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Separated Bike Lanes on Higher Speed Roadways

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Conor Semler Kittelson and Associates

Housekeeping

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Panelists

Darren Buck | Federal Highway Administration

Karen Dixon | Texas A&M Transportation Institute

Conor Semler | Kittelson and Associates

FHWA Introduction

Darren Buck | Federal Highway Administration

Developing CMFs for Separated Bicycle Lanes

Contracting Officer's Representative -- Ann Do

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Texas A&M Transportation Institute

Introduction

The US experienced 846 bicycle fatalities in 2019 due to roadway-related crashes

It is crucial to place priority on analyzing and enhancing the safety of bicyclists

To enhance the safety of bicyclists, transportation agencies have been constructing Separated Bike Lanes (SBL) (aka, protected bike lanes)

https://cdn1.vectorstock.com/i/1000x1000/87/60/bike-crash-vector-68760.jpg

What Is A Separated Bike Lane (SBL)?

Separated Bicycle Lanes (SBL/protected bicycle lanes): bicycle lanes that are separated from adjacent motor vehicles with a <u>buffer with a vertical element</u>

How safe are SBLs?

Goal of This Project

Developing crash modification factors (CMFs) for SBL facilities

CMF is used to calculate the estimated number of crashes after implementing a given countermeasure at a location

$$CMF = \frac{Estimated\ Crashes\ with\ Treatment}{Estimated\ Crashes\ without\ Treatment}$$

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What Did We Need?

Increasing the number of bicyclists → Increase in the number of crashes

→ Bike exposure is a critical variable for the models

→ Annual average daily traffic (AADT) or ADT is a commonly used variable for roads so…

→ Annual average daily bicycles (AADB) or ADB is needed for bicycle facilities

However

AADB/ADB is not widely collected

↓

Ultimately exposure models were developed using surrogate variables

Data Collection

Original intent was to conduct short bicycle counts in the spring of 2020 and then extrapolate to known values proximate to locations

Then … COVID hit and all plans changed

1) Used data from jurisdictions with some bicycle counts (Austin, Cambridge, Denver, San Francisco, Seattle)
2) Navigated corridors using Google Street View and manually developed data tables with numerous variables that could be evaluated as influential
3) Developed exposure models
4) Developed CMFs

Preliminary Data Assessment

Team reviewed number and type of bicycle lanes that were present at the five study locations. Austin and Denver data did not have substantial variability and so the data for these two locations was set aside to use for validation testing.

Variables Collected Using Street View and Included in the Analysis Database

- Operation (Roadway 1-way versus 2-way, Bicycle 1-way versus 2-way)
- Traffic Control at bounding intersections (None, 2-way STOP, 4-way STOP, Signalized)
- Parking (Parallel, angle (head in), angle (back in)
- Bicycle Facility (No bike lanes, painted bike lanes but no buffer, painted bicycle lanes with buffer adjacent to motor vehicle lane)
- Separated bicycle lane with buffer and vertical element
- SHARROW – Ultimately excluded
- Shared Use Path – Ultimately excluded
- Other

Facility continuity and distance to nearest bicycle facility were included later

Developing Exposure Models

Cambridge, MA	San Francisco, CA	Seattle, WA
1. Number of sites: 16 intersections 2. Data range: every year 2003-2006 and every other year since 2008 3. Time: AM and PM peak 4. Since 2015, Eco Totem was installed as a permanent counter	1. Number of sites: the city had both permanent and temporary counters for each year 2. Data range: 2016 to 2021, not all the years were available for all the sites 3. Time: 7 days a week and 24 hours a day	1. Number of sites: 12 counters were installed but data from 10 were available 2. Data range: 2014 to 2021 3. Time: 7 days a week and 24 hours a day

Study Design for Developing CMFs

- Conducted cross-sectional analyses with a focus on midblock locations
- Considered locations with SBL (treated sites) and without SBLs (comparison sites)
- The traditional bicycle lane was considered as the base condition
- Propensity Score was used to evaluate the similarity between the covariates of treated and untreated sites
- Larger dataset → segments with AADT/ADT and AADB/ADB of zero were removed

