



Intersection Control Evaluation, Pedestrian and Bicycle Safety at Intersections, & Roadway Cross- Section Reallocation

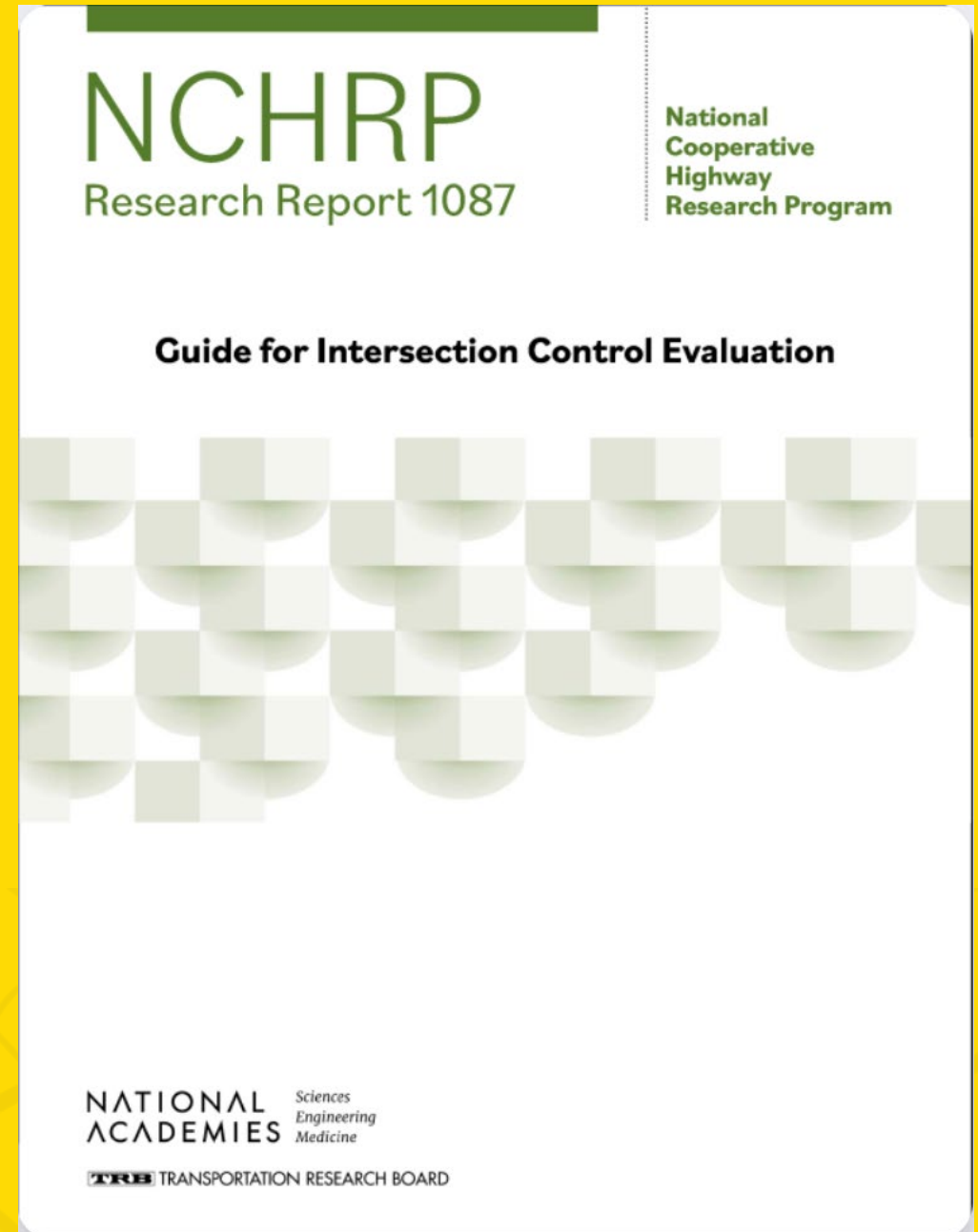
NCHPR 1087, NCHRP 948, and NCHRP 1036



Cameron Bennett, EIT
Engineering Associate
Kittelison & Associates, Inc.

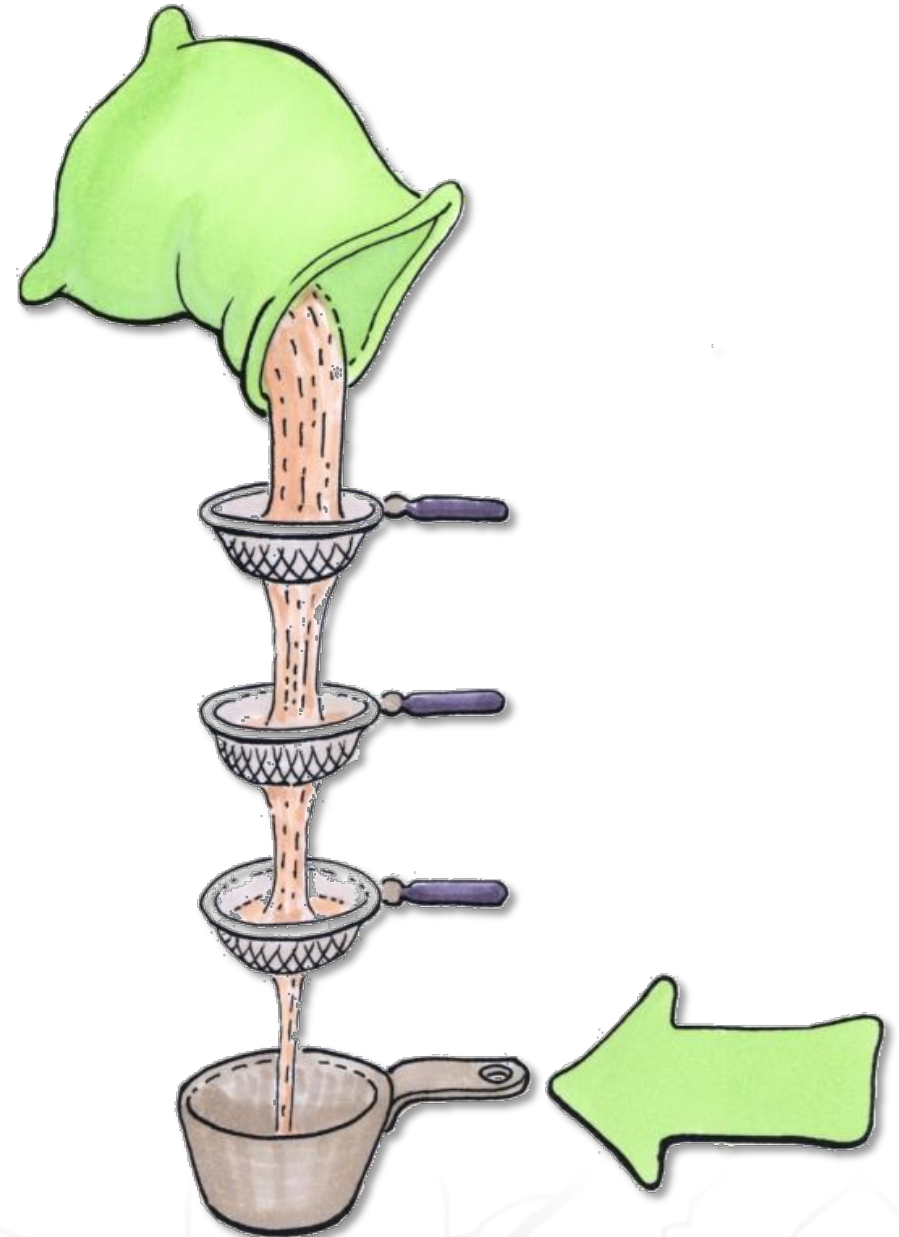
Intersection Control Evaluation

NCHRP 1087

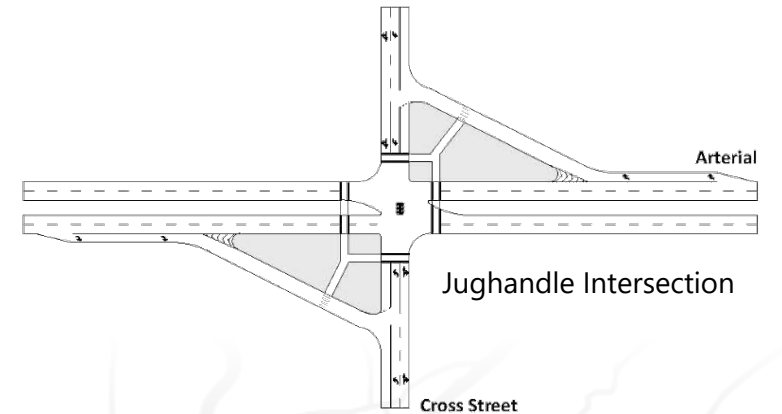
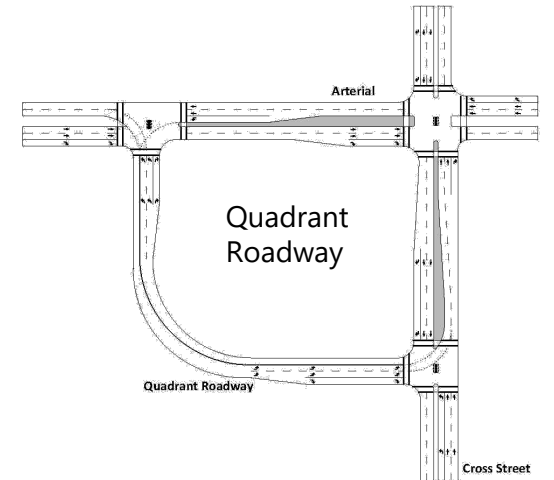
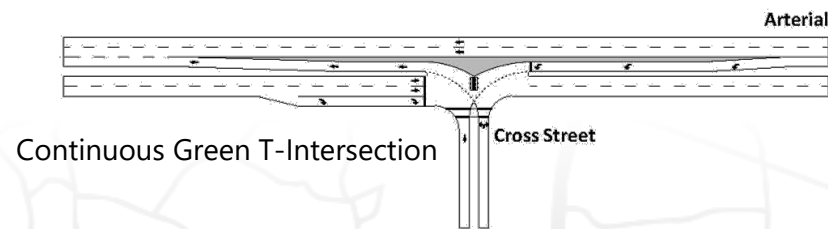
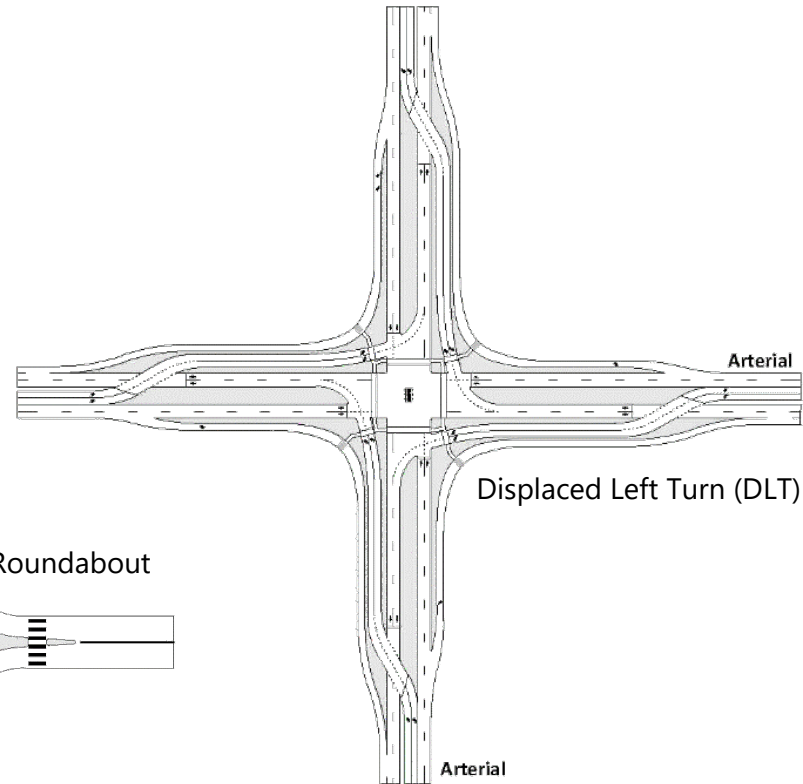
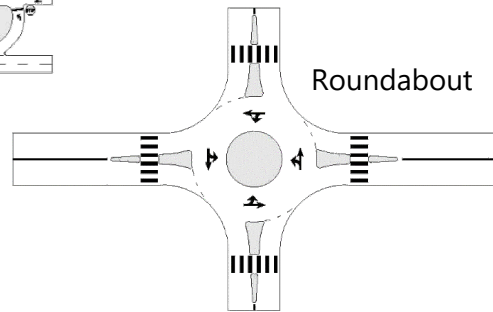
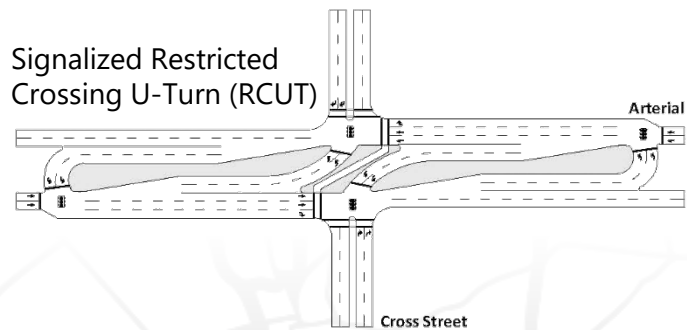
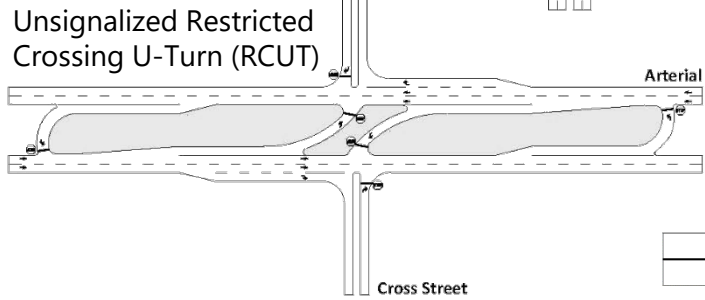
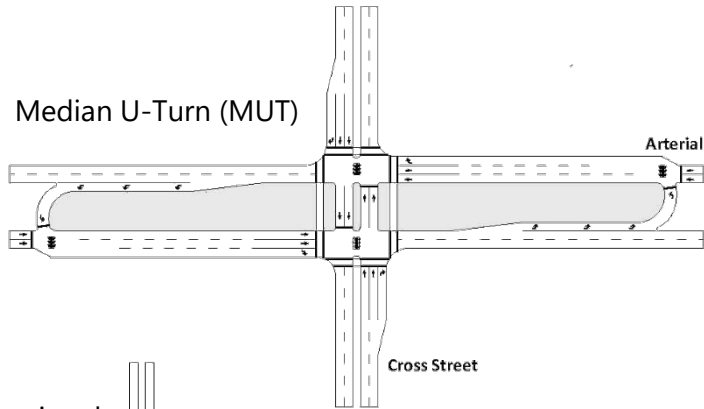


What is Intersection Control Evaluation?

