Beyond the Standard Standards –

An Examination of Two Innovative Bikeway Designs from San Francisco

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ABSTRACT

In San Francisco, similar to many dense cities, there is a high demand for on-street parking and high volumes of transit and motor vehicle traffic must share limited space. San Francisco has gone beyond traditional, North American design standards as it addresses the need to improve accommodation of cyclists. San Francisco presents two of their innovative approaches:

- Combined Parking Lane and Bike Lane ("Floating Bike Lane")

  This treatment is used to accommodate cyclists on streets with part time tow-away lanes. Space for cyclists on the roadway shifts during the day as parking is allowed or restricted. This successful treatment has worked along a waterfront arterial in San Francisco and can be very useful for communities wishing to find a balance between providing peak hour traffic capacity, on-street parking, and accommodation of cyclists.

- Shared Roadway Marking ("Sharrow")

  Shared roadways on which motor vehicles and bicycles share the same (sometimes narrow) lanes have some common issues, such as:
  - Bicyclists riding too close to parked cars in the "door zone,"
  - Motorists unaware of and/or not respecting cyclists' rights to legally take narrow lanes, and
  - Bicyclists riding on sidewalks or the wrong direction on roadways.

  This treatment addresses these issues by placing a marking on the roadway at a fixed distance from the curb face, encouraging bicyclists to ride outside of the "door-zone" and increasing motorist awareness that cyclists may legally ride away from the edge of the roadway, even if it means taking the lane.

San Francisco has documented these designs (along with over fifteen others) within the Supplemental Design Guidelines section of its Bicycle Plan. A study proving the effectiveness of the Shared Roadway Marking (now an approved traffic control device for shared bikeways in California - the first in the United States) will also be discussed.

1.0 INTRODUCTION

As part of its recent Bicycle Plan Update, San Francisco included two additional elements: the development of a set of design guidelines that would supplement existing national and state traffic manuals and the study of pavement markings to be used on roadways where cyclists and motorists share the same space. As a result of these efforts, a set of Supplemental Design Guidelines were developed and a pavement marking adopted by the state for use on shared roadways. This paper will discuss the Supplemental Design Guidelines but focus on the "Floating Bike Lane" design and Shared Roadway Marking.

2.0 SUPPLEMENTAL DESIGN GUIDELINES

2.1 BACKGROUND

The use of traffic control devices, like signs and pavement markings, in the United States is governed by the Manual on Uniform Traffic Control Devices (MUTCD). Some states, like California, have supplements to the MUTCD that may include some deviations either in type of traffic control devices or in the use of such devices.

With regards to the development and design of bikeways, something not very advanced in the United States given the country's priority of accommodating personal motor vehicle use over the past 50+ years, these manuals fall short, describing solutions for only fairly rudimentary design issues. Given these constraints, and the overall challenges of accommodating cyclists in a dense urban environment with high demand for limited street space, San Francisco decided to create a local manual that included more innovative design approaches and traffic control devices that have been used or discussed around North America and the world, but not yet incorporated into state or national manuals in the U.S.

2.2 PROCESS

As part of the recent update of San Francisco's Bicycle Plan (something that happens approximately every 5 years), the city's consultants were asked to develop a local manual for bikeway design. The City and the consultants worked together to compile various bikeway designs not included in current manuals and created the San Francisco Supplemental Design Guidelines.

2.3 RESULTS

Included in the Supplemental Design Guidelines are various bikeway designs and traffic control devices. Below is a partial list:

- Colored Bicycle Lanes
- Contra-flow Bicycle Lanes
- Bicycle Boxes
- Floating Bicycle Lanes

- Bicycle Boulevards
- Left Turn Lanes for Bicyclists
- Back-in Angled Parking with Bike Lanes
- Shared Roadway Markings
- Bicycle Lane Design through Double Turn Lanes

Since the completion of the Supplemental Design Guidelines, a number of these facilities have been installed, including a contra-flow bike lane (Figure 1), a bicycle box (Figure 2), floating bike lanes (discussed below), left turn lanes for bicyclists (Figure 3), shared roadway markings (discussed below), and bike lane designs through double turn lanes (Figure 4). San Francisco is moving ahead with a Request to Experiment with colored bicycle lanes, and the process to approve legislation allowing the use of back-in angled parking is currently underway.

