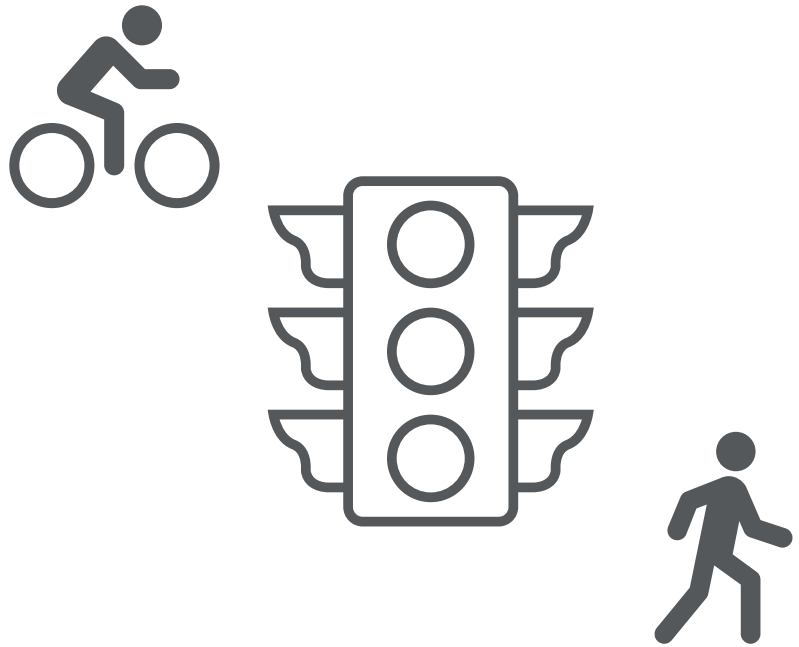
From Guidance to the Ground:

APPLYING PEDESTRIAN AND BICYCLE DESIGN AT SIGNALS ACROSS SCALES



ITE Mid-colonial District Annual Meeting

April 16, 2026

SESSION OVERVIEW

National

TOOLE DESIGN

State

pennsylvania DEPARTMENT OF TRANSPORTATION

Local

City of Philadelphia

WHY IS THIS SO IMPORTANT?

“Hold paramount the safety, health, and welfare of the public.”

- National Society of Professional Engineers Code of Ethics

TOOLE DESIGN

Traffic fatalities are a crisis affecting *all road users*.

40,901

Lives lost on US roads in 2023

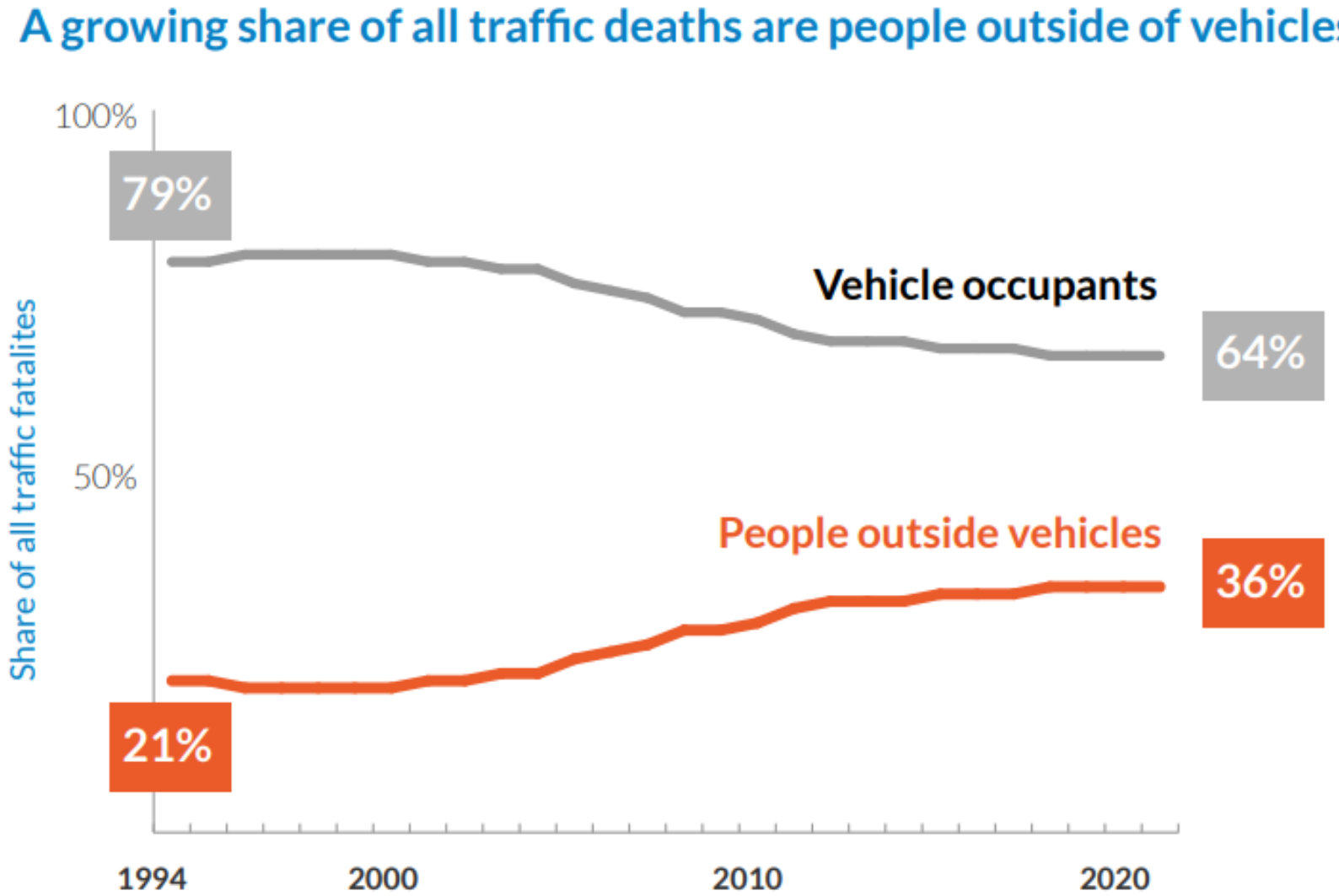
Source: NHTSA Traffic Safety Facts, 2023 Data

