Relationship Between Lane Width and Speed

Review of Relevant Literature

Prepared for the Columbia Pike Street Space Planning Task Force
by the Parsons Transportation Group
September 2003

Summary

Many factors influence a driver's choice of speed on an individual street. In addition to lane width, these factors include roadway curvature, roadside development, type of traffic control, and many others. It is challenging to isolate the effect of lane width on speed. Two general methods to quantify this relationship appear in the literature:

- ***Before-and-after studies of a single roadway segment (case studies).*** When a roadway is restriped to provide narrower lanes, before-and-after speed results can imply a relationship between speed and lane width. This method is desirable because when a single site is evaluated, the effects of lane width can be more carefully isolated. However, this method has two disadvantages. First, all restriping projects change something in addition to lane width. Even if curb lines are not changed, narrower lanes allow surplus pavement to be occupied by another feature, such as left-turn bays, on-street parking, or bike lanes—changes in speed may be attributable as much to these features as to the narrowed lanes. Second, because this method reports results from only a single site, the results are entirely dependent on characteristics of that site, and they may not apply to other sites with different characteristics.

- ***Studies of several roadway segments of varying lane widths.*** With this method, a researcher can determine the differences in speed among a large number of roadway segments with different lane widths and derive a relationship between lane width and speed. An advantage of this method is that it uses a much larger sample size, so the results are more likely to apply elsewhere. However, there are inevitably differences between the sites studied other than lane width. Lane width may contribute to all of the observed speed differences, or it may contribute to very little. For example, a street in downtown Washington with 12-foot lanes will probably have *lower* speeds than a commuter route into the city with 10-foot lanes. Researchers must attempt to select sites that minimize this source of error.

There is no consensus in the literature on the relationship between lane width and speed. Some studies have shown speed reductions of as much as 3 mph for every foot of lane narrowing; other studies show a more slight speed reduction of about 1 mph per foot of lane narrowing or no significant effect at all. The studies generally agree that there is wide variability between sites, suggesting that lane width alone is not responsible for the entire speed reduction.

Several studies have reported the use of lanes 10 feet wide (or slightly narrower) with no perceived operational difficulties to buses and trucks. The following examples of narrow streets exist in Washington, D.C:

- 18th Street, NW, between E and K Streets, has average lane widths of 9.5 feet and carries 9 buses per hour during peak hours.
- Connecticut Avenue, NW, between the Taft Bridge and Chevy Chase Circle, has average lane widths of 10 feet and carries 11 buses per hour during peak hours.

Buses measure about 8.5 feet in width, and side-view mirrors extend about a foot on either side, making the mirror-to-mirror width about 10.5 feet. Passenger vehicles measure about 6 feet in width, while large trucks and SUVs are often about 7 feet wide. Side-view mirrors usually add between 6 and 12 inches to vehicles' total width.

Although 10-foot-wide lanes are generally acceptable in the literature, there is a strong preference to provide wider curb lanes to ease bus operation, separate traffic from roadside drainage and drainage features, and better accommodate on-street bicycles. Often, curb lanes are assumed to be 2 feet wider than interior lanes.

Lane width does not appear to be correlated to collision rate. Narrower lanes have been both credited for reductions in collisions and blamed for increases in collisions. In both cases, lane width alone is not the primary cause of changes in collision rate. For instance, narrowing lanes to provide left-turn bays is very likely to decrease collisions, but the drop in collisions can be nearly entirely attributed to the left-turn provisions.

Annotated Bibliography

Copies of the documents summarized below are available upon request.

Harwood, Douglas W., "Effective Utilization of Street Width on Urban Arterials," National Cooperative Highway Research Program Report 330, Transportation Research Board, August 1990.

- "Projects where narrower lanes were installed to provide space for installation of a center two-way left-turn lane generally reduce accidents by 24 to 53 percent. Projects where narrower lanes were installed to provide additional through traffic lanes on an arterial street generally did not affect midblock accident rates, but did increase accident rates at intersections."
- "Four percent of highway agencies have used 8 ft lanes on urban arterials, while 42 percent of agencies have used lanes of 9 ft or narrower, and 88 percent of agencies have used lanes of 10 ft or narrower."
- "More than 67 percent of highway agencies that have implemented narrower lanes reported no adverse traffic operational or safety problems. Other agencies reported some specific problems including: increases in sideswipe accidents; straddling of lane lines, particularly by trucks and buses; and turning problems at intersections, particularly for trucks and buses."
- Lanes narrower than 12 feet reduce the capacity of a roadway. Streets with 11' lanes have 3% less capacity than streets with 12' lanes. Likewise, streets with 10' lanes have 7% less capacity than streets with 12' lanes; streets with 9' lanes have 10% less capacity than streets with 12' lanes.

