

Orlando, FL

November 7-8, 2024



2024 TRANSPORTATION SYMPOSIUM



Strategies for Enhancing Pedestrian Safety at Intersections

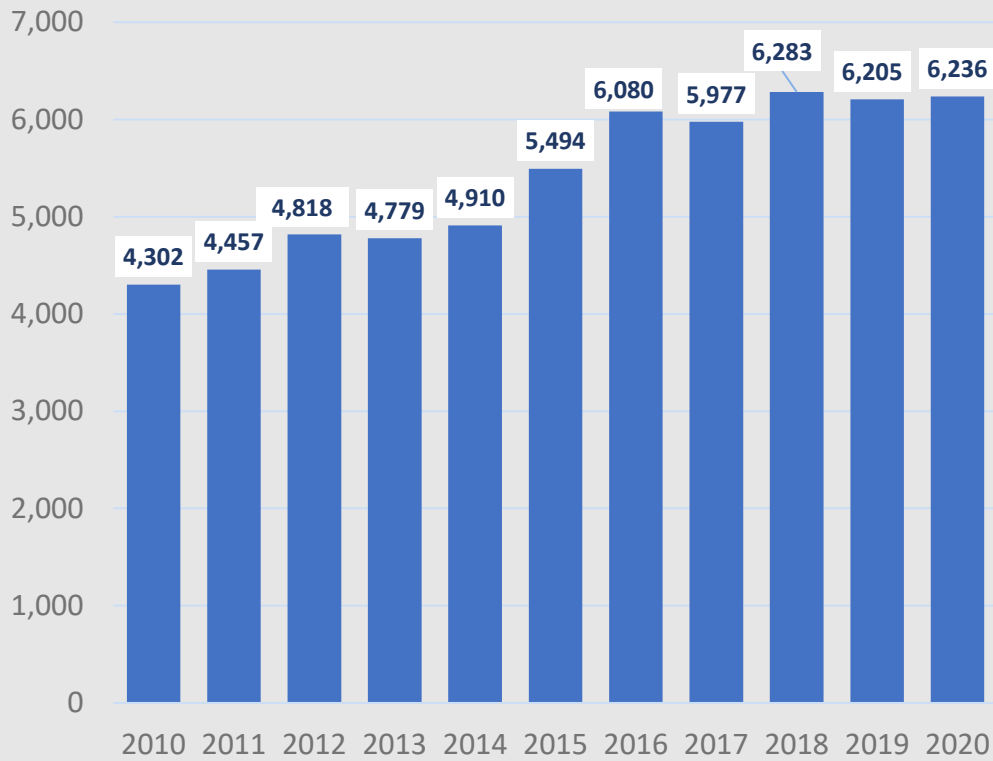
Mark Doctor

FHWA Resource Center

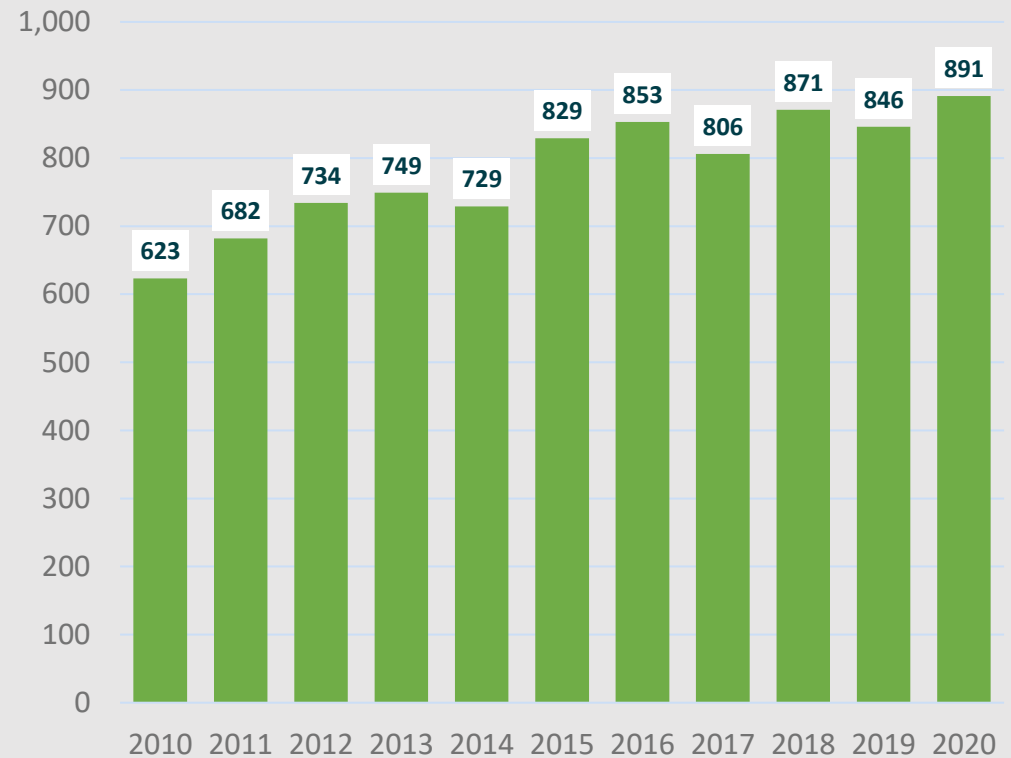


National Trends

Total US Pedestrian Fatalities 2010-2020

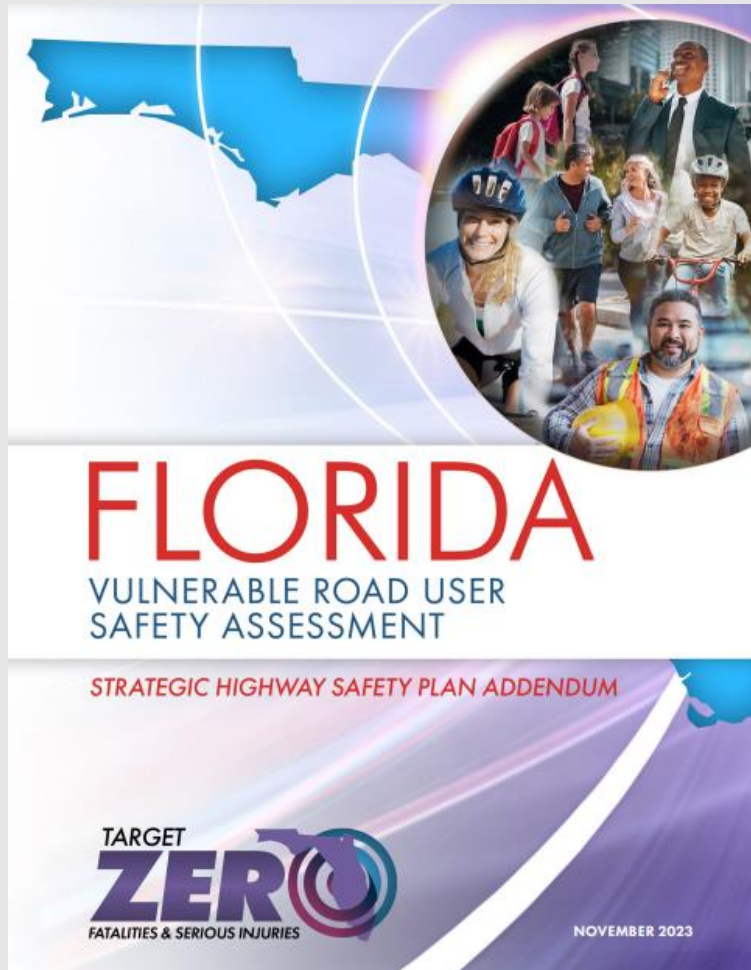


Total US Bicyclist Fatalities 2010-2020



Source: NHTSA

Florida Trends



PEDESTRIAN & BICYCLISTS

ACCOUNT FOR

27%

OF ALL FATALITIES
IN FLORIDA DURING
2017-2021

Source: Florida Department of Highway
Safety and Motor Vehicles (FLHSMV).

LOCATION OF CRASHES
FOR 2017-2021 BY ROAD
MAINTAINING AGENCY:

STATE: 40%

CITY: 35%

COUNTY: 17%

OTHER: 8%

Source: FDOT Pedestrian & Bicycle
Crash Facts.

OVER

3,600 PEDESTRIANS
DIED AND OVER

6,800 WERE **SERIOUSLY**
INJURED

IN FLORIDA DURING **2017-2021**

Source: FLHSMV

OVER

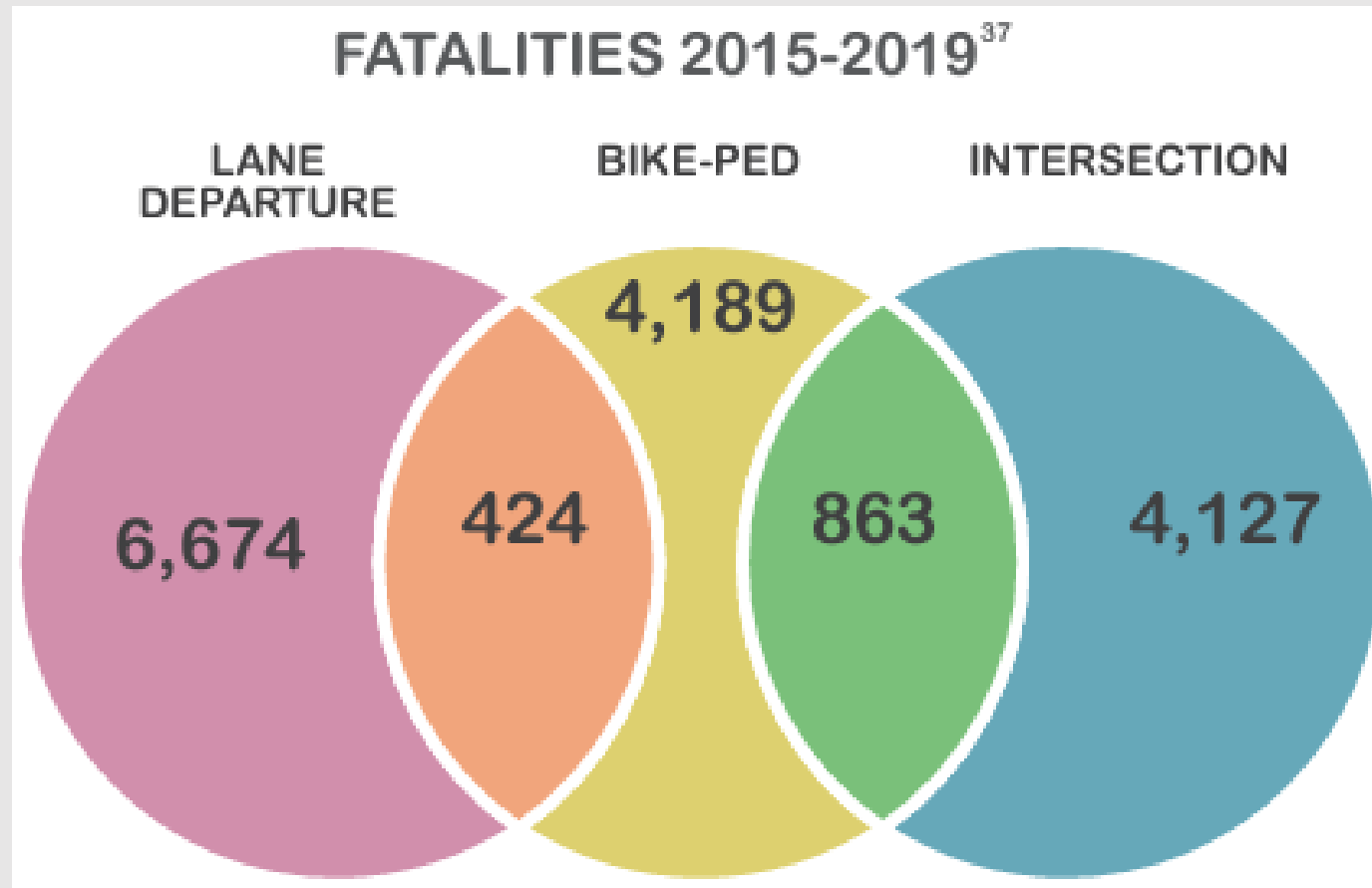
800 BICYCLISTS
DIED AND OVER

3,800 WERE **SERIOUSLY**
INJURED

IN FLORIDA DURING **2017-2021**

Source: FLHSMV.

Florida's Reality



Data Source: Florida Strategic Highway Safety Plan

https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/safety/shsp-2021/shsp_mar21.pdf?sfvrsn=5452dad_0

In **Florida**, there is **one pedestrian death** at an intersection every **50 hours**

At least 3 pedestrians will **die** every week

...at or near an intersection.