CMF Estimation

Dependent variable had multiple scenarios (e.g., SBL, traditional bicycle lane, etc.) → single-parameter estimation was not practical

Linear combinations of the coefficients were developed through various models

Base condition:
1. Traditional
2. Buffered

SBL:
1. Flexi-post
2. Blended

Various Bicycle Lanes

Without Separated Bicycle Lanes

Painted Bicycle Lanes / No Buffer

Painted Bicycle Lanes with Buffer

With Separated Bicycle Lanes

Flexi-posts

Blended

Range of Final CMFs

CMF Treatment	San Francisco Only	San Francisco + Cambridge	San Francisco + Cambridge + Seattle	Suggested CMF
Baseline Condition – Traditional Bicycle Lane				
Vertical Element (varies)	0.509	--	--	0.51
Flexi-Posts	0.324	0.276	0.498	0.28 to 0.50
Flexi-Posts or Blended	0.462	0.417	0.640	0.42 to 0.64
Baseline Condition – Flush Buffered Bicycle Lane				
Vertical Element (varies)	0.480	--	--	0.48
Flexi-Posts	0.352	0.363	0.441	0.35 to 0.44
Flexi-Posts or Blended	0.502	0.548	0.567	0.50 to 0.57
Baseline Condition – Traditional Bicycle Lane or Flush Buffered Bicycle Lane				
Vertical Element (varies)	0.494	--	--	0.49
Flexi-Posts	0.338	0.316	0.468	0.32 to 0.47
Flexi-Posts or Blended	0.481	0.478	0.602	0.48 to 0.60

Validation Activities

- When the CMF results were tested in Austin, the models validated indicating that there was no statistical difference between the Austin data and the three-state data.
- Though the Denver models did not statistically exclude their equivalence to the three-state model, by inspection the effects in Denver were noticeably different. This could be due to different climates, the high elevation, or even a lack of variability in the Denver database.

So which one should I use?

Before Condition	After Condition	CMF	SE Estimate
Significant at the 0.01 level			
Traditional Bicycle Lane	SBL with Flexi-posts	**0.498**	0.173
Flush Buffered Bicycle Lane		**0.441**	0.297
Traditional or Flush Buffered Bicycle Lane		**0.468**	0.267
Significant at the 0.05 level			
Traditional Bicycle Lane	SBL with blend of Flexi-posts and other vertical elements	**0.640**	0.203
Flush Buffered Bicycle Lane		**0.567**	0.253
Traditional or Flush Buffered Bicycle Lane		**0.602**	0.212

Simple Example

Problem:

A segment of road with traditional bicycle lanes experiences approximately 20 bicycle-related crashes each year. If the managing agency converts the bicycle lane to a SBL and the vertical elements are flexi-posts only, how many bicycle-related crashes can be expected each year following SBL implementation?

Solution:

20 crashes per year x 0.498 = 10 (when rounded up)

So … the SBL treatment can reduce bicycle crashes by approximately 50%!!

Summary and Future Work

1. The CMFs for SBLs show that with their implementation a transportation agency can expect to see a reduction in bicycle crashes by as much as 50% when compared to a traditional bicycle lane

2. The most effective SBL treatments were flexi-post treatments and treatments that were blended (most often flexi-posts and other vertical elements)

3. The research team acquired data for Austin, Texas and Denver, Colorado and used that data for validation. The findings were mixed.

4. The research team assessed the prospect of using intersection-only and corridor-type models. These two analysis options did not yield statistically viable results.

Thank You for Your Attention!

Questions?

