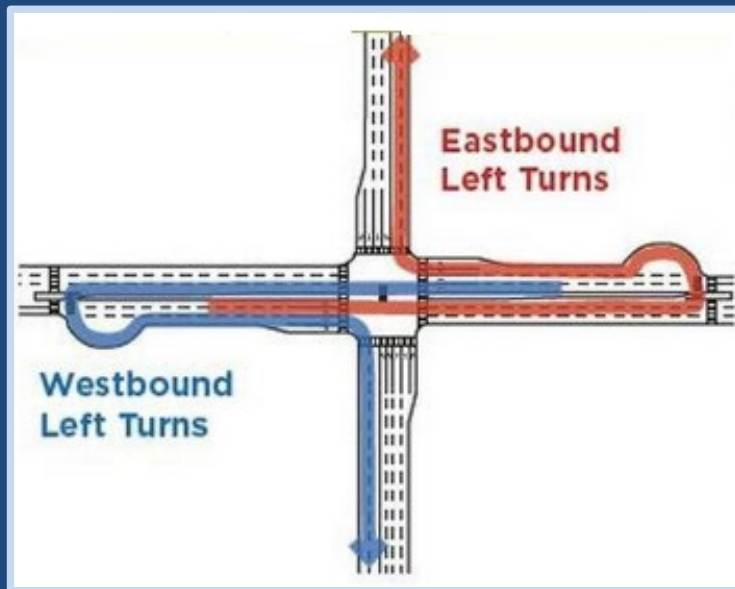


INNOVATIVE INTERSECTIONS & INTERCHANGES



2019 ACEC-KY/FHWA/KYTC Partnering Conference

September 2019

PROVEN SAFETY
COUNTERMEASURES

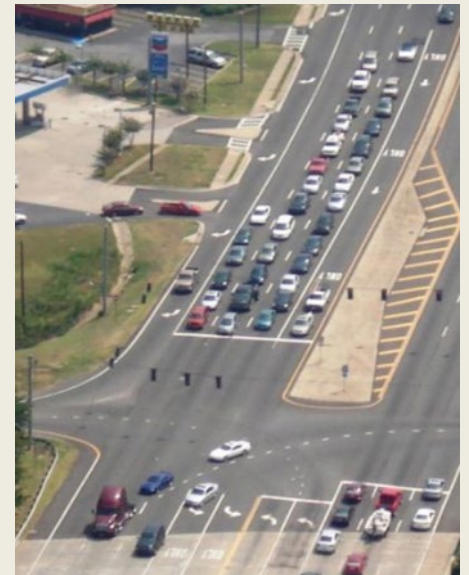


Mark Doctor, PE
FHWA Resource Center

INTERSECTION CHALLENGES

Do you have

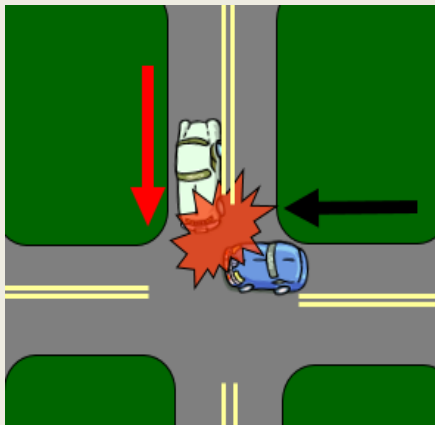
- increasing congestion?
- severe crashes?
- mobility concerns for pedestrians and bicyclists?
- limited budgets?
- inability for more right-of-way?



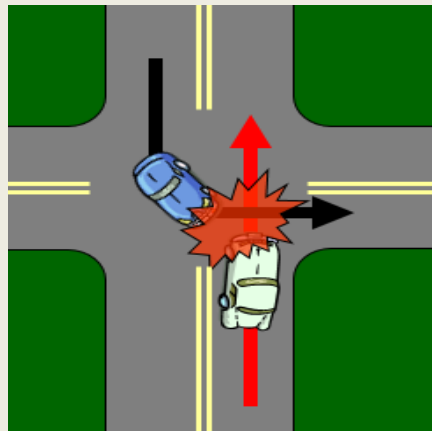
INTERSECTION CONFLICTS

Intersections are planned points of conflict in the road system.

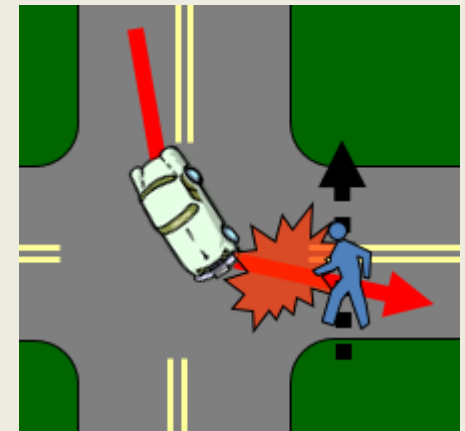
People – some in motor vehicles, others walking or biking – cross paths as they travel through or turn from one route to another. Where different paths cross, join or separate - conflict points occur.



Right-angle collisions account for over 40% of fatal crashes at intersections



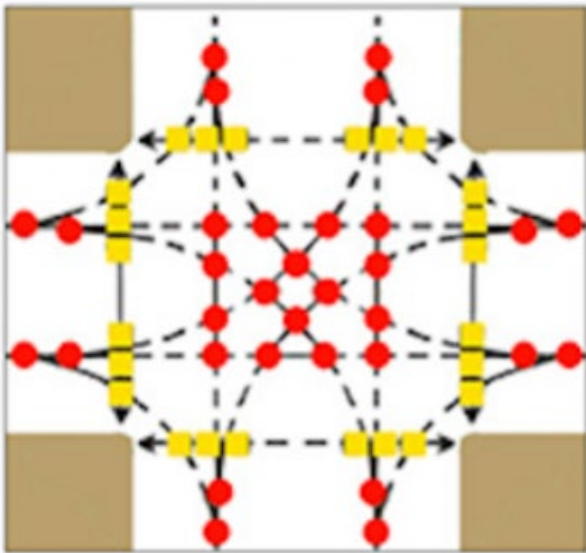
Left turn crashes account for over 20% of fatal crashes at intersections



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

INTERSECTION CONFLICT POINTS

“Conventional” Intersection



● 32 Vehicle conflicts

■ 24 Pedestrian conflicts

Conflict Points may be thought of as “Collision Potential”

If a person commits an error (poor judgement or traffic control violation)

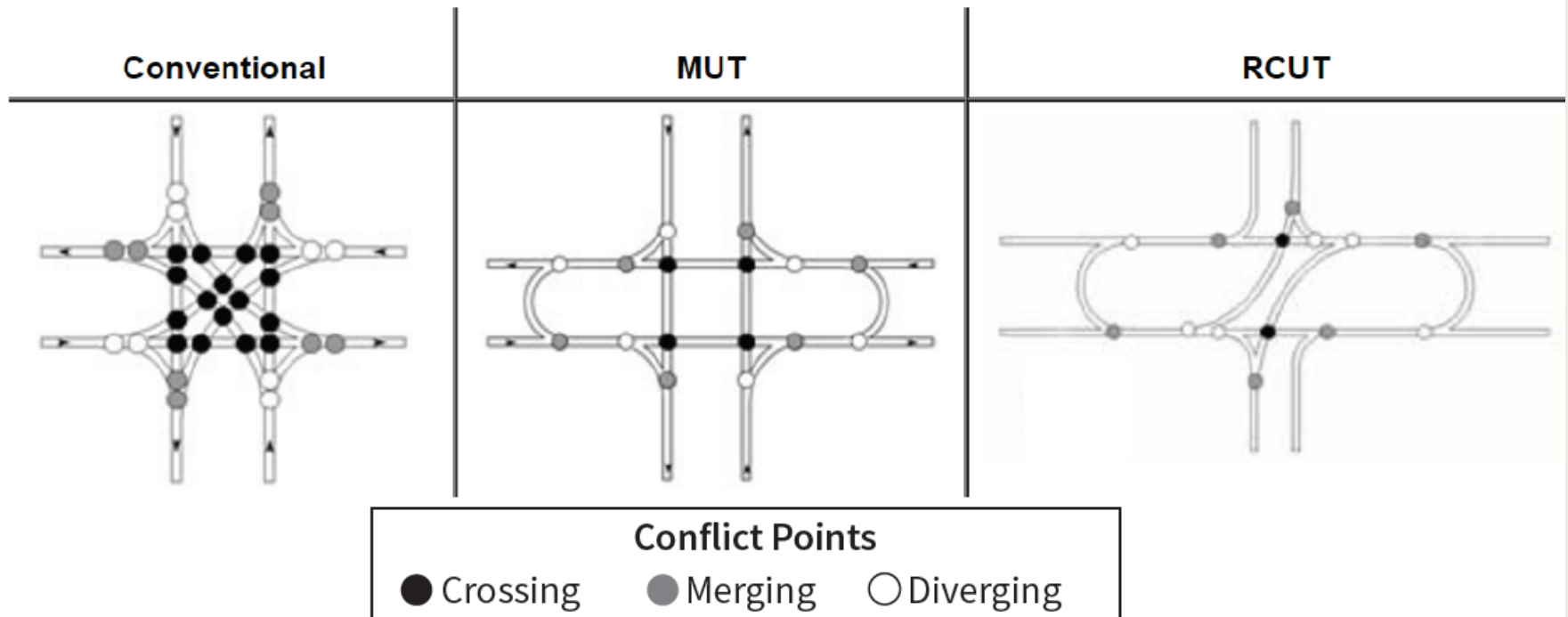
REDUCED LEFT TURN CONFLICT INTERSECTIONS



PROVEN SAFETY COUNTERMEASURES

Reducing the number and severity of conflict points

MUT and RCUT Can Reduce Conflict Points by 50%



REDUCED LEFT TURN CONFLICT INTERSECTIONS



U-Turn Based Left-Turn Movements (or “Redirected Left-Turn Movements”)

Restricted Crossing U-Turn (RCUT)

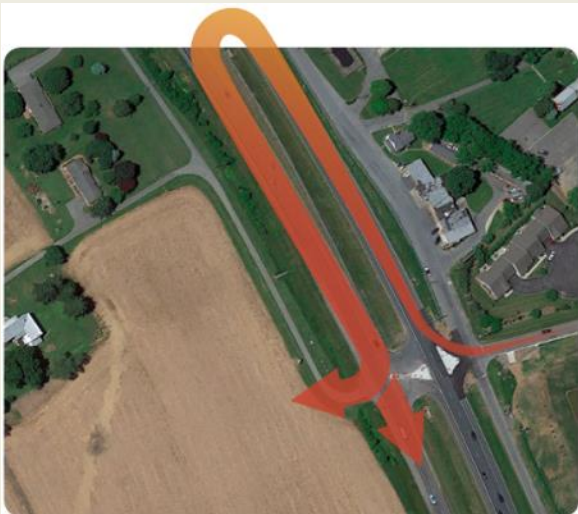


Figure 1: Frederick County, MD RCUT Intersection
Source: Google Earth

Median U-Turn (MUT)



