Improving Traffic Signals for Bicycling and Walking

Darren Buck Federal Highway Administration
Eddie Curtis Federal Highway Administration
Peter Koonce Portland, OR
Peter Furth Northeastern University

Housekeeping

- ⇨ Submit your questions
- ⇨ Webinar archive: www.pedbikeinfo.org/webinars
- ⇨ Live transcript: https://link.ai.media/session?plink=HSRC
- ⇨ Certificates and professional development hours
- ⇨ Follow-up email later today
- ⇨ Review previous episodes and sign up for upcoming sessions

Join us for Part 2…

Multimodal Traffic Signal Design and Operations for Public Agencies

Tuesday, July 13, 2021

2:00 to 3:30pm Eastern Time

Hosted by the Institute of Transportation Engineers

https://www.pathlms.com/ite/courses/32735

Today's Panel

Darren Buck

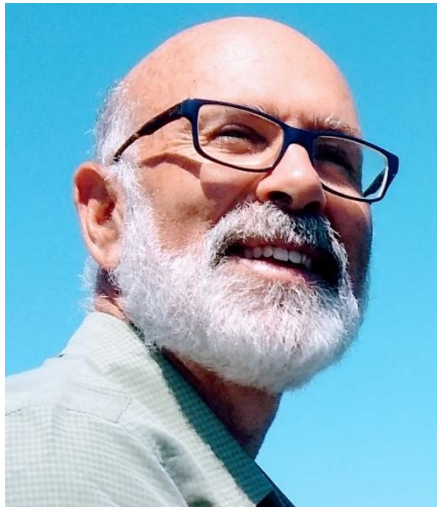
Federal Highway Administration

Eddie Curtis

Federal Highway Administration

Peter Koonce

Portland, OR



Peter Furth

Northeastern University

Strategic Agenda Update

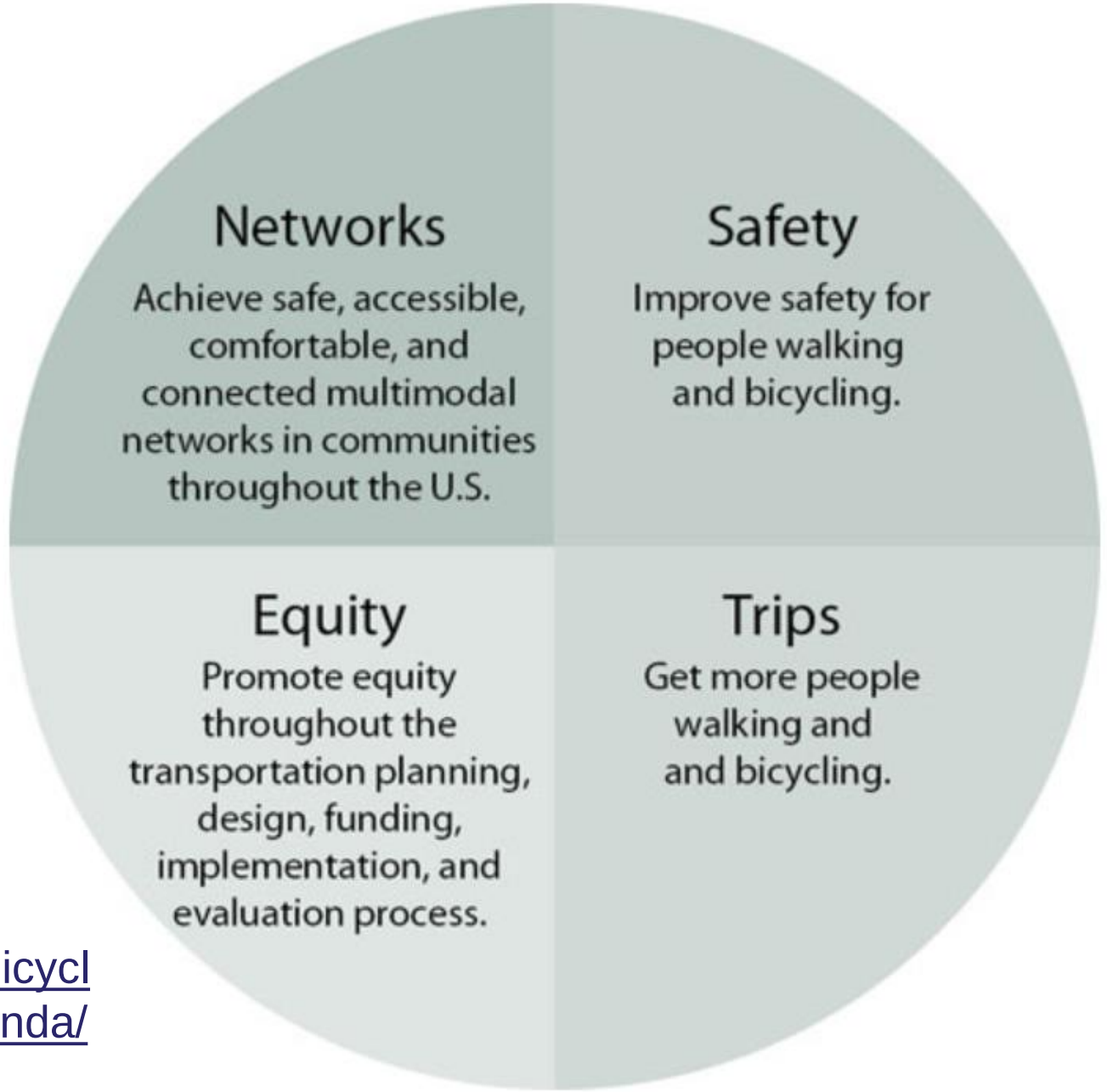


Image from: https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/strategic_agenda/

Objectives Driven Program

Source FHWA http://ops.fhwa.dot.gov/publications/fhwahop20002/ch2.htm#objectives-based

Improving Traffic Signals for People Cycling and Walking

Peter Koonce, P.E.
Portland, OR
June 9, 2021

Webinar Outcomes

Identify design approaches that make traffic signals safer and more comfortable for nonmotorized road users.

Understand strategies for improving intersections through geometric changes, signal timing, protected phasing, and more.

Outline

- Policies
- Design issues
- Techniques from Peter Furth
- Examples


pol·i·cy


PEDESTRIANS
BICYCLES
PUBLIC TRANSIT
COMMERCIAL VEHICLES
TAXIS
HIGH OCCUPANCY VEHICLES
SINGLE OCCUPANCY VEHICLES


2+

A healthy community, vibrant neighborhoods... ***and bicycles everywhere !***

PORTLAND BICYCLE PLAN FOR 2030

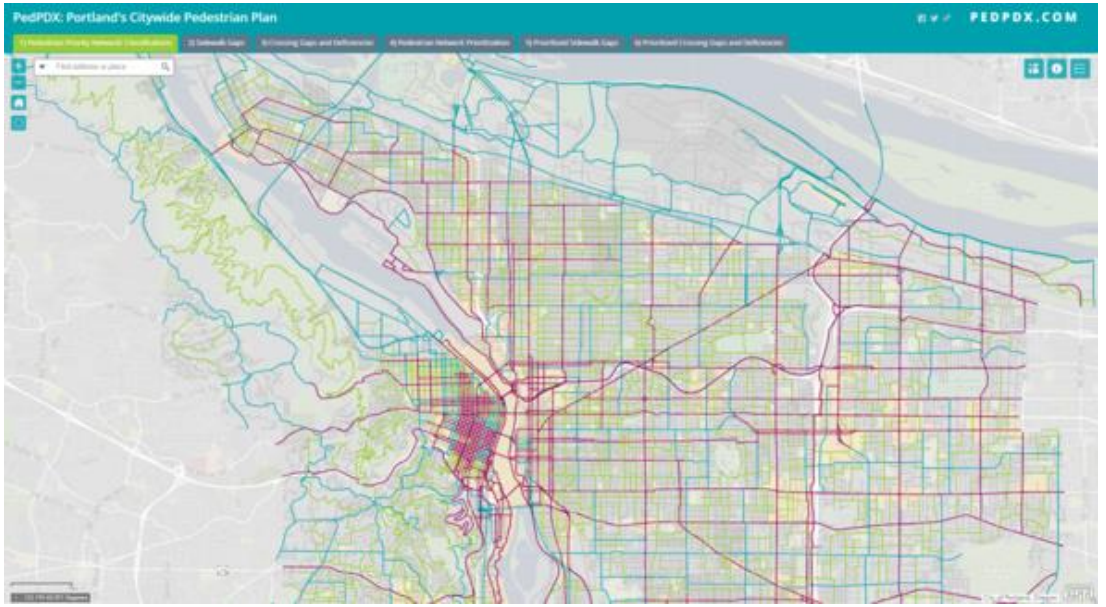
A WORLD-CLASS BICYCLING CITY

CITY OF PORTLAND TRANSPORTATION

Plans → Policies & Practices

PED PDX

PORTLAND'S CITYWIDE PEDESTRIAN PLAN

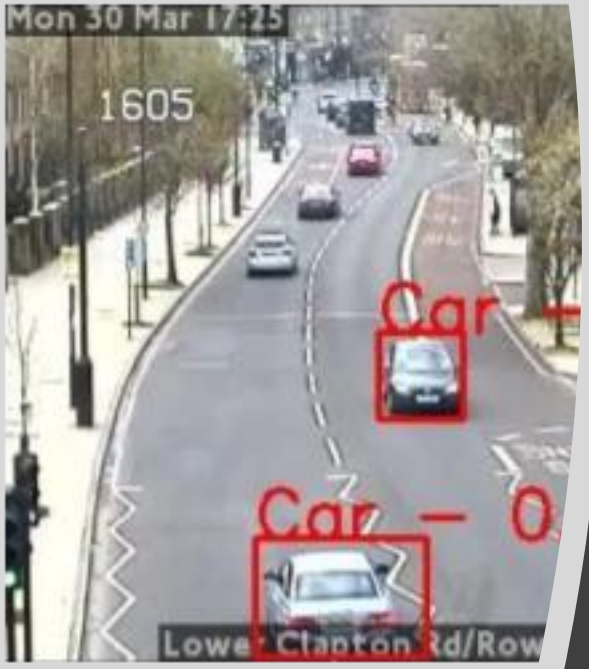


Source: [Ped PDX: Portland's Citywide Pedestrian Plan]

Write Plans that are Actionable

- Counting People, Not Cars
- Measure/track performance
- Make walking & cycling safe
- Increase multimodal advantage
- Rewrite existing guidance

Counting People at Traffic Signals



Detection for Multimodal Traffic is still emerging

Source: [Data Science Campus, UK]

What's in the Toolbox?