1,166

Number of bicyclists killed in 2022

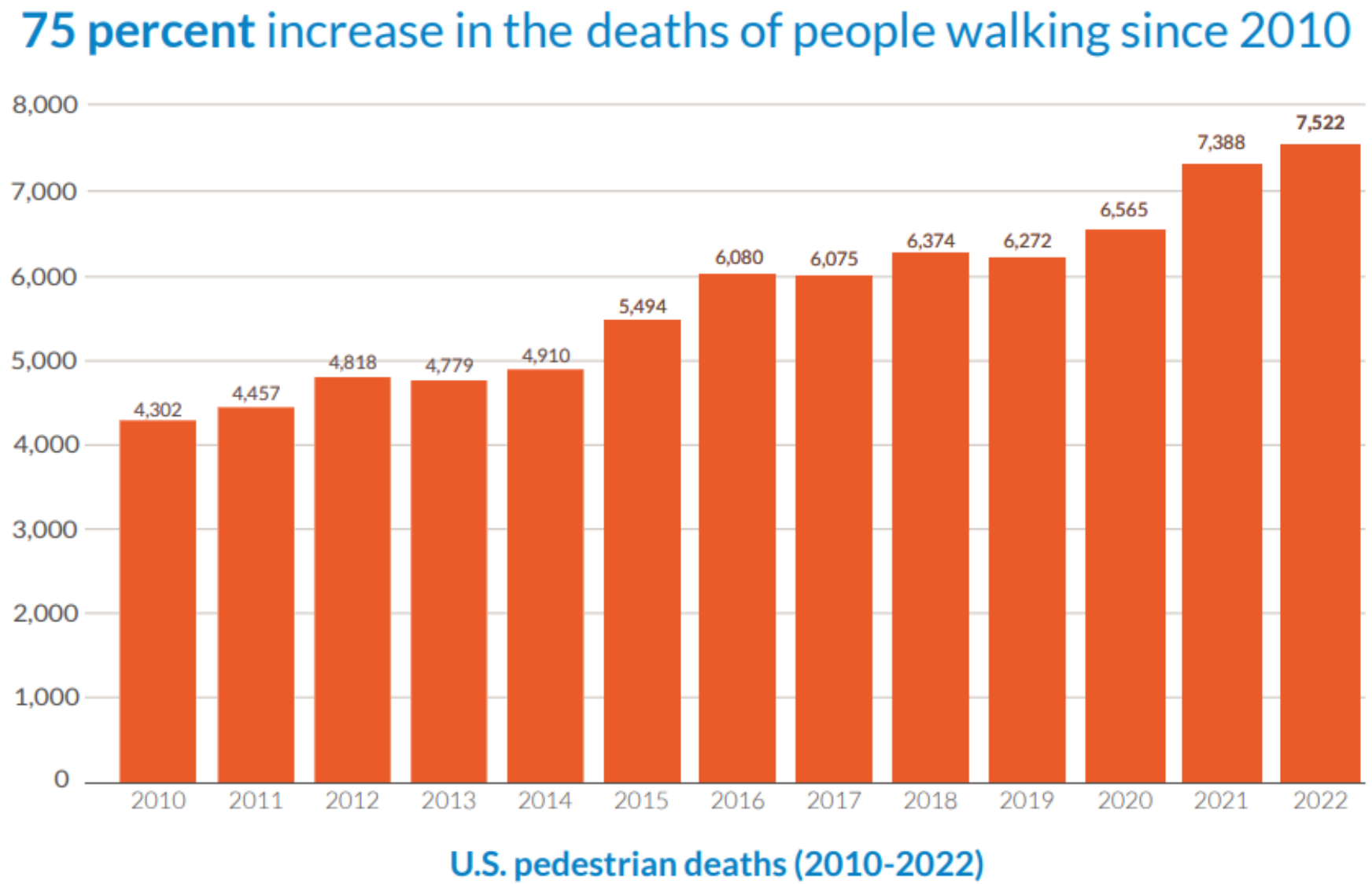
Source: NHTSA Traffic Safety Facts, 2023 Data

Bicyclists have 1% of trips but 3 % of fatal crashes



Dangerous By Design 2024 (Smart Growth America and National Complete Streets Coalition)

TOOLE DESIGN



Dangerous By Design 2024 (Smart Growth America and National Complete Streets Coalition)

TOOLE DESIGN

Today's presentations will discuss these types of crashes:

Right-hook crashes

more common

Left-hook crashes

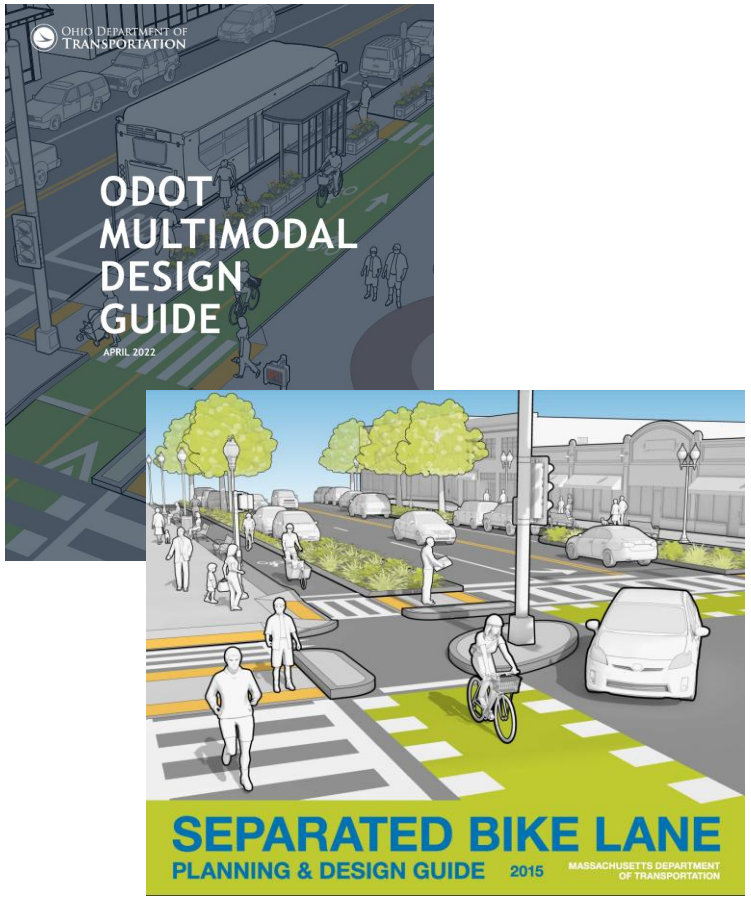
more severe

NATIONAL GUIDANCE

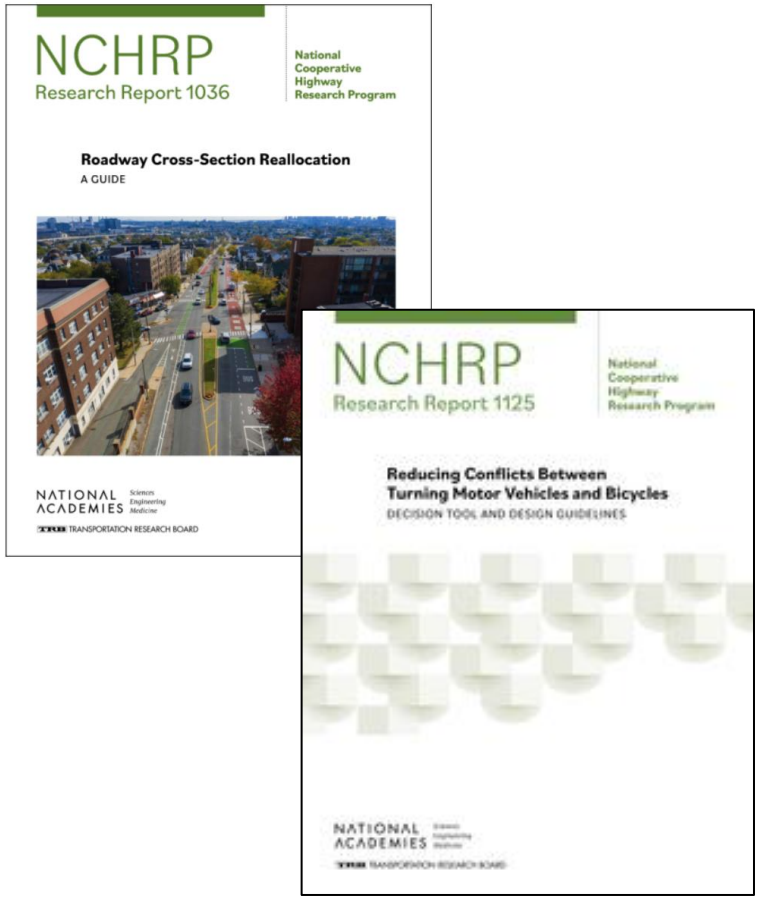
GUIDANCE COMES IN MANY FORMS

National-Level Guidance

Look Beyond Your Borders



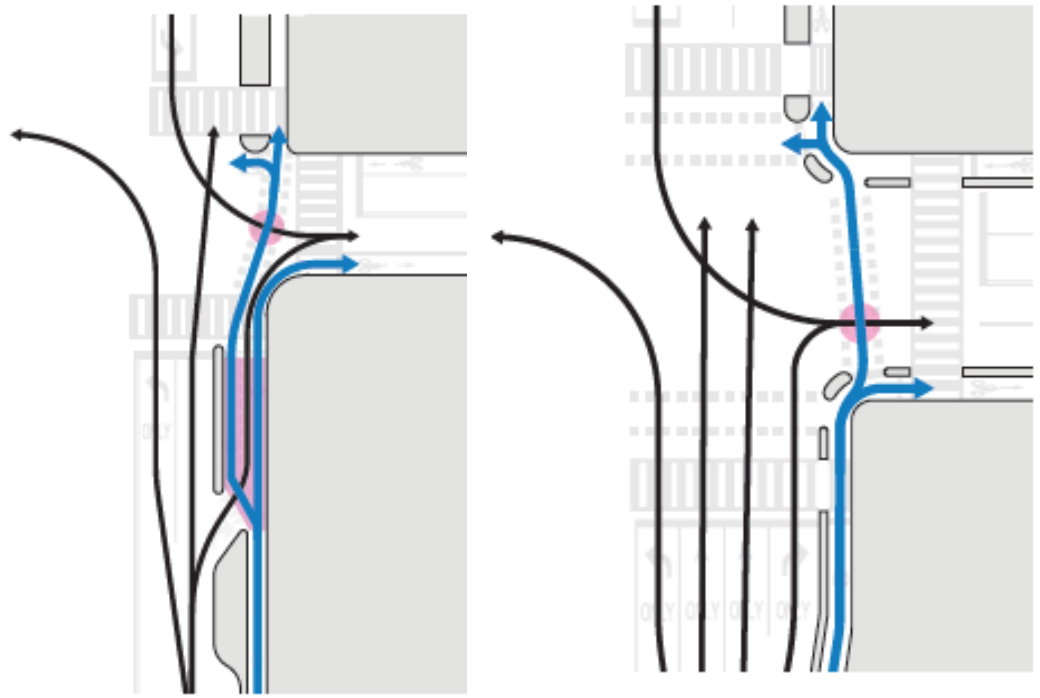
Stay Informed



TOOLE DESIGN

INTERSECTION DESIGN OBJECTIVES