Texas A&M Transportation Institute

Karen Dixon, Ph.D., PE

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CMFs for the Combined Dataset

Condition	CMF	Estimate	SE Estim	p.val	Significance
Flush buffer[a]	1.128	0.121	0.173	0.484	—
Flexi-posts[a]	0.498	-0.698	0.264	0.008	**
Flexi-posts[b]	0.441	-0.819	0.297	0.006	**
Flexi-posts[c]	0.468	-0.758	0.267	0.005	**
Blended[a]	0.822	-0.196	0.252	0.437	—
Blended[b]	0.729	-0.316	0.300	0.292	—
Blended[c]	0.774	-0.256	0.263	0.331	—
Flexi-posts[d]	0.605	-0.502	0.318	0.114	—
Flexi-posts or Blended[a]	0.640	-0.447	0.203	0.028	*
Flexi-posts or Blended[b]	0.567	-0.568	0.253	0.025	*
Flexi-posts or Blended[c]	0.602	-0.507	0.212	0.017	*

a. Base condition: Traditional bicycle lane
b. Base condition: Flush buffered bicycle lane
c. Base condition: Traditional or Flush buffered bicycle lane
d. Base condition: Blended vertical element

* Statistically significant at the 0.05 level.
** Statistically significant at the 0.01 level.
A dash means not statistically significant

Separated Bike Lanes on Higher Speed Roadways

FHWA Toolkit Guide

May 25, 2023

U.S. Department of Transportation
Federal Highway Administration

CADMUS

KITTELSON & ASSOCIATES

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

Agenda

- Introductions
- Project Background
- Project Objective
- Literature Review
- Toolkit Guide Key Takeaways
- Case Studies
- Questions and Discussion

Introductions and Project Team

- **FHWA**
  - Darren Buck, FHWA
  - Bernadette Dupont, FHWA
- **Research Team**
  - Conor Semler, Kittelson & Associates
  - Nick Foster, Kittelson & Associates
  - Kaitlyn Schaffer, Kittelson & Associates
  - John Hicks, Kittelson & Associates
  - Dan Gelinne, University of North Carolina Highway Research Center

Stakeholder Committee

- Dongho Chang, Washington State Department of Transportation (DOT)
- Nathan Wilkes, City of Austin
- Eric Virag, City of Austin
- Matthew Roe, National Association of City Transportation Officials (NACTO)
- Cary Bearn, NACTO
- Paul Benton, City of Charlotte
- Violet Wilkins, Massachusetts DOT
- Mike Murphy, Massachusetts DOT
- Josh Saak, Ada County Highway District
- Gary Obery, Oregon DOT
- Jenn Rhodes, City of Orlando
- Peter Ohlms, Virginia DOT
- Nicole Hahn, City of Fort Collins
- Jacob Rueter, Minnesota DOT

Background

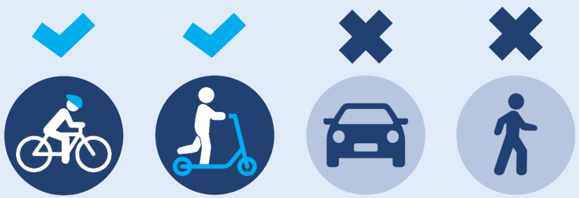
- In 2021, the U.S. Department of Transportation (USDOT) released the National Roadway Safety Strategy
- The National Transportation Safety Board (NTSB) concluded in 2019 that separated bike lanes could reduce bicyclist fatalities and injuries
- FHWA has included separated bike lanes in Proven Safety Countermeasures to make bicycling safer
- FHWA's Bikeway Selection Guide generally recommends separated bike lanes or shared-use paths on roads with speeds greater than 30 mph to provide a low-stress bicycling experience
- FHWA's 2023 crash modification factor (CMF) study showed a clear trend that, with the implementation of separated bike lanes, a transportation agency can expect to see a reduction in bicycle crashes

Project Objective

- **Develop a toolkit guide for implementing separated bike lanes on higher speed roadways (40 mph +)**
  - Synthesize existing research and guidance for separated bike lanes
  - Identify best practices for policies, planning, and design
  - Identify potential obstacles, key considerations, and experiences from practitioners
  - Document example case studies
  - Not intended to be a detailed design guide

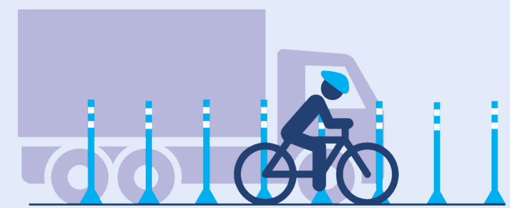
How did we define separated bike lanes?