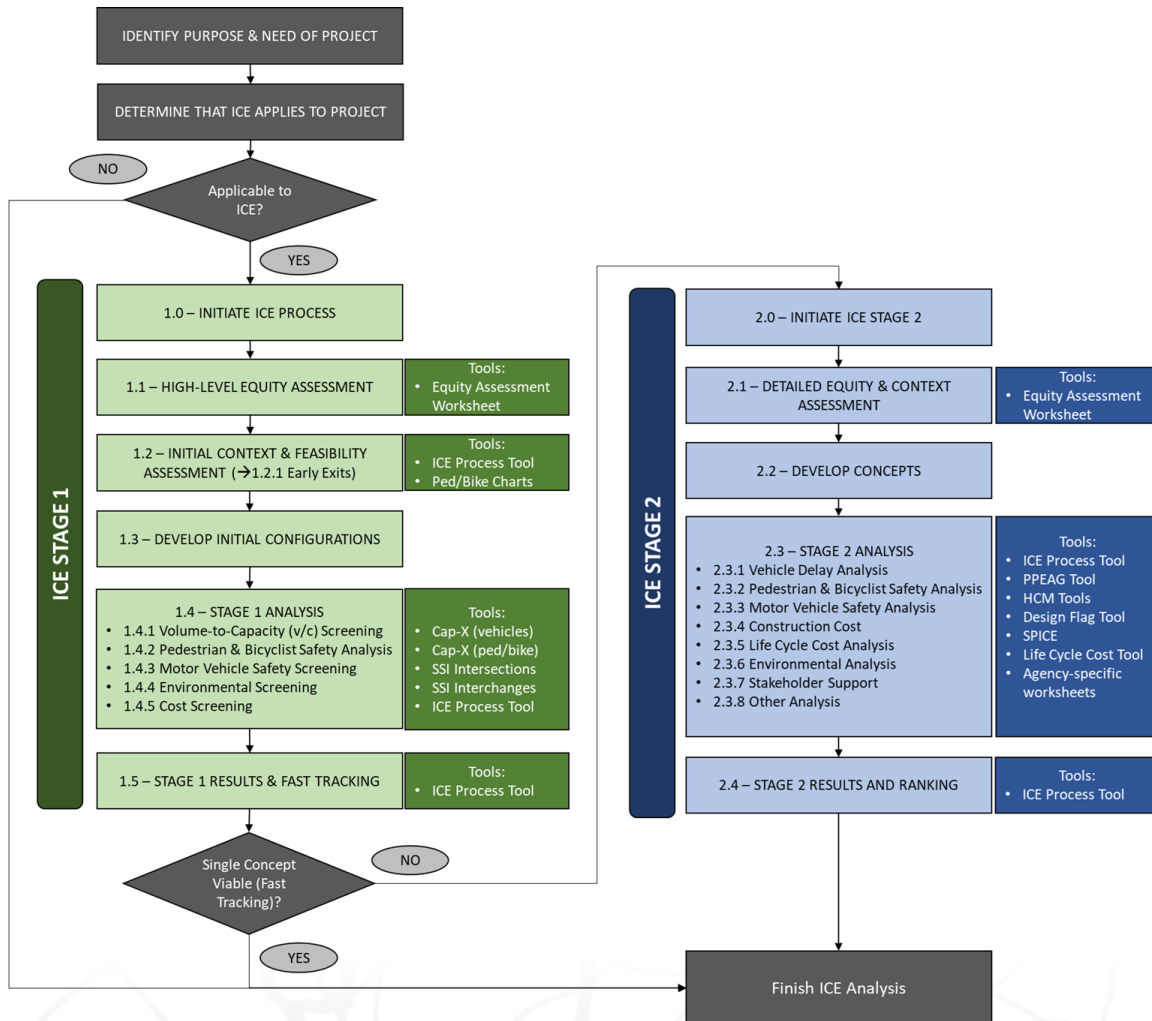
- A process for assessing trade-offs between different intersection **forms** and **control** types.
- Can become a policy establishing the general applicability and legal underpinnings for the process.



Innovative Intersection Forms



Typical Intersection Control Evaluation Process



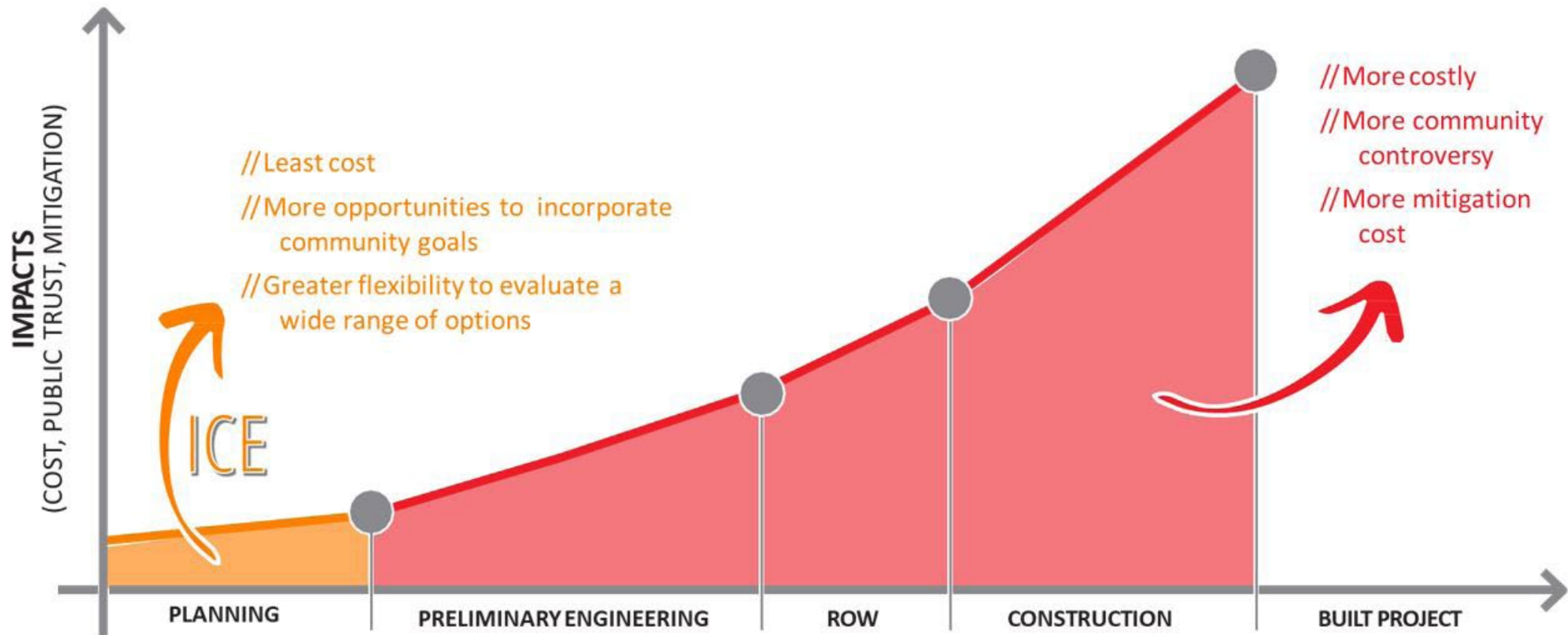
Stage 1: high-level screening

- Identify 'early exit' alternatives not feasible given project context

Stage 2: detailed assessment









- Vehicle Delay
- Pedestrian and Bicyclist Safety
- Motor Vehicle Safety
- Construction Cost
- Life-Cycle Cost
- Environment Analysis
- Stakeholder Support
- Other Analysis

Intersection Control Evaluation (ICE) in the Project Life Cycle



Tools to Support Intersection Control Evaluation

Spreadsheets tools (part of ICE Guide)

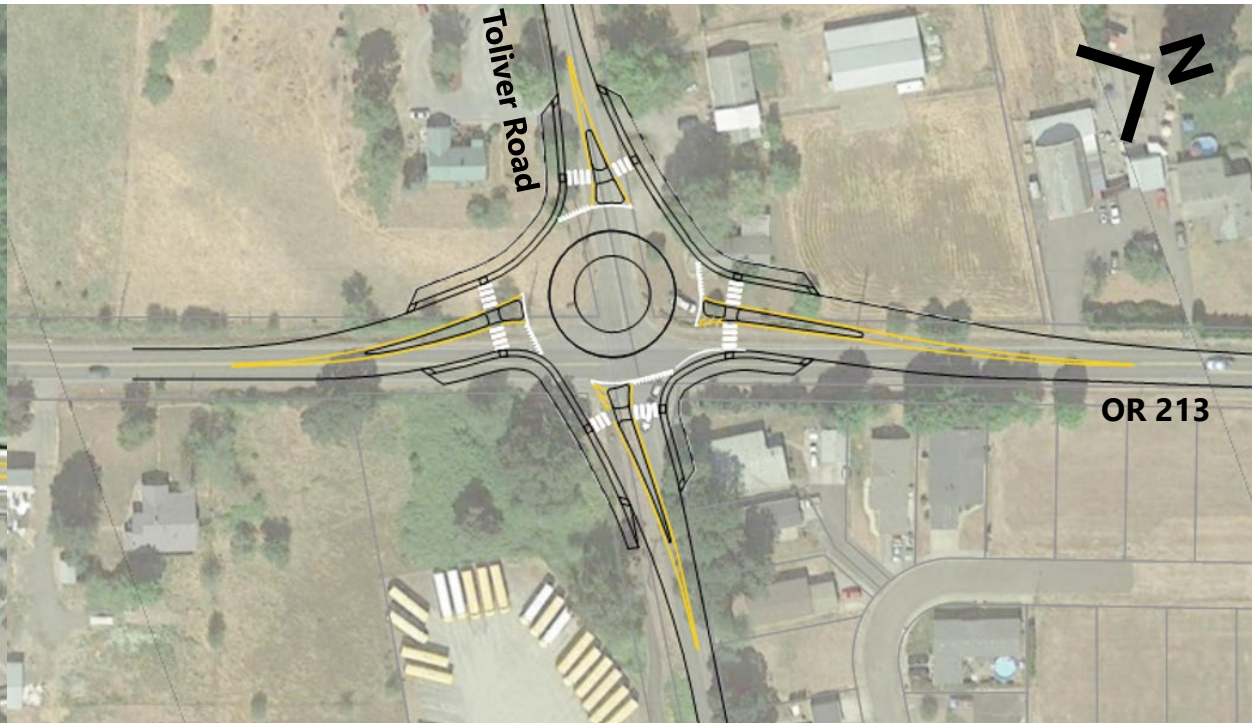
-  • ICE Process Tool
-  • Capacity Analysis for Planning of Junctions (CAP-X) Tool
-  • Planning and Preliminary Engineering Applications Guide (PPEAG) ICE Tool
-  • Equity Assessment Tool
-  • 20 Flags Calculator Tool
-  • Safe Systems for Intersections (SSI) Tools
-  • Safety Performance for Intersection Control Evaluation (SPICE) Tool
-  • Life-Cycle Cost Estimating Tool (LCCET)

Other Tools

- Agency-Level ICE Tools
 - PennDOT Web ICE Tool
 - VDOT VJuST Tool
- Safety Screening Tools
 - CrashKit™
- Operations Analysis Software
 - Synchro
 - HCS
 - VISSIM
 - VISTRO
 - Etc.






















Intersection Control Evaluation

Example: OR 213 at Toliver Road



Intersection Control Evaluation

Example: OR213 at Toliver Road

Alternative	Operations	Safety	Cost	Freight	Pedestrian/ Bicycle	Overall
No Build						
Signal						
Roundabout						
Legend						
 = 1 point (worst)		 = 2 points		 = 3 points (best)		

Intersection Control Evaluation Example: OR213 at Toliver Road



Multimodal Integration in Intersection Control Evaluation

NCHRP 948


NCHRP

RESEARCH REPORT 948

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

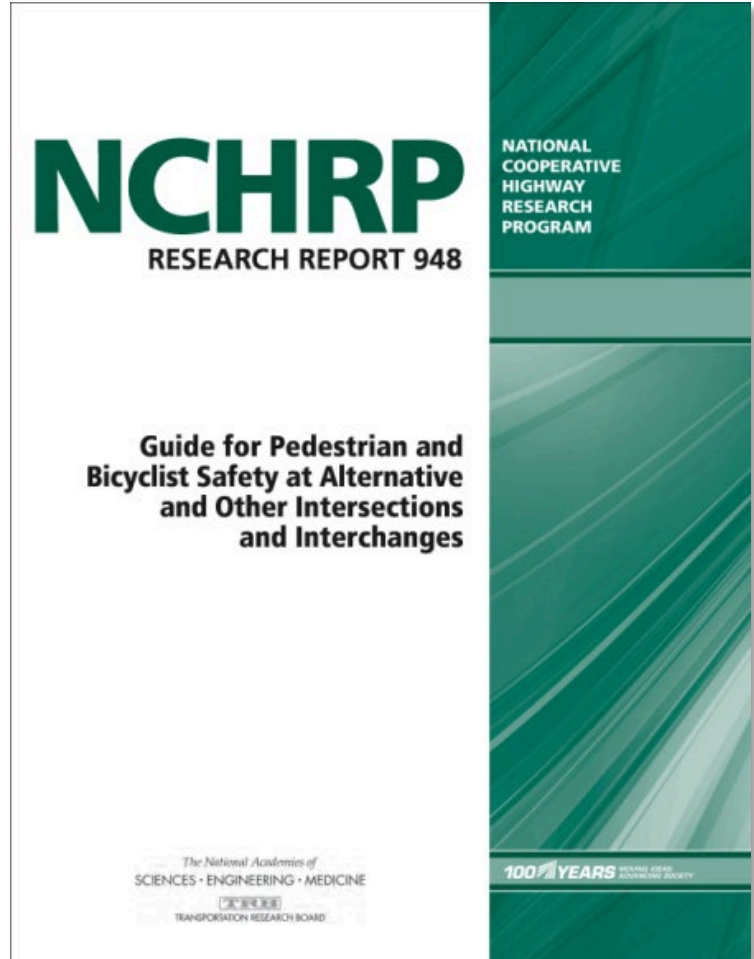
**Guide for Pedestrian and
Bicyclist Safety at Alternative
and Other Intersections
and Interchanges**

The National Academies of
SCIENCES • ENGINEERING • MEDICINE


TRANSPORTATION RESEARCH BOARD

100 YEARS MOVING OUR
ADVANCING SOCIETY

Motivation



- Pedestrian and bicyclist crashes are more rare than vehicular crashes
 - Difficult to develop predictive safety models
- Growing desire to proactively enhance safety
 - Integrate safety in planning and design

What makes an Intersection Safe and Comfortable for People Walking and Biking?

