Wide Outside Through Lanes: Effective Design of Integrated Passing Facilities

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Abstract

The function of wide outside through lanes as passing facilities is presented. Space requirements for safe, lawful, and comfortable same-lane passing between cycle traffic and a variety of larger vehicles under different conditions is discussed. Effective positioning of cyclists according to best cycling practices is used as a reference point around which overtaking facilities may be designed. Understanding of effective bicycle driving techniques allows roadway engineering to be done in a manner compatible with safe and lawful cycling.

Introduction

Ordinary (non-freeway) streets carry a diversity of vehicle types at a wide range of speeds. State law assigns operators of all of these vehicles the rights and responsibilities of drivers on roadways. In order to reduce potential social friction and user stress among drivers who wish to travel at different speeds, traffic engineers often design roadways to facilitate overtaking. When a driver traveling in a marked lane overtakes a narrow vehicle (such as a bicycle), the width of the lane is a critical factor in the driver's decision to pass by either (a) changing lanes, or (b) staying within the same lane as the narrow vehicle. Changing lanes to pass requires a driver to find an appropriate gap in traffic in the adjacent lane. Under most conditions this can be done easily and conveniently. But if there is substantial traffic in the adjacent lane, or if sight lines are poor, the driver may have to wait some time for an appropriate passing opportunity. The driver must meanwhile travel at the speed of the slower traffic.

The overtaking of bicycle traffic by automobile traffic has gained particular interest among the public and the traffic engineering community because of the potential difference in speeds and the popularity of both modes for travel on important roads that serve important destinations. Some motorists may feel inconvenienced by the presence of bicycle traffic, and some cyclists may feel intimidated by situations where they believe they may be creating inconvenience for automobile users. In traffic situations where changing lanes to pass cyclists may be awkward or inconvenient, traffic engineers may facilitate passing without changing lanes by providing adequate pavement space for such overtaking to occur at safe and legal distance. Drivers wishing to overtake slower users are relieved of the legal and necessary burden of yielding to the adjacent line of traffic when that traffic is positioned far enough to the left. This can be facilitated through design by moving the left-hand lane stripe far enough to the left, creating a wider lane. An example of such a wide lane is shown in Figure 1.

Figure 1: This wide lane allows automobile drivers to easily overtake cyclists without changing lanes, and is comfortable for casual cyclists to use even cycling two-abreast. (Wayne Pein Photos)

Wide lanes are sometimes referred to as bicycle facilities in traffic engineering literature. But strictly speaking, wide lanes are not required for bicycle travel, which is allowed on all ordinary roads; the extra width provides an optional improved passing facility. Roads with narrow lanes often carry substantial bicycle traffic; drivers of wide vehicles cannot pass these cyclists at safe and lawful distance without moving into the next lane, as shown in Figure 2. This is the typical practice seen on narrow-lane roads. But cyclists occasionally experience drivers attempting to pass at unlawfully close and unsafe distance within the same narrow lane, particularly when there is traffic occupying the adjacent lane. Although unsafe passing is primarily a law enforcement issue, this behavior is less common in wide lanes. As a result, many cyclists as well as motorists are proponents of wider pavement on roads that carry substantial traffic as a way to minimize the potential for conflict.

Figure 2: This 10' wide lane does not provide enough room for automobile drivers to overtake cyclists at safe and lawful distance within the same lane. Automobile drivers routinely move into the adjacent lane to pass. (Wayne Pein Photo)

Wide lanes work equally well for motorists overtaking other low-speed narrow vehicles such as mopeds and motor scooters, and depending upon width, facilitate overtaking of stopped busses, delivery trucks, and slowed right turning vehicles. Bicyclists also enjoy such passing advantages when they are the faster vehicle.

As the number of automobile-cyclist overtaking events increases, the community benefit of enhanced passing facilities increases. But there are a large number of factors that may affect the decision to outfit a road with such a space arrangement. These may include bicycle and motor vehicle traffic volumes, design speed, cyclist demographics, available right of way, cost of construction, and pedestrian crossing distances. Communities will likely weigh these issues on a case-by case basis, and may choose to concentrate on education and enforcement to promote safer behavior by overtaking motorists in those areas where roadway improvements are not made. A discussion of the effects of bicycle traffic on trip time and roadway capacity is provided by Forester [1]. Warrants or guidelines for when to provide passing facility enhancements are outside the scope of this article. Also, since different streets will carry different types of traffic at different concentrations and speeds through different types of neighborhoods, there is no perfect, one-size-fits all overtaking facility design that is always most appropriate. This article concentrates on the functional design issues related to best practices of bicycle operation and safe, lawful overtaking so that road designers can apply these basic principles to different streets in context.