MUT Left Turn Maneuver from a Major Road, Birmingham, MI
Source: MUT Video FHWA-SA-14-018



MUT Left Turn Maneuver from a Minor Road, Birmingham, MI
Source: MUT Video FHWA-SA-14-018

RCUT – RESTRICTED CROSSING U-TURN

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

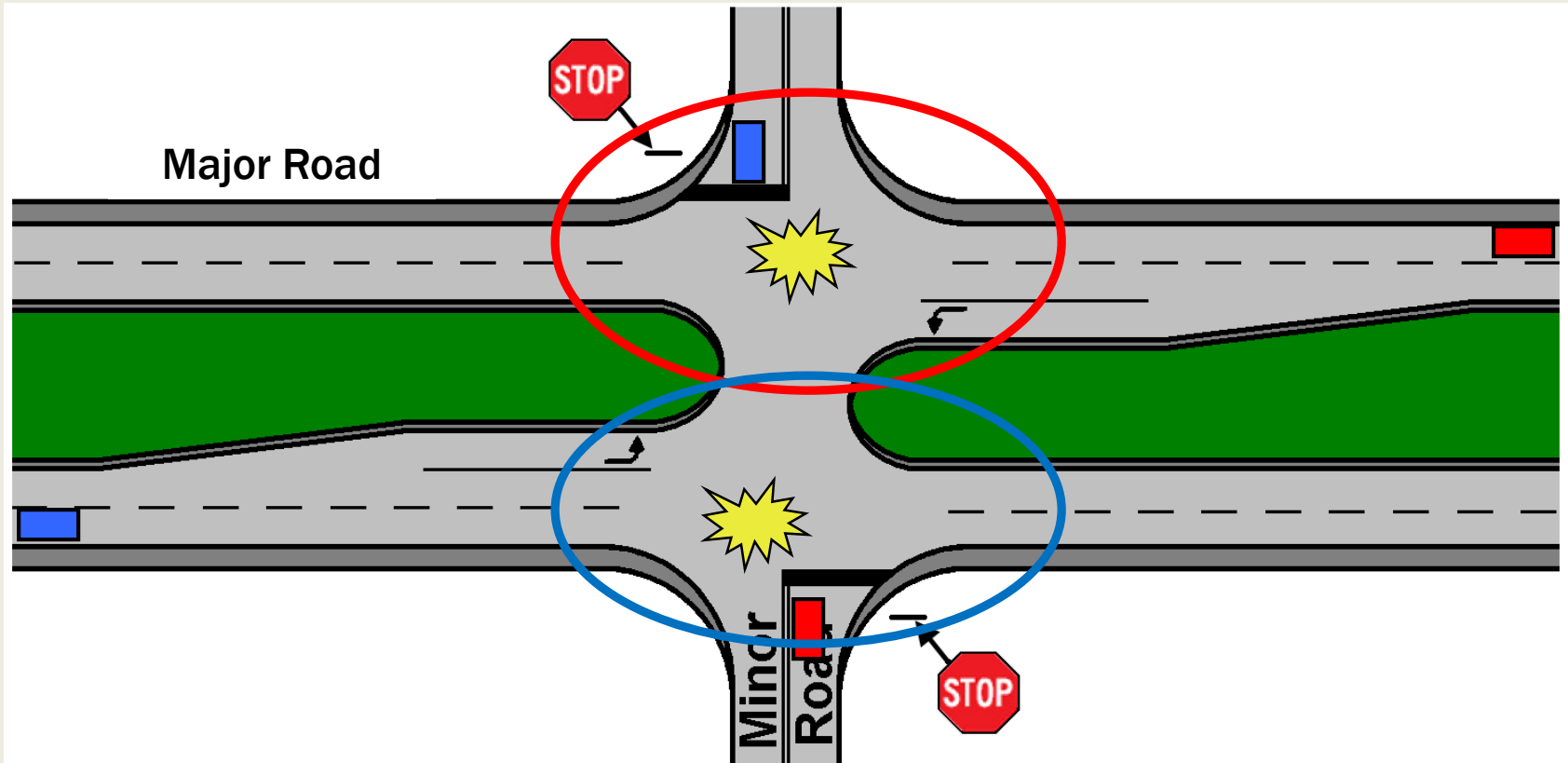


At-grade intersections with directional medians so minor road traffic must turn right and make a U-turn to cross or make the left-turn maneuver.

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

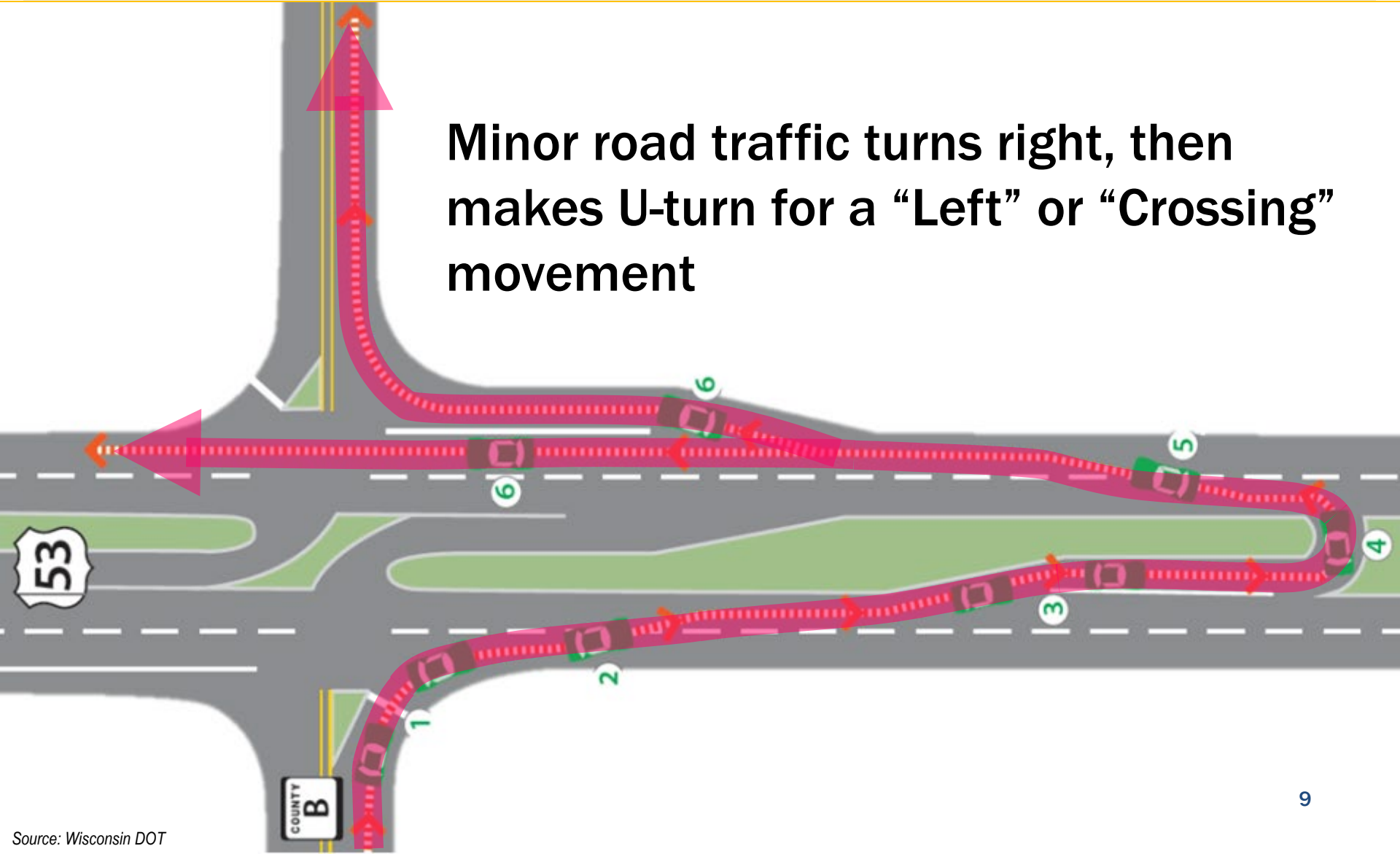
DIVIDED HIGHWAY WITH OPEN MEDIAN

Problem: Far-Side Right-Angle Collisions



RCUT DISTINGUISHING FEATURES

Minor road traffic turns right, then makes U-turn for a “Left” or “Crossing” movement



FEWER CONFLICT POINTS



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

RCUT APPLICABILITY

Is the RCUT only applicable for rural divided highways?

NO !!! – They are also very applicable for signalized suburban arterials!!!



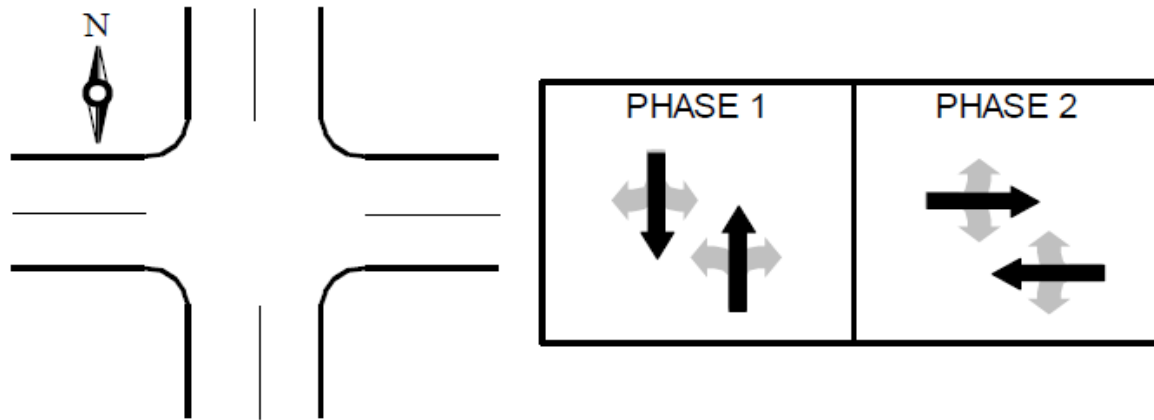
If we have a congested arterial – how do we typically “solve” the problem???

IS ADDING MORE LANES THE ANSWER?

