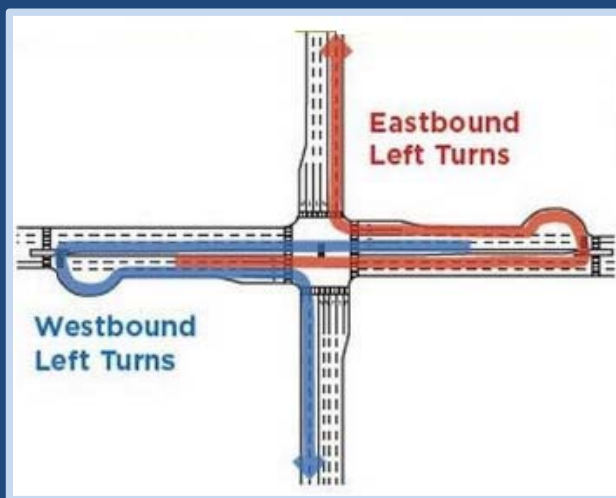
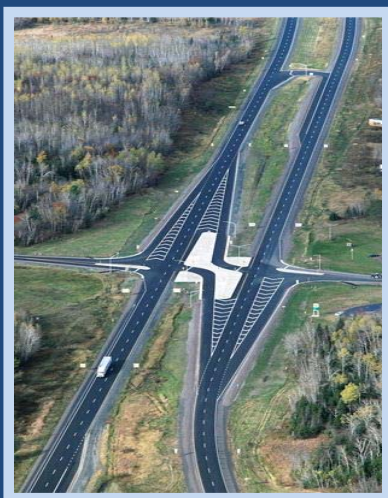




Webinar

October 18, 2017

# REDUCED LEFT-TURN CONFLICT INTERSECTIONS



PROVEN SAFETY  
COUNTERMEASURES



# PRESENTER

**Mark Doctor, PE**

**Safety & Design Engineer**

**Federal Highway Administration**

**Atlanta, GA**

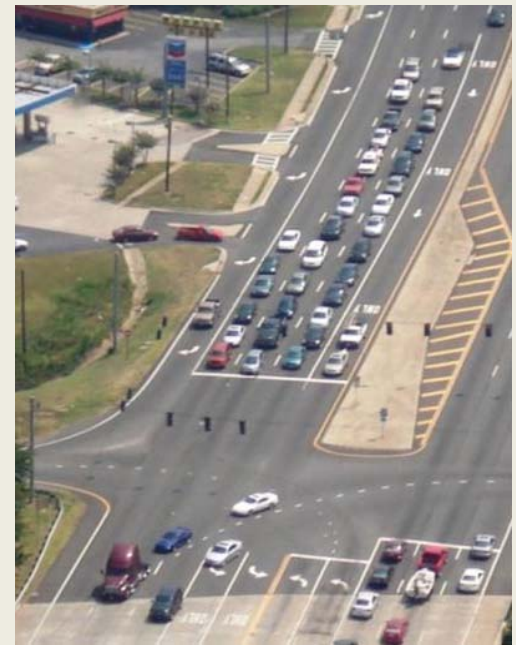
**(404) 562-3732**

**[mark.doctor@dot.gov](mailto:mark.doctor@dot.gov)**

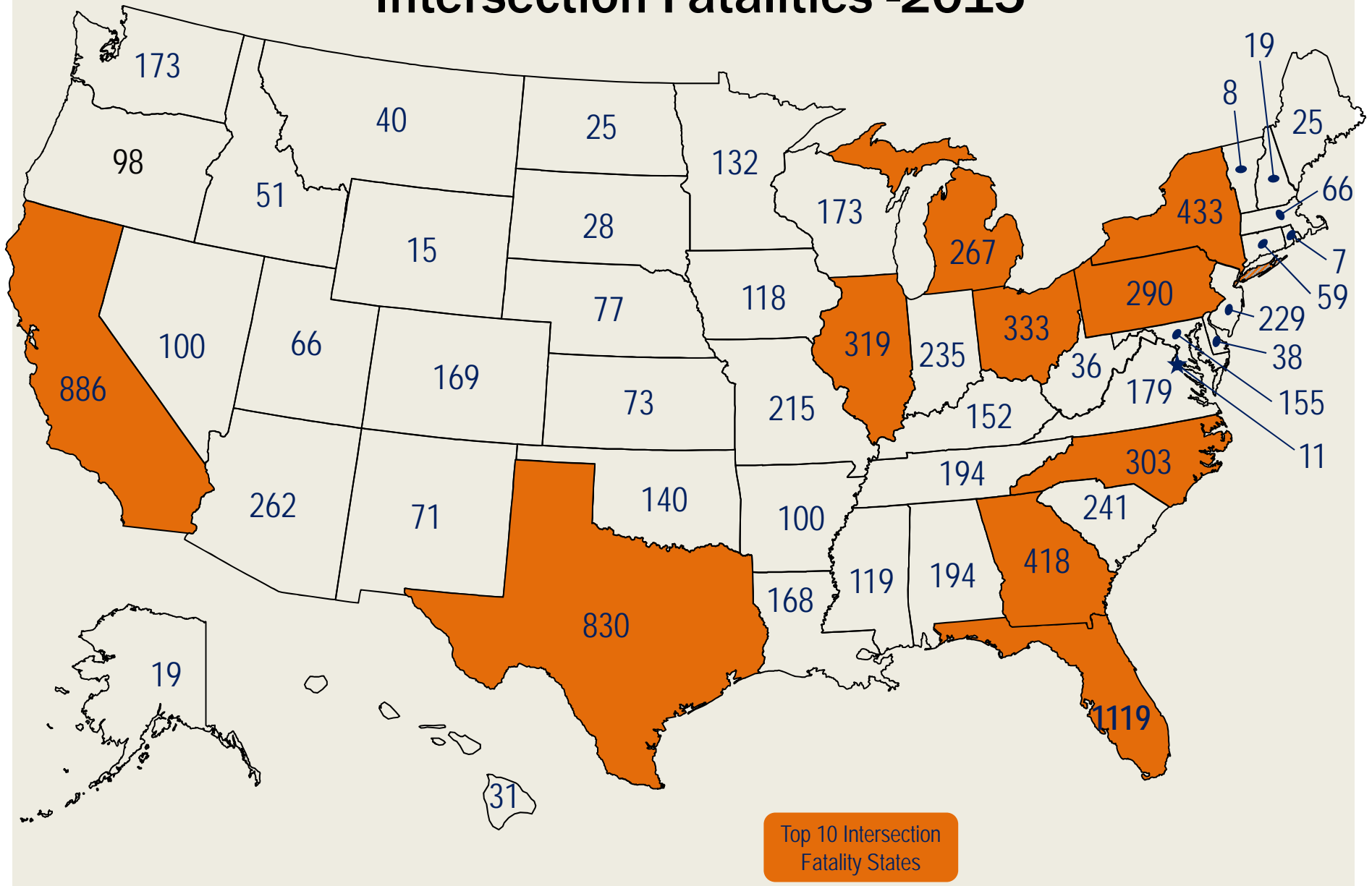


# WHAT ARE THE CHALLENGES?

- Increasing Congestion
- Too Many Crashes
- Mobility for all modes
  - Bicycles, Pedestrians, Transit
- Not Enough Funding
- Time Consuming Projects
- Inability for more right-of-way
- Impacts of projects
  - Environmental, social, economic



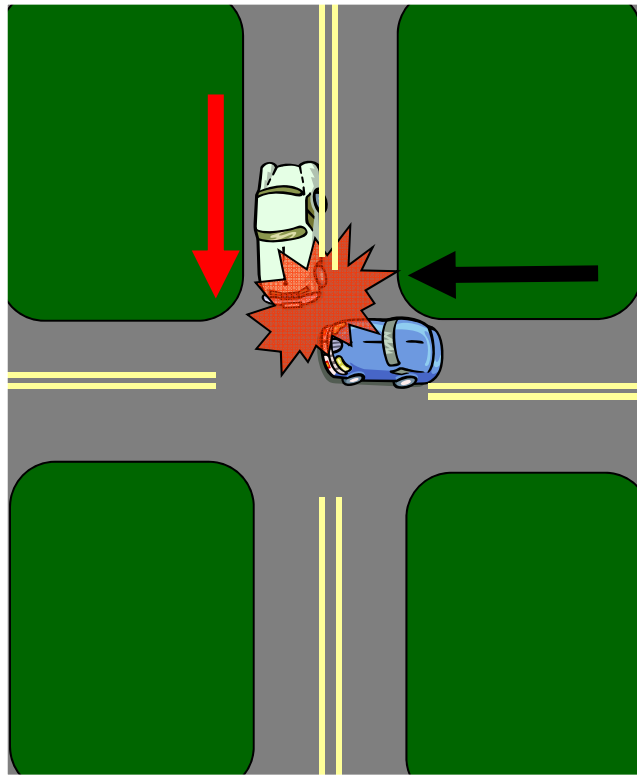
# Intersection Fatalities -2015



Top 10 Intersection Fatality States

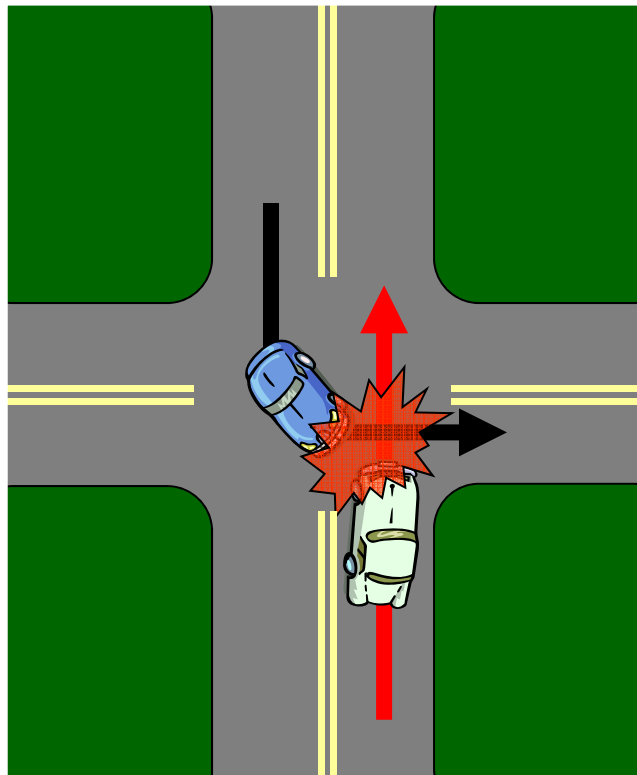
Data source: FARS (2015)

# INTERSECTION SAFETY FACTS



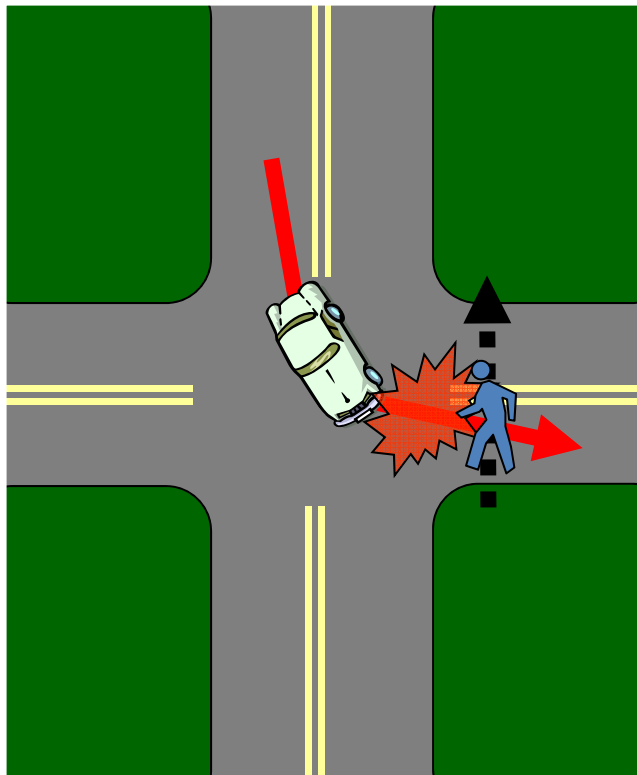
**Angle crashes account  
for over 40% of fatal  
crashes at  
intersections**

# INTERSECTION SAFETY FACTS



**Left turn crashes  
account for over 20%  
of fatal crashes at  
intersections**

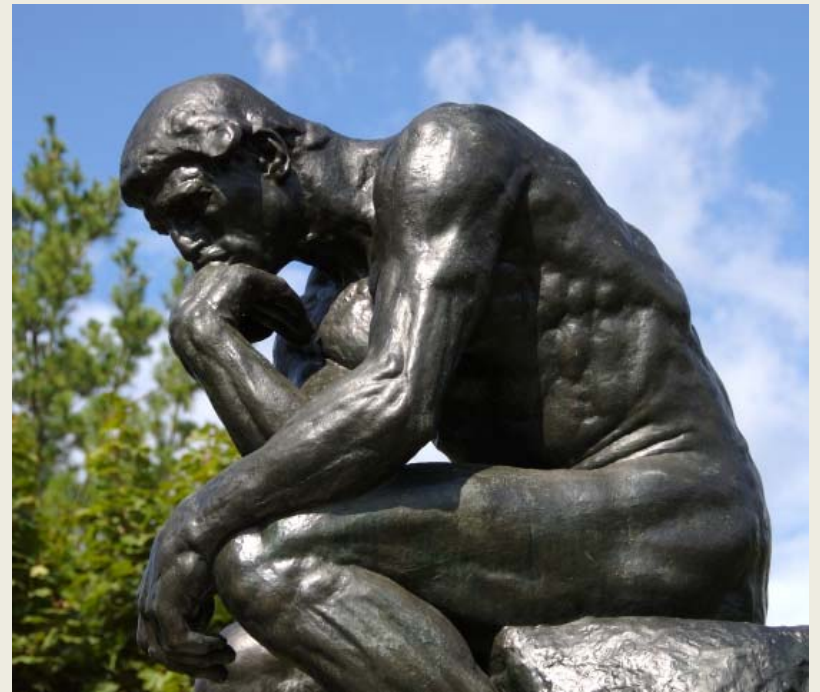
# INTERSECTION SAFETY FACTS



**Ped/Bike crashes  
account for 25% of  
fatal crashes at  
signalized intersections**

# Doctor's Postulate on Intersection Safety

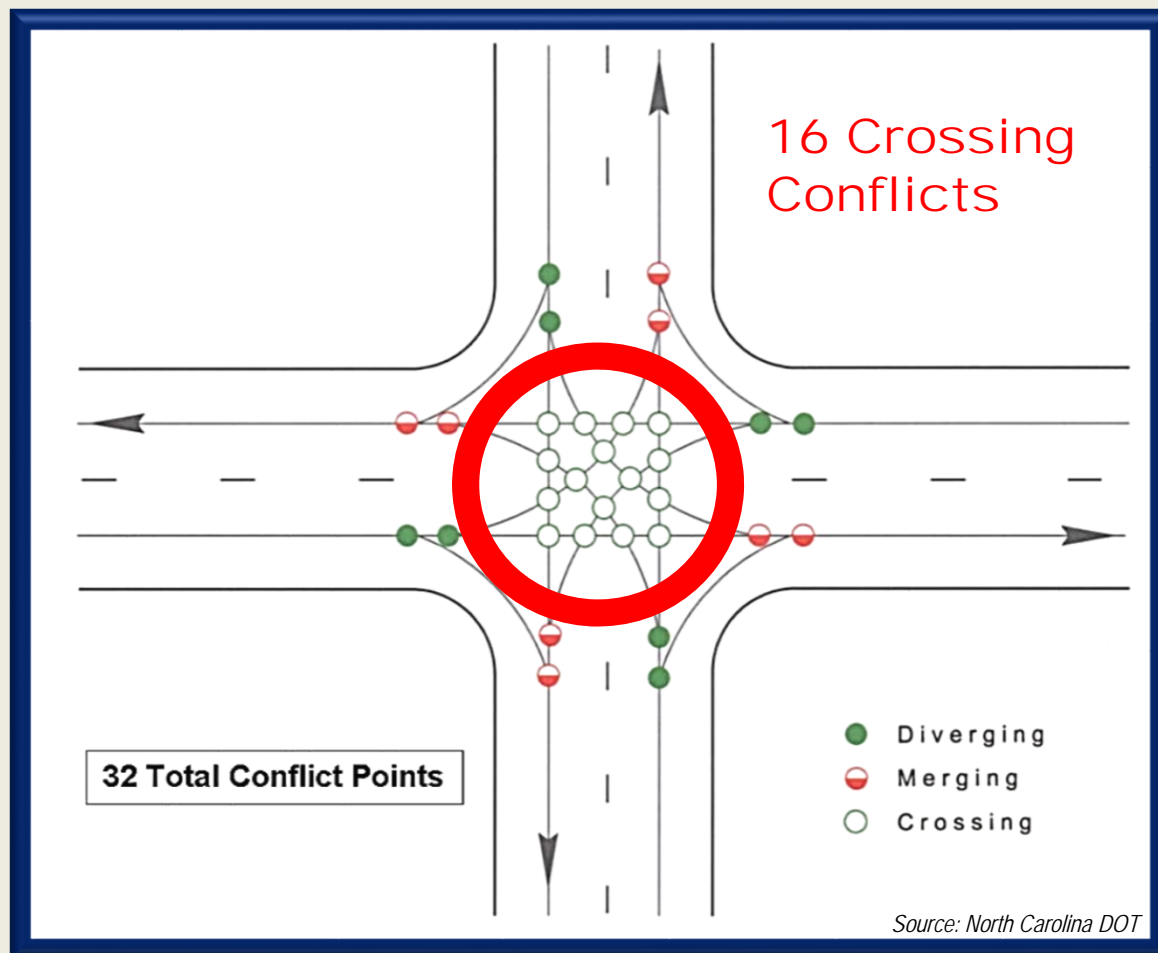
**“If you give drivers the opportunity to make a mistake, eventually they will.”**





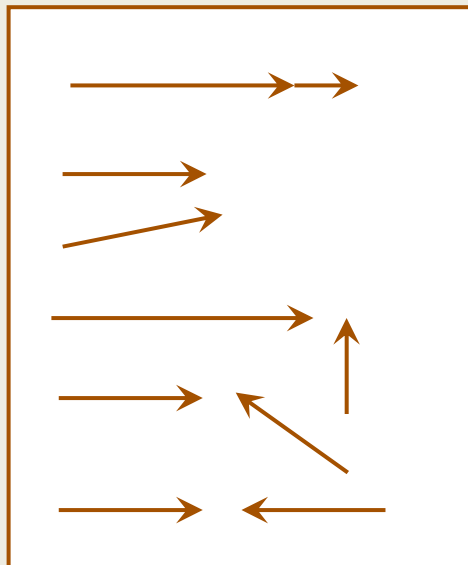
# INTERSECTION CONFLICT POINTS - VEHICLES

Crossing maneuvers occur where vehicle travel paths cross one another, merging maneuvers occur where vehicles from one traffic stream enter into another, and diverging are located at points in which vehicles depart a traffic stream.