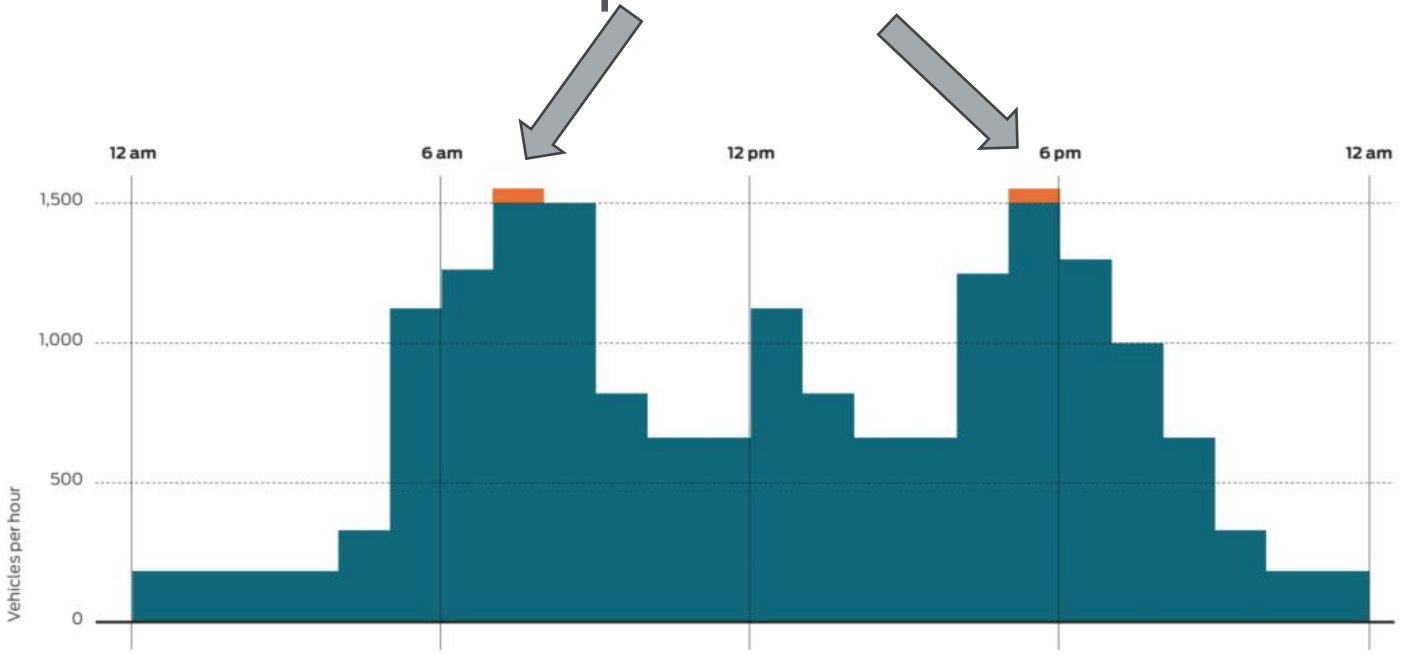
- AASHTO Bike Guide Chapter 5
  - 5.8.1. Minimize Exposure to Conflicts
  - 5.8.2. Reduce Speeds at Conflict Points
  - 5.8.3. Communicate Right-of-Way Priority
  - 5.8.4. Providing Adequate Sight Distance
  - 5.8.5. Transitions to Other Facilities
  - 5.8.6. Accommodating Persons with Disabilities



