Executive Summary: Evaluation of Four Experimental Bicycle Safety Devices in Austin, Texas

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As the number of trips made by bicycle continues to increase, there exists a greater need to safely accommodate bicycles within the transportation network. Four experimental bicyclist safety devices were installed and studied in Austin, Texas to determine if they offered a substantial improvement in bicyclist and motorist safety. Shared Lane Markings were particularly effective at encouraging bicyclists to ride at the lane position indicated by the marking and encouraging motorists to change lanes when passing, but were not always effective at reducing instances of sidewalk riding and other unsafe behaviors. Signs that read "Bicycles May Use Full Lane" marginally improved bicyclist position in the lane and substantially increased the space between bicyclists and passing motorists when installed on a commuter route. No improvement in safety was found on recreational routes. Yellow-green color was applied inside bike lanes at areas where a bike lane and motor vehicle lane crossed paths. The colored lanes increased turn signal use by motorists at all sites and at perpendicular crossing areas, motorists were more likely to yield to bicyclists. Bicycle boxes were particularly effective at increasing the predictability of bicyclist stopping position at intersections and encouraged bicyclists to depart the intersection before motorists. Although the bicycle boxes were accompanied by "No Right Turn on Red" signs, motorists often disobeyed the sign.

Since Austin's bicycle program was re-established in 1992, the city has seen a significant growth in bicycle facilities. Douma and Cleaveland (2008) documented a statistically significant increase in bicycle mode share in Austin from 1990 (0.87%) to 2000 (1.19%) in Census block groups with new bicycle routes developed during that period. During that same time period, the journey-to-work bicycle mode share for Austin increased significantly from 0.76% to 0.95%. The University of Texas at Austin is the most-frequented destination in Austin with approximately 68,000 students, faculty, and staff members. The university estimates that 5-7% of all trips to campus are made by bicycle (BMA, 2007).

While the proportion of commuting trips made by bicycle appears to be increasing, it remains small. Surveys studying the factors affecting bicycling demand show safety to be a major concern. In a survey of bicyclists in Texas, 69% of respondents stated they feel bicycling is "somewhat dangerous" or "very dangerous" from the standpoint of traffic crashes (Sener et al., 2009). Given these results, a need exists to improve the safety of bicyclists on roads.

In February 2009, the Bicycle and Pedestrian program within the City of Austin commissioned the Center for Transportation Research (CTR), a research branch of The University of Texas at Austin, to study the effects of four experimental devices on bicyclist and motorist safety along multi-lane facilities in Austin, Texas. Since 2008, the researchers at CTR have studied the operations and safety of on-street bicycle facilities.

Ultimately, four experimental devices were chosen for study. Shared Lane Markings and signs that read "Bicycles May Use Full Lane" were installed to make motorists aware of the potential presence of bicyclists and to encourage bicyclists to ride toward the center of the lane and away from the curb. Bicycle Boxes were installed at intersections to allow bicyclists to take a position at the front of a queue of vehicles, thereby making motorists more aware of the bicyclist's presence and reducing the chance that the bicyclist was hit by a right-turning motorist. Finally, colored lane markings were installed at areas where bike lanes and motor vehicle lanes crossed paths. The marking was intended to alert motorists to the presence of bicyclists and to improve the predictability of bicyclist and motorist behavior when crossing the colored conflict area.

Based on input from the Austin bicycling community, the Bicycle Advisory Council, the City of Austin Bicycle and Pedestrian Program, and the Center for Transportation Research, the devices were each installed at multiple locations within Austin. In order to measure the effectiveness of each device at each site, cameras positioned along the facility recorded pre- and post-implementation data about bicyclist and motorist behavior. Those datasets were compared to determine if a substantial improvement in safety had occurred. To help evaluate each device on its own merit, no educational or

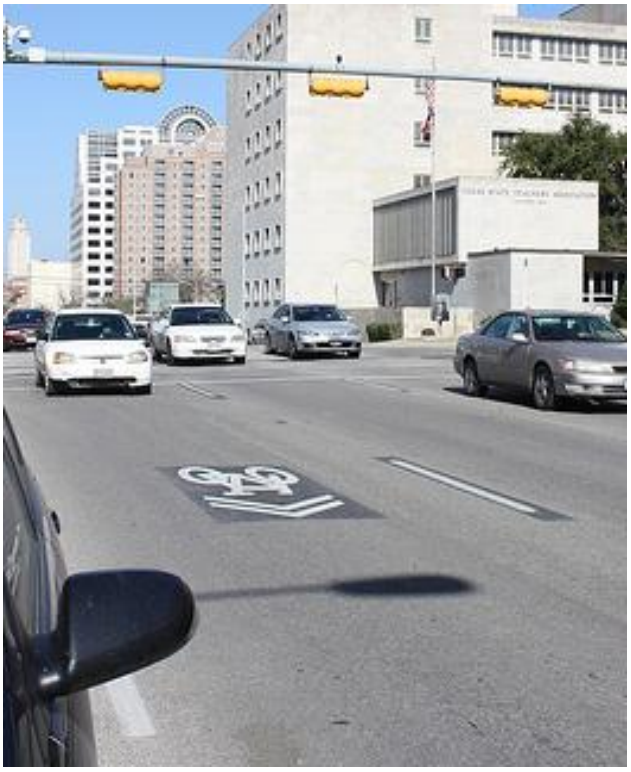
informational campaign was conducted during the study. Data was collected between June 2009 and March 2010.

