Critique of :

Effect of Wide Curb Lane Conversions on Bicycle and Motor Vehicle Interactions

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Bicycling Matters

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Effect of Wide Lane Conversions on Bicycle and Motor Vehicle Interactions is a report produced by the University of North Carolina Highway Safety Research Center for the Florida Department of Transportation. The report was prepared in cooperation with the State of Florida Department of Transportation, the USDOT, and the FHWA. It can be found online at: http://www.dot.state.fl.us/research-center/Completed_Safety.htm

My critique of the report begins on page 4 below. The critique includes sections entitled **Citation Errors**; **Methodological Errors**; **Critique of Summary of Results I**, **III**, and **IV**; and **Critique Conclusions**.

For reader convenience, reproduced below on pages 1 to 3 are the **Abstract**, results **Table 3**, **Figure 5**, and **Summary of Results** from the *Effect of Wide Lane Conversions on Bicycle and Motor Vehicle Interactions* report.

Abstract:

> "The main objective of this project was to examine the operational effects of converting 14-foot WCLs to an 11-foot travel lane with a 3-foot undesignated lane at various locations in Broward County, Florida. Six midblock and four intersection sites were selected for study. The selected study sites were a mix of configurations to provide comparisons. One of the midblock sites where the stripe was newly added did not have curb and gutter. Two of the midblock sites had previously been striped with the 3-foot undesignated lane. The study design was before-after in which the data were collected prior to and after the stripe designating the 3 foot lane was deployed. The ideal would have been before-after with comparison sites, but obtaining matching comparison sites would have been very difficult. Videotapes were taken of bicyclists riding through the midblock and intersection locations before and after placement of the undesignated lane striping. In the locations where the 3-foot stripe was already in place, the videotaping was done to examine whether changes were occurring over time. To an extent, these previously-striped roadways served as control or comparison sites. Once the videotaping was complete, software was used to extract images at all midblock locations so that before-after lateral spacing measurements could be obtained. After the new striping: (1) bicycles were ridden, on average, 7 to 9 inches further away from the gutter pan seam, (2) motor vehicles were driven, on average, 6 to 12 inches farther away from the gutter pan seam, (3) passing motor vehicles were driven, on average, 3 to 5 inches closer to bicycles at curb and gutter sites; conversely, passing motor vehicles were driven, 4 to 6 inches farther away from bicycles at the sites where the stripe was already in place, (4) the addition of the stripe at new locations had the effect of reducing the amount of motor vehicle encroachment into the adjacent lane on these multi-lane roadways."

Table 3. Change in lateral spacing, relative to "before" period, by site. [Note: reproduced]

Site	Traffic Volume vpd	Curb Presence	Bicycle (only) Lateral Change (inches)	Motor Vehicle (only) Lateral Change (inches)	Bicycle-Motor Vehicle Separation Change (inches)
M-1	19,600	Curb	9	12	- 4
M-2	34,800	Curb	9	10	- 3
M-3	28,100	Curb	7	6	- 5
M-4[a]	9,700	No Curb	- 2	5	6
M-6[b]	19,500	Curb	- 1	3	5
M-7[b]	45,000	Curb	0	- 4	4

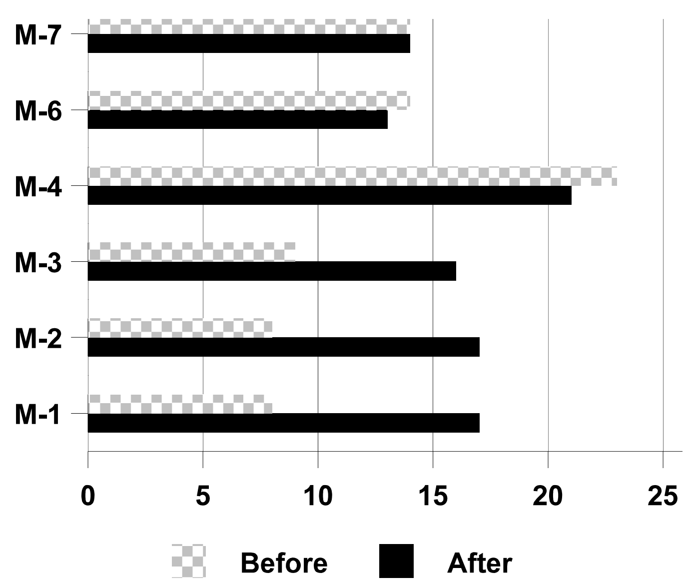
a. "before" and "after" subjects were unequal, invalidating the data
b. "before" and "after" conditions were the same; both had 3 foot lanes
[Note: I've added the a. and b. annotations for clarity. See Methodological Errors for details.]

