A Survey of Planning, Design, and Education for Bikeways and Bus Routes on Urban Streets

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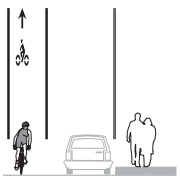

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Introduction

The City of Oakland has many policies to promote multimodal transportation including the Transit First/Complete Streets Policy, Pedestrian Master Plan, Bicycle Master Plan, and Transit Streets Cooperative Agreement. These policies encourage multimodal transportation but generally do not provide direction and guidance for resolving conflicts between motorists, transit operators, bicyclists, and pedestrians.

Most modes of transportation in Oakland share the same street network which can create competition between different modes and may complicate street operations. Particularly in cities with irregular street grids, there are limited opportunities to prioritize different modes on different streets in the same corridor. Overlapping bikeway networks and bus networks can present unique challenges for both bicycle and transit planners. These challenges include:

1. Resolving the competing needs for limited right-of-way;
2. Managing the differences in size and weight between cyclists and buses;
3. Accommodating the comparable travel speeds of cyclists and buses that result in "leapfrogging."

This survey reviews the available literature as well as the policies, guidelines, and design treatments in Oakland and other cities for managing bicycle/bus conflicts in a multimodal framework.

Literature Review

The available literature is limited to the following two reports that specifically address design alternatives and recommendations for bikeways and bus routes on urban streets.

Michelle De Robertis and Rhonda Rae in "Buses and Bicycles: Design Alternatives for Sharing the Road" (2001) discuss the conflicts between shared routes and evaluate design alternatives to accommodate the shared use of street space. Designs discussed by the authors include bus only lanes where cyclists are permitted, bike lanes between the bus lane and auto traffic lanes, contra-flow bike lanes, left-side bike lanes on one-way streets, and median bike lanes. The authors analyze each design alternative for its advantages and disadvantages. No one design is without disadvantage.

The second report, "Bus-Bike Interaction within the Road Network" by Austroads (2005), also reviews the conflicts posed by bike and bus network interactions and provides a toolkit for minimizing conflicts. The design guidelines describe shared bike and bus lanes, separated bike and bus lanes, intersections where buses turn, bus stops with bike lanes, and other potential conflict points.

Some of the designs described by the reports are used in the San Francisco Bay Area while others are more common in other regions and countries. Following a discussion of planning issues, this report examines a collection of design treatments and describes their associated advantages and disadvantages. Where available, examples from California and the United States are used to illustrate these design treatments because of their greater applicability to local design standards.

Planning for Bicycle and Bus Networks

In California, bicyclists are allowed on all public roadways except for prohibitions that may apply to specific freeways, bridges, and tunnels. Most cities do not have explicit policies regarding the development of bikeways on bus routes. However those that do can be grouped into two categories:

1. Cities where such network overlap is universally allowed; and
2. Cities where network overlap is considered on a case-by-case basis.

Cities that generally allow network overlap include Vancouver (Canada) and Portland. Other cities such as San Francisco, Denver, San Diego, and Minneapolis allow network overlap on a case-by-case basis. These cities consider factors like traffic speeds, bus headways, alternative routes, and available funding when assessing how bicycle and bus networks should overlap.

As part of its Bicycle Master Plan (2007), the City of Oakland compared potential bikeways to existing bus routes to minimize the complications in both design and operations of having designated bikeways on heavily used transit streets. Based on their headways and ridership, bus lines were categorized by overall importance into a hierarchy of four groups. The most important transit streets—those with "rapid/trunk lines" and "major lines"—were avoided where possible and bikeways designated on parallel streets. Where this solution was not possible due to Oakland's irregular street grid, the proposed bicycle facilities were chosen to minimize potential effects on bus operations. In particular, an effort was made to avoid the conversion of travel lanes to bicycle lanes on rapid/trunk and major lines. For this type of project, the City of Oakland includes the following considerations in the project's feasibility study to assess the effects of the proposed bikeway project on bus operations:

1. Bus Travel Times: What is the sum of the delays created by the proposed project at the controlled intersections in the project area and along the bus line?
2. Bus Stop Access: What is the effect of queue lengths on the bus accessing its stops? What is the effect on traffic gaps for bus egress from the stop?
3. Incident Delays: How will double-parked vehicles (including delivery vans, garbage trucks, private vehicles, and the like) affect bus movements? (This study parameter only applies to projects that would result in one travel lane per direction.)
4. Total Travel Delay: What is the bus's total travel delay in the project area associated with bus travel times, bus stop access, and incident delays (if applicable)?
5. Cumulative Effects: What other bikeway and/or streetscape projects are proposed on the rapid, trunk, or major bus line in question? Would those projects have similar effects on bus travel times?