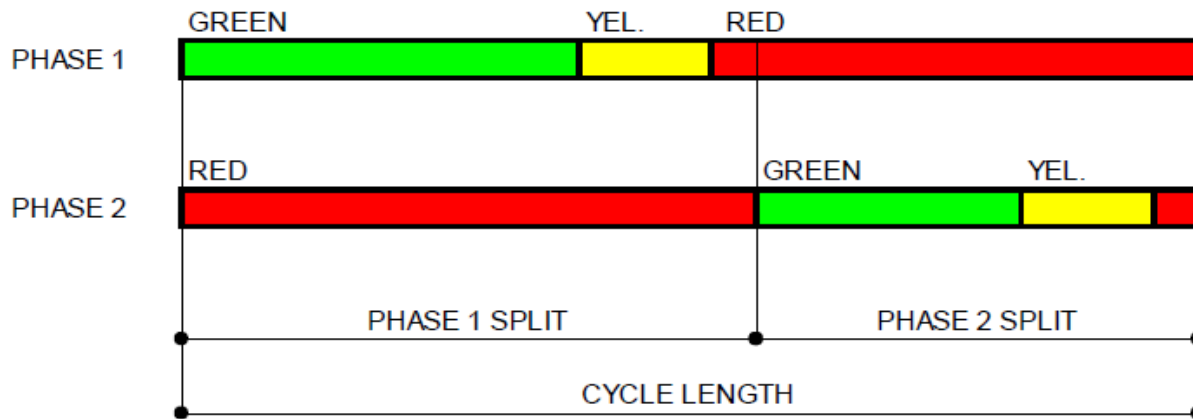


**“It’s the signals,
stupid”**

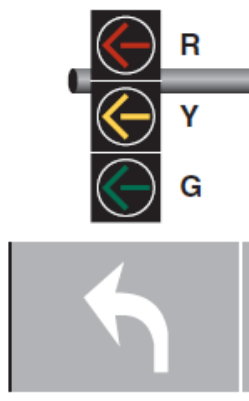
SIGNAL PHASING



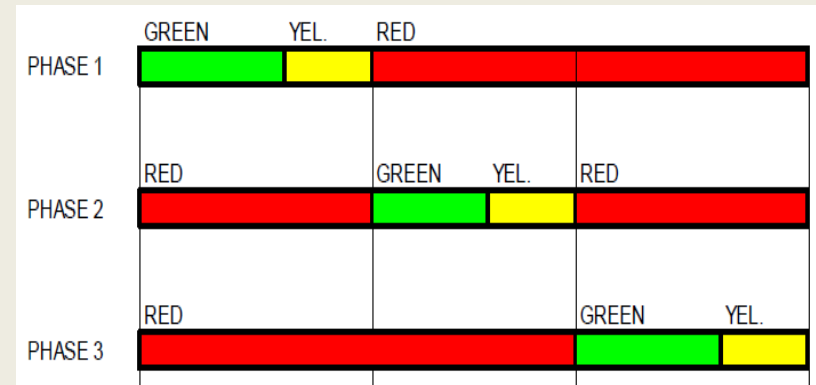
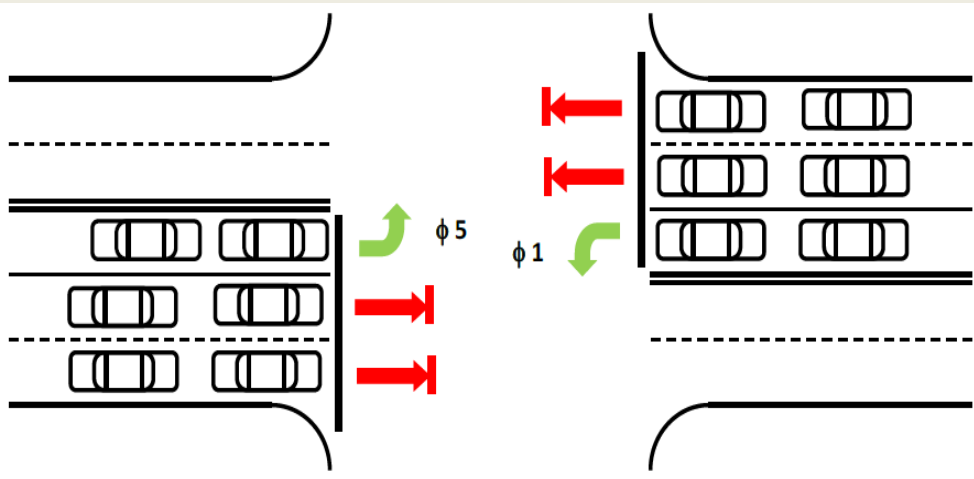
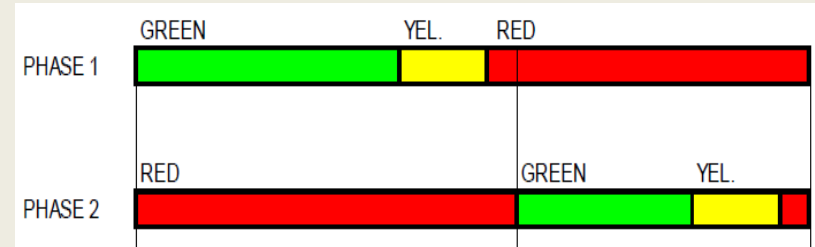
Basic two-phase signal operation



SIGNAL PHASING



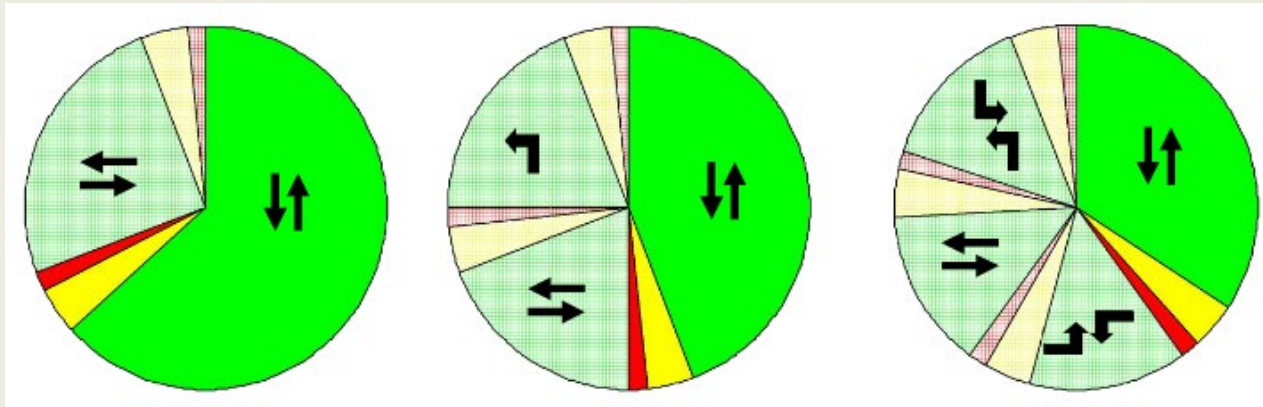
Adding “protected” left-turn phases is common as volumes increase



THE “SECRET SAUCE”

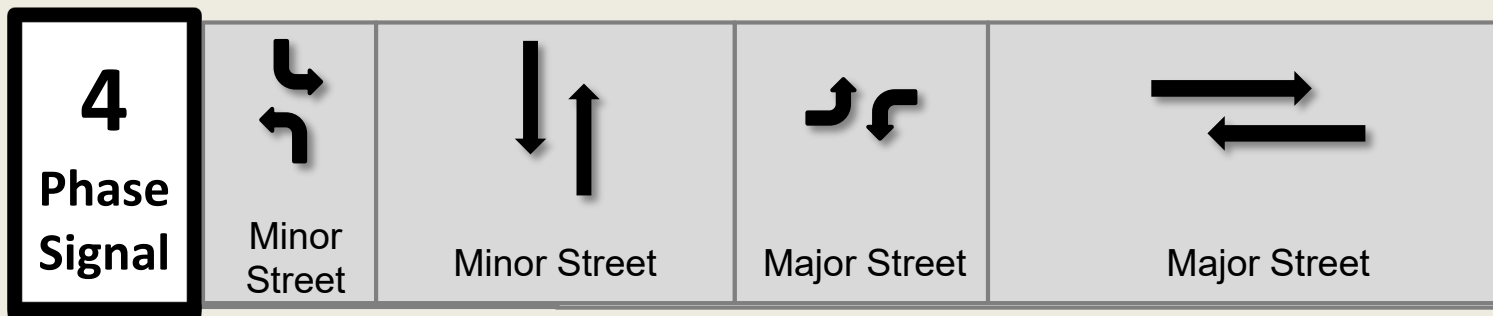
Fewer phases (intervals) allows more green time for the major through movement and decreases intersection delays

- Fewer phases also means less “lost time”