The authors wrote on page 7:

> "Table 3 shows the differences in mean lateral spacing from before to after by site. Positive values indicate a shift to the left, away from the gutter pan seam (or edge of the roadway at site M-4). Negative values indicate a shift to the right, or closer to the gutter pan seam (or edge of the roadway at site M-4)."

Figure 5. [Note: Reproduced]

Average distance in inches of bike to gutter pan seam or edge of road before and after the addition of the 3-foot stripe.



Summary of Results [Note: Reproduced. Roman numerals used in place of bullets for clarity.]

"This study of the conversion of a 14-foot wide curb lane to an 11-foot travel lane with an undesignated 3-foot lane produced the following results:

I. The **lateral spacing of bicyclists** from the gutter pan seam was greater with the stripe as compared to without the stripe. The addition of the stripe affected lateral spacing differently for different sites. On average, bicycles were ridden 7 to 9 inches farther away from the gutter pan seam at Sites M-1, M-2 and M-3 where the stripe was newly added. This would provide a greater margin of safety for bicyclists.

II. The **lateral spacing of motor vehicles** from the gutter pan seam was greater with the stripe as compared to without the stripe. This would be expected with the shift of the travel lane to the left by 3 feet with the addition of the stripe. As above, the addition of the stripe affected lateral spacing differently for different sites. On average, motor vehicles were driven 6 to 12 inches farther away from the gutter pan seam at Sites M-1, M-2 and M-3 where the stripe was newly added.

III. Overall, the **lateral spacing between bicycles and motor vehicles** was greater with the stripe as compared to without the stripe, but the effect was not as clear cut as for the other lateral spacing measures above. Once again, the addition of the stripe affected lateral spacing differently for different sites. On average, passing motor vehicles were driven 3 to 5 inches closer to bicycles at newly-striped Sites M-1, M-2 and M-3. This could be indicative of increased comfort level for both modes, where motor vehicle drivers believe bicyclists will ride within the striped area, and bicyclists believe motor vehicle drivers will not cross into their space in the striped area. Conversely, passing motor vehicles were driven 4 to 6 inches farther away from bicycles at the comparison sites where the stripe had already been in place.

IV. The addition of the stripe had the effect of reducing the amount of **motor vehicle encroachment** into the adjacent lane on these multi-lane roadways. The effect varied by site. On average, encroachments were reduced by approximately 15 to 40 percent at the sites where a stripe was newly added."

Critique of *Effect of Wide Lane Conversions on Bicycle and Motor Vehicle Interactions*

Citation Errors

In the Introduction on page 1 and in the References of the report, the authors cite a study that examined the "shared-use arrow," and give credit to Hunter, W.W., Pein, W.E. and Stewart, JR in that order. The correct citation is Pein, W.E., Hunter, W.W., and Stewart, JR. as can be seen at: http://www.dot.state.fl.us/Safety/ped_bike/handbooks_and_research/research/finalwwh.pdf which shows the study in question, *Evaluation of the Shared-Use Arrow*.

Following the vernacular of the FDOT, the authors chose to call a 3-foot wide area intended for bicycle use an "undesignated" lane since it cannot be marked as a bike lane because it is substandard width, even by bike lane standards. Calling it a "shoulder" allegedly resulted in confusion and improper shoulder style marking at junctions by the roadway striping crew. Since the space is designed as a lane (rather than a shoulder), yet is only 3 feet wide, a more accurate term would be "substandard" lane.

The case study excerpt on pages 2-4 describes, and shows in a Figure 4, that 3-foot bike lanes were painted, marked, and signed, yet also contradictorily notes that "Because this type of facility....does not meet any current standards, bicycle signage and pavement markings are not used." This carelessness calls into question the validity of the speculative claims made in the excerpt. One must also question the authors of the paper for accepting such an obvious error.

Methodological Errors

Subjects for both "before" and "after" study were mainly recruited School Resource Officers from the Sheriff's Department. However, as noted on page 6 of the report, at M-4 the "before" subjects were bicycle club enthusiasts, while the "after" subjects were the Officers. These are unequal groups, as described below, invalidating proper research protocol and thus the results for site M-4. Since the data for M-4 are skewed, the results for all sites combined are also biased.