TOOLE DESIGN

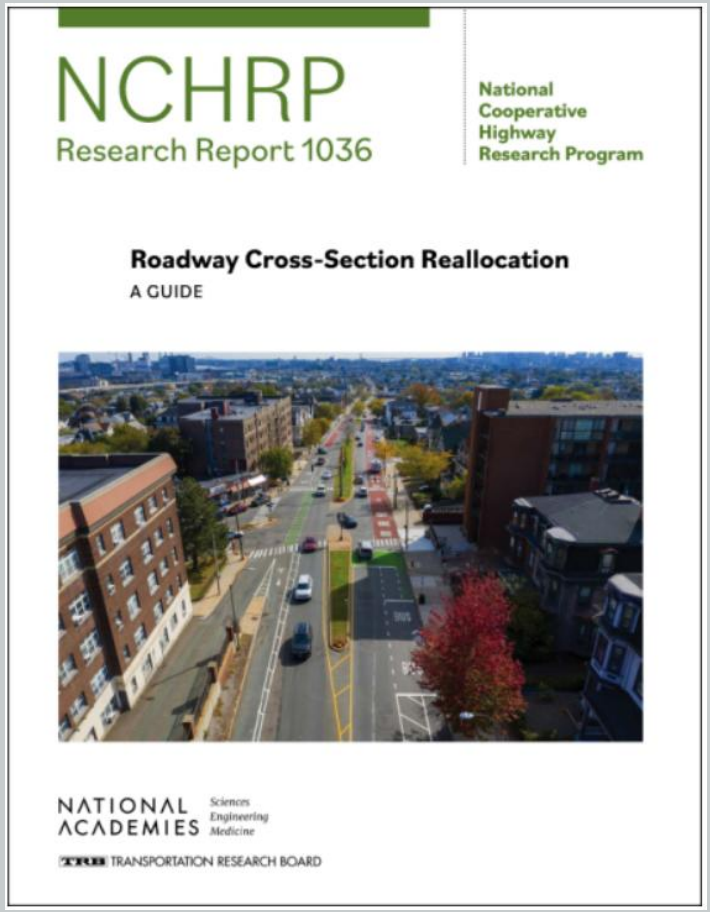
ALL DAY CONSIDERATIONS

Designing for peak hours



NACTO Urban Street Design Guide

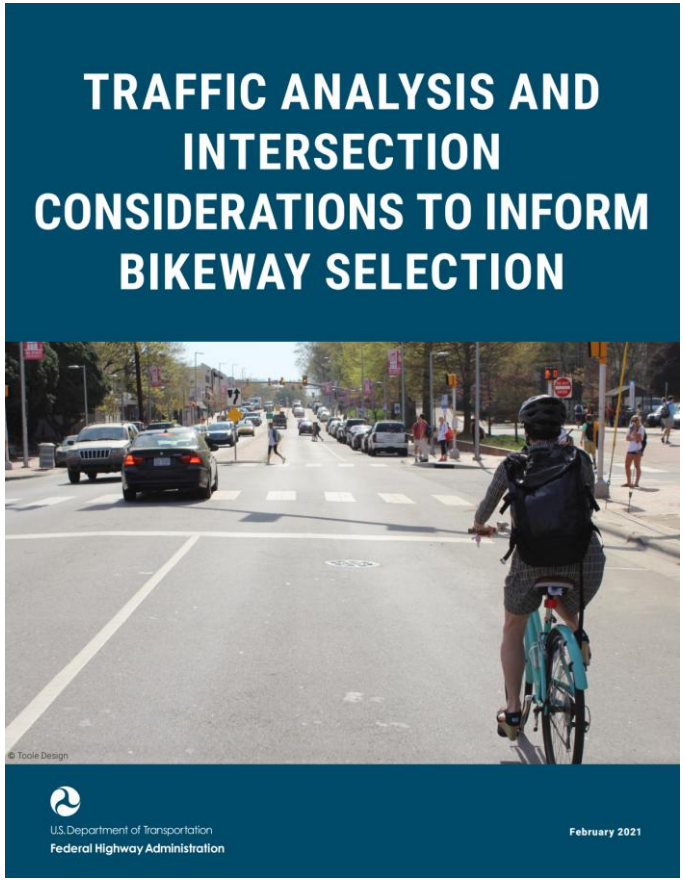
Leads to higher speeds during all other hours of the day



1. **Hourly demand-to-capacity (d/c) ratio**
2. **16-hour efficiency**
3. **16-hour excess lane-capacity**
4. **Total hours below capacity**

TOOLE DESIGN

FHWA'S TRAFFIC ANALYSIS AND INTERSECTION CONSIDERATIONS



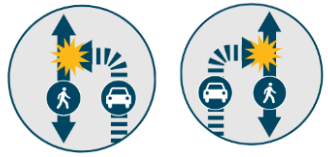
Important supplement to the FHWA Bikeway Selection Guide:

- Recommends adjusting assumptions to fit within a holistic approach and allow motor vehicle traffic analysis to INFORM not DRIVE decisions
- Includes Discussion Prompts to support making difficult choices at constrained intersections.

INTERSECTION TREATMENTS

LEADING PEDESTRIAN INTERVALS

Addressing these conflict types



- Install on a case-by-base basis using vehicle OR pedestrian volume

Warrant	Turning Vehicles Volume (A)	Pedestrian Volume (B)
Vehicle Peak Hour	≥130 per hour	≥25 per hour
Pedestrian Peak Hour	≥100 per hour	≥50 per hour
4-Hour Vehicular and Ped Volume	≥105 per hour	≥30 per hour
8-Hour Vehicular and Ped Volume	≥100 per hour	≥25 per hour
School Crossing	≥50 per hour	

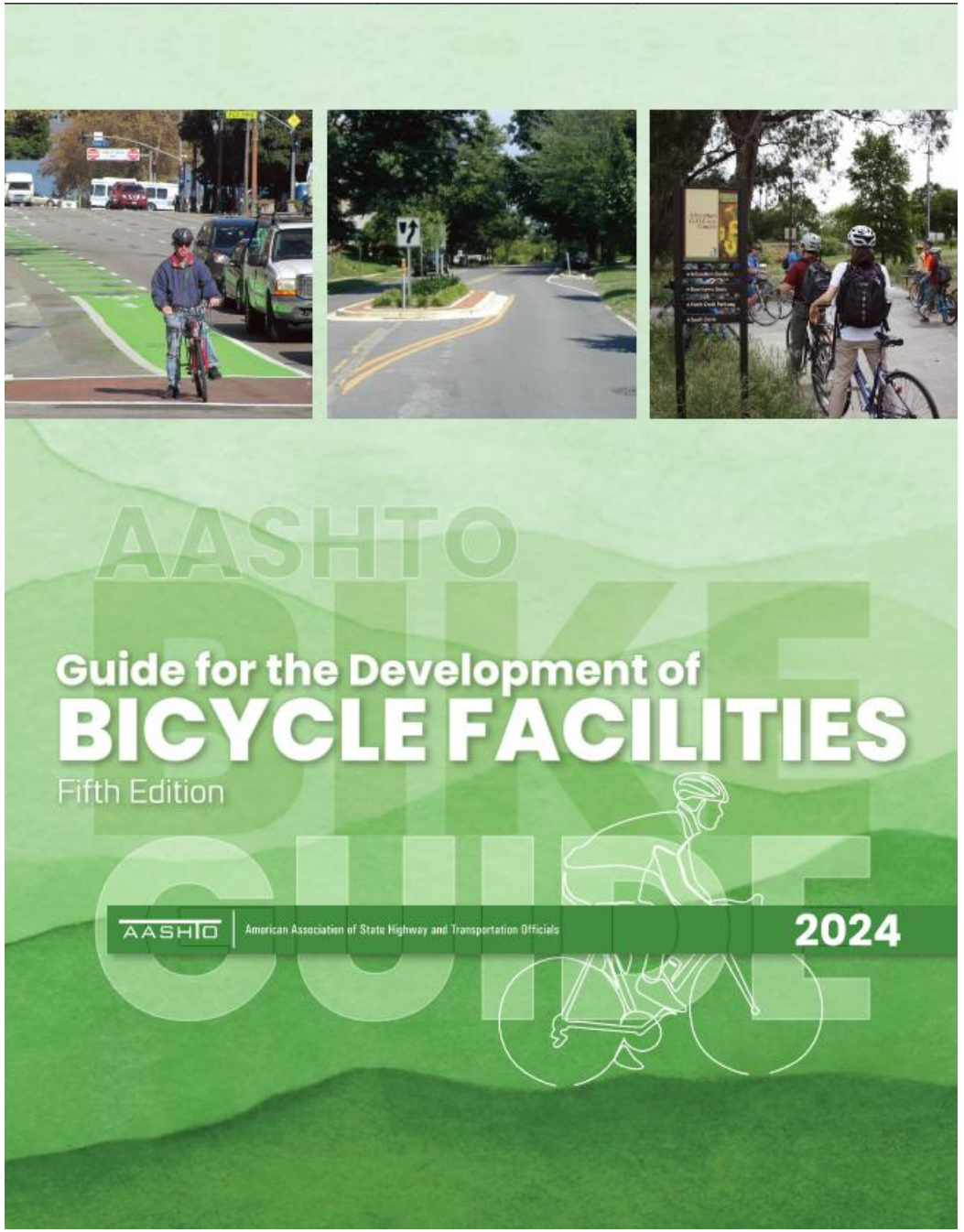
ODOT Multimodal Design Guide

- Install systemically based on priortization criteria (e.g., existing high crash rates, location near a school, commercial hub)