BETTER

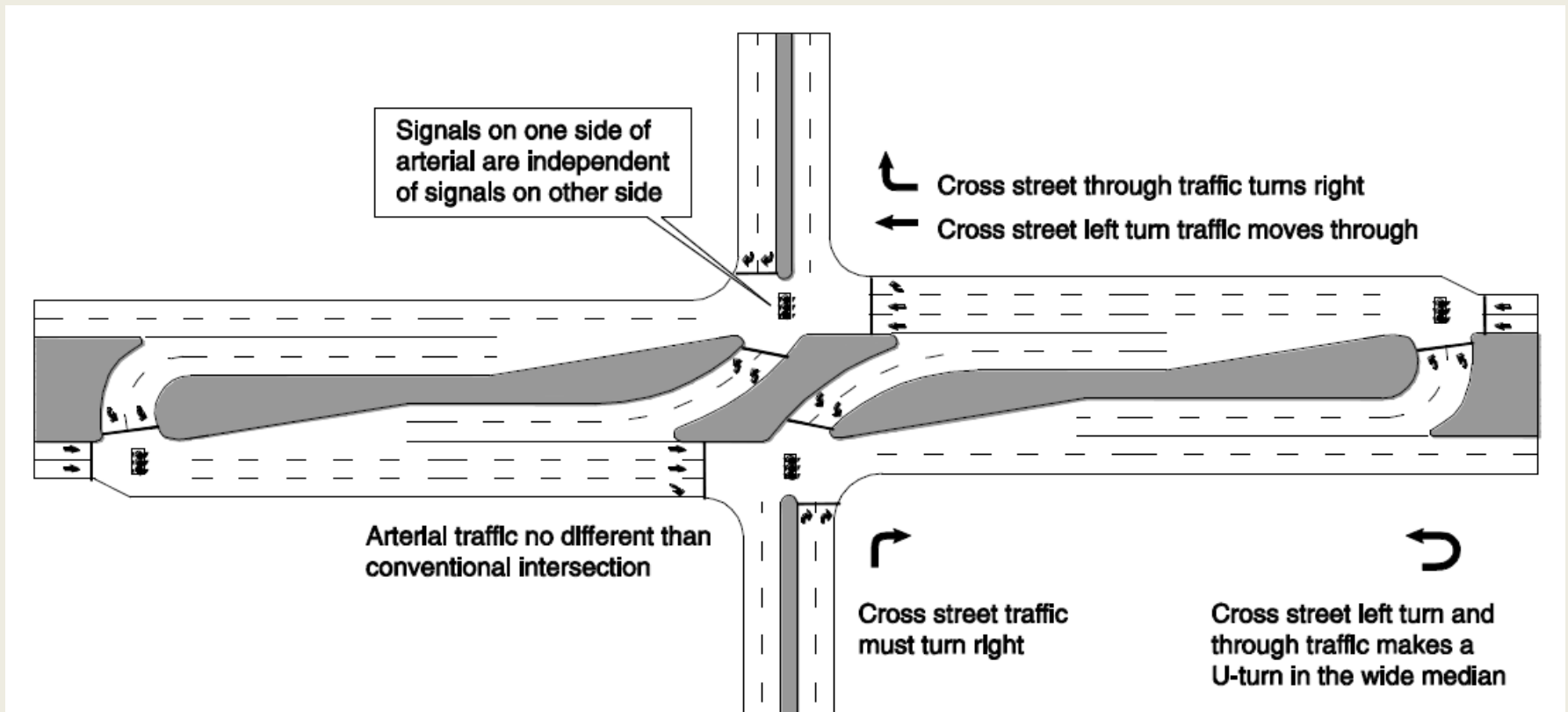
SIGNAL PHASING



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



SIGNALIZED RCUTS



SIGNALIZED RCUT



**SR 4 Bypass at Symmes Rd
Fairfield, OH**

SIGNALIZED RCUT



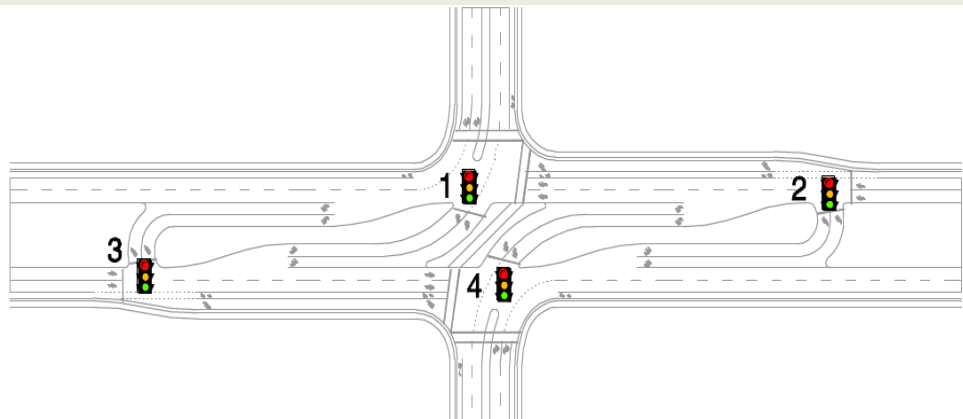
SR 4 Bypass at Symmes Rd Fairfield, OH

BETTER SIGNAL OPERATIONS

Conventional intersection



Superstreet intersection

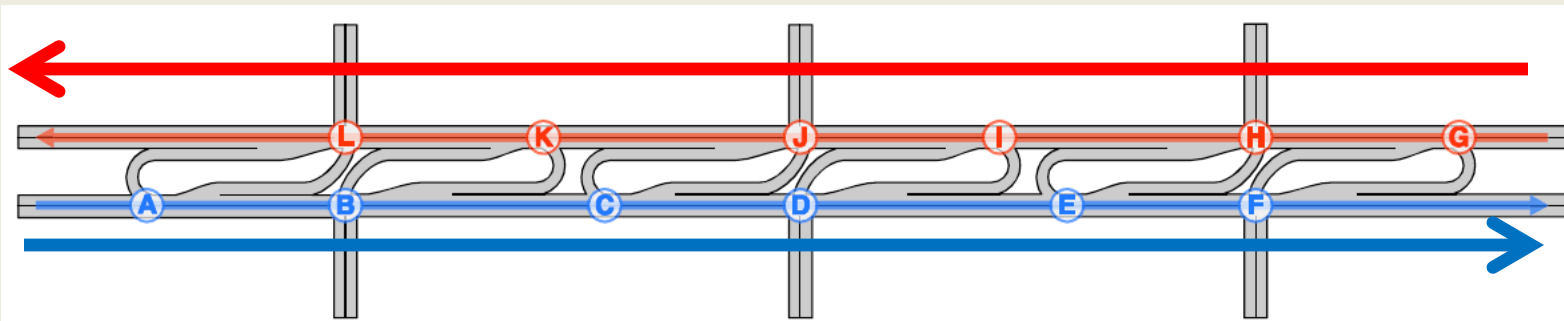


- Signalized RCUTs with 2-phases allow more green time to the major street through
- Better signal progression
- Shorter cycle lengths than comparable conventional intersections may be possible
- Shorter cycles reduce delay for most vehicles and for pedestrians

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

BI-DIRECTIONAL PROGRESSION

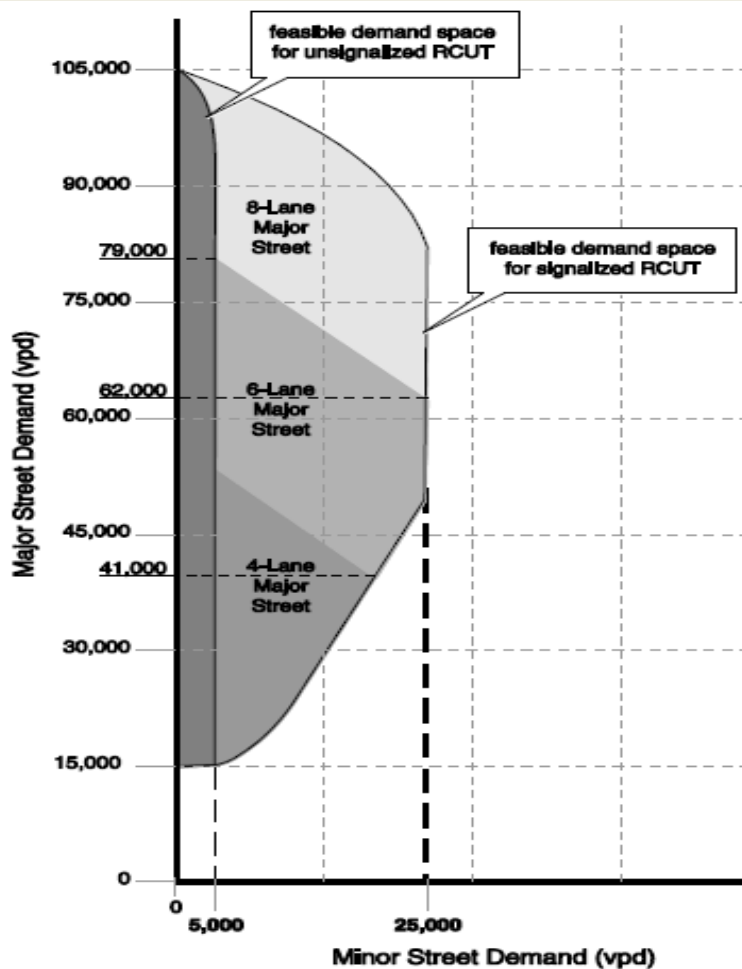
- Each direction may operate independently
- Directions can be progressed at different speeds and/or signal spacing



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

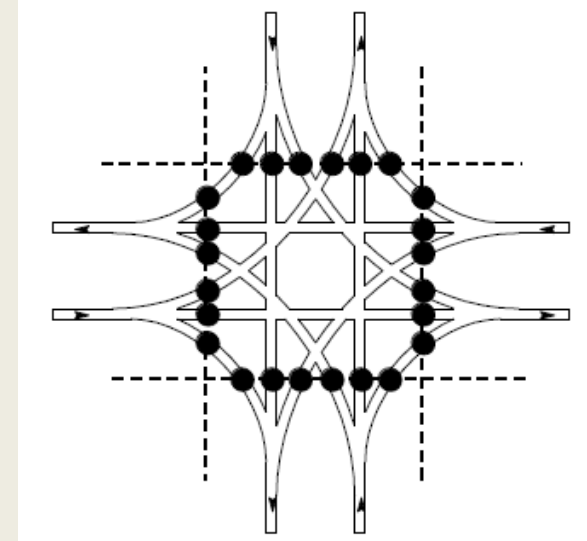
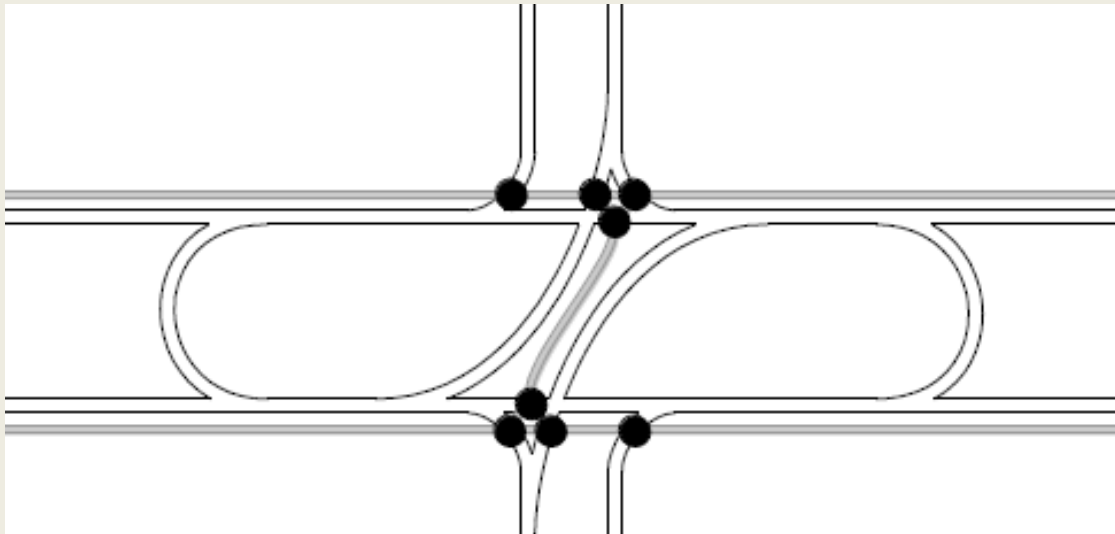
RCUT FEASIBLE DEMANDS