It would be expected that more experienced bicycle club members would operate farther left than typical bicyclists. As shown in Figure 5 on page 2 above, the School Resource Officers typically rode very close to the edge of pavement in the "before" period, 8-9 inches at sites M-1 to 3, and at times directly on the edgeline as can be seen in photos in Appendix A of the report. This indicates a very low knowledge of proper and defensive bicycling, in other words, riding skill. Figure 5 also shows that the bicycle club enthusiasts rode 23 inches from pavement edge at their M-4 "before" site, 14-15 inches further left than the School Resource Officers at their "before" sites M-1 to 3, and further left than the Officers at any of their "after" sites M-1 to 4.

Additionally distorting the data at M-4, the orange cones were placed directly on the edgeline in the "after" period, whereas they had been placed well off-road in the "before" period, as can be seen in the image in Appendix A of the report. It is possible that the cones compelled the School Resource Officer "after" subjects to ride farther left than they might otherwise have ridden. Indeed, they operated 4-8 inches further left at M-4 than at any other "after" site.

The recruited subjects "...exhibited varying levels of riding skill." The authors do not explain what measures they used to determine this. However, since the authors recognized that different skill levels existed, there should have been a partitioning of results based on bicyclist skill level, but this was not done. At the least, the authors should have acknowledged the different lateral positioning between the bicycle club members and the School Resource Officers, and discussed the implications in the results at M-4 and for all sites combined.

The authors attempted to justify having a random sample of subjects, saying "The composition of the group [the School Resource Officers] varied between the before and after periods, and exhibited varying levels of riding skill in both time periods." However, individual subjects made multiple passes over a given roadway segment during data collection. This makes the data, and particularly the bicyclist lateral position data, homogenous.

It is also possible that overtaking motorists recognized the Officers on bicycle by their uniforms and passed these law enforcement officials differently, perhaps with greater caution and thus space, than when passing the bicycle club subjects. It is also worth noting that subjects knew they were being filmed, which could have affected their riding and therefore the data.

Critique of Summary of Results I. Lateral spacing of bicyclists.

The authors wrote:

> "On average, bicycles were ridden 7 to 9 inches farther away from the gutter pan seam at Sites M-1, M-2 and M-3 where the stripe was newly added. This would provide a greater margin of safety for bicyclists."

The authors do not describe what the alleged "greater margin of safety" is from. Whatever danger the authors had in mind, 7 to 9 inches from it is likely not practical, except from the wheel-deflection hazard of an uneven gutter pan seam.

As discussed earlier, the authors fail to acknowledge that "before" subjects at M-4, the more experienced bicycle club enthusiasts, rode an average of 23 inches from the edge line. This is 14-15 inches further from the edge line than the School Resource Officers at "before" sites M-1 to 3 (which also did not have a 3-foot stripe) and further from the edge line than any of the Officer subjects at any of the "after" sites with 3-foot stripe (see Figure 5 on page 2). This indicates that experience results in better lateral spacing than painting a stripe.

Knowledgeable bicycle drivers choose their lateral position based on many conditions, including their speed, parallel traffic conditions, available width, surface conditions, presence of intersections and driveways and cross/turning traffic conditions, and others. The informed bicyclist typically uses considerably more lane space than unwitting bicyclists, and as much as the full lane width. A bike lane removes the ability of bicycle drivers to choose their lateral position with impunity, constraining bicycle drivers to what is often a location too close to the more hazardous side of the road.

Critique of Summary of Results III. Lateral spacing between bicycles and motor vehicles.
The authors wrote:

> "On average, passing motor vehicles were driven 3 to 5 inches closer to bicycles at newly-striped Sites M-1, M-2 and M-3. This could be indicative of increased comfort level for both modes, where motor vehicle drivers believe bicyclists will ride within the striped area, and bicyclists believe motor vehicle drivers will not cross into their space in the striped area."

The effect of closer passing when bicyclists are behind a stripe is due solely to motorist perception and action. As long as the bicyclist is in his own segregated area, the motorist need not adjust to the bicyclist. Bicyclist comfort and belief that motorists will not cross the stripe has nothing to do with it. There is no reason why bicyclists would want motorists to pass closer.