How Much Width?

The total width required to afford safe, lawful, and comfortable overtaking of cyclists by wider vehicles includes the width of the vehicles, users' shy distance to each side of the travel lane or adjacent traffic, and adequate spacing between them. The relationships between these distances are illustrated in Figure 3.

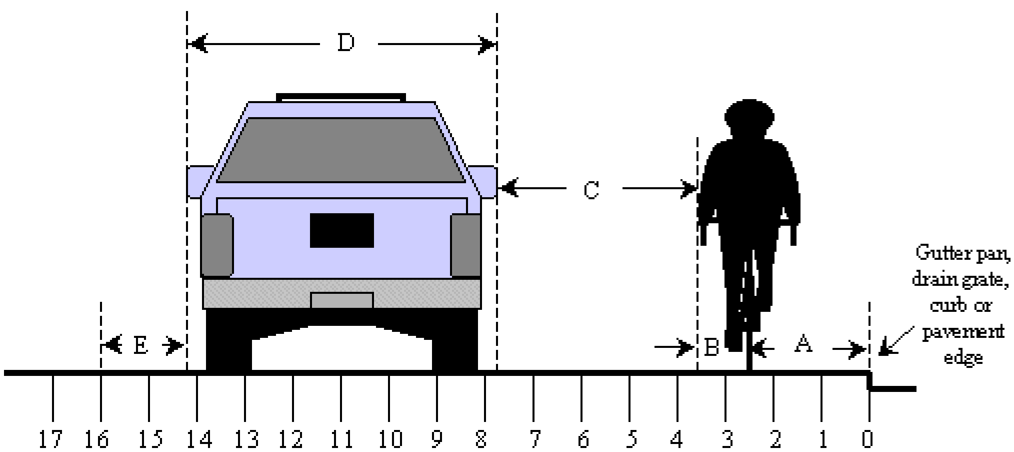

Figure 3: Distribution of space required to accommodate parallel operation of a bicycle and a typical motor vehicle (e.g. an SUV).

The component distances are as follows:

> A. Shy distance on the paved surface between the cyclist's wheels and the gutter pan seam, drain grate, curb, or other surface discontinuity, whichever is closest. This space is required for maneuvering, balance and recovery. Typically between two and four feet, this may be even wider when descending a hill at high speed, when sight lines are poor, or where edge surface conditions are poor, and may be narrower at slower speeds or where the gutter pan is smooth and flush with the travel lane. On non-curb-and-gutter roadways, the cyclist's tires should also be assumed to be to the left of the fog line in order to avoid debris on the shoulder or to avoid a right-turn-only lane if present.

B. One-half of the width of the cyclist (typically just over one foot) or, in the case of wider vehicles such as trikes and trailers, the distance of the left edge of the vehicle to the rightmost wheel.

C. Passing distance between cyclist and automobile - three feet is the legal minimum in those states that define it specifically for overtaking of cyclists; most DOTs and state-endorsed safety materials recommend this as an absolute minimum. This minimum space is recommended because cyclists are exposed and thus more vulnerable on open vehicles, because they require some wiggle room for balance and recovery, and because wind blasts from passing vehicles can destabilize cyclists. Drivers are always required by law to operate safely, and as vehicle speeds increase, more that three feet of passing space is required for safety. At slow speeds, some cyclists feel comfortable with less than three feet of clearance space provided that they have three feet or more of recovery area to their right. Empirical evidence on real-world streets typically yields average passing distances of four to five feet, and substantially more where traffic and roadway space allow.

D. Width of the motor vehicle including mirrors, typically just over 6 feet for SUVs, and about 9 feet for buses, commercial trucks and RVs.

E. Shy distance between the motor vehicle and the adjacent traffic lane. Comfortable distance is usually at least one foot.