- Crossing few lanes at a time
- Crossing one direction of traffic at a time
- Adequate crossing opportunities in the form of gaps or stops/yields
- Short cycle lengths (if signalized)
- Slow vehicle speeds at conflict points
- Users make one decision at a time
- Intuitive to use

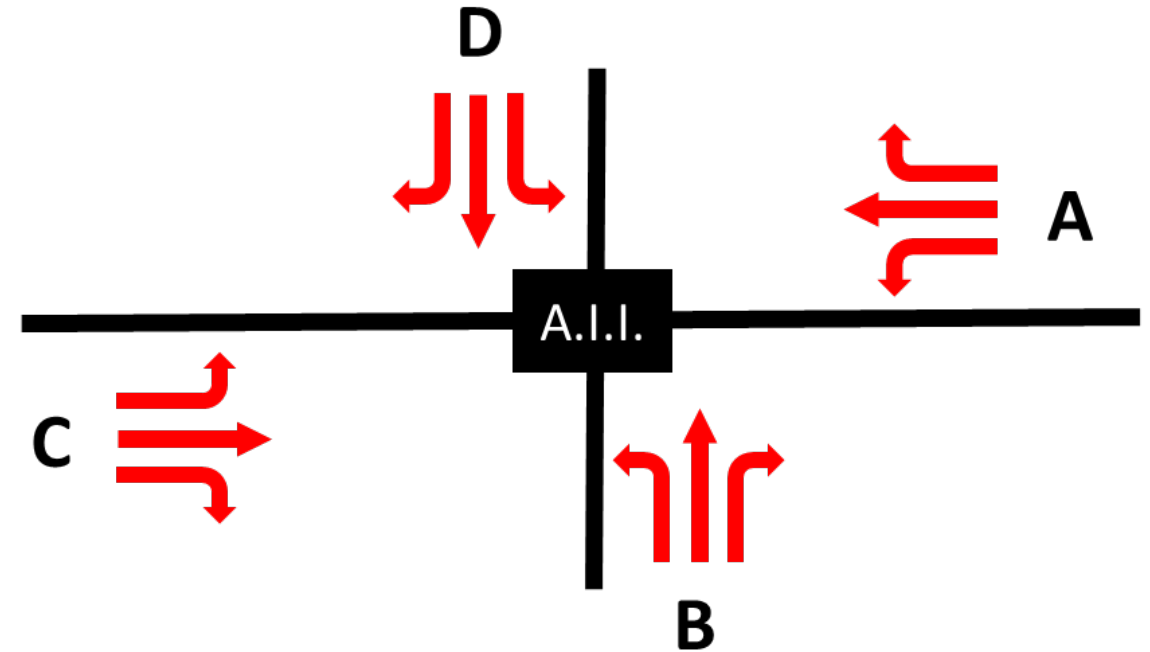
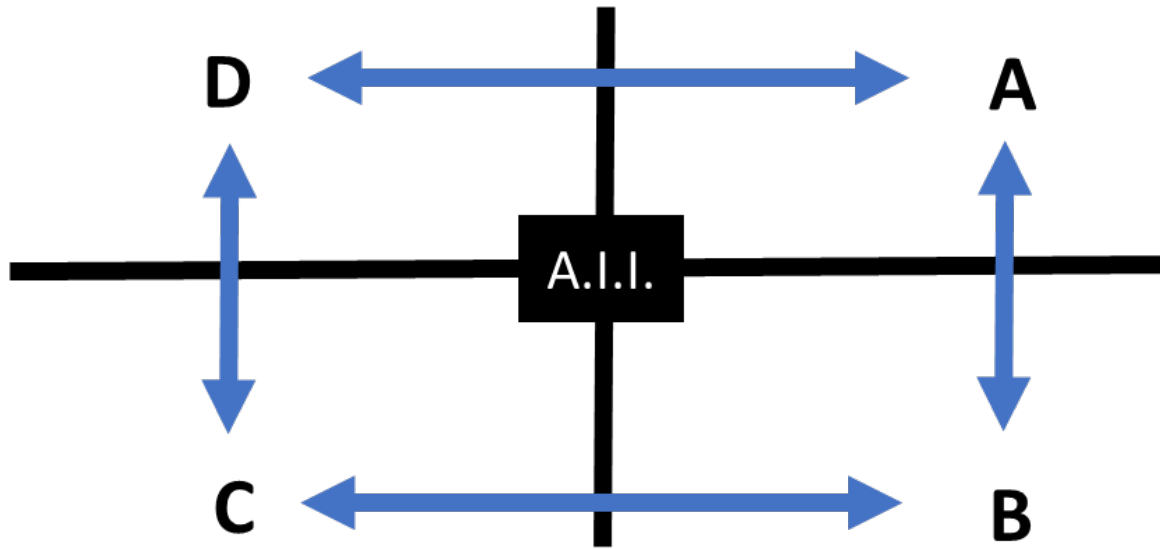


Design Flag Assessment Method

20 Questions for Pedestrian and Bicyclist Safety

Motor Vehicle Right Turns	Uncomfortable/Tight Walking Environment	Nonintuitive Motor Vehicle Movements	Crossing Yield- or Uncontrolled Vehicle Paths
Indirect paths	Executing Unusual Movements	Multilane Crossings	Long Red Times
Undefined Crossing at Intersections	Motor Vehicle Left Turns	Intersecting Driveways and Side Streets	Sight Distance for Gap Acceptance Movements
Grade Change	Riding in Mixed Traffic	Bicycle Clearance Times	Lane Change Across Motor Vehicle Lane(s)
Channelized Lanes	Turning Motorists Crossing Bicycle Paths	Riding Between Travel Lanes, Lane Additions, or Lane Merges	Off-tracking Trucks in Multilane Curves

Applying Design Flags

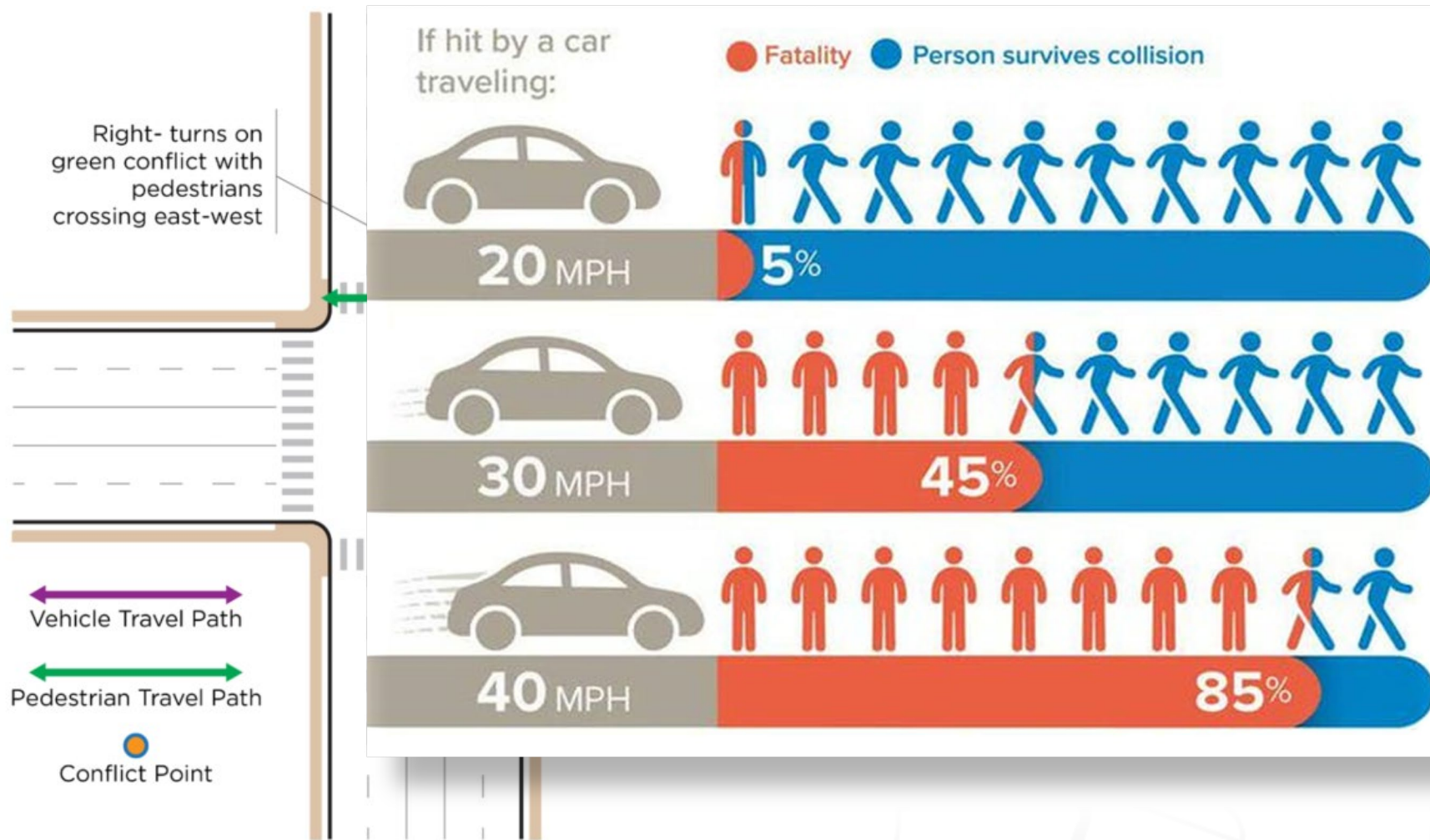


Yellow vs. Red Flags

Yellow Flags — design elements negatively affecting user comfort (increasing user stress) or the quality of the walking or cycling experience.

Red Flags — design elements directly related to a safety concern for pedestrians or bicyclists.

Design Flag 1: Motor Vehicle Right Turns



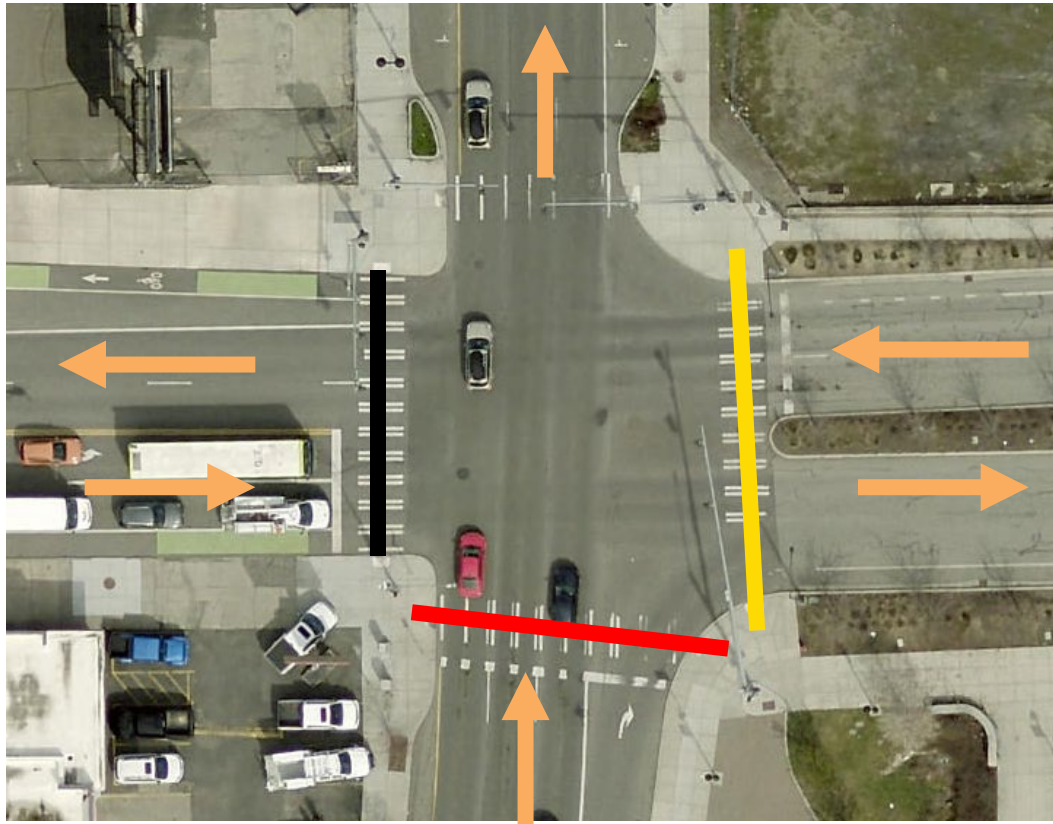
Applicable Mode |

and red-flag thresholds.