# SAFETY AND KINETIC ENERGY

Intersection crash severity is highly influenced by speed and angle of impact



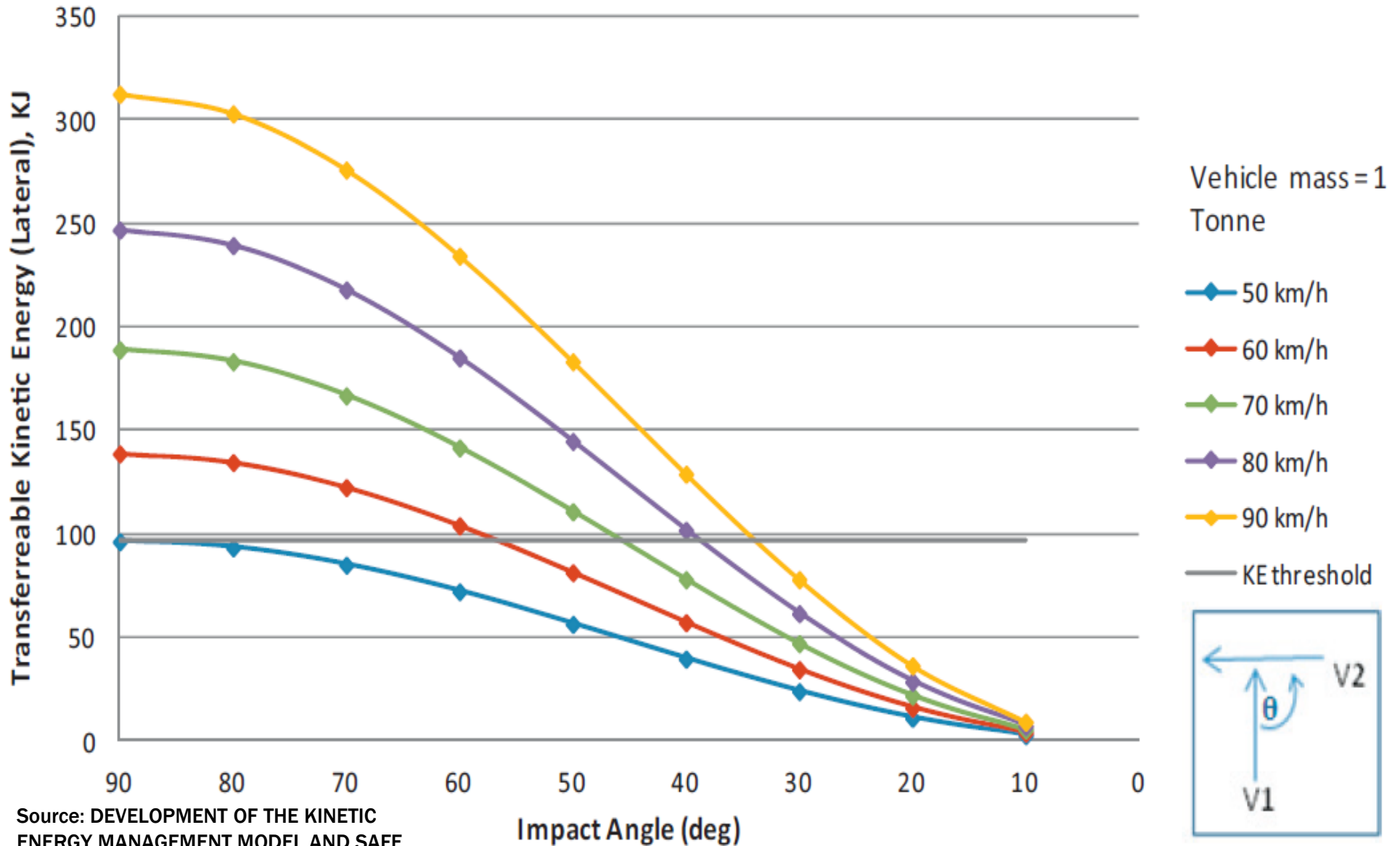
Rear-end  
Sideswipe  
Angle  
Angle  
Head-on

Least severe  
Most severe

# SAFE SYSTEM APPROACH

- Adopted by Australia, New Zealand and several Canadian Provinces
  - Based upon original Vision Zero (Sweden) & Dutch Sustainable Safety Principles
  - Key Principles:
    - Principle #1 Recognition of Human Frailty
    - Principle #2 Acceptance of Human Error
    - Principle #3 Forgive Road Environment and Crash Energy Management
    - Principle #4 Systems Approach and Shared Responsibility for Safety (Human-Vehicle-Infrastructure-Speed)
- Designing for Kinetic Energy**
- 

## Transferable Kinetic Energy (Lateral) vs Impact Angle and Travel Speed



Source: DEVELOPMENT OF THE KINETIC ENERGY MANAGEMENT MODEL AND SAFE INTERSECTION DESIGN PRINCIPLES  
MONASH UNIVERSITY (Melbourne, Australia)

Fig. 1. Influence of impact angle on transferrable kinetic energy.

Is this why roundabouts are so effective  
at reducing severe crashes?

**YES !!!**

**8**

conflict points

**75% reduction in  
Motor Vehicle conflicts**

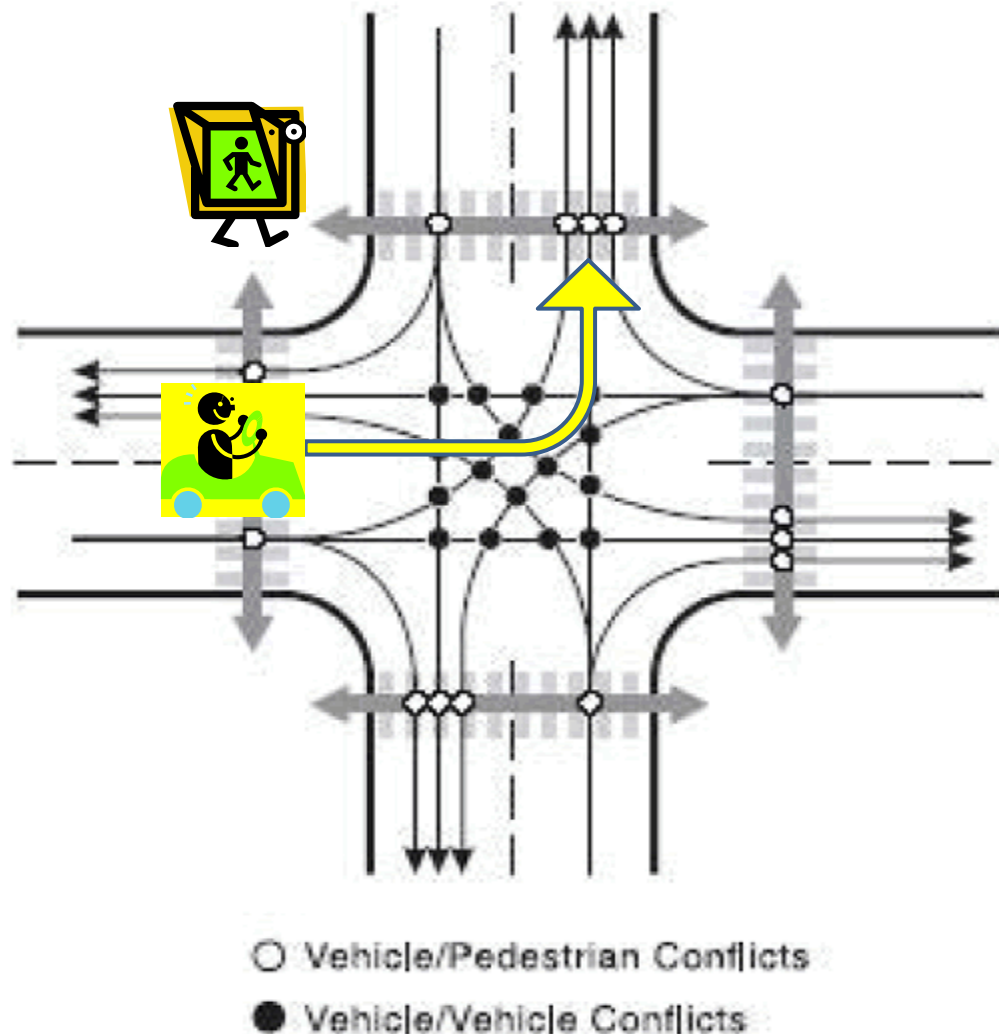
- *Low speed impacts*
- *Low angle impacts*



# INTERSECTION CONFLICT POINTS – VEHICLES/PEDS

Four vehicle/pedestrian  
conflicts per crossing

*Conflicts involving  
RTOR and  
“permissive” left turns  
can be particularly  
problematic*



