How Wide Should a Wide Lane Be?

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Introduction

Roads and travel lanes come in a variety of widths. Two-foot-wide bicycles easily fit on any road. Thus, additional lane width on traffic-intense roads to "accommodate" bicyclists, whether as a Wide Outside Lane (WOL) or a Bike Lane (BL), is first an enhancement to enable easier overtaking of bicyclists by motorists, and second, an improvement for bicyclist comfort. WOLs are simply wider normal lanes, essentially like a BL road without the BL stripe (Figures 1 and 2).

Figure 1. A 4 ft BL with 12 ft standard lane.

Figure 2. A 16 ft WOL, BL stripe removed.

Professional consensus has heretofore assigned the optimal width of WOLs to between 14 and 16 feet from edge of usable pavement to lane line. But the 2 foot difference between 14 and 16 feet is huge, especially given that bicycles are only 2 feet wide. Moreover, there is broad confusion and misinterpretation regarding appropriate WOL width and its consequences, which has led to false indictments of WOLs. This paper is an attempt to examine the issues and shed light on pervasive confusion.

Literature Review

AASHTO's 1999 *Guide for the Development of Bicycle Facilities* states (p. 17): "In general, 4.2 m (14 feet) of usable lane width is the recommended width for shared use in a wide curb lane....On stretches of roadway with steep grades where bicyclists need more maneuvering space, the wide curb lane should be slightly wider where practicable [4.5 m (15 feet) is preferred]. The 4.5-m (15-foot) width may also be necessary in areas where drainage grates, raised reflectors on the right-hand side of the road, or on-street parking effectively reduce the usable width."

The *Guide* also notes, "With these exceptions in mind, widths greater than 4.2 m (14 feet) that extend continuously along a stretch of roadway may encourage the undesirable operation of two motor vehicles in one lane, especially in urban areas, and therefore are not recommended." This specious comment will be examined in detail in this paper.

The *Guide for the Development of Bicycle Facilities* contradicts AASHTO's own *A Policy on Geometric Design of Highways and Streets*, the "Green Book" and "bible" for highway designers which states (p. 122): "Wide outside traffic lanes (**15 foot minimum** if no shoulder)."

The Federal Highway Administration's (FHWA) *Selecting Roadway Design Treatments to Accommodate Bicycles* advises 14 to 16-foot lanes depending on the number of lanes, motor traffic intensity, sight distance, and the presence or absence of on-street parking.

Bicycle Transportation, 1994, by John Forester recommends the following widths shown in tables reproduced below:

Table 24-1. Lane Widths Required for Lane Sharing on Two Lane Roads.

Speed of Motor Traffic (mph)	Outside Lane Width (ft)
25-44	14
45-65	16

Table 24-2. Lane Widths Required for Lane Sharing on Multi-lane Roads.

Speed of Motor Traffic (mph)	Outside Lane Width (ft)
30-44	12 is tight; 14 better
45-64	14
65+	16

Forester recommends slightly less space on multi-lane roads than two-lane roads for a given speed because the greater overall width of multi-lane roads affords additional leeway.

The NCDOT *North Carolina Bicycle Facilities Planning and Design Guidelines* says "On roadways that accommodate both bicycles and motor vehicles within the travel lanes, 4.2 m (14 ft) of usable width should be provided on the outside through lanes... Some experts have recommended 4.5 m (15 ft) of usable width.... However, widths greater than 4.2 m (14 ft) can encourage the operation of two motor vehicles in one lane. This is likely to occur near intersections with heavy turn volumes during periods of peak congestion. Such conditions may reflect the need to consider improvements at the intersection." The last two sentences are pivotal.

Discussion
Engineers typically specify 12-foot lanes as ideal minimum when providing strictly for motor traffic. Level of Service (LOS) analysis is performed by making adjustments for "less-than-ideal" conditions, one of which is lanes less than 12 feet. However, when providing lanes wider than 12 feet for "bicycling" enhancement (easier motorist overtaking, bicyclist comfort, and improved operations), there is confusion as to what is ideal. Fourteen feet have often been advised, but how can this be ideal when it is only 2 feet wider than the ideal 12 feet, and a bicycle is 2 feet wide?