Intersection Challenges



- Safety for all users
- Capacity choke points
- Access to adjacent parcels
- Right-of-way constraints
- \$\$\$

SAFE SYSTEM PRINCIPLES



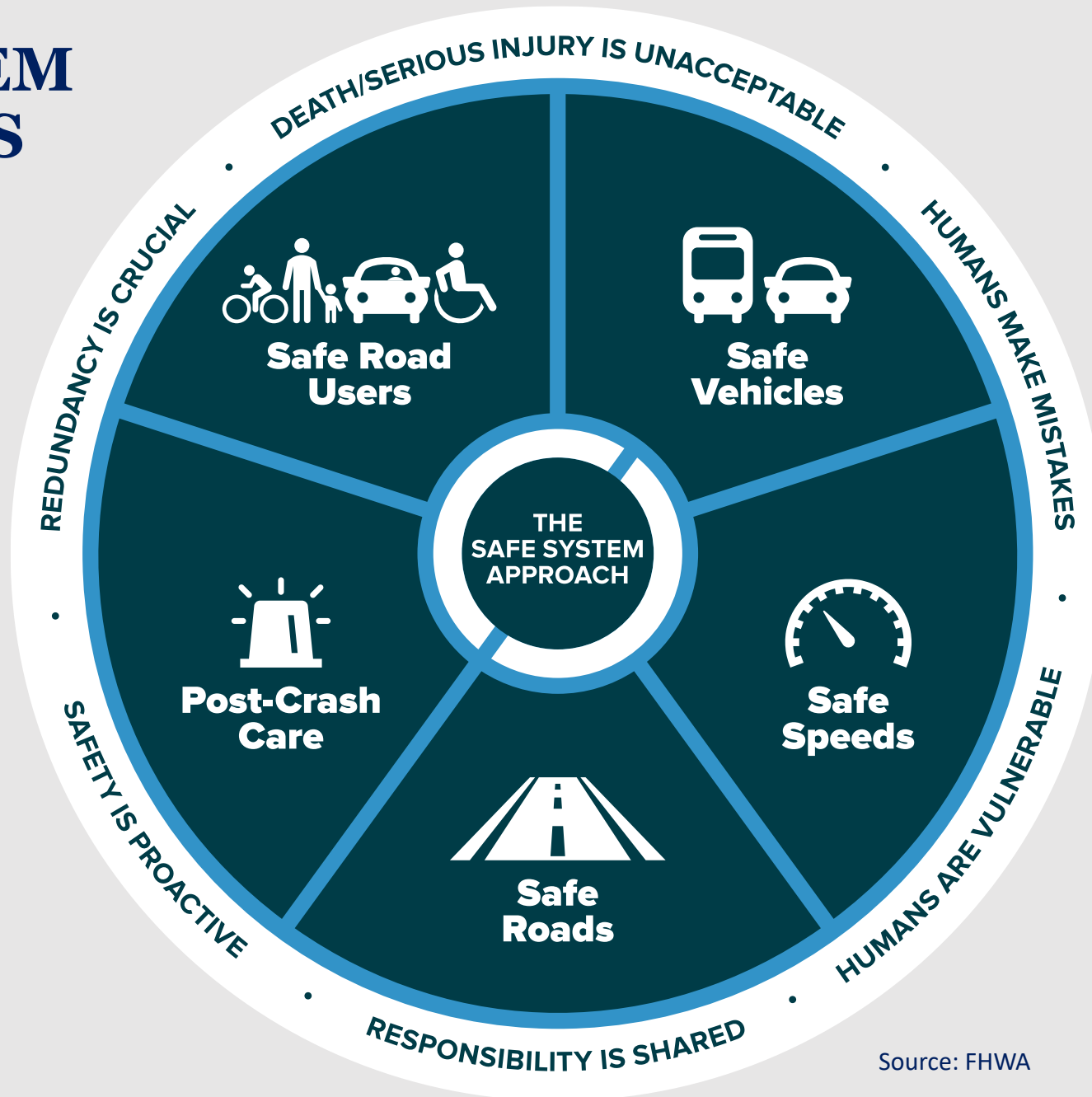
Death/serious injury is unacceptable



Humans make mistakes



Humans are vulnerable



Responsibility is shared

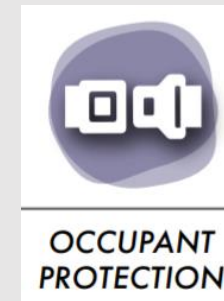
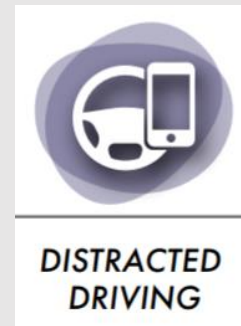


Safety is proactive



Redundancy is crucial

Why are people killed and seriously injured on our roads?...

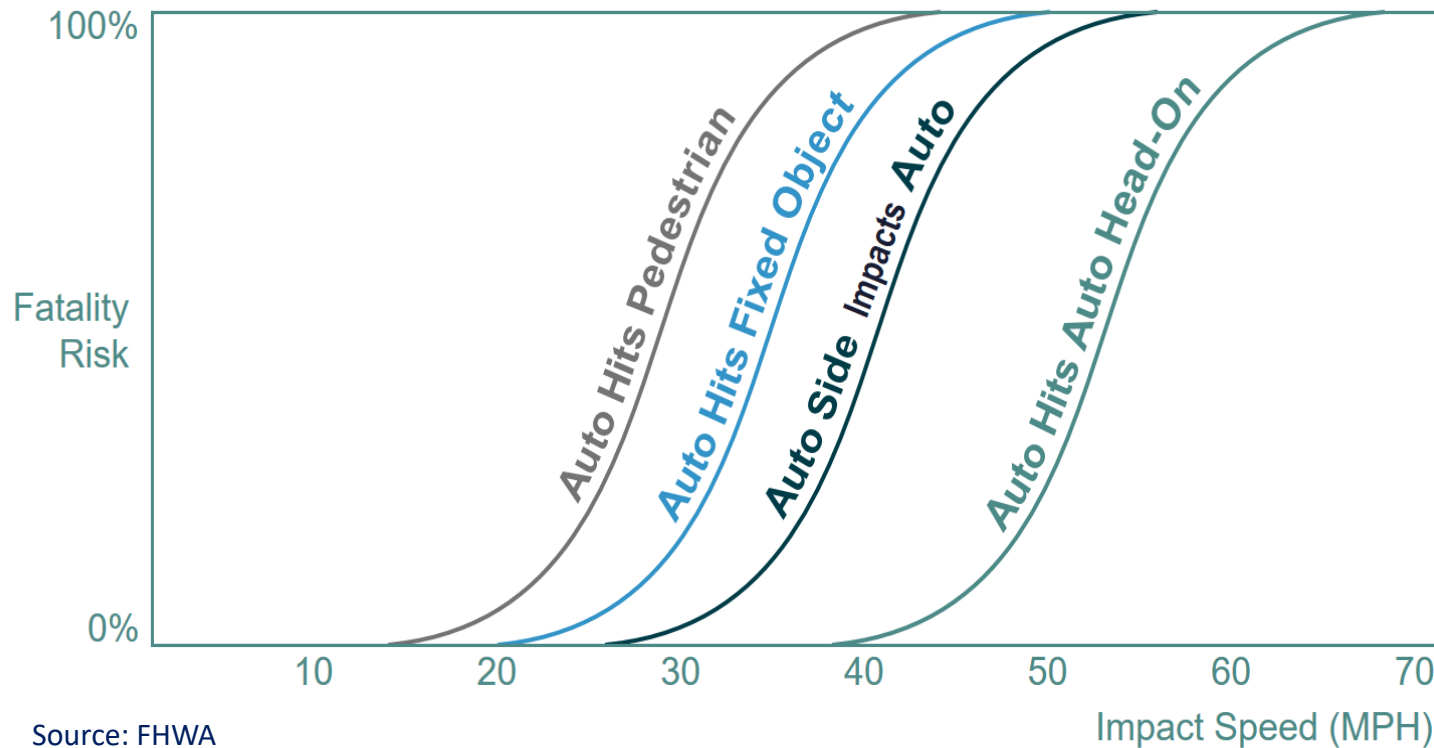


People are killed and seriously injured on the roads when the collision forces transferred onto the human body exceed tolerable thresholds.



Humans are
vulnerable

Safer Roads by Managing Kinetic Energy



$$K = \frac{1}{2}mv^2$$

Velocity is a Vector

- Speed
- Direction (angle of impact)

Hit by a vehicle
traveling at:

23
MPH



10%
Risk of Death

Hit by a vehicle
traveling at:

32
MPH



25%
Risk of Death

Hit by a vehicle
traveling at:

42
MPH



50%
Risk of Death

Hit by a vehicle
traveling at:

50
MPH



75%
Risk of Death

Hit by a vehicle
traveling at:

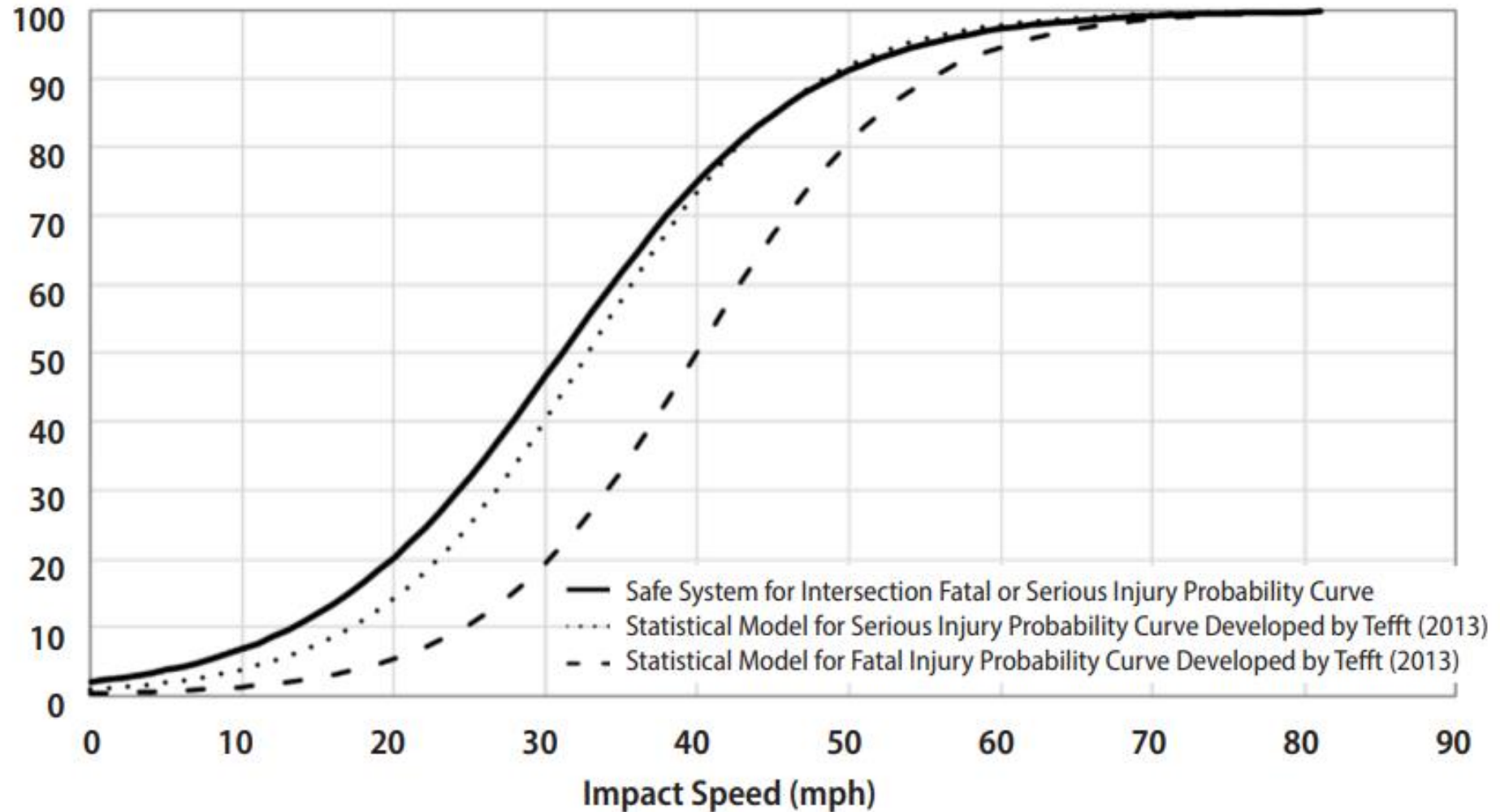
58
MPH



90%
Risk of Death

Human tolerance to impact speed

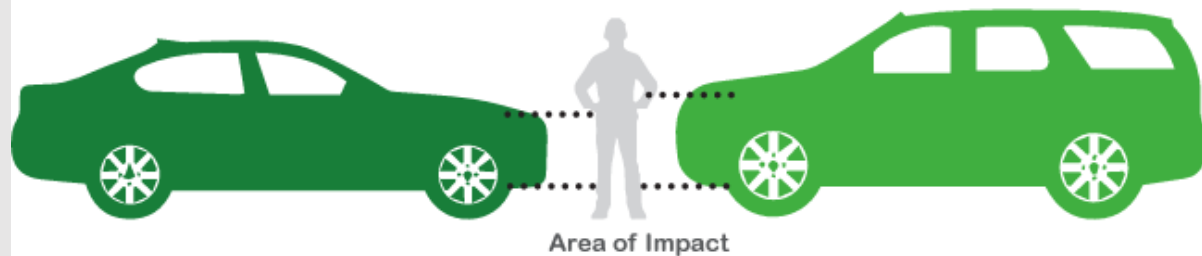
Probability of Fatal or Severe Injury for Pedestrians or Cyclists Involved in a Crash