TOOLE DESIGN

AASHTO BIKE GUIDE

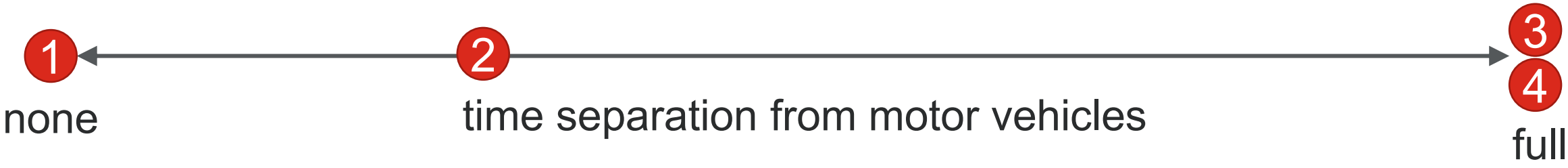
- 10.1 Introduction
- 10.2 Design Guidance for Traffic Signal Control
- 10.3 Traffic Signal Phasing for Managing or Reducing Conflicts
- 10.4 Traffic Signal Timing for Bicyclists
- 10.5 Bicycle Signal Design Consideration
- 10.6 Detection for Bicycles
- 10.7 Design Guidance for Pedestrian Hybrid Beacons
- 10.8 Toucan Crossings with Traffic Signals



TOOLE DESIGN

Addressing these conflict types

1. Bike phase on with conflicting permissive vehicle turns
2. Leading bicycle interval with no conflicts, then bike phase on with conflicting permissive vehicle turns
3. Bike phase on with non-conflicting thru vehicle movement (no conflicts)
4. Protected bike phase: Bike phase on with no other vehicle movements



10.3.5. SIGNAL PHASING SCHEMES FOR REDUCING CONFLICTS

Table 10-1: Recommended Hourly Turning Traffic Thresholds for Time-Separated Bicycle Movements

	Left Turn Crossing One Vehicle Lanes	Left Turn Crossing Two Vehicle Lanes
One-Way Bike Lane	≥ 100 ≥ 150*	≥ 50 ≥ 150*
Two-Way Bike Lane	≥ 50 ≥ 100*	ANY ≥ 100*