Further, a standard 12-foot lane plus a standard BL of 4 feet totals 16 feet. Additional width should be added to the BL when the standard lane is narrower than 12 feet. The *North Carolina Bicycle Facilities Planning and Design Guidelines* states, "Additional width also is desirable when the width of the adjacent traffic lane is less tan 3.6 m (12 ft). This is an important addition because the effective clearance between a bicyclist and adjacent traffic is a function of the combined width of both the bike lane and the adjacent traffic lane." In essence, the total pavement width when BLs are present should be 16 feet or more. Why then is a mere 14 feet considered acceptable when a WOL is specified? Given that much emphasis is placed on bicyclist "comfort" from overtaking motor traffic — it is the reason BLs or WOLs are specified in the first place — it is logical to question the relatively narrow 14 foot specification.

Figure 3. A 16 foot WOL is the same width as a typical BL road.

The 2000 Highway Capacity Manual assigns "passenger-car equivalents" for bicycles in lanes of different widths. In a lane less than 11 feet wide, a bicycle is equal to 1.0 or 1.2 cars, depending on whether the bicyclist's movement is unopposed or opposed (making a left turn). If the lane is 11 to 14 feet wide, the figures are 0.2 or 0.5. However, in lanes wider than 14 feet a bicycle is equal to 0.0 cars. In other words, in narrower lanes a bicycle takes up some space, reducing roadway capacity (as do motor vehicles), but in lanes greater than 14 feet a bicycle has zero negative impact (Figures 4 and 5 below). This provides strong rationale for 15 or more feet.

Figure 4. In a 10-foot lane, bicyclists are considered to have the same capacity impact as 1.0 cars.

Figure 5. In a 15-foot lane (grate edge to centerline in this case), bicyclists have zero negative impact on roadway capacity.

WOL width recommendations of 14 feet have been based on providing the least amount of space to allow reasonable sharing at the least fiscal cost. There is no reason 14 feet must be adhered to where it has been recommended; 15 or 16 feet can be used. There exists, however, broad confusion regarding the possibility of motorist/motorist lane sharing in WOLs of 15 or 16 feet. Like a virus, this myth has often been repeated in various publications.

The FHWA sponsored research performed by the University of North Carolina Highway Safety Research Center comparing BLs and WOLs (Hunter, et al., 1999). On two separate occasions the study states that wide curb lanes (WCLs) that are too wide are undesirable. It says, "A desirable width for WCLs is 4.3 m [14.1 ft]. Lanes wider than 4.6 m [15.1 ft] sometimes result in the operation of two motor vehicles side by side" [ft added for clarity]. It says elsewhere, "WCLs should be 4.0 [13.1 ft] to 4.6 m [15.1 ft] wide to provide enough width for lane sharing but not so much width that motorists form two-lanes at intersections (McHenry and Wallace, 1985)."

However, in this FHWA study the *average* width of 16 WCL study sites was 4.7 m (15.4 ft), which is wider than the supposed recommended maximum 4.6 m (15.1 ft) that allegedly results in the claimed deleterious effect of doubling up of motor vehicles. Although this alleged effect was deemed important enough to mention two times in its literature review, it was not found in this study. But the result that no effect was found was not reported, and so the cycle of misinformation was again prominently allowed to continue.

The assertion of motorist/motorist lane sharing along a stretch of roadway with 15 or 16 foot widths is not supported by seminal research. Maryland Department of Transportation clinical studies found that on multi-lane highways, optimal lane width was greater than 13.8 feet and less than 17.6 feet, and suggested 15 feet as optimum pavement width for shared use saying, "Highway departments should promote increased lane widths within the normal construction program on closed section highways and bridges on which bicyclists are expected and permitted to 15.0 - 15.5 feet depending on traffic and bicycle volumes."(McHenry and Wallace, 1985; Jones, 1978).

As noted in the Literature Review above, the *North Carolina Bicycle Facilities Planning and Design Guidelines* says, "However, widths greater than 4.2 m (14 ft) can encourage the operation of two motor vehicle in one lane. This is likely to occur near intersections with heavy turn volumes during periods of peak congestion. Such conditions may reflect the need to consider improvements at the intersection."