Vehicle Trends

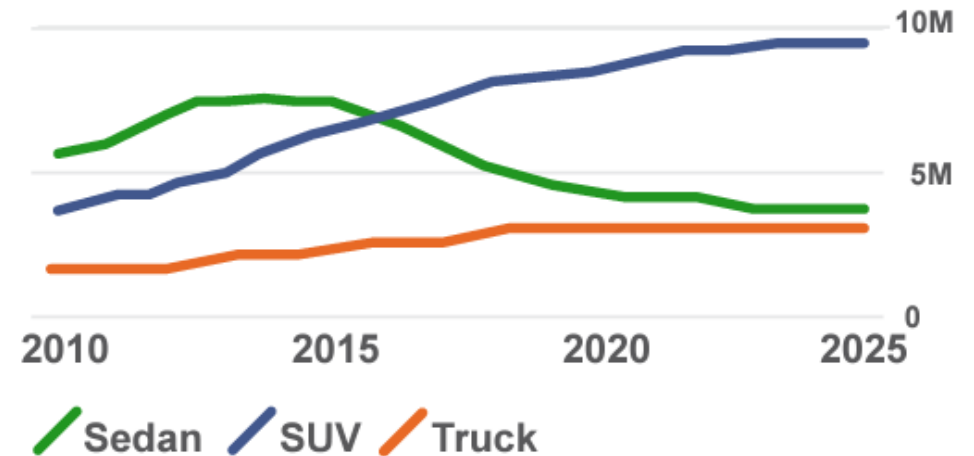
HIGHER IMPACTS

Taller than cars, SUVs strike pedestrians higher on the body, increasing the likelihood of severe injury or even death.²⁰



THE RISE OF SUVs

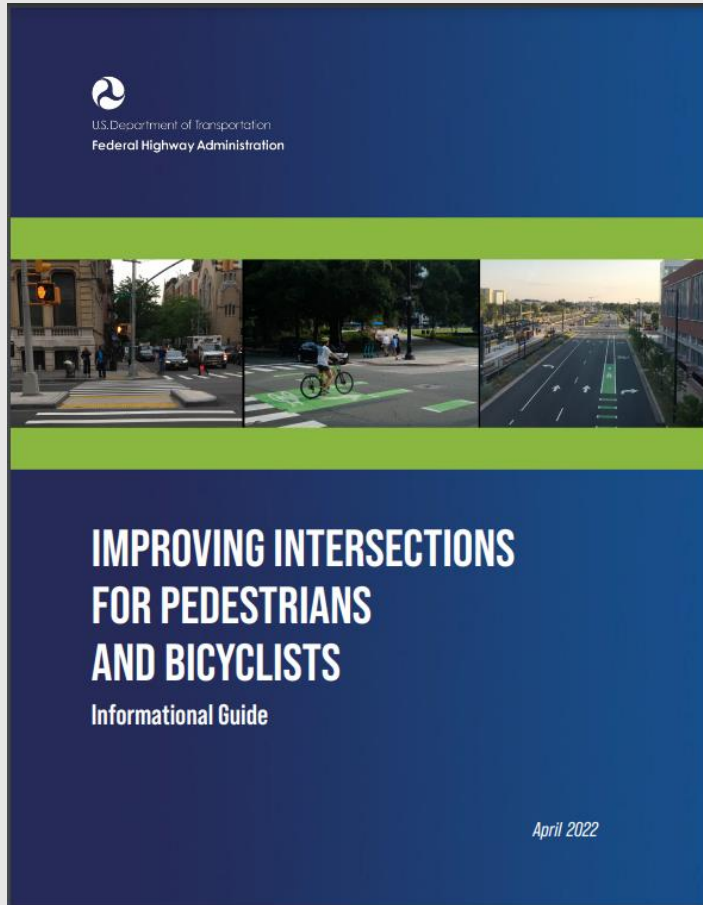
Sales of larger vehicles surpassed sedans over the last decade.²¹



20) U.S. Department of Transportation, Federal Highway Administration. (2019). Bikeway Selection Guide

21) Florida Department of Transportation. (2021). FDOT Design Manual, Section 223 Bicycle Facilities

New(ish) Resource!



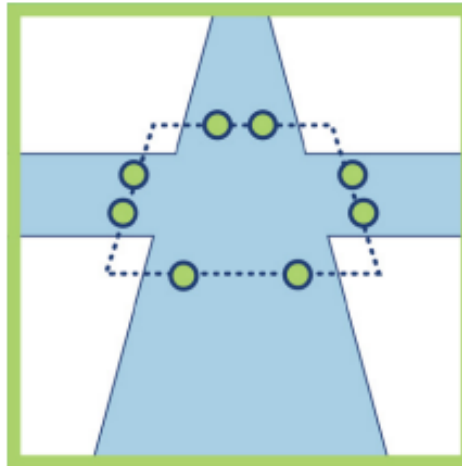
“The purpose of this guide is to inform the state of the practice concerning intersection planning and design to implement solutions that help achieve the goal for zero fatalities and serious injuries while also making roads better places for walking and bicycling.”

<https://safety.fhwa.dot.gov/intersection/about/fhwasa22017.pdf>

Improving Intersections for Peds & Bikes



**Expect Pedestrians and Bicyclists
at All Intersections**



Use a Safe System Approach



**Provide Access for
All Ages and Abilities**

Fact Sheets



Roundabouts

Roundabouts are circular intersections characterized by channelized approaches and counterclockwise traffic flow around a central island.

Design Features

- Traffic approaching the roundabout yields to traffic already in the circular roadway.
- Upper islands can help define approaching vehicular traffic and encourage slower speeds and/or yielding.
- Entree at roundabouts are well-controlled and well-arranged. Consequently, pedestrian activity and crossings at both entries and exits should be carefully planned to increase the confidence of the yielding. This is particularly important for making crossings accessible for pedestrians with low or no vision.
- Intersecting roadways are arranged in lower median islands, but a separate cycle crossing at each approach can be used to provide a more complete set of crossings at a roundabout and may not be suitable for bicyclists of all ages and abilities.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Benefits

- Roundabouts are highly adaptable and have been proven to work across a range of contexts, from top speed rural to low speed urban.
- The upper islands serve as a pedestrian and bicycle crossing facility, allowing pedestrian and bicycle crossings in one direction of vehicular traffic, at a time.
- Median islands, perimeter medians, and slower vehicle approach speeds increase the confidence of the yielding.
- Roundabouts can potentially reduce the total number of vehicle collisions and increase the level of improved operational performance.

Intersection Types

SHARED LANE

The single lane roundabout features shared lanes for pedestrians and bicyclists with the roundabout entry and driveway merge with most vehicle traffic, similar to the design before returning to the base lane after exiting.



CONSIDERATIONS

- The crossings are particular to the route vehicle traffic and are not shared with other vehicles in the same area, increasing the safety of pedestrian and bicycle crossings.
- Another crossing facility may be used to provide a more complete set of crossings at a roundabout and may not be suitable for bicyclists of all ages and abilities.

References

- Houghton, L., Benner, J., Tasic, C., Wrayburn, J., and ... (2016). *Transportation Planning and Design: An International Guide*. Second Edition. CRC Press, Taylor & Francis Group, Washington, DC.
- Schenker, B., Rodriguez, L., Jansz, P., Myers, E., ... (2016). *Transportation Planning and Design: An International Guide*. Second Edition. CRC Press, Taylor & Francis Group, Washington, DC.



SEPARATED BIKE LANE
The single lane roundabout design features separated bike lanes with the roundabout crossings, similar to the marked pedestrian crossings.

CONSIDERATIONS

- This design combines pedestrian and bicyclist crossings in the same area, increasing the safety of pedestrian and bicycle crossings.
- The roadway design incorporates a shared lane with the roundabout crossings, similar to the marked pedestrian crossings.
- The design may also include a shared lane with the roundabout crossings, similar to the marked pedestrian crossings.

CONSIDERATIONS

- Bicyclists have the option to cross the roundabout crossings and are not shared with other vehicles in the same area, increasing the safety of pedestrian and bicycle crossings.
- Another crossing facility may be used to provide a more complete set of crossings at a roundabout and may not be suitable for bicyclists of all ages and abilities.

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Median U-Turn Intersections

Median U-Turn (MUT) intersections refer to any intersection replacing direct left turns at an intersection with indirect left turns that rely on a U-turning vehicle combination.

Design Features

- Direct left turns are prohibited from either or both major and minor roads.
- Conventional through movements and right turns are allowed from both the major and minor roads.
- The main intersection requires fewer traffic signals than a conventional intersection through the elimination of minor road through and right-turn movements.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Benefits

- MUT intersections reduce the overall number of vehicle conflict points and prevent all users with fewer conflicting movements to exist at a time.
- The main intersection is signalized to increase the confidence of the yielding. This is particularly important for making crossings accessible for pedestrians with low or no vision.
- Intersecting roadways are arranged in lower median islands, but a separate cycle crossing at each approach can be used to provide a more complete set of crossings at a roundabout and may not be suitable for bicyclists of all ages and abilities.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Intersection Types

SEPARATED BIKE LANE

This design features separated bike lanes with the roundabout crossings, similar to the marked pedestrian crossings.



CONSIDERATIONS

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SIDEPATH
This design features sidepaths for the roundabout crossings, similar to the marked pedestrian crossings.

CONSIDERATIONS

- This design combines pedestrian and bicyclist crossings in the same area, increasing the safety of pedestrian and bicycle crossings.
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- The design may also include a shared lane with the roundabout crossings, similar to the marked pedestrian crossings.

CONSIDERATIONS

- Bicyclists have the option to cross the roundabout crossings and are not shared with other vehicles in the same area, increasing the safety of pedestrian and bicycle crossings.
- Another crossing facility may be used to provide a more complete set of crossings at a roundabout and may not be suitable for bicyclists of all ages and abilities.

Restricted Crossing U-Turn Intersections

Restricted Crossing U-Turn (RCUT) intersections replace direct through and left-turn movements from the minor approaches with an indirect movement of a right-turn vehicle combination.

Design Features

- Intersections are signalized or unsignalized.
- Direct left-turn and through movements are prohibited from the minor road approach.
- The main intersection requires fewer traffic signals than a conventional intersection through the elimination of minor road through and right-turn movements.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Benefits

- RCUTs reduce the overall number of vehicle conflict points and prevent all users with fewer conflicting movements to exist at a time.
- When signalized, fewer phases are needed as compared to a traditional signalized intersection, resulting in shorter overall traffic signal cycle lengths and decreased delay.
- Specifically, the reduced number of conflict points and fewer number of conflicting movements crossed at a time can reduce risk while crossing.
- An unsignalized RCUT location, where right-turn signal is not used, may be used to provide a more complete set of crossings at a roundabout and may not be suitable for bicyclists of all ages and abilities.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Intersection Types

SIDEPATH

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CONSIDERATIONS

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CONSIDERATIONS

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Displaced Left Turn (DLT) Intersections

Displaced Left Turn (DLT) intersections are cross-street intersections that can be applied to high-volume signalized arterial intersections—especially those characterized by heavy left-turn volumes that conflict with heavy opposing through volumes.

Design Features

- Left-turning vehicle traffic crosses over the main intersection and proceeds through traffic at signalized intersections upstream of the main intersection.
- Through movements and left turns occur simultaneously at the main intersection.
- A pedestrian or bicyclist crossing the intersection and roadway networks and in advance of all intersection crossings.
- The DLT is designed primarily to minimize vehicular delay and promote "continuous flow," which can be long cycle lengths with increased delay for pedestrians and bicyclists.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Benefits

- Most DLTs include channelized bike lanes and medians to protect left-turn traffic. These lanes serve to provide a safe space for pedestrians and bicyclists.
- In some cases, the "yield" of the queue and roadway may be developed. This allows bicyclists to cross the intersection and proceed through traffic at signalized intersections upstream of the main intersection.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Intersection Types

SEPARATED BIKE LANE

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CONSIDERATIONS

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Diverging Diamond Interchange (DDI)

Diverging Diamond Interchanges (DDIs) are characterized by crossover intersections at the ramp termini where cross-street traffic crosses over to the left-hand side of the roadway between the ramps to allow unopposed left turns to and from the ramps. DDIs are used in situations with grade-separated interchanges.

