

*Evaluation
of the
Shared-Use
Arrow*



Evaluation of the Shared-Use ARROW

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Background

A bicycle lane stripe provides a lateral positioning reference for both motorists and bicyclists, and the presence of the stripe, as well as signs, informs motorists that bicyclists are typically present upstream. In contrast, the absence of bicycle-specific pavement markings in wide outside lanes (also known as wide curb lanes), another widely acknowledged way to accommodate bicyclists, obviously means that there is no reference for lateral positioning, or a visual cue to the existence of upstream bicyclists.

Another argument put forth is that bicycle lanes are clearly marked spaces for bicyclists that have been shown to draw riders off of adjacent sidewalks and onto the roadway, a desirable outcome given the inherent dangers of sidewalk riding. On the other hand, because there are no bicycle-specific markings in wide outside lanes, they are not recognized as an on-road bicycle “facility” by many bicyclists, resulting in a higher incidence of adjacent sidewalk riding than could otherwise be the case.

ARROW Design

The shared-use ARROW (Figures 1 & 2) was developed with the intention of addressing these deficiencies of wide outside lanes. Furthermore, for situations at which sufficient pavement width exists to choose between striping a bicycle lane or leaving a wide outside lane, the shared-use ARROW may offer a third option, “bridging the gap” between the two existing treatments. Unlike a bicycle lane stripe, the shared-use ARROW does not restrict bicyclists and motorists to separate areas of

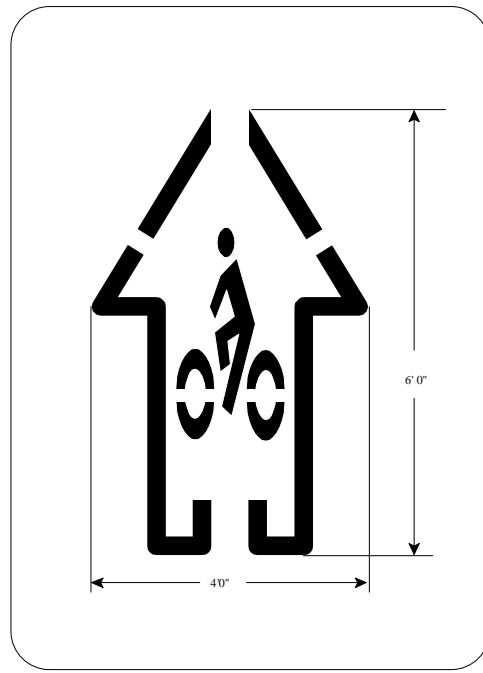


Figure 1. Shared-use ARROW.

the roadway, thus addressing several potential problems of bicycle lanes. The shared-use ARROW also requires less pavement marking materials than a bicycle lane stripe, and the ARROW reinforces the correct direction of travel, an issue of great importance for bicycling safety.



Figure 2. On-street placement of Shared-use ARROW .

The shared-use ARROW was originally developed by James Mackay, the Bicycle and Pedestrian Planner for the city and county of Denver, CO (Figure 3). The City of San Francisco, through Manito Velasco, Assistant Transportation Engineer, has also used the ARROW. They elongated it from 4'3" to 6' and also altered the placement specifications. The current ARROW builds upon these efforts by establishing a widened opening along its centerline in an

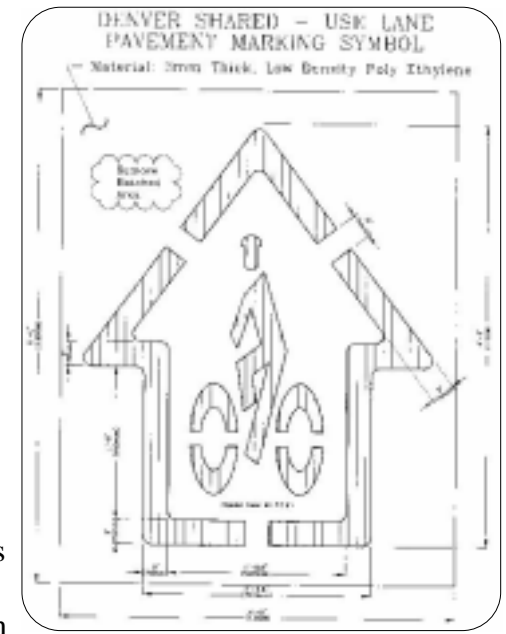


Figure 3. Original symbol design.

effort to channelize and make it more obvious to bicyclists to track down the centerline of the symbol. This was based on personal communications with James Mackay and Manito Velasco, who both noted through observations that bicyclists tended to track over the symbol.