Without a segregating stripe, the bicycle driver has the right-of-way in the standard travel lane. The motorist's overtaking maneuver, if within the lane, is ambiguous, and thus more cautious. The motorist typically affords more clearance, and if necessary reduced speed. Such would be the case when overtaking any slower or stopped vehicle. Bicyclists influence motorist overtaking behavior by their within-lane position, but motorists alone choose the passing distance.

The authors wrote:

> "Conversely, passing motor vehicles were driven 4 to 6 inches farther away from bicycles at the comparison sites [M-6 and M-7] where the stripe had already been in place [in the "before" period]."

The authors say in the abstract and on page 5 of the report that sites M-6 and M-7 were used

> "...to examine whether changes were occurring over time. To an extent, these previously-striped roadways served as control or comparison sites."

If the data at M-6 and M-7 are to be believed, then what is the explanation for the contrary result of increased passing distance in the "after" condition with the same striping as the "before" condition at these two sites? Is it the opposite of the authors' explanation for the results at sites M-1 to 3? That is, over time with a 3-foot lane stripe in place, motorists at M-6 and M-7 were *less* comfortable passing bicyclists and therefore passed with added clearance? The authors offer no explanation for this unexpected and contradictory result.

The purpose of having control sites is to rule out alternative explanations for differences in behavior, so that any differences can be reliably attributed to the striping treatment. Since there were unexpected differences over time at the control sites, a plausible explanation is that the data are inaccurate, or something besides the presence of a stripe is responsible for the changes at all of the sites.

The authors combined the data from all 6 sites, including the invalid data from M-4 and suspect data from M-6 and M-7, and conclude in the Summary that "Overall, the lateral spacing between bicycles and motor vehicles was greater with the stripe as compared to without the stripe..." What is the explanation for this conclusion? Clearly, this determination is a mistake.

Critique of Summary of Results IV. Motor vehicle encroachment.
Considering only sites, M-1, M-2, and M-3, the following excerpted Table 2 reproduced from the report shows that encroachments did diminish from the "before" to the "after" periods.

Table 2. Percent Encroachments.

	"Before"		"After 1"		"After 2"	
	No	Yes	No	Yes	No	Yes
M-1	22.0	78.0	54.2	45.8	53.1	46.9
M-2	69.6	30.4	88.2	11.8	76.9	23.1
M-3	36.1	63.9	44.1	56.0	49.1	50.9

However, the significance of this reduction in encroachment is questionable. On page 16 in the Summary the authors claim that "Less encroachment by motor vehicles into the adjacent traffic lane should also result in improved motor vehicle safety." This is conjecture since no safety dis-benefit had been or has ever been found due to motorists encroaching when overtaking bicycle drivers, especially on multi-lane roads.

Motorists routinely overtake other motorists by fully changing lanes. When overtaking bicycle drivers, a full lane change is often not necessary. Frequently motorists overtake by merely moving adequately left, "encroaching" on the adjacent lane. Such a maneuver is routine, but the authors of this and other flawed studies falsely attempt to portray this as dangerous.

Tellingly, the authors don't discuss that there was still a significant amount of encroachment in the "after" periods even though bicyclists were in their own "undesignated" lane. Since lanes are placed in order to channelize both motor and bicycle vehicles, this clearly demonstrates that a 3-foot "lane" adjacent to an 11-foot lane is very substandard.

It is likely that more motorists fully changed lanes when overtaking in the 14-foot lane as compared to an 11-foot lane with a 3-foot lane. This is especially true for those bicyclists who operated further left in the 14-foot lane, thus compelling a lane change. Those motor vehicles that changed lanes fully would not have been considered in measuring passing distance, when, in fact, by changing lanes they gave maximal clearance. This discrepancy would skew the data.

As there were fewer encroachments when the 3-foot lane was striped, on average motorists had to be passing closer; 3 to 5 inches at sites M-1 to 3. But when operating as intended by design, an 8-foot wide heavy truck tracking down the center of the 11-foot lane will pass a bicyclist tracking down the center of the 3-foot lane with just 2 feet of clearance, not considering side mirrors. When tracking along the left lane line and not encroaching, the heavy truck will clear the bicyclist by 3.5 feet. A 6-foot wide passenger vehicle operating similarly will afford 3 and 5.5 feet respectively. All but the 5.5 feet of clearance are woefully and frighteningly inadequate, yet the authors of this study espouse duping both motorists and bicyclists into these situations.