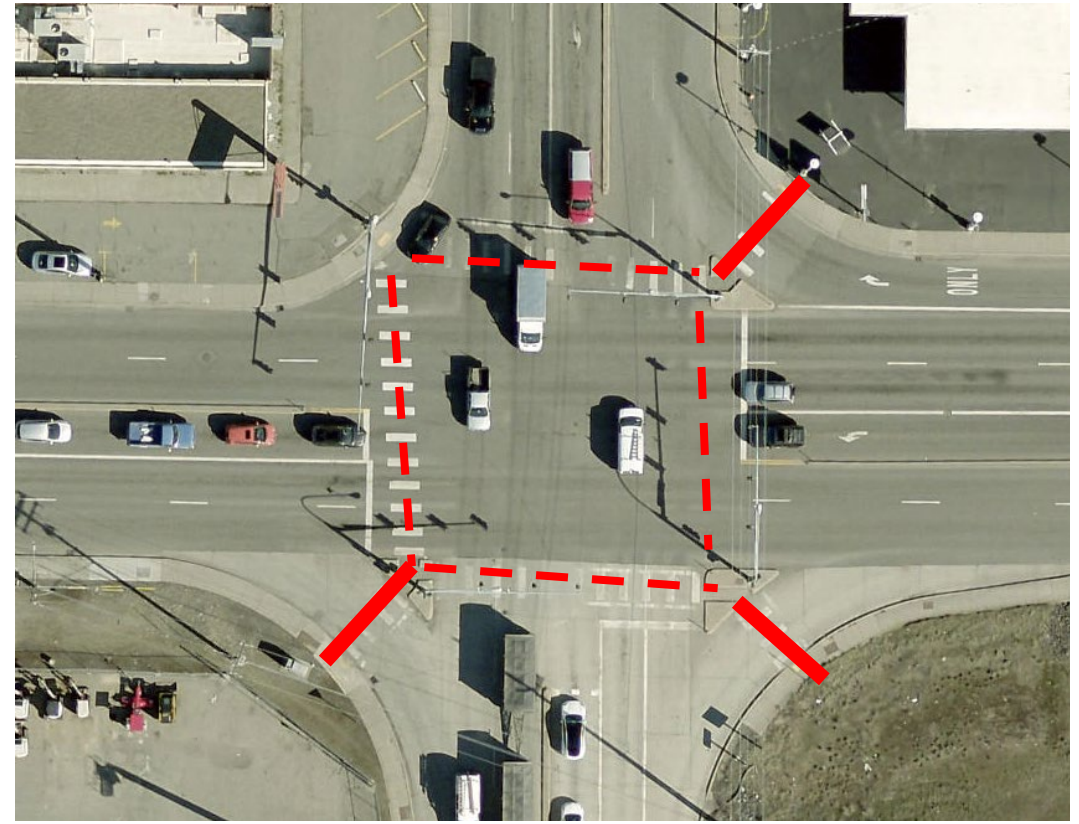
Yellow-Flag Threshold*	Red-Flag Threshold*
≤ 20 mph AND ≤ 50 veh/h	> 20 mph OR > 50 veh/h

or
 realized (with no right-turns-on-red), or speeds are
 flag is eliminated.

Design Flag 1 at Conventional Intersections



Vehicles permitted to turn right across marked crosswalks.



Intersection with channelized turn lanes.

Design Flag 1: Potential Treatments



Right-Turn-on-Red
Restriction



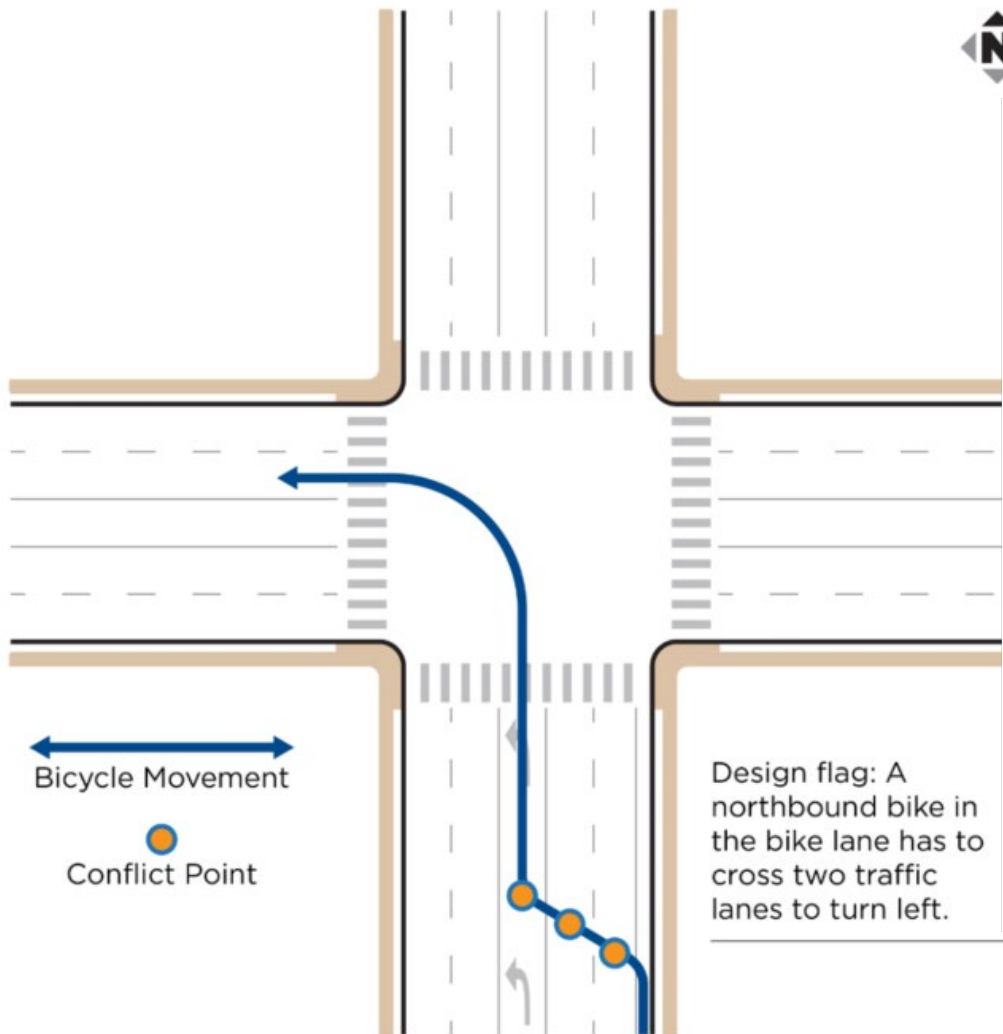
Leading
Pedestrian Interval



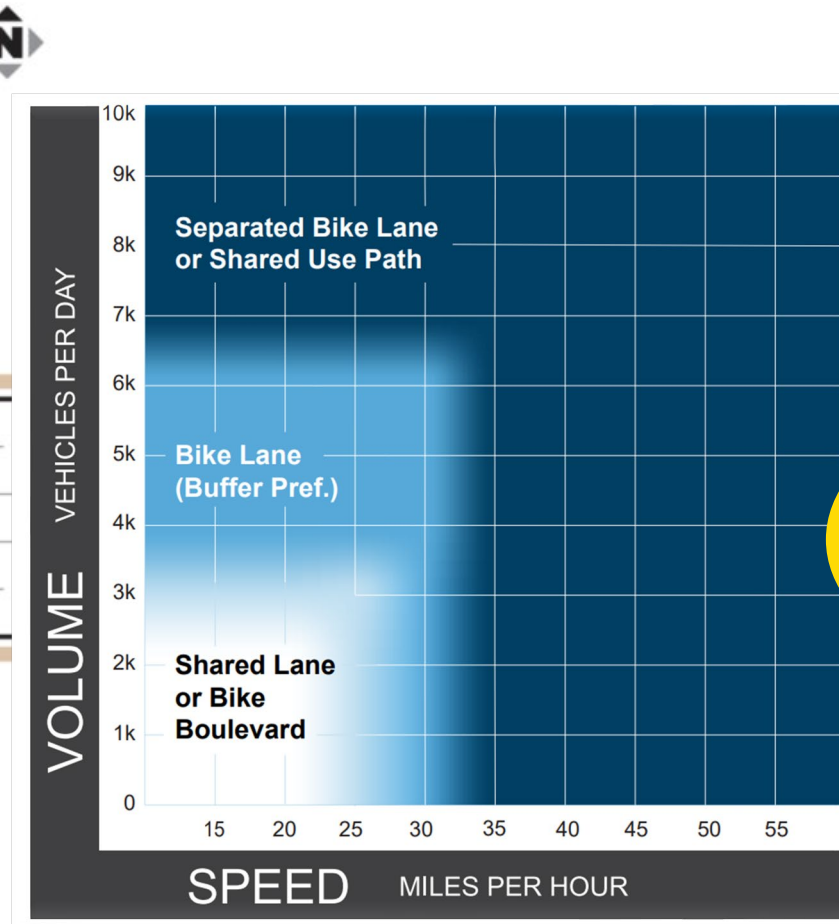
Separating
Driver Decisions
& Reducing Speed

Design Flag 16: Lane Change Across Motor Vehicle Travel Lane

Applicable
Mode



Design flag: A northbound bike in the bike lane has to cross two traffic lanes to turn left.



ed-flag thresholds.