## Intersections are usually the bottlenecks



**IS ADDING MORE LANES THE ANSWER?**

# BIGGER IS NOT ALWAYS BETTER

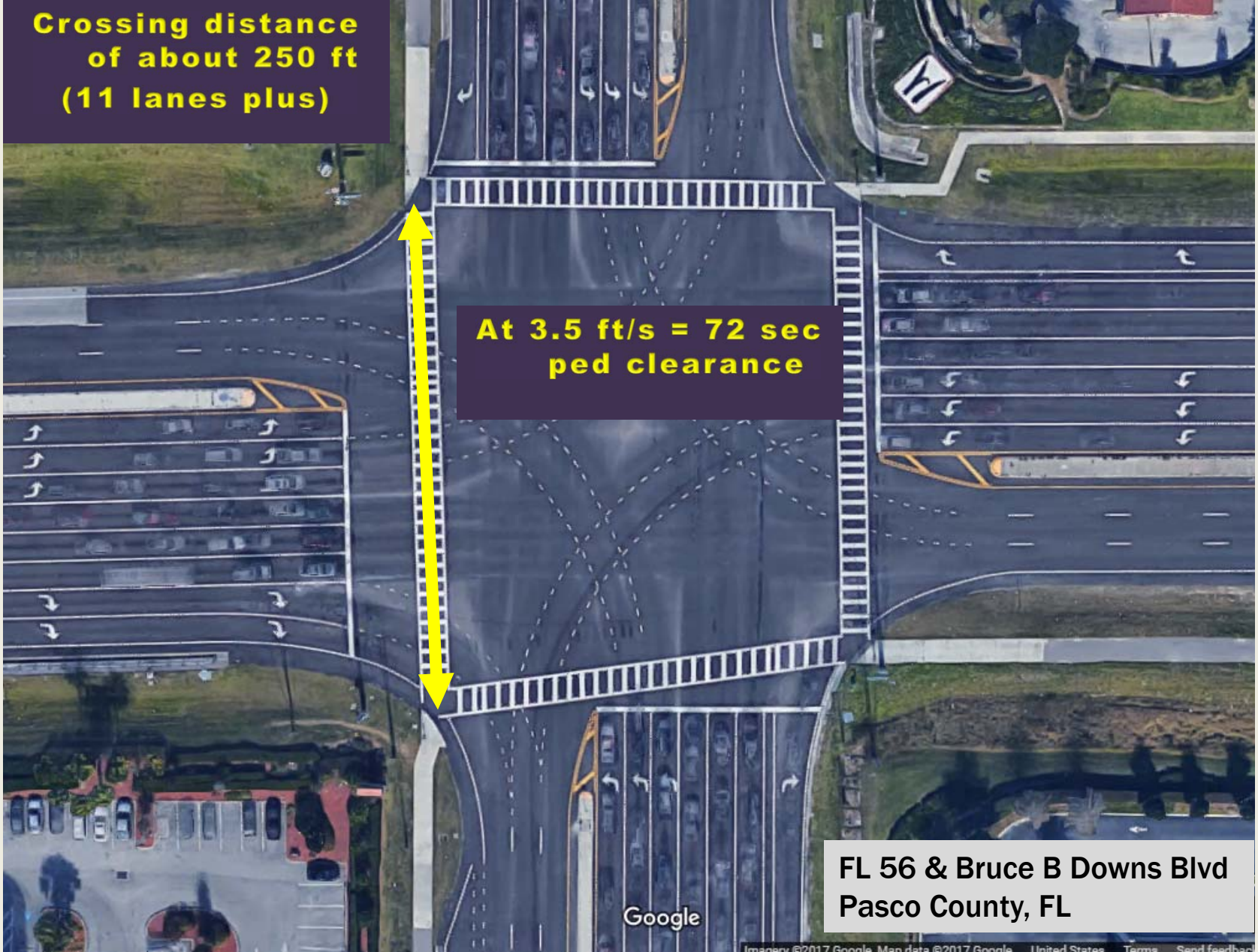




# Large Intersections increase the crossing time for pedestrians and bicycles

**Crossing distance  
of about 250 ft  
(11 lanes plus)**

**At 3.5 ft/s = 72 sec  
ped clearance**



**FL 56 & Bruce B Downs Blvd  
Pasco County, FL**

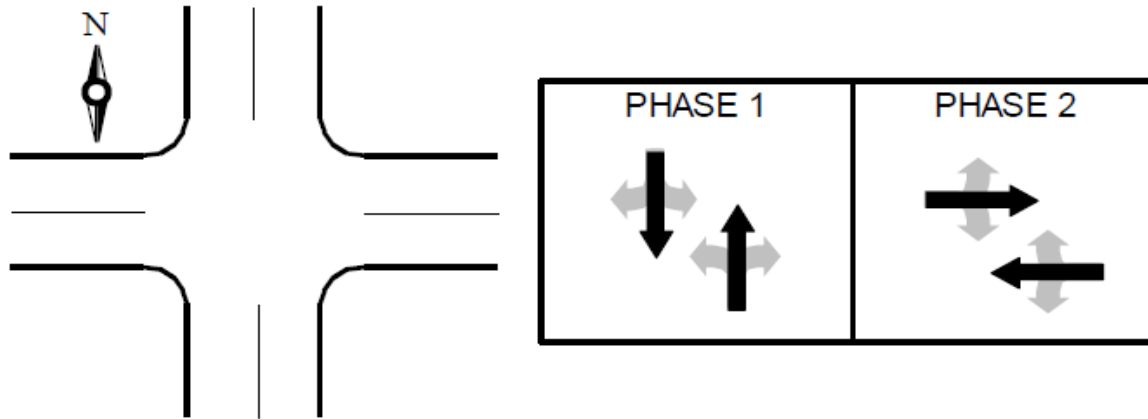
Google

**Your intersection might be too big if ...**

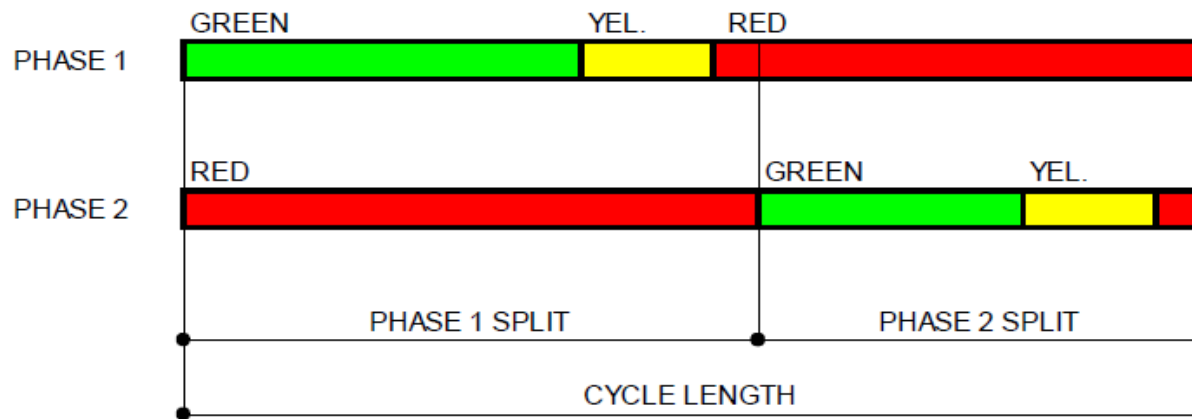


**You need 3 digits on  
the countdown timer**

# SIGNAL PHASING

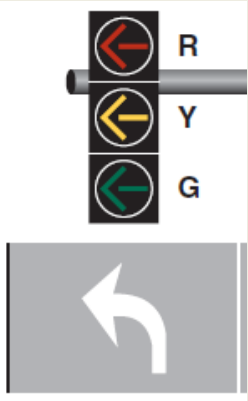


Basic two-phase signal operation

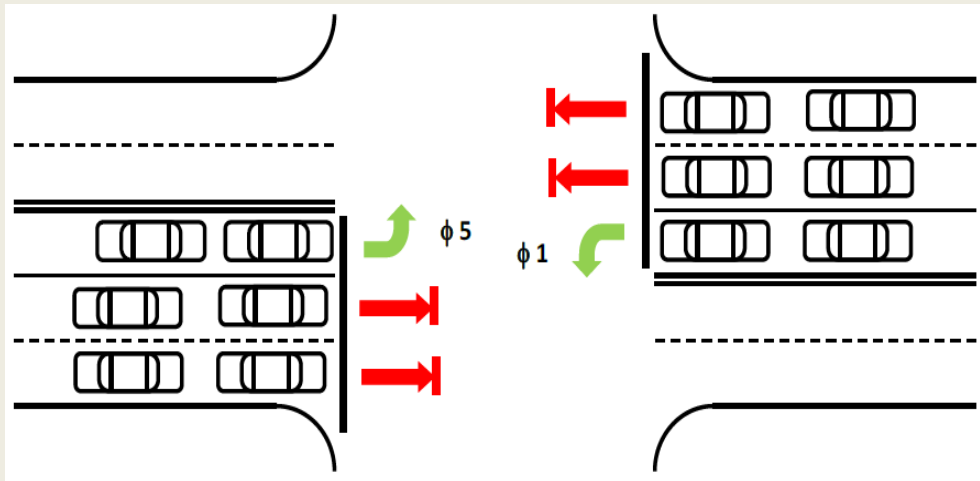
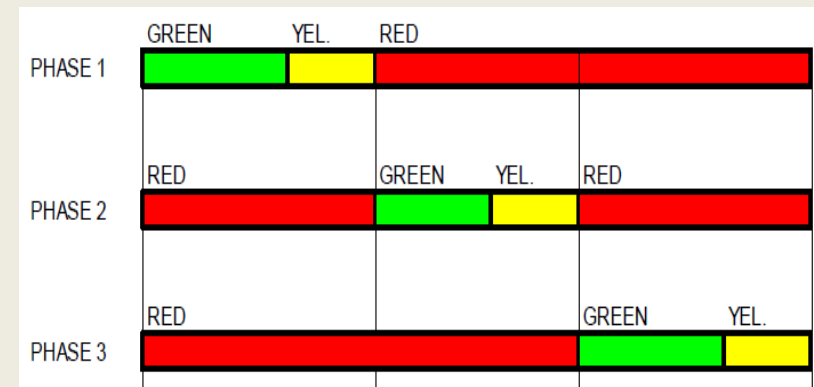
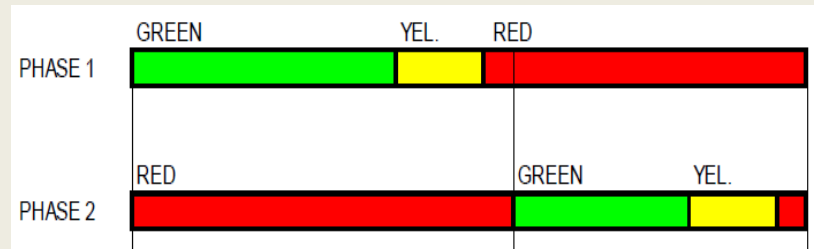


Source: MnDOT Traffic Signal Timing and Coordination Manual

# SIGNAL PHASING

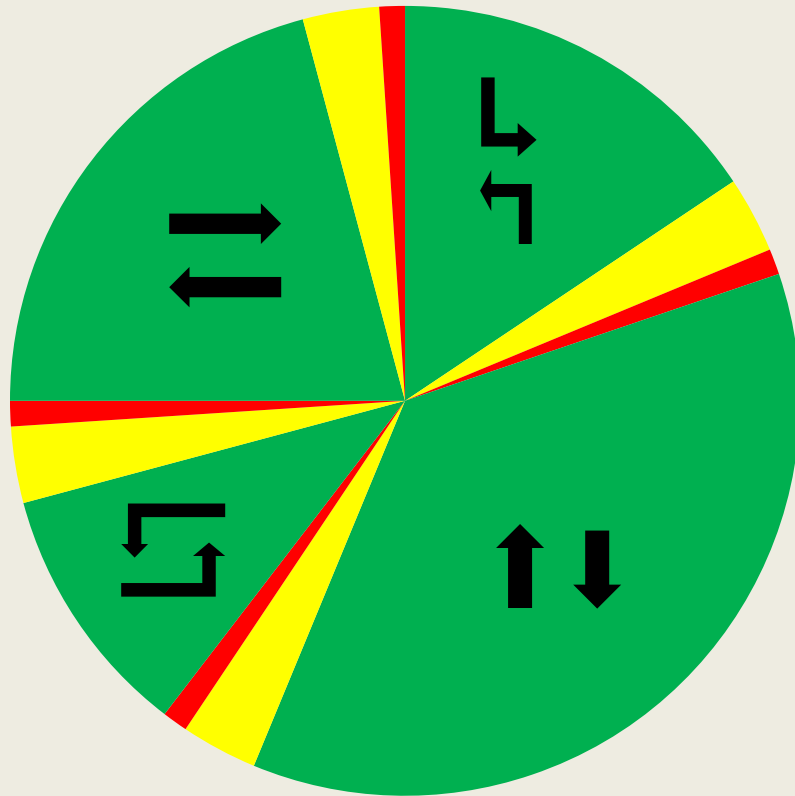


Adding “protected” left-turn phases is common as volumes increase



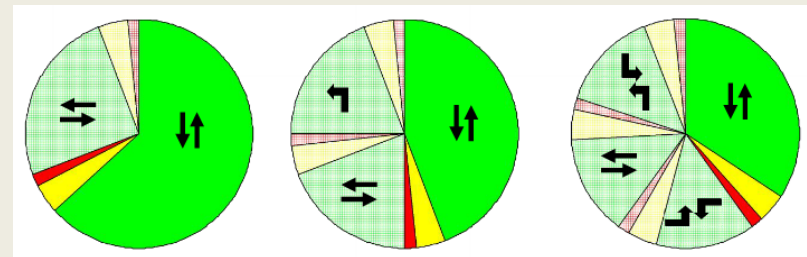
Source: MnDOT Traffic Signal Timing and Coordination Manual

# SIGNAL PHASING WITH PROTECTED LEFTS ON MAJOR AND MINOR STREETS



Fewer phases allows more time for the major through movement and decrease intersection delays

- Fewer phases also means less "lost time"



← BETTER

# SIGNAL PHASING



Strategically relocating left turn movements can provide more green time to through traffic



# IN SUMMARY ...

**Fewer phases – GOOD / Left turns - BAD**

Photo: 2-Phase operation at a Median U-turn Intersection



ALL RIGHT  
IS  
ALRIGHT

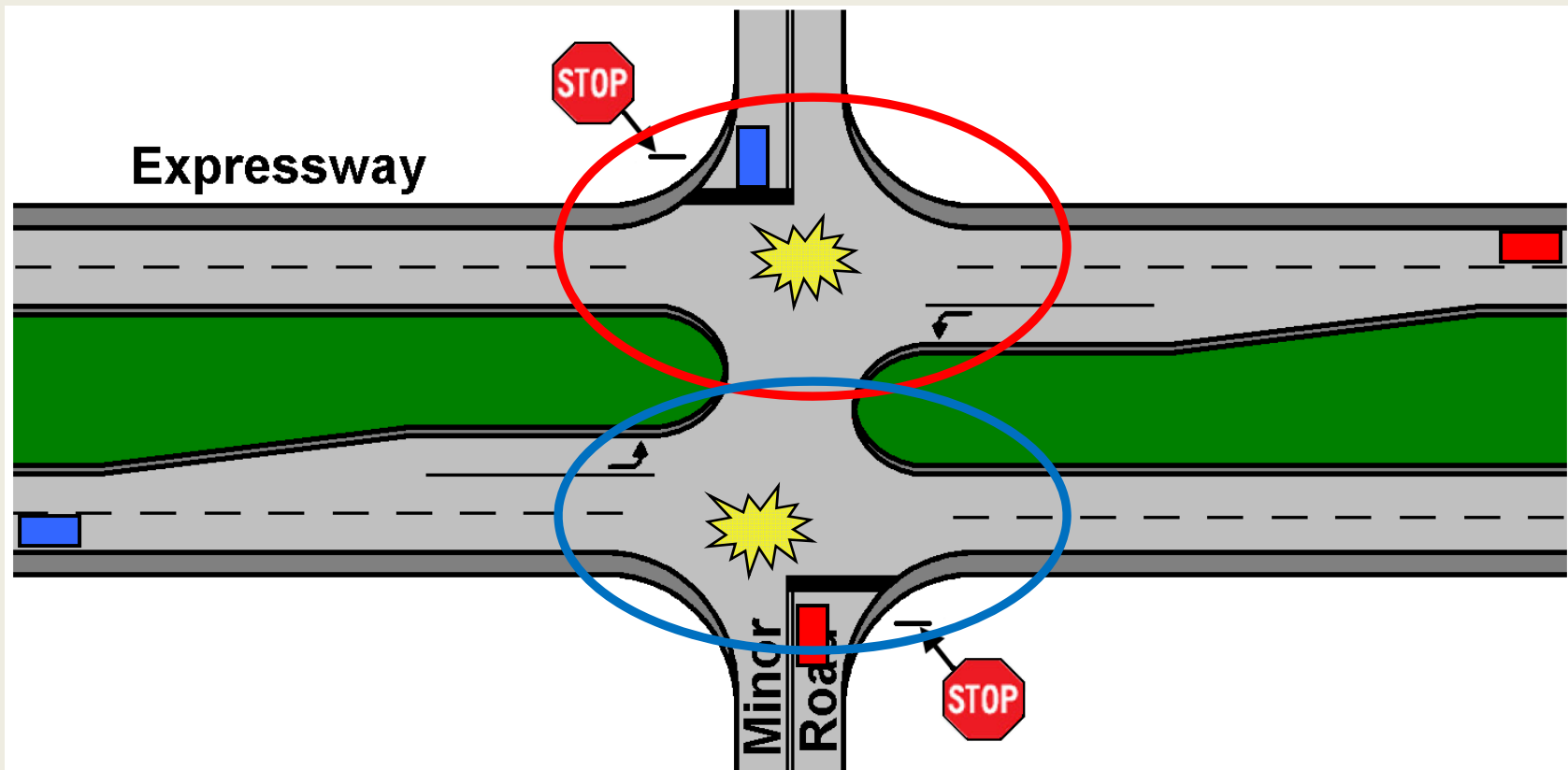
# CROSSING CONFLICTS



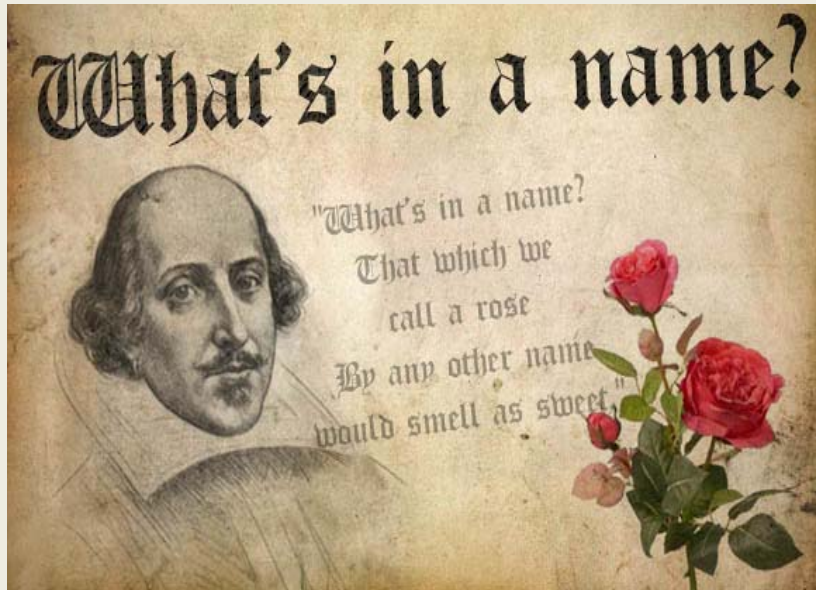


# DIVIDED HIGHWAY WITH OPEN MEDIAN

## Problem: Far-Side Right-Angle Collisions



# Restricted Crossing U-Turn (RCUT)



Also known as:

- J-turn Intersections
- Superstreets
- Synchronized streets
- Reduced conflict intersections

The intersection formerly known as RCUT:



# RCUT – RESTRICTED CROSSING U-TURN

*(also known as J-turns, Reduced Conflict Intersections, Superstreets and Synchronized Intersections)*



At-grade intersections with directional medians so minor road traffic must turn right and make a U-turn to cross or make the left-turn maneuver.

Typically all movements from the major road are “normal” (some variations close the median and left-turns are made via U-turn maneuvers).