Figure 1: Contraflow Bike Lane in Golden Gate Park, SF

Figure 2: “Bike Box” to Allow Left Turning Cyclists to Position Themselves

Figure 3: Left Turn Bike Lane

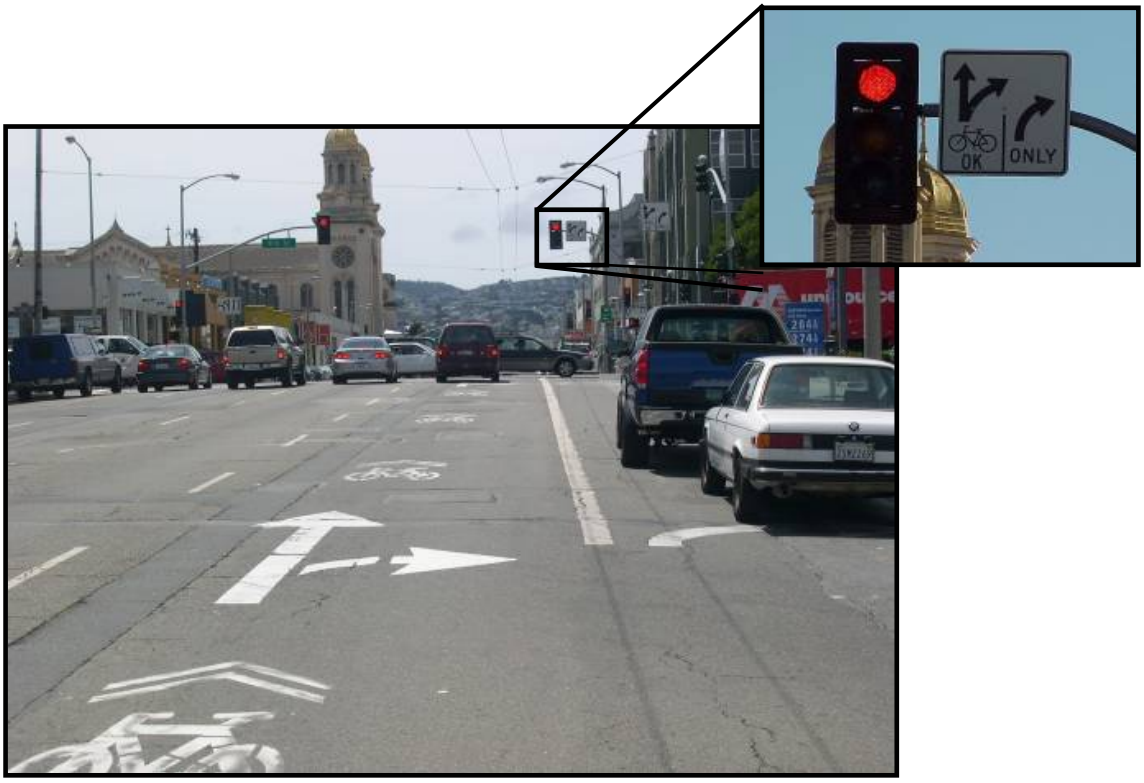

Figure 4: Bicycle Treatment at Double Turn Lane

San Francisco will continue to implement and evaluate the use of these various designs as it improves its bicycle route network and confronts unique (and not-so-unique) design challenges. Below are more detailed discussions of two the designs/traffic control devices: the “floating bike lane” and the shared roadway marking.

3.0 FLOATING BIKE LANE

3.1 BACKGROUND

The Embarcadero is a waterfront arterial in San Francisco that replaced a freeway heavily damaged by the Loma Prieta Earthquake of 1989. The roadway varies from 4-6 lanes (2-3 in each direction) and currently handles weekday traffic volumes of 40-50,000 vehicles per day.

After the roadway was constructed and while the area along the waterfront continued its evolution, it was determined in some areas that there was a need for on-street parking during non-peak traffic periods. During peak periods, there would be a tow-away restriction to uncover a third travel lane in each direction. While accommodation of bicyclists was intended along the length of the roadway, there was a problem with how to designate road space for cyclists to use along the sections of road with part time parking.

One option was to stripe two rows of shared roadway markings (to be discussed more fully later in this paper) along each direction of the roadway, one along the curb to show where cyclists would ride when there was no parking allowed and the other further away from the curb for cyclists when parking was allowed. This was rejected on the basis that two rows of bicycle specific markings could be confusing to road users. Also, it is generally desirable to explore options which give cyclists their own striped space on the roadway prior to simply accepting shared lane markings in narrow lanes.

