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 preferred 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 along a commuter route. No improvement in safety was found along the non-commuter site. Yellow-green color was applied inside bicycle lanes at areas where a bicycle lane and motor vehicle lane crossed paths. The colored lanes increased turn signal use by motorists at all sites; 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.

Over the last 20 years, the City of Austin has seen a significant growth in bicycling and bicycle facilities. Between 1990 and 2008, a statistically significant increase in bicycle mode share was observed among Austin residents in census block groups with new bicycle routes developed during that period—from 0.87% to 1.19%. During that same time period, the journey-to-work bicycle mode share for Austin increased significantly from 0.76% to 0.95%.[i] 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 to 7% of all trips to campus are made by bicycle.[ii]

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 Texas bicyclists, 69% of respondents stated they feel bicycling is "somewhat dangerous" or "very dangerous" from the standpoint of traffic crashes.[iii] Given these results, a need exists to improve the safety of on-street bicyclists.

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. In the past five years, CTR has conducted and published research about bicyclist operations and safety on shared 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 or on-street parked vehicles. 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 struck by a right-turning motorist. Finally, colored lane markings were installed at areas where bicycle 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 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, cameras positioned along each study site 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. A minimum of two weeks was allowed between collecting the pre- and post-implementation datasets to afford all road users the opportunity to decide how to interact with each new device. Data was collected between June 2009 and March 2010.

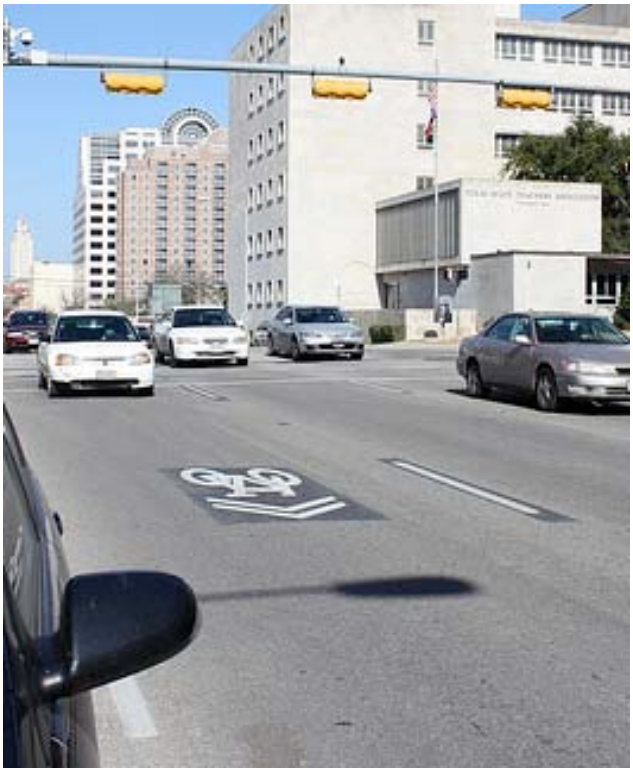
The following sections summarize the study results and make recommendations regarding future use of each device.

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

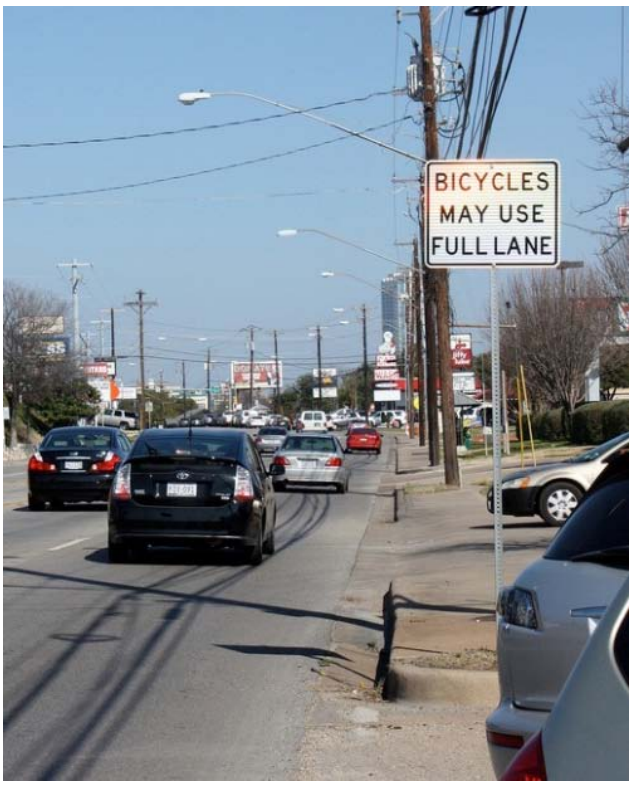
Shared Lane Markings and signs are two very different devices, but both are designed to encourage bicyclists and motorists to safely share the full lane. A Shared Lane Marking (or *sharrow*) is a thermoplastic symbol that is affixed to the street surface in the motor vehicle lane that bicyclists are most likely to utilize—bicyclists are encouraged to ride at the position on the road indicated by the sharrow. For this study, sharrows were 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 fifth 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, sharrows were placed in the center of the lane because there was not sufficient space for bicyclists and motorists to operate side-by-side. At Dean Keeton Street, where the outside lane is wider, sharrows were placed on the right side of the lane and were meant to guide bicyclists between bicycle lanes on blocks upstream and downstream of the studied road segment. At all sites, the sharrows were found effective at encouraging bicyclists to ride closer to the center of the lane, resulting in more predictable, safer conditions. The average distance bicyclists rode from the edge of the lane (called *lateral position*) increased only marginally, usually between four and eight inches, but a large shift in the mode[1] occurred along multiple sites—at least