Provide Better Crossings

Separating Vehicles in Time

High Visibility Crosswalks

On-street Parking Restrictions

Improved Street Lighting

Car-Free/Light Experiences

Improved Driver Behavior

- **Traffic Signal Strategies**
  - Delayed Turn
  - Protected/Separated Turns
- **Geometric Changes**
  - Mixing Zones
  - Offset Crossing

Measure/Track Performance

Countermeasure Implementations

- Leading Pedestrian Intervals
- Protected Left Turns (for cycling & walking)
- No Turn on Red
- Active beacons
- Bike boxes
- Accessible intersections

Tracking Outcomes

- Fatals & Serious Injuries
- Traffic speeds
- Walking/Cycling Mode split
- Community health
- School trip behavior
- Perceptions of safety

Measure/Track Performance

	Example
• Leading Pedestrian Intervals	• 20 per year
• Protected Left Turns (for cycling & walking)	• 3 new locations per year
• No Turn on Red	• Pilot area (downtown?)
• Active beacons	• 3 new locations per year
• Bike boxes	• As needed
• Accessible intersections	• 20-year plan for ADA compliance

Peter Furth's Slides

Users of the "traffic signal" vary depending on land use & transportation context


Consider
Comfort
for our
Customers

NCHRP 926: Guidance to Improving Pedestrian and Bicycle Safety at Intersections

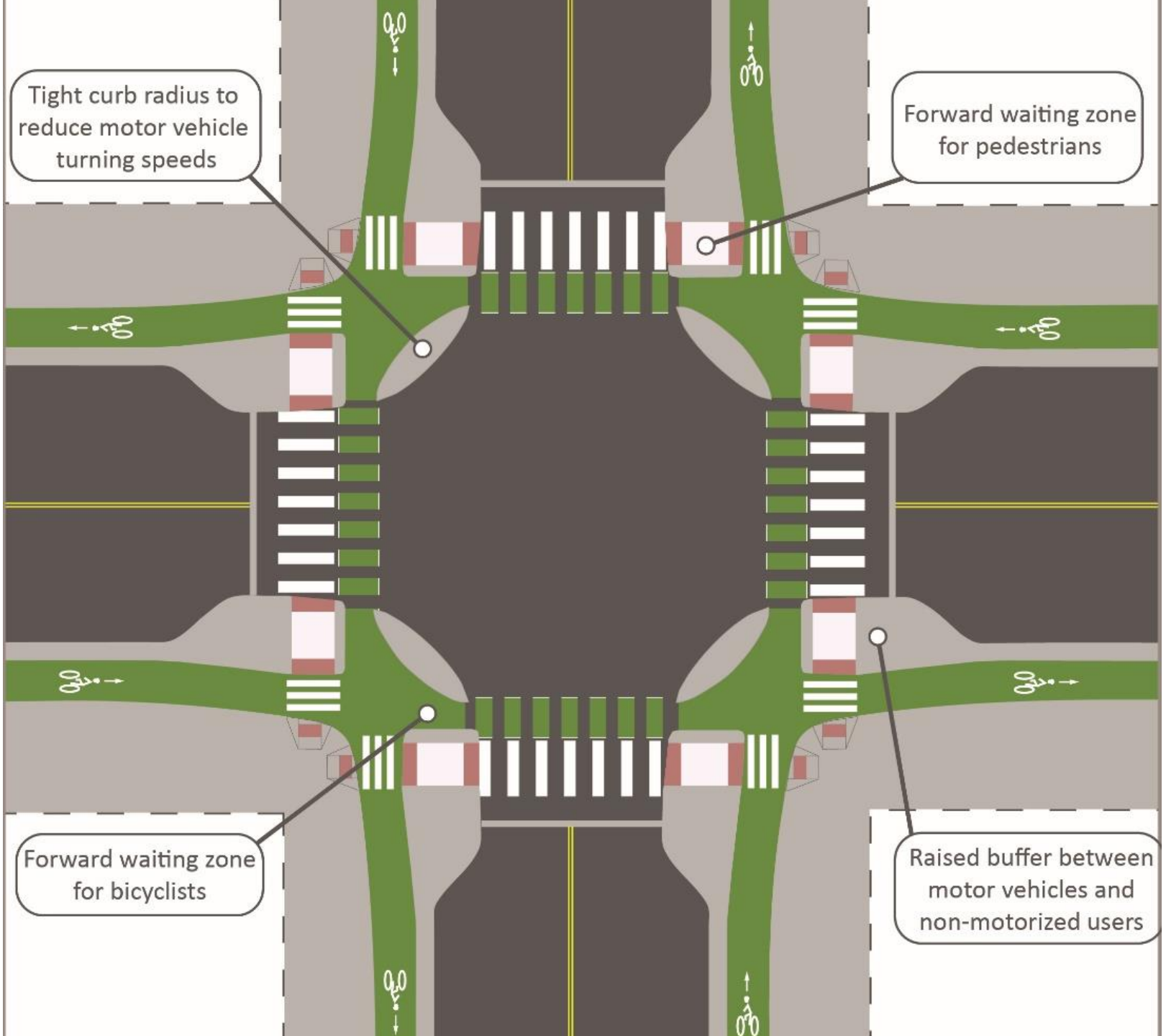
A new resource for transportation practitioners

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

TOOLE DESIGN

KITTELSON & ASSOCIATES

Funding provided by the National Cooperative Highway Research Program (NCHRP) and the Transportation Research Board of the National Academies of Science.


Tight curb radius to reduce motor vehicle turning speeds
Forward waiting zone for pedestrians
Forward waiting zone for bicyclists
Raised buffer between motor vehicles and non-motorized users

Recommended Pedestrian Measures Based on Traffic Context

Roadway Type (Number of Travel Lanes and Median Type)	Vehicle ADT < 9,000			Vehicle ADT 9,000–12,000			Vehicle ADT 12,000–15,000		
	Speed Limit (mph)								
	≤30	35	≥40*	≤30	35	≥40*	≤30	35	≥40*
2 Lanes	1	1	2	1	1	2	1	1	3
3 Lanes	1	1	2	1	2	2	2	3	3
4 Lanes with raised median**	1	1	2	1	2	2	2	3	3
4+ Lanes without raised median	1	2	3	2	2	3	3	3	3

Tier 1 – Supports motorist yielding
Tier 2 – Requires intervention to induce motorist yielding
Tier 3 – Separate modes or require motorists to stop

Cycling Countermeasures Guidance

Crash Types

Table 25. Countermeasure Summary Matrix

Effectiveness

Countermeasure	Tier 1: Supports motorist yielding	Tier 2: Requires intervention to induce motorist yielding	Tier 3: Separate modes or require motorists to stop	Public Process: 1 to 5 scale : 1 = no public process and 5 =extensive public process	Motorist Traveling Straight: Motorist failed to yield to pedestrian	Motorist Traveling Straight: Pedestrian failed to yield	Motorist Traveling Straight: Pedestrian dash	Motorist Traveling Straight: Bike crossing paths with uncontrolled motorist	Motorist Traveling Straight: Bike rides through/out - STOP sign	Motorist Traveling Straight: Motorist drives out into bike - STOP controlled	Motorist Traveling Straight: Bike rides through/out - signalized intersection	Motorist Turning: Motorist left turning into pedestrian parallel path	Motorist Turning: Motorist right turning into pedestrian parallel path	Motorist Turning: Motorist right turning into bike - same direction	Motorist Turning: Motorist left turning into bike - opposite direction
Active Warning Beacons	M	M	L	1	●	●	●	●	●			●	●	●	●
Advance Stop/Yield Lines	H	M	L	1	●	●	●	●	●						
All-Walk Phase	M	H	H	3	●	●	●					●	●		
Bicycle Lane Extension through Intersections	M	L	L	1				●		●				●	●
Bicycle Signals	M	M	H	1							●			●	●
Bike Boxes	M	M	M	1										●	
Continuous Raised Medians	H	H	H	4	●	●	●	●	●		●	●			●
or Hardened Centerlines	H	H	H	1								●			●
Crossing Barriers	L	M	H	5	●	●	●	●							

Protected Signal Phasing Guidance

Inventory of Policies and Guidance Used by Other Agencies

- Oregon DOT Left-Turn Policy
- Los Angeles DOT Policy
- NCHRP Report 812: Signal Timing Manual
- MassDOT Separated Bike Lane Design Guide
- New York City DOT
- British Columbia Active Transporation Guide