1 INTENDED EXCLUSIVELY FOR BICYCLISTS AND SCOOTERS



2 HORIZONTAL BUFFER SEPARATES BICYCLISTS FROM MOTOR TRAFFIC

3 HAS SOME TYPE OF VERTICAL ELEMENT WITHIN THE BUFFER SPACE



Research Summary

- Higher speeds are a risk factor for crashes and injuries
- Separated bicycle lanes improve safety for all modes
- Separated bicycle lanes influence driver behavior
- Everyone is more comfortable with separated bicycle lanes, drivers too.

Source: DDOT

Gaps in the Literature

- Little research focused on application of bicycle facilities specifically on higher speed roads

Source: Joe Linton/Streetsblog

Existing design guidance

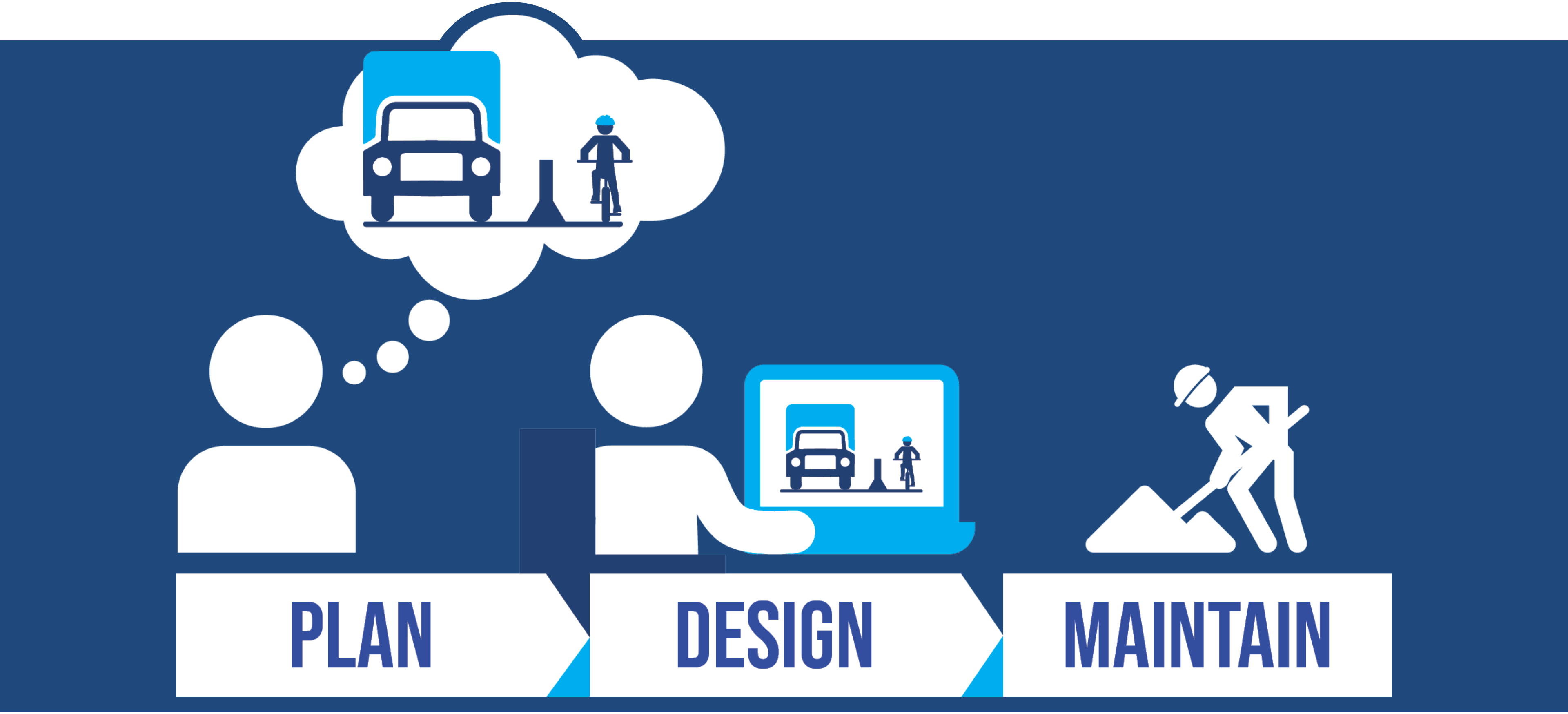
- AASHTO Guide for the Development of Bicycle Facilities
- Separated Bike Lane Planning and Design Guide (FHWA)
- Bikeway Selection Guide (FHWA)
- Traffic Analysis and Intersection Considerations to Inform Bikeway Selection (FHWA)
- On-Street Motor Vehicle Parking and the Bikeway Selection Process (FHWA)
- Urban Bikeway Design Guide (NACTO)
- Designing for All Ages and Abilities (NACTO)
- Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges (ITE)
- Small Town and Rural Multimodal Networks (FHWA)
- State and local planning and design guides