[1] Mode is a statistical term meaning the value that is most common in a distribution. In this case, the modal bicyclist lateral position is the position in the lane that was most often used by bicyclists.



A Shared Lane Marking installed on Guadalupe Street in downtown Austin

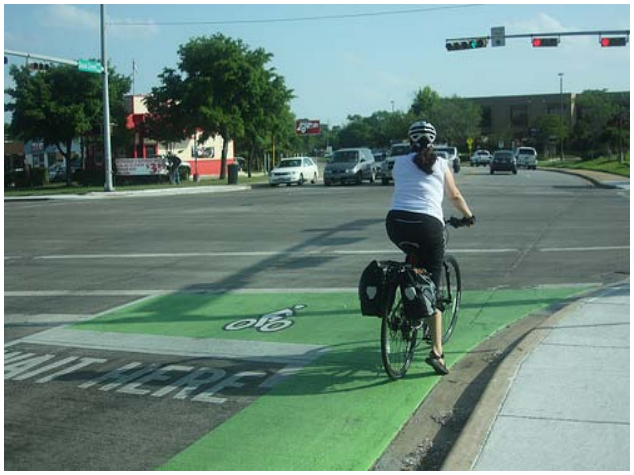


A "Bicycles May Use Full Lane" sign installed on South Lamar Boulevard

three feet in many cases. 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 stalls after the installation of the sharrows, but at other sites, no significant decrease in unsafe bicyclist behavior occurred. This may suggest that bicyclists choose to bypass motorist queues and ride on the sidewalk for convenience, not for perceived lack of safety. Regarding 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, all of which indicate safer motorist behavior.

"Bicycles May Use Full Lane" signs were installed along two multi-lane facilities: on the northbound side of South Lamar Boulevard, which connects South Austin to Downtown, and on Pleasant Valley Road near Cesar Chavez Street, a facility that connects East Austin neighborhoods to a park and trail system. The difference in bicycling population types between the two sites had a profound influence on the effectiveness of the signs on bicyclist and motorist behavior. Bicyclists on South Lamar Boulevard were observed to ride marginally closer to the center of the lane after the installation of the signs. Further, motorists were less likely to pass and provided substantially 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 South Lamar Boulevard 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 Road, 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, making it impossible to make a substantial recommendation.

This study concludes that Shared Lane Markings should be considered an effective bicycle safety device and be used to improve both bicyclist and motorist behavior along multi-lane facilities as either a stand-alone device or as a means to connect two facilities with bicycle lanes. Each of the three



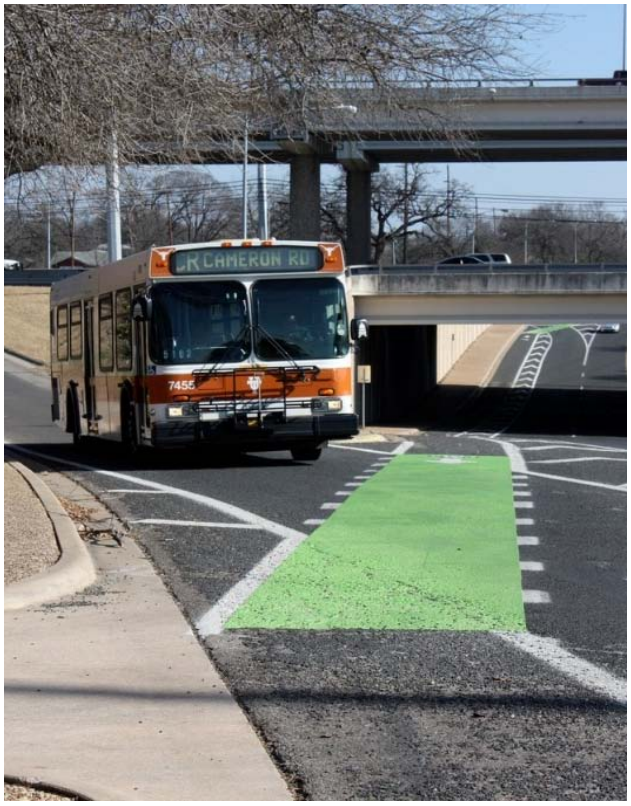
A bicycle box installed at the intersection of Shoal Creek Boulevard and Anderson Lane