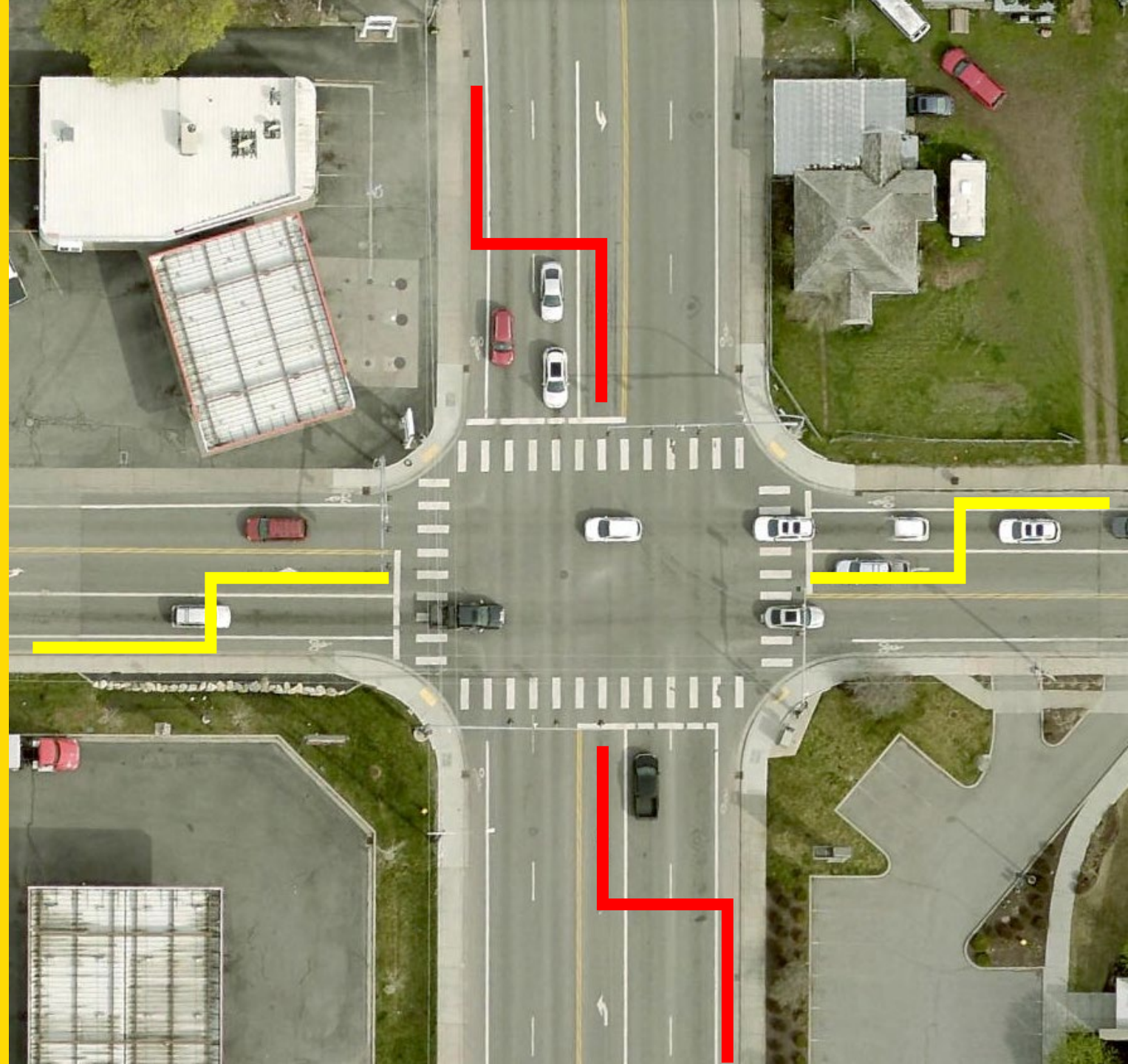
Yellow-Flag Threshold

Red-Flag Threshold

25–35 mph
OR
3,000–7,000 vpd

>35 mph **OR**
>7,000 vpd

Design Flag 16 at Conventional Intersection



Design Flag 16: Potential Treatments



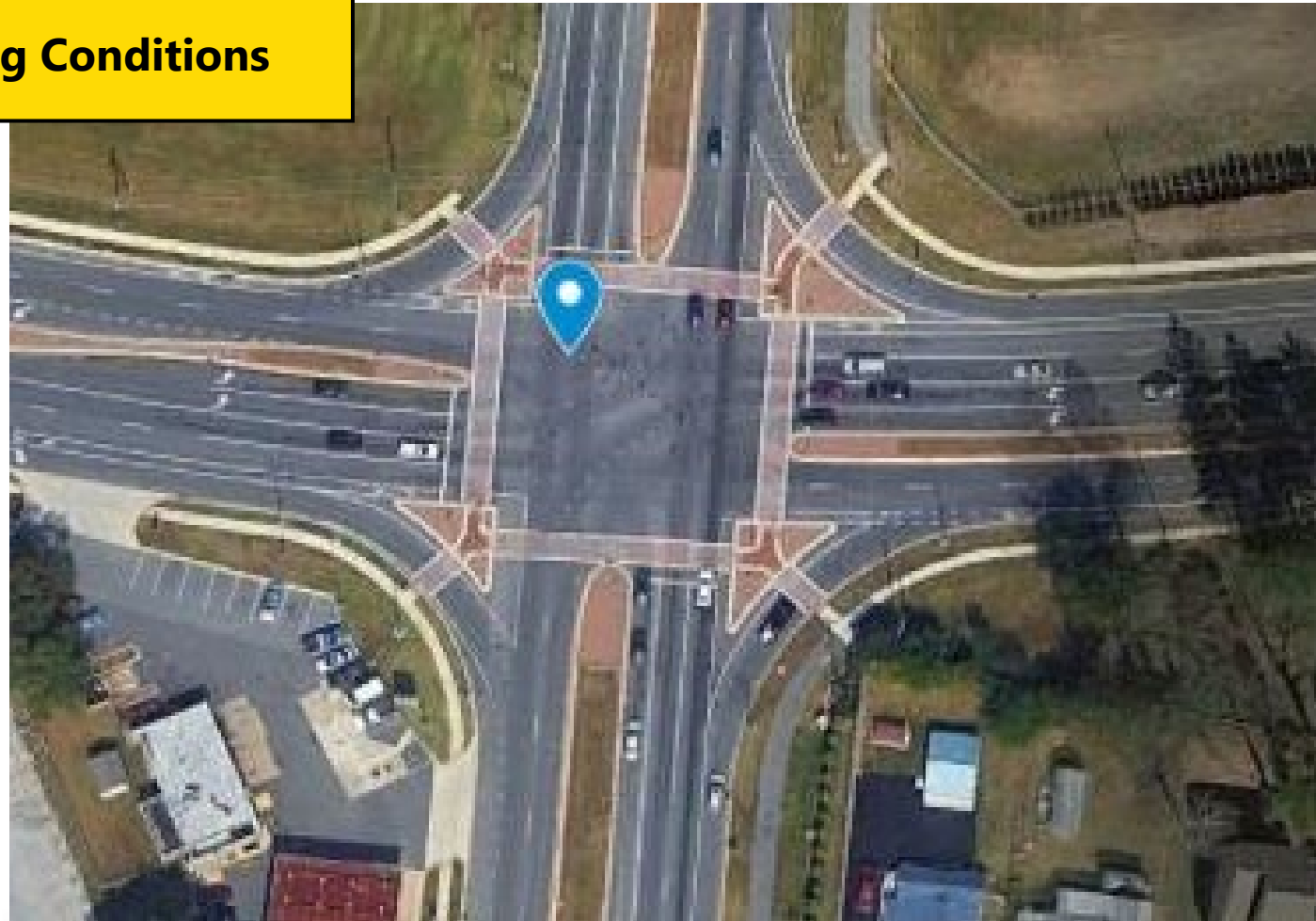
Intersection Bike Boxes, Two-Stage
Left Turn Box



Ramp to sidewalk before intersection
for cyclists to use crosswalk

Example application (Wilmington, DE)

Existing Conditions

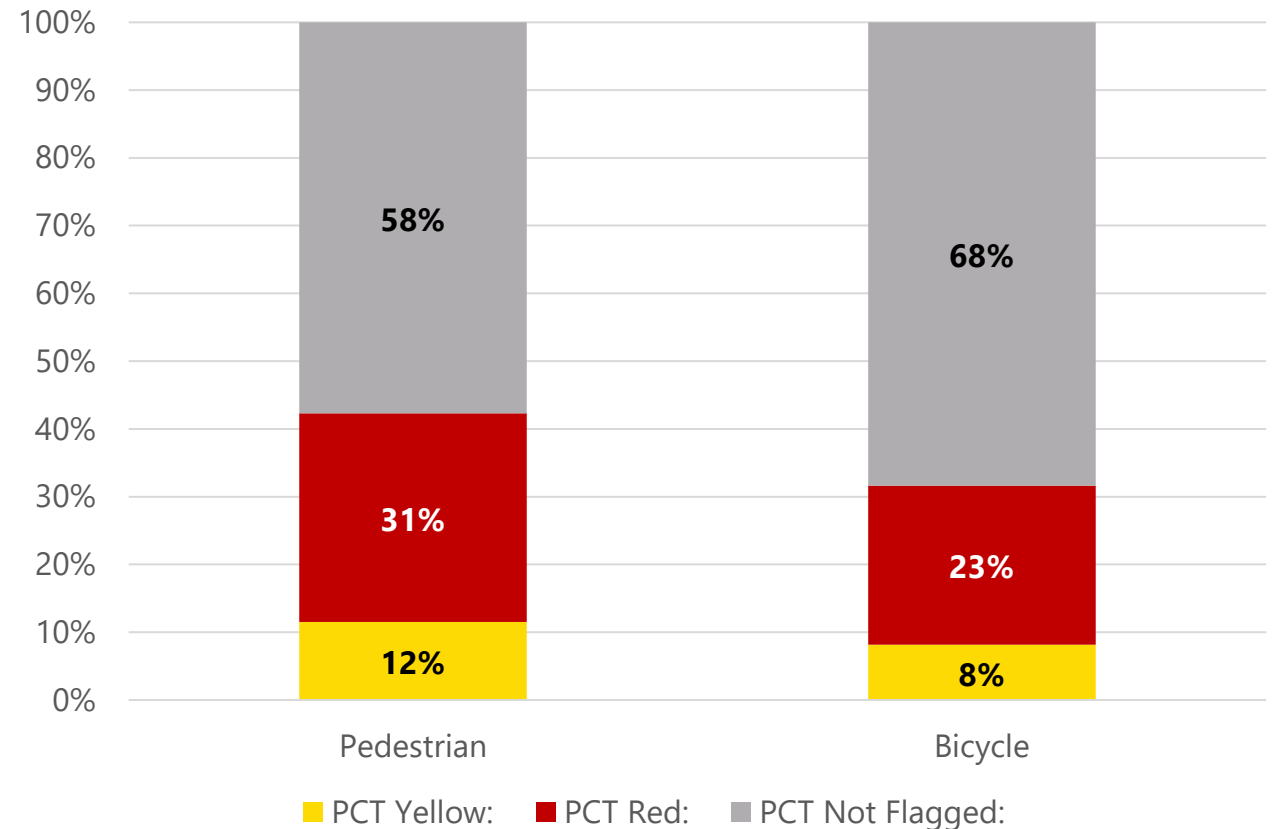


Results: Existing Conditions

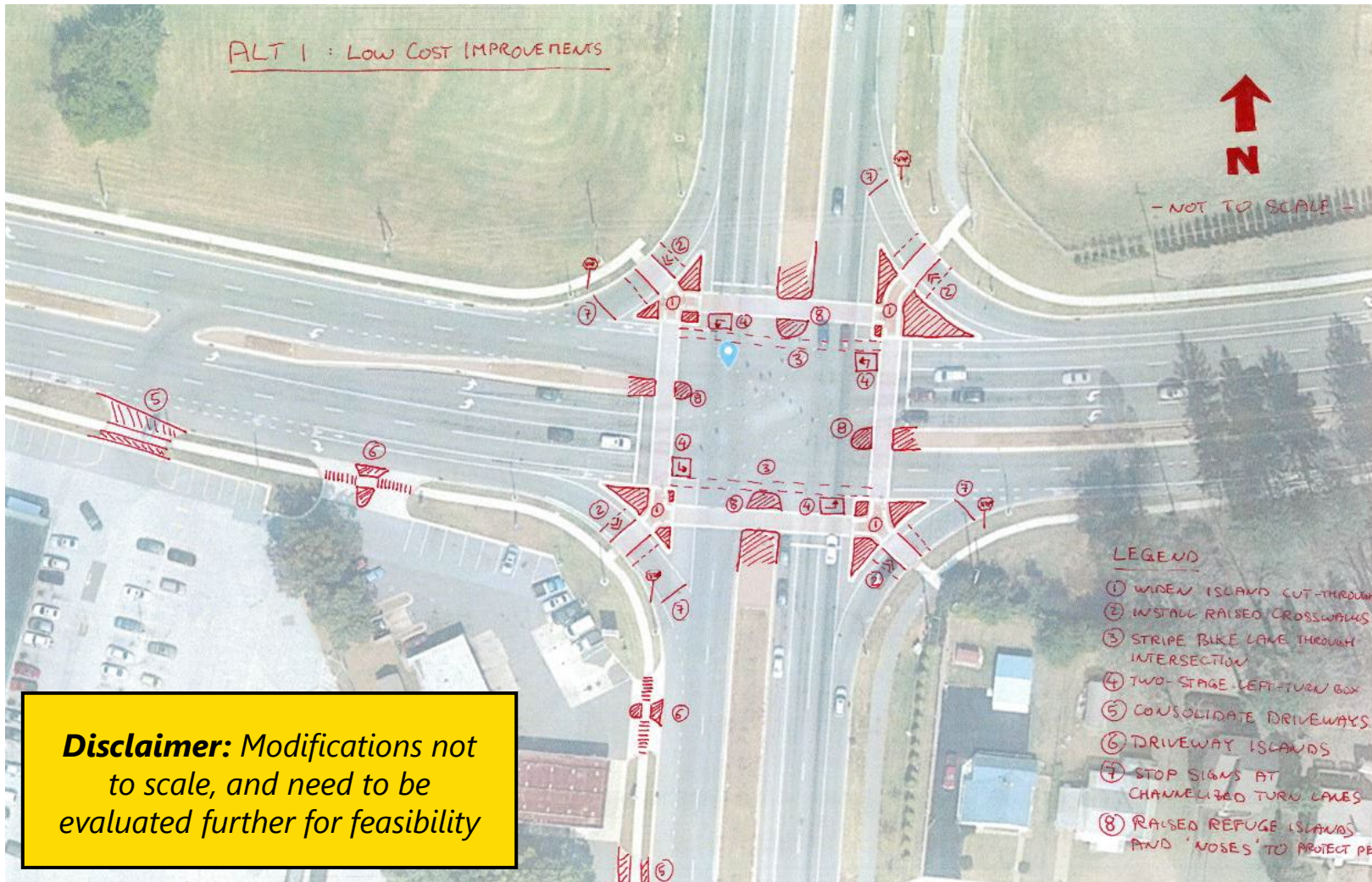
- Motor Vehicle Right Turns
- Tight Walking Environment
- Crossing Yield Control Path
- Multilane Crossing*
- Long Red Times*
- Intersecting Driveways*
- Sight Distance
- Riding in Mixed Traffic
- Bicycle Clearance Times
- Lane Change Across Vehicle Lanes
- Channelized Lanes
- Motorist Crossing Bike Path
- Riding Between Travel Lanes