As shown in Figure 3, when a cyclist operating with his tires 2.5 feet from the gutter seam is passed by an SUV at a typical distance of about four feet, the left side of the SUV will be about 14 feet from the gutter. With 12-foot lanes, the driver encroaches two feet into the adjacent lane. (Real-world road cyclists observe that such encroachment is fairly typical on roads with 12' lanes) A 14-foot wide lane accommodates this overtaking maneuver with no shy distance to the adjacent lane, but with little or no encroachment. A 16-foot wide lane provides about two feet of shy distance to the left edge of the lane. This shy distance is most desirable where there is oncoming traffic in the adjacent lane or if the left edge of the lane is bordered by a raised center median.

Any increase in lane width above 12 feet can provide some improvement in passing convenience and comfort under many conditions, even if it is just reducing the amount of encroachment by overtaking drivers into the adjacent lane. The more width is provided, the greater the number of different vehicle types (such as vans and wide trailers) that can pass at safe distance without crossing the lane line, and the greater the buffer space provided by drivers of normal-width cars. A width of 13 feet is better for overtaking than 12; 14 is better than 13; 15 is better than 14. The North Carolina Department of Transportation publication *North Carolina Bicycle Facilities Planning and Design Guidelines* makes the following recommendations:

> *On roadways that accommodate [passing between] both bicycles and motor vehicles within the travel lanes, 4.2 m (14 feet) of usable width should be provided on the outside through lanes. Studies have shown that any additional width on outside through lanes is beneficial. In determining the usable width of an outside through lane, adjustments need to be made for obstructions. Bicyclists shy away from obstructions such as drainage grates, parked vehicles and longitudinal ridges between the pavement and gutter sections. An extra 0.3 m (1 ft) of "shy distance" should be added for flush or depressed obstructions, such as a joint or soft shoulder.*

Figure 4 shows the typical positioning of a cyclist and automobile driver comfortably sharing a 16' lane side-by-side.

Figure 4: Comfortable cycling and same-lane overtaking in a 16' wide lane. (Wayne Pein Photo)

Many municipalities use standard lane widths of 16 feet for two-lane roads because this width allows cars and emergency vehicles to pass parked or disabled vehicles without crossing the center line or mounting a center median if present. A 16-foot lane also provides just enough space for a city bus or truck to pass a cyclist safely when done at slow speed, as shown in Figure 5. Figure 6 depicts an SUV driver overtaking to the right of a cyclist preparing to turn left from near the center of the roadway, as the cyclist is required to do by state law. Left-turning cyclists prefer to have some shy distance between their left hand signal and oncoming traffic. A 16-foot wide lane provides this space plus adequate space for safe and lawful overtaking by the SUV driver. Figure 7 depicts a cyclist safely and lawfully overtaking a stopped city transit bus.

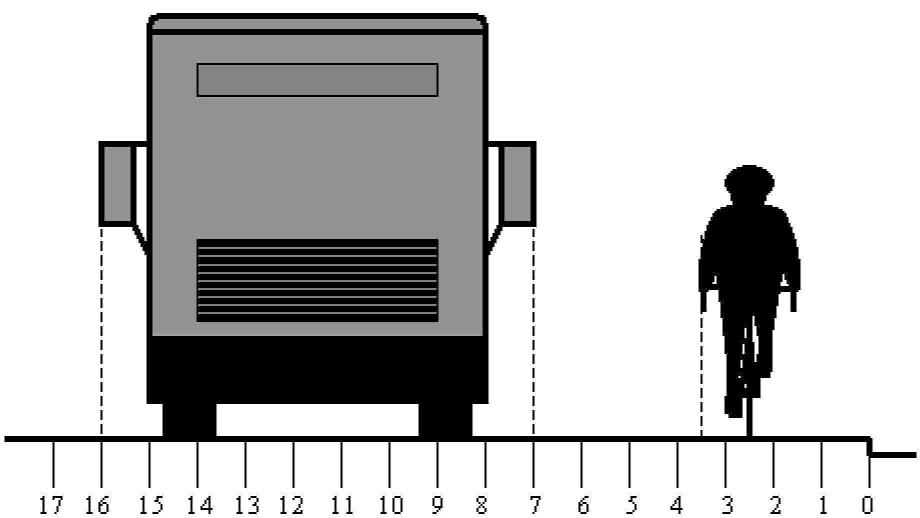

Figure 5: Minimum space required for low-speed overtaking by a city bus with a mirror span of 9 feet. Greater passing distance is required if the bus is traveling at high speed.