Most publications that warn against lanes wider than 14 feet have failed to note that any doubling up of motor vehicles occurs not along midblock sections, but at high volume intersections that may need improvements. Unfortunately this has been promulgated as an indictment of WOLs. Further, drivers are observed to pass to the right of stopped traffic if the pavement space exists, whether striped as BL or shoulder space or not, but these striped facilities are not denounced as encouraging or enabling this alleged poor behavior.

Many cities have very wide lanes as standard design for two-lane collector streets. The standard 2-lane collector road for Cary, NC for example is 32 feet total, comprising two 16-foot lanes. This allows motor vehicles to pass the occasional parked car without crossing the center line (marked or unmarked). Also, for two-lane roads with raised center medians and curbs, the standard width is usually a 16-foot lane minimum. This enables emergency vehicles, in particular fire trucks, to pass disabled or illegally parked vehicles. If doubling up of motor vehicles was a concern, municipalities would not have such wide lanes as standard designs.

Simply examining the relevant widths reveals that motorist/motorist sharing in a 15 or 16-foot lane is unlikely. Cars are about 6 feet wide and heavy trucks 8 feet, and typically track in the center of the lane, and no closer than about 2 feet from the left line. This leaves only 5-7 feet for another narrow motor vehicle on the right. To have motorist/motorist lane sharing in 15 or 16-foot lanes, both drivers must be purposefully illegally trying to do so, an unlikely scenario except at intersections (where the behavior may actually be desirable) or in very rare situations under stop or near stop conditions. If such behavior is observed, a sign such as FORM SINGLE LANE can be installed. It is also worth noting that the presence of a bicyclist prevents motorist/motorist lane sharing.

Similarly, analyzing widths and clearances is illustrative with respect to lane sharing with bicycles. A bicycle is 2 feet wide and tracks an average of 1.5 feet from the edge of pavement in a WOL (Pein, 1999). This should be considered a minimum. Thus, the bicyclist's left side is a minimum of 2.5 feet from pavement edge. A 6-8 foot motor vehicle tracking with its left side directly on the lane line will pass the bicyclist with 4.5-6.5 feet clearance in a 15-foot lane and 3.5-5.5 feet in a 14-foot lane. Figure 6 shows a heavy truck clearing a bicyclist by 4.5 feet without encroachment in a 15-foot lane. A 14-foot lane would result in encroachment or closer passing. Note that typical overtaking distance between motorist and bicyclist is 5.5 feet (Harkey and Stewart, 1997). A 6- foot wide passenger car would afford 2 more feet of clearance.