**Mitigated but not eliminated*

Existing Conditions - Results

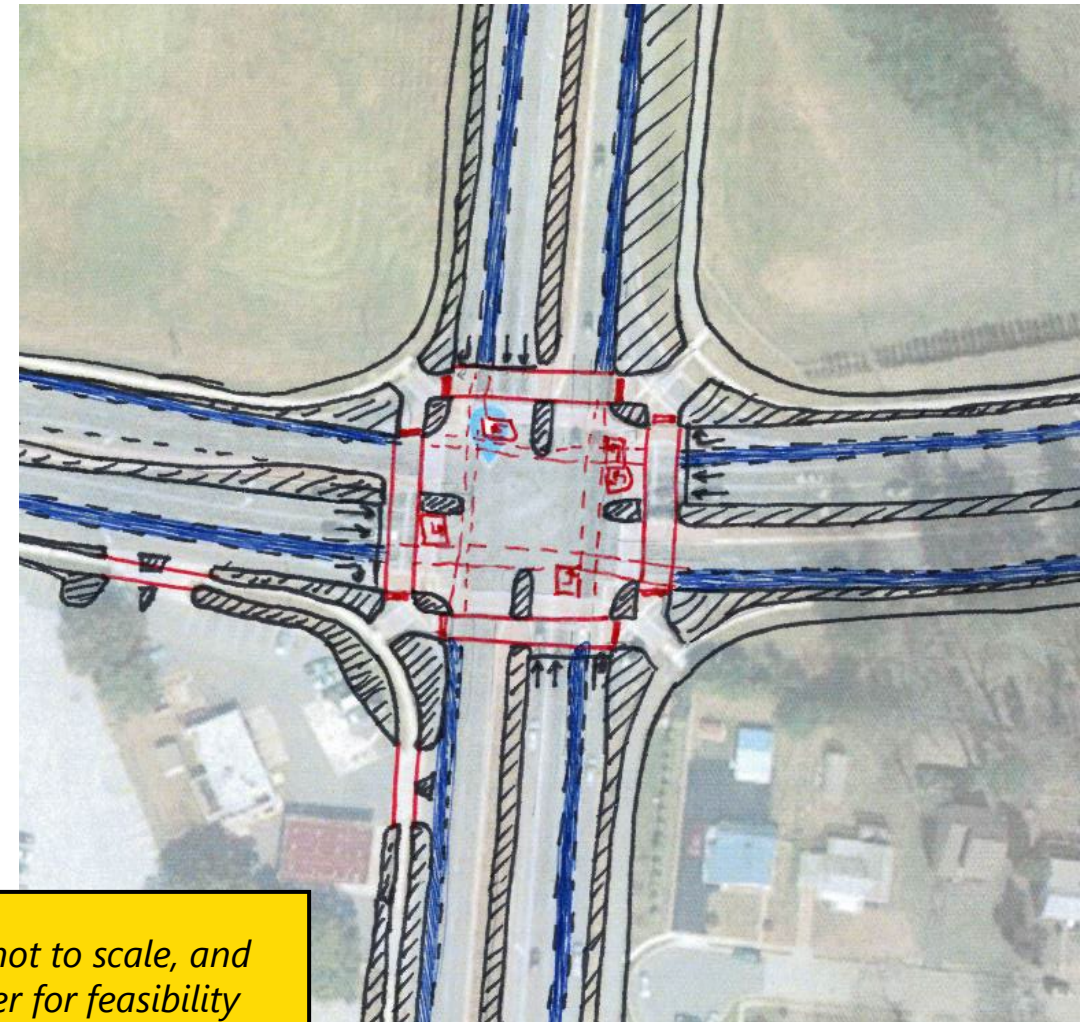
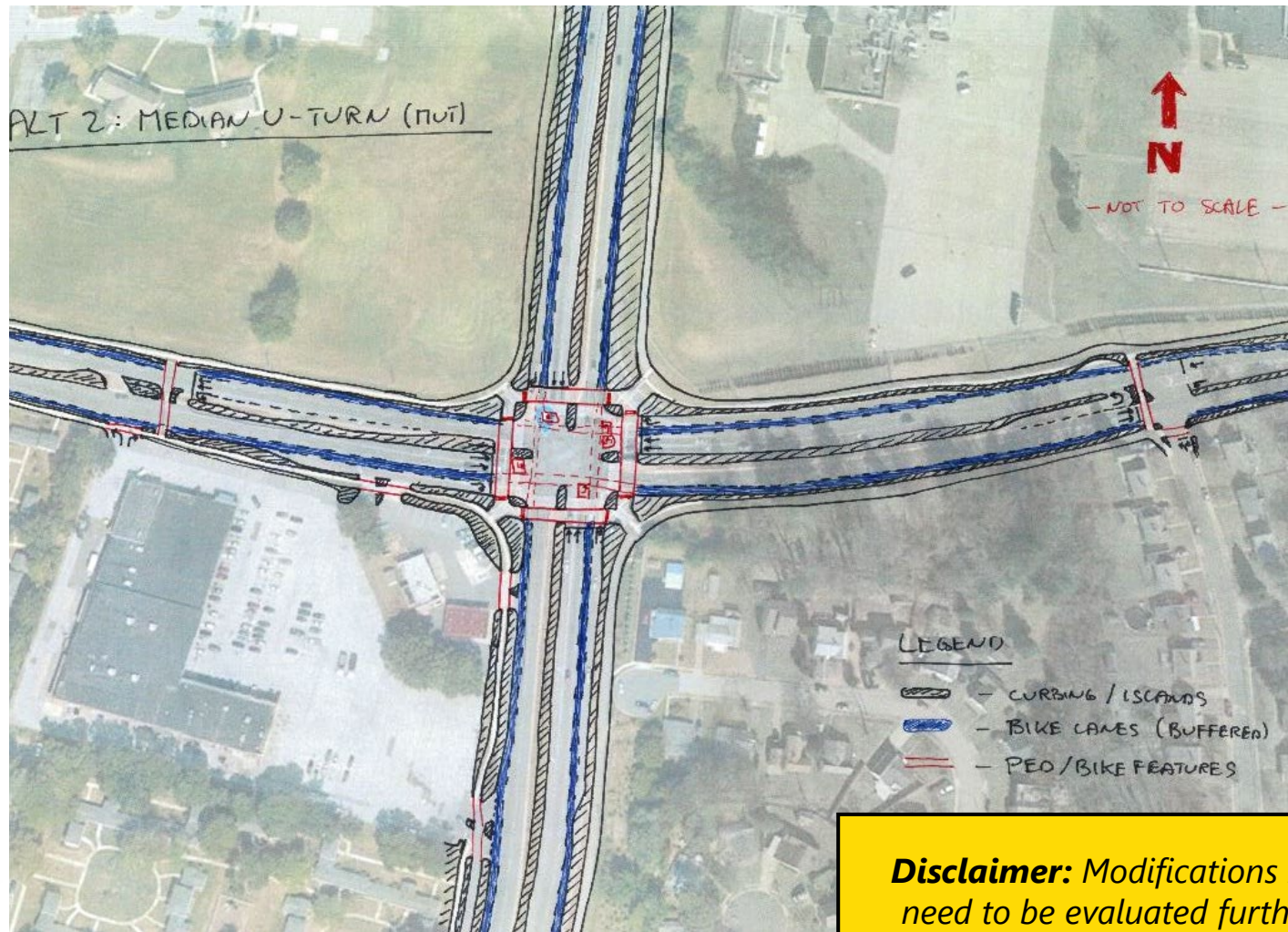


Concept 1: Low-Cost Improvements



1. Widen Island Cut-Throughs
2. Install Raised Crosswalks
3. Stripe Bike-Lane Through Intersection
4. Add Two-Stage Left-Turns
5. Consolidate Driveways
6. Build Driveway Islands
7. Install Stop Signs at Channelized Turn Lane Exits
8. Raised Refuge Islands and 'noses' to protect pedestrians

Concept 2: Median U-Turn (MUT)



Disclaimer: Modifications not to scale, and need to be evaluated further for feasibility

Concept 1 – Low-Cost Improvements

- ~~Motor Vehicle Right Turns~~
- ~~Tight Walking Environment~~
- Crossing Yield Control Path**
- Multilane Crossing***
- Long Red Times***
- Intersecting Driveways***
- ~~Sight Distance~~
- Riding in Mixed Traffic**
- Bicycle Clearance Times**
- ~~Lane Change Across Vehicle Lanes~~
- Channelized Lanes**
- Motorist Crossing Bike Path**
- Riding Between Travel Lanes**

**Mitigated but not eliminated*

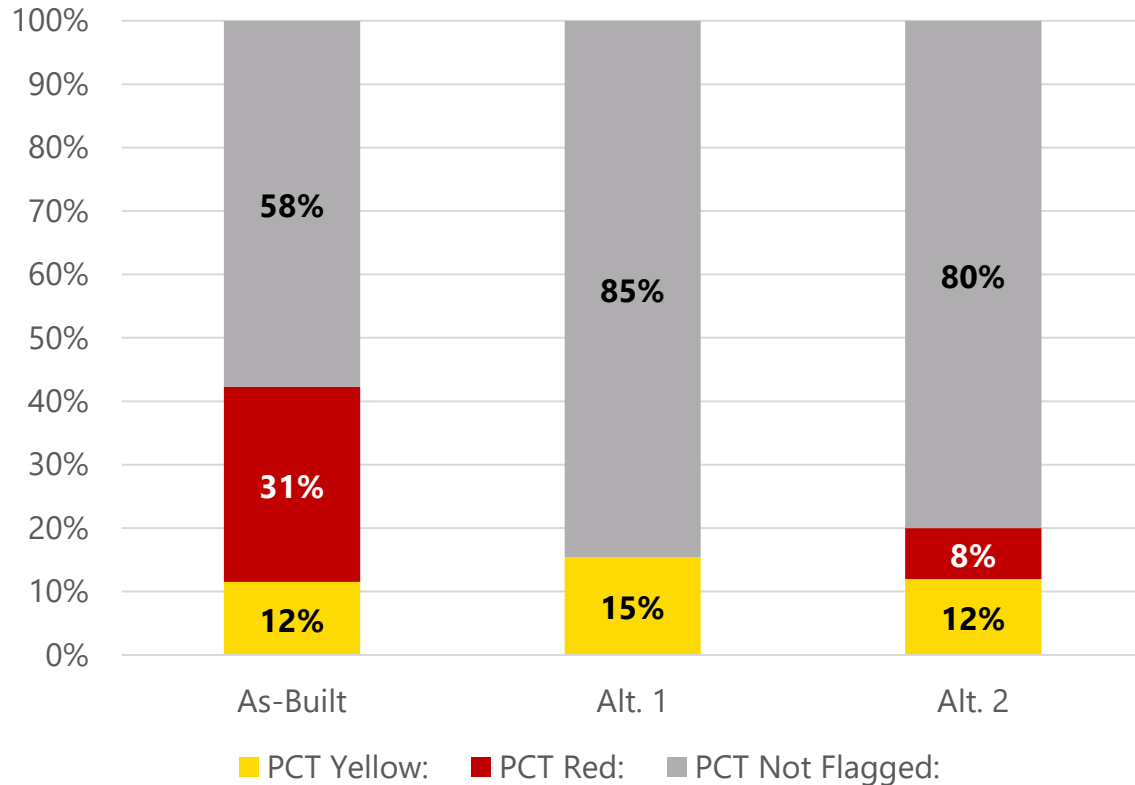
Concept 2 – MUT Reconfiguration

- Motor Vehicle Right Turns**
- ~~Tight Walking Environment~~
- ~~Crossing Yield Control Path~~
- Multilane Crossing***
- Long Red Times***
- Intersecting Driveways***
- ~~Sight Distance~~
- ~~Riding in Mixed Traffic~~
- ~~Bicycle Clearance Times~~
- ~~Lane Change Across Vehicle Lanes~~
- ~~Channelized Lanes~~
- Motorist Crossing Bike Path**
- Riding Between Travel Lanes**

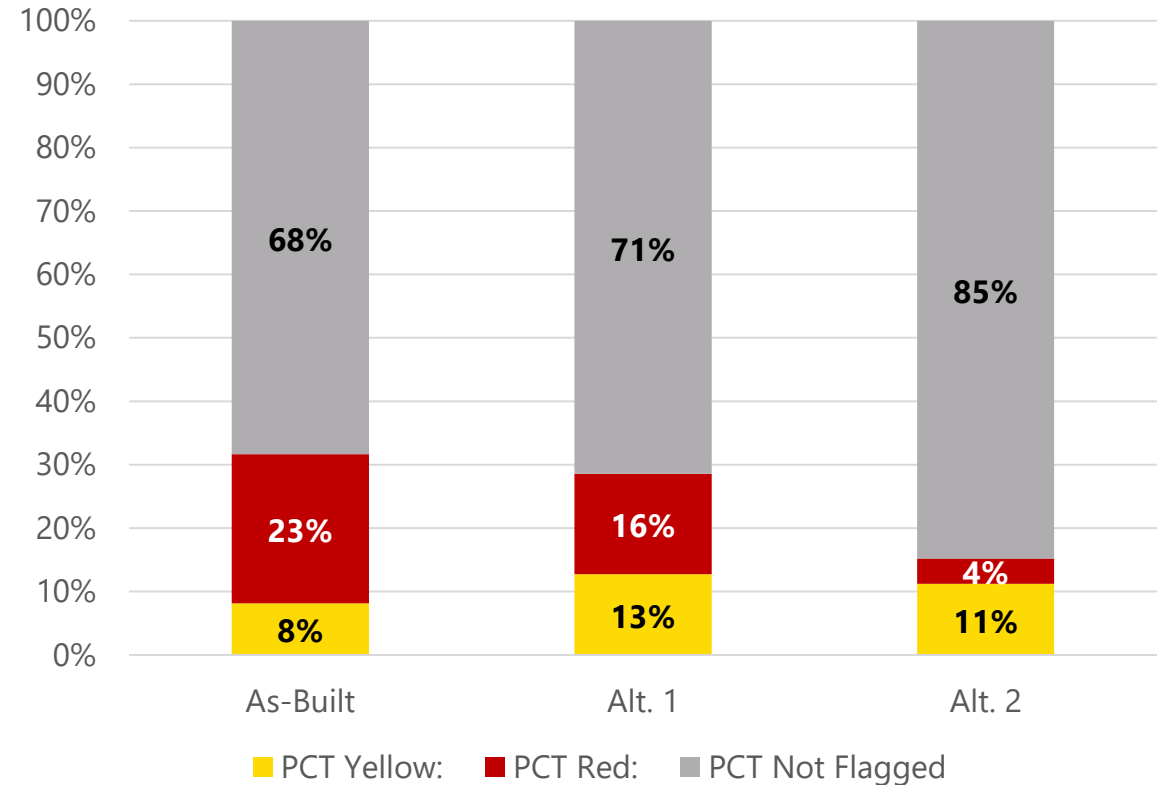
**Mitigated but not eliminated*

Quantitative Assessment of Alternatives

Pedestrian Assessment



Bicyclist Assessment



Roadway Cross-Section Reallocation

NCHRP 1036

NCHRP
Research Report 1036

National
Cooperative
Highway
Research Program

Roadway Cross-Section Reallocation A GUIDE



**NATIONAL
ACADEMIES** Sciences
Engineering
Medicine

TRB TRANSPORTATION RESEARCH BOARD

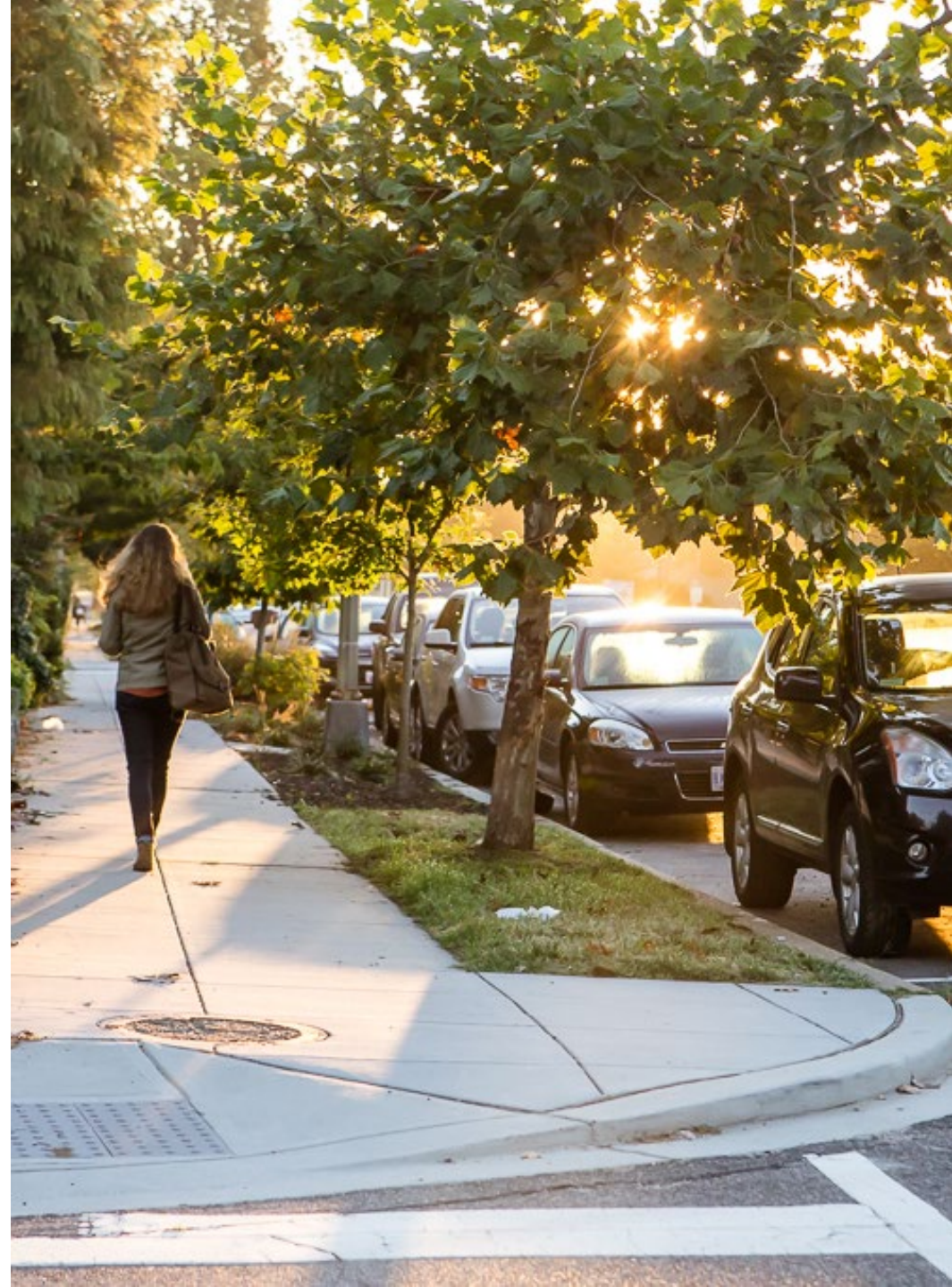


“That won’t work.”