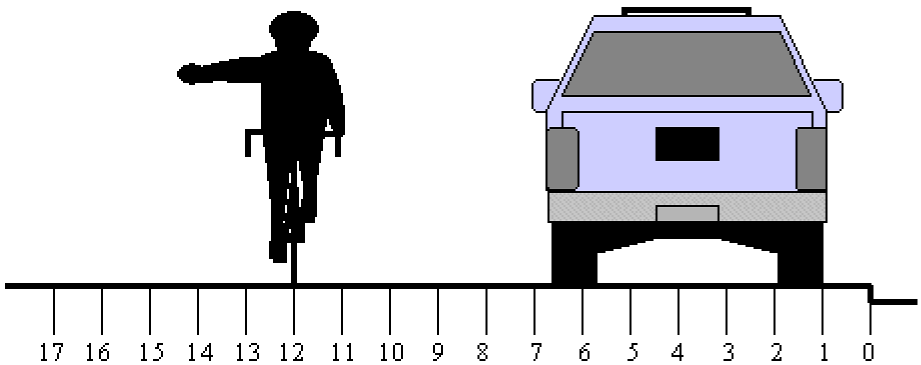

Figure 6: SUV overtaking to the right of a left-turning cyclist.

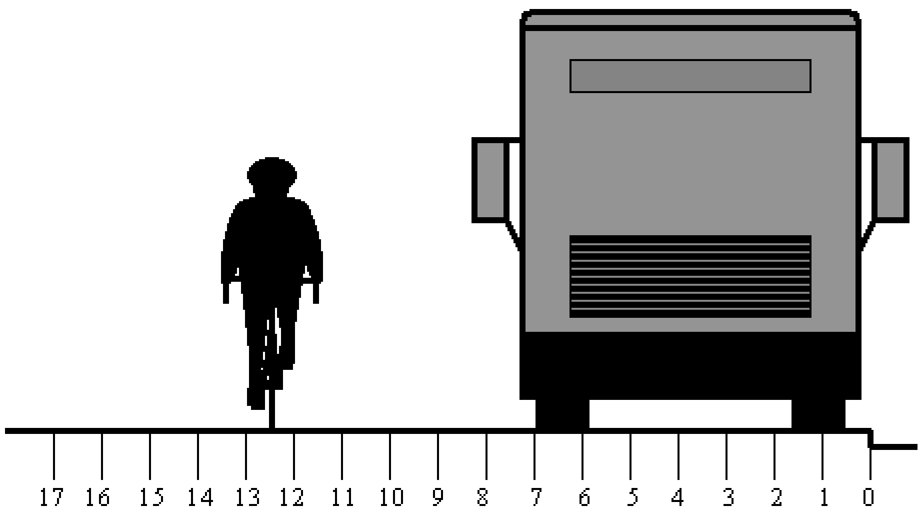

Figure 7: Cyclist overtaking to the left of a stopped city transit bus.

When large vehicles such as trucks and buses overtake a cyclist at high speed, the wind blast can destabilize the cyclist and cause him or her to swerve in a hazardous manner. This wind blast is a function of distance and speed, as shown in the chart in Figure 8. This chart appears in *North Carolina Bicycle Facilities Planning and Design Guidelines*. For higher-speed arterial roads carrying truck traffic at speeds of 50 mph and above, the minimum distance for a tolerable wind blast force ranges from four to six feet. But "tolerable" is likely a stronger wind blast than what would be considered "comfortable" by some cyclists. Roadway designers may wish to consider providing greater passing distance where high speeds and/or volumes of truck traffic are expected. Education and enforcement of vehicle operators to reduce their speed when passing is another strategy that can improve cyclist safety and comfort.

