

Designing Freeway On-Ramps and Off-Ramps that Work for Bicyclists

Jasmine Stitt, TE, AICP

Senior Transportation Planner, Complete Streets Performance Coordinator, District 4
Office of Transit and Active Transportation, California Department of Transportation,
Oakland, CA

Abstract

Interchanges have historically not prioritized the needs of bicyclists and pedestrians and have often been designed with a primary focus on motor vehicle capacity. These auto-centric interchanges are often a barrier to biking. The California Department of Transportation (Caltrans) and local jurisdictions have been retrofitting and designing new interchanges in an effort to create comfortable, low-stress connections for people biking. This paper presents an overview on designing freeway on-ramps and off-ramps to reduce barriers for people biking and create a more comfortable, convenient, and connected bicycle network.

Introduction

Access-controlled highways, often called freeways, divide communities and create barriers for people walking and biking. Interchanges, where freeways meet the local road network with on ramps and off ramps, are often high-speed and high-volume roadways. Crossing freeway interchanges can be uncomfortable and stressful for cyclists, forcing cyclists to cross multiple streams of high-volume and high-speed traffic. As cities build out their bicycle network, many freeway crossings remain a gap in the bikeway network. Interchanges, historically, have been primarily designed around motor vehicle throughput, with minimal or no bicycle and pedestrian infrastructure. This is slowly changing. The California Department of Transportation, Caltrans, has been undergoing a shift in how they design these facilities. It is now Caltrans Policy that all projects funded or overseen by Caltrans provide comfortable, convenient, and connected facilities for people walking, biking, and taking transit (Director's Policy 37). Newer interchanges are not just merely accommodating bicyclists but using infrastructure to provide low-stress facilities for cyclists of all ages and abilities. Caltrans developed the Bicycle Best Practices, to be a resources to planners and engineers when developing bikeways on Caltrans facilities. The Best Practices includes examples of built or designed interchanges that meet the needs of people biking.

This paper presents key principles for designing interchanges for people biking of all ages and abilities, presents examples for the more common interchange types, and presents interim design considerations that can be incorporated in repaving and near-term improvements. The considerations, concept, and design presented in this paper were vetted through Caltrans District 4 (Bay Area) functional units, Caltrans bicycle/pedestrian planning staff, partner agencies, and bicycle advocates in the Bay Area.

Key Principles to Designing All Ages and Abilities Interchanges

While each interchange is unique, there are some key considerations for all interchanges, regardless of type, to design them to work for cyclists. The first key consideration is to maintain physical separation between bicyclists and vehicles as much as possible. Shared routes (Class III Bike routes) and even bicycle lanes (Class II Bike Lanes) in a shoulder are typically not preferred for multi-lane interchanges, with speeds in excess of 30 mph. Many interchanges have multiple lanes and operate around 30- 45 mph. Motorists can start accelerating to freeway speeds before they are on the mainline and use the ramps to start that acceleration. Maintaining physical separation between bicyclists and vehicles as much as possible minimizes conflicts and ensures errant motorists don't drift into the bicyclist's path of travel. With these considerations, Class IV (Separated bikeways) and Class I (Multi-use paths) are generally the preferred bike facility types for interchanges.

The second key consideration is minimizing the potential for conflict at the ramp crossing as much as possible. The on-ramp/off-ramp termini where the path of motor vehicles crosses the path of cyclists and pedestrians have the potential for high-speed conflicts. Uncontrolled crossings should be avoided as much as possible. Signalized intersections separate bicyclists from motor vehicle traffic in time and clarify the right of way. For interim applications, rectangular rapid flashing beacons (RRFBs) can be used to help clarify the right of way and increase pedestrian and bicyclist visibility, though they wouldn't be considered an all ages and abilities intersection treatment for multi-lane approaches in excess of 30 mph. The turning radius should also be designed as small as possible to reduce turning speeds.

The following sections detail how these principles can be applied to specific interchange configurations.