The following sections summarize the study results and make recommendations regarding future use of each device.

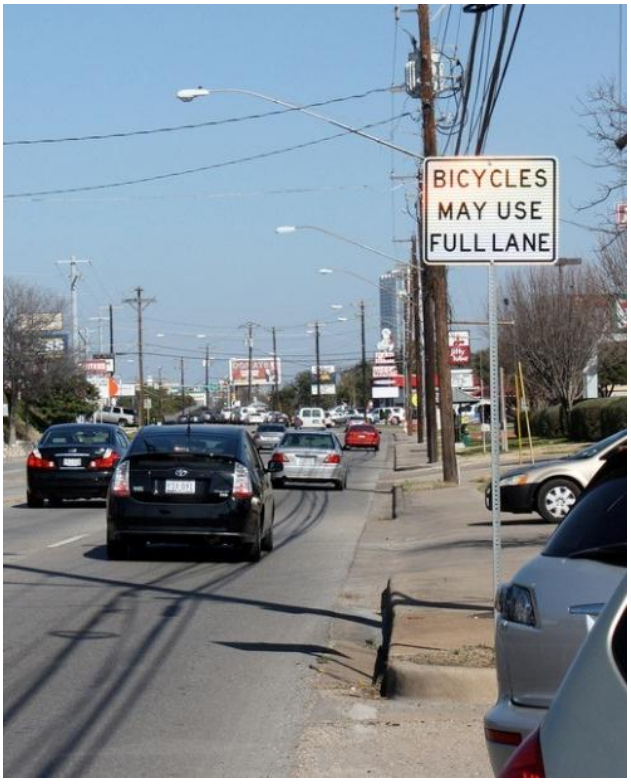
Shared Lane Markings and "Bicycles May Use Full Lane" Signs

Shared Lane Markings and signs are two very different devices, but both are designed to encourage bicyclists and motorists to safely share the full lane. A Shared Lane Marking (or *sharrow*, as it is commonly called) is a thermoplastic symbol that is affixed to the street surface in the motor vehicle lane that bicyclists are most likely to utilize—bicyclists are encouraged to ride at the position on the road indicated by the sharrow. For this study, sharrows were typically spaced 250 feet apart or placed at the beginning of each block, whichever was more appropriate for the site. "Bicycles May Use Full Lane" signs, on the other hand, are custom-made regulatory signs that are erected alongside a facility. The signs were spaced one quarter to one half mile apart, as this is the typical spacing for regulatory signs.

The shared lane markings were installed along three unique multi-lane facilities: on Guadalupe Street near downtown Austin, on 51st Street near Airport Boulevard, and on Dean Keeton Street near The University of Texas campus. At the first two study sites, the sharrow was placed in the center of the lane because there is not sufficient space for bicyclists and motorists to operate side-by-side. At Dean Keeton Street, where the outside lane is wider, sharrows are placed on the right side of the lane and are meant to guide bicyclists between disconnected bike lanes. At the first two study sites, the sharrows were effective at encouraging bicyclists to ride closer to the center of the lane, resulting in more predictable, safer conditions. The average bicyclist lateral position increased only marginally, usually between 4" and 8", but a dramatic shift in the mode occurred along multiple sites. Along Dean Keeton Street, where bicyclists rode alongside on-street parked vehicles, the marginal increase in lateral position resulted in a significant decrease in the percentage of bicyclists who rode within the range of an opening car door. On other measures of bicyclist and motorist safety, the exact effect of the sharrow is unclear. At some sites, bicyclists were less likely to ride on the sidewalk or in empty on-street parking