- "Field observations do not suggest a major safety problem related to narrower lanes. It may be that many of the unforced encroachments on adjacent lanes are made in situations in which the driver is aware that no conflicting vehicles are present."
- "Narrower lane widths (less than 11 ft) can be used effectively in urban arterial street improvement projects where the additional space provided can be used to relieve traffic congestion or address specific accident patterns. Narrower lanes may result in increases in some specific accident types, such as same-direction sideswipe collisions."
- "Projects involving narrower lanes nearly always reduce accident rates [in conjunction with] installation of a center TWLTL[1] or removal of curb parking. . . . Projects involving narrower lanes whose purpose is to reduce traffic congestion by providing additional through lanes may result in a net increase in accident rate, particularly for intersection accidents."
- "Lane widths as narrow as 10 ft are widely regarded by urban traffic engineers as being acceptable for use in urban arterial street improvement projects. . . . Lane widths less than 10 ft should be used cautiously and only in situations where it can be demonstrated that increases in accident rate are unlikely. For example, . . . this study found that 9- and 9.5-ft through-traffic lanes can be used effectively in projects to install a center TWLTL on existing four-lane undivided streets. On streets that cannot be widened, highway agencies should consider limiting the use of lane widths less than 10 ft (1) to project types where their own experience shows that they have been used effectively in the past, or (2) to locations where the agency can establish an evaluation or monitoring program for at least 2 years to identify and correct any safety problems that develop."
- "Curb lanes should be wider than other lanes by 1 ft to 2 ft to provide allowance for a gutter and for greater use of the curb lanes by trucks."
- "Narrow lane projects do not work well if the right lane provides a rough riding surface because of poor pavement condition or the presence of grates for drainage inlets. . . . Projects with narrower lanes may be most satisfactory at sites with curb inlets that do not have grates in the roadway."
- "Curb lane widths of at least 15 ft are desirable to accommodate shared operation of bicycles and motor vehicles. . . . Decisions concerning implementation of projects with narrower lanes should consider the volume of bicyclists using the roadway and the availability of other bicycle facilities in the same corridor."

"Guidelines for the Location and Design of Bus Stops," Transit Cooperative Research Program Report 19, Transportation Research Board, 1996.

- "A traffic lane used by buses should be no narrower than 12 feet in width because the maximum bus width (including mirrors) is about 10.5 feet. Desirable curb lane width (including the gutter) is 14 feet."

Fitzpatrick, Kay, et al, "Design Speed, Operating Speed, and Posted Speed Practices," National Cooperative Highway Research Program Project 15-18 draft final report, July 2002. Summary published in **Transportation Research Board Compendium of Technical Papers, 2003.**

- "Access density is the number of access points (driveways and intersections) per mile. . . . Higher speeds [are] associated with lower access densities."

[1] TWLTL = Two-way left-turn lane

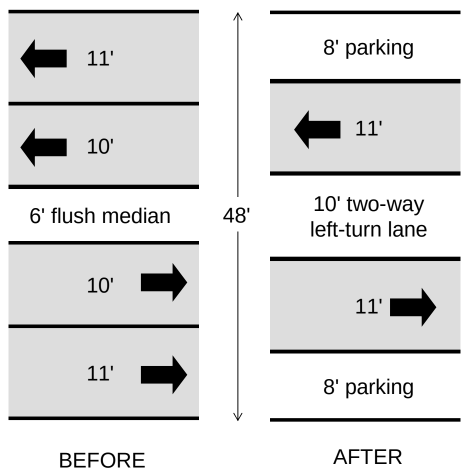
- "No relationship was apparent between lane width and speed."
- "While a relationship between operating speed and posted speed limit can be defined, a relationship of design speed to either operating speed or posted speed cannot be defined with the same level of confidence."
- "Design speed appears to have minimal impact on operating speeds unless a tight . . . curve is present."

Macbeth, Andrew G., "Calming Arterials in Toronto," Institute of Transportation Engineers Compendium of Technical Papers, 1998.