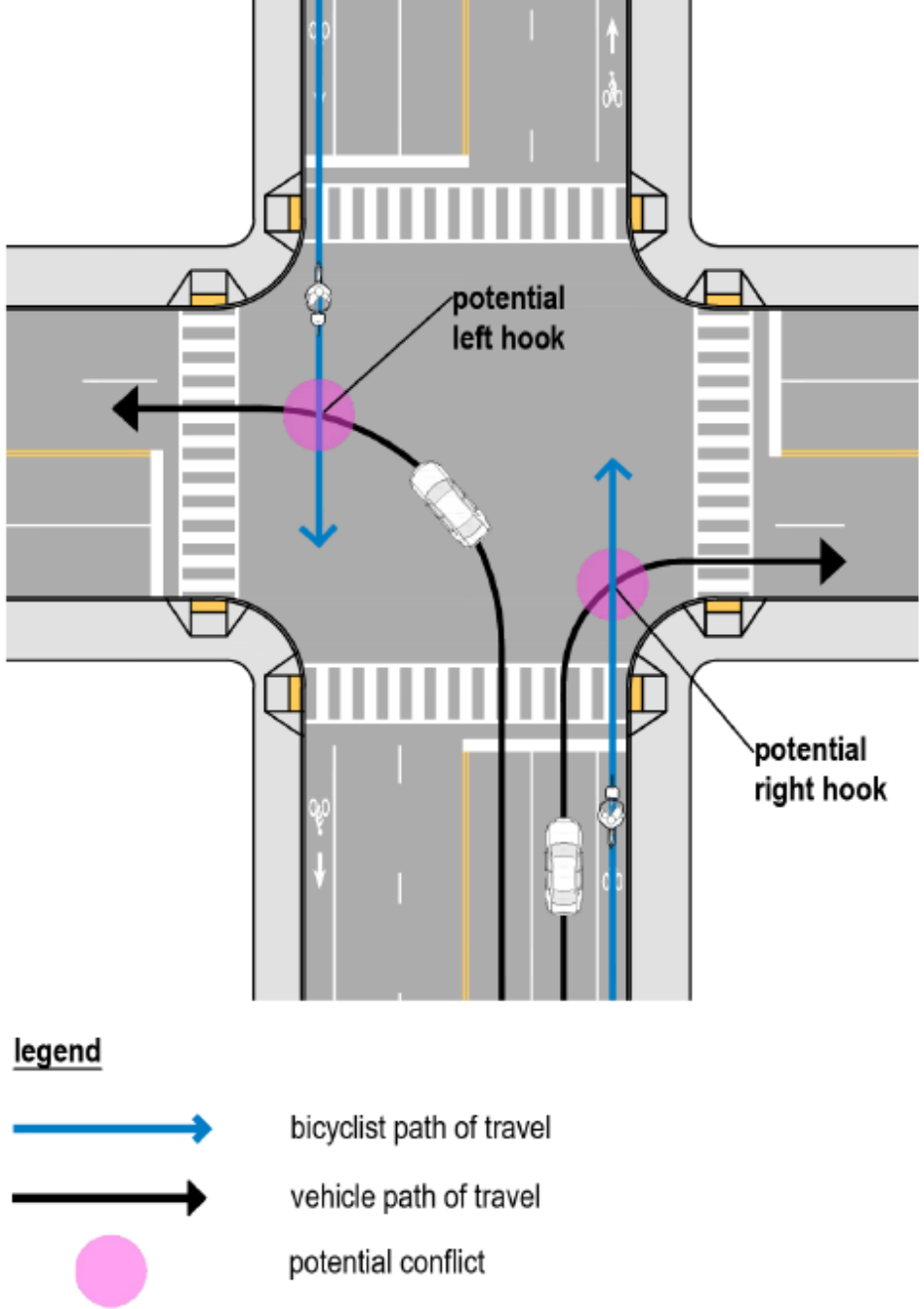


Figure 10-3: Left-Hook and Right-Hook Graphic

WHAT'S NEW? NCHRP RESEARCH REPORT 1125

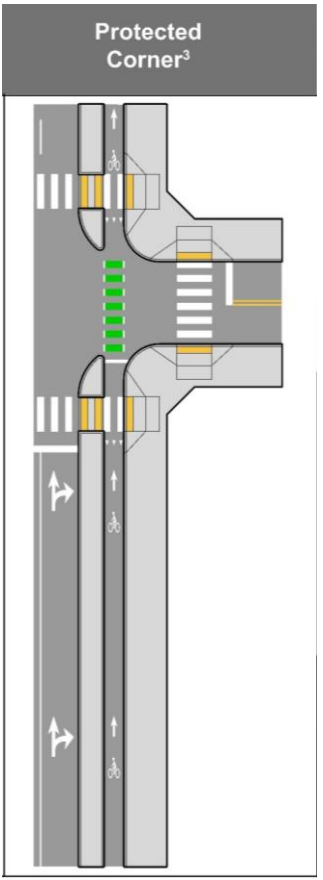
Addressing these conflict types

Methods	Scale	Strengths	Disadvantages
Micro-Crash Analysis	573 sites 233 crashes	• Direct measure of safety	• Observational method and rare events • Limited details of crash event actions • Variations in crash reporting • Needs accurate exposure information
Video-Based Conflict Analysis	28 sites 2,000+ hrs video 16k+ conflicts	• Detailed event-level data and many observations	• Observational method • Conflicts with VRUs harder to define consistently with metrics • Knowledge gap in correlation with crashes for VRUs
Human Factors Study (Simulator)	40 participants 640 turns ~8 hrs data	• Controlled experiment • Not limited to sites built • Detailed event and driver performance data	• Limited to drivers recruited to experiment • Challenge with translating performance measures to safety and design decisions • Practical limit on variables to explore

Method #4 - Incorporated previous research on bicyclists' comfort when interpreting results from the research.

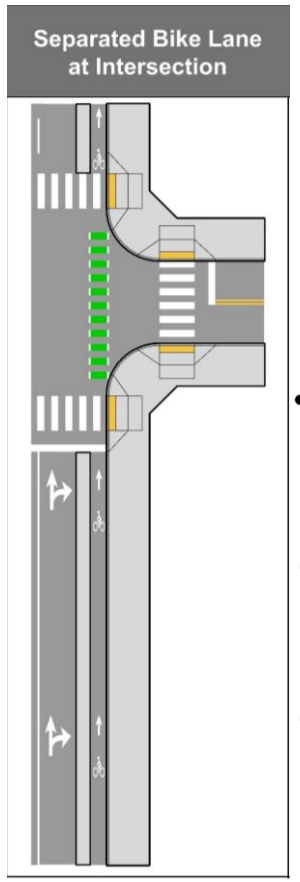
TOOLE DESIGN

FINDINGS FOR PREFERRED TREATMENTS



Protected corner are recommended for any locations where space can be reallocated to provide a protected corner.

- Middle crash rate in AUS, MSP, SEA* Lowest crash rate in NYC
- Similar number of conflicts as Mixing Zone
- Second lowest mean speed at conflict point
- People bicycling are the most comfortable with a Protected Corner



Separated bike lane treatment at the intersection is recommended where there is not space to provide a protected intersection.

- Highest crash rate in AUS, MSP, SEA Second highest crash rate in NYC**
- Lowest predicted number of conflicts
- Moderate mean speeds at conflict point
- People bicycling are comfortable at intersections that maintain separation