ARROW Placement

HSRC proposed a lateral placement of 2.5 feet from the curb face, which was based on the local conditions of a 15-foot wide lane with no gutter pan and preliminary BEFORE measurements which showed bicyclists riding 1.6 feet on average from the curb. Furthermore, with this specified spacing, it was expected that motor vehicle tires would be less likely to track over and wear out the marking. However, paving over the old gutter pan left a seam about 2 feet from the curb. Thus, instead of at 2.5 feet from the curb face, the ARROW was placed at 3.5 feet by Gainesville Public Works (Figure 4).

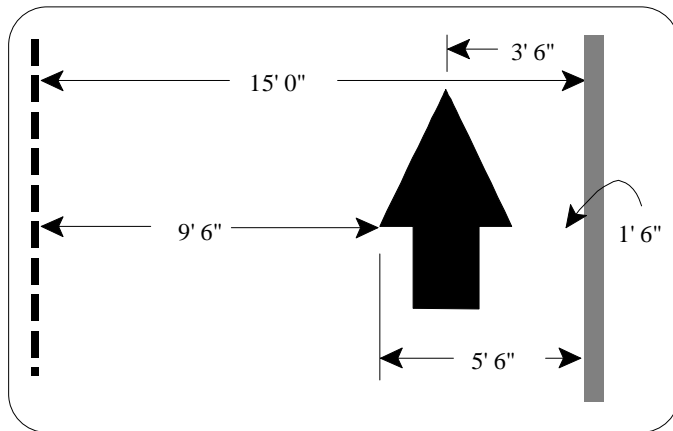


Figure 4. Actual lateral placement.

The longitudinal placement specifications as developed by James Mackay were followed. The ARROW was placed 20 feet after intersections, 80 feet in advance of an intersection, and spaced at roughly 200-foot intervals along the section.

Evaluation

A BEFORE/AFTER evaluation was conducted. Four locations along 13th Street (US 441) in Gainesville, FL were examined using videotaping equipment to record bicycles and motor vehicles. In this study area 13th Street has 4 lanes, a 30 mph speed limit, and carries approximately 35,000 vehicles per day. Figure 5 below shows the 4 sites depicted with arrows indicating the direction in which the camera was facing. Sites 1-3 were acceptable for all data that was to be collected, while one site (Site 4) was not acceptable for spacing measurements.



Figure 5. Site map.

Site 1 was at SW 8th with the camera on the east side of 13th and north side of SW 8th and facing south in order to examine northbound traffic. Site 2 was at Museum Rd. with the camera on the west side of 13th and south side of Museum facing north to film southbound traffic. Site 3 was at NW4th with the camera on the east side and north of NW4th looking south at northbound traffic. Site 4 was at University Avenue with the camera on the west side of 13th and the south side of University Avenue, facing north to capture southbound traffic.

Seventeen videotaping sessions approximately 2 hours in length were used to gather data both BEFORE and also AFTER the ARROW was installed for a total of 34 sessions. Concurrent with installation of the device, approximately 1 week of public awareness was conducted. A press release was prepared, and television crews filmed bicyclists riding along the stenciled street. Information about the stencil was widely disseminated to University of Florida students, faculty, and staff through normal channels.

The videotapes were examined by HSRC personnel. Three spacing measurements were made using Jandel Scientific SigmaScan Pro Image Measurement Software on still images of the videotape captured by Snappy Version 3.0. The measurements were Bicycle to Curb, Bicycle to Motor Vehicle, and Motor Vehicle to Curb.

Bicyclist position and direction were also noted, with the following six categories tallied:

1. In Street, With Traffic
2. In Street, Facing Traffic
3. Sidewalk, With Traffic
4. Sidewalk, Facing Traffic
5. Both In Street and On Sidewalk, With Traffic
6. Both In Street and On Sidewalk, Facing Traffic

Results

Bicyclist Position and Direction

The following lists show bicyclist position and direction BEFORE and AFTER placement of the ARROW:

BEFORE: N=913

- | | |
|------------------------------|--------------|
| 1. In Street, With Traffic | n=359; 39.3% |
| 2. In Street, Facing Traffic | n=1; 0.1% |
| 3. Sidewalk, With Traffic | n=393; 43.0% |
| 4. Sidewalk, Facing Traffic | n=92; 10.1% |
| 5. Both, With Traffic | n=68; 7.4% |
| 6. Both, Facing Traffic | n=0 |

AFTER: N=466

- | | |
|------------------------------|--------------|
| 1. In Street, With Traffic | n=211; 45.3% |
| 2. In Street, Facing Traffic | n=1; 0.2% |
| 3. Sidewalk, With Traffic | n=190; 40.8% |
| 4. Sidewalk, Facing Traffic | n=30; 6.4% |
| 5. Both, With Traffic | n=34; 7.3% |
| 6. Both, Facing Traffic | n=0 |

BEFORE the ARROW was placed, 39.3% of bicyclists rode In Street, With Traffic. AFTER the ARROW was placed, the proportion of bicyclists riding In Street, With Traffic increased to 45.3%. Comparing In Street, With Traffic with all other positions and directions combined (a 2x2 table, chi-square test) yields a statistically significant increase ($p < .05$) toward riding in the street with traffic AFTER the placement of the ARROW.