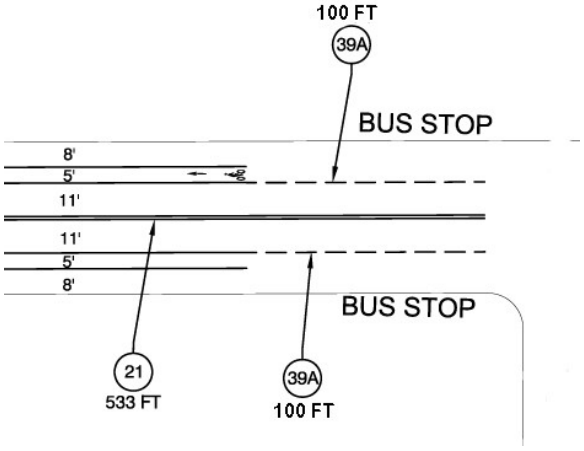
By assessing the potential effects on transit, the feasibility studies for such bikeway projects provide a more comprehensive accounting of the proposed project and thus guide decision-making on tradeoffs in a manner that consistent with the City's policies promoting multimodal transportation.

Design Treatments: Bike lane striping at bus stop

Cities including Oakland, San Francisco, and Vancouver (BC) have specific design guidelines for bike lane striping at bus stops. "Figure 1: Bike Lane Striping at Bus Stop" shows typical bike lane striping for both near and far side bus stops in Oakland. For this treatment, the bike lane stripe is skipped and the edge line stripe ends for the length of the bus stop.

Figure 1: Bike Lane Striping at Bus Stop

Typical Striping in Oakland



Purpose: To designate bus stops on streets with bike lanes.

Advantages:

- Provides indication to cyclists where buses may cross over the bike lane.
- Provides indication to bus drivers that they are crossing over the bike lane.
- On roadways where bus traffic is light, not many buses will cross over the bike lane.

Disadvantages:

- Buses must cross over the bike lane to reach the bus stop.

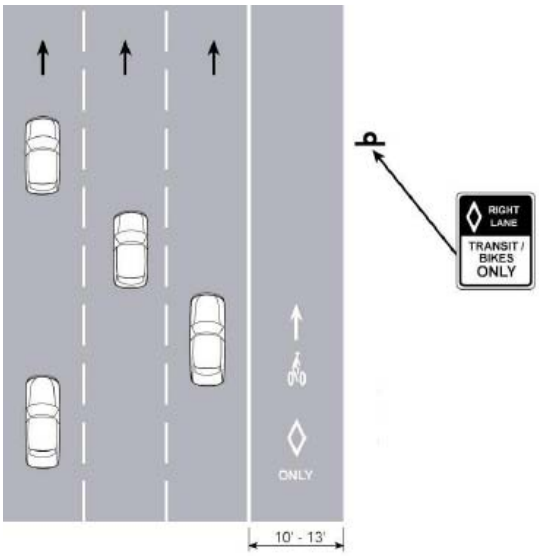
Design Treatments: Shared dedicated bus/bike lanes

Shared bike/bus lanes can be found in Vancouver (BC), Madison (WI), Toronto, Philadelphia, and Berlin. The City of San Francisco provides design guidelines for this treatment.

This design may apply where there is not enough room for each mode to have its own dedicated lane. San Francisco's design guidelines specify a shared lane of 10 to 13 feet in width. Where the lane is 14 to 17 feet, San Francisco recommends that each mode have its own lane. (See "Design Treatments: Bus lane at curbside with bike lane to left.")

This design is considered appropriate for streets with considerable automobile traffic, moderate to long bus headways, and where an alternative bikeway alignment does not exist.

Figure 2: Shared dedicated lanes



Source: San Francisco Metropolitan Transit Agency, City of San Francisco Bicycle Plan Update: Supplemental Design Guidelines (September 2003), 9. <http://www.sfmta.com/cms/bproj/documents/x_Appendix_A_updated_000.pdf> [11 January 2008].

Purpose:

- Installation of bike lane where there is not enough room for bikes and buses to each have their own dedicated lane.