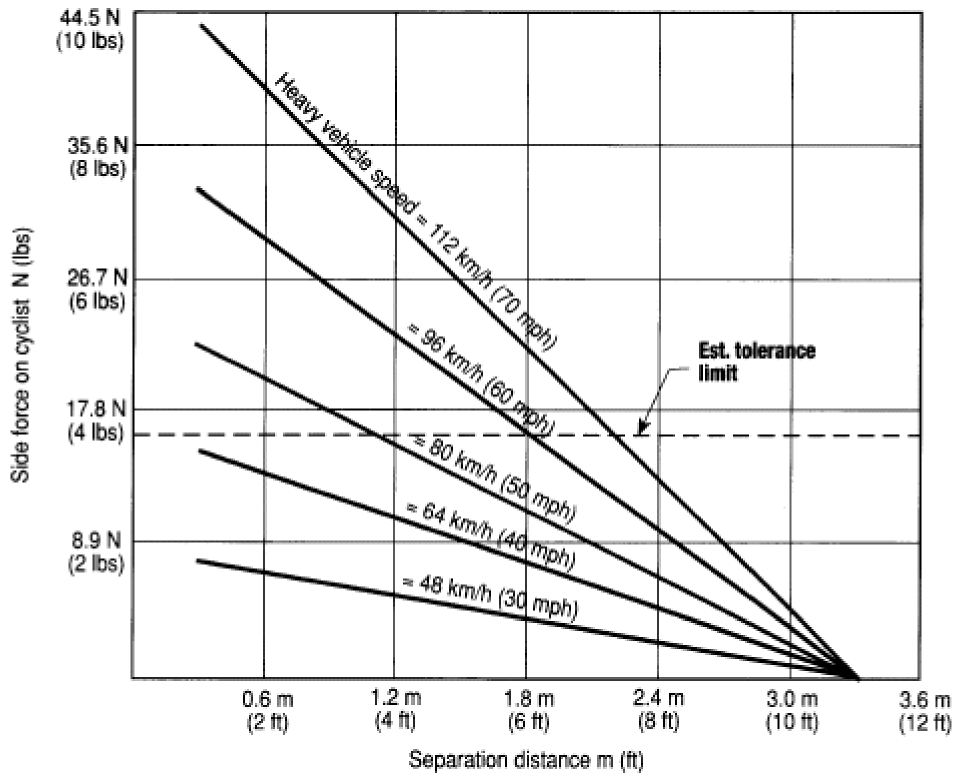

Figure 4-8: Aerodynamic forces caused by heavy motor vehicles passing bicyclists.

Source: A Bikeway Criteria Digest; USDOT Federal Highway Administration, 1977.

Figure 8: Wind blast forces on cyclists overtaken by heavy motor vehicles as a function of distance and speed.

The *North Carolina Bicycle Facilities Planning and Design Guidelines* suggests that 16 feet is the desired minimum amount of total space for safe and comfortable passing of cyclists. In the section on bicycle lane widths, the Guidelines states:

> *Under ideal conditions, minimum bicycle lane width is 1.2 m (4 ft). However, certain edge conditions dictate additional bicycle lane width. Additional width is also desirable if the width of the adjacent traffic lane is less than 3.6 m (12 ft). This is an important addition because the effective clearance between bicyclist and the adjacent traffic is a function of the combined width of both the bike lane and the adjacent traffic lane.*

From the preceding analysis, it should be obvious why many cyclists report greater comfort operating where 16 feet of total pavement width is provided for side-by-side operation (bike lane stripe or not) compared to narrower roads with the same traffic volume. Note that bike lane striping can be described accurately as the segregation of traffic by vehicle type within a through lane that is 16' wide or wider. Segregation by vehicle type has numerous disadvantages, especially where it conflicts with proper destination positioning (such as in Figure 6) or speed positioning (as in Figure 7), and has never been shown by scientific study to improve safety for cyclists. For deeper analyses comparing plain wide lanes to segregated lanes, see Pein [2], [3], and Goodridge [4]. For additional discussion of optimum wide outside lane widths, see Pein [5].

Placement of Wide Outside Through Lanes

There has been very little discussion in the highway engineering literature of how to effectively configure wide outside lanes at intersections. This is an important topic, because ineffective allocation of roadway space at intersections may waste the opportunity for easier overtaking or discourage safe and lawful positioning of cyclists traveling through the intersection. When provided in the context of bicycle transportation, a wide outside lane should normally be *a through lane*, not a right-turn-only lane. This is because if most of the traffic is headed straight through the intersection, and cyclists operate lawfully in the correct lane for their destination, then most of the same-lane automobile-overtaking-bicycle events will occur in the rightmost through lane. Traffic in the right-turn-only lane will be lower in volume, as well as comparably slower in preparation for the turn. The *North Carolina Bicycle Facilities Planning and Design Guidelines* uses the term "through lane" extensively in its discussion of wide outside lanes; for instance, from page 27: "At intersections with separate right-turn-lanes, the outside through lane should be widened...."