Bicycle to Curb

Bicycle to curb measurements were made to determine if the ARROW was associated with a change in the lateral positioning of bicyclists. This measurement was made when the bicyclist passed a selected point in the roadway, and was taken from the center of the front tire to the curb face. For each bicyclist it was noted whether any overtaking motor vehicles were present which could potentially be influential to where the bicyclist might position laterally.

BEFORE: Ideally, all BEFORE measurements were to be made at the exact location where the ARROW would later be placed, but this was not always possible. Typically, BEFORE measurements were made approximately within 100 feet of where the ARROW ultimately was placed.

The mean bicycle to curb measurement in the BEFORE period was 1.58 feet (n=311). A potentially influential motor vehicle was present 82% (n=255) of the time.

AFTER: Ideally, all AFTER measurements were to be made right at the ARROW, but again this was not always possible, and a small number of the measurements were made nearby.



Figure 6. Bicyclist at Site 1 in the after period for Bicycle to Curb measurement.



Figure 7. Bicyclist at Site 2 in the after period for Bicycle to Curb measurement.



Figure 8. Bicyclist at Site 3 in the after period for Bicycle to Curb measurement.

The mean bicycle to curb measurement in the AFTER period was 1.83 feet (n=192). A potentially influential motor vehicle was present 83% (n=160) of the time.

The difference between the BEFORE measurement of 1.58 feet and the AFTER of 1.83 feet (approx. 3 inches) was statistically significant ($p < .01$).

Bicycle to Motor Vehicle

This measurement was made when a motor vehicle with a driver with unobstructed view was directly next to the bicyclist, the front wheels of the motor vehicle and bicycle in line. The measurement was from the center of the bicycle front tire to the outside edge of the front right motor vehicle tire.

The mean bicycle to motor vehicle measurement in the BEFORE period was 6.00 feet ($n=92$). The mean bicycle to motor vehicle measurement in the AFTER period was 6.13 feet ($n=83$). The difference was not statistically significant.



Figure 9. Bicyclist at Site 1 in the after period for Bicycle to Motor Vehicle measurement.



Figure 10. Bicyclist at Site 2 in the after period for Bicycle to Motor Vehicle measurement.



Figure 11. Bicyclist at Site 3 in the after period for Bicycle to Motor Vehicle measurement.

Motor Vehicle to Curb

The distance from the outside edge of the front tire (or in some cases the rear tire) to the curb face was measured when there were no bicyclists nearby to influence the drivers' positioning. Equal numbers of images were taken from Sites 1-3 for the BEFORE and AFTER periods.

BEFORE: This spacing was taken as near as possible to where the ARROW would be located in the AFTER condition.

N=100; Mean = 6.32 feet

14 of the 100 motor vehicles were less than 5.5 feet from the curb face, and thus would have made contact with the ARROW had there been one.

AFTER: This spacing was measured at the ARROW.

N=100; Mean = 6.40 feet

16 of the 100 motor vehicles made contact with the ARROW.



Figure 12. Motor vehicle at Site 1 in the after period for the Motor Vehicle to Curb measurement.

6.40 feet was not statistically significant.



Figure 13. Motor vehicle at Site 2 in the after period for the Motor Vehicle to Curb measurement.



Figure 14. Motor vehicle at Site 3 in the after period for the Motor Vehicle to Curb measurement.

The difference between the BEFORE mean of 6.32 feet and the AFTER of

Comparisons of the Distributions of the Three Distance Measures

In addition to a statistical comparison of mean distances, it was of interest to examine the distributions of the three distance measures of Bike to Motor Vehicle, Bike to Curb, and Motor Vehicle to curb. These are depicted graphically in Figure 15 in the form of box and whisker plots for both the before and after conditions. For each measurement, the solid box extends from the 25th percentile observation to the 75th percentile. Thus, the height of the box is the interquartile distance (or IQD). The light band across the box indicates the median of the distribution while the mean is marked with an X. Thus, the box indicates both the center and spread of the distribution. The whiskers (dotted lines) extend from the top and bottom of the box to a distance of $1.5 \times$ the IQD or to the extreme value of the distribution, whichever is less. Extreme values beyond that are indicated by horizontal lines.

Figure 15 shows the small changes in mean values noted earlier and a more general shift in all three distributions toward slightly greater values in the after condition. The most notable change, however, is the increased spread in the distribution of bike-to-curb distance measurements (the middle plot) after the ARROW was in place. In particular, the proportion of bicyclists riding at distances of 1.75 to 2.5 feet from the curb increased substantially, giving these riders a larger space to maneuver toward the curb if motor vehicles encroached into this area. The shift in the distribution may also be reflecting increased comfort of cyclists using the shared lane.