3.2 DESIGN MEASURES IMPLEMENTED

To give cyclists a designated space along the section of roadway with part-time parking, the design shown in Figures 5 and 6 was finally chosen. When parking is allowed, cyclists use the space between the parked cars and the solid 100mm (4") wide white stripe, a space about 2.1m (7') wide depending how close cars park to the curb. When parking is not allowed, as shown in Figure 2, cyclists move to the right and use the 1.5m (5') wide shoulder. Motorists are able to use the third lane, which at 3.2m (9' 9") wide is more narrow than typical but wide enough to accommodate the generally slower traffic speeds one would expect during peak hours.

Prior to this final design, there was some trial and error. The 100mm (4") solid white line shown 4.5m (14' 9") from the curb in Figure 1 was initially further out at 4.7m (15' 6") and broken/dashed as a typical lane line would be. While this allowed for a 3.2m (10' 6") motor vehicle lane when no parking was allowed, it also created a wider space alongside the parked cars when parking was allowed, a space that looked like a typical travel lane but was actually too narrow to accommodate traffic. The result was motorists using the space and sideswiping parked cars and filling the space intended for cyclists.

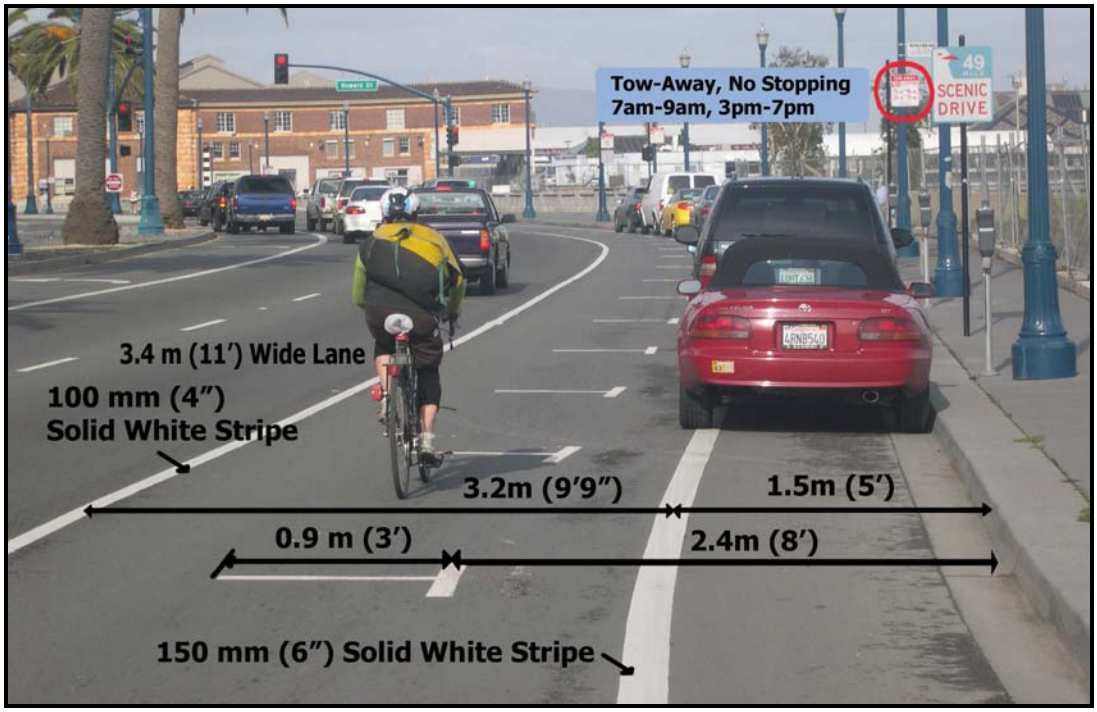

Figure 5: "Floating Bike Lane" with Part-Time Parking when Parking is Allowed

Figure 6: “Floating Bike Lane” with Part-Time Parking when Parking is Not Allowed

To make the space between the first 100mm (4”) wide lane line and the parked cars seem less like a travel lane to motorist when parking is allowed, the 100mm (4”) wide white line was moved closer to the curb face. It was also made solid to discourage crossing and make the lane seem less like a travel lane. The parking T’s, initially 2.1m (7’) from the curb, were relocated to be 2.4m (8’) from the curb and painted with longer stems. The placement was meant to further narrow the space by encouraging people to park their cars further from the curb while the longer stems were to make the space seem less like a travel lane. And finally, cross hatching was added in the 3.2m (9’ 9”) space at the beginning of the floating bike lane sections to further discourage motorists from using the space when parking was allowed (see Figure 7). While this was all meant to make the space more narrow and less attractive to motorists when parking is allowed, it still remains wide and attractive to cyclists.