- "Toronto's arterial road traffic calming has relied on . . . a reduction in the number of traffic lanes. . . . On a four-lane street, drivers wishing to travel faster than others may simply change lanes to pass a slower vehicle. When a street has been narrowed to two lanes, . . . vehicle speeds are limited by the speed of the leading vehicle in a platoon."

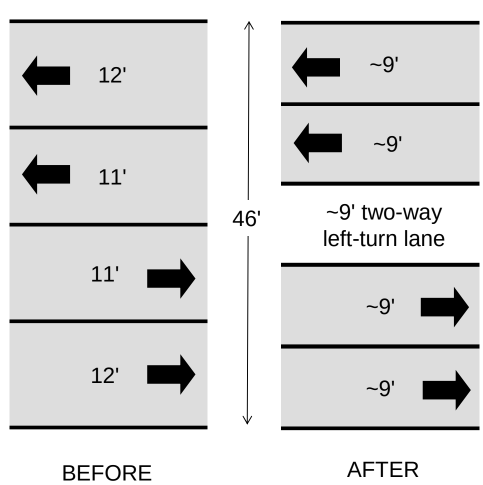
Skene, Michael, "'Traffic Calming' On Arterial Roadways?" Institute of Transportation Engineers Compendium of Technical Papers, 1999.

- "Most of the opposition [to traffic calming on arterial streets] . . . is from those who assume that traffic calming is a . . . movement to replace good engineering with bike lanes and slow inefficient traffic management schemes."
- Case study: Restriping of Cook Street corridor in Victoria, B.C., in November 1991. (See sketch at right.) The project's primary goal was reducing collisions, which were largely related to left-turning vehicles. Collisions dropped from 36 per year to 19 per year after the restriping. Average daily traffic is about 24,000 and dropped only slightly after restriping. Peak-hour volume dropped somewhat more; parallel arterial streets are available to accommodate traffic diversion. 85th percentile speeds were reduced from 32 mph to 29 mph, primarily due to loss of opportunities to pass slower-moving traffic.



Delabure, Brad; transportation planner, City of Victoria, B.C. Telephone conversation with R. Dittberner, September 22, 2003.

- Case study: Quadra Street corridor. As part of a landscaping and land-use revitalization project, the Quadra Street corridor was restriped from a 4-lane section to a 5-lane section with a two-way left-turn lane. (See sketch at right.) The goal of the project was providing a two-way left-turn lane without sacrificing capacity. Average speeds dropped from 30 mph to 25 mph, but much of the speed drop can be attributed to new landscaping (including street trees) and revitalized commercial development along the corridor. The street is a major transit route and houses several delivery-



intensive businesses, such as a furniture store. There have been only negligible operational problems with buses and trucks using the narrowed lanes.

West, James E., "Arterial Traffic Calming – Is It An Oxymoron?" Institute of Transportation Engineers Compendium of Technical Papers, 2000.

- "In Oregon, Special Transportation Areas (STA) have been designated in the Oregon Highway Plan. The STA designation is the state's way of formally recognizing certain sections of state highway as main streets, thus allowing the use of highway designs and mobility standards that are different from other highway designations, including the use of traffic calming features. An STA is intended to permit traffic movements along the main street to be balanced with the needs for local access and circulation."

Lum, Harry S., "The Use of Road Markings to Narrow Lanes for Controlling Speed in Residential Areas," *Public Roads* vol. 47 no.2, September 1983. Reprinted in ***ITE Journal* vol. 54, no. 6, June 1984.**

- "Pavement markings combined with raised pavement markers to create an impression of a narrower street have no effect on the mean speeds or the speed distributions of drivers on residential streets."

Martens, Marieke et al, "The Effects of Road Design on Speed Behaviour: A Literature Review," European Commission under the Transport RTD Programme, September 1997.

- "With decreased lane width, drivers show improved lane keeping, more accurate steering behaviour and a reduction in driving speed usually results. Yagar and Van Aerde (1983) found a reduction in speed of 1.1 mph for every foot of reduction in lane width beyond 13 feet." [Dimensions converted from metric.]
- "Both driving lanes and extra pavement strips on the left and right side of the road, for instance an emergency lane, contribute to the total amount of pavement width. This additional space [decreases] drivers' uncertainty, . . . something which usually leads to higher speeds. . . . The mean speed with a pavement width of approximately 20 feet is about 50 mph and with a width of 26 feet, the mean speed increases to about 55 to 60 mph." [Dimensions converted from metric.]
- "It is very difficult to measure the effect of pavement width itself, independently of other road design factors. This can probably explain the fact that the relationship between width of pavement and driving speed was established in some studies, . . . whereas in other cases no effects could be found."