Barriers to Safe Street Design

- Peak hour intersection operations as a controlling factor in design
- Lack of transparency in the decision-making process
- In practice, safety has not always been the top priority



WHAT IS FAILURE?

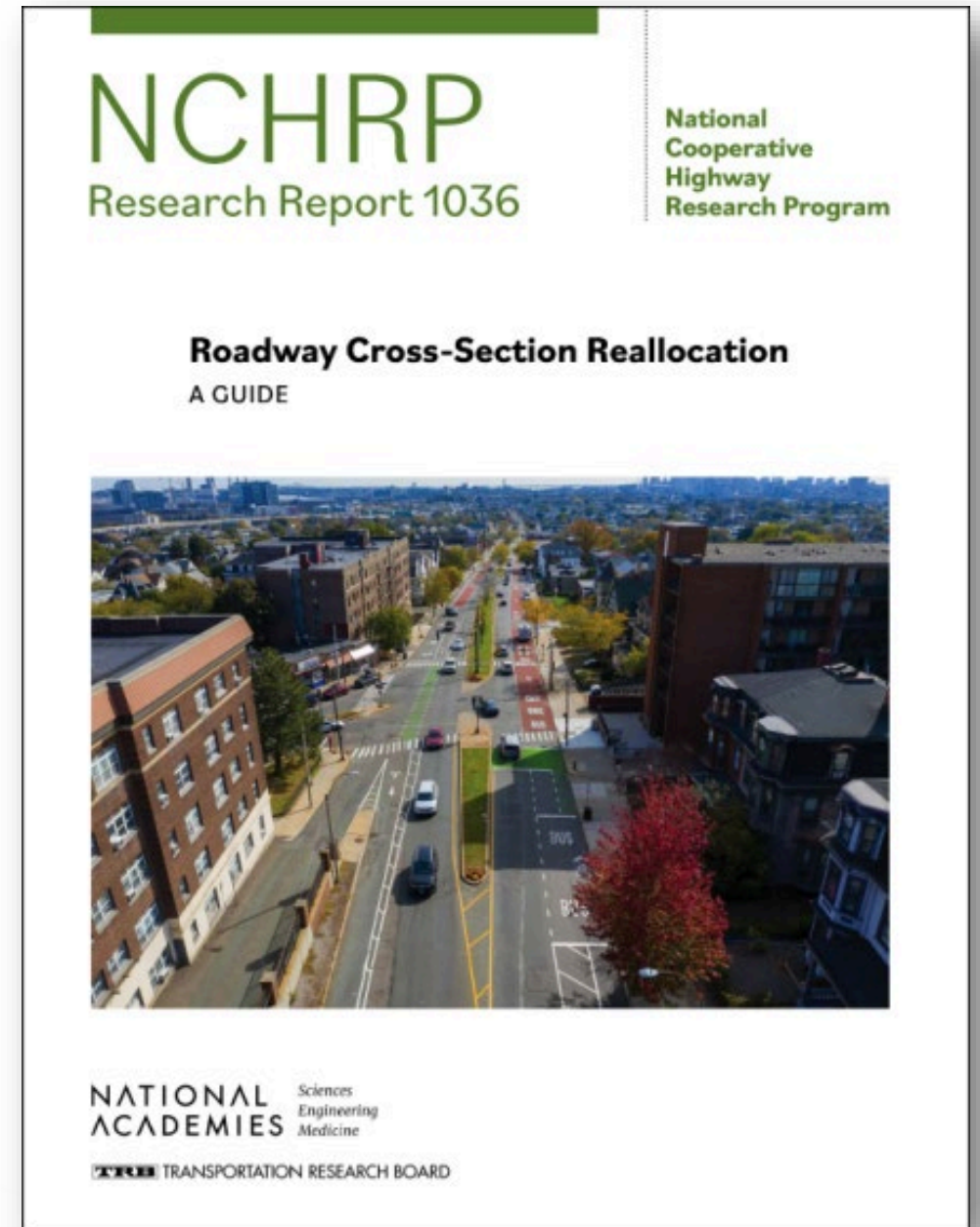


WHAT ISN'T?



A New Framework for Allocating Roadway Space

- Daylighting decision-making
- Raising the floor on safety
- Connecting decisions to outcomes



1
Define your limits
and set your goals.

2
Consider the context
through a safety lens.

3
Is there enough space
to build a safe road?

NO
Work within your
constraints to
ensure safety.

4
Overcome
the physical
barriers to safe
road design.

YES
What do you
want to achieve
beyond safety?

5
Develop
design options

6
Evaluate and
choose the
cross section
that serves your
community's
vision and
needs.

?
What happens when you
change your cross section?

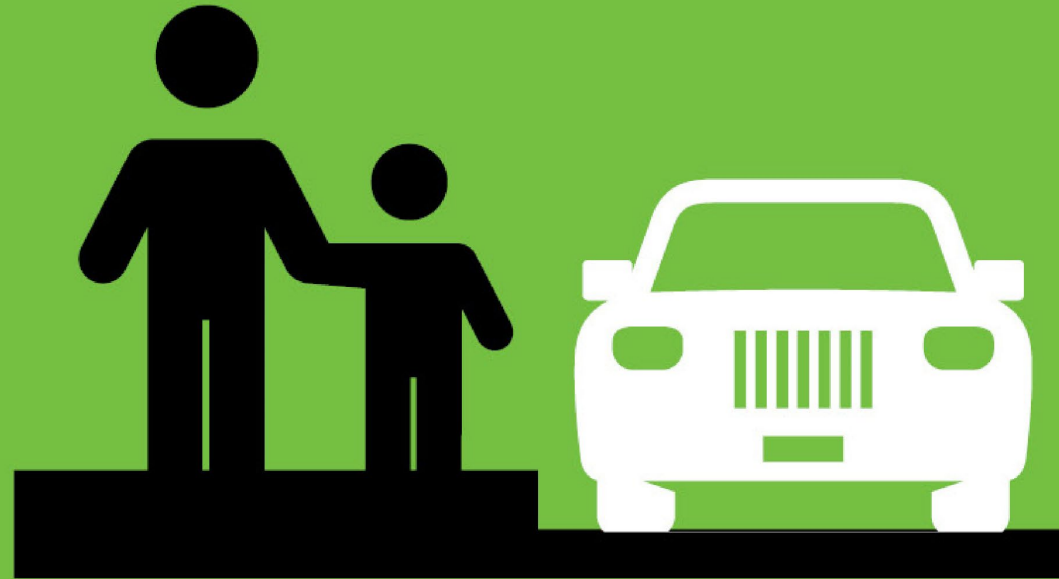
1 Define your limits and set your goals.



2 Consider the context through a safety lens.



A safe street must be safe for all users!

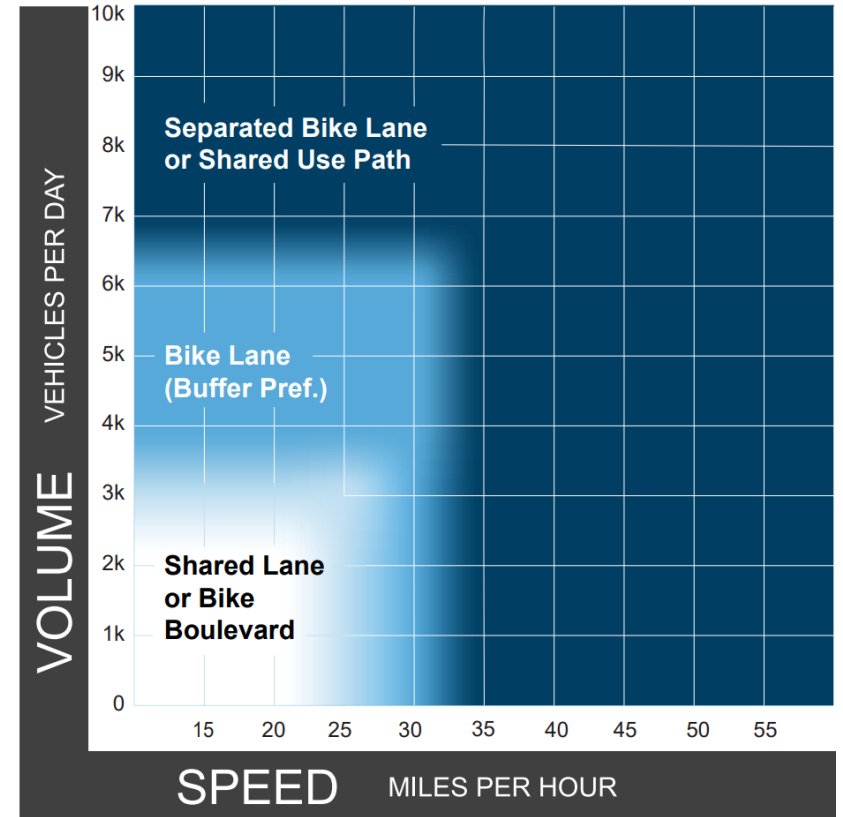
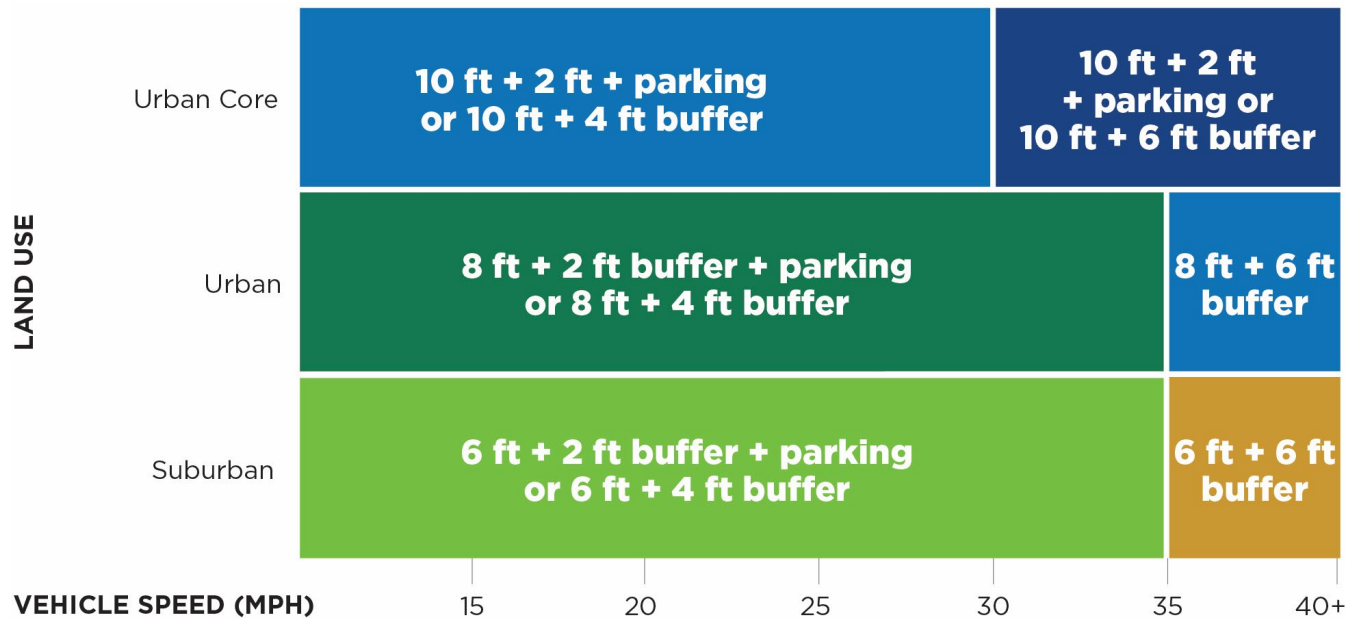


Determine the **minimum safe travel space** for people walking, bicycling, riding transit, and driving.

2

Consider the context through a safety lens.

Recommended sidewalk and buffer widths



Preferred Bikeway Type for Urban and Suburban Context

3 Is there enough space to build a safe road?

NO

**Work within your
constraints to ensure safety.**



4 Overcome the physical barriers to safe road design.



Reduce dimension needed for driving



Reduce dimension needed for bicycling/walking



Lower speed



Reduce vehicle volumes



Safe parallel facility



Close street to traffic



Convert to shared street (woonerf)

3 Is there enough space to build a safe road?

YES

**What do you want to achieve
beyond safety?**



5 Develop design options: what happens when you change your cross section?

Choose a few suitable alternatives to evaluate. The community priorities from Step 1 may make some options more desirable.