Traffic Signal Phasing Policy Comparison

CRITERIA	ODOT LEFT-TURN POLICY	LADOT LEFT-TURN POLICY	STM2 LEFT-TURN GUIDANCE
Multiple left-turn lanes	✓	✓	✓
Restricted sight distance	Based on AASHTO	Based on LADOT Standard Drawing	< 5.5 seconds of travel time
Number of opposing lanes of traffic	3+	4+ (including bike)	4+
Intersection geometry	✓	✓	
Maneuverability of particular classes of vehicles	✓	✓	
Intersection of two major streets		"Boulevard" classification	
Crash history involving left-turn movements	5+ within 1 year period (within last 3 years, including pedestrian-related)	3-5+ within recent 1 year period; 6+ within recent 2 year period; 7+ within recent 3 year period	4+ within 1 year period; 6+ within 2 year period; 7+ within 3 year period
Crash history involving pedestrians		3-4+ within recent 5 year period	
Speed of opposing traffic	45+ mph	45+ mph	45+ mph
Adequacy of gaps	✓		
Proximity to a school		Within 500 feet or one block	
"Vision Zero" corridors		✓	
Safety concerns			
Community support			
Pedestrian Districts			
Major City Bikeways			
Product of opposing through and left-turn hourly volumes	50,000 (for 1 opposing lane); 100,000 (for 2 opposing lanes)	100,000 (including 5x conflicting pedestrian volume)	50,000 (for 1 opposing lane); 100,000 (for 2-3 opposing lanes)
Product of conflicting pedestrian and left-turn hourly volumes		10,000	
Left-turn volume	200+ hourly		3+ per cycle during peak hour
High pedestrian volumes	✓	100+ hourly	
High bicycle volumes	✓		
High percentage of left-turning heavy vehicles	✓		
Projected volumes warrant a different mode	Within 5 years	✓	
Opposing left-turn mode	✓	✓	
U-turns permitted	✓		

LADOT Protected Left Guidance

Criteria	Oregon DOT	LADOT	Signal Timing Manual 2
Product of conflicting pedestrian and left-turn volume (hr)		10,000 or cross product	
Left-turn volume	200+ hourly		3+ per cycle during peak hour
High pedestrian volumes	✓	100+ hourly	
Bicycle criteria	**none**	**Consider bike lane**	**none**

Traffic Signal Phasing

Based on Speed of Vehicle Traffic

TABLE G-32 // CONSIDERATIONS FOR TIME-SEPARATED BICYCLE MOVEMENTS - LOW SPEED STREETS (50KM/HR AND BELOW)

PROTECTED BICYCLE LANE OPERATION	MOTOR VEHICLES PER HOUR TURNING ACROSS PROTECTED BICYCLE LANE			
	Two-Way Motor Vehicle Road			One-Way Motor Vehicle Road
	Right Turn	Left Turn Across One Lane	Left Turn Across Two Lanes	Right of Left Turn
Uni-Directional	250	150	50	250
Bi-Directional	150	100	0	150

TABLE G-33 // CONSIDERATIONS FOR TIME-SEPARATED BICYCLE MOVEMENTS – HIGH SPEED STREETS (>50 KM/HR)

PROTECTED BICYCLE LANE OPERATION	MOTOR VEHICLES PER HOUR TURNING ACROSS PROTECTED BICYCLE LANE			
	Two-Way Motor Vehicle Road			One-Way Motor Vehicle Road
	Right Turn	Left Turn Across One Lane	Left Turn Across Two Lanes	Right of Left Turn
Uni-Directional	100	100	0	100
Bi-Directional	50	50	0	0

Source: British Columbia Active Transportation Design Guide

CYCLING AT A CROSSROADS

The Design Future of New York City Intersections

September 2018

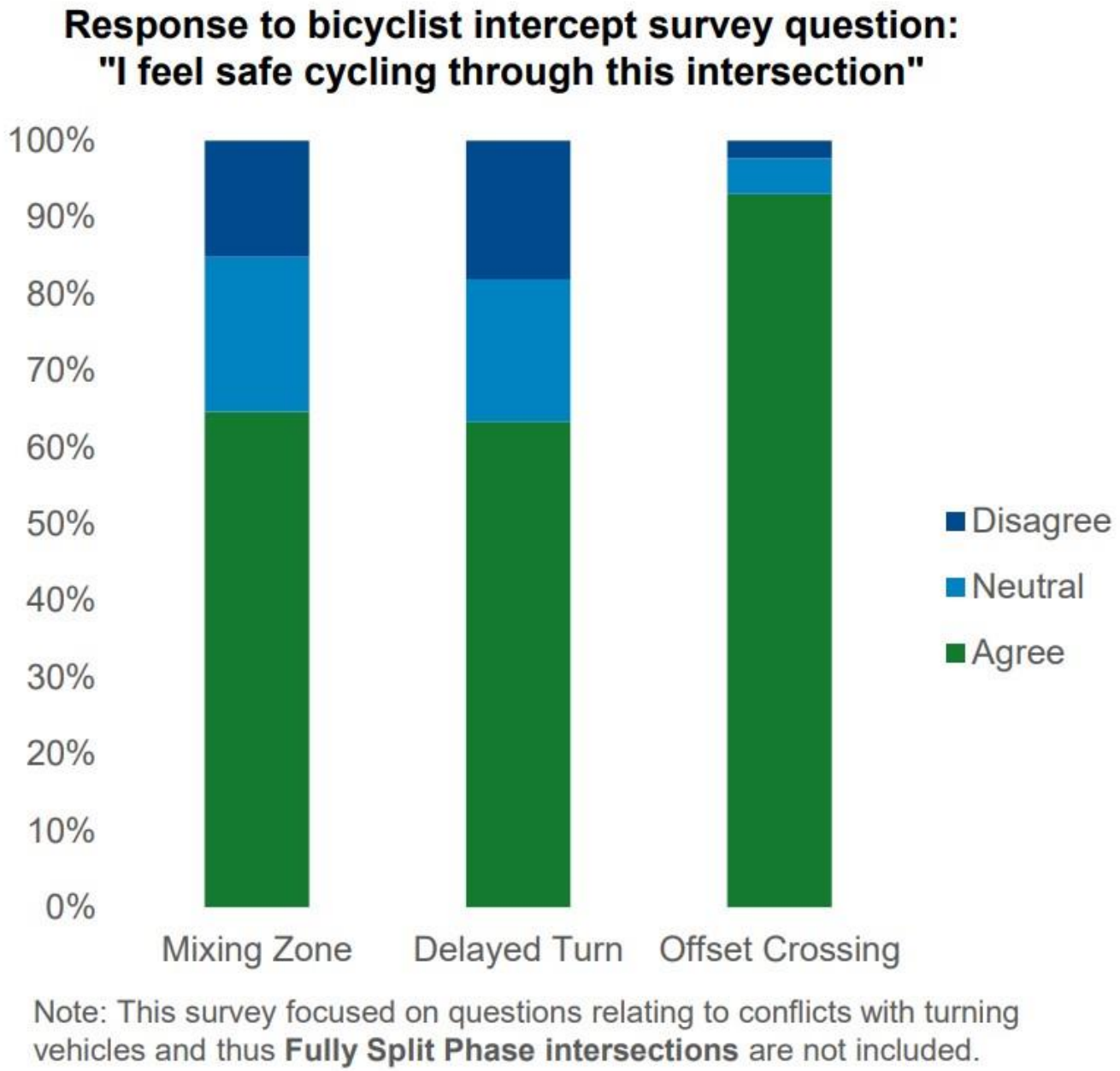
VISION ZERO
nyc.gov/visionzero

NEW YORK CITY DOT

[Study Design (nyc.gov)]

Mixing Zones

- bicycle crash rate reduction of 27%
- allow vehicles to turn across a protected bike lane (PBL)
- used at smaller intersections
- bicyclist comfort is lower at this type of intersection