- 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

PEDESTRIAN-VEHICLE CONFLICT POINTS

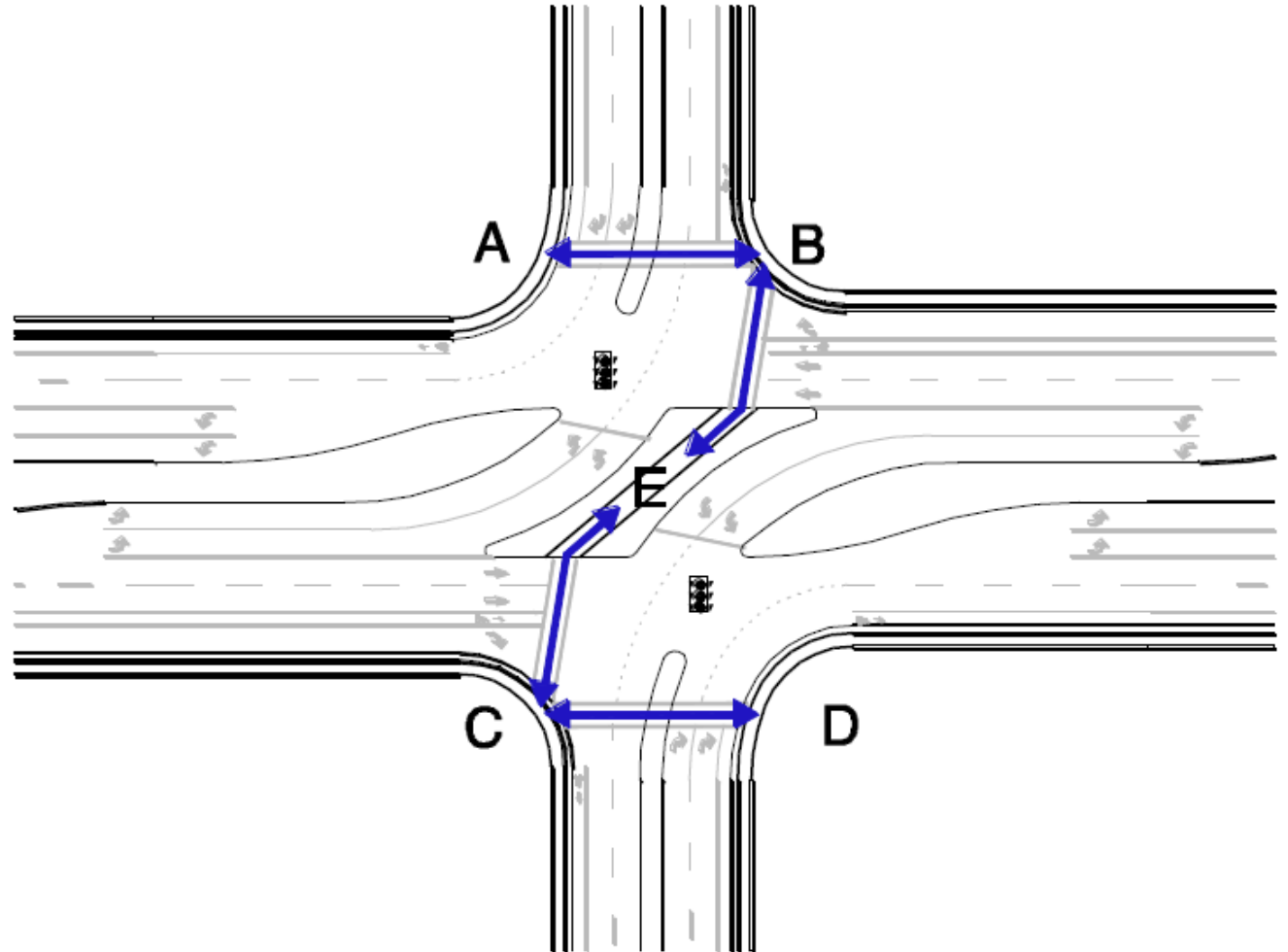
RCUT Intersection
8 conflict points



**Conventional
Intersection**
24 conflict points

PEDESTRIAN CROSSWALKS

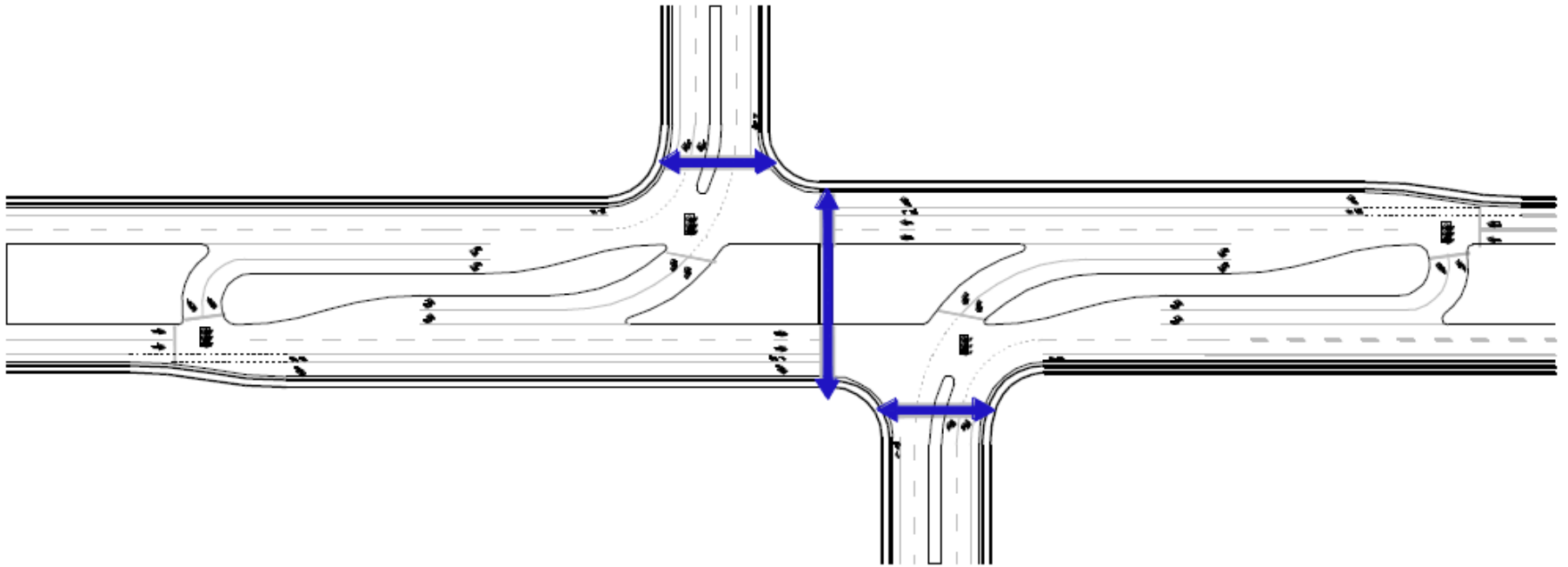
Pedestrian
crosswalk
pathways at a
signalized
RCUT



PEDESTRIAN “Z” CROSSING



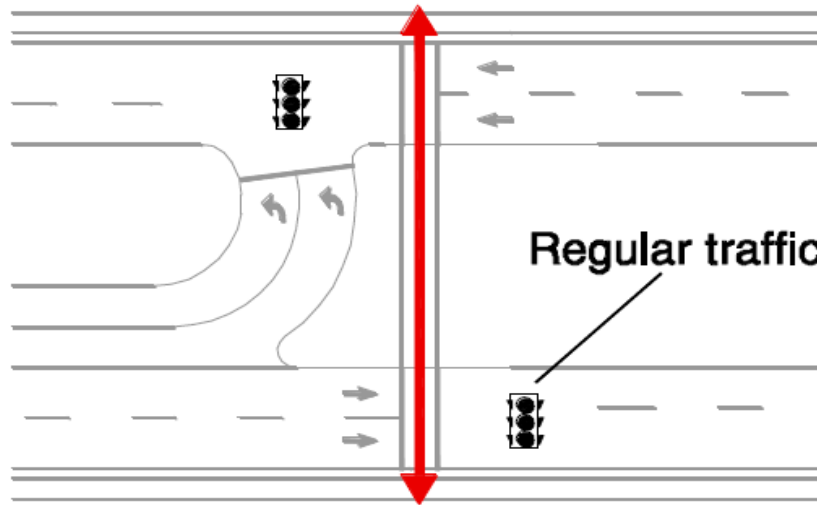
OFFSET APPROACHES OPTION



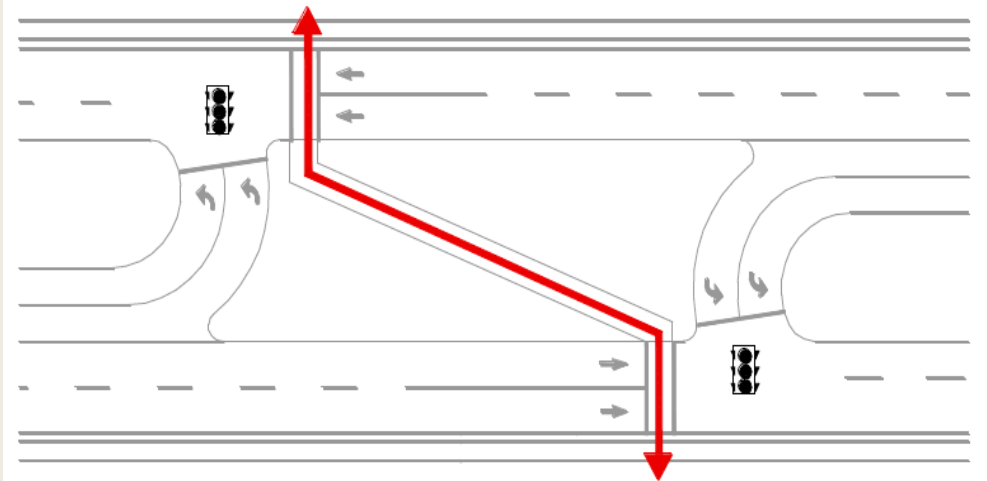
This variation should be strongly considered in developing areas where the minor street or driveway locations have not yet been established.