An example of a wide outside through lane beside a right-turn-only lane is shown in Figure 9. If the through lane turns into a right-turn-only lane, cyclists must merge left into the through lane. To provide the same overtaking benefits for through-traveling automobile drivers, the space in the outside lane must be redistributed to the through lane. This can be accomplished with a taper, as shown in Figure 10. The distance over which this transition takes effect should be on the order of a hundred feet or more in order to allow cyclists time to negotiate a merge prior to reaching the intersection.

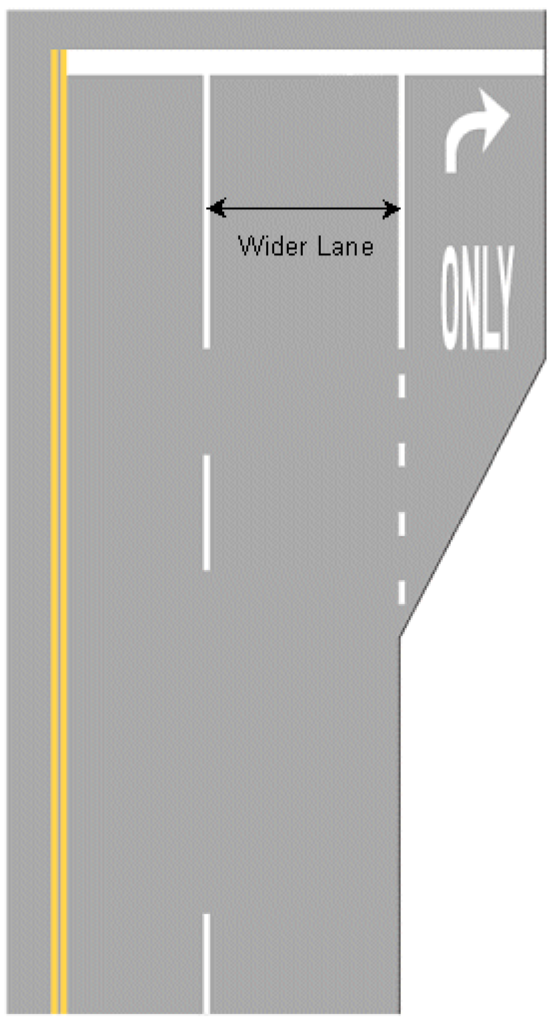

Figure 9: Design of a wide outside through lane at an intersection.

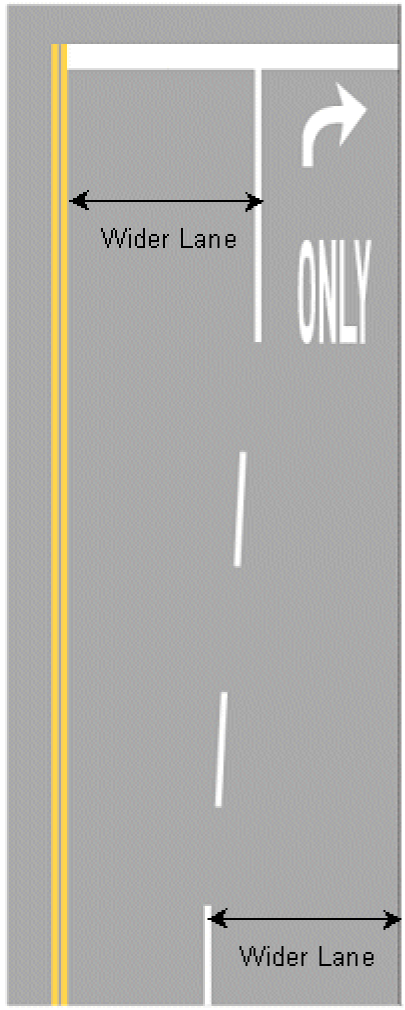

Figure 10: Transition of space where an outside lane becomes a right-turn-only lane. Taper distance is shown compressed for schematic illustration purposes.

Long, high-speed right-turn-only lanes can make cyclists uncomfortable where they result in traffic overtaking cyclists on both sides at high speeds. This becomes especially uncomfortable for cyclists if the through lane is narrow, thus increasing their friction with through traffic. Keeping the through-lane substantially wider than the right-turn-only lane encourages through-cyclists to stay in the correct lane. Minimizing the use of high-speed right-turn-only lanes in general may also improve cyclist comfort and reduce the problem of improper cycling.