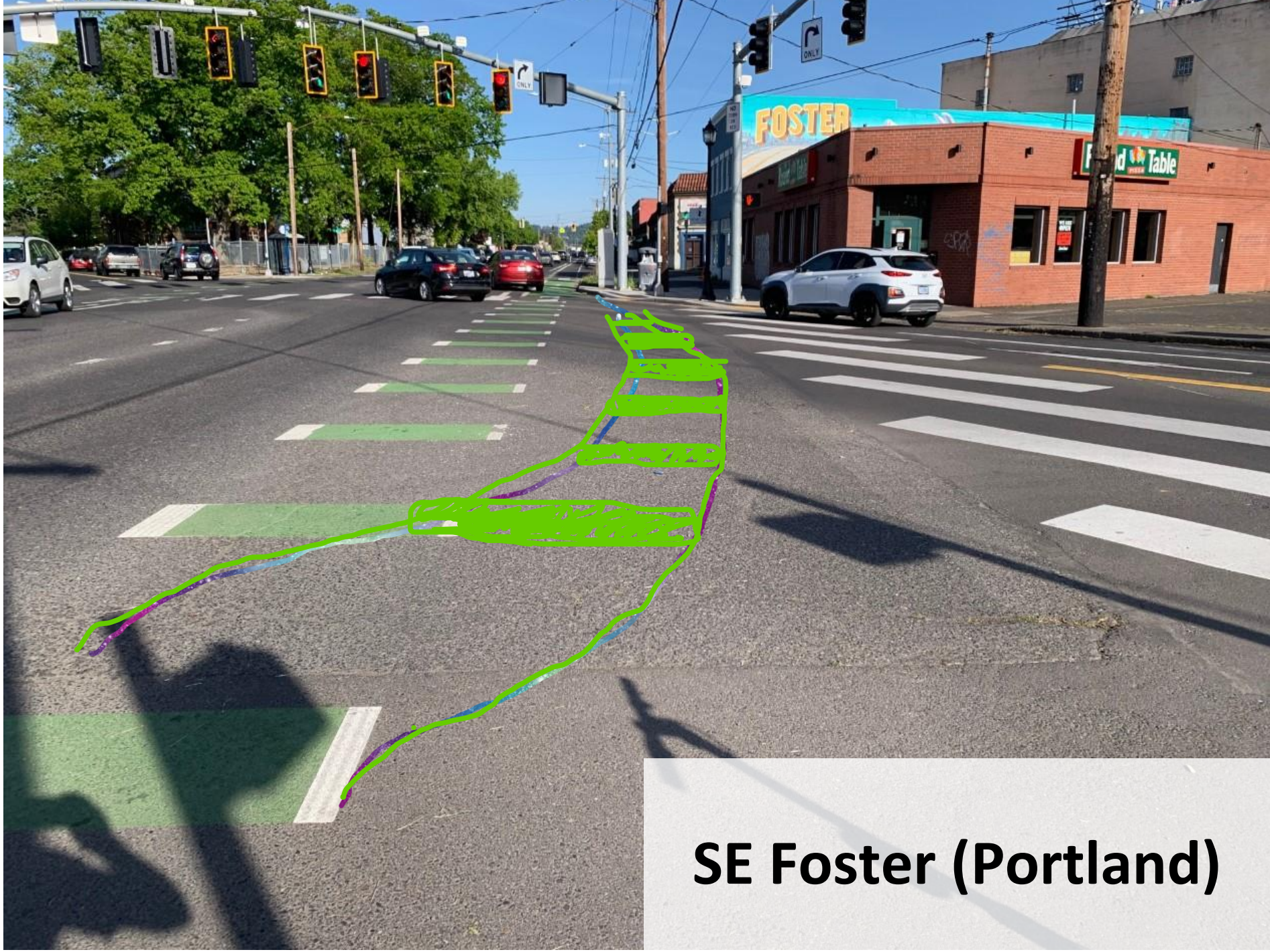


Source: Cycling at Crossroads, NYCDOT

West 19th & Burnside
Portland, OR

West 19th & Burnside (farside)

SE Foster (Portland)



SE Foster (Portland)

Delft, Netherlands

Delft, Netherlands

Separation from Vehicles at Intersections

NE 55th & Prescott
Portland, OR

Source: Toole Design Group

12th Ave S & King St
Seattle, WA

Signalization Principles

Signalization Principles

- Shorten signal cycles
- Prioritize multimodal travel
- *Minimize number of signal phases*
- Set Slow progression speeds
- Adjust timing for off-peak
- Consider fixed time signals

Source: NACTO Urban Street Design Guide, 2013

Signalization Principles

- Shorten signal cycles
- Prioritize multimodal travel
- *Minimize number of signal phases*
- Set slow progression speeds
- Adjust timing for off-peak
- Consider fixed time signals
- Employ advanced logic & detection

Signalization Principles

- Eliminate signal coordination

- Rethink use of detection

Eliminate Traffic Signal Coordination

Fully actuated signals can respond more quickly to demand

Source: Reducing Pedestrian Delay, 2012

With Coordination, Shorten Signal Cycle Lengths and Lower Progression Speeds

- Long enough to accommodate pedestrian crossings
- Short enough to encourage compliance and manage speeds
- Slow enough to encourage safe travel by all modes

Multimodal traffic benefits from shorter cycle lengths

More on Traffic Engineering Treatments…

July 13, 2021 webinar with City of Seattle

Peter Koonce, P.E.
peter.koonce@gmail.com
@pkoonce

Some Techniques to Make Traffic Signals Work Better for Pedestrians & Cyclists

Peter G Furth

Northeastern University

Look for publication of a guidebook from NCHRP 03-133,
Guidebook for Traffic Signal Design and Operations Strategies for Non-Motorized Users

1. Measuring pedestrian delay
2. Dirty little secrets about coordination with long signal cycles
3. Maximizing the Walk interval
    A. Longer Walk intervals
    B. Ped Recall
4. Multistage crossings
5. Protection from left turn conflicts
6. Protection from right turn conflicts
    A. Complete separation in time
    B. Pedestrian head start (“partial protection”)
        1. Leading Ped Interval
        2. Protected intersection layout, with head start in space
        3. Delayed Turn, a.k.a. Leading Thru Interval, Leading Bike Interval

1. Calculating & Reporting Average Pedestrian Delay

"Only what's measured counts"

Level of Service	Average Pedestrian Delay (s)	Likelihood of Noncompliance
A	< 10	Low
B	≥ 10 - 20	
C	> 20 – 30	Moderate
D	> 30 – 40	
E	> 40 - 60	High
F	> 60	Very high

Highway Capacity Manual, 2000

Policy:
Whenever vehicular delay is reported, ped delay must be reported, too.

How can this happen?

	Average ped delay	Average vehicle delay
Plan that was implemented	123 sec	35 sec
Alternative plan	45 sec	35.5 sec

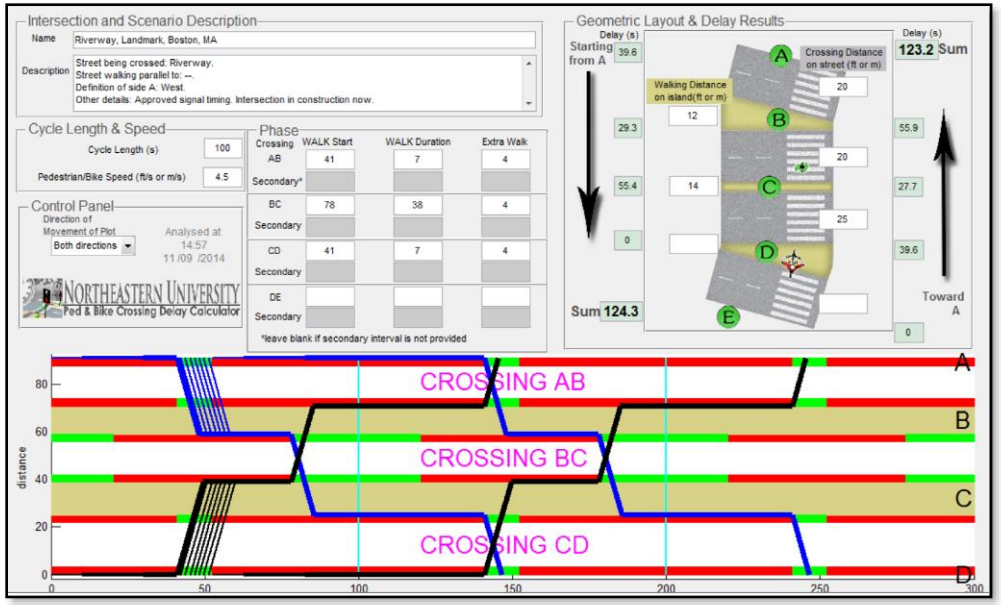
How to Calculate Average Pedestrian Delay

- Simple phasing: use a formula.

$$Avg\ Delay = \frac{(Cycle\ Length - Walk)}{2} * \frac{(Cycle\ Length - Walk)}{Cycle\ Length}$$

- Multistage crossings:

Northeastern University Ped & Bike Crossing Delay Calculator



2. Dirty Little Secrets about Coordinating Intersections with Long Signal Cycles

For cars:

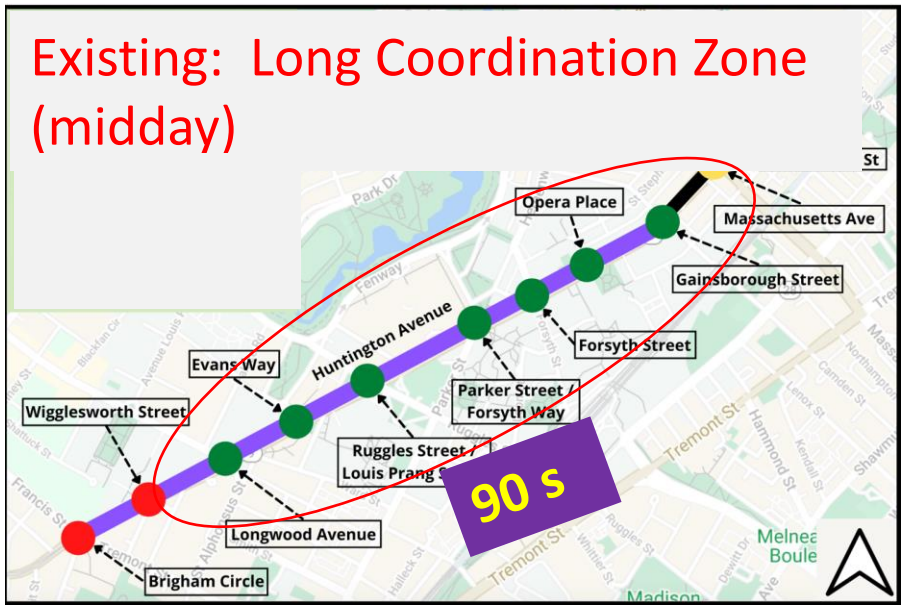
- ❑ Doesn't usually deliver the ethereal "green wave" being sought for
- ❑ After 100 s, increasing cycle length barely increases capacity