A Shared Lane Marking on Guadalupe Street in downtown Austin

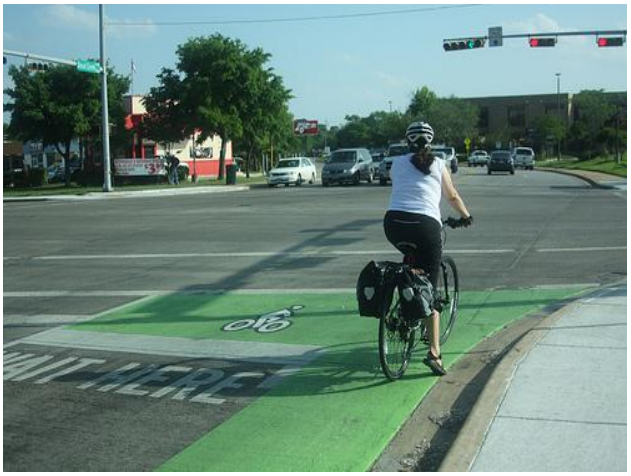


A "Bicycles May Use Full Lane" sign installed on Lamar Boulevard

stalls after the installation of the sharrows, but at other sites, no significant decrease in unsafe bicyclist behavior occurred. Regarding safe motorist behavior, motorists were more likely to change lanes when passing, less likely to pass, and less likely to encroach on the adjacent lane when passing.

"Bicycles May Use Full Lane" signs were installed along two multi-lane facilities: on the northbound side of Lamar Boulevard, a popular commuter route, and on Pleasant Valley Road near Cesar Chavez Street, a recreational bicycling route. The difference in bicycling population had a profound influence on the effectiveness of the signs on bicyclist and motorist behavior. Bicyclists on Lamar Boulevard were generally observed to ride closer to the center of the lane after the installation of the signs. Further, motorists were less likely to pass and provided more space when they did, but motorists were significantly more likely to encroach on the adjacent lane while passing. It should be noted that encroachment is only unsafe when another motorist occupies the adjacent lane—a variable that was not recorded in this study. Like the sharrow study sites, the signs on Lamar were ineffective at decreasing instances of sidewalk riding, suggesting that both signs and sharrows are most effective at improving the safety of bicyclists already utilizing the full lane. Along Pleasant Valley, the majority of bicyclists rode on the sidewalk, making data on bicyclist lateral within the full lane position and motorist safety exceptionally difficult to collect.

Taken together, this study recommends that Shared Lane Markings are an effective tool to improve both bicyclist and motorist behavior along multi-lane facilities when used as either a stand-alone device or as a means to connect two facilities with bicycle lanes. Each of the three facilities studied had a posted speed limit between 30 and 35 mph with traffic volumes ranging between 200 and 275 vehicles per hour per lane. Regarding "Bicycles May Use Full Lane" signs, there is a reasonable expectation that such signs can improve the safety of bicyclists along commuter routes where many bicyclists already utilize the full lane. Further research or corroborating findings by another institution could help determine the exact effect such signs have on safety.



A colored bicycle box at Shoal Creek Boulevard and Anderson Lane

Bicycle Boxes at Intersections

Bicycles face considerable safety risks when navigating intersections, since both bicyclists and motorists are often unsure of how to best position themselves at red lights. A bicycle box (or bike box) is a for-bicycles-only stopping area located in the full lane between the motorist stop line and the crosswalk bar. Bicyclists approaching an intersection via a bike lane can pull into the bike box and take the first position within the queue, thereby improving their visibility, allowing them to depart the intersection first, and reducing their chance of being struck by right-turning vehicles. To reduce the chance that motorists encroached on the bike box, "No Right Turn on Red" signs were installed at the intersection.

Bike boxes were installed at the intersection of 38th Street and Speedway near The University of Texas and at the intersection of Shoal Creek Boulevard and Anderson Lane, a popular recreational bicyclist route in north Austin. Data collected from these sites were compared between three phases: no bike box, bike box markings only, and bike box markings with yellow-green color. The addition of color to the bike box and the approaching bike lane was intended to further improve the safety and predictability of bicyclists at the intersection.

After the bike box markings were installed at Shoal Creek Boulevard and Anderson Lane, bicyclists were more likely to depart the intersection first and motorists were less likely to stop beyond the stop line. After the addition of color, however, bicyclists took a significantly more predictable position at the

intersection—69% of bicyclists stopped in the bike lane adjacent to the bike box and 22% stopped in center of the bike box. The color also encouraged bicyclists to use the bike lane when approaching the intersection.

At Speedway and 38th Street, the addition of the bike box markings encouraged cyclists to use the bike lane when approaching the intersection and more bicyclists departed the intersection first. The addition of color reduced the proportion of bicyclists that stopped beyond the bike box from 57% to 44% of all bicyclists, but the color did not further encourage bicyclists to enter the bike box—68% of bicyclists chose to stop in the bike lane adjacent to the bike box. Since the bike lane continued on the other side of the intersection and nearly all bicyclists were traveling straight through, it is likely that bicyclists did not see the need to properly utilize the bike box.