Design Features

- Movements and both ramps should be controlled to improve crossings for pedestrians and bicyclists.
- Between the crossover intersections, pedestrian and bicyclist crossings should be provided at either side of the main roadway.
- The DDI design features a median island between the crossover intersections to minimize vehicular delay and promote "continuous flow," which can be long cycle lengths with increased delay for pedestrians and bicyclists.
- Install overhead lighting to illuminate driveway and roadway networks and in advance of all intersection crossings.

Benefits

- The design combines pedestrian and bicyclist crossings in the same area, increasing the safety of pedestrian and bicycle crossings.
- The roadway design incorporates a shared lane with the roundabout crossings, similar to the marked pedestrian crossings.
- The design may also include a shared lane with the roundabout crossings, similar to the marked pedestrian crossings.

Intersection Types

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Restricted Crossing U-Turn Intersections

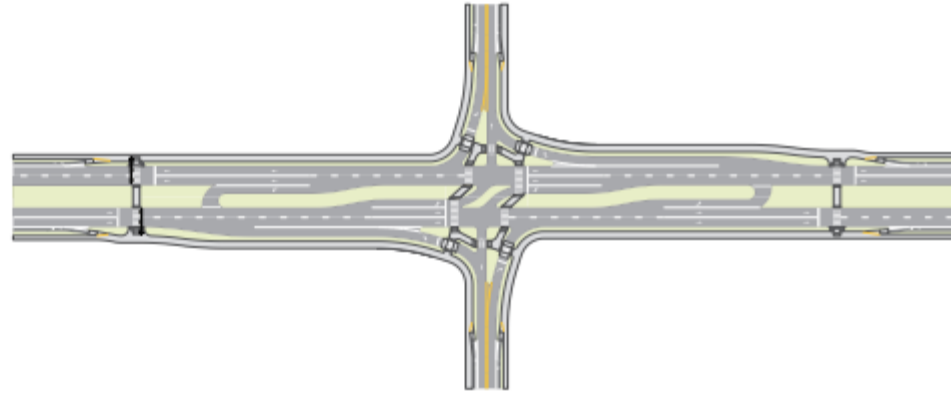
Restricted Crossing U-Turn (RCUT) intersections replace direct through and left-turn movements from the minor approaches with an indirect movement of a right-turn/U-turn combination.



All graphics source: FHWA

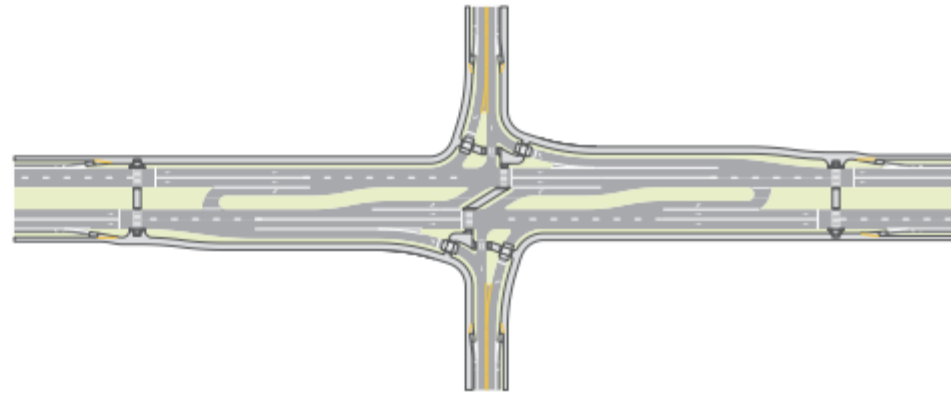
SIDEPATH

This design features sidepaths through the intersection, as well as crosswalk positioning that more closely resembles a traditional intersection.



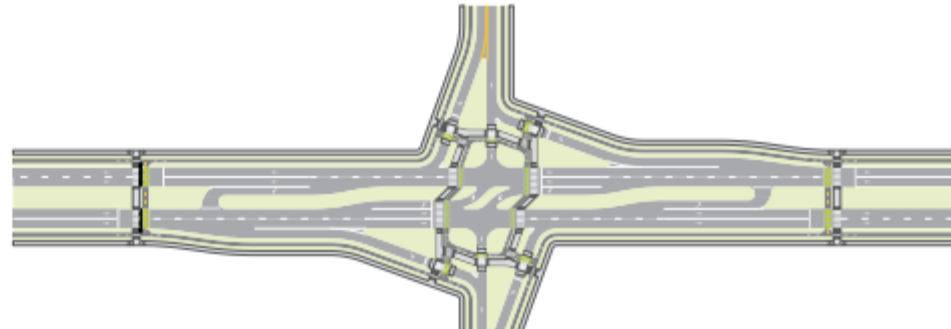
SIDEPATH Z-CROSSING

The RCUT layout optimized for motor vehicles calls for a “Z-pattern” pedestrian crossing at the main intersection. This reduces conflict points between motorists, bicyclists, and pedestrians, but causes crossing pedestrians and bicyclists to travel out of their direct, intended path.



SEPARATED BIKE LANE

This RCUT design features separated bike lanes and a more direct and intuitive pedestrian and bicyclist crossing configuration at the intersection.



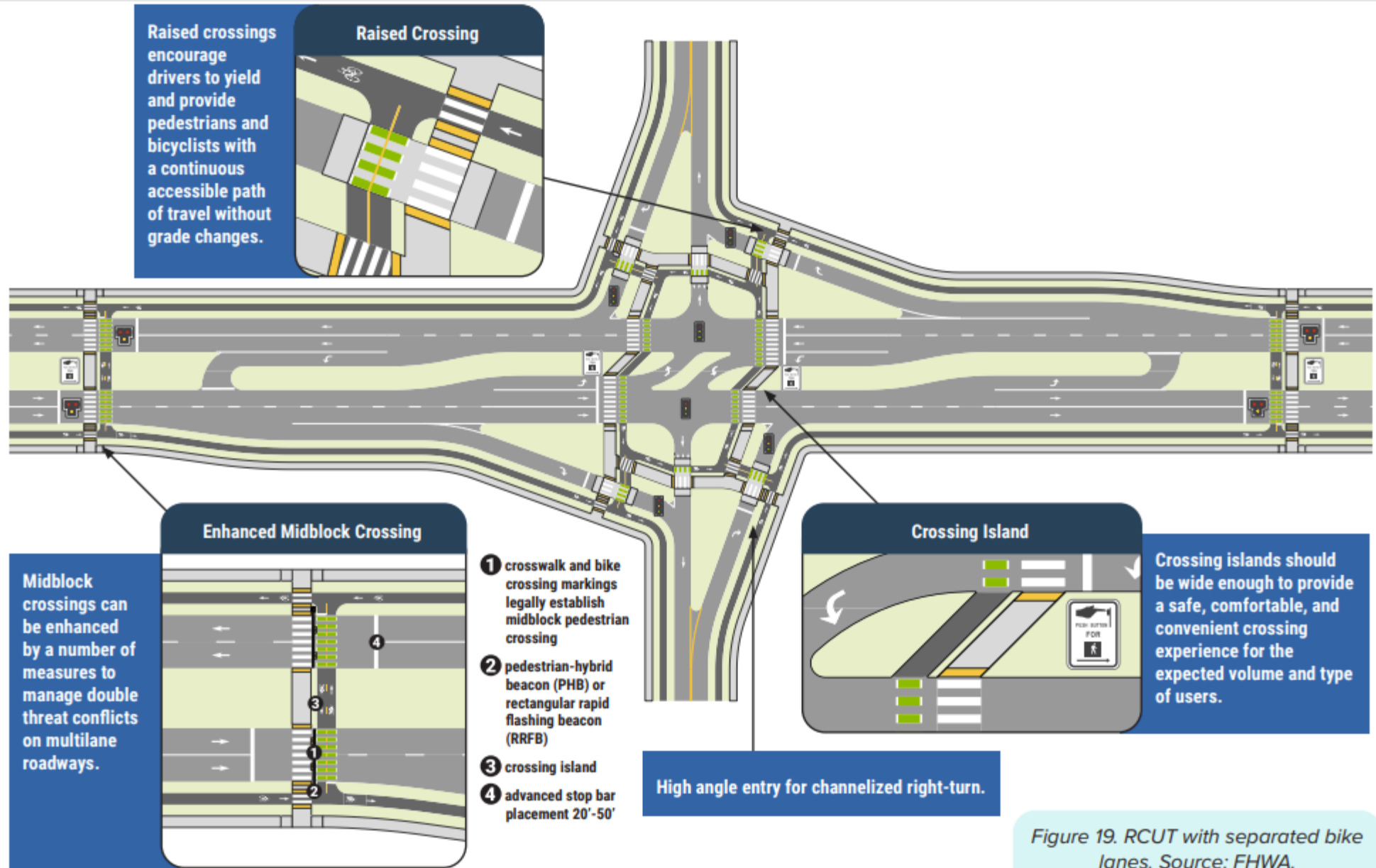


Figure 19. RCUT with separated bike lanes. Source: FHWA.

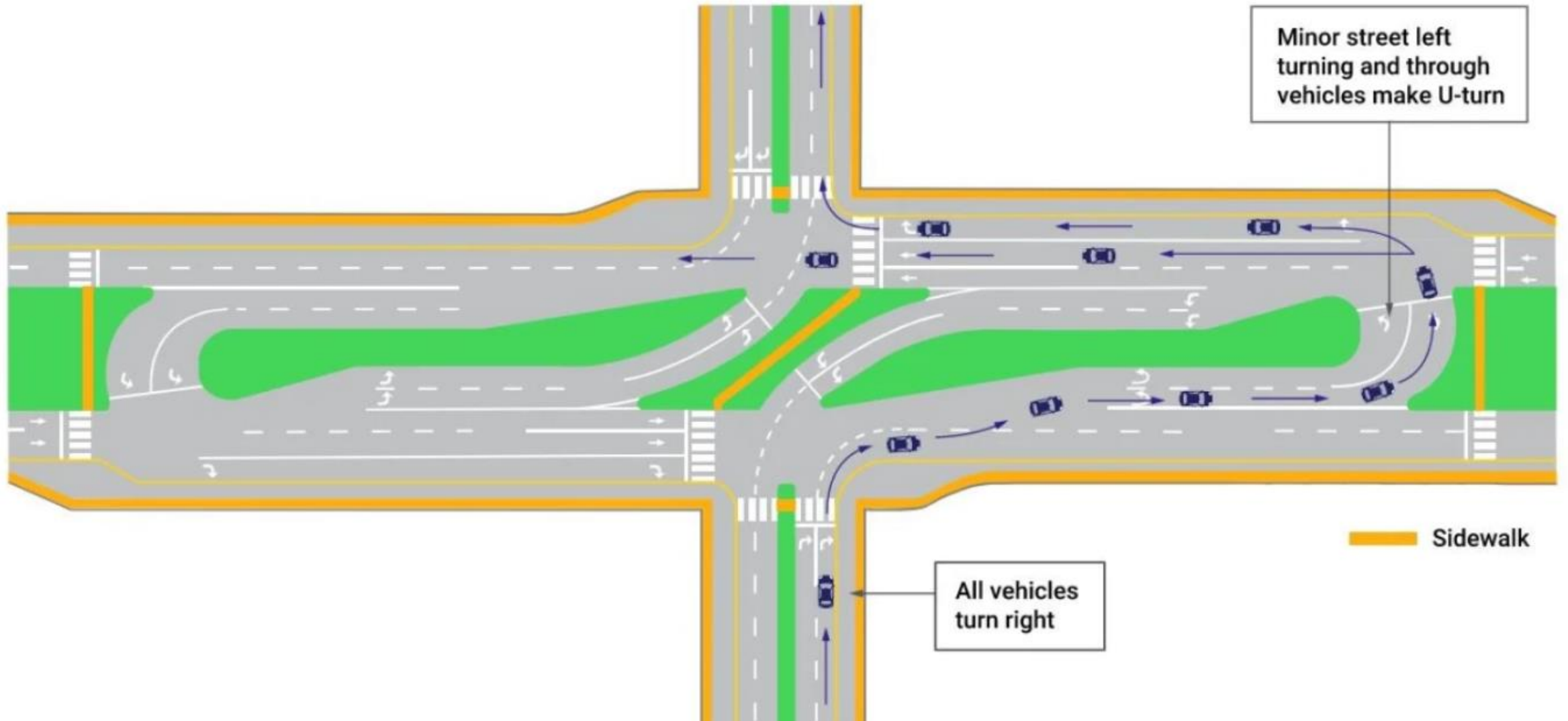
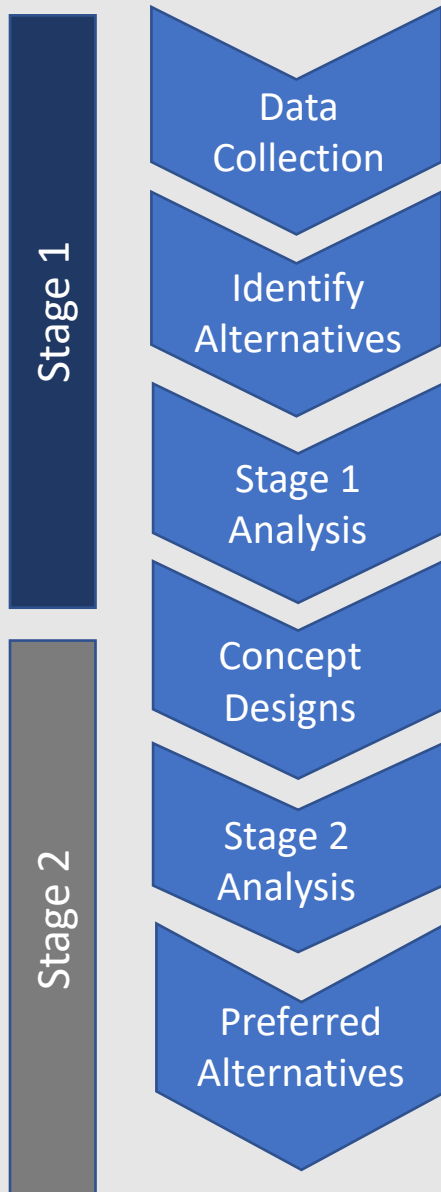