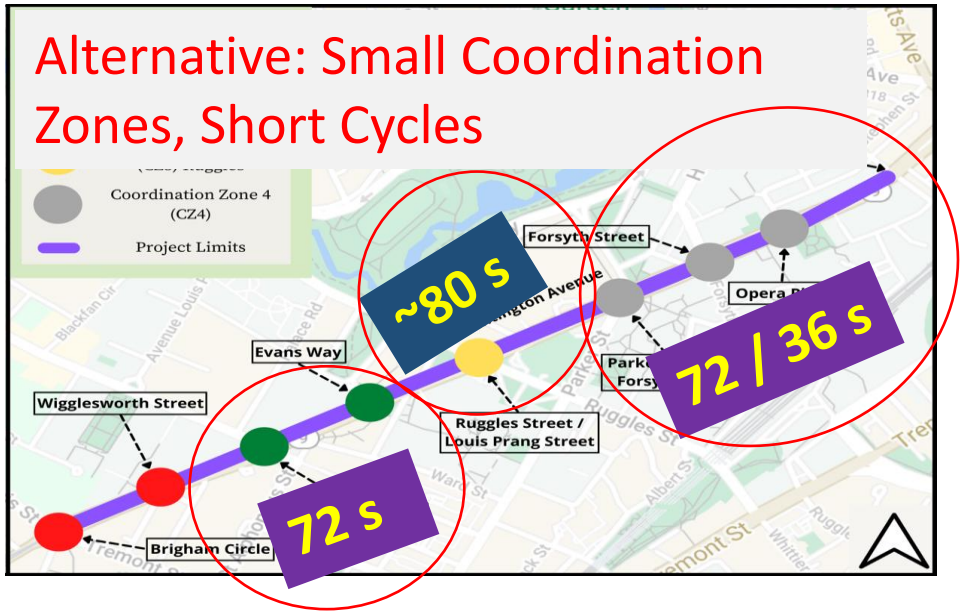
For pedestrians:

- ❑ Long delay
- ❑ More conflicting turns per cycle
  - ❑ Ex: 240 turns/hr. What if C = 60 s? C = 120 s?

For safety:

- ❑ Promotes speeding
  - ❑ Study: speeding opportunities per hr = 1,900, versus 920 w small coordination zones, short cycles



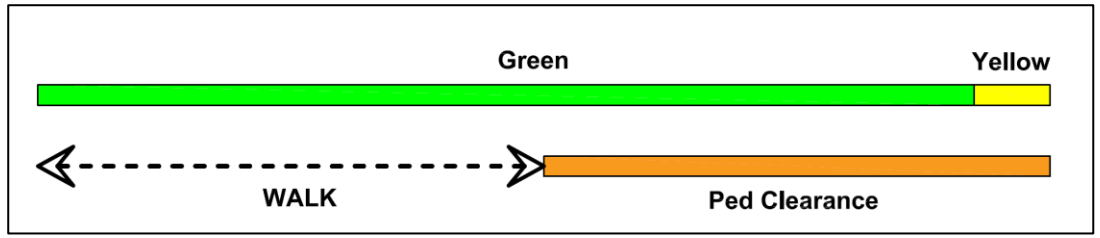


3. Maximize the Walk Interval

Not this:

but this:

[Make the WALK interval as long as will fit within the parallel vehicular phase]

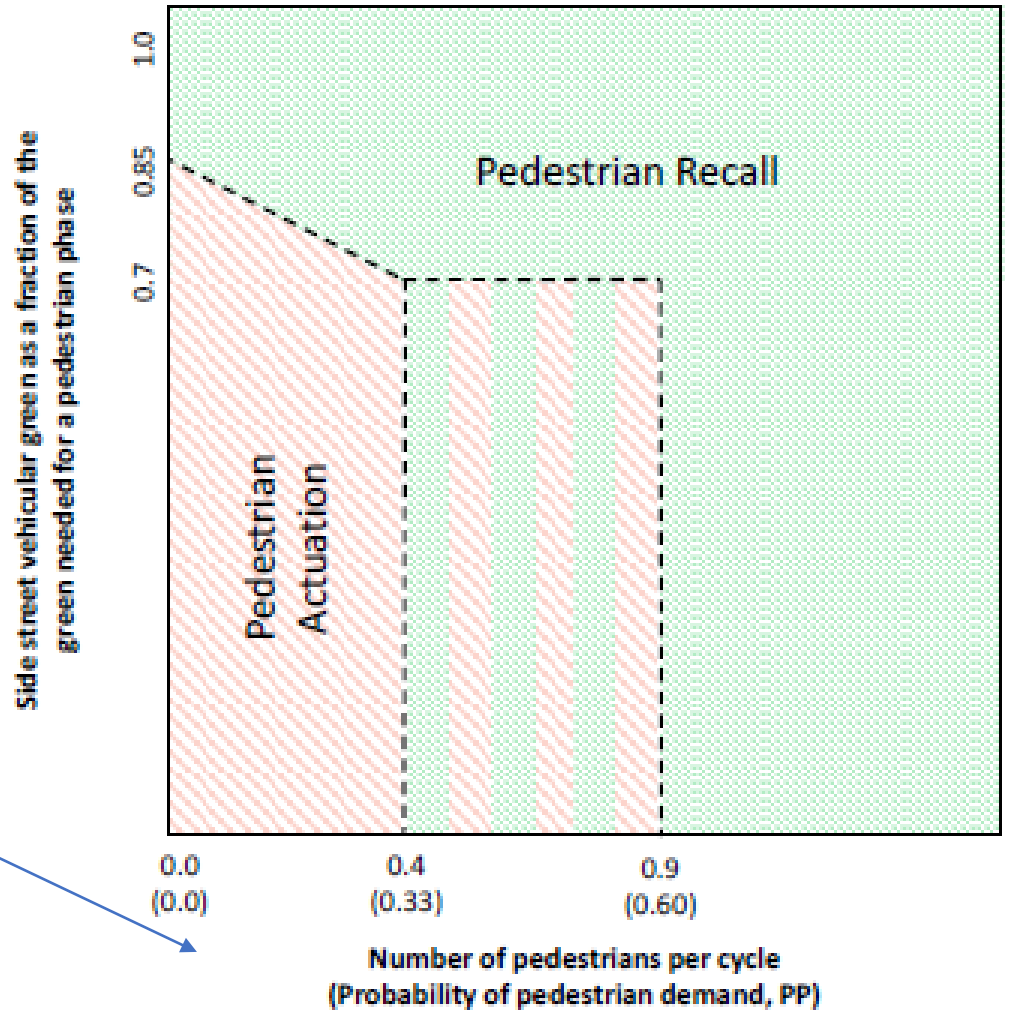


- Less pedestrian delay
- Better compliance
- Crossing becomes accessible to slower pedestrians

- For coordinated phases, use the setting “Rest in WALK”
- For others, ask: How long does the green usually last?

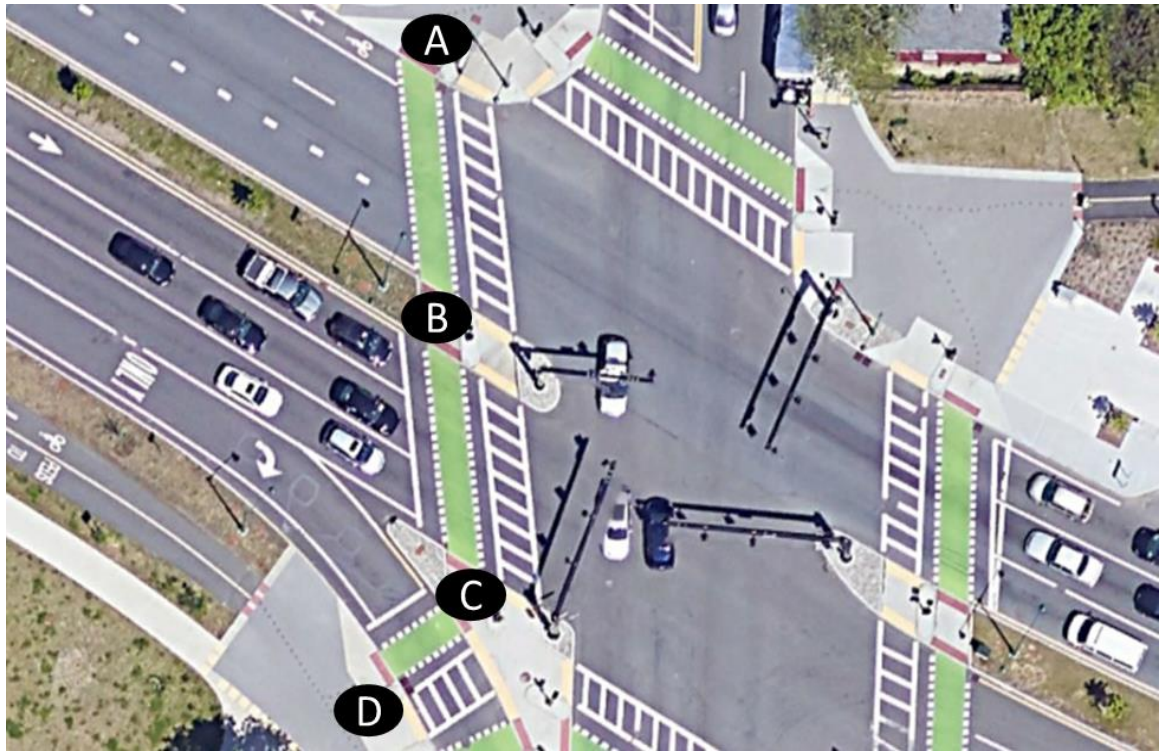
… and make greater use of Pedestrian Recall

