persuade drivers to return to the center lane. One can also envision these islands being used to notify drivers entering an ABL of their proper position.

These channelizing islands are centered on the broken delineation separating the center travel lane from the bike lane. These islands leave room for cyclists to pass unhindered on the right side. To maintain lane width for vehicles and cyclists, the road can be widened at these points although some installations narrow the center travel lane between islands for traffic calming purposes.

Figure 19 Photo of Staggered Soft Islands (Courtesy Michael Williams)

These islands come in two types. The first type can be driven over and are considered mountable (these are also called soft islands). The second type of island cannot be driven over and forces drivers to return to the center lane (these are known as hard islands). Both types can be used in a paired manner (directly across from each other), placed in a staggered fashion or used as a single element on one side only. Paired islands can be joined with a speed bump for additional traffic calming. It should be noted that the two types of islands lie on a spectrum; one could create an island with a 2-3" curb which could be driven over but provides more encouragement than the softer variety.


Figure 20 Photo of Paired Hard Islands (Courtesy Peter Furth)

More information on these islands can be found in the white paper and on a web page created by Dr. Peter Furth located at http://www.northeastern.edu/holland2016sustrans/systematic-safety-2/sustainable-safety-2-van-emmerik-and-nitka/.

On ABLs, vehicles should pass these islands on the left side. The MUTCD does not address pavement markings for islands which are intended to be passed only on the left side. In the face of unsuitable regulations, one could modify Figure 3B-15C with arrows to communicate passage on the left only. A modification of the MUTCD is required in this case.

Section 3B.10 provides a formula for calculating the taper length for pavement markings leading up to, and away from, the island. Unless islands and markings exceed 5 feet in width, the formula results always fall below the required minimums. The minimum taper lengths called out are 100 feet in urban areas and 200 feet in rural areas.

MUTCD Section 2C.64 prescribes object markers for channelizing islands. OM3-R object markers are appropriate object markers for placement on channelizing islands. Versions of the R4-8 sign may be applicable but could be confusing as well. Placement of a member of the R4-8 sign family should be considered on a case-by-case basis. An R4-8 sign may help with the lack of guidance on pavement markings.

Raised Bike Lanes

It may be possible to create an ABL with raised bike lanes but I have not seen this design in practice nor have I heard this discussed anywhere. I doubt the utility of this idea but I include it as an out-of-the-box concept that might generate other ideas.

The primary problem with this approach is the impact on steering caused by longitudinal elevation transitions. This is especially problematic with motorcycles. Slow speeds and a gradual grade would mitigate this problem but their effects may not be sufficient.

The primary advantage of this approach is that a number of goals which are now accomplished by separate treatments could be achieved with one treatment. Those goals are:

1. Encourage drivers to return to the center lane after a bypass maneuver,
2. Enhance the traffic calming effect of an ABL, and
3. Communicate the purpose of the road to unfamiliar drivers.

One could envision a bike lane approximately 1-2” higher than the center lane with a transition which was easily mountable by vehicles, including motorcycles. This could create sufficient unease for drivers with right and left wheels at different heights and cause them to move back to the center lane sooner rather than later. This could eliminate the need for channelizing islands and provide an additional sense of separation for all road users.

Half-ABLs

I define a half-ABL as a street with a permeable bike lane, delineated with a broken line, on one side of the street only. The other side of the street can have a different facility type or no facility at all. No centerline is present.

The examples of half-ABLs I have found, below, appear to achieve different goals.

Some examples of half-ABLs are listed below with a link to where they can be found on Google Maps.

1. Summer Street in Somerville, MA is a narrow street on a significant grade. The street has a bike lane delineated with broken lines on the uphill-bound side but sharrows marked in the travel lane on the downhill-bound side. A parking lane also exists on the downhill-bound side of the street.
   I assume this facility was installed because the City wanted bike facilities on Summer but was unwilling to remove the parking on the downhill side. The speed differentials on the uphill side required more protection than the downhill side. This resulted in a narrow bike lane (4 foot wide, positioned next to a concrete curb) which could be used by vehicles when necessary on the uphill side and a shared travel lane on the downhill side. As of May, 2019, I have heard that Somerville has chosen to install at least one more of these

Figure 21 Half ABL in Somerville, MA (Courtesy of Phil Goff, Alta Planning+Design)

2. Shaw Road in Gibsons, B.C. in Canada was slated to receive an ABL but political concerns forced the installation of a half-ABL. This was installed in 2017. Google street view does not yet show the facility.

488 Shaw Rd
Gibsons, BC V0N 1V8, Canada

Figure 22 Half ABL in Gibsons, B.C.
(Courtesy Gavin Davidson, Alta Planning+Design)

49.400764, -123.518642

https://goo.gl/maps/QzzmzLq6fEp

1. Oosterstraat in Utrecht, Netherlands has a short segment preceding an intersection with Zonstraat which appears to feature a half ABL. It is unclear exactly what one would call this facility since the street has a centerline. The line delineating the bike lane is broken which signifies permeability, the bike lane pavement is not contrasting and the other side of the street appears to have no bicycle facility at all. This could also be viewed as a short length of bike lane or long entry into the bike box at intersection.

Figure 23 Possible Half ABL in Utrecht (Courtesy Google)

Oosterstraat 3
3581 MK Utrecht, Netherlands
52.085649, 5.130713

2. Zonstraat in Utrecht, Netherlands features a contraflow half ABL. The street is one-way for vehicles but two-way for bicycles. It has no centerline, broken line delineation for the bike lane, a parking lane on the other side of the bike lane, the cobble layout pattern in the parking and bike lanes are the same but different from travel lane. Bikes traveling in same direction as cars ride in travel lane and contraflow bikes ride in bike lane. The street is narrow, approximately 17' wide. My guess is 5.5' for parking lane (the cars don't really fit inside the parking lane), 8' for travel lane and 4' for bike lane.

Figure 24 Half ABL on Zonstraat in Utrecht (Courtesy Google)

Zonstraat 41-43
3581 MP Utrecht, Netherlands
52.085337, 5.132565