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

MID-BLOCK PED CROSSING OPTION



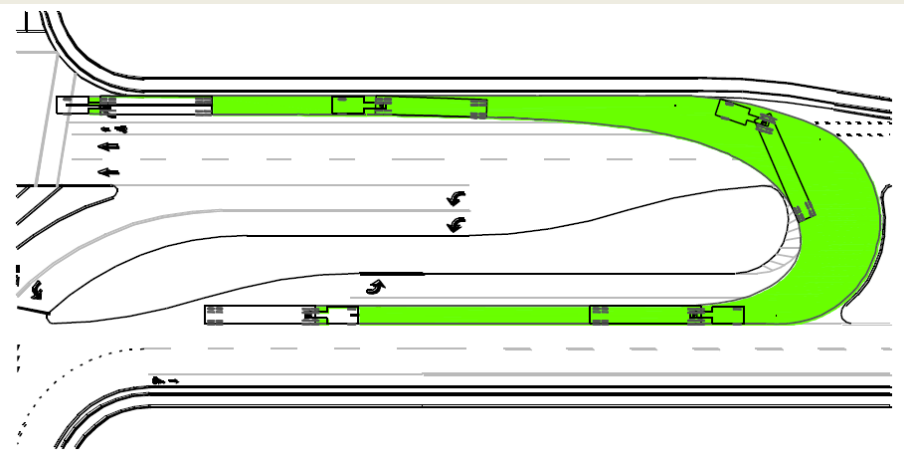
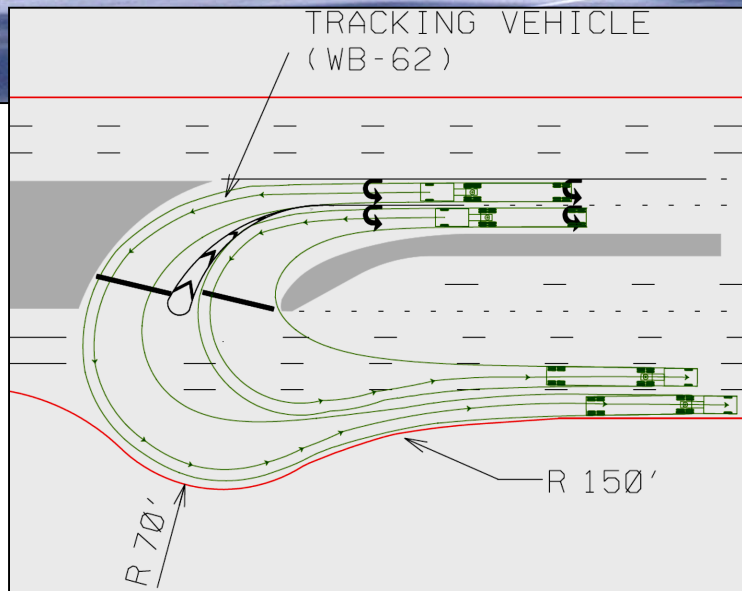
Adding pedestrian signal will not interfere with signal progression!!!



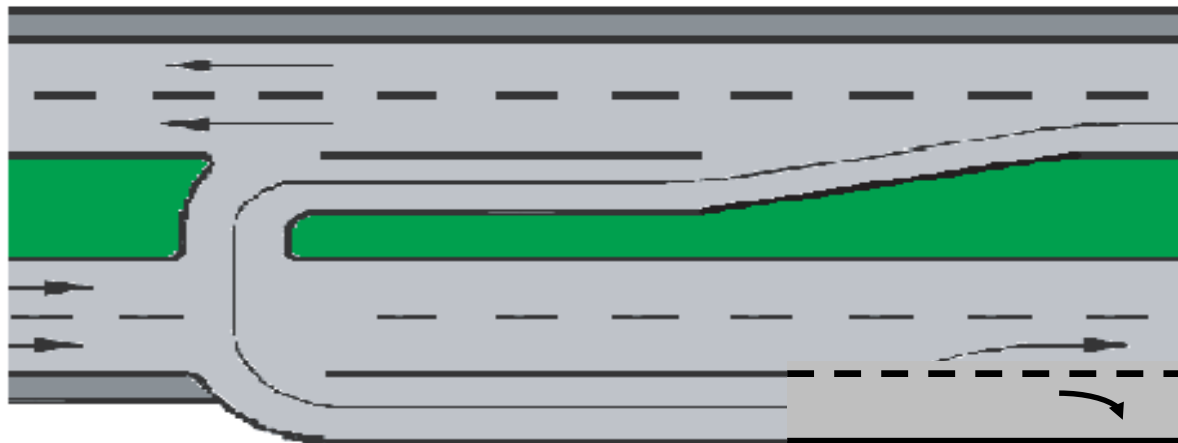
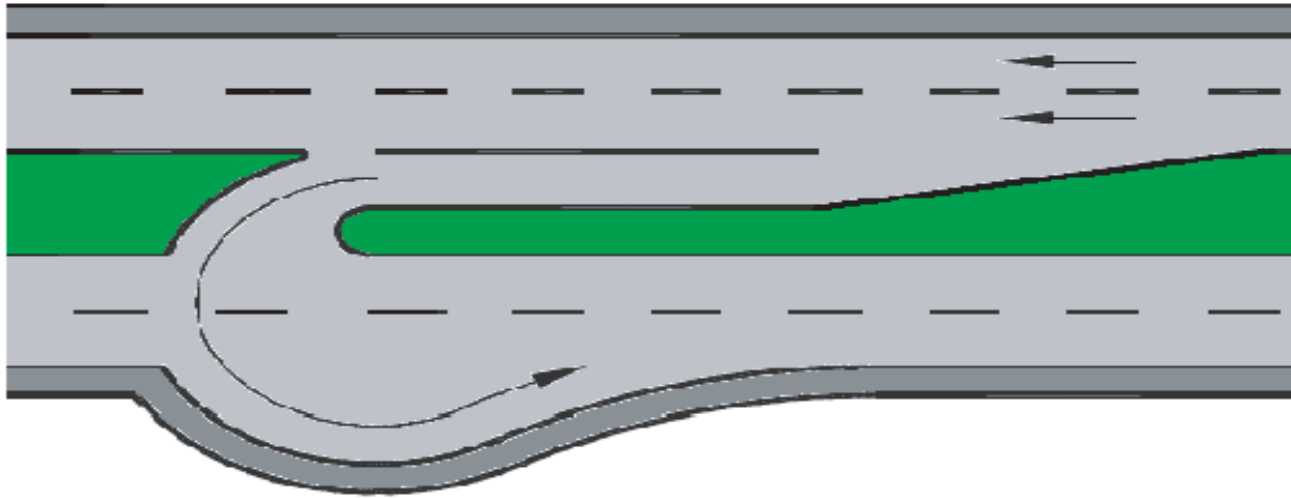
Accommodating Truck Movements



RCUT INTERSECTION – LOON



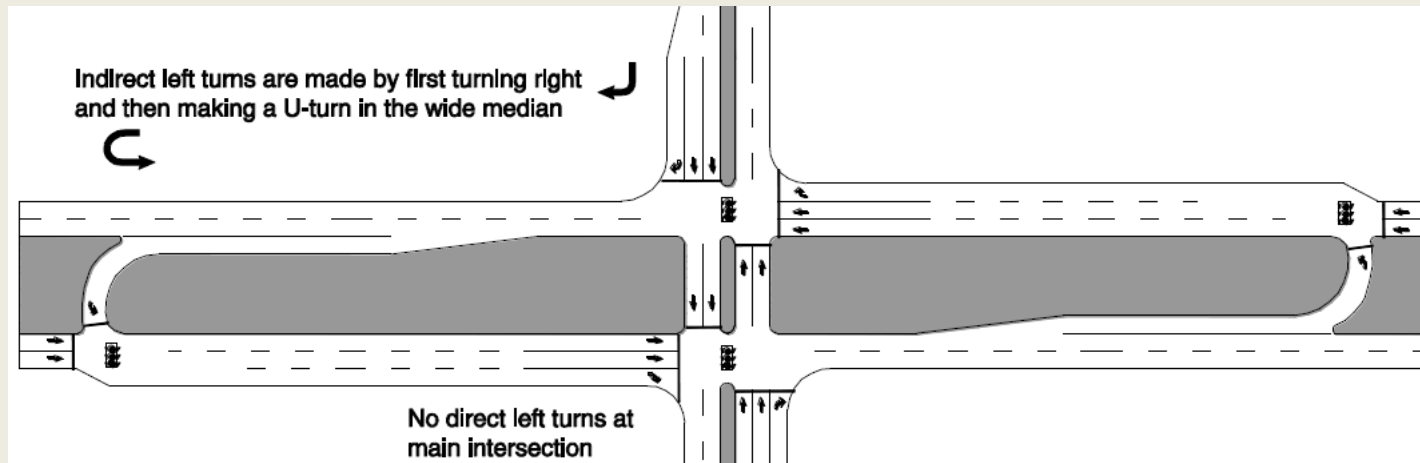
LOONS & U-TURN ACCELERATION LANES



Could begin
right turn lane

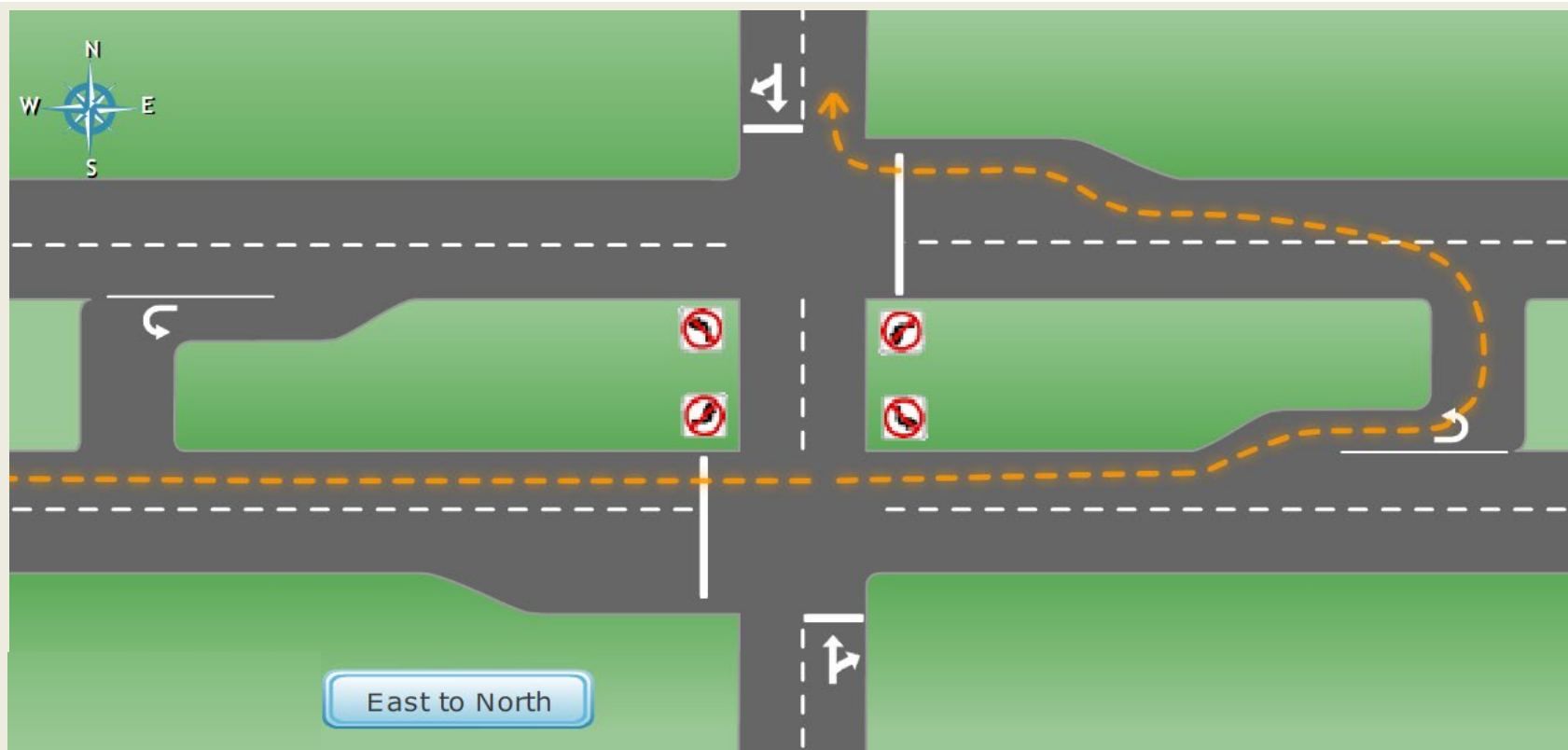
MUT – Median U-Turn

(aka Michigan Left)