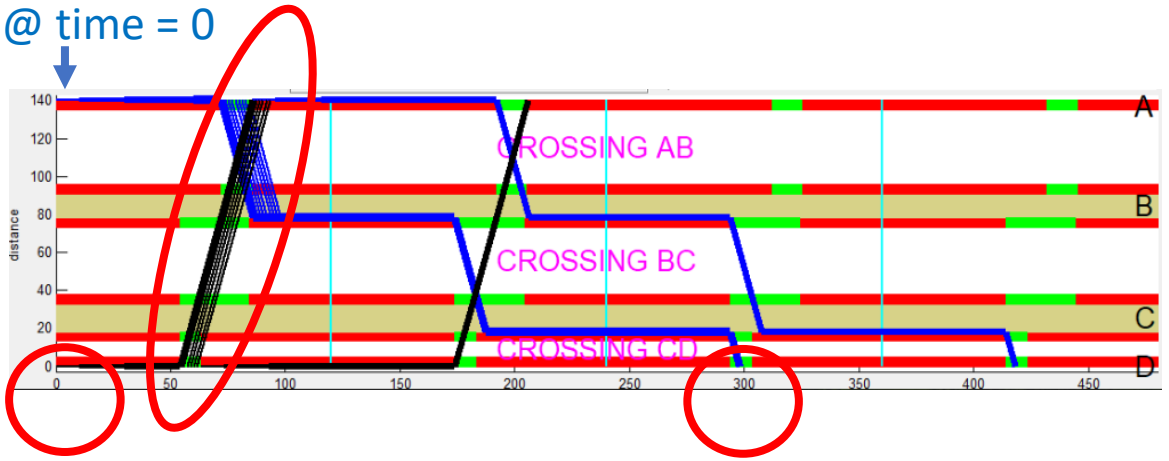
- If cross street traffic needs at least 70% of the time peds need
- If there are more than 0.9 (maybe even 0.4) pedestrians per cycle



Cesme, B., Furth, P. G., Casburn, R., & Lee, K. (2021). Development of Pedestrian Recall Versus Actuation Guidelines for Pedestrian Crossings at Signalized Intersections. *Transportation Research Record*, 03611981211002846.

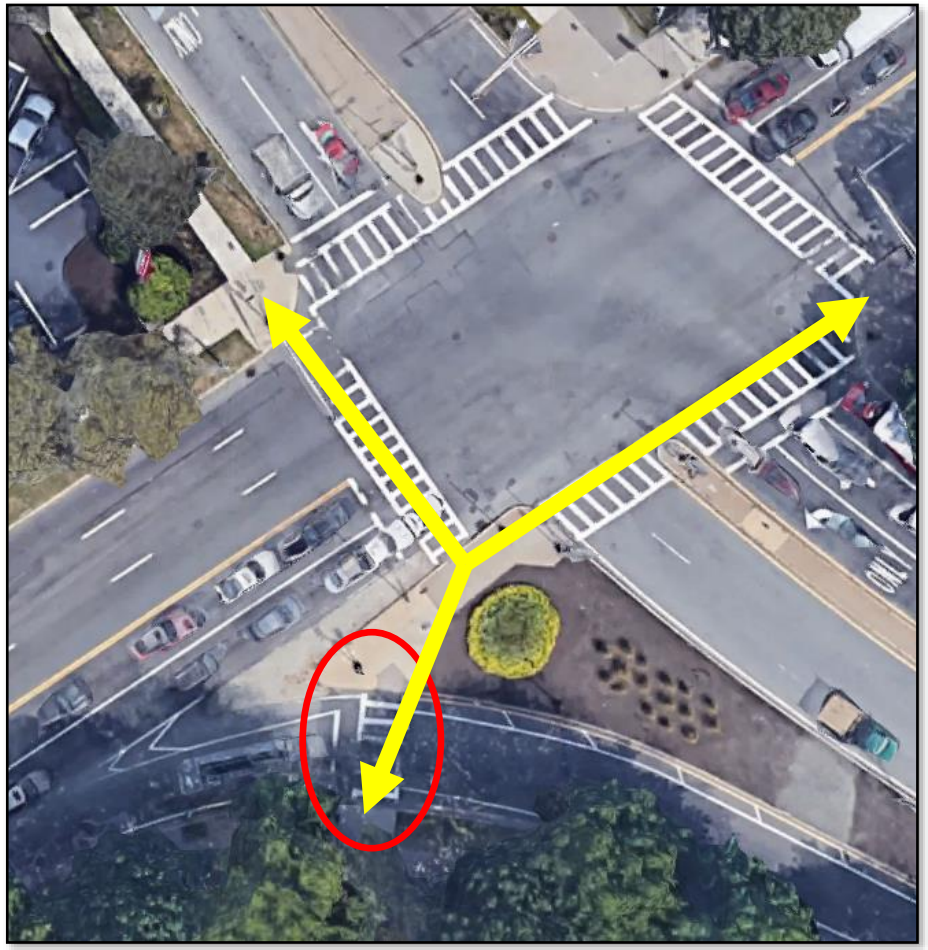
4. Avoid Multistage Crossings –
Unless you provide good pedestrian progression





Average ped delay, northbound	Average ped delay, southbound
51 sec	241 sec

Vital on signalized slip lane crossings:
Provide 2 or more pedestrian phases per cycle



***Reservice**: twice per cycle*

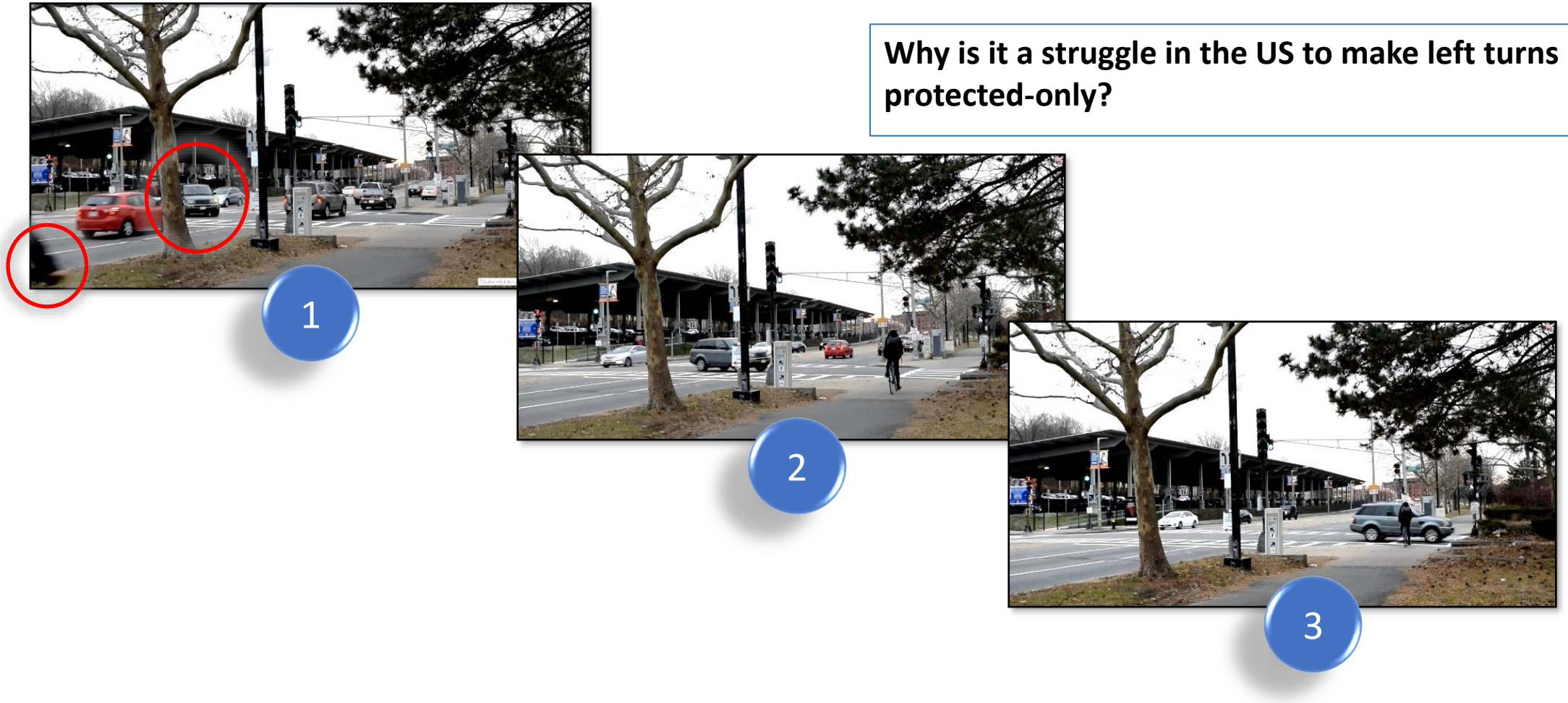
***Run free:** on demand, allowing cars 10 s green between ped phases*

5. Protecting Bikes and Peds from Left Turn Conflicts

Amsterdam Policy: On multilane roads, left turns are protected only, never “permitted”.

British Columbia Policy: Similar.