Source: Kittelson & Associates, Inc.

Current Challenges

1. Lack of guidance
2. Maintenance concerns
3. Driveways & intersections
4. Separated bike lanes on higher speed roads relatively rare

Structure of the Toolkit Guide



Planning

Justify the project

- Identify safety or network need
- Leverage planned projects
- Identify support and engage the community

Analyze funding options

- Federal
- Local
- Private sector

Enact supportive policies

- Vision Zero
- Safe System approach
- Design guidelines

Designing – Vertical Separation

DELINEATOR POSTS

- Common separators due to low cost, visibility, ease of installation
- Modify driver behavior
- Do not provide crash protection
- Less durable than other separators
- Consider converting these types of buffers to a more permanent style when design and budgets allow
- May need to change barrier type as speed increases for bicyclist comfort

PARKING STOPS

- Inexpensive, low linear barrier
- High level of durability
- Provides near-continuous separation
- Provides better barrier for safety and comfort than delineator posts

PARKED CARS

- Can provide an additional level of protection and comfort for bicyclists
- Less common on higher speed roads
- Additional vertical elements, such as delineator posts, should be paired with this design
- Must provide an access aisle for accessible parking

Source (left to right): Virginia Department of Transportation, National Transportation Safety Board, Oregon Department of Transportation

Designing – Vertical Separation

BARRIERS

- Provides highest level of crash protection among these separation types
- Requires little maintenance
- May require additional drainage and service vehicle solutions
- Crash cushion should be installed where the barrier end is exposed

RAISED MEDIAN CURB

- More expensive to construct
- Provides a continuous raised buffer that is attractive and requires little long-term maintenance

RAISED BIKE LANE

- Provides high level of comfort for bicyclists
- More expensive to construct than on-street separated bike lanes
- Different pavement types, markings, or buffers may be necessary to keep bicyclists and pedestrians separated at sidewalk level
- 3” mountable curb may be used to permit access of sweeping equipment if placed at an intermediate level

Source (left to right): Public domain, Virginia Department of Transportation, Virginia Department of Transportation