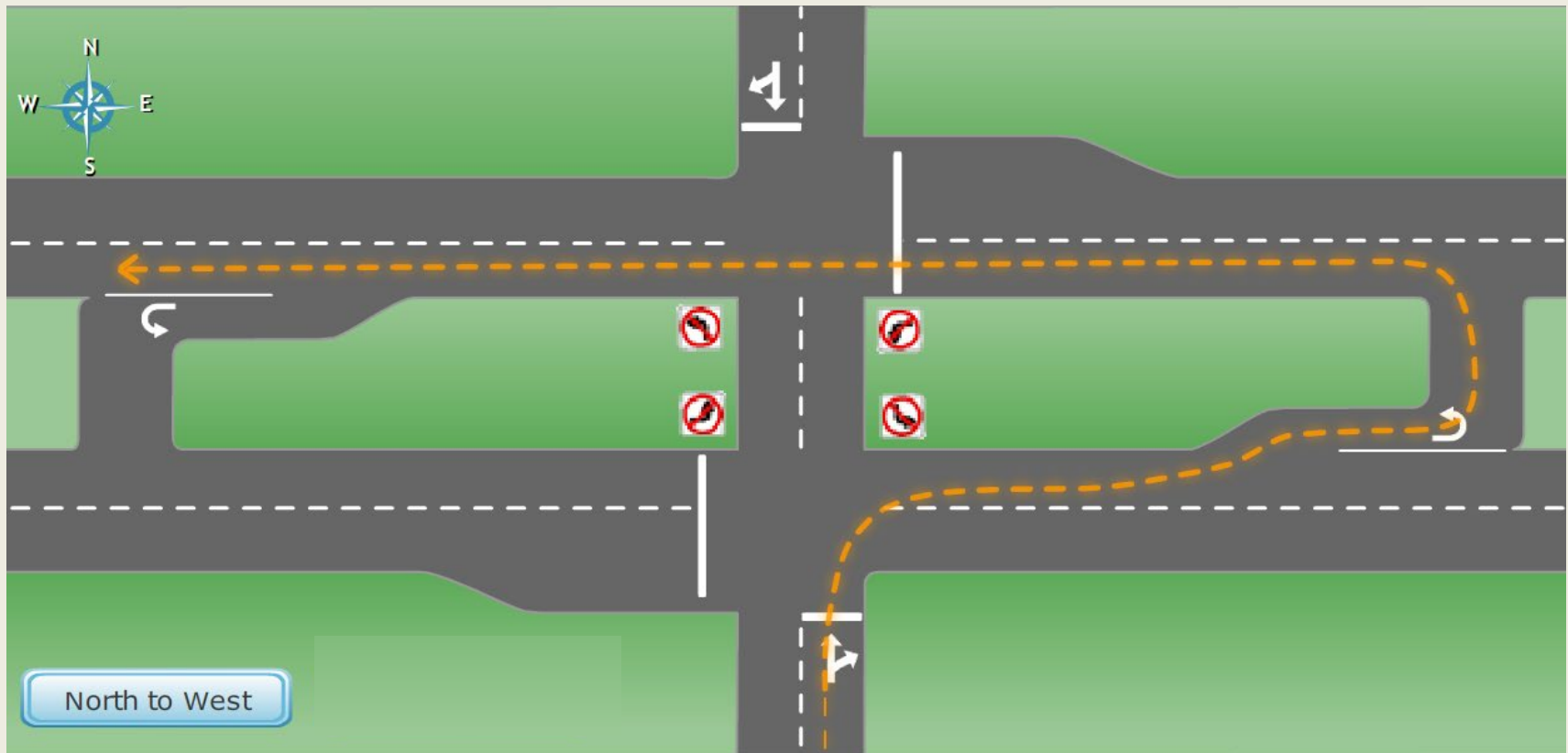
- At-grade intersections with *indirect* left turns using a U-turn movement in a wide median and/or loon
- The MUT eliminates direct left turns on both intersecting streets, reducing the number of signal phases and conflict points at the main intersection

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.

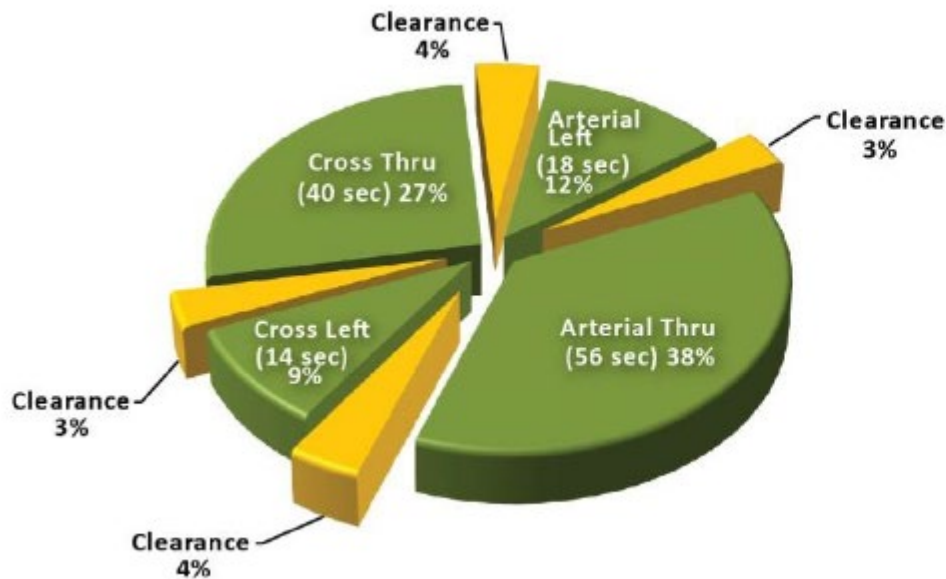
MUT – LEFT TURN FROM MINOR ROAD



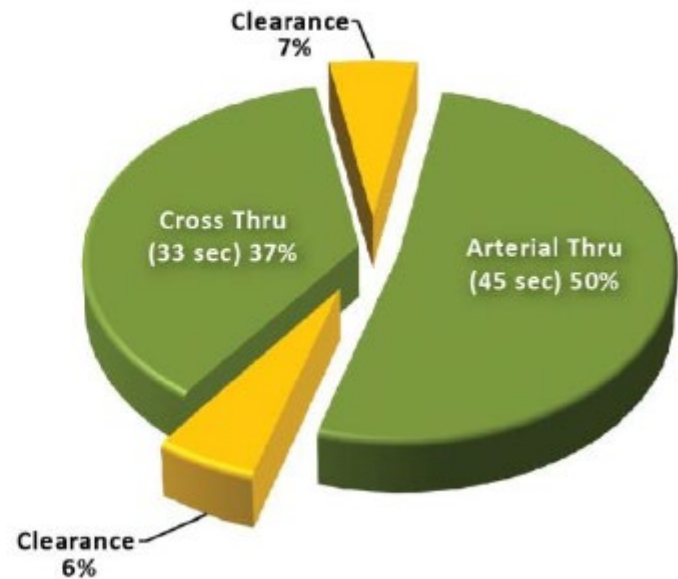
Vehicles on the minor street that wish to turn left at the major street are directed to turn right, make a U-turn movement at the same crossover, and then proceed through the main intersection.

SIGNAL OPERATIONS

150-Second Multi-Phase Cycle



90-Second Two-Phase Cycle

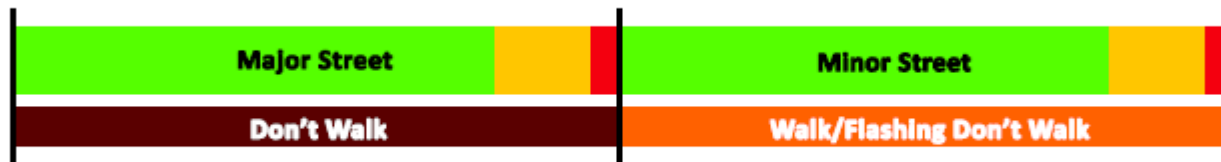


The MUT removes left-turn phasing, which results in fewer clearance intervals in the intersection cycle and to operate well with a shorter cycle length than a comparable multi-phase cycle

PEDESTRIAN WALK PHASES



Typical Conventional Intersection Signal Cycle



MUT Intersection Signal Cycle

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).

MUT APPLICABILITY

Is the MUT only applicable for divided highways with wide medians?

NO !!! – The strategy can also be applied on roads without wide medians!!!



THRU-TURN INTERSECTION



Source: <https://www.youtube.com/watch?v=a11wVxLle6s>



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

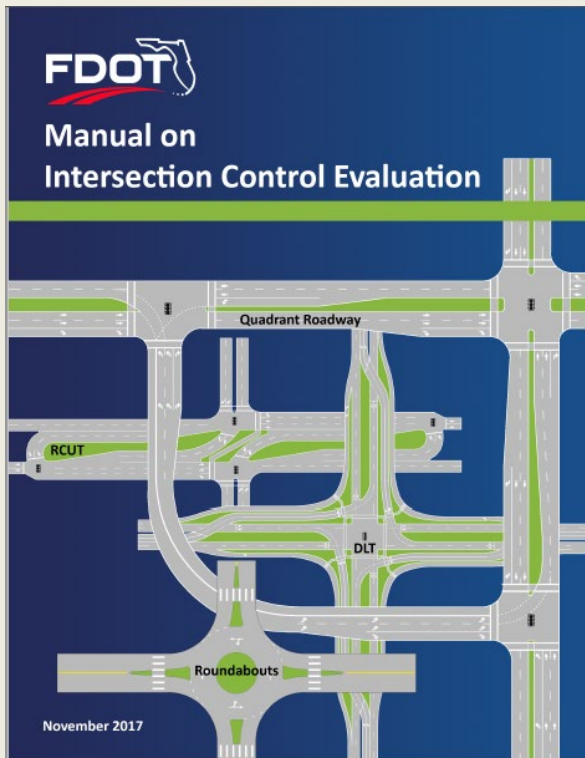
Return to the intersection and make a right.



EXPRESS LEFT

Tucson, AZ

INTERSECTION CONTROL EVALUATION



“The goal of ICE is to better inform the FDOT’s decision-making to identify and select a control strategy meeting the project’s purpose and need, fitting the intersection location’s context classification, providing safe travel facilities for all road users, and reflecting the overall best value.”