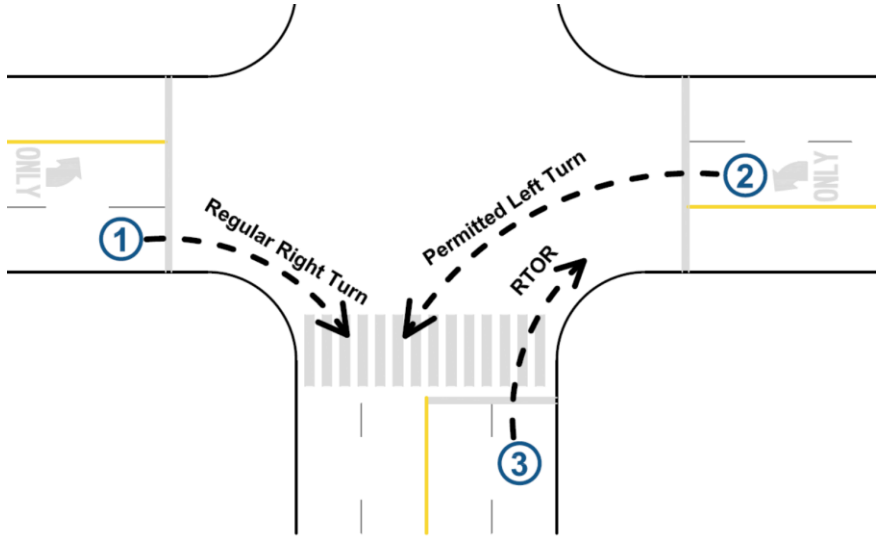
Why is it a struggle in the US to make left turns protected-only?



6. Conflicting Right Turns

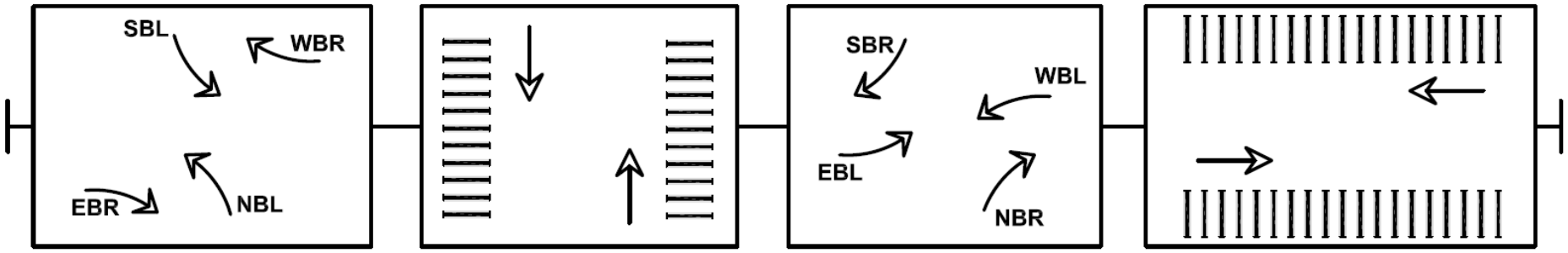
A. ***Full protection: Time separation for peds and right turns***

B. ***Partial protection:***
   1. *Leading Pedestrian Interval*
   2. *Protected Intersection geometry*
   3. *Delayed Turn (a.k.a. leading bike interval)*



A. Separate Ped-Bike Crossing Phase, in time, from Right Turns

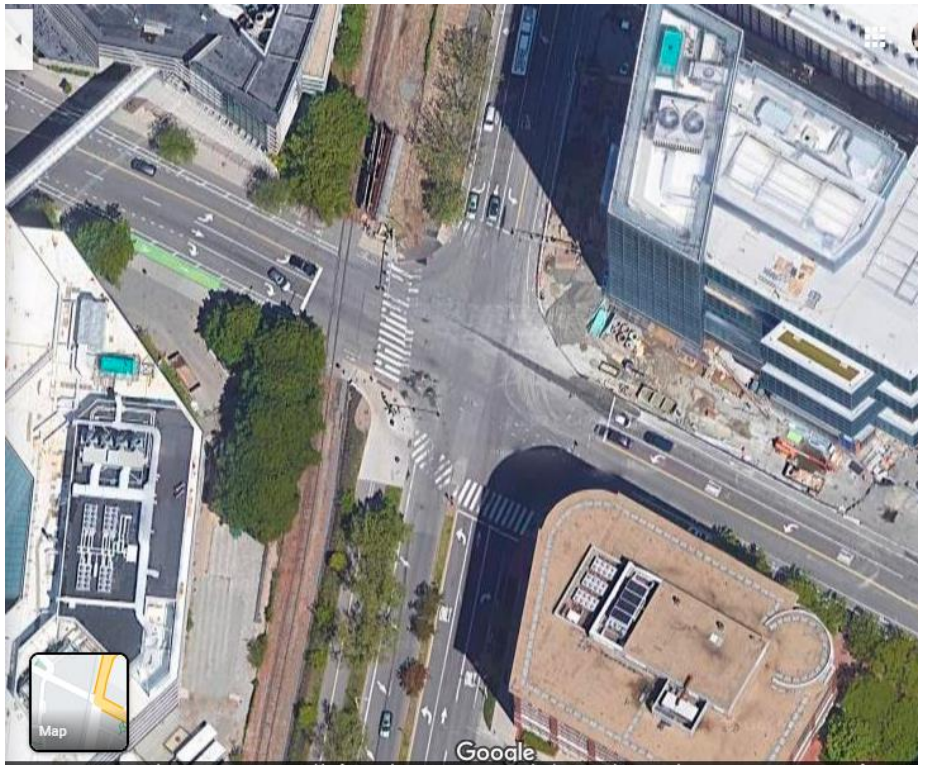
1. Serve right turns during the left turn phase



Cambridge, MA

Broadway at Galileo Way

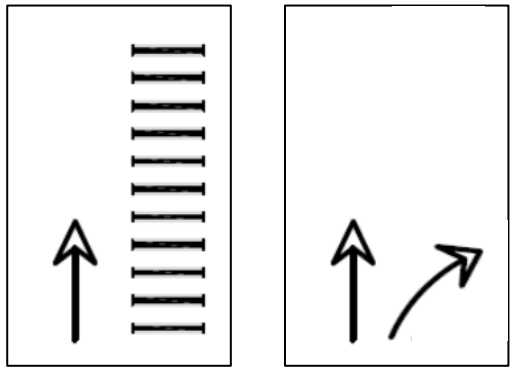
"A night and day difference for pedestrians and bikes"



A. Separating Ped-Bike Crossing Phase, in time, from Right Turns

What if there is no left turn phase?

2. Split the thru phase: part for peds-bikes, part for right turns



Many NYC intersections

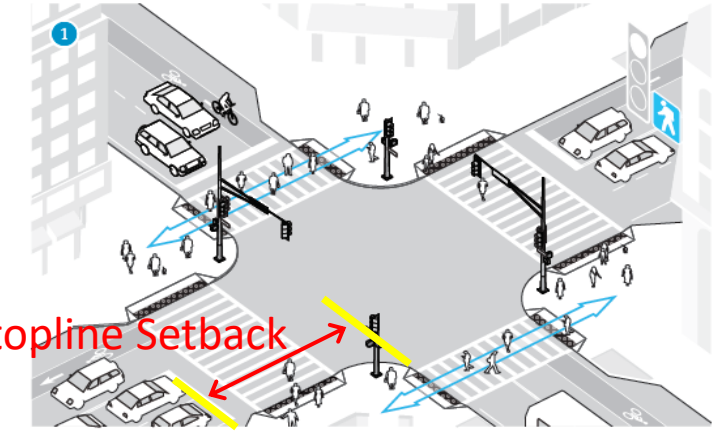
"Believability"

Will peds and cyclists feel that the signal is protecting them, or restricting them?

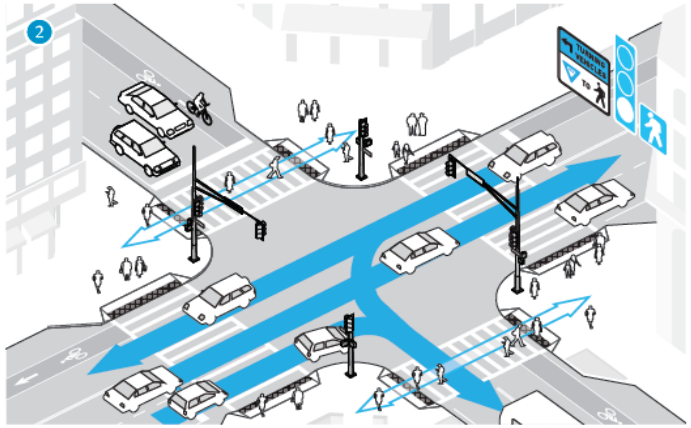
B. Partial Protection: A head start for peds-bikes

1. Leading Pedestrian Interval

2. Protected intersection Layout: a head start in space



Leading interval (3-7 s): Peds only



Concurrent traffic with turn conflicts

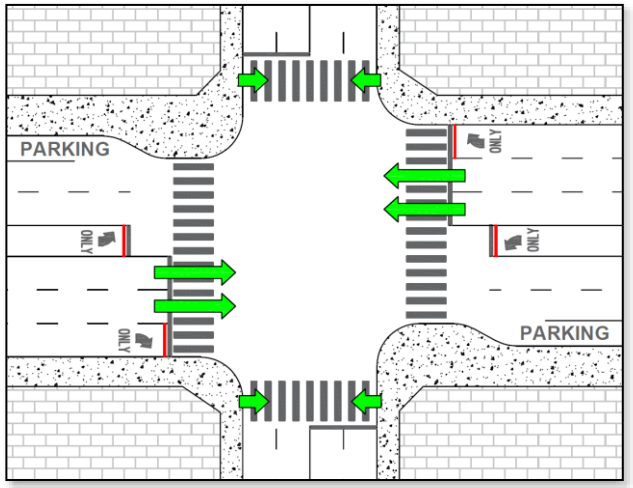
1. Audible signal needed
2. May bikes use it, too?
3. Can force the cycle to be longer – and so in Netherlands:
    - NOT used where “protected intersection” layout gives peds/bikes a large head start *in space.*