# REMEMBER ...

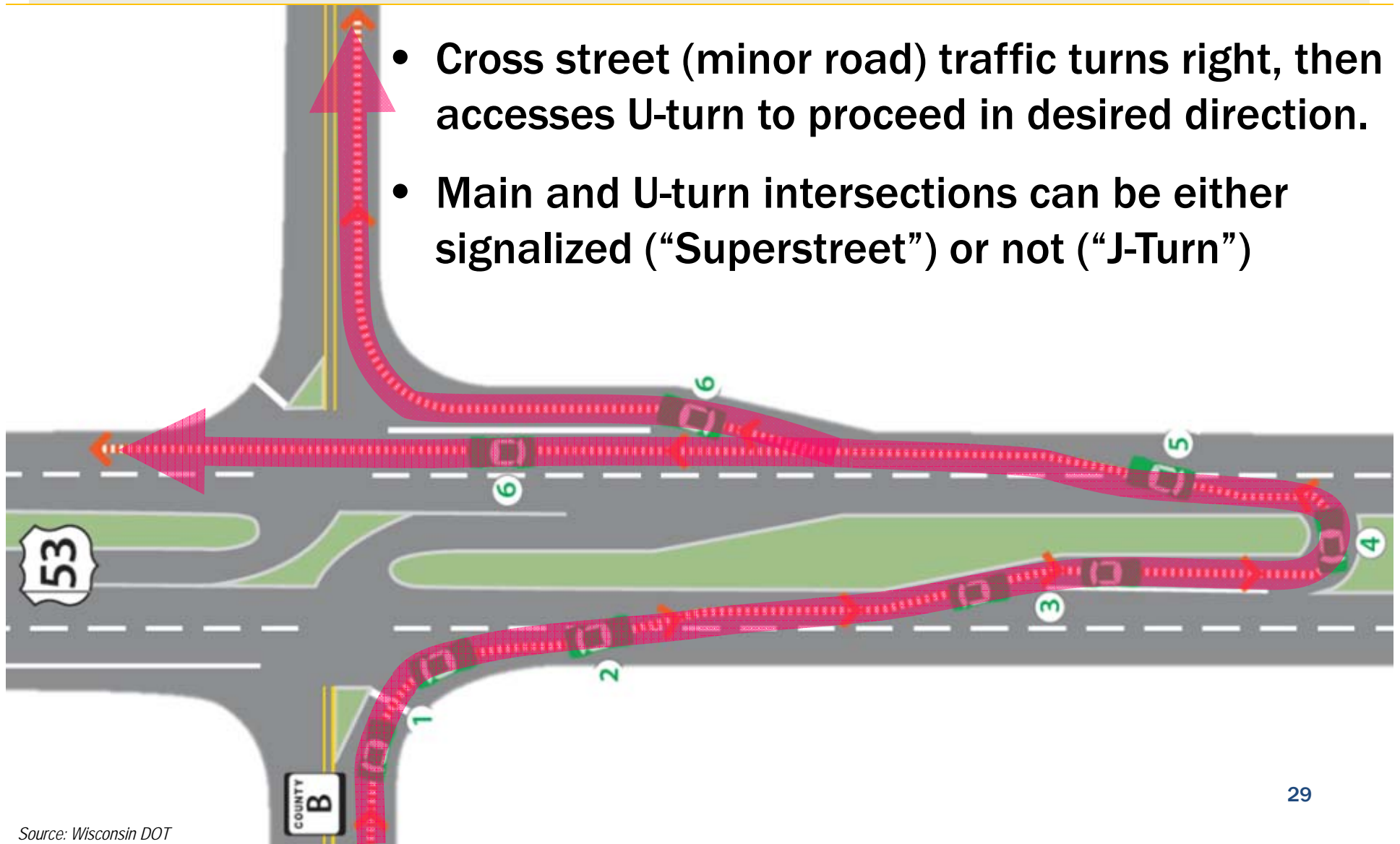


Photo: View from minor street approaching RCUT intersection

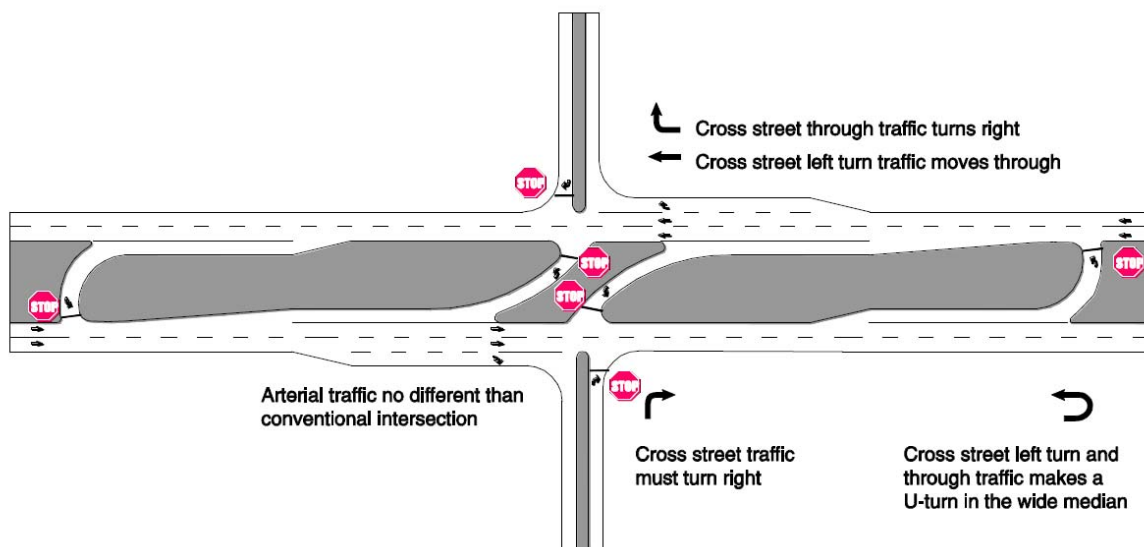


# RCUT DISTINGUISHING FEATURES

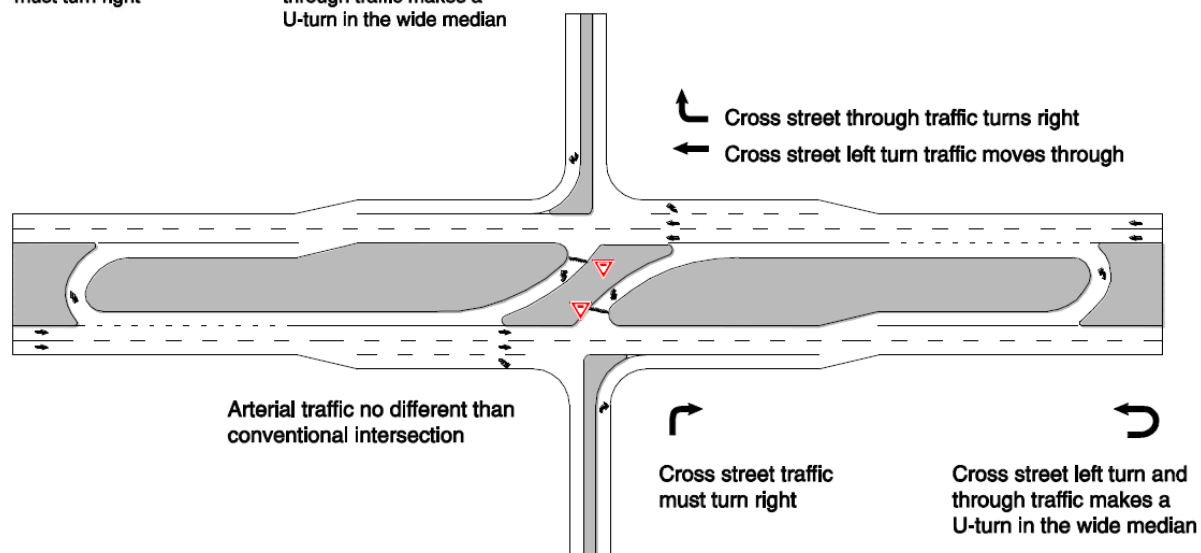
- Cross street (minor road) traffic turns right, then accesses U-turn to proceed in desired direction.
- Main and U-turn intersections can be either signaled (“Superstreet”) or not (“J-Turn”)



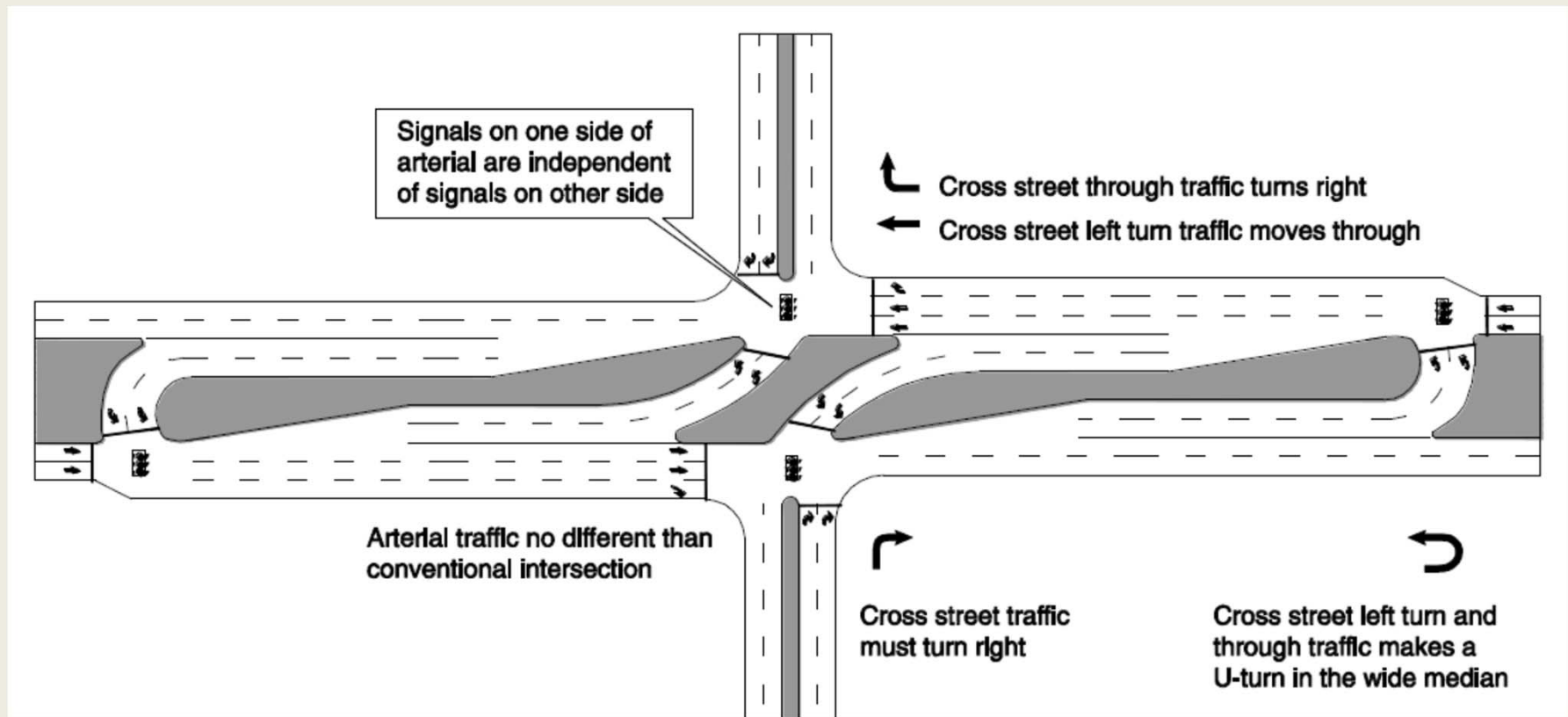
# UNSIGNALIZED RCUTS



Turns can be STOP or YIELD controlled



# SIGNALIZED RCUTS



# SIGNALIZED “SUPERSTREET”



SR 4 Bypass at Symmes Rd  
Fairfield, OH



# SIGNALIZED “SUPERSTREET”



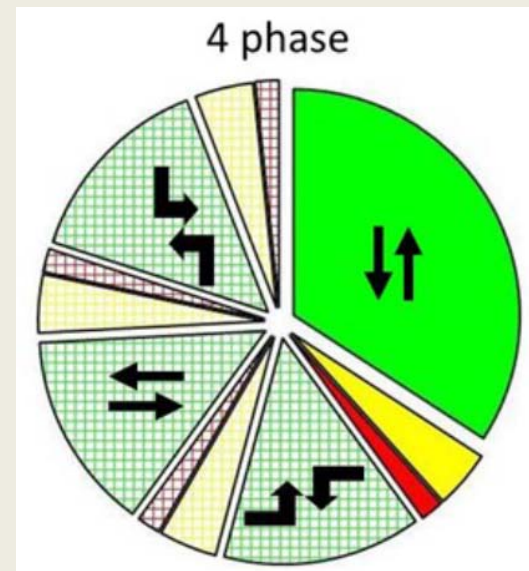
SR 4 Bypass at Symmes Rd Fairfield, OH

**Remember – “*It’s the signals, stupid!!!*”**

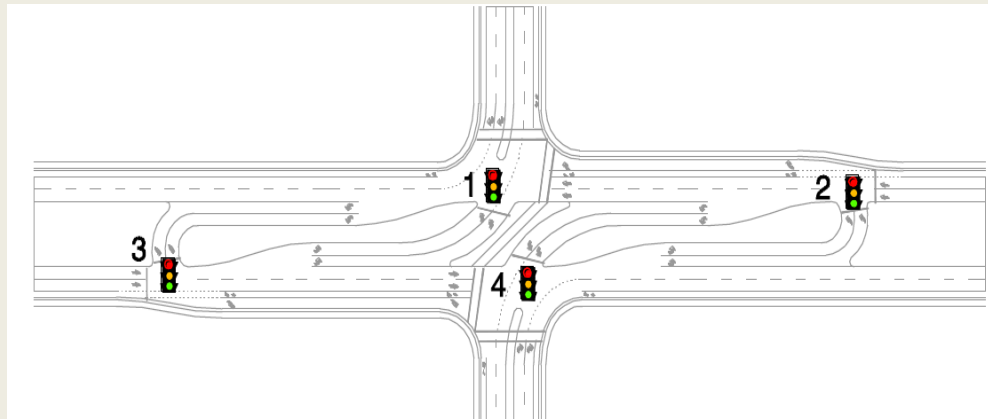
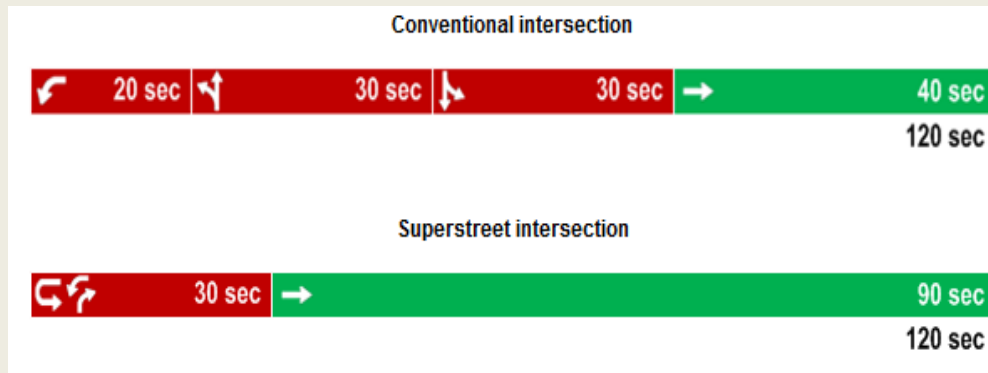


# NEW DEVELOPMENT ALONG ARTERIAL

## Problem: Proliferation of Four-Phase Signals



# BETTER SIGNAL OPERATIONS

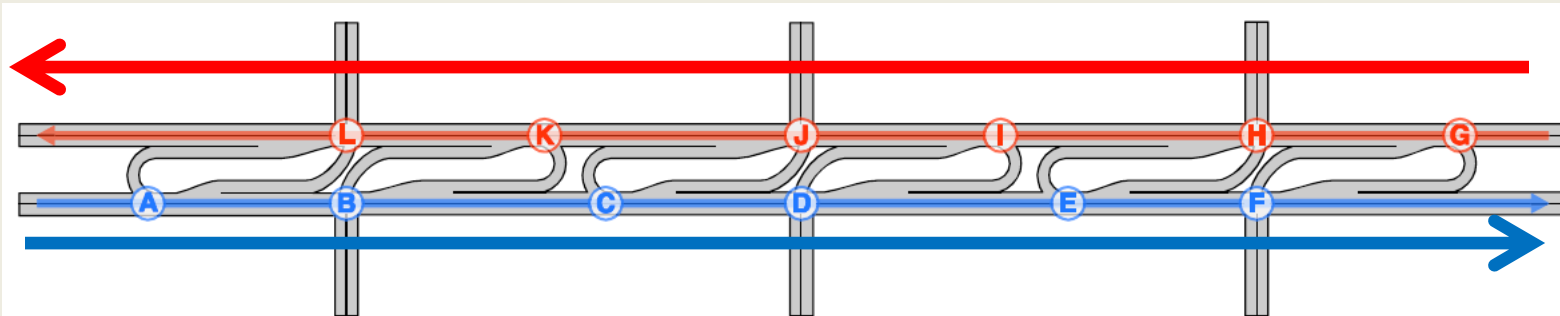


- Signalized RCUTs typically operate with only 2-phases allowing more green time to the major street through
- Shorter cycle lengths than comparable conventional intersections may be possible
  - Shorter cycles reduce delay for most vehicles and for pedestrians

**RCUTs offer an ability to have different cycle lengths in the two directions of the major street**

# BI-DIRECTIONAL PROGRESSION

- Each direction may operate independently
- Directions can be progressed at different speeds and/or signal spacing



Direction	Parameter	F	E	D	C	B	A
Right to left	Signal	F	E	D	C	B	A
	Distance from previous signal, ft	750	650	1000	700	600	Not applicable
	Offset to start of green, sec	74	59	46	26	12	0
Left to right	Signal	G	H	I	J	K	L
	Distance from previous signal, ft	Not applicable	600	850	1050	600	600
	Offset to start of green, sec	0	12	29	50	62	74

*Note: Assumed progression speed of 50 feet per second (34 mph) in both directions*



## **RCUT CORRIDORS**

US 17 in  
Brunswick  
County, NC

# HomeWork Assignment



**View these video case studies:**

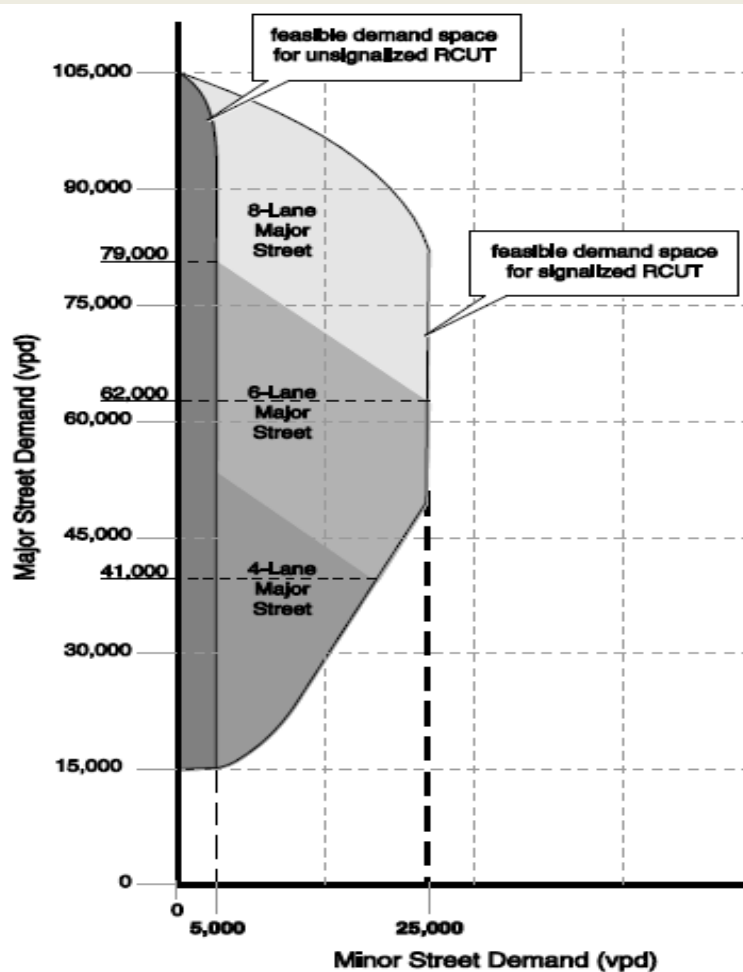
**1. State Route 55 Bypass, Holly Springs NC**

**<https://www.youtube.com/watch?v=AxliLzv-GOA>**

**2. U.S. Route 17 Corridor, Wilmington/Leland NC**

**<https://www.youtube.com/watch?v=LB5nTDSVEzs>**

# RCUT FEASIBLE DEMANDS



- Applicable to a wide range of Major Street ADTs
- At minor street demands <5,000 vpd, consider unsignalized RCUTs
- For minor street demands of more than 25,000 vpd, consider other alternative intersections (such as a MUT or DLT) that would generally serve the minor street more efficiently