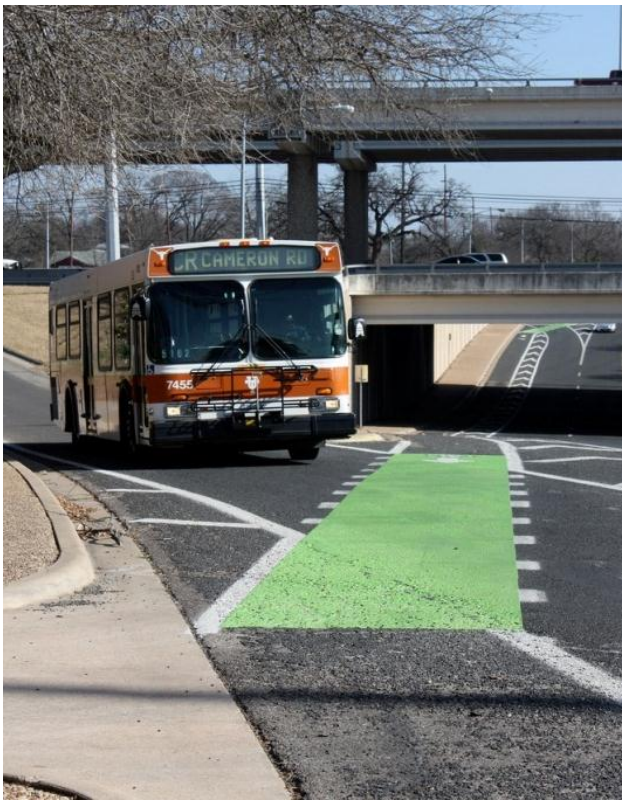
Ultimately, bike box markings are recommended for installation at intersections where a majority of motorists do not turn right on red and the volume of bicyclists is high. An educational campaign aimed at informing the public on how to properly utilize a bike box could provide further safety improvements. When financially viable, the addition of color to the bike box should be considered, since bicyclists using colored bike boxes were more likely to stay within the bike box/bike lane area and depart the intersection first.

Colored Lane Markings at Conflict Areas

Bike lanes provide a safe, delineated lane of travel for bicyclists as they share the road side-by-side with motorists. However, conflicts between bicyclists and motorists are common at points where the bike lane and motor vehicle lane cross paths—such as places where a bicycle lane crosses a highway exit ramp or a right-turn only lane crosses a parallel bike lane. In order to alert motorists of potential conflicts with bicyclists at these areas and to encourage bicyclists to stay in the bicycle lane through these conflict areas, four dashed conflict sites within Austin were colored with reflective yellow-green thermoplastic. To clarify the purpose of the colored lanes, explanatory signs were installed near the conflict area.

The colored lanes were installed along two unique multi-lane facilities near The University of Texas campus. Three colored lanes were installed on Dean Keeton Street where the bike lane intersects the I-35 exit and entrance ramps at a right angle. A colored lane was also installed on San Jacinto Boulevard near Duval Street where a right-turn bay crosses over a bike lane that runs parallel to the motor vehicle lanes.

After the installation of the colored lanes, motorists crossing the bike lane on Dean Keeton Street were more likely to yield to bicyclists and were more likely to use a turn signal when crossing the colored conflict area. Over 95% of bicyclists on Dean Keeton Street used the dashed bike lane to cross the conflict area before the addition of color, so the improvements in bicyclist behavior were negligible. At the conflict area on San Jacinto Boulevard, bicyclists were more likely to use the bicycle lane to approach the conflict area and were also more likely to stay in the bike lane throughout the colored conflict area. Motorists were more likely to utilize a turn signal when crossing the colored conflict area but less likely to yield the right of way to bicyclists—preferring instead to cross in front of bicyclists beyond the colored section. These results suggest that while motorists were made more aware of the potential conflict with bicyclists (as evidenced by



One of the colored lanes installed on Dean Keeton Street at the conflict area with Interstate 35

increased turn signal use), they are unsure of how to cross the bike lane once the color is added. This confusion on the part of motorists could be attributed to the lack of an educational campaign and the unfavorable sign placement of the “Yield to Bikes” sign on San Jacinto Boulevard.

Given these results, colored bicycle lanes and the accompanying “Yield to Bikes” signs are strongly recommended at conflict areas where bicyclists and motorists will cross perpendicular to one another. The color treatment and accompanying sign should also be considered at sites similar in geometry to San Jacinto Boulevard, where motorists must cross a parallel bicycle lane, due to the observed improvement in bicyclist predictability and increased motorist turn signal use. An education campaign targeted at motorists is likely important, especially in the latter case, to alert motorists of the proper way to cross the colored conflict area.

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Copies of the full reports for each device can be obtained from the Center for Transportation Research at the University of Texas in Austin by e-mail at ctrlib@uts.cc.utexas.edu or by phone at (512) 232-3100.