Ewing, Reid, *Traffic Calming: State of the Practice,* Institute of Transportation Engineers, 1999.

- "Relative to wide streets, narrow streets may calm traffic. Vehicle operating speeds decline somewhat as individual lanes and street sections are narrowed (but only to a point). Drivers also seem to behave less aggressively on narrow streets, running fewer traffic signals, for example. Further, one study reports higher pedestrian volumes on narrow streets than on wide streets. . . .

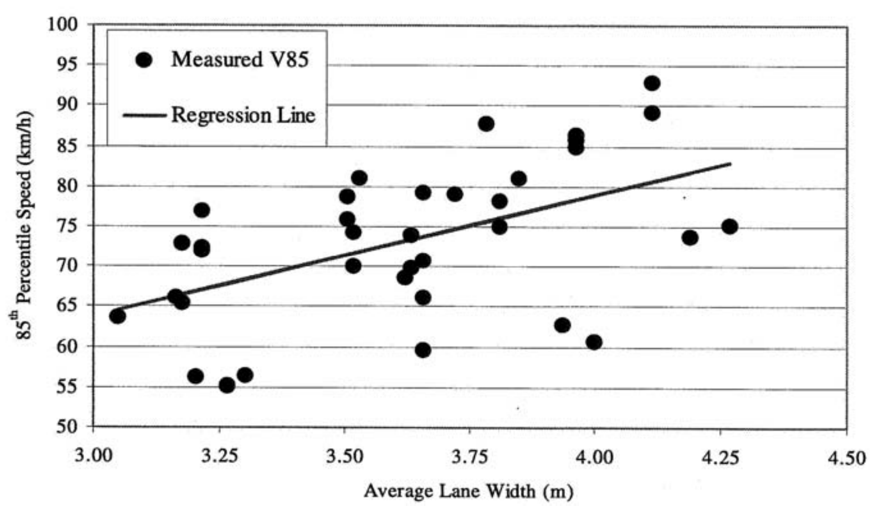
However, all other things being equal, bicyclists may prefer a wide street to a narrow street that has speeds 10 mph slower."

Heimbach, Clinton L. et al, "Some Partial Consequences of Reduced Traffic Lane Widths on Urban Arterials," Transportation Research Record 923, Transportation Research Board, 1983.

- Four-lane undivided urban roadways of various widths were analyzed to determine the effects of lane width on speeds and collisions.
- During off-peak hours, lane width correlates to speed at a rate of 0.6 mph per foot of lane width, as part of a multivariate expression with a correlation coefficient of 0.57. This suggests that narrowing lanes by one foot would tend to reduce speeds by 0.6 mph, when other factors are held constant.
- During peak traffic hours, the rate increases to 1.0 mph per foot of lane width, again as part of a multivariate expression, this time with a correlation coefficient of 0.53.
- Collisions increase as lanes are narrowed, but the relationship is not linear, so it cannot be expressed as a rate of collisions per foot of lane width. However, for typical values of other multivariate variables, narrowing lanes by one foot tends to increase collisions by 3 to 5 percent.

Fitzpatrick, Kay et al, "Design Factors That Affect Driver Speed on Suburban Arterials," Research Report 1769-3, Texas Transportation Institute, June 2000.

- On four-lane arterial streets, "speeds tend to be lower for narrower lanes. . . . When lane widths are 1 ft greater, [85th percentile] speeds are predicted to be 2.9 mph faster." [Dimensions converted from metric.] However, there is a substantial amount of site variability in the data, as illustrated by the plot at right.



- "The presence of a median (i.e., either a raised or a two-way left turn lane) indicated higher speeds than when no median was present." 85th percentile speed on streets without a median was about 38 mph, compared to speeds of 42 mph with a raised median and 44 mph with a two-way left-turn lane.
- Speeds decrease as the access density—number of intersecting driveways and intersections—increases. "The highest speeds for access densities above about 18 pts/mi are approximately 6 mph lower than the highest speeds for access densities below 18 pts/mi."
- In the studied data set, average speed was independent of signal spacing; however, signals in this study were relatively sparse, with an average of 2 signals per mile and never more than 4 signals per mile.