Figure Source: Florida DOT

Intersection control evaluation (ICE)



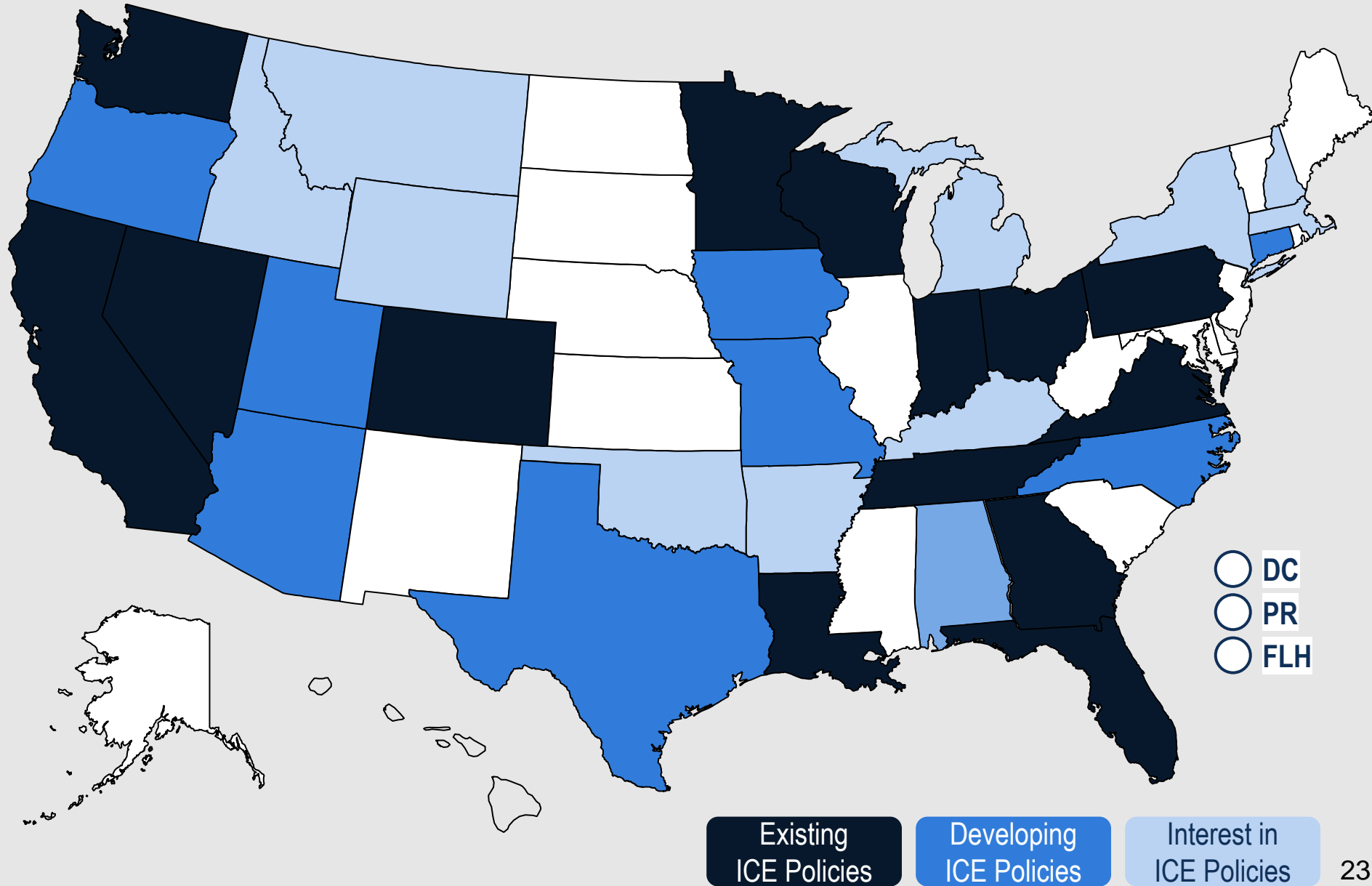
Stage I is a scoping stage

- Initially consider a full array of options
- Use screening tools that consider operational and safety goals, project needs, and practicality
- Develop a short list of alternatives that merit further consideration & analysis to be carried into Stage II

Stage II is an alternative development & selection stage

- Objectively differentiates among the alternatives brought forward from the Stage I scoping analysis
- Preferred alternative(s) determined based on more detailed evaluations
 - Multimodal provisions
 - Safety performance
 - Operational performance
 - Lifecycle benefits and costs
 - Environmental, utility, and right-of-way impacts

ICE Policies & Guidance - 2024



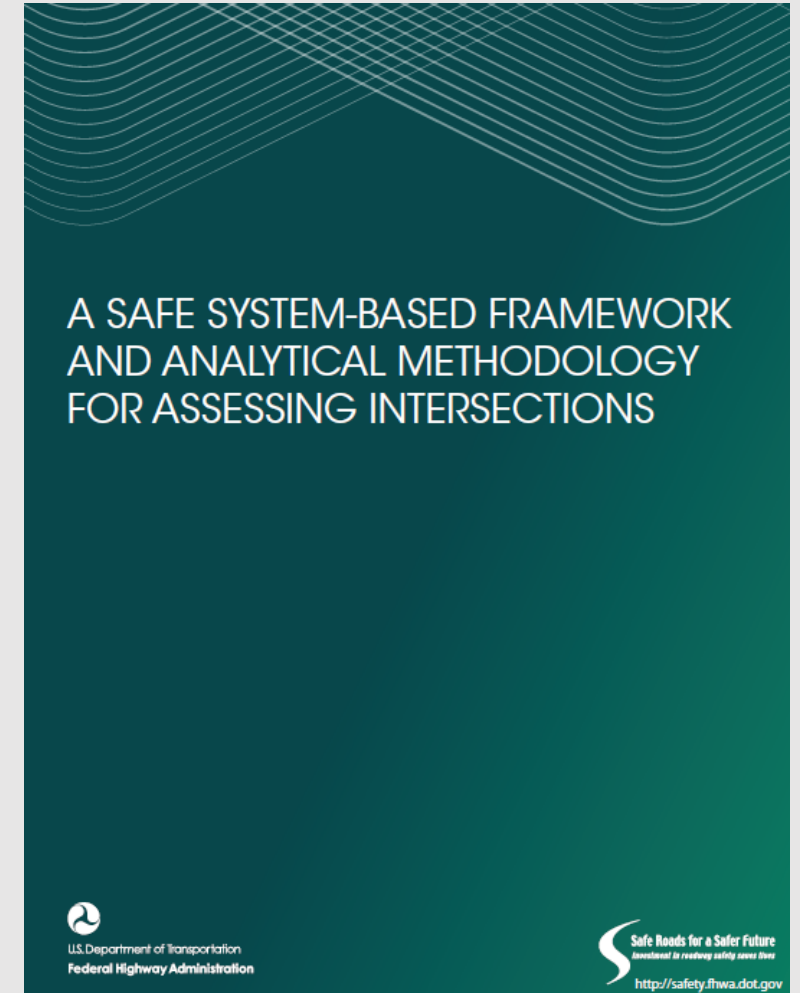
Safe System for Intersections (SSI) Framework



Objectives:

- Readily implementable
- Common project-level data inputs
- Stage I ICE (scoping phase)

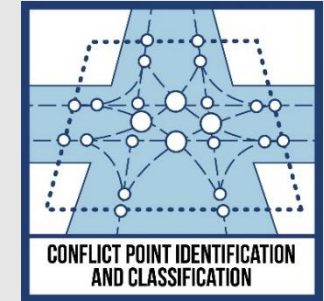
Full report and Tech Brief available at
<https://safety.fhwa.dot.gov/intersection/ssi/index.cfm>
Report Number FHWA-SA-21-008



SSI Method Overview

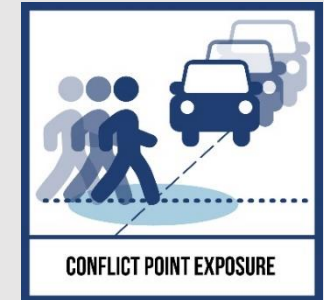
1. Conflict point identification and classification

Crossing, merging, diverging, nonmotorized



2. Conflict point exposure

Volumes (vehicular and nonmotorized)



3. Conflict point severity (probability of FSI)

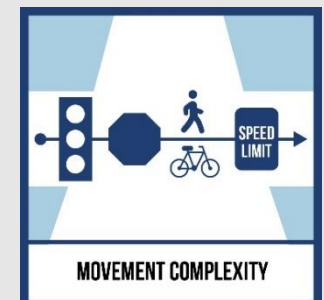
Vehicle-vehicle: speeds and conflict angles

Nonmotorized: speeds



4. Movement Complexity

- Conflicting traffic
- Traffic control devices
- Additional complexity for nonmotorized users



SPICE FDOT V5.1.1

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
Safe System for Intersection (SSI) Inputs																	
<i>Specify the geomtric, exposure, severity, and conflicting traffic complexity inputs required for an SSI analysis.</i>																	
1. Roadway Geometry					Lanes	Major Street Designation							Required Inputs				
Major number thru lanes (one direction)						Select major street direction					N-S		Default Available, Override Optional				
Minor number thru lanes (one direction)						Median Presence on Major Road							Planning-Level Default Input				
						Median Presence on Minor Road							Computed Value, Override Optional				
2. Complete the "Exposure" inputs. These inputs will apply to all interesections selected for analysis.																	
3. Complete the "Severity" inputs																	
4. Complete the "Conflicting Traffic Complexity" inputs																	
2. Exposure - All Intersections																	
Average Daily Traffic (veh/day)			Open	Design	ADT Directional Split			Nonmotorized Total ADBP (ped-bike/day)			Activity Level						
Major			==	==	Major			0.50			Open Year Total Intersection NM			Low (20)			
Minor			==	==	Minor			0.50			Design Year Total Intersection NM			Low (20)			
Are turning movement ADT values available?						If "Yes", input values in Table 2-A					<i>(or overwrite ped movement ADBPs below)</i>						
Are peak hour turning movement counts available?						If "Yes", input values in Table 2-B					Nonmotorized Movement ADBP (ped-bike/day)			Open			
If no turning movment volumes or counts are available, a user can optionally override the planning-level default turning movment proportions in Table 2-C										Major NM 1 (NM mvmt crossing Maj1)			5				
										Major NM 2			5				
										Minor NM 1			5				
										Minor NM 2			5				
Table 2-A: Turning Movement (vol/day)				Table 2-B: Turning Movement Counts (Optional)				Table 2-C: Turning Proportions (optional)									
		Open	Design			Mvmt	AM Peak	AM %	PM Peak	PM %	Avg %						

“Design Flags”



RED Flags: for design elements directly related to a SAFETY concern for pedestrians or bicyclists

Yellow Flags: for design elements negatively affecting USER COMFORT (i.e., increasing user stress) or the QUALITY of the walking or cycling experience.