Designing – Vertical Separation

Key Considerations

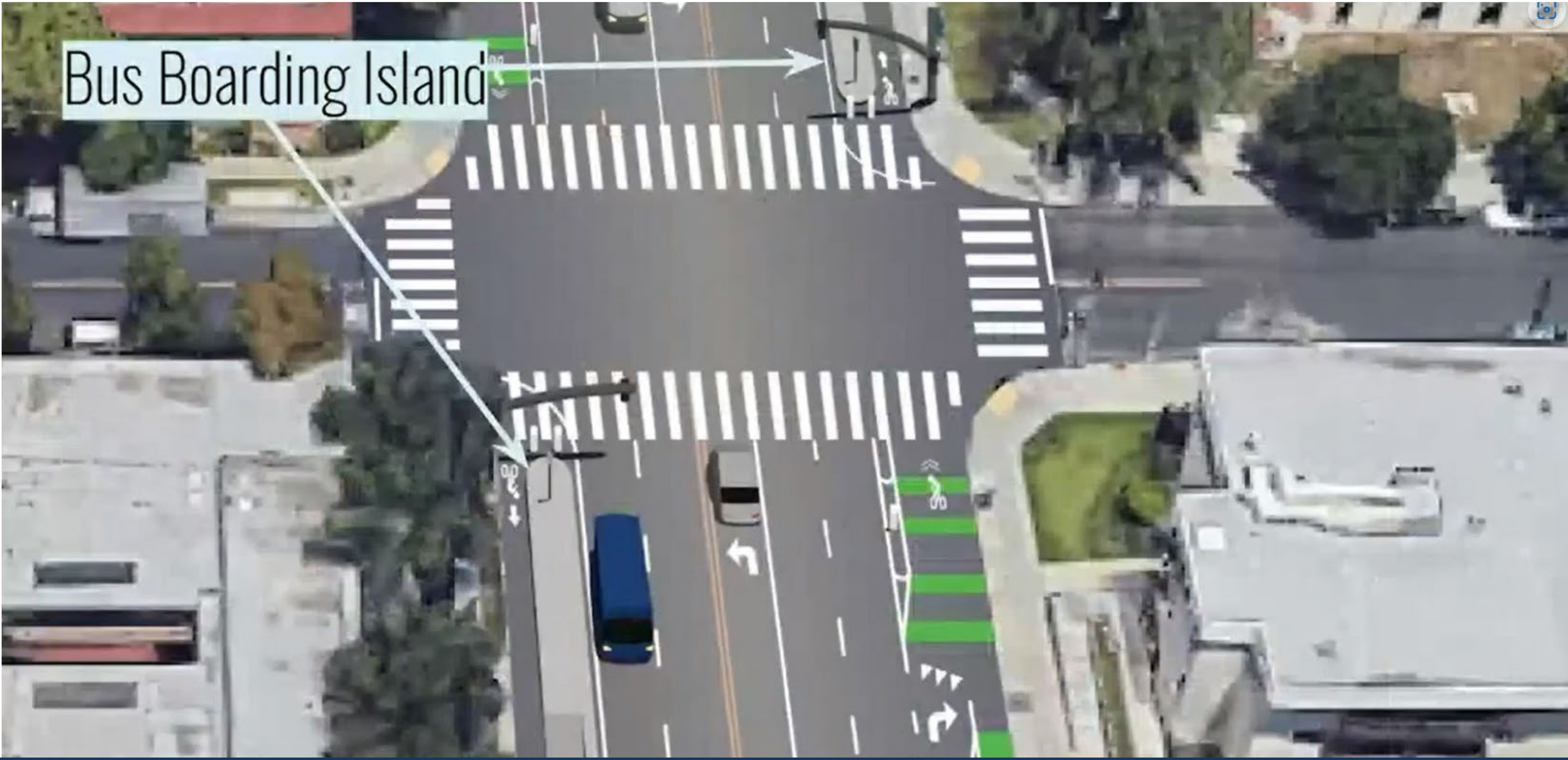
- Cost
- Perceived safety
- Durability
- Maintenance
- Stormwater management
- Run-off-road crashes
- Aesthetics
- Construction needs and impacts
- Width required
- Strategies to lower design speed