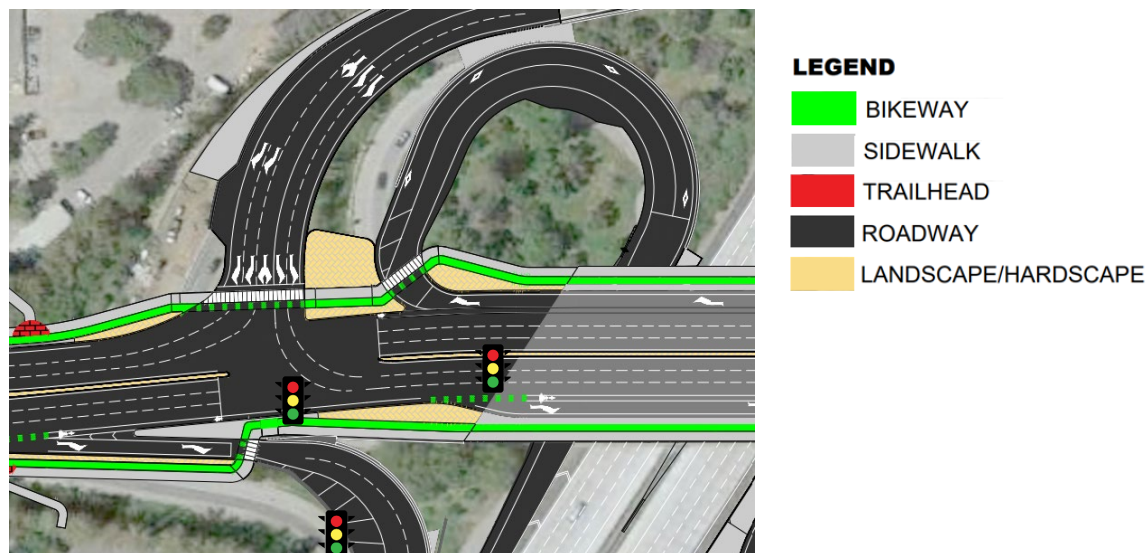
Partial Clover Leaf Interchanges

Partial clover leaf interchanges are probably the most common interchange type. These interchanges typically can handle large volumes of car traffic, which presents challenges to cyclists, but a combination of bicycle infrastructure features can increase visibility and

minimize conflict between motorists and active transportation users to provide a lower-stress crossing. The I-280 and Wolfe Road interchange in the City of Cupertino, a facility that is currently under construction and expected to be completed in the winter of 2027, shows how low-stress bikeways can be implemented on a partial clover leaf interchange. This interchange contains a Class IV (separated) bikeway that is separated from motorists with a hardscape or where there is room landscape buffer. This bikeway is also raised to sidewalk level, providing further separation between bicyclists and motorists. Green infrastructure is also used to further separate cyclists from motorists.

The I-280 Wolfe Rd interchange also has a signalized crossing at each of the points where the path of cyclists crosses an on or off ramp. The on/off ramp also meets the local road as close to 90 degrees as possible. This minimizes crossing distance for cyclists and pedestrians. This interchange also contains a truck turning apron, which accommodates large trucks but also reduces the turning speed of passenger vehicles. This interchange also reduces the number of travel lanes that bicyclists and pedestrians cross at the on ramps; both on ramps increase the number of travel lanes after the on ramp crosses the bikeway and crosswalk. This ensures enough queuing space while minimizing crossing distances.