facilities studied had a posted speed limit between 30 and 35 mph with traffic volumes ranging between 200 and 400 vehicles per hour per lane, so this recommendation can only be made for multi-lane facilities with speeds and volumes within those ranges. Regarding "Bicycles May Use Full Lane" signs, there is a reasonable expectation that such regulatory signs can improve the safety of bicyclists along roadways where bicyclists regularly utilize the full lane and are not particularly prone to sidewalk riding. Further research or corroborating findings by another institution could help determine the exact effect such signs have on safety. Until more conclusive data can be obtained for signs, Shared Lane Markings should be considered before signs, despite higher per-unit and per-mile costs.[2]

Bicycle Boxes at Intersections

Bicyclists face considerable safety risks when navigating intersections, since both bicyclists and motorists are often unsure of how to best position themselves during 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. When used properly, bicyclists approaching an intersection via a bicycle lane can pull into the bike box and take the first position within the queue, thereby improving their visibility, allowing

[2] Sharrows cost $192 per unit, including labor and materials. Given the MUTCD-recommended spacing of 250 feet, sharrows can be installed in one lane for $3,684 per mile. Signs were installed for $93 each. Given standard sign spacing, signs can be installed for $372 per mile.



One of the colored lanes installed along Dean Keeton Street at Interstate 35

them to depart the intersection first, and reducing the chance of being struck by right-turning vehicles. In other parts of the United States, bike boxes are extended across several lanes of traffic to facilitate left-turning bicyclists. This study examined the impact of bike boxes on improving the safety of bicyclists at intersections, so bike boxes were installed across only one lane. To reduce the chance that motorists encroached on the bike box, "No Right Turn on Red" signs were installed on the traffic signal masts at each 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, which lies along a popular 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, visibility, 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 bicycle lane adjacent to the bike box and 22% stopped in center of the bike box. The color also encouraged bicyclists to use the bicycle lane when approaching the intersection.

At Speedway and 38th Street, the addition of the bike box markings encouraged cyclists to use the bicycle 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 bicycle lane adjacent to the bike box. Since the bicycle 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. If the downstream conditions are such that bicyclists must share the full lane, bike boxes can encourage bicyclists to take the safest lane position before crossing the intersection. In configurations where a bicycle lane is provided downstream, there is little incentive for the bicyclist to enter the bike box, therefore making the bike box a less effective tool. An educational campaign aimed at informing the public on how to properly utilize a bike box could provide further safety improvements and increase the predictability with which road users interact with the bike box. When financially viable[3], the addition of color to the bike box should be considered, since motorists were less likely to encroach on a colored bicycle box and 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

Bicycle 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

[3] A bike box without color costs about $856 in materials and labor. The addition of color would increase the total cost by $1784.

the bicycle 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 bicycle 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. Given the typical dimensions of a colored lane conflict area (about 4 feet wide and 50 feet long), the colored lane and explanatory sign device could be installed for $1,368.[4]

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

After the installation of the colored lanes, motorists crossing the bicycle lane on Dean Keeton Street were more likely to yield 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 bicycle 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 bicycle 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 increased turn signal use), they were unsure of how to cross the bicycle lane once the color was added. This confusion on the part of motorists could be attributed to the lack of an educational campaign and the non-ideal sign placement of the "Yield to Bikes" sign on San Jacinto Boulevard.

[4] The yellow-green thermoplastic material cost $4.46 per square foot; explanatory signs were $33 per unit. Labor was $383 for each colored lane (about 200 square feet each) and $60 per sign.

Given these results, colored bicycle lanes and the accompanying "Yield to Bikes" signs are strongly recommended at conflict areas where bicyclists and motorists are guided across the bicycle lane at the colored conflict area by lane markings or curbs, such as is the case where a bicycle lane crosses a freeway exit ramp. The color treatment and accompanying sign should also be considered at sites similar to the San Jacinto Boulevard site, due to the observed improvement in bicyclist predictability and increased motorist turn signal use. However, they should be considered carefully to guide motorists to cross the conflict area at the appropriate point. An education campaign targeted at motorists is likely an important component in leveraging the full potential of the device, 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.

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