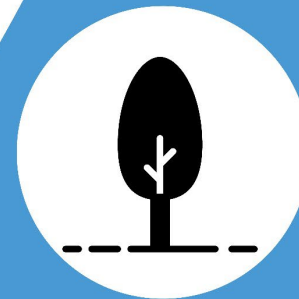
**Wider
Sidewalk**



Bus-Only Lanes



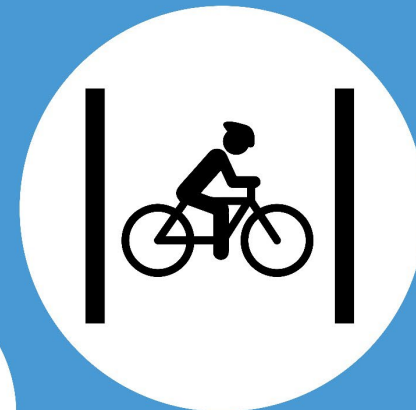
**On-street
parking**



Medians



**Add Traffic
Lanes**



**Wider
Bike Lanes**

6 Evaluate and choose the cross section to serve your vision and needs.

Compare the likely outcomes of the alternatives you developed in Step 5.

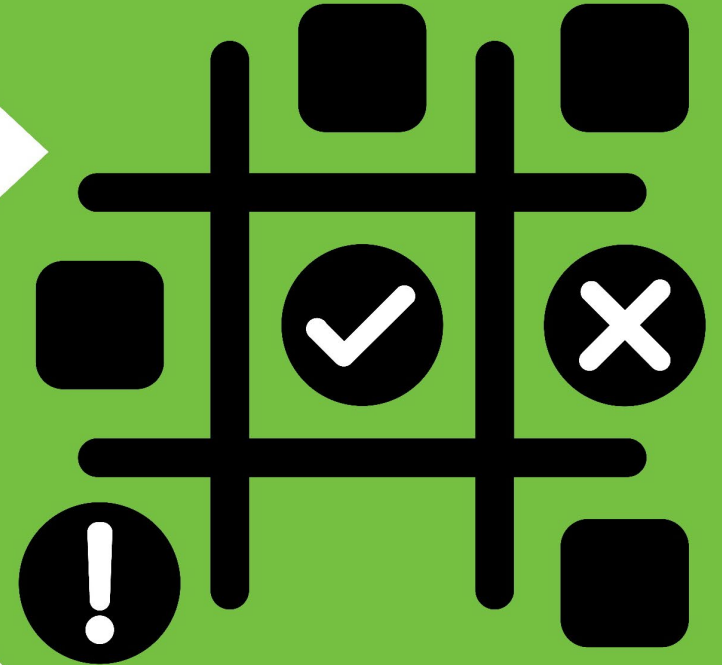
Safety

Operations

Equity

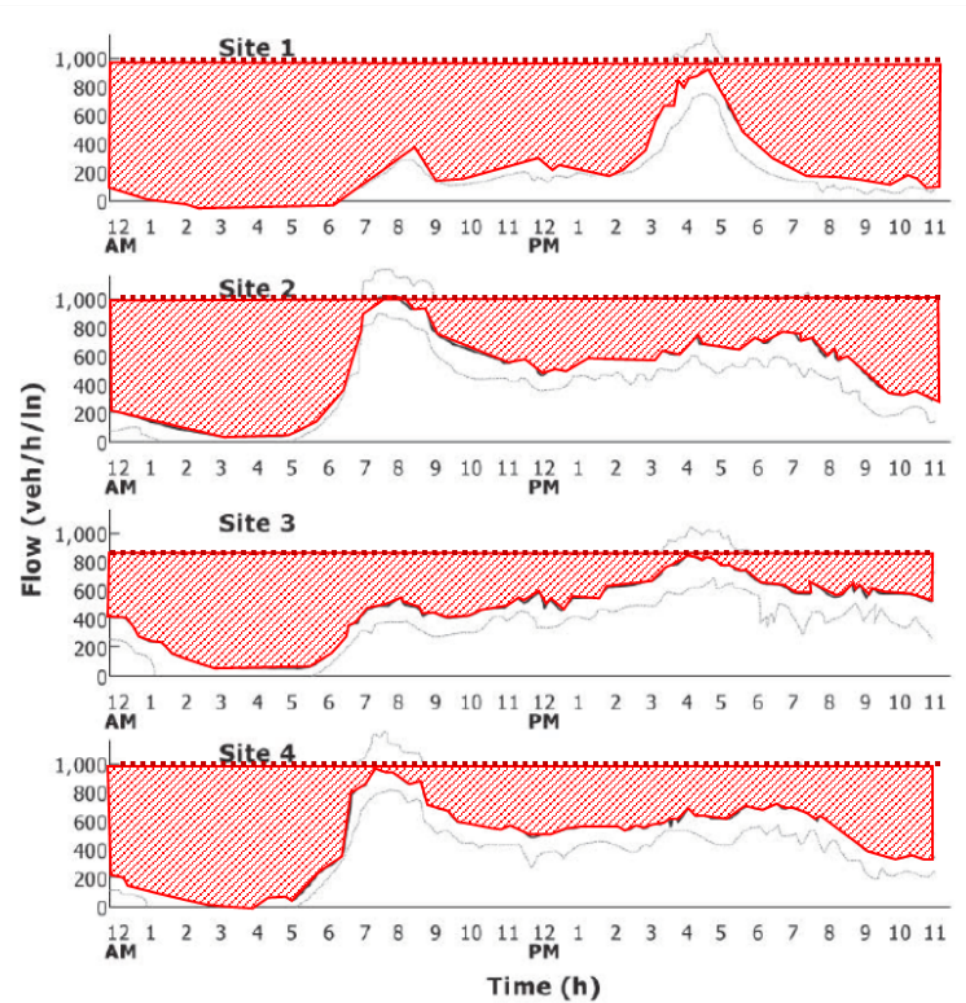
Economy

Environment



Why Consider 24-Hour Capacity?

Designing for peak-hour (or 15-minute!) capacity results in unused capacity for most of the day!



..... Design volume based on 30th highest hour of year

▨ Sum of unused capacity over 24-hour period if designing for 30th highest hour of year

WHAT'S WRONG WITH UNUSED CAPACITY?

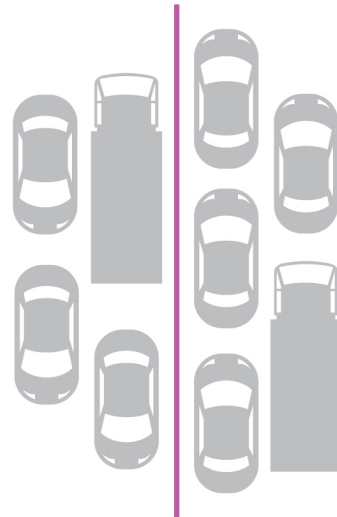
UNDER CAPACITY = HIGHER SPEEDS

WHICH ARE ASSOCIATED WITH INCREASED AND MORE SEVERE CRASHES



OVERDESIGNING FACILITIES

FOR CARS MAKES THEM LESS SAFE FOR PEOPLE WALKING AND BIKING



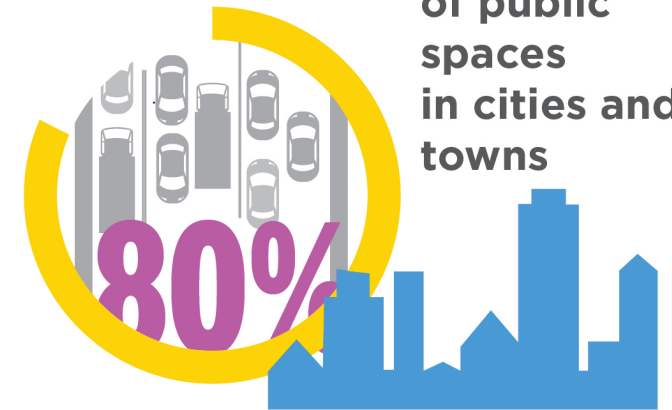
THE MORE TRAVEL LANES, THE

LONGER WAIT TIMES

FOR ALL MODES

STREETS MAKE UP MORE THAN

of public spaces in cities and towns

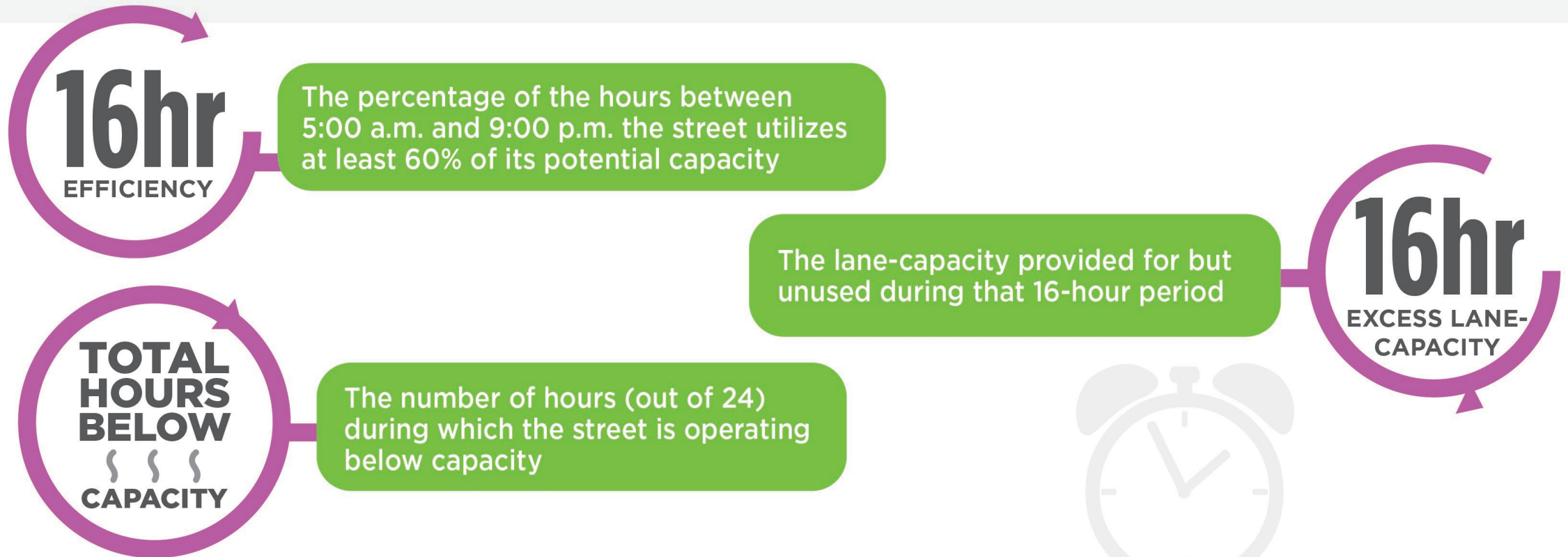


THE 24-HOUR CAPACITY FRAMEWORK

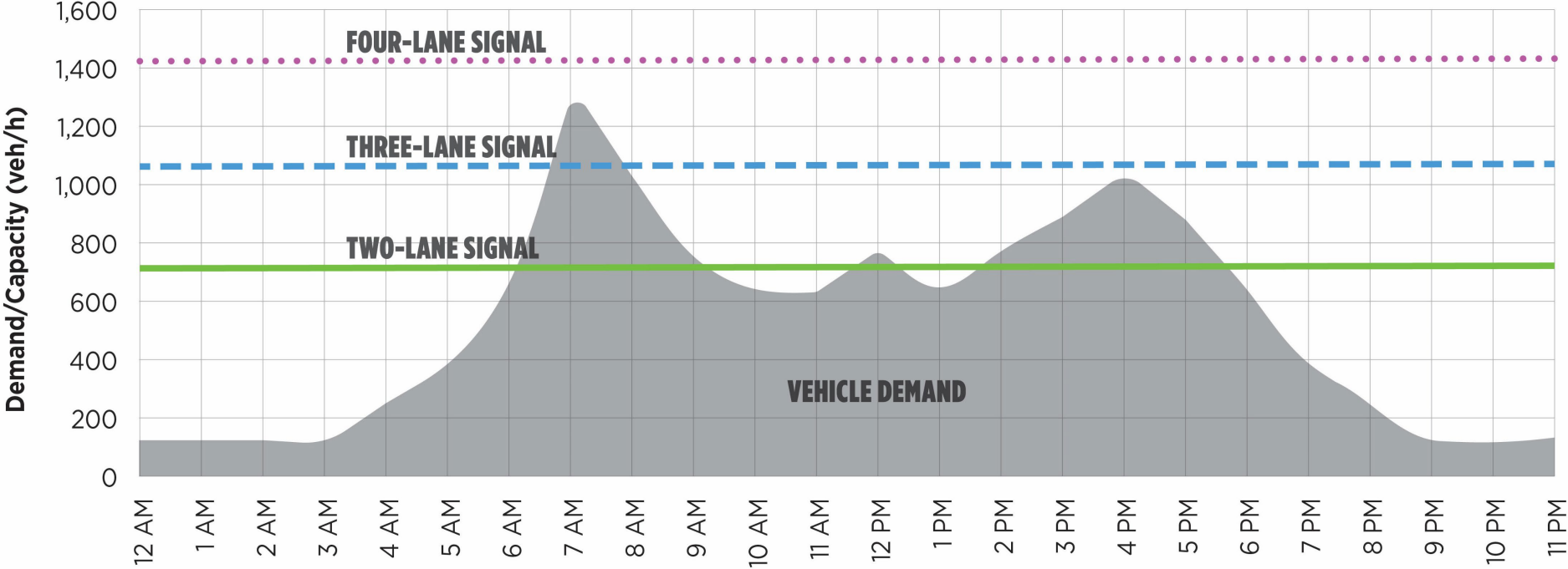


HOURLY DEMAND-TO-CAPACITY (D/C) RATIO

allows practitioners to assess whether demand exceeds capacity at any time during the day and, if so, for how long



ALL-DAY INTERSECTION ASSESSMENT



Intersection Control	Max Demand-to-Capacity Ratio (d/c)	16-Hour Efficiency	16-Hour Excess Capacity (Lane Hours)	Total Hours Below Capacity
FOUR-LANE SIGNAL	0.89	31.3%	15.9	24
THREE-LANE SIGNAL	1.18	50.0%	8.2	23
TWO-LANE SIGNAL	1.77	81.3%	2.2	16



Questions?

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