Design Principles for Ped Facilities

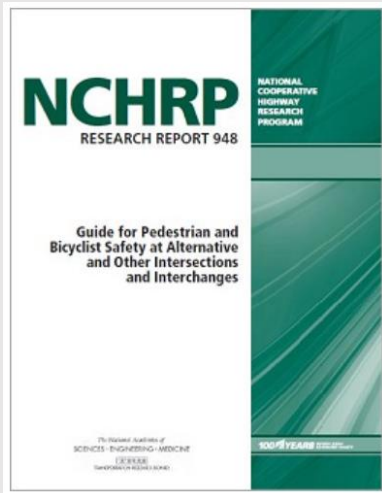
- Pedestrian Routing and Delay



- Provide a highly visible and coherent route;
- Consider pedestrian desire lines and reducing out-of-direction travel
- Minimize the use of multistage crossings unless a multistage crossing can reduce delay or eliminate crossings of high-volume, free-flow ramps;
- Minimize pedestrian exposure to high-speed and/or high-volume traffic movements.

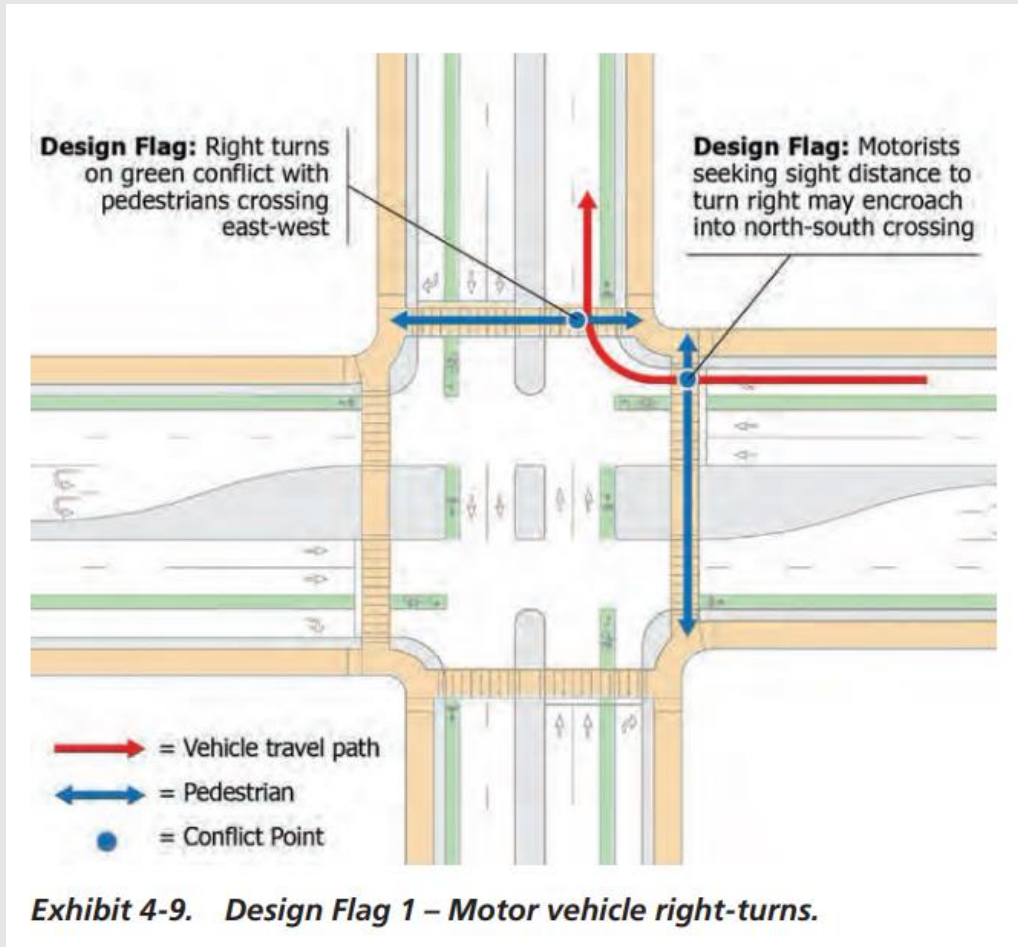
Design Principles for Ped Facilities

Minimizing Conflicts w/ Motor Vehicles



- Maximize visibility between pedestrians and motorists;
- Reduce motor vehicle speeds at conflict areas with uncontrolled or concurrent motor vehicle movements
- Separating movements in time using traffic controls.
- Separating movements in space using geometry.
- Minimizing exposure to conflicts with motorists by providing short crossing distances.
- Minimizing the speed of vehicles at conflict points.

20 Flags



Vehicle speed directly relates to pedestrian safety... Similarly, an increase in the number of vehicles turning across a pedestrian's path increases the likelihood of the pedestrian to encounter a vehicle while crossing. Turning speeds less than or equal to 20 mph and vehicle volumes less than or equal to 50 veh/h are therefore given a yellow flag, while a turning speed or volume beyond these thresholds increases the safety risk for the pedestrian and results in a red flag.

Exhibit 4-10. Design Flag 1 – Yellow- and red-flag thresholds.

Flag	Applicable Mode	Measure of Effectiveness	Yellow-Flag Threshold*	Red-Flag Threshold*
Motor Vehicle Right-Turns	Pedestrian	Vehicle Turning Speed & Vehicle Volume	<=20 mph AND <= 50 veh/h	>20 mph OR >50 veh/h

Note: mph = miles per hour; veh/h = vehicles per hour

* If the vehicle movement is stop-controlled or signalized (with no right-turns-on-red), or speeds are below 10 mph (e.g., through a raised crosswalk) this flag is eliminated.

20 Flags

Exhibit 4-5. Summary of design flags pedestrian and bicycle assessment.

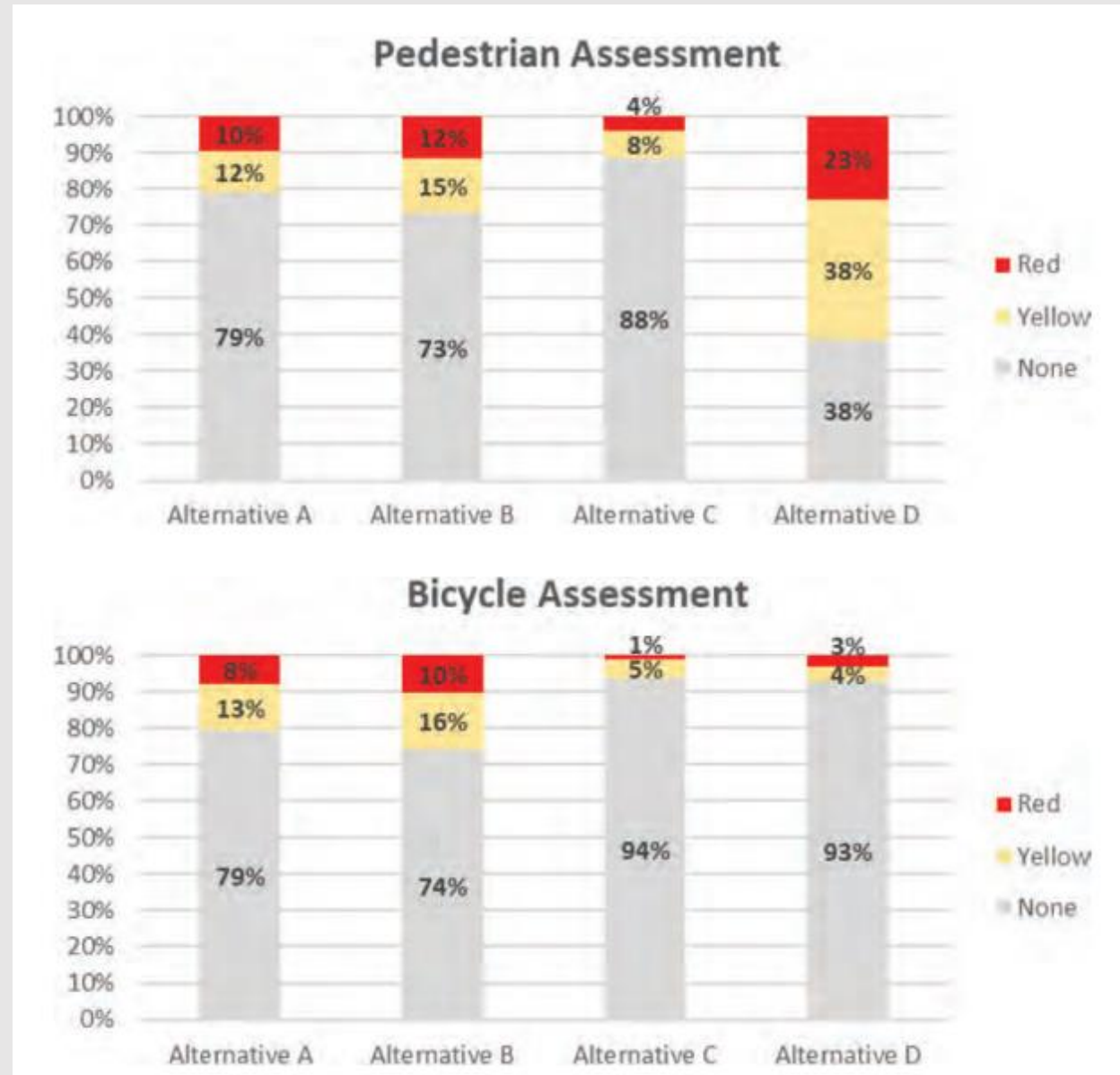
Sec.	Design Flag	Bikes	Peds.	Flag Type	Flag Description
4.4.1	Motor Vehicle Right-Turns		X	Y/R	Permissive motor vehicles right-turns across pedestrian paths
4.4.2	Uncomfortable/Tight Walking Environment		X	Y	Pedestrian facilities of narrow width
4.4.3	Nonintuitive Motor Vehicle Movements		X	Y/R	Motor vehicle movements arriving from an unexpected direction
4.4.4	Crossing Yield- or Uncontrolled Vehicle Paths	X	X	Y/R	Yield or uncontrolled pedestrian crossings
4.4.5	Indirect Paths	X	X	Y/R	Paths resulting in out-of-direction travel
4.4.6	Executing Unusual Movements	X	X	Y	Movements that are unexpected given local context
4.4.7	Multilane Crossings	X	X	Y/R	Crossing distances of significant length across multiple lanes
4.4.8	Long Red Times	X	X	Y/R	Excessive stopped delay at signalized crossings
4.4.9	Undefined Crossings at Intersections	X	X	Y	Unmarked paths through intersections
4.4.10	Motor Vehicle Left-Turns	X	X	Y/R	Permissive and protected left-turns across pedestrian and bicycle paths

4.4.11	Intersection Driveways and Side Streets	X	X	Y/R	Driveways or streets within intersection area of influence
4.4.12	Sight Distance for Gap Acceptance Movements	X	X	R	Providing adequate sight distance to conflict points
4.4.13	Grade Change	X	X	Y/R	Vertical curves adjacent to intersections
4.4.14	Riding in Mixed Traffic	X		Y/R	On-street bicycle facilities on high-speed/volume roads
4.4.15	Bicycle Clearance Times	X		Y/R	Bicycles require longer clearance times than vehicles at signals
4.4.16	Lane Change Across Motor Vehicle Travel Lane(s)	X		Y/R	Lane changes by bicycles across motor vehicle lanes
4.4.17	Channelized Lanes	X		Y/R	Bicyclist Traveling in Channelized Lane Adjacent to Motor Vehicles
4.4.18	Turning Motorists Crossing Bicycle Path	X		Y/R	Lane changes by motor vehicles across bicycle facility
4.4.19	Riding between Travel Lanes, Lane Additions, or Lane Merges	X		Y/R	Bicycle lanes with motor vehicle lanes on both sides
4.4.20	Off-Tracking Trucks in Multilane Curves	X		Y/R	The tendency of trucks to swing into bicycle lanes while turning

Note: Sec. = Section in this Guide; Peds. = Pedestrians; X = Applicable to this mode; Y = Yellow; R = Red

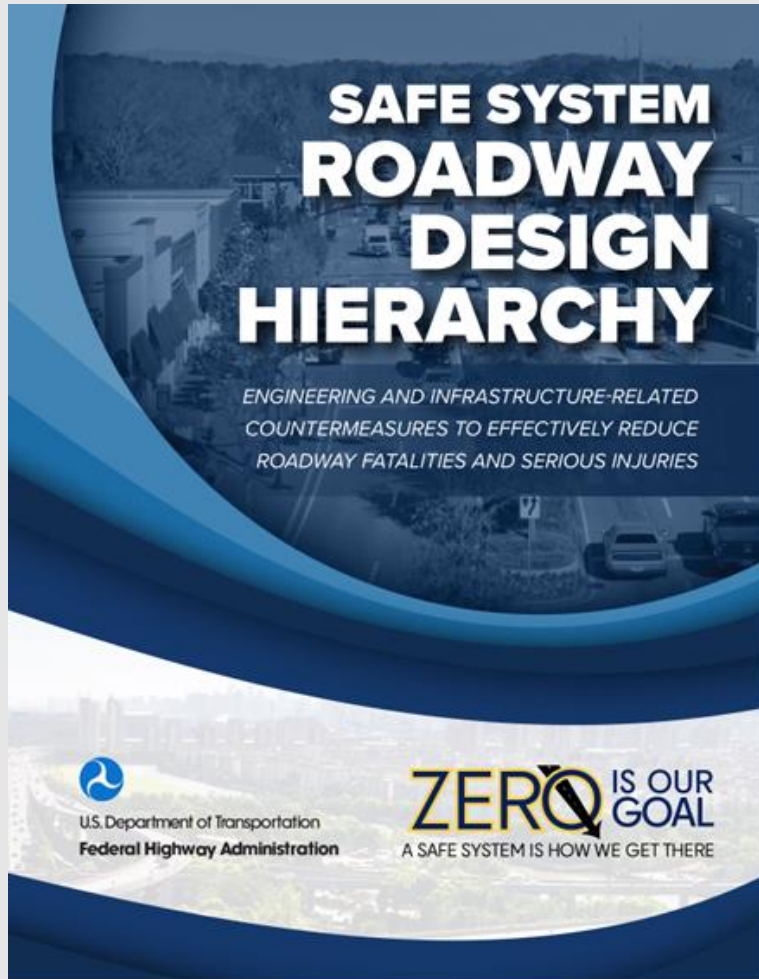
Source: NCHRP 948

20 Flags



Source: NCHRP 948

Safe System Roadway Design Hierarchy



“The purpose of the hierarchy is to help transportation agencies and practitioners identify and prioritize countermeasures and strategies when developing transportation projects.”