Critique Conclusions
Effect of Wide Lane Conversions on Bicycle and Motor Vehicle Interactions has citation errors, and methodological errors which call into question the veracity of the findings. The error of unequal "before" and "after" subjects resulted in invalid data at site M-4. Data from M-4 may also have been distorted by different orange cone placement in the "before" and "after" periods. Contradictory results on motorist overtaking distance are not explained; the data from M-6 and M-7 are likely in error. The data from all sites combined must therefore be in error.

The School Resource Officers operated so close to the road edge in the "before" condition that unrealistic data likely resulted. Given that recruited subjects are logistically necessary, yet is an inherently biased population, a better approach would be to recruit bicyclists knowledgeable of lateral positioning effects, thus modeling exemplary rather than poor behavior. Indeed, the more experienced bicycle club members were found to ride further left in the normal 14-foot lane than the inexperienced Officers operating in the 3-foot substandard lanes, but this was not discussed.

The data from sites M-1, M-2, and M-3 show that by striping a 3-foot "undesignated" lane on a previously 14-foot lane, inexperienced recruited bicyclists moved 7-9 inches further left, motorists passed 3-5 inches closer, and encroachments were greatly reduced. The alleged benefits of these changes are suspect, while the dis-benefits to bicycle drivers are profound.

The authors assert that less encroachment is a safety enhancement, but provide no rationale or evidence in support. Reduced encroachment indicates closer motorist passing, which is not a benefit to bicyclists. Based on the 14-foot total width and available clearances, vehicles that did not encroach may have passed bicyclists very closely.

Before the striping, bicycle drivers had 14 feet of lane in front of them from which to choose their optimal lateral position for the conditions then existing. By converting the 14-foot lane into a 3-foot substandard lane and 11-foot "motor vehicle" lane, bicyclists' space is effectively reduced to the narrow 3-foot width, by law or by motorist coercion. A bicycle driver operating to the left of the line would be a persona non grata. This is not a benefit to bicyclists.

In closing, the authors write:

> "It is recommended that additional evaluations of striping an undesignated lane be conducted.... Overall, this pilot study has indicated that this type of roadway striping has the potential to improve both bicycle and motor vehicle safety, even given the limitations of the study design, and the technique certainly seems deserving of further study."

In contrast to these assertions, it is abundantly clear that striping a substandard lane is a very poor infrastructure design that should be abandoned. The authors claim potential safety improvement, but do not acknowledge that without the stripe there exists no danger. The strategy of confining bicyclists to a 3-foot segregated area, while absolving motorists of their duty to react to bicyclists, and encouraging grossly inadequate overtaking distance when operating as intended (tracking down the centerline) is a pursuit that borders on malfeasance.

Effect of Wide Lane Conversions on Bicycle and Motor Vehicle Interactions cites in its References several papers that have been critiqued elsewhere. These critiques are located at:

http://www.humantransport.org/bicycledriving/library/SharedUse_critique.pdf
http://www.humantransport.org/bicycledriving/library/door_zone.pdf
http://humantransport.org/bicycledriving/library/critique_BCI.pdf

I have read your critique and skimmed the original report.

I might make one additional comment: I do not understand why AVERAGE spacing is used as an appropriate measure of distance between car and bicycle.

1. I would not expect the distances to be normally distributed. In particular, they are truncated at 1 inch (0 would be a collision). I would expect this distribution to look more like a negative binomial distribution or a truncated normal distribution -- and these have much, much different statistical properties.

2. #1 is important because the mean will be highly affected by behavior that has nothing to do with safety. From a bicyclist standpoint, as long as the vehicle is 3 feet from the cyclists, whether it is 3 feet or 13 feet away is of no consequence. What the cyclist really cares about is being buzzed at very close distances.

3. Some strategies to deal with #1 and #2 might include
(a) evaluating the data is terms of "too close" versus "far enough", similar to the analysis done in terms of whether the motor vehicle moved into the other lane or not.
(b) truncating all observations of distance from the cyclist at, say, 4 feet. If the car is 10 feet away, count it as 4 feet away. Another possible alternative would be to take the log of distance, but the audience probably doesn't think in log space so this would make the article more confusing to its intended audience.

Truncating would not affect the validity of the F-test done on the data. While truncating does make normal data less normal, this data isn't normal to begin with.