Figure 7: Cross-hatching at Beginning of “Floating Bike Lane” Treatment

Would these efforts to make the space less attractive to motorists when parking was allowed result in the space not being used by motorists when parking was restricted and they were expected to drive in the third lane? From observations, motorists use the 3.2m (9’ 9”) wide third lane as intended when parking is not allowed. The theory is that while it is not a conventional looking lane, motorists, especially when traffic congestion reaches certain levels (like those found during peak hours), will use whatever reasonable space is available to them. An analogy is that the design works as a pressure release valve with the unusual looking third lane used only when traffic levels reach a certain level.

Use of signs associated with this unusual arrangement has been minimal. While it was tempting to try to sign these stretches to explain what is going on, initial sign designs were found to be either too complicated or incomplete. Though it was always an option if the roadway lane markings were not sufficient, it was determined that signage explaining the part time use of the space was actually not necessary. The only signs pertinent to the design are the tow-away signs (circled in Figure 5) and the merge sign used in the southbound direction where three full time lanes enter the section with the floating bike lane and narrow to two travel lanes when parking is allowed (see Figure 8). Bike route signs are also along this area (Figure 9).

Figure 8: Merge Sign at Approach to Section of Road with Floating Bike Lane

Figure 9: Bicycle Route Signs

There have been request to install bicycle markings on the street but, as mentioned earlier, two rows of markings would be necessary for cyclists as they shift from one space to another, resulting in a confusing arrangement. Cyclists tend to stay to the right, so when there is no parking allowed, they naturally ride in the 1.5m (5') wide shoulder. When parking is allowed, they ride in the space between the parking and the 100mm (4") solid white stripe.

3.3 EVALUATION

While there has not been a quantitative evaluation of the design, observations indicate the space is working as intended. Feedback from cyclists, motorists, and employees of the Port of San Francisco along the Embarcadero has been utilized throughout the process. Initial feedback and observations are what yielded the modifications to the design, while the current good feedback and lack of negative feedback has reflected observations that the design basically works. The primary comment heard currently is that there should be pavement markings for cyclists, but the potential confusion caused by trying to mark a shifting space would likely outweigh any benefits.

3.4 RESULTS

The result of this trial and error process to accommodate cyclists along a roadway with part time parking is shown in Figures 1 and 2. If this approach is used, the key is to not make the space between the parked cars and the first 100mm (4") lane line too wide. With the 100mm (4") lane line initially at 11.5m (15' 6") from the curb, the space was wide enough to attract motorists when parking was allowed. This 11.5m (15' 6") width resulted in sideswipes with parked vehicles and motorists in the space intended for cyclists. These widths should be adjusted as necessary for local conditions, such as the average width of vehicles and the typical motorists' behavior/aggressiveness. Another key is to ensure that traffic levels are reasonably accommodated when parking is allowed so that there is less temptation to try to use the space intended for cyclists.

3.5 CONCLUSIONS AND RECOMMENDATIONS

Based on observations, good feedback from cyclists, and lack of significant negative feedback, the current design is considered effective. While not perfect, with its slightly confusing, unorthodox design, it successfully accommodates cyclists, part-time on-street parking, and motorists needing additional capacity during peak hours. And it does so with minimal signage, leading one to conclude that while the design is unorthodox, it uses fairly predictable road user behavior to its advantage. Cyclists naturally tend to stay to the right and motorists will use a space even if it is not clearly for their use if traffic congestion reaches certain levels and the space is reasonably accommodating.

4.0 SHARED ROADWAY MARKING

4.1 BACKGROUND

Shared roadways make up the majority of most bike route networks in the United States. These shared roadways are often comprised of curb lanes too narrow for motorists and bicyclists to safely share side by side (defined here as "substandard width"). On these roadways, the following problems often occur:

- Cyclists are pressured into hazards on the edge of the road/lane, such as the "door zone" (Figure 10) where motorists leaving parked cars may suddenly open their door in a cyclist's path, a common problem in the U.S.
- Motorists attempt to pass cyclists closely or intimidate cyclists legally in the lane
- Cyclists decide to ride on the sidewalk illegally
- Cyclists ride on the wrong way on the road

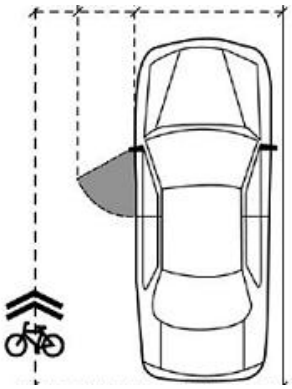

Figure 10: The "Door Zone"

Though these problems are faced regularly by municipalities, there is no accepted pavement marking standard for shared roadways. The City of Denver attempted to address this issue by developing an arrow with cyclist symbol inside to be placed in shared lanes. San Francisco used this marking on some streets but determined that the marking could be more visible.