Advantages:

- Avoids buses crossing over the bike lane to access bus stops.
- Provides roadway space for bicyclists that is separated from private motor vehicles.

Disadvantages:

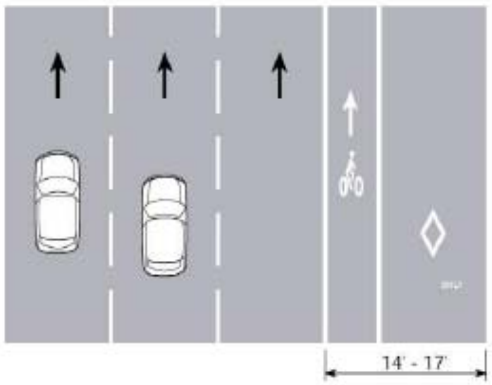
- Potential for bike/bus conflicts, including leapfrogging, throughout lane.
- Requires sufficient right-of-way for the dedicated bus/bike lane.

Design Treatments: Bus lane at curbside with bike lane to left

Some cities recommend that bicycles and buses each have their own dedicated lane where there is 14 to 17 feet of available right-of-way. The San Francisco design guidelines propose the dedicated bike lane to the left of the bus lane. This design eliminates the problem of the bus crossing over the bike lane at bus stops. However, it puts cyclists between auto traffic and buses. Austroads (2005, p. 51) and New Zealand's association of transport and traffic authorities do not recommend this design because bicyclists are located in between motor vehicle traffic.

This design can be used on streets with significant automobile traffic where an alternative bikeway alignment does not exist.

Figure 3: Bike lane to left of bus lane



Source: San Francisco Metropolitan Transit Agency, City of San Francisco Bicycle Plan Update: Supplemental Design Guidelines (September 2003), 9. <http://www.sfmta.com/cms/bproj/documents/x_Appendix_A_updated_000.pdf> [11 January 2008].

Purpose:

- Separation of bicycles and buses in dedicated lanes.

Advantages:

- Buses do not cross over the bike lane to access bus stops.

Disadvantages:

- Cyclists are positioned between buses and auto traffic.
- Requires sufficient right-of-way for the bike lane and bus lane.

Design Treatments: Left side bike lanes

Left side bike lanes are advantageous for transit drivers. This design removes the bicyclist from potential conflict with buses. However; it places cyclists on the roadway where auto drivers may not expect them.

Purpose:

- Removes cyclists from bus's path of travel.

Advantages:

- May reduce dooring because the driver-side doors (that are used more frequently) open towards the curb.
- May reduce left-hook collisions by improving the visibility of cyclists.

Figure 4: Left side bike lanes

Fell Street, San Francisco. Source: Jennifer Donlon [10 April 2008].

Disadvantages:

- This treatment only works on on-way streets.
- Slower traffic is generally understood to keep right.
- Cyclists are in a position where drivers may not expect them.

Other Design Options

Some cities have implemented other types of designs to address bike and bus interactions including bike lane by-passes and median bikeways. These design options are not as common and may have serious flaws that create safety hazards.

Bike Lane By-Pass

Austroads describes a bike lane bypass at bus stops, shown in "Figure 5: Bike lane by-pass." This design avoids the problem of buses crossing the bike lane. However, the treatment requires adequate space to create the bypass and there is the potential for conflict between cyclists and pedestrians accessing the bus stop. Portland also has a bike lane by-pass at a light rail stop.

Purpose:

- Prevent bike and bus conflicts at bus stops.

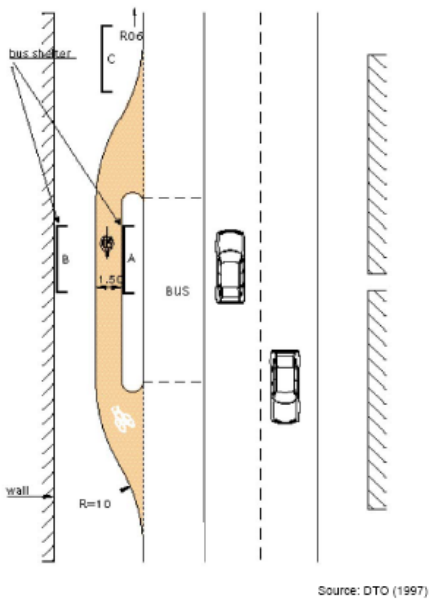
Advantages:

- Avoids buses crossing the bike lane to access bus stops.