# SAFETY – FEWER CONFLICT POINTS



**The RCUT has fewer total conflict points, fewer crossing conflicts and eliminates far side angle collisions**

# NORTH CAROLINA



**88% Reduction in fatal & severe injury crashes**

**59% decrease in total crashes**



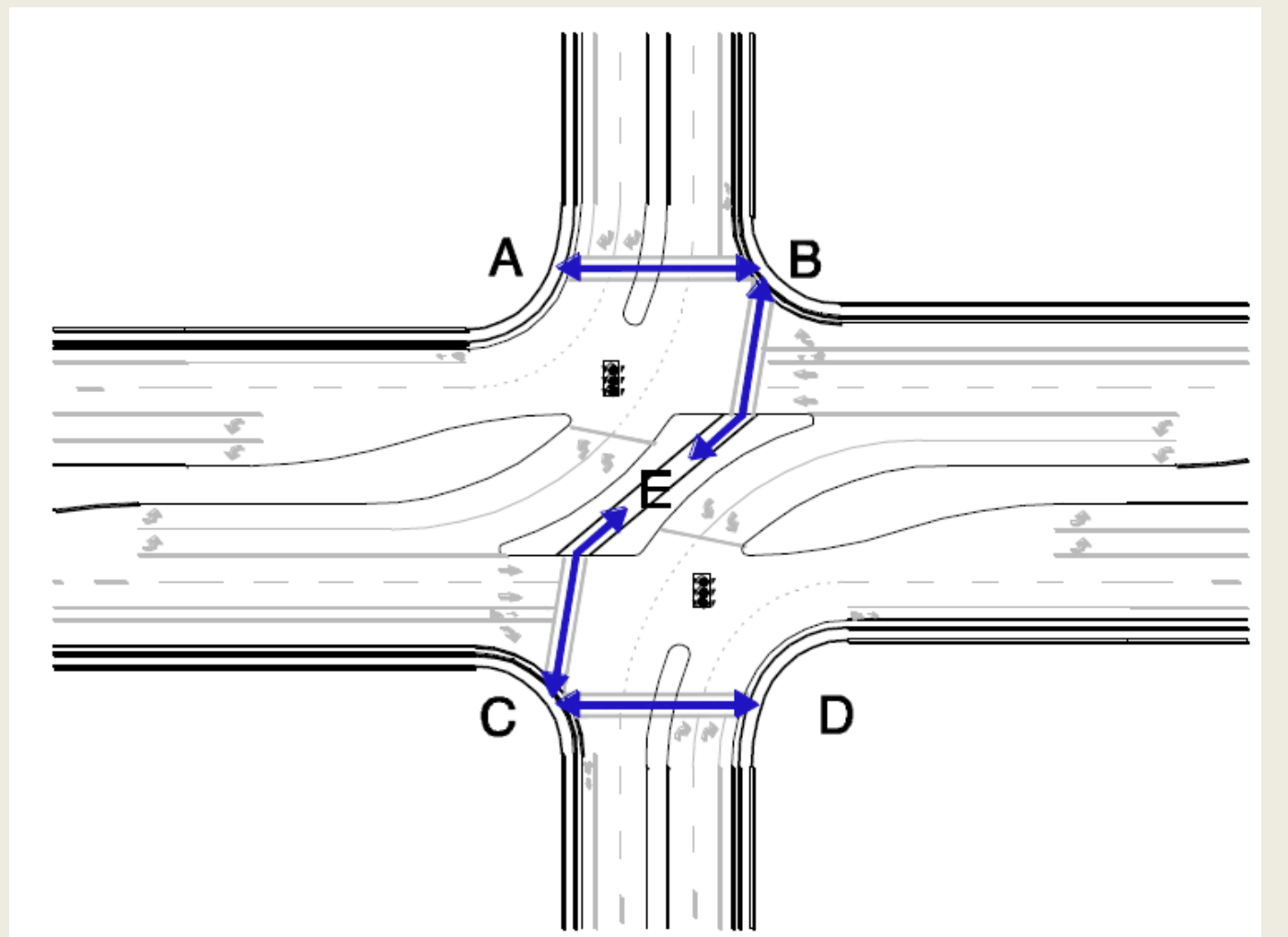
**Sample of 93 un-signalized RCUT intersections across the state with over four years of crash data adjusted for volume changes**

*Source: Carrie Simpson, P.E., Traffic Safety Project Engineer, North Carolina DOT*

# PEDESTRIAN CROSSWALKS

Pedestrian crosswalk pathways at a signalized RCUT

Question: Will pedestrian crossings take longer in an RCUT?

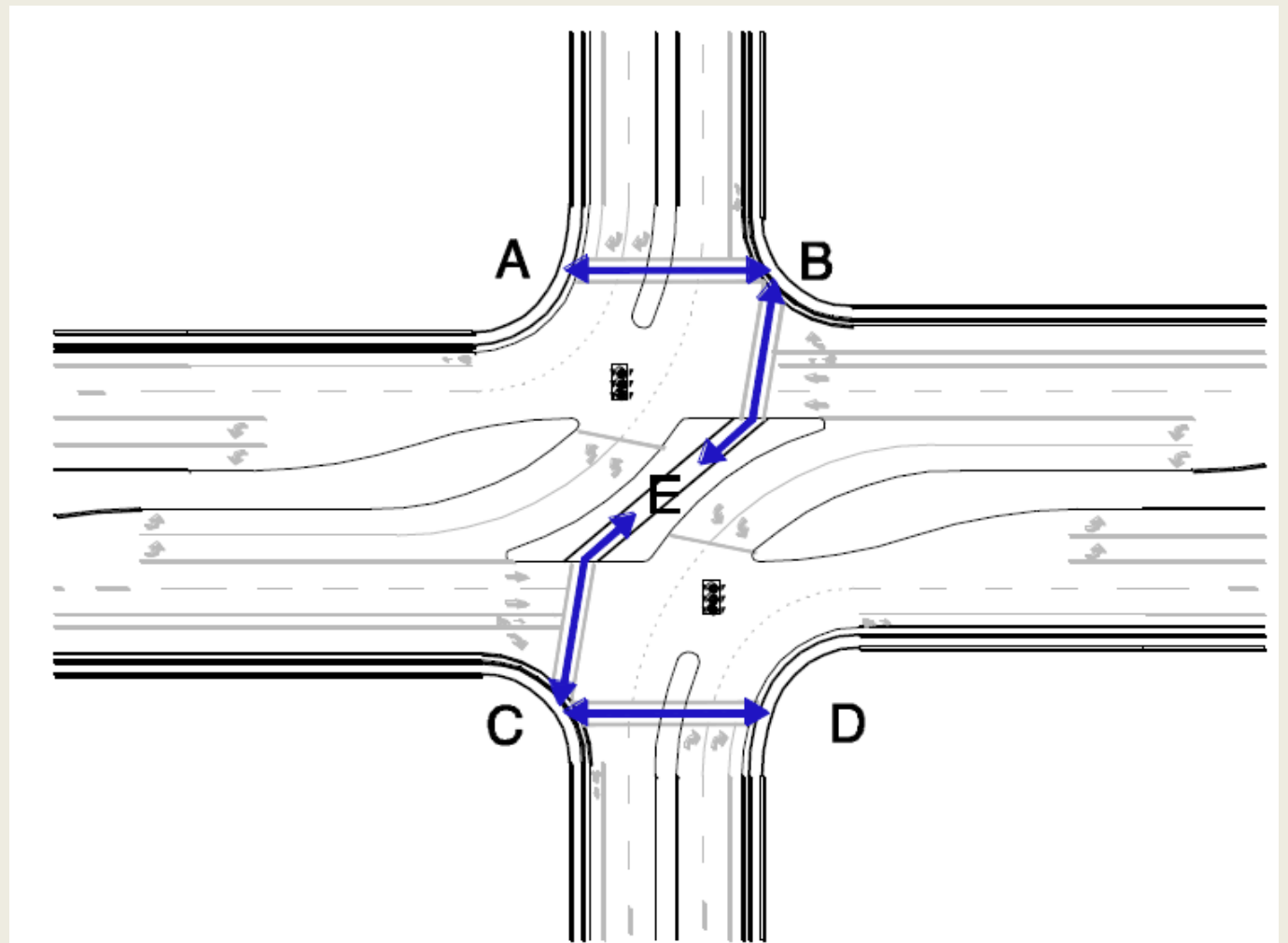


# PEDESTRIAN CROSSWALKS

A-B & C-D  
Likely Shorter  
(fewer lanes to cross)

B-E-C could be shorter if cycle length is reduced

A-D  
Likely Longer  
(extra crossing)



# PEDESTRIAN “Z” CROSSING



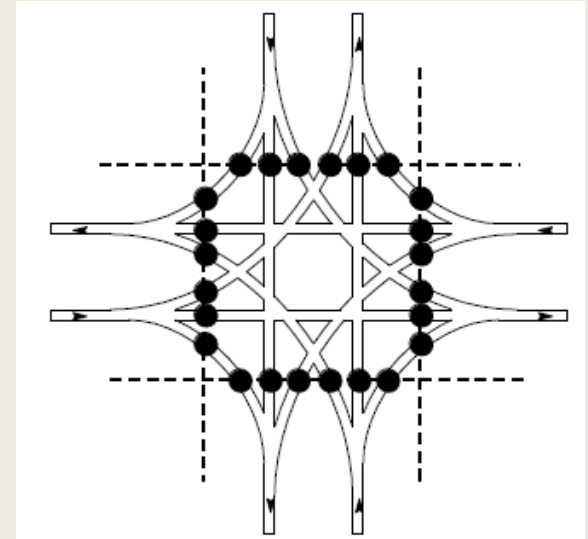
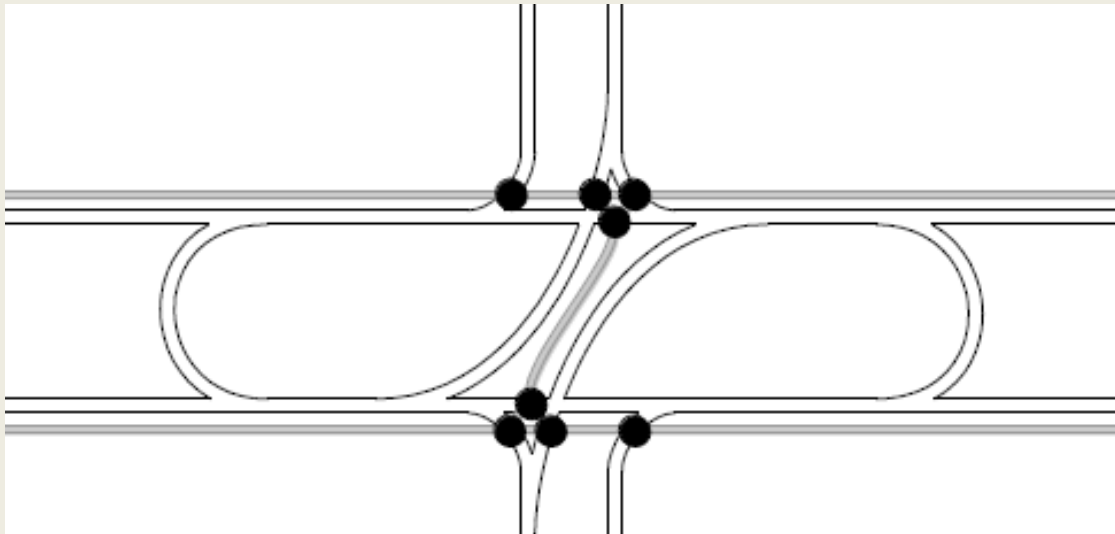
# PEDESTRIAN “Z” CROSSING



Signalized RCUT intersection in operation near San Antonio, TX

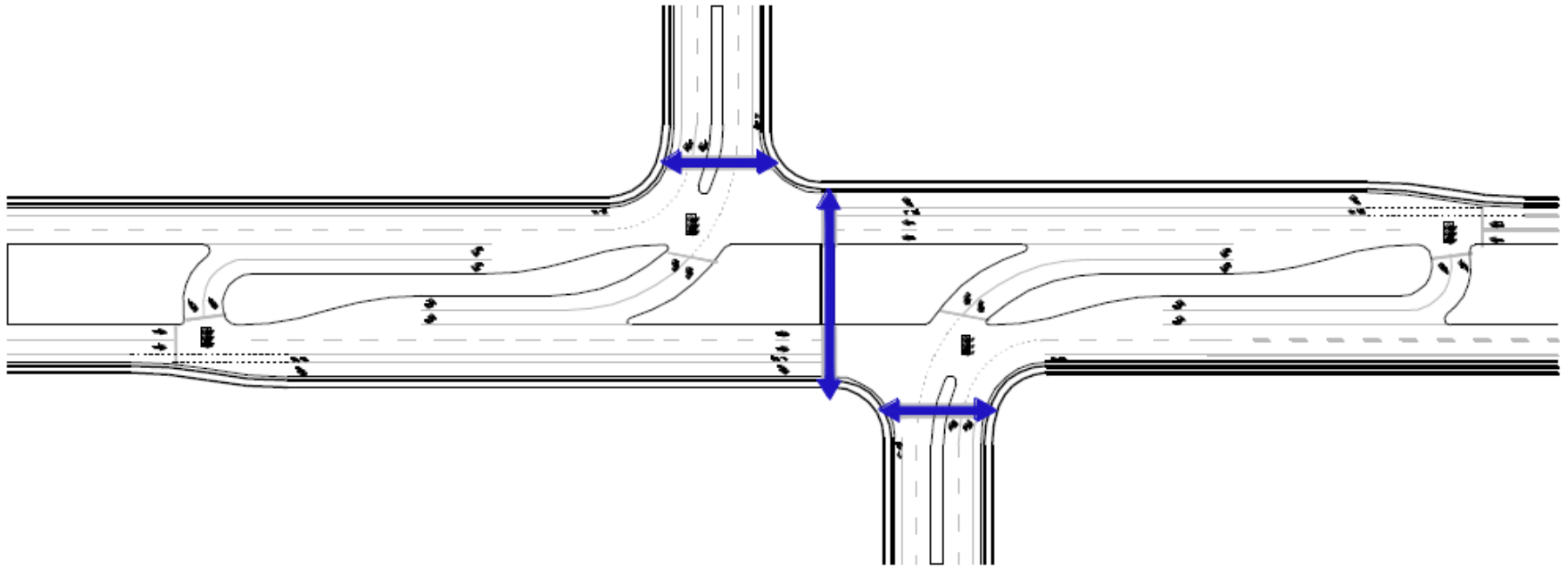
# PEDESTRIAN-VEHICLE CONFLICT POINTS

**RCUT Intersection**  
**8 conflict points**



**Conventional**  
**Intersection**  
**24 conflict points**

# OFFSET APPROACHES OPTION

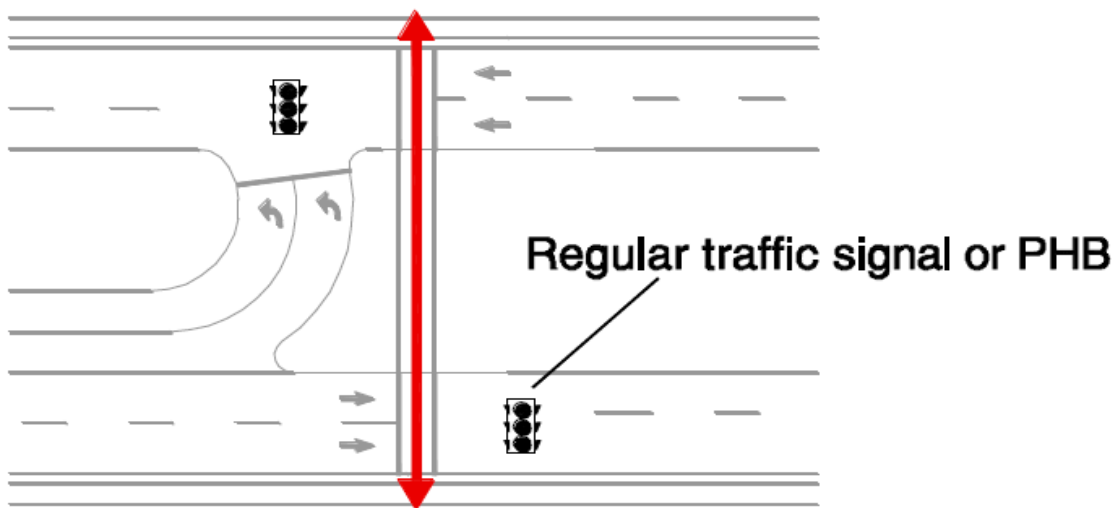


This variation should be strongly considered in developing areas where the minor street or driveway locations have not yet been established.

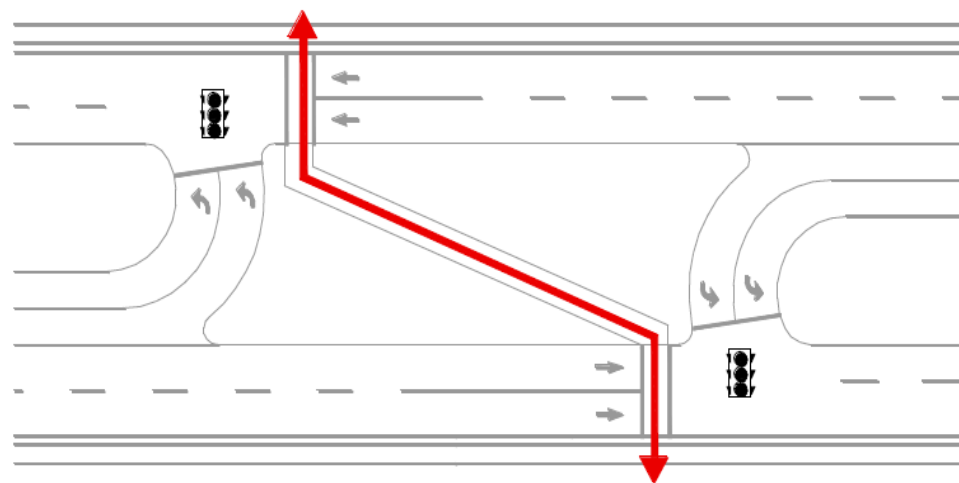
Wayfinding signs for pedestrians should be used to direct pedestrians to the proper crossing location.