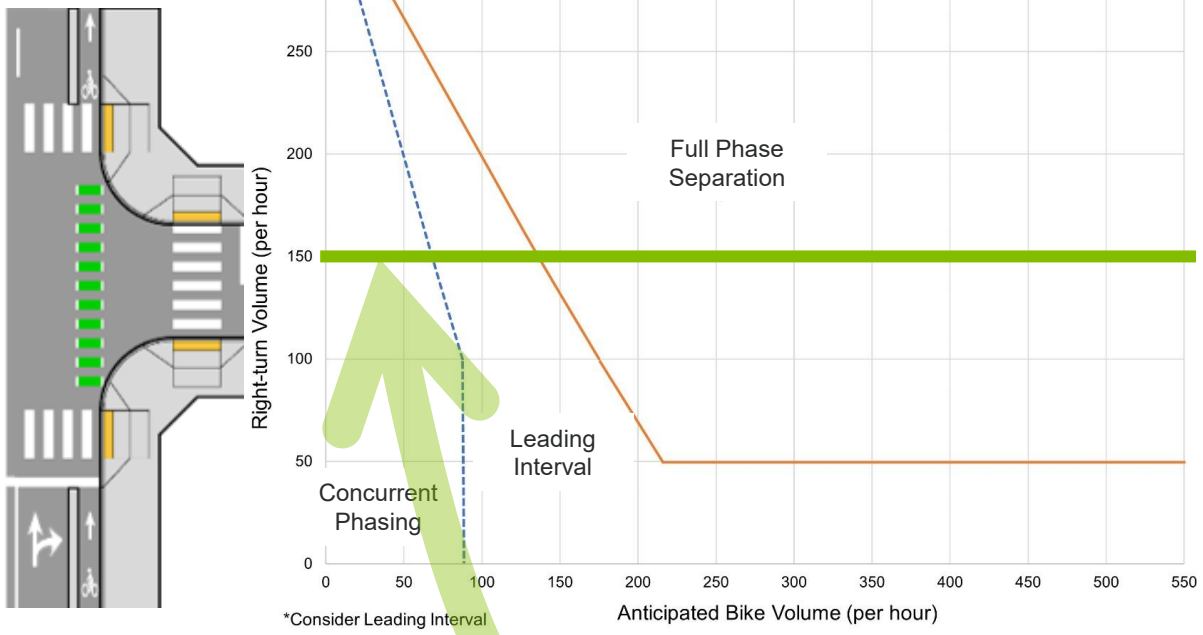
TOOLE DESIGN

Limitation: small sample size

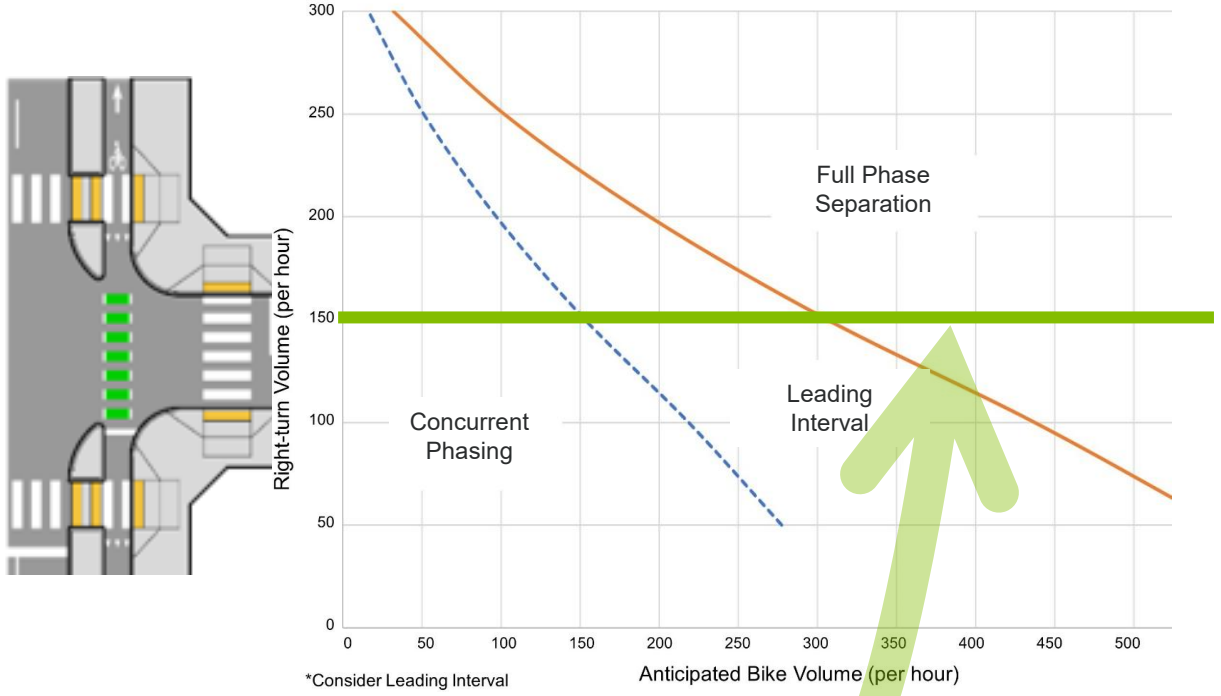
****Limitation: exposure models may not fully capture number of bicyclists using streets with these treatments***

REVISED THRESHOLDS FOR PHASE SEPARATION

Separated Bike Lane



Protected Intersection



Threshold from AASHTO is 150 vph regardless of intersection treatment and bicycle volume

TOOLE DESIGN

LEFT-TURN PHASHING

Addressing these conflict types

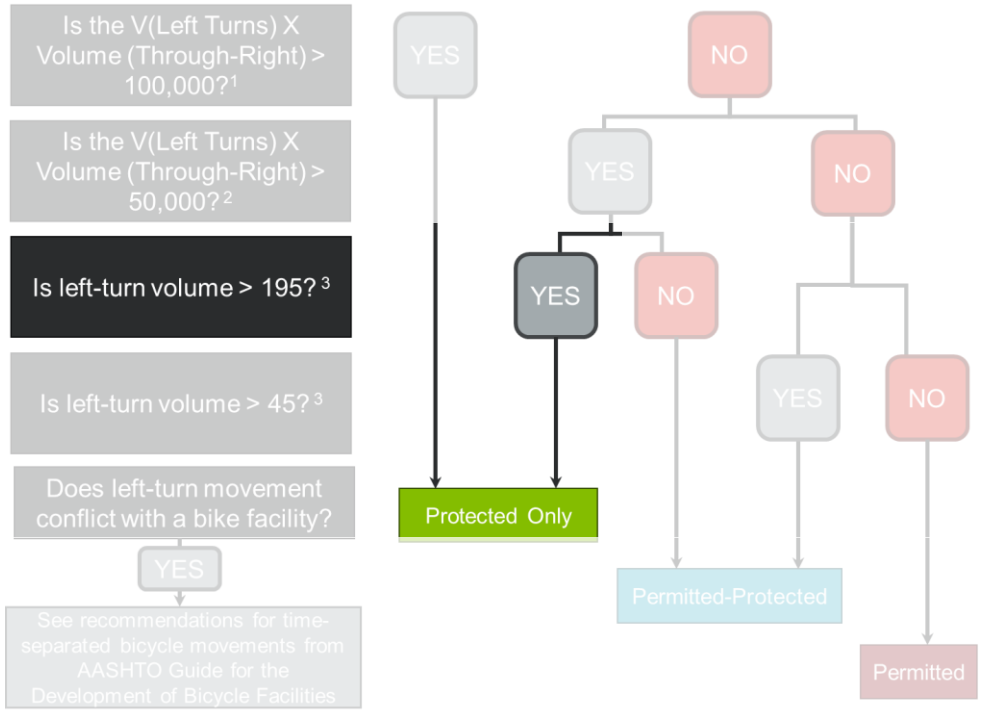
- Left-turn phasing can be used to address pedestrian-vehicle conflicts
- National standard does not exist, so look to state or local

Boston Transportation Department
Signal Operations Design Policy

Left Turn Phasing Strategies

Protected-only left-turn phasing should be applied in the following cases:

h. Left turns across two opposing through lanes if the left turn crosses a bike lane or a crosswalk, unless permitted left turn phasing would generate no more than 1.5 permitted left turns per cycle.



TOOLE DESIGN

Designing for bikes and pedestrians at signals isn't about adding features—it's about reshaping how we allocate priority, time, and space at the most complex points in the network.