4.2 DESIGN MEASURES IMPLEMENTED

After obtaining permission to experiment from the California Traffic Control Device Committee (CTCDC), the state committee responsible for discussing and recommending changes to manuals dictating the type and use of official traffic control devices, San Francisco hired a consultant to review a number of marking designs and study the best two in the field. The two marking designs (see Figures 11 and 12) were placed on six city streets with substandard curb lane widths (5.1m [16'10"] to 6.7m [22'] wide, with parking).

Figure 11: "Bike and Chevron"

Figure 12: "Bike-in-House"

Based on previously recorded observations which showed that car doors open to approximately 2.9m (9’ 6”) from the curb face, the markings were placed 3.4m (11’) from the curb, giving cyclists with 0.6m (2’) wide handlebars approximately 150mm (6”) of clearance from opened doors.

4.3 EVALUATION

“Before” and “after” video was taken at each marking location, and a limited number of surveys were distributed to cyclists and motorists to determine their understanding of the marking designs. Recorded behaviors taken with video included:

- Cyclists’ positions on roadway (e.g. distance from parked cars)
- Motorists’ positions (e.g. distance from cyclists when passing)
- Cyclist direction (with or against traffic)
- Cyclist location (street or sidewalk)
- Conflicts between cyclists and motorists

4.4 RESULTS

After reviewing videotape of 2400 cyclists and 2400 motorists, the most effective pavement marking design, the “bike and chevron” (Figure 11), was shown to:

- Encourage cyclists to ride 200mm (8”) further away from the door zone
- Encourage motorists to give 0.7m (2’ 3”) more space when passing cyclists
- Reduce the incidence of wrong way riding by 80%
- Reduce the incidence of sidewalk riding by 35%

There was no statistically significant change in hostile/aggressive behavior by motorists, but this may be attributed to the very small number of observed conflicts in both the “before” and “after” video tapes.

Through the motorist and cyclist surveys, it was determined that the meaning of the markings was not always clearly understood.

4.5 CONCLUSIONS AND RECOMMENDATIONS

As a result of this study, the bike and chevron design (Figure 11) was recommended by the California Traffic Control Device Committee as a pavement marking to be included in the MUTCD 2003 California Supplement. As of October 2004, the CTCDC and Caltrans had developed draft language for inclusion of the marking in the manual. The language discusses the optional use of this marking on roadways used by bicyclists, and gives placement guidance. In September 2005, Caltrans adopted the marking as an official traffic control device, the first standard marking in the United States for shared roadways.

San Francisco is developing a set of local warrants to help determine on what streets the markings will be placed. Thus far, the following list has been developed of data to consider:

- Curb lane width
- Parking turnover
- Traffic volumes
- Dooring, overtaking, mid-block bicycle collision history
- Gap in otherwise continuous bike path or bike lane
- Current demand by cyclists
- Prevailing speeds by motor vehicles and cyclists
- Prevalence of cyclists riding on sidewalk or in wrong direction
- Anticipated addition of bicycle lane to street

Based on the results of the surveys taken as part of the study, outreach campaigns explaining this new marking will continue. As the first markings were applied, San Francisco launched a campaign using bus tail cards advertising and explaining the shared lane marking (see Figure 13). This campaign aims to explain the marking (along with the concept of shared lanes and doorings) and direct people to our website (www.bicycle.sfgov.org) which includes a “Frequently Asked Question” list and more detailed information about the marking, the study, and the process that lead to its adoption.

Figure 13: Outreach Effort Using Bus Tailcards

5.0 CONCLUSION

The San Francisco Bicycle Route Network was established approximately 10 years ago. Since then, the network has been completely signed with bicycle route signs and steadily improved, primarily with the addition of on-street bicycle lanes. This has resulted

in increased numbers of cyclists (100+% increase in trips to work by bike from 1990 to 2000, according to the 2000 U.S. Census) and decreasing numbers of crashes (down ~30% since 1998). This work has made San Francisco the U.S. city with the highest rate of bicycle use for trips to work (according to the 2000 Census for cities of populations greater than 500,000 people).

In the past two years or so, as the design challenges associated with improving the network have become more complex, greater efforts have been made to seek solutions not provide by existing traffic manuals in the United States. With time, some of the designs discussed in this paper will become more commonplace and, like the shared roadway marking, become recognized as official traffic control devices, giving people working on bicycle transportation issues in the United States more tools with which to work.

6.0 REFERENCES

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