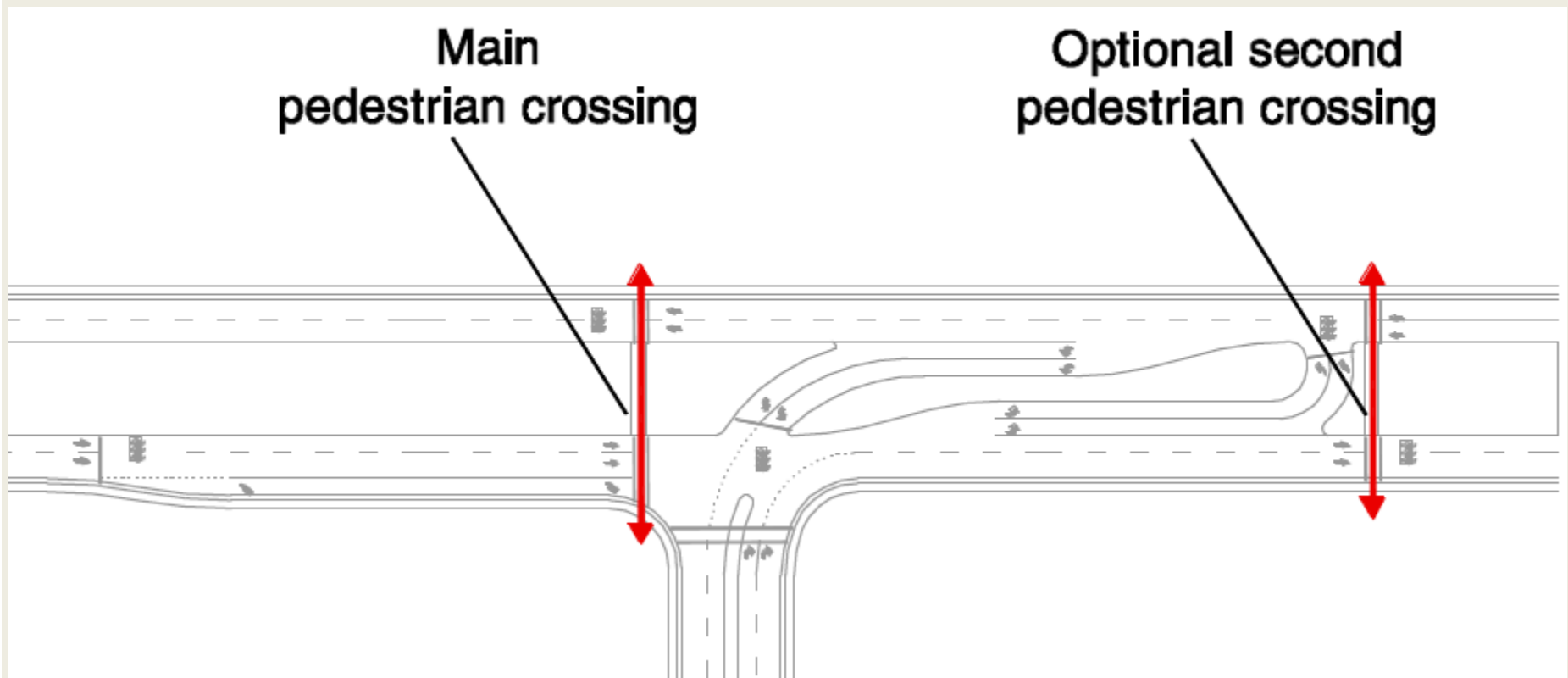
# MID-BLOCK PED CROSSING OPTION



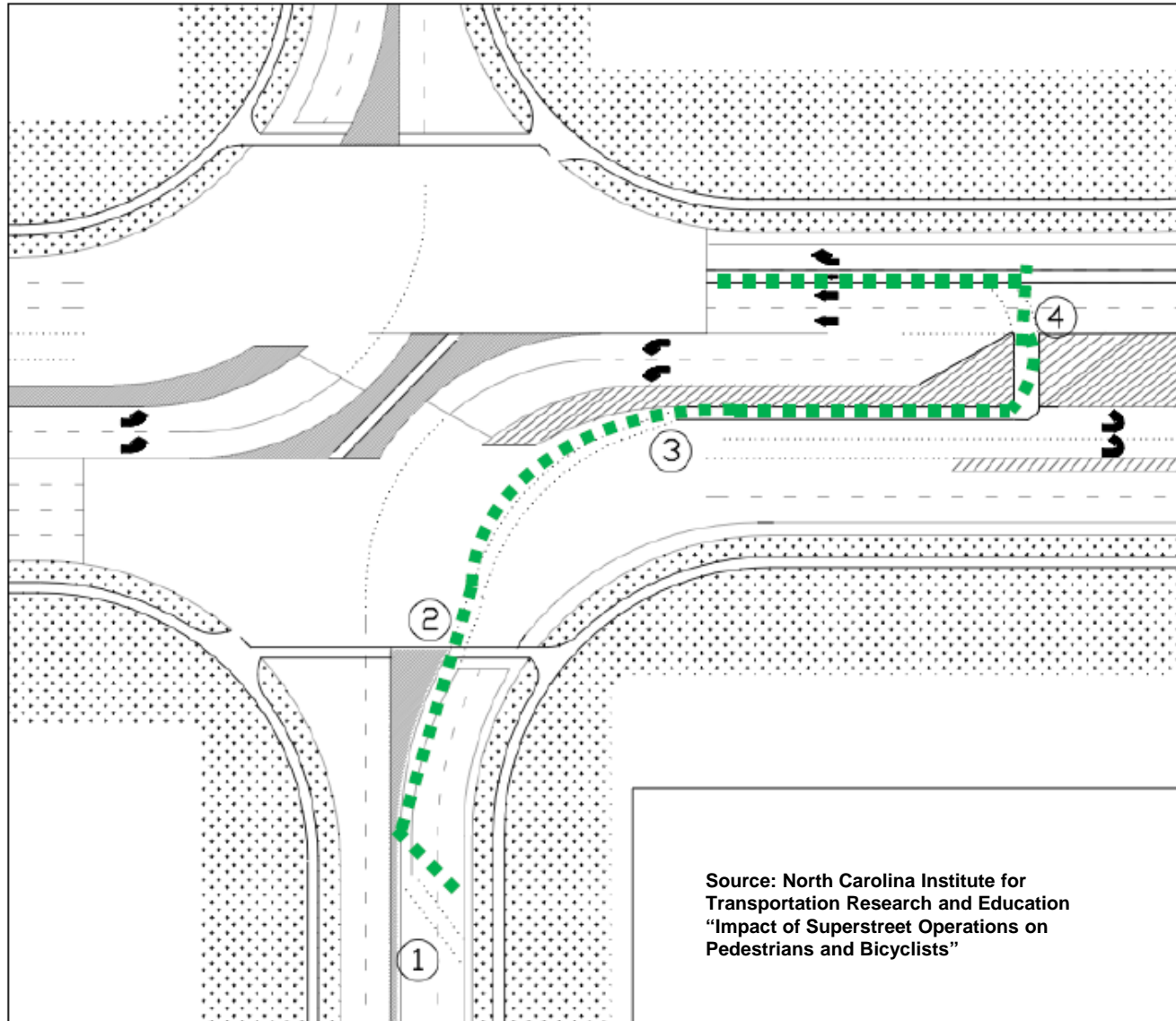
**Adding pedestrian signal will not interfere with signal progression!!!**



# PED CROSSINGS AT 3-LEG RCUTS



# Bicycle U-turn Bay Concept

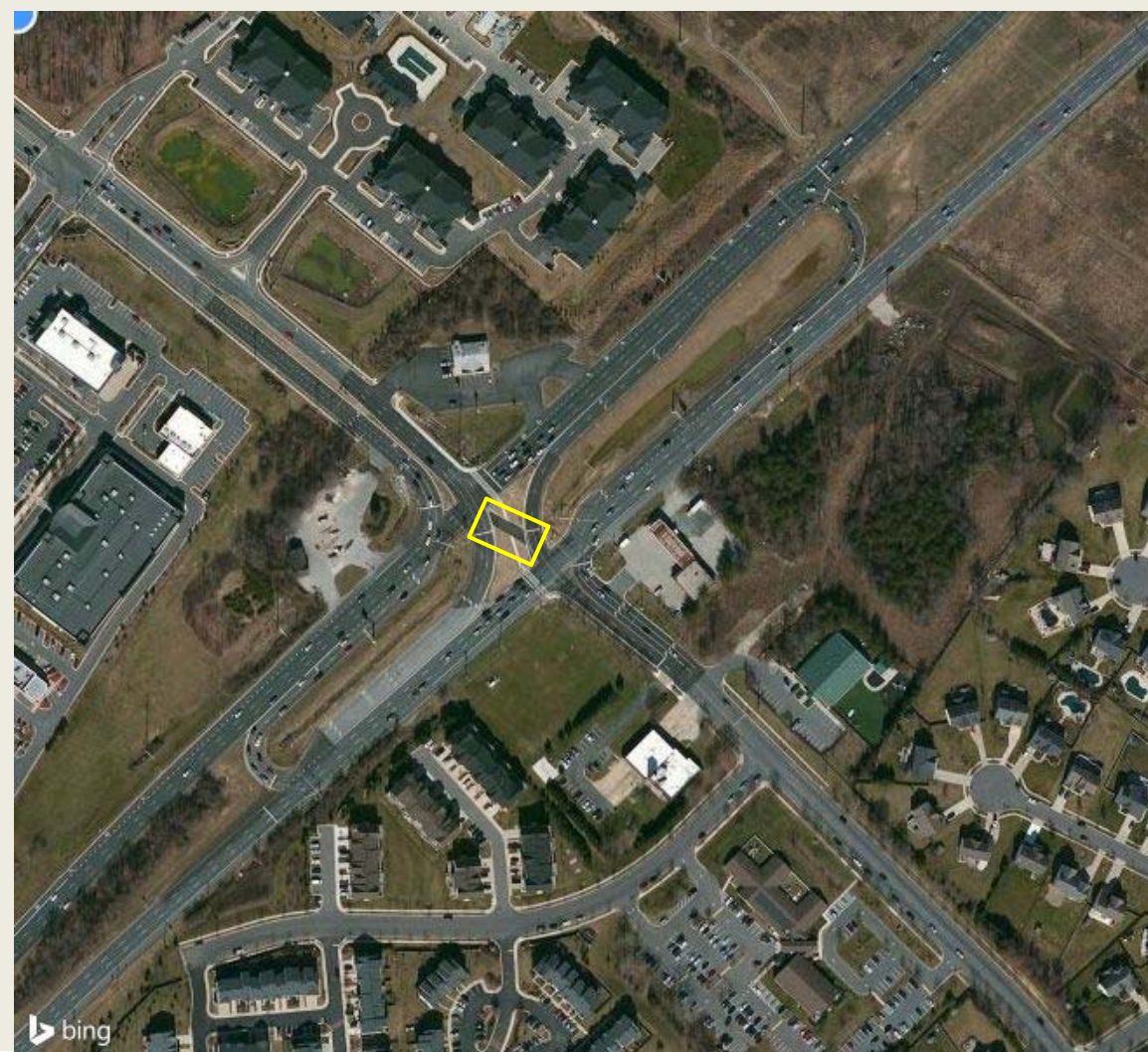




North Carolina

**Curb cut design to assist bicyclists crossing at a rural RCUT with stop sign**

# EMERGENCY VEHICLE CUT THROUGH



# Mountable Curb – Rural Unsignalized

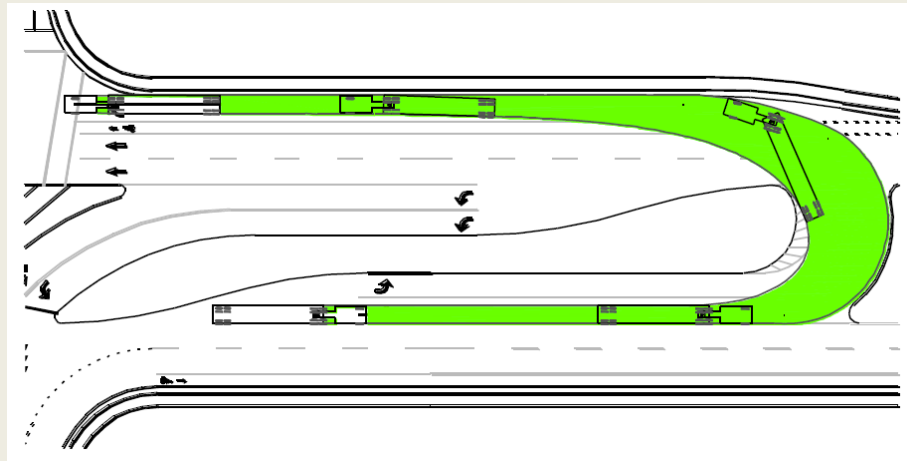
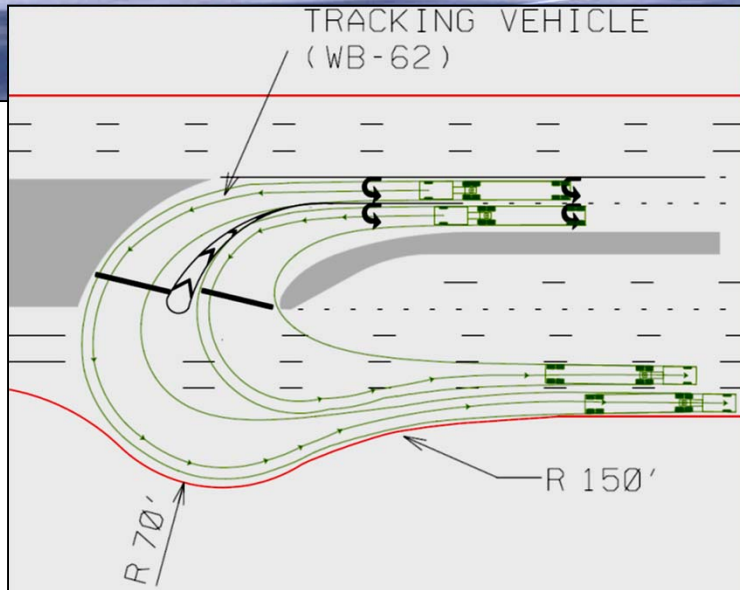


Cologne, MN

# Accommodating Truck Movements



# RCUT INTERSECTION - LOON

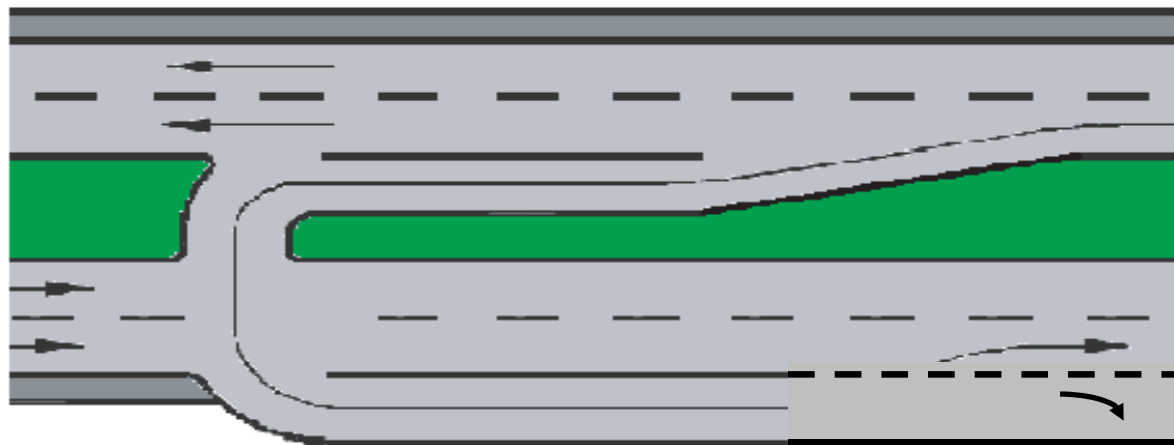
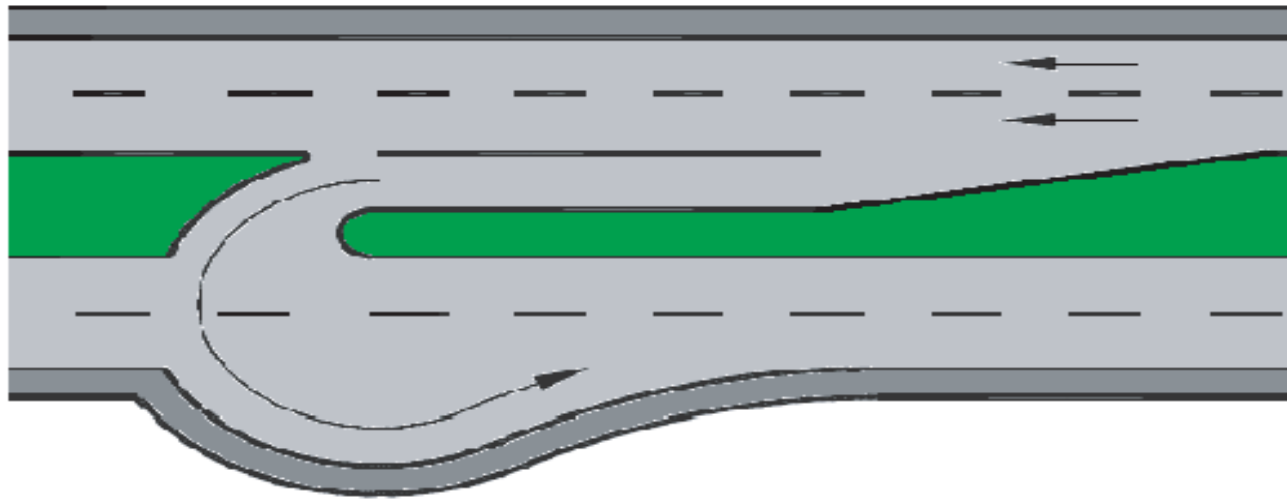