Figure 1- Wolfe Road/ I-280 Class IV bikeway incorporated in a partial Clover Leaf Interchange



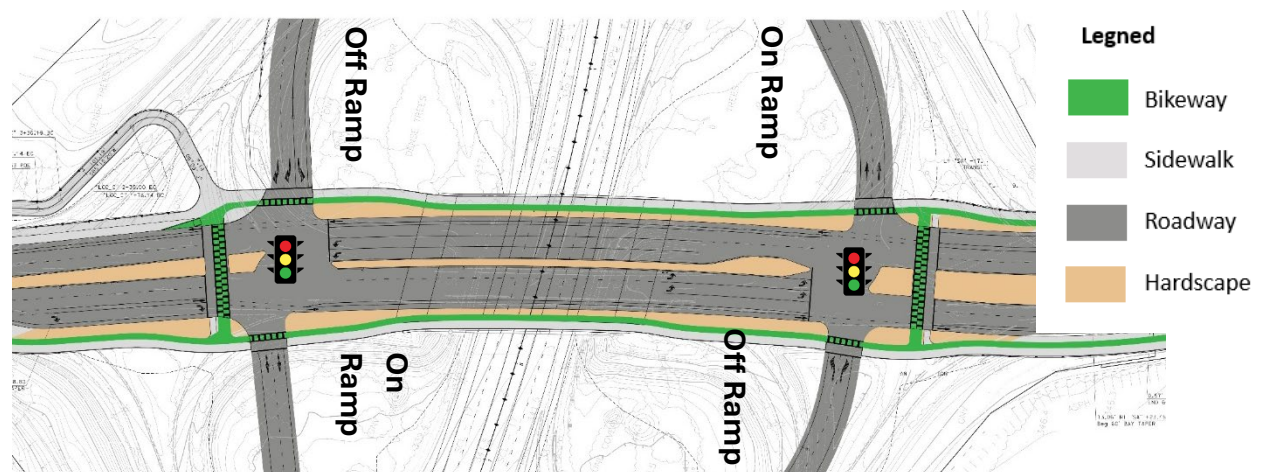
Diamond Interchanges

Diamond interchanges typically contain characteristics that provide more comfortable bicycle access than alternative configurations. Diamond interchanges normally have the on-ramp/off-ramps intersect the local roadway at 90 degrees, facilitating slower turning

speeds and minimizing long crossing distances. Intersections are often signal or stop-controlled, with motorists stopping before turning, increasing the likelihood that they will see and yield to bicyclists or pedestrians, compared to uncontrolled crossings. The proposed Hwy 17/ Hwy 9 interchange in the City of Los Gatos demonstrates how a diamond interchange can provide low-stress bikeways. This interchange is currently in the early stages of project development. It is currently undergoing environmental clearance, with an expected construction start date in 2028. This interchange contains a Class IV (separated) bikeway that is separated from motorists with a hardscape. This bikeway is also raised to sidewalk level, providing further separation between bicyclists and motorists.

This interchange utilizes elements of a protected intersection at the interchange to further reduce the potential for conflict at the ramp intersections. The smaller corner radii minimize the speed of turning vehicles. The forward stop bar allows cyclists to wait in a dedicated, visible space ahead of vehicle traffic during a red light, providing a head start when the light turns green. The setback crossing places the cross bike and crosswalk about 10 feet away from the main road, allowing drivers to turn 90 degrees and better see cyclists before crossing their path.

Figure 2: Hwy 17/ Hwy 9 Class IV bikeway incorporated in a Diamond Interchange



Grade Separated Crossings at Interchanges

Crossing bicycle facilities through an interchange has a greater potential for conflict because of higher travel speeds and lane configurations. One solution to this is to eliminate the conflicts between motorists and bicyclists by grade separating the bicycle/pedestrian facility at on/off ramp crossings. This is perhaps the most common way to accommodate cyclists and pedestrians at new interchange reconstructions in the Bay Area, with multiple examples already built at Gilman/ I-80, Tribble Road/ De La Cruz Blvd /

US 101, and US 101/ Blossom Hill Rd. This can be built on any interchange type, including partial cloverleaves, diverging diamonds, roundabouts, or diamond interchanges. This design should be used thoughtfully, as it directs cyclists and pedestrians to one side of the interchange; it can increase out-of-directional travel. This facility type also typically requires the use of loops to handle the grade change, which can increase the travel distance further. Wayfinding should be provided to assure users can reach their destination through the use of off-street facilities. This interchange type works particularly well when it is connecting to an existing trail facility. The Gilman/I-80 interchange connects with the Bay Trail in Berkeley. The US 101/ Blossom Hill Road connects with the Coyote Creek Trail. This provides a seamless bike connection and enhances connectivity for the area.