Designing – Intersections & Driveways

Key Considerations

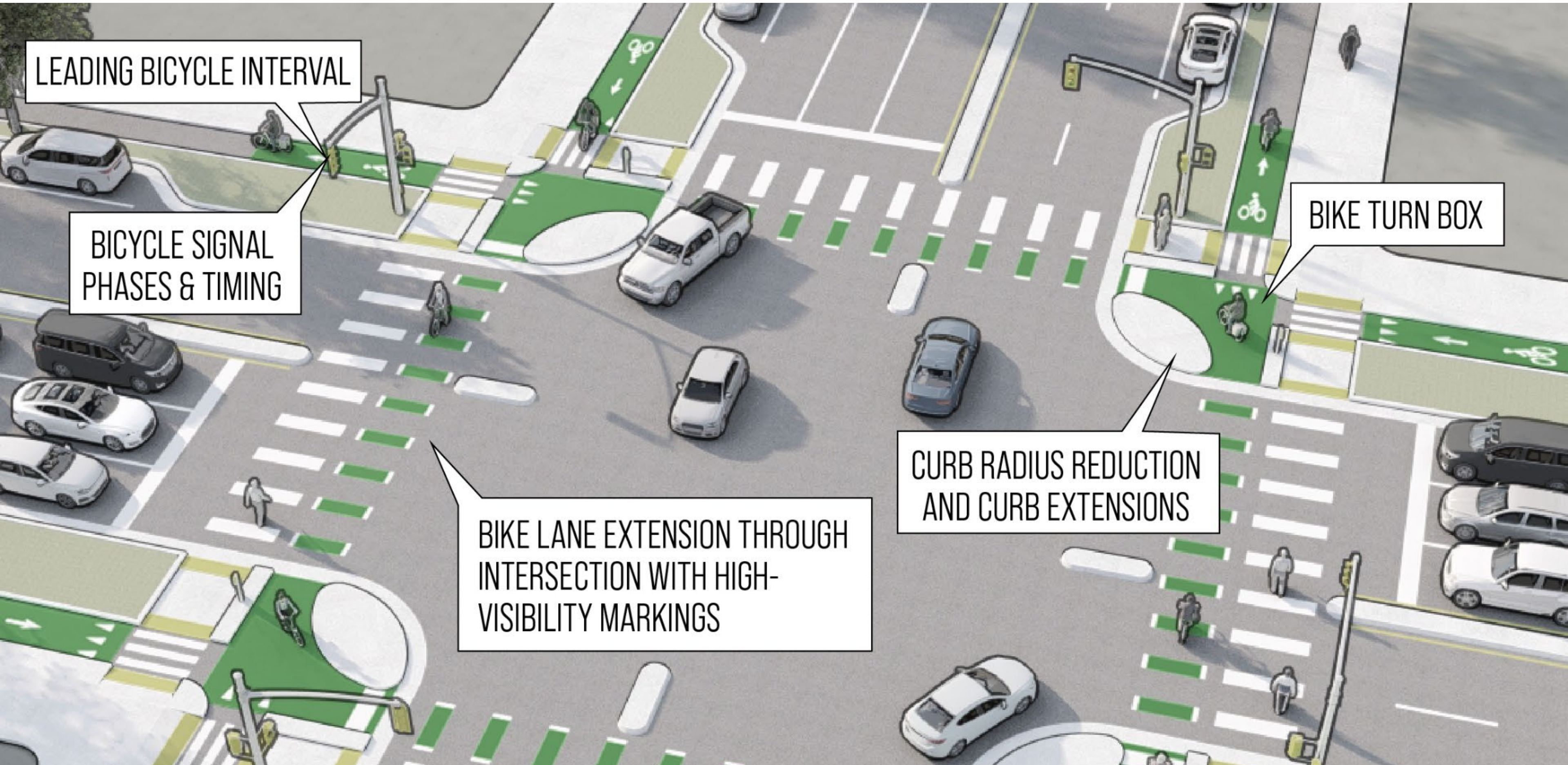
- Access Management
- One-way vs. two-way bike lanes
- Visibility at crossings
- Mixing zones and deceleration lanes
- Signalized intersections

Mixing Zones & Deceleration Lanes



Source: Los Angeles Department of Transportation

Signalized Intersections



Source: Adapted from Massachusetts Department of Transportation

Maintaining

1. Stormwater Management
2. Asset Management
3. Street Sweeping
4. Seasonal Maintenance

Key Questions

What form of separation is needed on a higher speed road?

How can separated bike lanes on higher-speed roads be maintained through driveways and intersections?

How can agencies sustain safe separated bicycle lane operations on high-speed roads?

Case Study – Austin, TX

Source: Austin Corridor Program Office

- 4 miles of separated bicycle lanes
- Curb separated
- 45 mph speed limit
- 38,000 AADT (2021)
- One-way, street level

Case Study – Pomona, CA

Source: Joe Linton/Streetsblog

- 1.5 miles of protected bicycle lanes
- Raised curb with flexible delineator posts
- 45 mph
- Two-way, street level

Questions and Discussion

Discussion

- ⇨ Send us your questions
- ⇨ Follow up with us:
  - ⇨ General Inquiries pbic@pedbikeinfo.org
- ⇨ Archive at www.pedbikeinfo.org/webinars