# LOON SIZE DEPENDS ON MEDIAN WIDTH

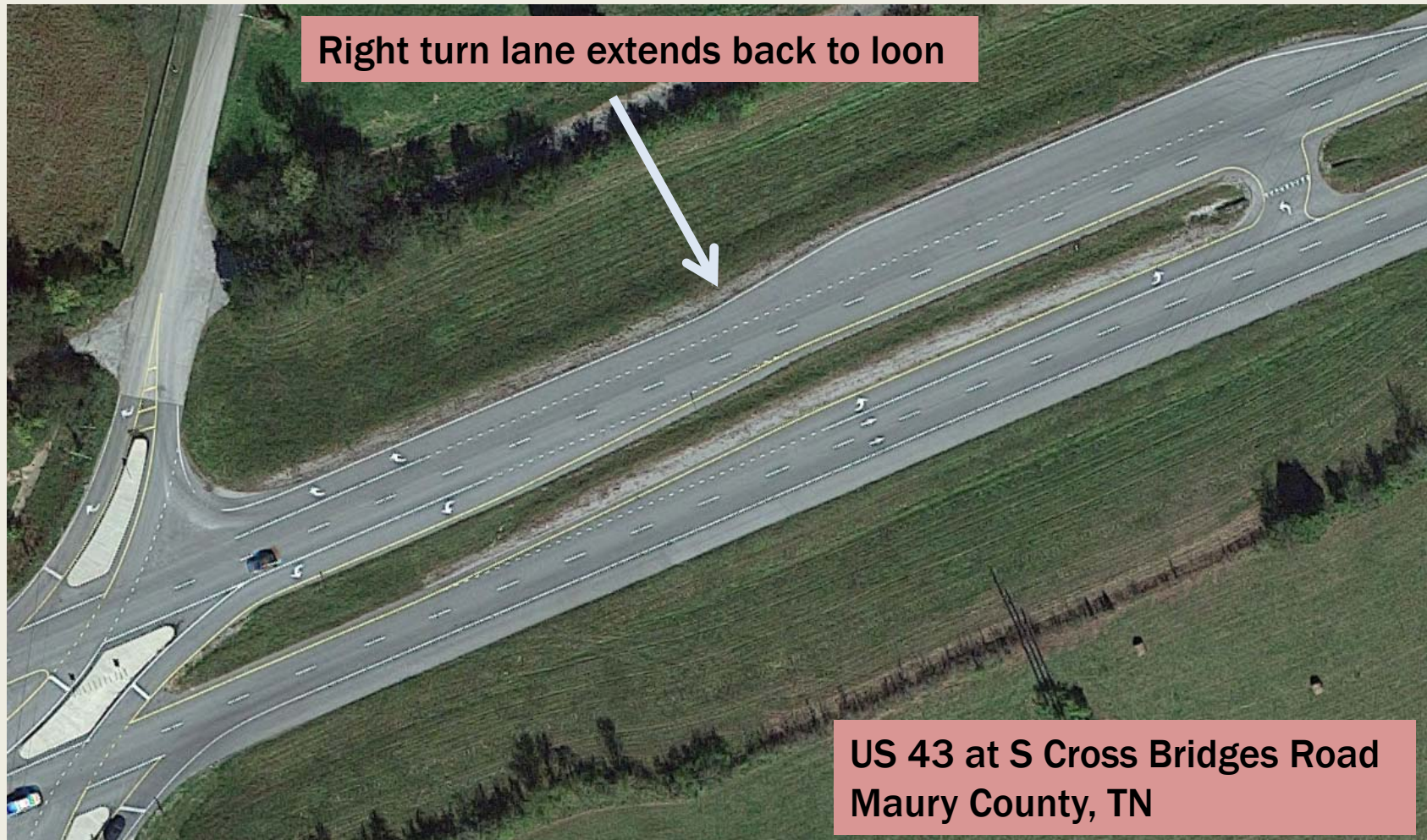


# LOONS & U-TURN ACCELERATION LANES



Could begin  
right turn lane

# LOONS & U-TURN ACCELERATION LANES

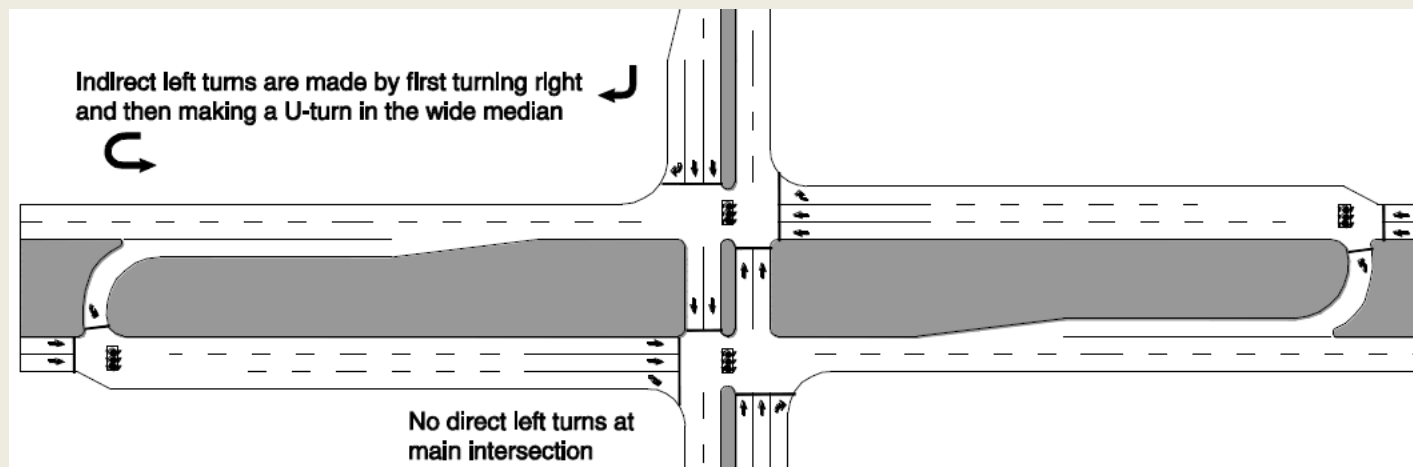


Right turn lane extends back to loon

US 43 at S Cross Bridges Road  
Maury County, TN

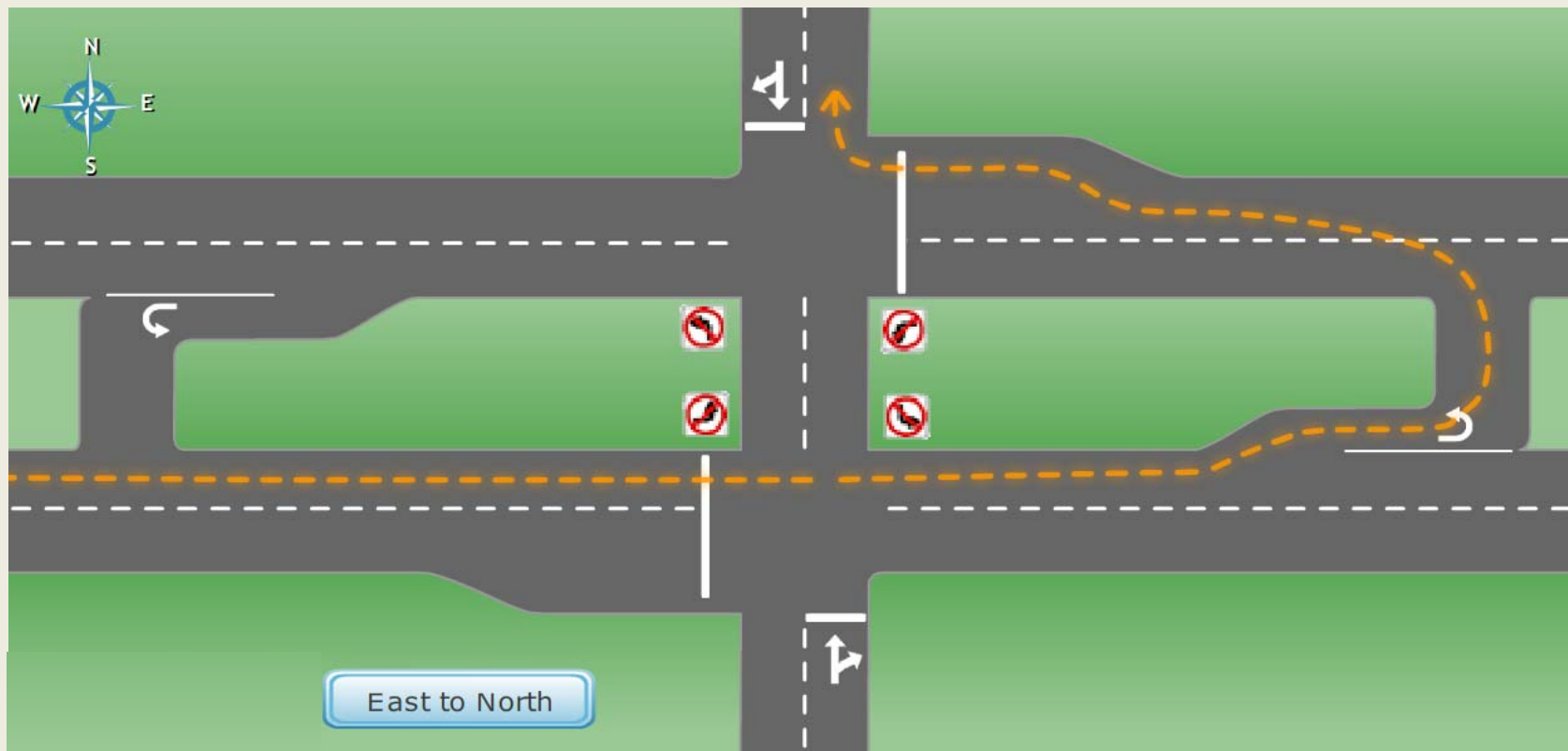
# MUT – Median U-Turn

*(aka Michigan Left)*



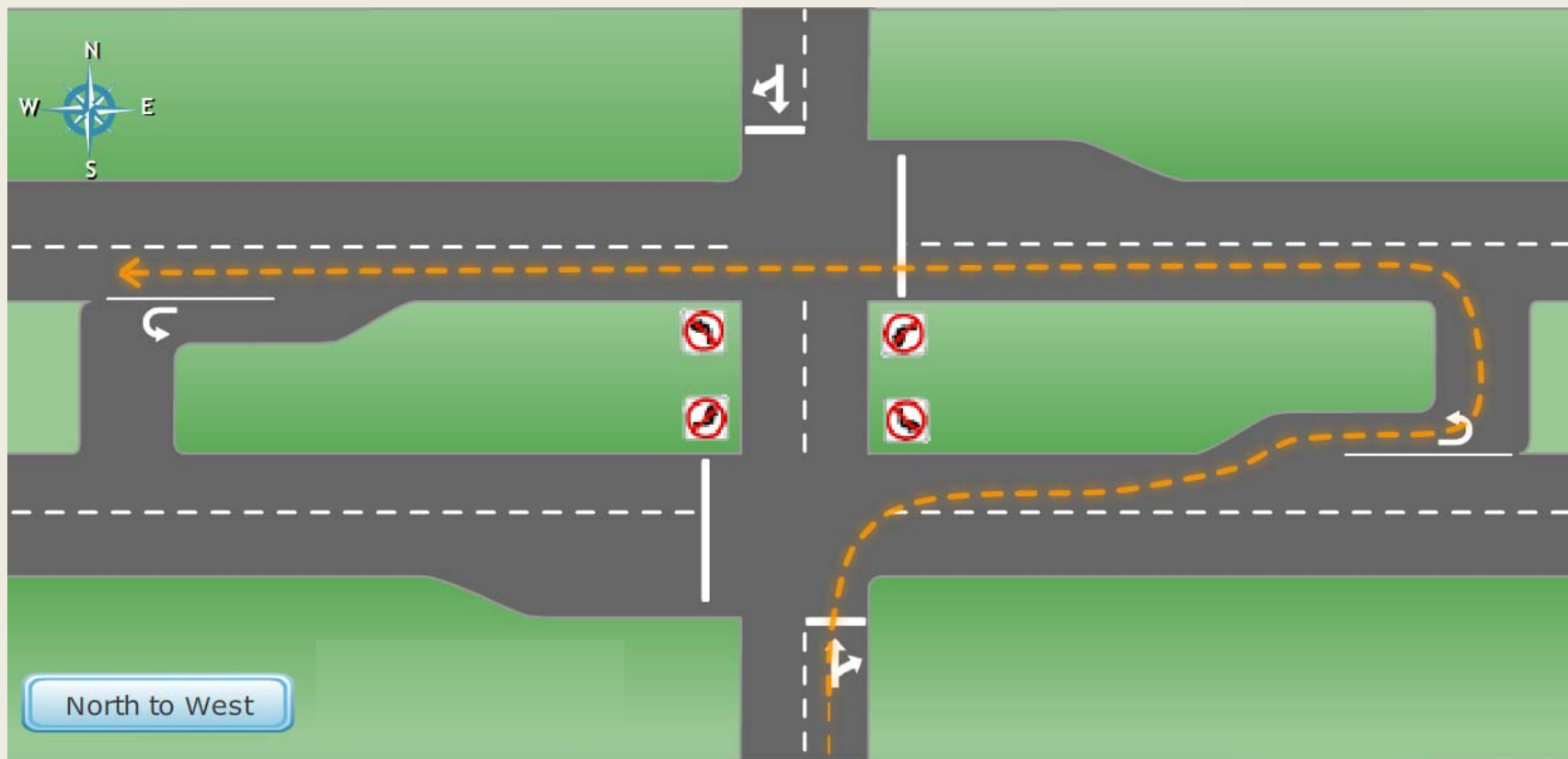
- At-grade intersections with *indirect* left turns using a U-turn movement in a wide median and/or loon
- The MUT eliminates direct left turns on both intersecting streets, reducing the number of signal phases and conflict points at the main intersection

# MUT – LEFT TURN FROM MAJOR ROAD



Vehicles on the major street (or the street with the median) that want to turn left are directed through the main intersection to a U-turn movement at a downstream directional crossover (usually signalized), and proceed back to the main intersection to then turn right onto the minor street.

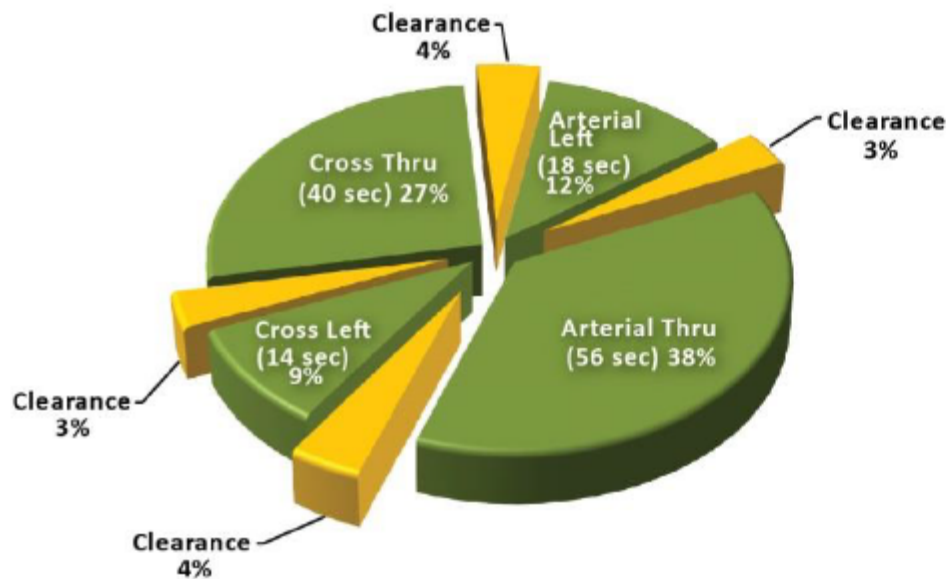
# MUT – LEFT TURN FROM MINOR ROAD



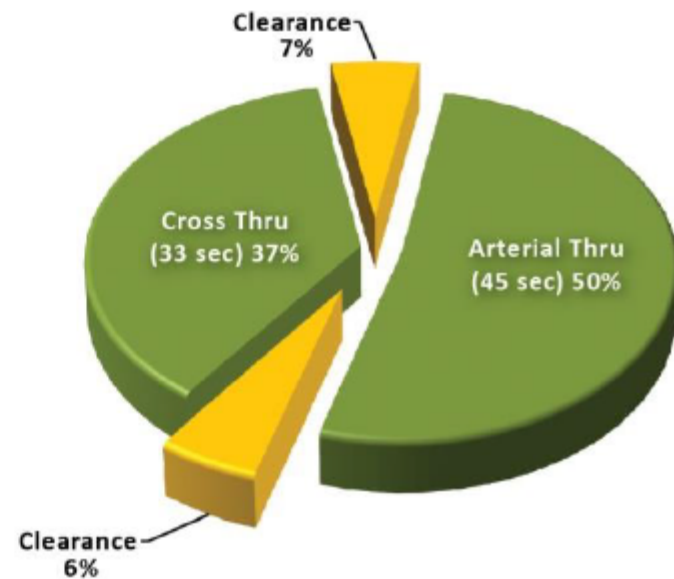
Vehicles on the minor street that wish to turn left at the major street are directed to turn right, make a U-turn movement at the same crossover, and then proceed through the main intersection.