Figure 3: US-101/ Blossom Hill Rd interchange in Santa Clara County



Class I (Multi Use Path) Bike/ped overcrossing at an on ramp at US 101/Blossom Hill Rd



Class I (Multi Use Path) Bike/ped undercrossing at an on ramp/ of ramp at US 101/Blossom Hill Rd

Interim Applications: The Tight Merge vs the Direct Path

While interchange reconstruction projects have the most opportunity for robust bicycle and pedestrian improvements, restriping or retrofitting existing interchanges presents an opportunity to improve biking and walking facilities. Installing Class IV (separated bikeway) and installing intersection treatments through an interchange remains a key priority for interim applications. While each interchange's geometry is unique, there are two techniques that have been utilized to accommodate Class IV bikeways at on ramps/ and off-ramps. These two techniques can be referred to as the tight merge and the direct path. Each has its drawbacks, each may suit particular ramp geometries better, and some cycling communities may prefer a particular application over another. It is always preferred to outreach to each community to get their feedback on bikeway and pedestrian designs when choosing amongst design options.

The on-ramp tight merge, shown in Figure 4, moves the conflict point of bicyclists and

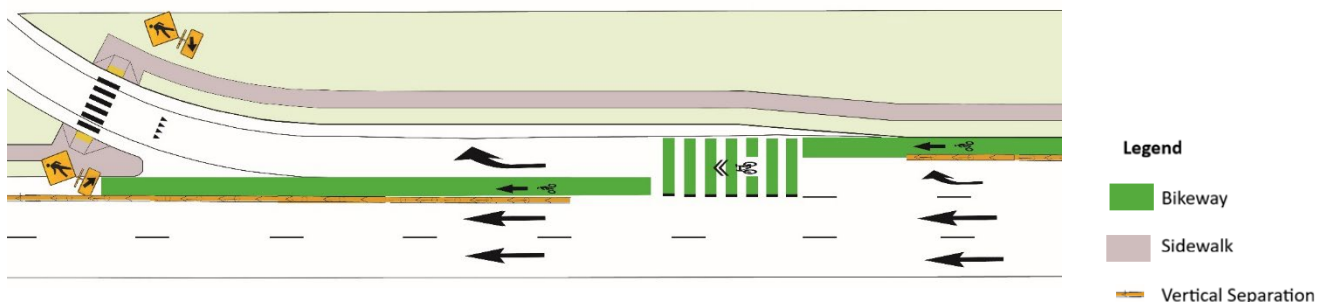
Figure 4 The On Ramp – Tight Merge at Cutting Blvd/ I-80 interchange



motor vehicles closest to where motor vehicles turn, which is where the motor vehicle's speed decreases for drivers performing a right turn. This design option keeps the separation between bicyclists and motorists as long as possible. This design also avoids long “floating” bike lanes, which are not comfortable facilities. Floating bike lanes are bike lanes positioned between two motor vehicle travel lanes, installed to position cyclists to the left of a right-turn lane, as is required by the CA MUTCD. Crossing unsignalized ramps at a perpendicular angle minimizes crossing distance and exposure to crash risk. This facility wouldn't be considered an all-ages and abilities facility and would only be an interim design until more robust bicycle improvements could be installed. This facility can be installed with RRFB and yield markings preceding the crossing. This facility type was installed in Contra Costa County at the Cutting Blvd/ I-80 interchange.