On-Street Parallel Parking

On-street parallel parking requires cyclists to allow themselves additional shy distance away from the door zone. The sudden opening of car doors directly in front of cyclists is a common cause of bicyclist crashes and injuries in urban areas (see survey of research by Allen [6]). Cyclists are more narrow than approaching automobiles and are therefore more likely to go undetected by passengers about to disembark from parked cars. A cyclist operating at speed will often be unable to stop or merge to the left safely in time when a door is opened without warning. For these reasons, traffic cycling training provided by organizations such as CAN-Bike and the League of American Bicyclists teaches cyclists to ride at least five feet away from the side of parked cars to eliminate the risk of dooring.

Some traffic engineering departments have attempted to facilitate convenient automobile-overtaking of cyclists by directing cyclists to ride within the door zone by marking bike lane stripes and stencils in the door zone, as shown in Figure 11. Experts in cycling safety charge that this is a highly unethical practice that directly contradicts safe-cycling instruction and best bicycling practices. Cyclists operating in door-zone bike lanes have been injured and killed (see Allen, [7]) as the result of the sudden opening of doors.

Figure 11: Left: A door-zone bike lane. (www.bicycledriver.com photo) Right: Scene of a cyclist fatality that resulted from a dooring incident in a door-zone bike lane in Cambridge, MA. (Robert Winters Photo)

If space for overtaking of cyclists operating in a safe manner is to be constructed in the vicinity of on-street parking, the cyclists' shy distance must be increased to keep them well outside of the door zone. A discussion of door zone width and a table of widths for different vehicles is provided by John Allen in [8]. Figure 12 shows the spacing of an SUV overtaking a cyclist tracking a safe distance (B+A+DZ) away from a parked SUV of width W located at a distance F from the edge of the parking space. The width required for a city bus to make the same maneuver is shown in Figure 13. If this space cannot be provided with a wide enough lane, then cyclists should be encouraged through an education campaign to operate near the center of the travel lane, and motorists should be encouraged and enforced to change lanes to pass cyclists.

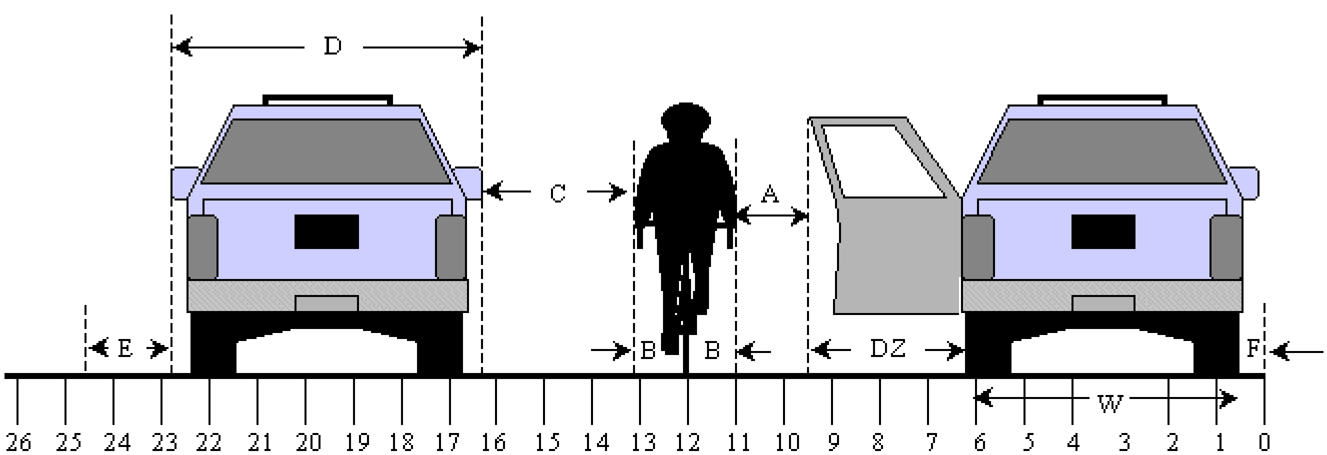

Figure 12: An SUV overtaking a safely-operating cyclist traveling beside on-street parking.