# SIGNAL OPERATIONS

150-Second Multi-Phase Cycle

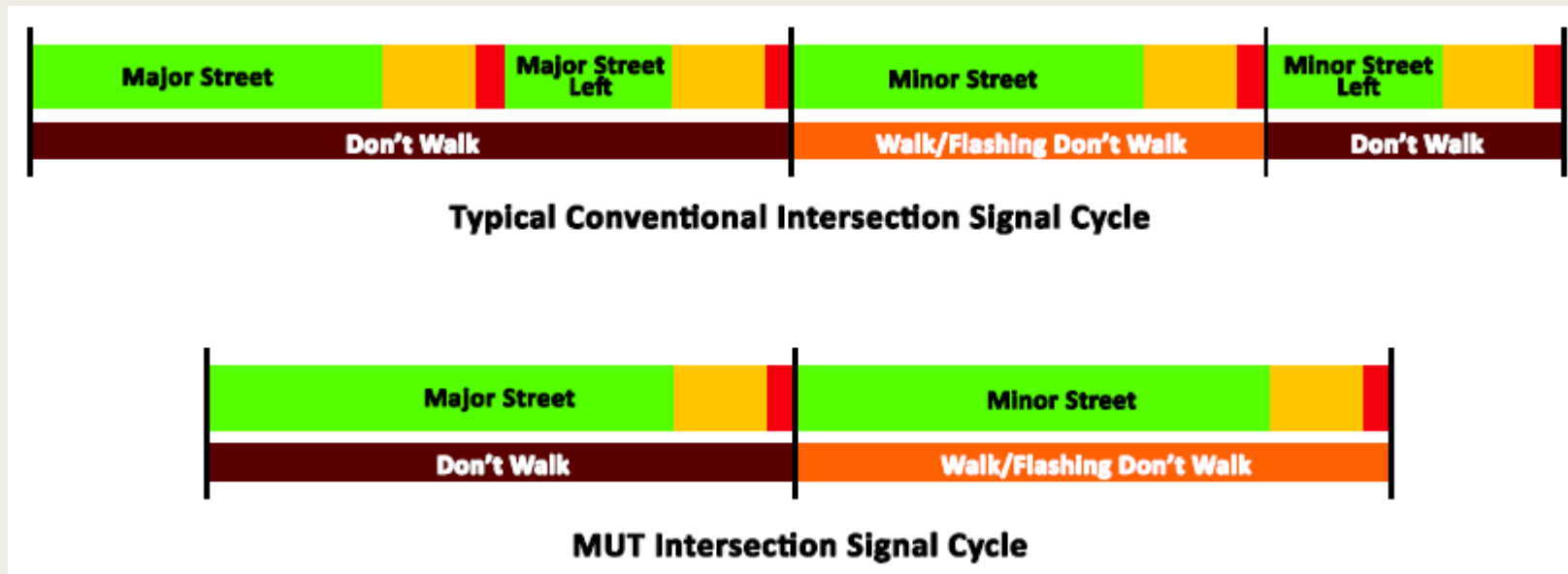


90-Second Two-Phase Cycle



The MUT removes left-turn phasing, which results in fewer clearance intervals in the intersection cycle and to operate well with a shorter cycle length than a comparable multi-phase cycle

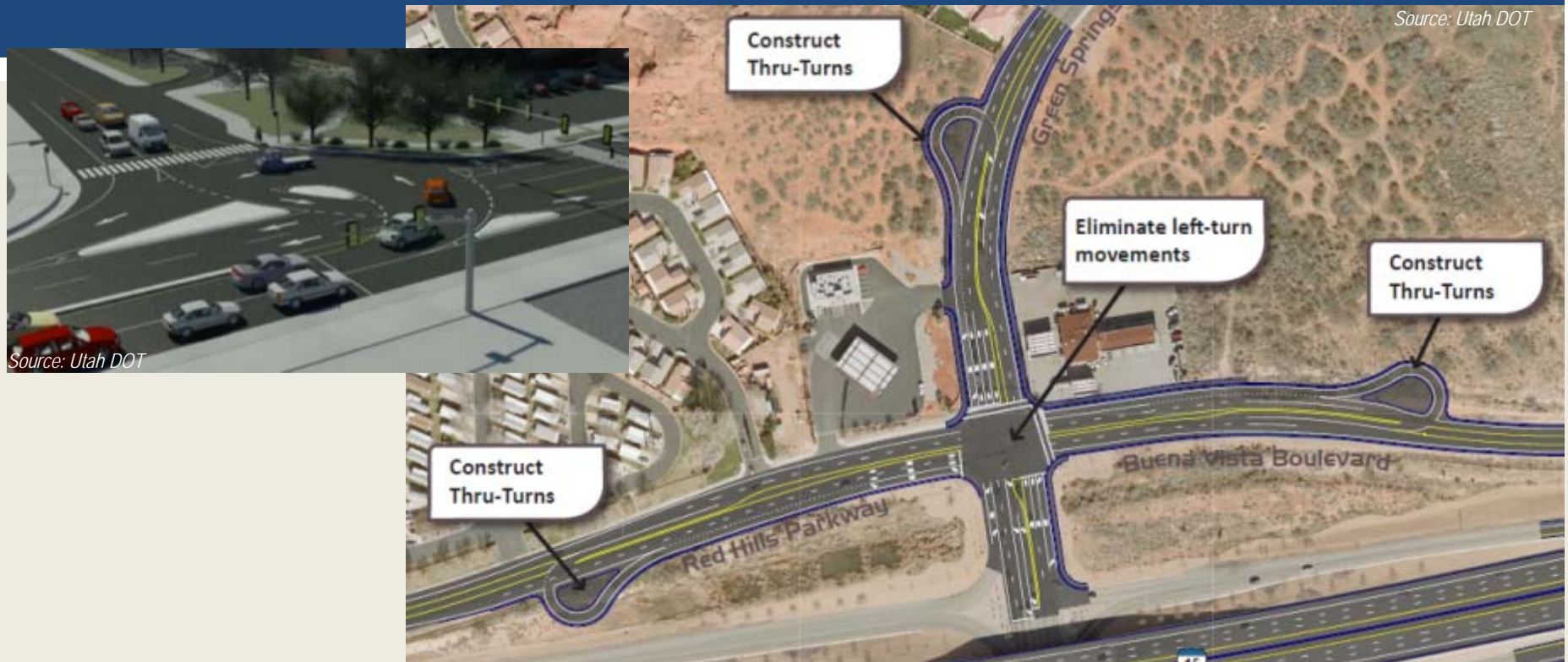
# PEDESTRIAN WALK PHASES



The two-phase signal at a MUT typically allows a shorter signal cycle length compared to a comparable conventional intersection, but with similar green times for pedestrians and vehicles. This benefits pedestrians by creating more pedestrian phases per hour along with less “don’t walk” time between “walk” times (i.e., less wait time between walk signals).



# U-TURN INTERSECTIONS: THRU TURN



- Similar to MUT in that direct left-turns are eliminated from main intersection
- Substitutes a paved bump-out or “loon” beyond the outside lane (or coinciding with a sidestreet tee intersection or driveway) for the wide median of a MUT



# THRU-TURN

- 12300 South/State Street in Draper, UT
- Adjacent to I-15 Freeway
- Three signalized U-turns 500-600 feet from intersection
- More Green Time for Thru Movements
- Reduce Congestion and Improve Safety



**12300  
South at  
State St.**

**Draper,  
UT**



**U-turn & T  
intersection**



# EXPRESS LEFT

LEARN THE TURN

## IT'S EASY –

Go through, **make a U**, then **right at the light**

*Vehicles will pass through the intersection and use the Express Left™ turn to head North or South.*

## HOW IT WORKS

- 1** Drive straight through the intersection and pull into a turning lane to your left.
- 2** A traffic signal will stop approaching traffic to allow the vehicles in the turning lane to make a U-turn into a designated right turn lane. These traffic signals will be timed with the intersection traffic signals to limit through traffic to only one stop.
- 3** Return to the intersection and make a right.



# EXPRESS LEFT

Tucson, AZ

# HomeWork Assignment



**View these video case studies:**

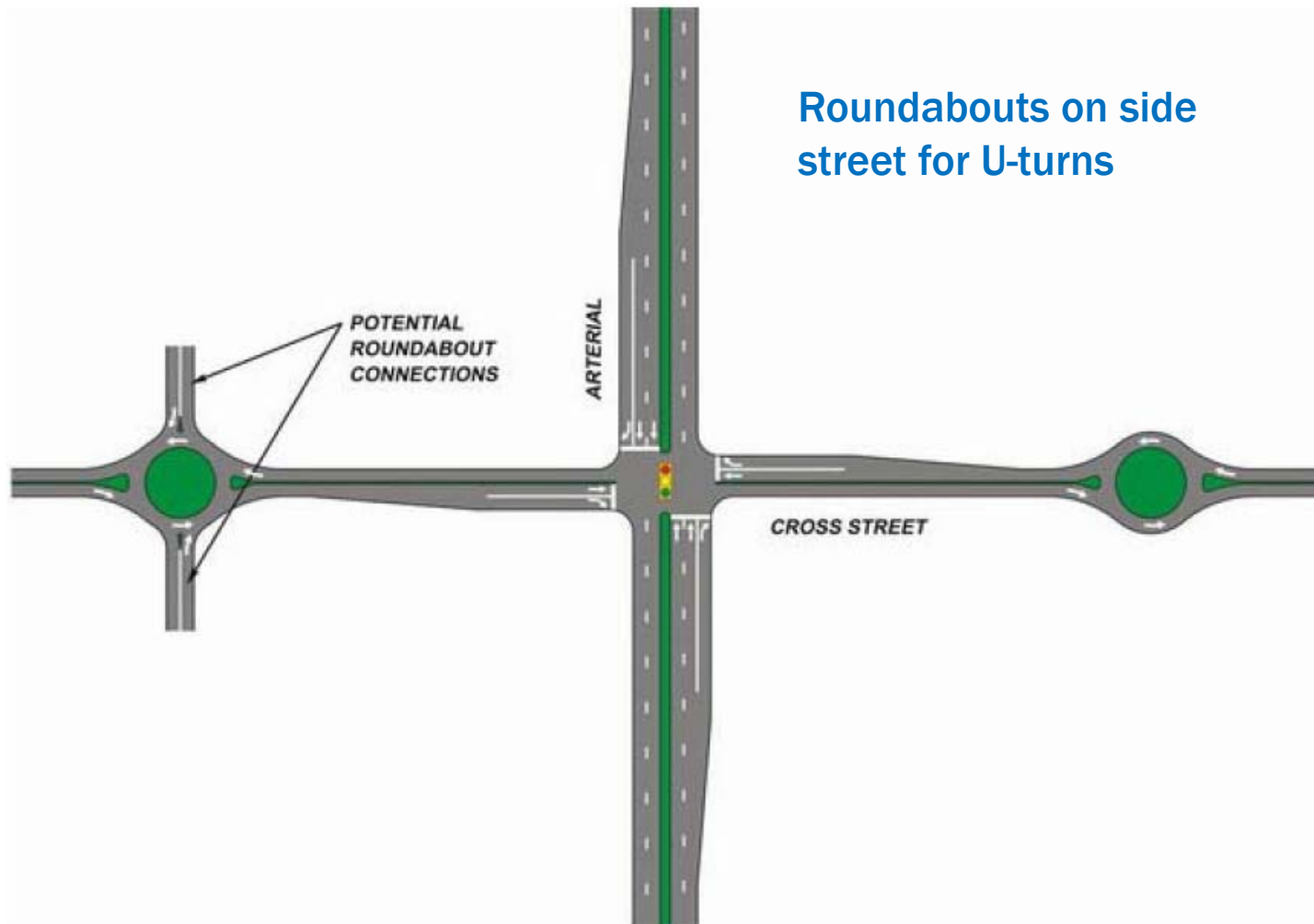
**1. ThrU-Turn in Boise ID**

<https://www.youtube.com/watch?v=N-jC-8fgpTk>

**2. ThrU-turn in Layton, Utah - Hill Field Road**

<https://www.youtube.com/watch?v=8VcNBkSaK08>

# BOWTIE INTERSECTION



# QUADRANT ROADWAY INTERSECTION (QRI)



Eliminates some or all left turn movements at the main intersection by relocating the movements onto a connector (or quadrant) roadway



# JUGHANDLE INTERSECTIONS



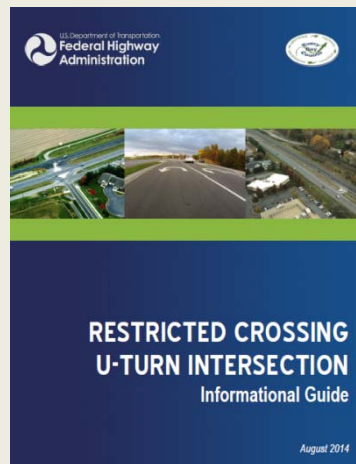
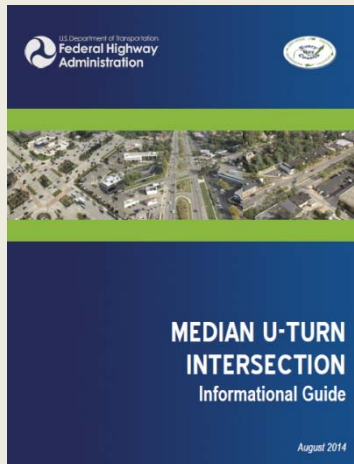
Jughandles have been around in the US since at least the 1950s.

Main intersection of choice in New Jersey.



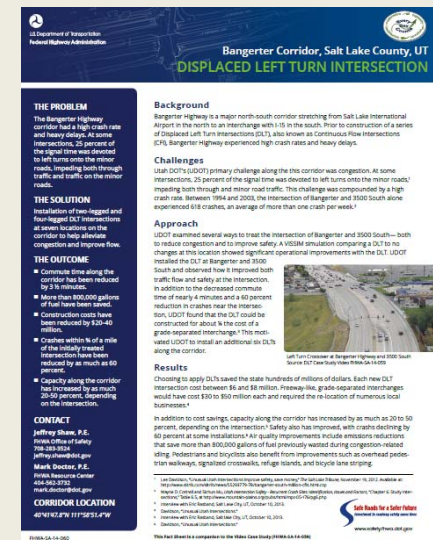
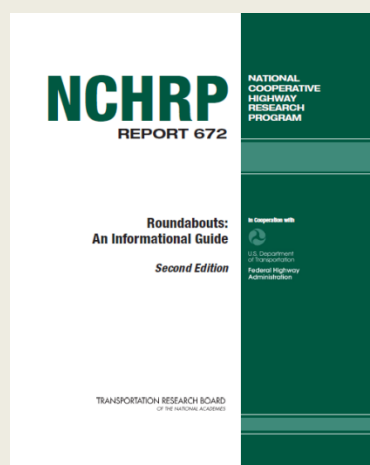
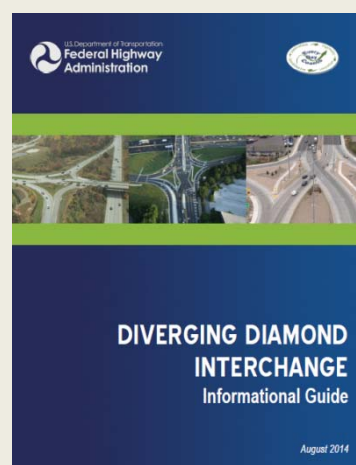
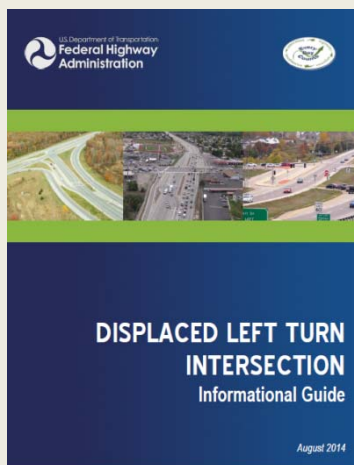
Fruitville Road at Sarasota Center Boulevard, Sarasota, FL

# RESOURCES



For easy access ...

[safety.fhwa.dot.gov/intersection/](http://safety.fhwa.dot.gov/intersection/)



## POLL QUESTION

**What are the reasons why your agency wouldn't consider implementing these intersection types?**



**THANK YOU !!!**

**QUESTIONS**