<https://www.fdot.gov/traffic/TrafficServices/Intersection-Operations.shtm>

Unsignalized At-Grade Intersections



Conventional Minor Street or All-Way Stop: At minor-street stop (2-way stop) intersections, vehicles on minor street stop and give right-of-way to major street. At all-way stop (AWS) intersections, all vehicles must stop and take turns entering the intersection. Both (4-leg) intersection types have 32 baseline conflict



Mini Roundabouts: Roundabout type characterized by a small diameter and traversable central island; offers most of the benefits of single-lane roundabouts with added benefit of a smaller footprint; best suited to lower-speed environments and where environmental constraints preclude use of a larger roundabout with a raised



Single-Lane Roundabouts: Form of circular intersection in which traffic travels counterclockwise around a central island and in which entering traffic must yield to circulating traffic. Circulating traffic has priority with entries controlled by yield. Geometry slows all traffic into and thru the roundabout. At a 4-leg roundabout there



Multilane Roundabouts: Share same circulatory travel and yield-at-entry in single-lane roundabouts, but include multiple entry and circulatory lanes for one or more approaches that must accommodate vehicles traveling side by side. Important design features include proper entry path alignment and geometry, signing and



Restricted Crossing U-Turn (RCUT): Redirects minor street left turn movements as right-turns followed by a U-turn movement via a downstream directional crossover in the median (+/- 500 feet from the main intersection). An RCUT intersection has 14 conflict points and can provide substantial safety benefits with



RIRO w/Downstream U-Turn: Redirects minor street thru & left turn movements as right-turns followed by a U-turn via directional median crossover (+/- 500 feet from main intersection). Major street lefts are also made indirectly, passing the crossing street and using the same U-turn crossovers in the median. Minor street



Unsignalized High-T: Unsignalized 3-leg intersection features raised channelization to separate "top" thru movement from turning lanes at intersection, allowing the through movement to operate continuously. A high-T intersection has 9 baseline conflict points, the same as a conventional 3-leg.

Signalized At-Grade Intersections



Signalized Intersection: The most common type of signalized intersection with high driver familiarity. Signal could be simple two-phase or more complex 8-phase to serve vehicular demand. Left turns can be permitted or protected (or combination of both). At a conventional 4-leg intersection there are 32 baseline



Median U-Turn: Left turn movements otherwise occurring at the main intersection are made via U-turns in the median, preceding or following right turns. U-turns may be only on major roadway or on both major and minor roadways. A



conventional MUT has 16 baseline conflict points and has shown significant **Signalized RCUT:** Similar to the Median U-turn but features break in cross-street traffic that allows signals on opposite directions to operate independently. Left turns can make directly turns onto the minor road but minor road thru and left turn movements are made using the directional



U-turn crossovers. An RCUT has 14 **Displaced Left-Turn (DLT):** Left turn traffic crosses opposing lanes in advance of main intersection and are stored in additional lanes. At main intersection, thru and left turns can be made simultaneously during same signal phase. A full DLT (both routes) has 28 baseline conflict points; a partial DLT (one route) has 30 baseline



Continuous Green-T: Three-leg intersection that features raised channelization to allow the "top" through movement to operate under continual green. The opposite direction intersects with the major and minor street lefts at a signalized intersection (minor left turns merge with the continual through



Jughandle: Much like an at-grade diamond interchange, ramps on the major street diverge from the right side in advance of a cross street intersection, removing the left turn movement from directly at the cross-street intersection. Major street left turns are made at minor, stop-controlled intersections on the cross-street. Left

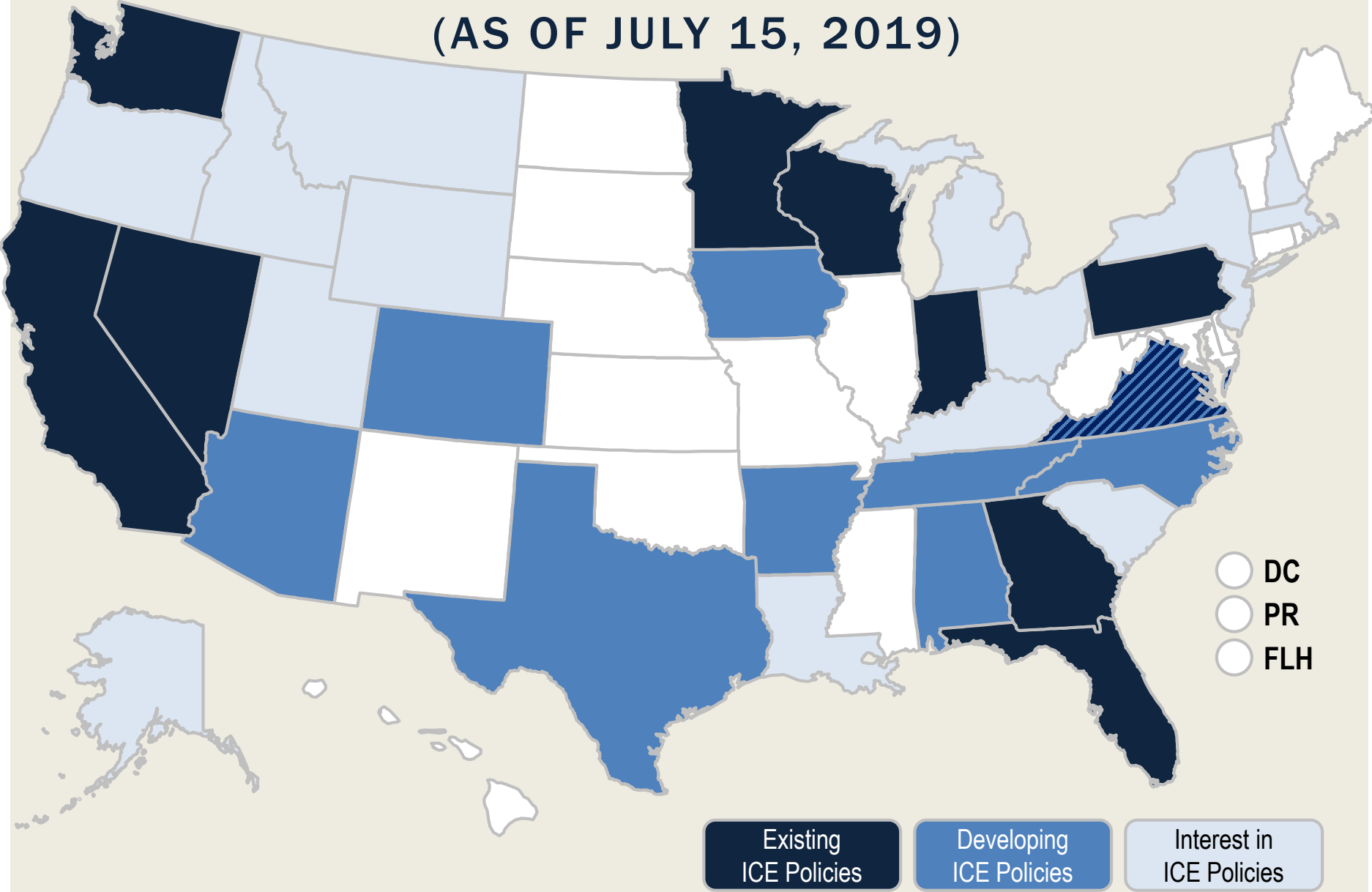


Quadrant Roadway: Left turns are removed from the main intersection via an additional roadway in one intersection quadrant. Left-turn movements are routed from the arterial and cross-street (using unique turning paths for each approach) onto the quadrant roadway to complete the left turn movement at the quadrant roadway

ICE promotes the consideration of the wide array of intersection forms and control options including variations on typical forms

STATE PROGRESS ON ICE POLICIES

(AS OF JULY 15, 2019)

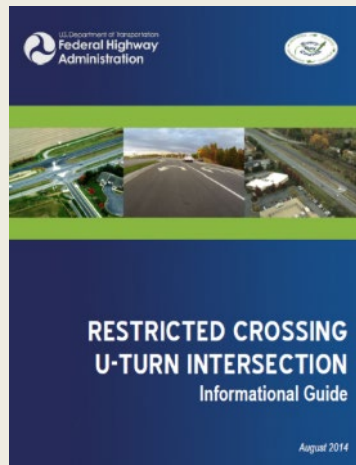
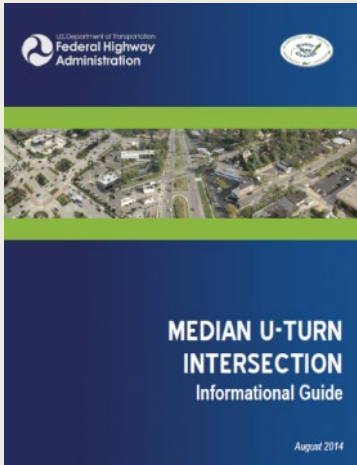


Existing
ICE Policies

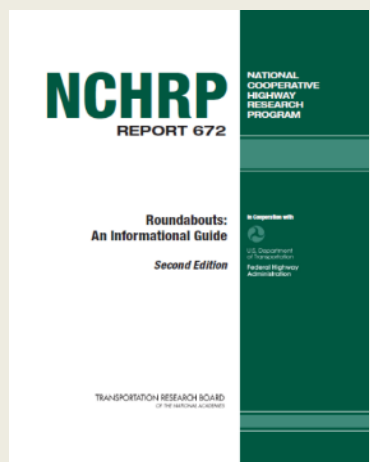
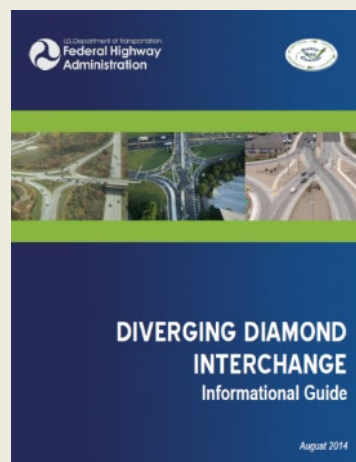
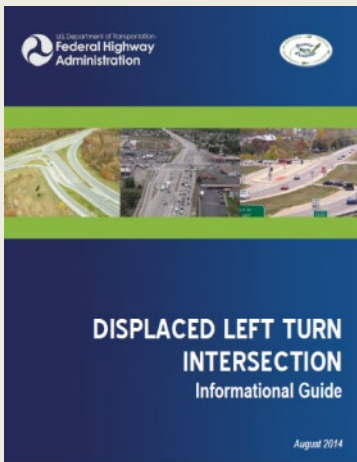
Developing
ICE Policies

Interest in
ICE Policies

RESOURCES



For easy access ...
safety.fhwa.dot.gov/intersection/



THANK YOU !!!

QUESTIONS???