Roundabouts Save Lives!

- TIER 1 REMOVE SEVERE CONFLICTS**
- TIER 2 REDUCE VEHICLE SPEEDS**

Live, Work, and Explore Along the Rural Road to Zero

Roundabouts on rural roads:

Reduce all speeds to between 15 to 25 mph

Reduce severe injury crashes by **88%**

Source: Federal Highway Administration (FHWA) Roundabouts & Rural Highways <https://safety.fhwa.dot.gov/intersection/roundabouts/fhwasa14097.pdf>

U.S. Department of Transportation
Federal Highway Administration

U.S. Department of Transportation
Federal Highway Administration

OFFICE OF SAFETY
Proven Safety Countermeasures

Roundabouts

The modern roundabout is an intersection with a circular configuration that safely and efficiently moves traffic. Roundabouts feature channelized, curved approaches that reduce vehicle speed, entry yield control that gives right-of-way to circulating traffic, and counterclockwise flow around a central island that minimizes conflict points. The net result of lower speeds and reduced conflicts at roundabouts is an environment where crashes that cause injury or fatality are substantially reduced.

Roundabouts are not only a safer type of intersection; they are also efficient in terms of keeping people moving. Even while calming traffic, they can reduce delay and queuing when compared to other intersection alternatives. Furthermore, the lower vehicular speeds and reduced conflict environment can create a more suitable environment for walking and bicycling.

Roundabouts can be implemented in both urban and rural areas under a wide range of traffic conditions. They can replace signals, two-way stop controls, and all-way stop controls. Roundabouts are an effective option for managing speed and transitioning traffic from high-speed to low-speed environments, such as freeway interchange ramp terminals, and rural intersections along high-speed roads.

Safety Benefits:
Two-Way Stop-Controlled Intersection to a Roundabout

82%
reduction in fatal and injury crashes.¹

Signalized Intersection to a Roundabout

78%
reduction in fatal and injury crashes.¹

For more information on this and other FHWA Proven Safety Countermeasures, please visit <https://safety.fhwa.dot.gov/provencountermeasures/> and <https://safety.fhwa.dot.gov/intersection/roundabouts/index.cfm>.

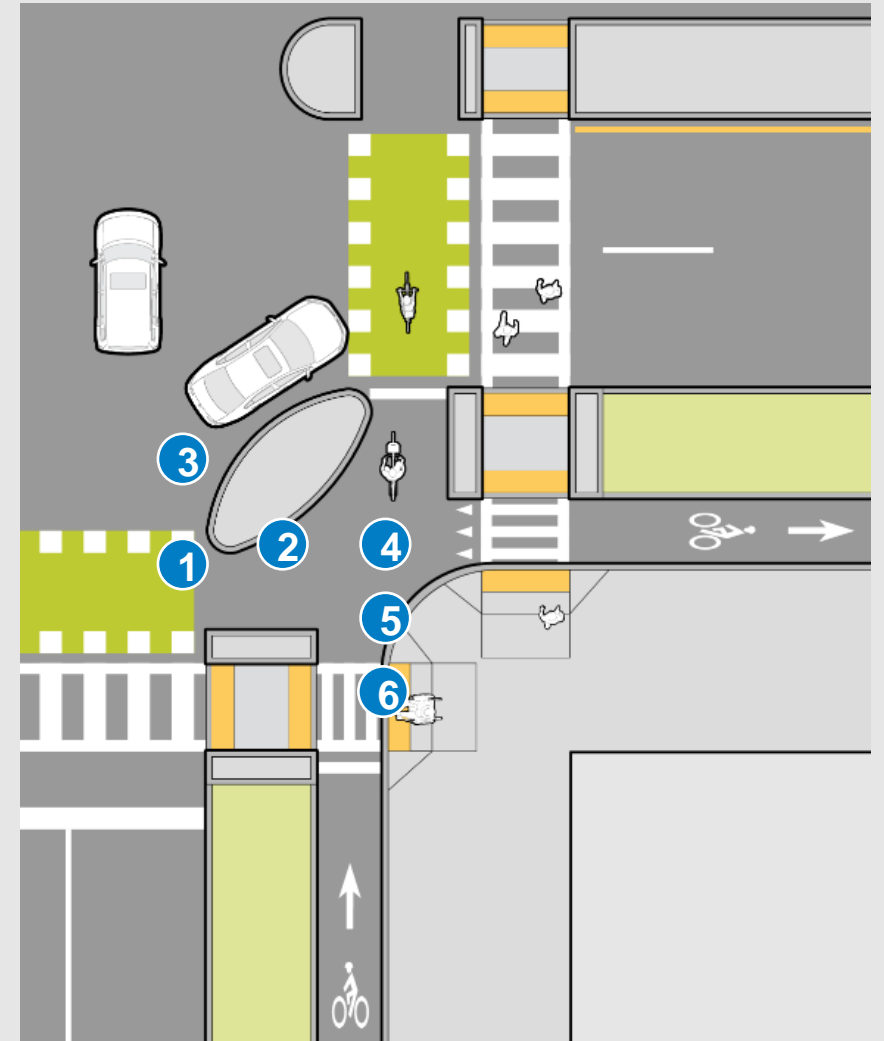
FHWA-SA-21-042

1 AASHTO, The Highway Safety Manual, American Association of State Highway Transportation Professionals, Washington, D.C., (2010).

ZERO IS OUR GOAL

Protected Intersections

- 1 Corner refuge island
- 2 Forward bicycle queuing area
- 3 Motorist yield zone
- 4 Pedestrian crossing island
- 5 Pedestrian crossing separated bike lane
- 6 Pedestrian curb ramp

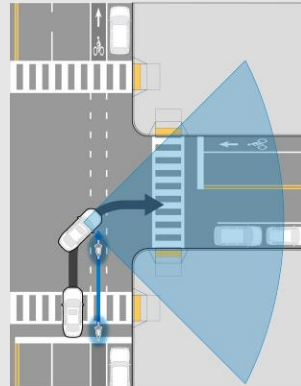


Protected Intersections

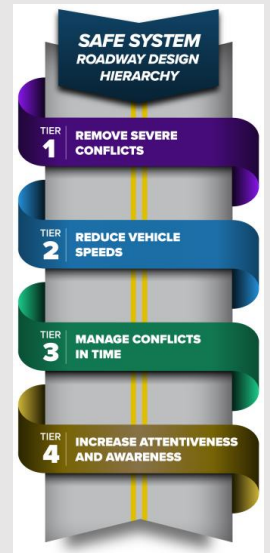
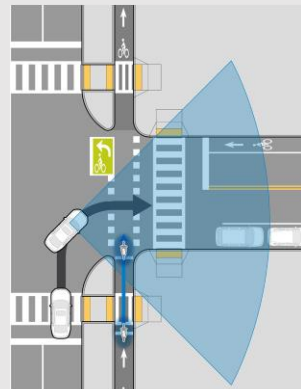


Visibility at Conflict Points

motorist's view at
conventional bike lane



motorist's view at
separated bike lane



Visibility at Conflict Points



protected intersection



photo source: Jonathan Maus

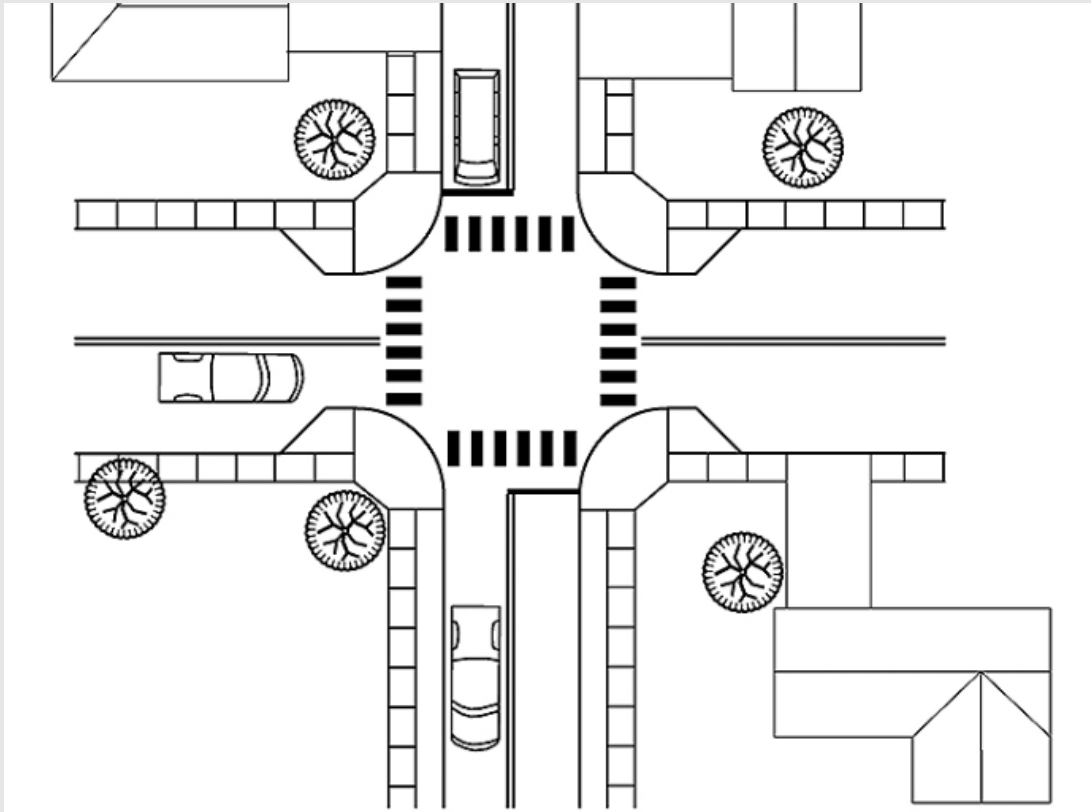
conventional bike lane



- Yielding increased from 34% to 38%
- Right-turn speeds reduced 2.6 mph

https://rosap.ntl.bts.gov/view/dot/66612/dot_66612_DS1.pdf

Corner Extensions



Source: Delaware DOT



Source: Hillary Orr



Left turn centerline hardening

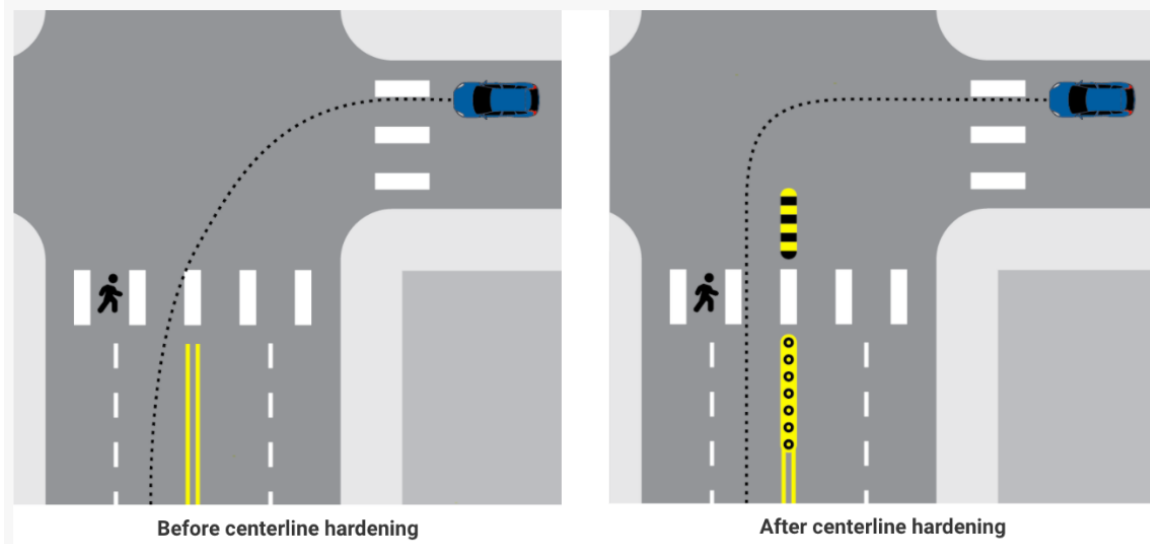


Image source: [Insurance Institute for Highway Safety](https://www.iihs.org/iihs/newsroom/2019/07/23/centerline-hardening-protects-pedestrian-from-left-turning-vehicles)



<https://ssti.us/2020/07/30/centerline-hardening-protects-pedestrian-from-left-turning-vehicles>



Leading Pedestrian Interval (LPI)



Source: FHWA

- Increased visibility of crossing pedestrians.
- Reduced conflicts between pedestrians and vehicles.
- Increased likelihood of motorists yielding to pedestrians.
- Enhanced safety for pedestrians who may be slower to start into the intersection.