B. Partial Protection: A head start for peds-bikes

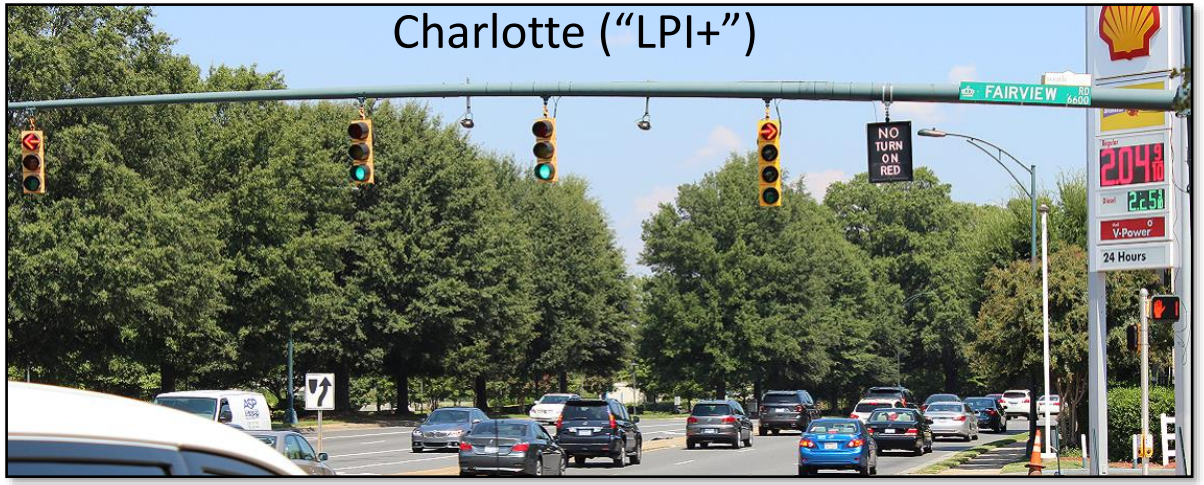
3. Delayed Turn, a.k.a. Leading Thru Interval, Leading Bike Interval

a. With exclusive turn lane; red arrow followed by flashing yellow arrow

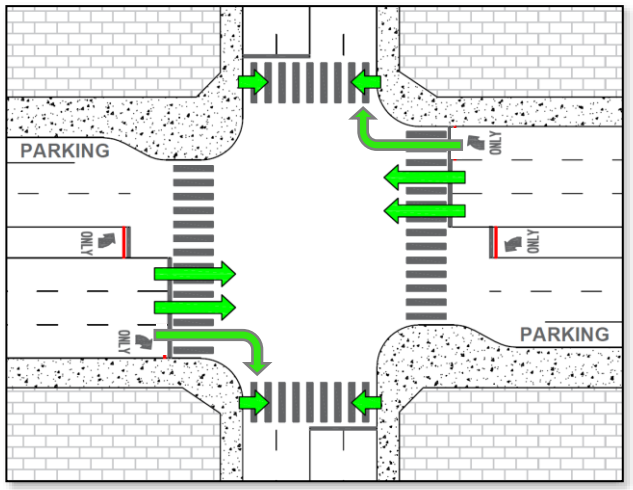
Leading interval (7-10 s)



Charlotte (“LPI+”)



Rest of thru phase

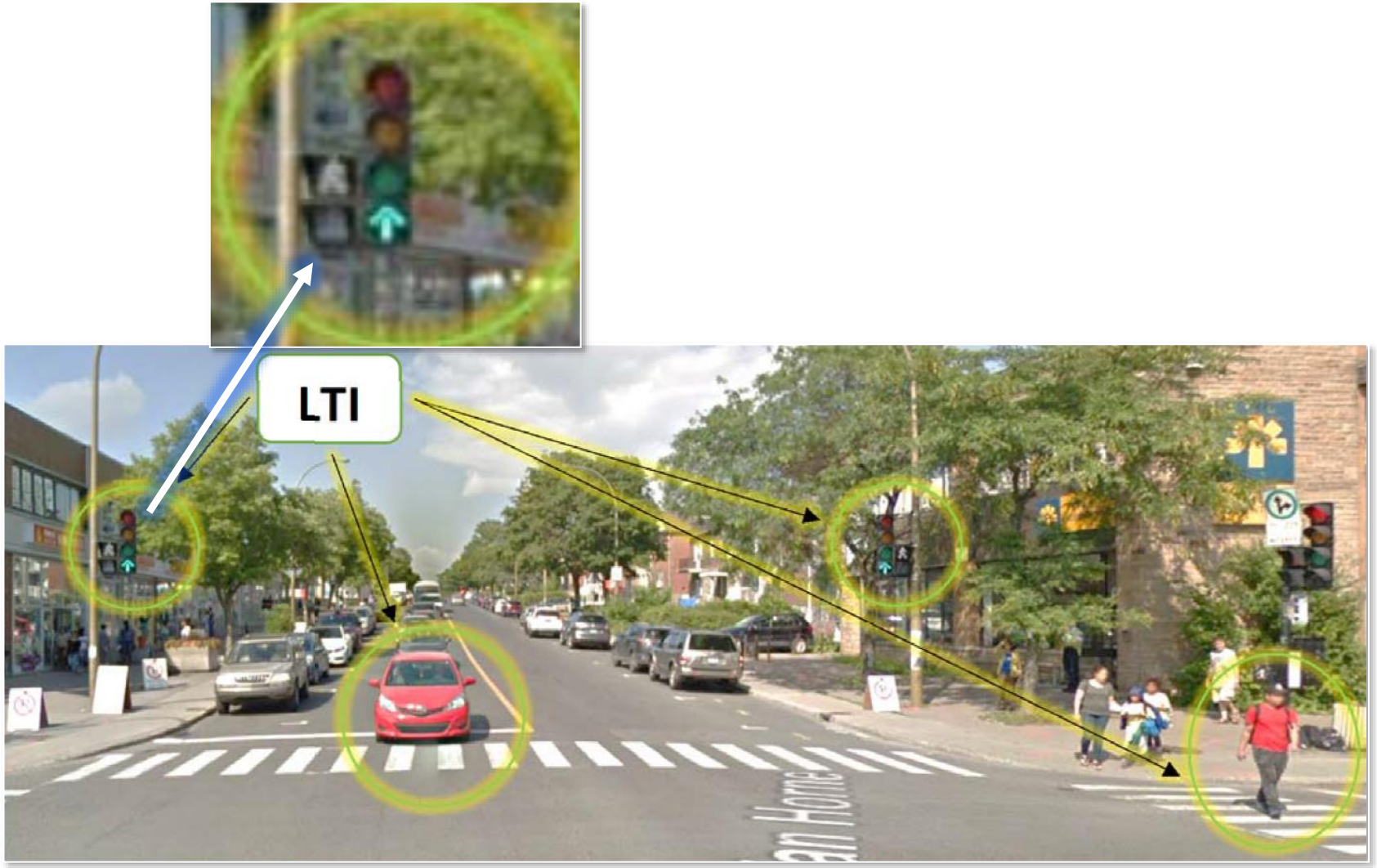


New York City, during flashing yellow arrow

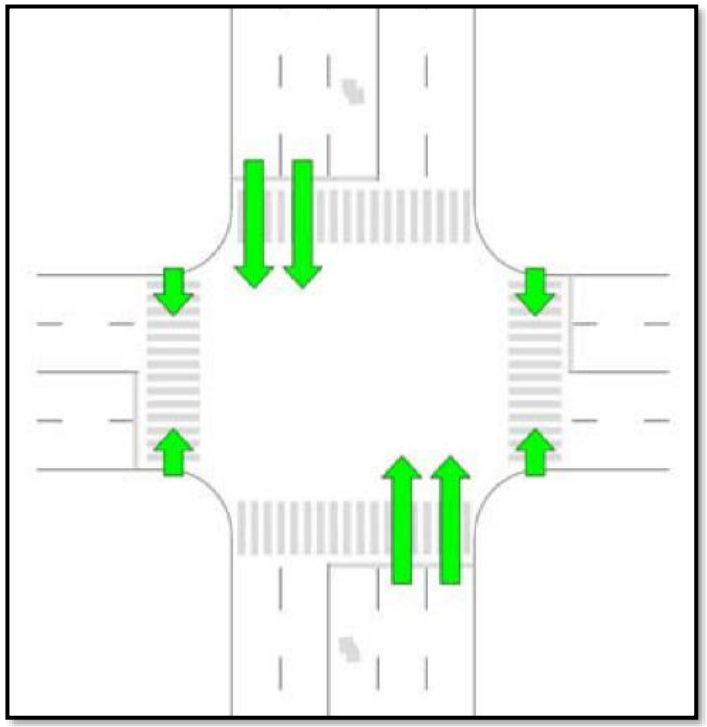
B. Partial Protection: A head start for peds-bikes

3. Delayed Turn, a.k.a. Leading Thru Interval, Leading Bike Interval

a. Without exclusive turn lane (Montreal)



Leading interval (7-10 s)



Discussion

- ⇨ Send us your questions
- ⇨ Follow up with us:
  - ⇨ Darren Buck darren.buck@dot.gov
  - ⇨ Eddie Curtis eddie.curtis@dot.gov
  - ⇨ Peter Koonce peter.koonce@gmail.com
  - ⇨ Peter Furth p.furth@northeastern.edu
  - ⇨ General Inquiries pbic@pedbikeinfo.org
- ⇨ Archive at www.pedbikeinfo.org/webinars