Disadvantages:

- Potential for bike and pedestrian conflicts.
- Requires sufficient right-of-way.
- Cyclists must merge back into traffic in front buses.

Figure 5: Bike lane by-pass



Source: Austroads, *Bus-Bike Interaction within the Road Network* AP-R266/05 Sydney: Austroads Incorporated, 2005.), 59. <http://www.sfmta.com/cms/bproj/documents/x_Appendix_A_updated_000.pdf> [11 January 2008].

Source: City of Portland Office of Transportation.

Median bikeways

Median bikeways are used in Lima (Peru) on streets with heavy bus traffic, short headways, and high demand for curb space. The New York City Department of Transportation has plans to build a median bikeway along the Sands Street entrance to the Manhattan Bridge in Brooklyn (Figure 6).

This design eliminates cyclist conflicts with buses accessing stops and with automobiles turning right. However, the design poses significant challenges for bicyclists accessing the bikeway, crossing intersections along the bikeway, and exiting the bikeway to reintegrate with automobile traffic.

Figure 6: Median bikeways

Source: New York City Department of Transportation, <http://www.nyc.gov/html/dot/html/pr2005/pr05_43.shtml> [2 April 2008].

Purpose:

- Separates bicyclists from bus and automobile traffic.

Advantages:

- Avoids buses crossing the bike lane to access bus stops.
- Avoids conflicts with right turning automobiles.

Disadvantages:

- Creates hazards at intersections with through and turning auto traffic.
- Creates hazards for cyclists who wish to turn left or right.
- Curbside parcels are less accessible to bicyclists.

Median bus lanes

Median bus lanes are used in San Francisco, CA and Eugene, OR. Often these designs are implemented to facilitate bus movement but it also resolves other issues. Median bus lanes eliminate bus conflicts with cyclists and right turning vehicles. However, the design poses challenges for pedestrian crossings, placement of passenger loading areas, and vehicle left turns.

Figure 7: Median bus lanes

Market Street, San Francisco. Source: Jennifer Donlon [28 May 2008].

Purpose:

- Separates buses from cyclist and automobile traffic.

Advantages:

- Avoids buses crossing the bike lane to access bus stops.
- Avoids bus conflict with right turning automobiles.
- Avoids bus conflict with automobile traffic.

Disadvantages:

- Creates potential hazards for passengers crossing traffic lanes to reach bus stop.
- Creates vehicle left-turn traffic conflict with buses.
- Requires street space for passenger loading/waiting area.

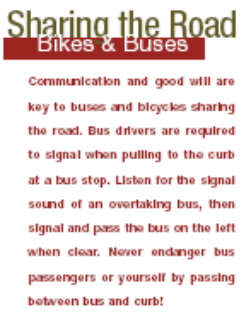
Education Programs for Cyclists

Bus-specific education programs and campaigns for cyclists are found in the Bay Area as well as in other cities.

AC Transit provides guidance to bicyclists in their brochure "Sharing the Road: Bikes & Buses" along with user information for the bicycle racks on buses (**Figure 8: AC Transit**).

A collaborative effort between the San Francisco Municipal Transportation Agency (SFMTA), San Francisco County Transportation Authority (SFCTA), and the San Francisco Bicycle Coalition (SFBC) produced the Coexist Campaign. **Figure 9** is a component of this safety campaign on bike-bus interactions that appeared on billboards and buses.

Figure 8: AC Transit



Source: AC Transit Bike Brochure. <http://bicycling.511.org/pdf/ACTransit_bikebrochure.pdf> [8 April 2008].

Figure 9: San Francisco Cyclist Education Campaign

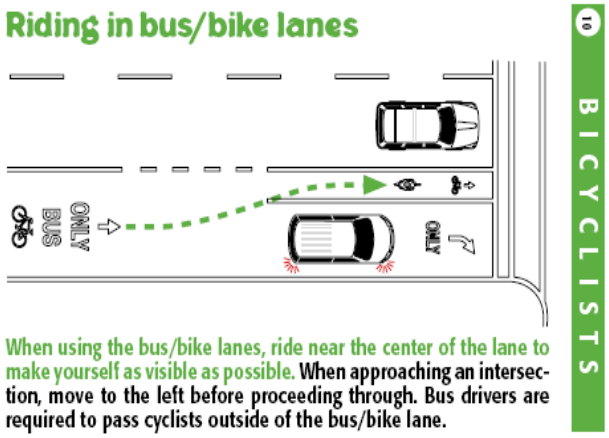
Source: San Francisco MTA, Coexist (30 January 2008). <http://www.sfmta.com/cms/bsafe/3828.html> [8 April 2008].