Before/After Comparisons of Distributions of Three Distance Measures

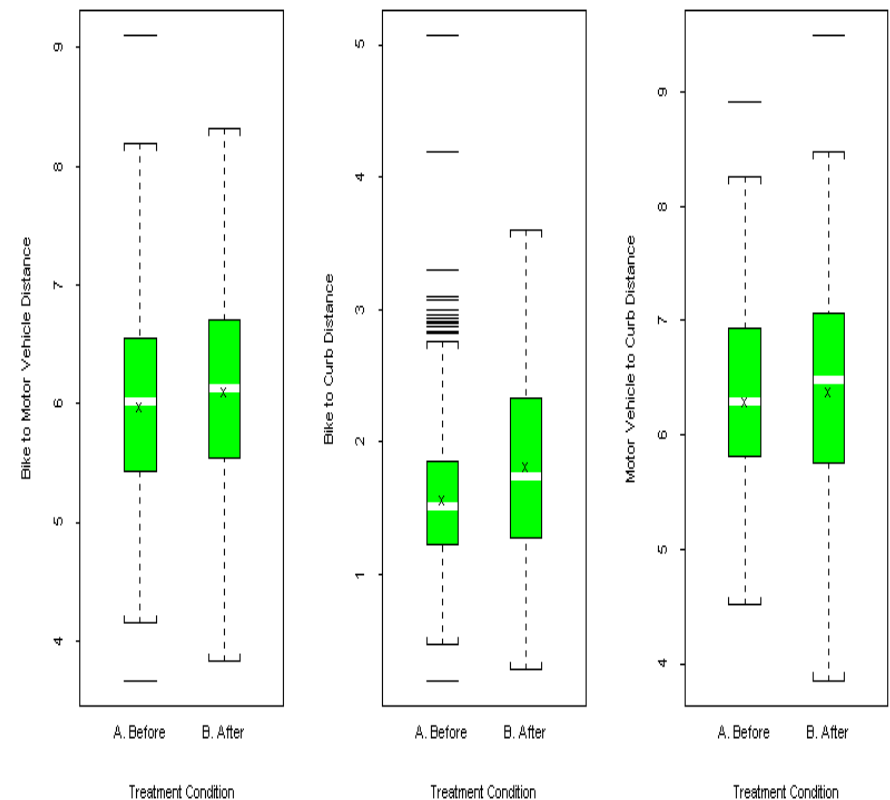


Figure 15. Distributions of measurements of Bike to Motor Vehicle, Bike to Curb, and Motor Vehicle to Curb.

Discussion

For this evaluation, the measures of effectiveness pertained to before and after measurements of bicycles and motor vehicles from the curb and from each other. Bicycle to Curb was the only measurement that showed a statistically significant difference between the BEFORE and AFTER conditions. Although the difference between the BEFORE mean measurement of 1.58 feet and the AFTER of 1.83 feet was statistically significant, this .25 feet (1.83 - 1.58), or 3 inches, is not practically significant. This does not represent enough of a meaningful shift in distance for real world application. Furthermore, this amount may fall within the measurement error of the software/data reducer, especially considering that BEFORE measurements were made with the bicyclist farther from the camera.

There was an interesting difference in the *distributions* of the measurements that were made, and the difference was again associated with the Bicycle to Curb distance. There was increased spread in the lower end of the distributions in the AFTER period, such that the proportion of bicyclists riding 1.75 to 2.5 feet from the curb increased substantially, in effect increasing their safety margin.

There was a statistically significant increase in the proportion of bicyclists riding in the street after placement of the ARROW. This shift from the sidewalk to the street should increase safety by putting cyclists where they are more visible to motorists and out of conflict with vehicles entering or exiting driveways that cross sidewalks, as well as reduce the conflicts with pedestrians.

The 13th Street corridor was chosen because there were enough bicyclists riding on a daily basis to make data collection efficient. In retrospect, however, the number of cyclists may be a factor that mitigates against possible shifts in the distance measures of effectiveness. It is certainly possible that motor vehicle drivers on this route are well attuned to the presence of bicyclists, and thus may already have shifted their traffic lane location away from the curb to account for the space needs of bicyclists before the ARROW was installed. However, the shift in the lower end of the Bicycle to Curb

measurement which yielded more riding space for bicyclists is compelling enough to “keep the jury out” on this shared lane treatment a bit longer. More trials in other locations are recommended and should result in more conclusive findings.

Acknowledgments

We would like to thank Brian Kanely and Phil Mann of the City of Gainesville Public Works - Engineering Department for all their help with getting the stencil cut and then placed on the street, as well as arranging the press conference and related materials for the public awareness campaign. Thanks also to Kenny Richardson for videotaping, and to Linda Dixon for reviewing the report.

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