The off-ramp direct path design option, shown in Figure 5, moves the conflict point of bicyclists closer to the roadway where motor vehicles merge with local road traffic. The

Figure 5 The On Ramp Direct Path – Similar facility built at Auto Mall Parkway/ I-80 in Fremont, CA



option drops the separation and utilizes a about 100-foot merge point marked with green pavement marking and sharrows before starting the separated bikeway on the left side of turning vehicles. A benefit of this treatment is that it is a more direct route and a more expected merging movement, especially for strong and confident cyclists. A drawback of this treatment is that it forces cyclists and motorists to negotiate the merge at high speeds. Green striping, signage, and a sharrow marking highlight the merge point, alerting motorists to expect. This design utilized a partially separated floating bike lane, which is a bike lane positioned between two lanes of motor vehicle traffic with a vertical separation between the outside lane of traffic and the bike lane. While this wouldn't offer the same benefit of a full Class IV facility, it offers some benefit in constrained situations. The row of vertical separation may act as a traffic calming feature that may increase the comfort of cyclists and reduce motor vehicle speeds. A version of this design has been installed in Alameda County at the Auto Mall Parkway/ I-80 interchange and the Fremont Blvd/ I-80 interchange.

Figure 6 Partially Separated Floating Bike Lane at an Interchange in Fremont, CA



Design Considerations for Interim Applications

Installing Class IV separated bikeways where possible is a key component of designing on-ramps and off-ramps that are comfortable and convenient for cyclists. In California, Class IVs through interchanges typically require a Design Standard Decision Document (DSDD) to implement. The California Highway Design Manual requires a shoulder at interchanges (HDM 300-33). Class II bike lanes may be included as part of the shoulder (HDM 300-2), but Class IV separated bikeways do not, as the vertical separation prohibits motorists from entering the bikeway. The shoulder requirement can be circumvented with a Design Standard Decision Document (DSDD) that documents the design decisions of engineers that differ from the Highway Design Manual. DSDDs can add time and uncertainty to projects, especially quick build projects, but Caltrans is committed to installing comfortable, convenient and connected bikeways across the state highway system, and has approved DSDDs submitted by local agencies to install Class IV separated bikeways through interchanges, such as the City of Fremont, and has used DSDDs in its own SHOPP projects to install Class IV through interchanges, such as the interchange at SR 82 and SR 87, in the City of Mountain View.

While concrete separation, or a similarly robust hardscape, is the preferred material for separation on Class IV separated bikeways. Interim applications may be unable to use permanent materials due to cost or other constraints. In these applications, channelizers have been used by Caltrans to provide separation, and are generally preferred over delineators by maintenance staff, bike/ped planning staff and the cycling community. The channelizer, Qwick Kurb, provides a robust separation, is on Caltrans's list of authorized delineation materials and is also highly visible at night.

Figure 7: Class IV bikeway with Qwick Kurb at SR 82 and SR 87



Conclusion

While interchanges have historically not prioritized the needs of bicyclists and pedestrians, Caltrans and local jurisdictions on the Bay Area are retrofitting and designing new interchange to create comfortable, low-stress connections for people biking. A key competent of these interchange is to incorporate Class IV separated bikeways and intersection treatments at the on/off ramps. These improvements, which can be installed in a variety of different configurations are shown to increase bikeway network connectivity.

References:

1. California Department of Transportation. (2025). Caltrans Bike Plan Update. Retrieved here: <https://dot.ca.gov/-/media/dot-media/district-4/documents/d4-office-transit-active-transportation-docs/d4-bike-plan-update/caltrans-bicycle-best-practices-final-a11y.pdf>
2. California Department of Transportation. (2022). Caltrans Class IV Bikeway Guidance (DIB -89- 02).
3. Valley Transportation Authority. (2022). VTA Bicycle Technical Guidelines.
4. California Department of Transportation. (2023). Authorized Material List for Signing and Delineation Materials.
5. California Department of Transportation. (2019). Highway Design Manual seventh edition.
6. Delaware Valley Regional Planning Commission. (2019). Guidance for Pedestrian and Bicycle Facilities at Expressway Interchanges in Southeastern Pennsylvania.