In a joint effort, the Warrington Borough Transport and the Warrington Cycle Campaign published an educational pamphlet for both cyclists and bus drivers. "Figure 10: Warrington Cyclist Education Information" is an excerpt from the pamphlet. It outlines the difficulties bus drivers face and offers suggestions to cyclists to avoid conflict with buses.

In Arizona, Pima County's Bicycle and Pedestrian Program has published "A Guide for Bicyclists and Motorists: Share the Road (2008 Edition)." This guide describes appropriate cyclist lane positioning in shared bike/bus lanes (Figure 11: Pima County Lane Positioning).

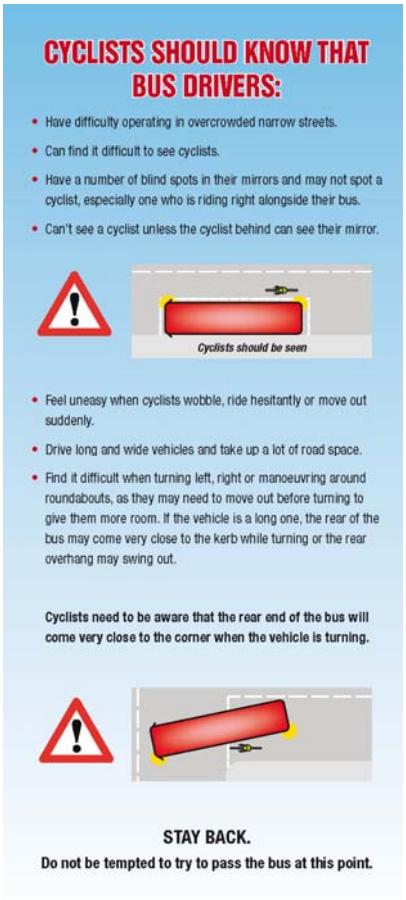
Metro Transit which covers the Minneapolis and St. Paul area in Minnesota also has had an educational campaign for cyclists who use transit routes. Metro Transit reminds cyclists to pass buses on the left, to ensure they are seen by drivers, as well as other safety reminders.

Figure 11: Pima County Lane Positioning



Source: Pima County Department of Transportation, *A Guide for Bicyclists and Motorists: Share the Road (2008 Edition)*, 10. <http://www.bikeped.pima.gov/Pubs/Share%20the%20Road3%201207.pdf> [18 January 2008].

Figure 10: Warrington Cyclist Education Information

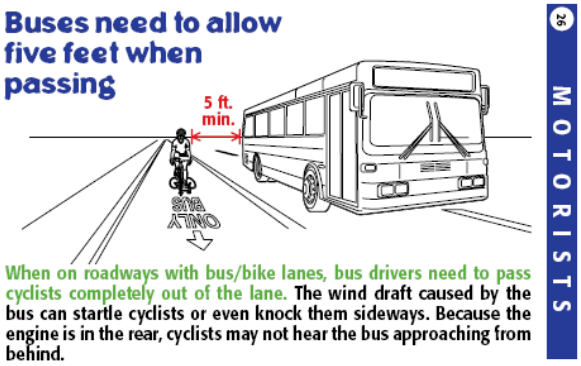


Source: Warrington Cycle Campaign, *Bus Drivers and Cyclists in Harmony* <http://homepage.ntlworld.com/pete.meg/wcc/report/WBT-bus-cycle.pdf> [18 January 2008].