Pedestrians vs Permissive Lefts



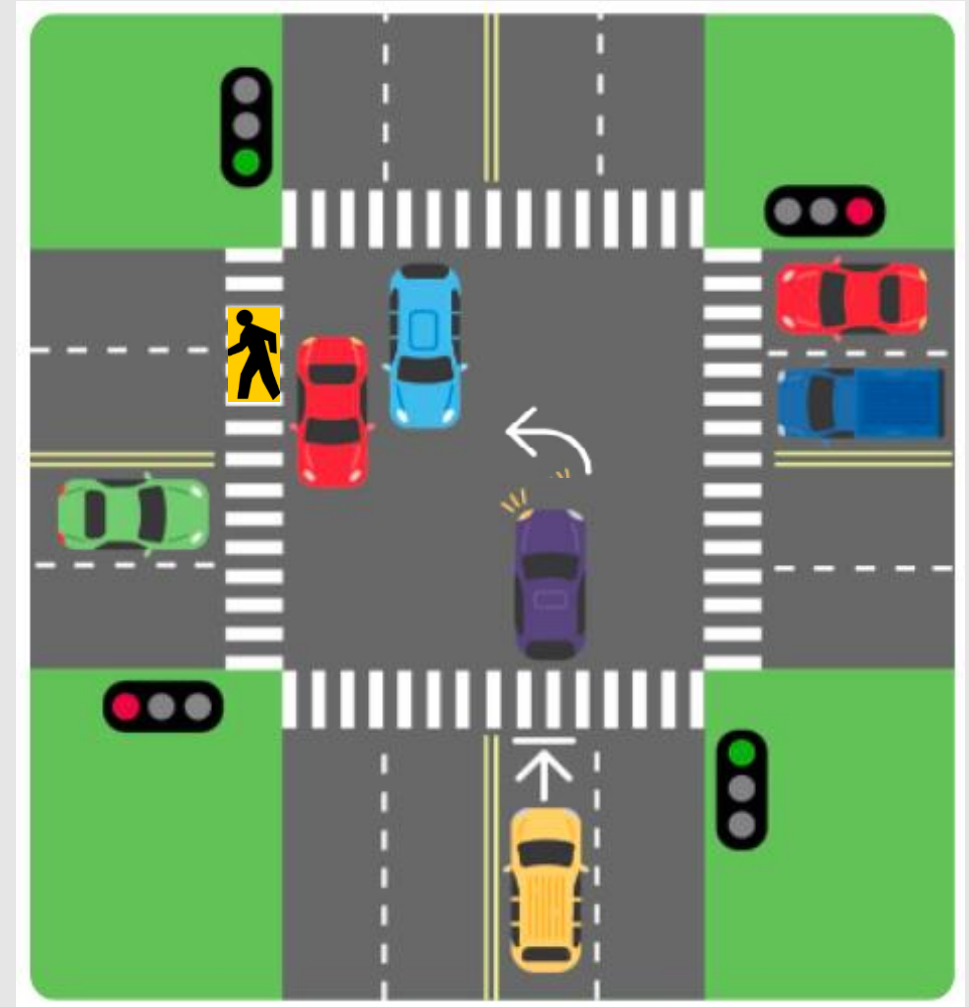
Source: FHWA.

- Left turning driver attention is focused on judging gaps in oncoming through traffic rather than looking out for pedestrians crossing the street.
- Drivers may attempt to accelerate quickly to take a short gap in oncoming traffic.
- During the left turn, the vehicle driver's line of sight is not clear, with the vehicle's A pillar concealing part of the outside view.

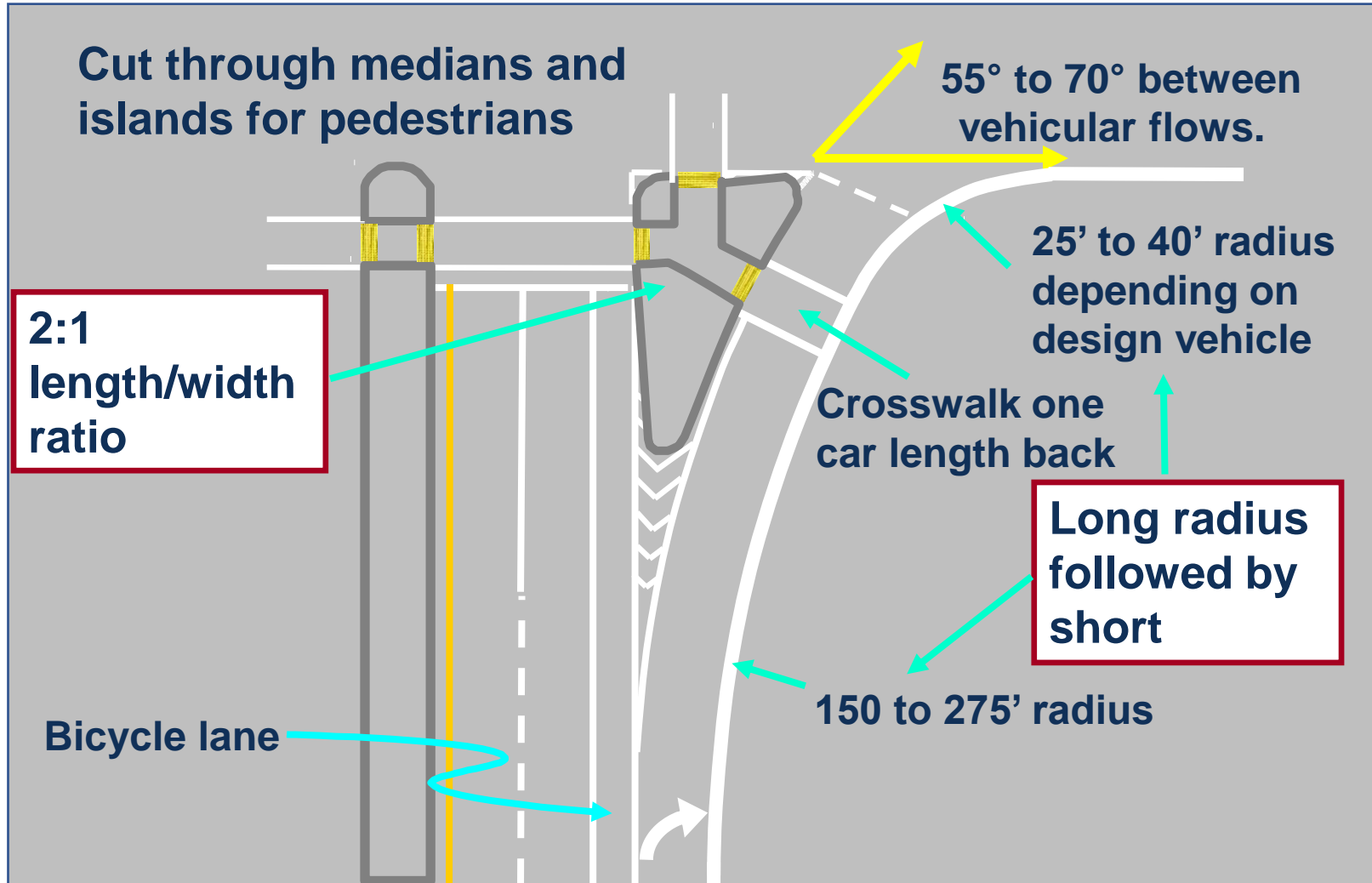
Protected Only Left Turn Signals

Consider:

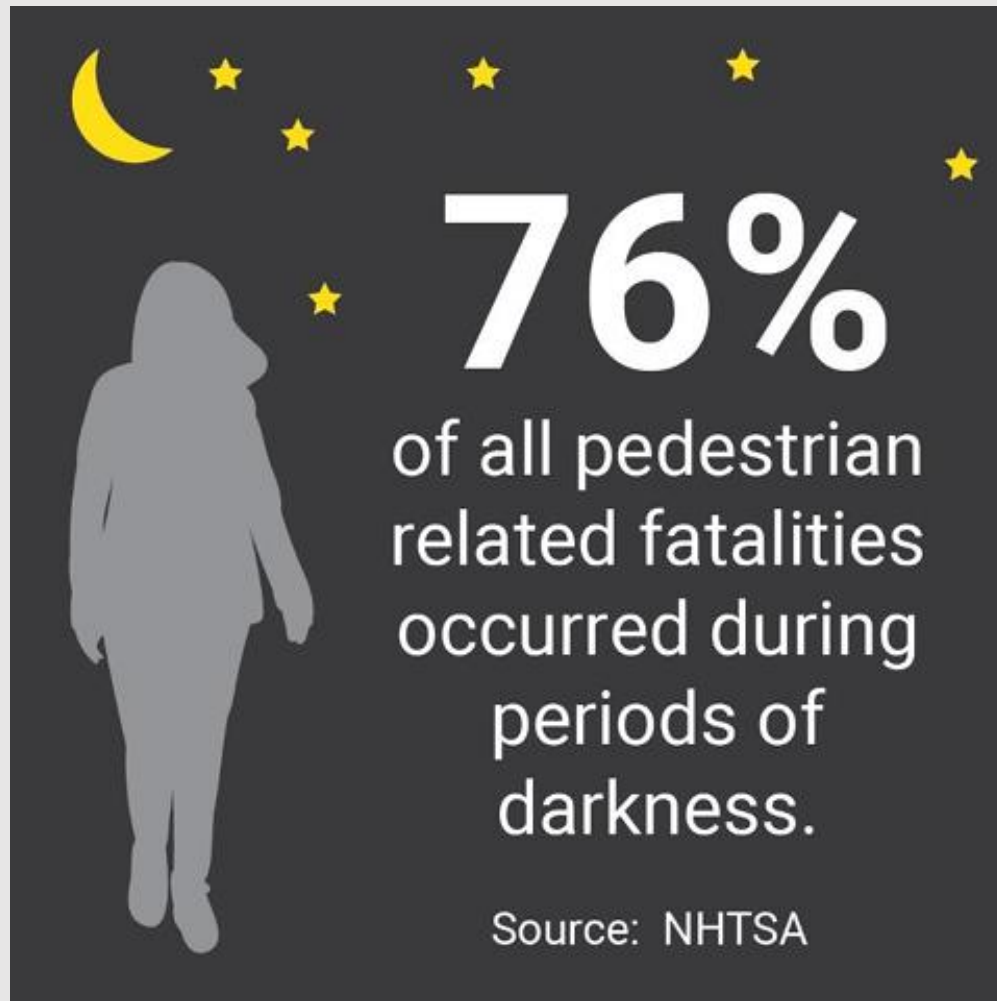
- Protected only left turn signal phasing; or
- Flashing Yellow Arrow to omit permissive movement when there is a pedestrian call



Right-Turn Slip Lanes: Design for Pedestrians



Nighttime Visibility



76%
of all pedestrian
related fatalities
occurred during
periods of
darkness.

Source: NHTSA

DANGER AT DUSK

MORE PEDESTRIANS ARE KILLED JUST AFTER SUNSET

 Street lighting can reduce all crash types and severities up to 42%.

High-visibility crosswalks can reduce pedestrian injury crashes up to 40%. 



U.S. Department of Transportation
Federal Highway Administration

Source: <http://www.cmfclearinghouse.org/>



U.S. Department of Transportation
Federal Highway Administration



FHWA Resource Center

Office of Technical Services

Mark Doctor, PE
mark.doctor@dot.gov