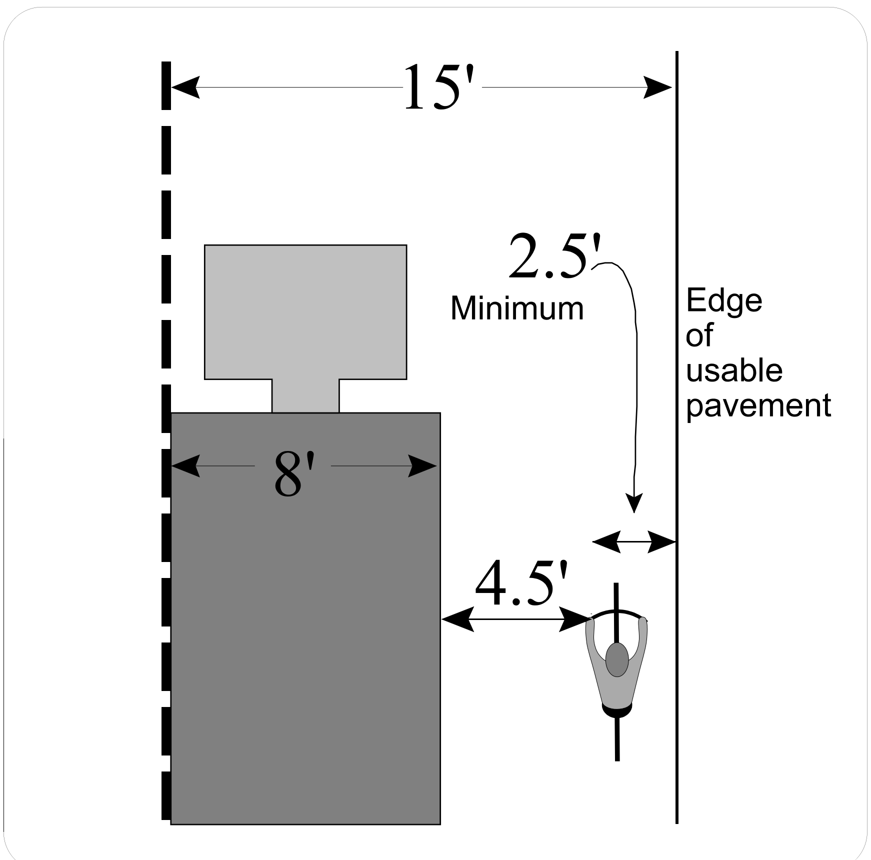

Figure 6. 15-foot lane spacing.

A Bikeway Criteria Digest, produced in 1977 by the Federal Highway Administration has a graph depicting side forces on bicyclists from passing heavy trucks, and provides operational rationale for increasing lane width and separation distance where speeds are very high (Figure 7 below). To stay below a tolerance limit of 4 lbs side load, bicyclists require a separation distance of approximately 5 feet from heavy vehicles traveling 55 mph. At 60 mph the separation requirement is 6 feet.

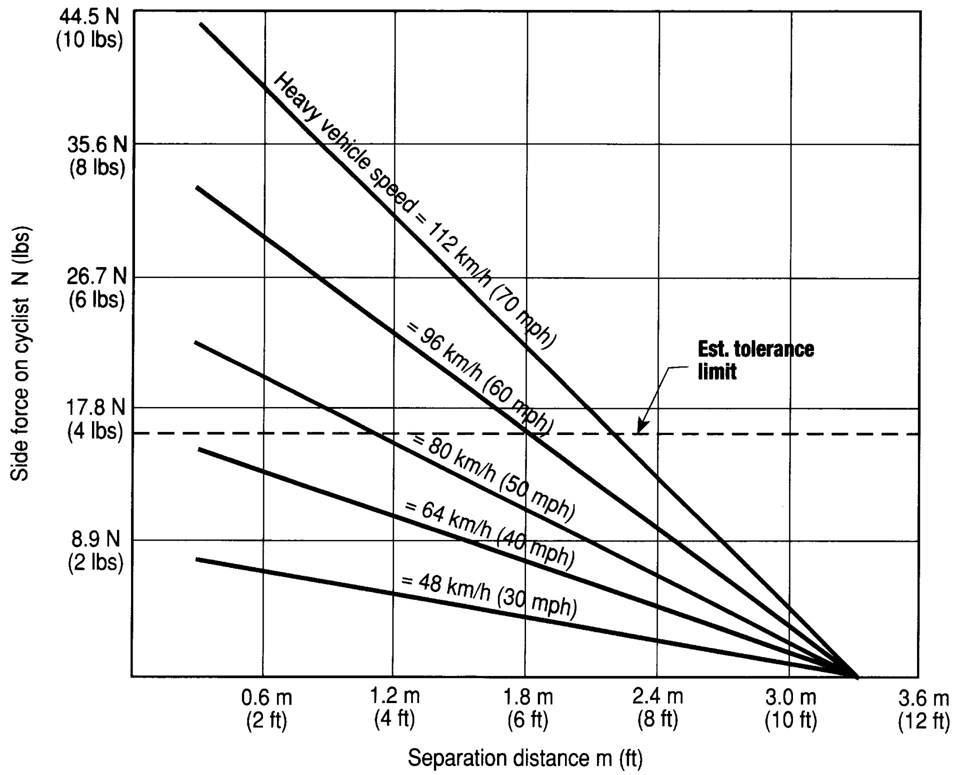

Figure 4-8: Aerodynamic forces caused by heavy motor vehicles passing bicyclists.

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

Figure 7. Wind blast force from heavy trucks.

Conclusions and Recommendations

The preponderance of research and empirical evidence indicates the ideal width of WOLs to be 15 feet for most conditions. Where there is significant heavy truck traffic and higher speeds, 16 feet may be warranted as long as debris is not expected to accumulate at the side to effectively reduce the usable width.