Education Programs for Bus Drivers

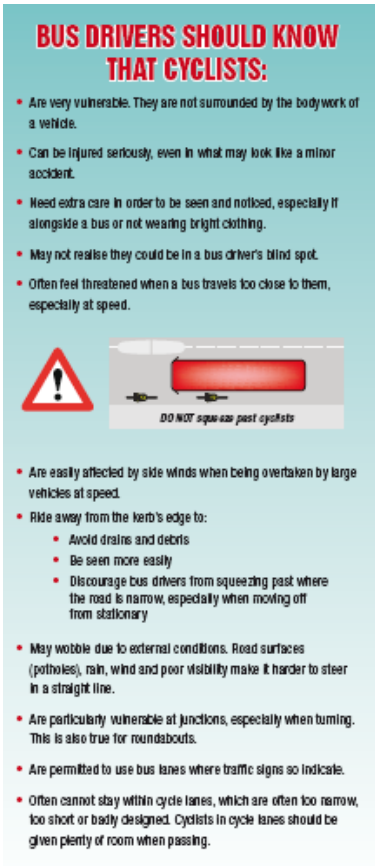
Both Pima County and the Warrington groups informational pieces also include education for bus drivers. The Pima County guide describes appropriate bus positioning for passing cyclists in shared lanes (Figure 13: Pima County Lane Positioning). The Warrington Educational Campaign outlines the difficulties cyclists face when riding on shared routes (Figure 12: Warrington Educational Campaign).

Figure 13: Pima County Lane Positioning



Source: Pima County Department of Transportation, *BusA Guide for Bicyclists and Motorists: Share the Road (2008 Edition)*, 26.<http://www.bikeped.pima.gov/Pubs/Share%20the%20Road3%201207.pdf> [18 January 2008].

Figure 12: Warrington Educational Campaign



Source: Warrington Cycle Campaign, *Bus Drivers and Cyclists in Harmony* <http://homepage.ntlworld.com/pete.meg/wcc/report/WBT-bus-cycle.pdf> [18 January 2008].

Not all education programs are formal. Each Valentine's Day, the San Francisco Bicycle Coalition distributes hand-made valentine cards to bus drivers. This program builds a friendly relationship between cyclists and bus drivers.

Figure 14: SFBC Valentine Cards to Bus Drivers

Source: San Francisco Bicycle Coalition, www.sfbike.org/?bb&bbid=178#3 [18 June 2008]

Conclusion

Overlapping bicycle and bus networks may create challenges in the planning, design, and operation of urban streets. Cyclists and buses have distinct design needs, significant differences in size and weight, and average travel speeds that are often comparable. The literature is limited, although some resources are available. The planning of bikeway and bus networks can consider these issues and avoid design tradeoffs where buses and bicycles can be prioritized on different streets in the same travel corridor. Where parallel and proximate routes do not exist, the detailed design of the roadway can encourage shared use by both bicyclists and buses. Design treatments such as specific bike lane striping at bus stops can provide guidance to cyclists and bus drivers on negotiating conflict points. Other design treatments like left side bike lanes seek to separate the path of travel of cyclists and buses on shared roadways. Shared bus and bike lanes provide benefits to both buses and cyclists by separating them from other motor vehicle traffic. However, this treatment does not directly address the bus/bike conflicts known as "leapfrogging." Some cities use dedicated bike lanes and bus lanes on the same street if sufficient right-of-way is available. In addition to the roadway design, education for bicyclists and bus drivers is a key consideration for encouraging shared roadways. The detailed messages of such educational campaigns will depend in part upon the design treatments in use.

References

AC Transit. *Designing with Transit: Making Transit Integral to Easy Bay Communities* (2004).

American Association of State Highway and Transportation Officials (AASHTO). *Guide for the Development of Bicycle Facilities, 3rd Edition*, 1999.

Austroads. *Bus-Bike Interaction within the Road Network*. AP-R266/05. Sydney: Austroads Incorporated, 2005.

DeRobertis, Michelle M., and Rhonda Rae. "Buses and Bicycles: Design Alternatives for Sharing the Road." ITE Journal 71, no. 5 (May 2001): 36-44.

Institute of Transportation Engineers (ITE). *Innovative Bicycle Treatments*, 2002.

Pima County Department of Transportation. *A Guide for bicyclists and motorists: Share The Road (2008 Edition).* <http://www.bikeped.pima.gov/Pubs/Share%20the%20Road3%201207.pdf> [18 January 2008].

San Francisco Municipal Transportation Agency. *City of San Francisco Bicycle Plan Update: Supplemental Design Guidelines*. September 2003. <http://www.sfmta.com/cms/bproj/documents/x_Appendix_A_updated_000.pdf> [11 January 2008].

San Francisco Municipal Transportation Agency. *San Francisco Bicycle Plan: Policy Framework Chapter 2 Bicycle Network*. No date. < http://www.sfmta.com/cms/bproj/documents/Chapter_2_final_BicycleNetwork.pdf > [11 January 2008].