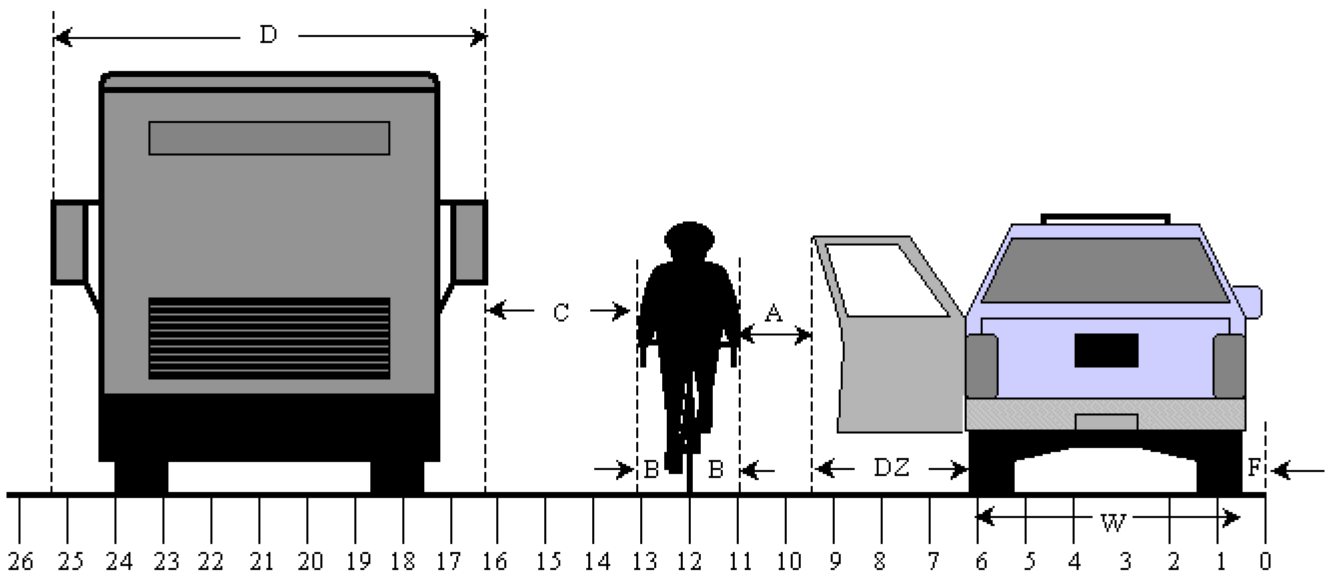

Figure 13: A city bus overtaking a safely-operating cyclist traveling beside on-street parking.

Conclusions

Engineering impacts on the safety, comfort, and convenience of motorist-overtaking-cyclist events are primarily a function of the provided pavement space. Passing-facility enhancements can make cycling more pleasant, but they are not bicycle facilities; the cycling facilities are, by state law, already there. Travel lanes narrower than 12 feet do not allow drivers of cars and wider vehicles to pass cyclists entirely within the same lane at safe and legal distance. Lanes substantially wider than 12 feet, e.g. 14 to 16 feet, allow for more possibilities for same-lane passing among a wider variety of vehicle types, with greater safety and comfort for both cyclists and overtaking drivers. Where right-turn-only lanes are provided at junctions, lane width enhancements related to overtaking of cyclists should be placed in the through lane where through-cyclists will operate. Near on-street parking, design of overtaking facilities must accommodate the need for cyclists to operate well outside the door zone. Since overtaking facility improvements are not feasible or advisable everywhere, public education and enforcement are important to remind overtaking operators of their duty to respect the safety and travel rights of slower operators in travel lanes.

References

[1] John Forester, Bicycle Transportation, 2nd Edition, MIT Press, 1994, also here.

[2] Wayne Pein, Wide Outside Lanes are Superior to Bike Lanes

[3] Wayne Pein, Critique of FHWA Bike Lane Versus Wide Curb Lane Study

[4] Steven Goodridge, Bike Lane Stripes: Do They Improve Conditions for Cycling?

[5] Wayne Pein, How Wide Should a Wide Lane Be?

[6] John Allen, Car-Door Collisions: A survey of research

[7] John Allen, The Dana Laird Crash

[8] John Allen, Measurements of widths of motor vehicles