A 14 foot lane is just a bicycle's width wider than the "ideal" 12 foot motor vehicle lane width, results in bicyclists having a 0.2 or 0.5 passenger-car-equivalents capacity impact, and necessitates closer passing or more encroachments than a 15 foot lane. A 15 foot lane approaches the 16 feet of standard lane plus BL total width, results in bicyclists having zero capacity impact, and affords greater passing clearance and less likelihood of encroachment.

False assertions that there is motorist/motorist lane sharing in lane widths of 15 and 16 feet have resulted from misinterpretation of research. This misconception has been repeated in various publications, which have failed to acknowledge that this effect occurs not on road sections, but at heavy-volume intersections that may need additional intersection improvements. This misinterpretation has resulted in an unfortunate and false indictment of 15 and 16-foot WOLs.

Opposition to and indictment of wide lanes has also come from those who believe that this pavement width increases speed, and assert that creating narrower "motor vehicle" lanes with BL stripes will slow motor traffic. However, *Traffic Calming: State of the Practice* published in 1999 by the Institute of Transportation Engineers states that, "In theory, the perceived narrowing could cause a modest speed reduction, just as a real narrowing causes a modest speed reduction. The theory is not borne out by empirical studies. Results from Howard County, MD, Beaverton, OR, and San Antonio, TX, suggest that vehicle operating speeds are as likely to increase as decrease with striping. One explanation is that centerlines and edgelines define the vehicle travel path more clearly, creating a gun barrel effect."

An outside lane that is too wide is more likely to accumulate debris at its right side. Motor vehicle tire and wind blast sweeps debris to the side. If the lane is 15 feet wide or less, motor vehicle lateral variability is more likely to result in debris' being swept laterally enough to be completely out of bicyclists' traveled way. This is safer and more pleasant for bicyclists, and obviates the need for costly municipal debris removal. At widths greater than 15 feet, debris is more likely to remain on pavement and possibly in bicyclists' traveled way. More and faster heavy truck traffic has a greater debris sweeping effect, and so may keep lanes wider than 15 feet clearer.

Figure 8. This 22 foot lane results in debris reducing the usable width. Cameron Avenue, Chapel Hill, NC.

References

American Association of State Highway and Transportation Officials. *Guide for the Development of Bicycle Facilities*, 1999. https://www.transportation.org/publications/bookstore.nsf/ViewPublication?openform&ParentUNID=B727279D15B5225A862569AC006005E8

Federal Highway Administration. *Selecting Roadway Design Treatments to Accommodate Bicycles*. http://safety.fhwa.dot.gov/fourthlevel/design_b.htm

Federal Highway Administration. *A Bikeway Criteria Digest*. 1977.

Forester, J. *Bicycle Transportation*, Second Edition.1994.

Harkey, D., and R. Stewart. Evaluation of Shared-Use Facilities for Bicycles and Motor Vehicles. In *Transportation Research Record 1578,* TRB, National Research Council, Washington, D.C., 1997, pp. 111–118. http://safety.fhwa.dot.gov/fourthlevel/design_b.htm

Hunter, Stewart, Stutts, Huang, Pein. *A Comparative Analysis of Bicycle Lanes Versus Wide Curb Lanes: Final Report* (FHWA-RD-99-034), and *Bicycle Lanes vs Wide Curb Lanes: Operational & Safety Findings and Countermeasure Recommendations* (FHWA-RD-99-035). 1999. http://safety.fhwa.dot.gov/fourthlevel/design_b.htm

Institute of Transportation Engineers. *Traffic Calming: State of the Practice*. August 1999. http://www.ite.org/traffic/tcstate.htm#tcsop

McHenry, S.R. and Wallace, M.J. *Evaluation of Wide Curb Lanes as Shared Lane Bicycle Facilities*, Maryland State Highway Administration, Baltimore, Maryland, 1985.

Jones, G. *On Road Improvements for Bicyclists*; Baltimore County Traffic Engineering Dept., 1978.

Pein, W.E., *Evaluation of the Shared Use Arrow*. 1999. http://www.dot.state.fl.us/safety/ped_bike/ped_bike_reports.htm#Evaluation of the Shared-Use Arrow