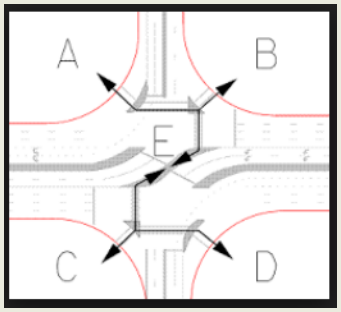
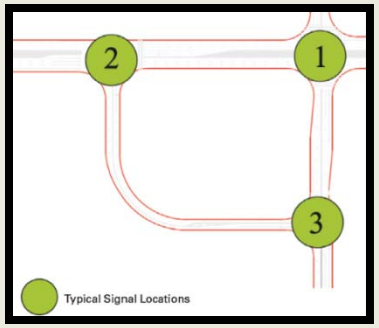
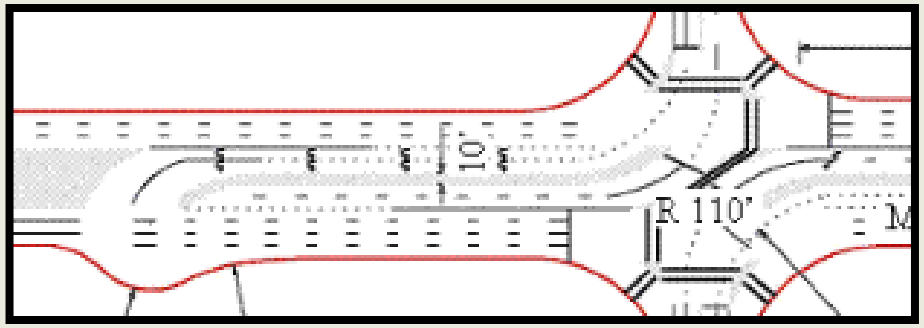
Innovative Intersections
Things You Need to Know About







FDOT D-7 Safety Academy
October 19, 2016

Mark Doctor
FHWA Resource Center
Atlanta, GA

HOW DO YOU FEEL???

... about innovative intersections???

Why is XYZ Boulevard so congested???

I remember when we widened it to four-lanes in each direction. There's no more room to add lanes!

BIGGER IS NOT ALWAYS BETTER

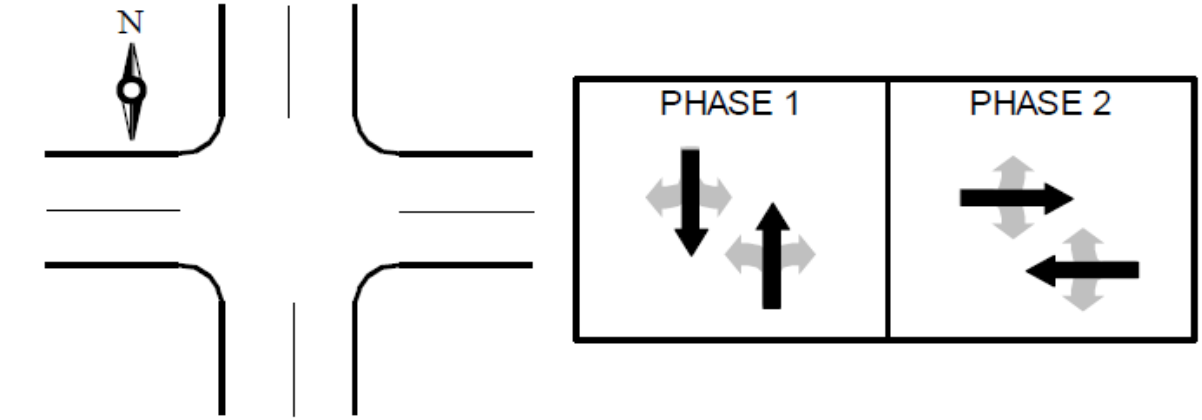
Changing how we design and operate intersections may allow us to save lives and build more efficient and effective projects

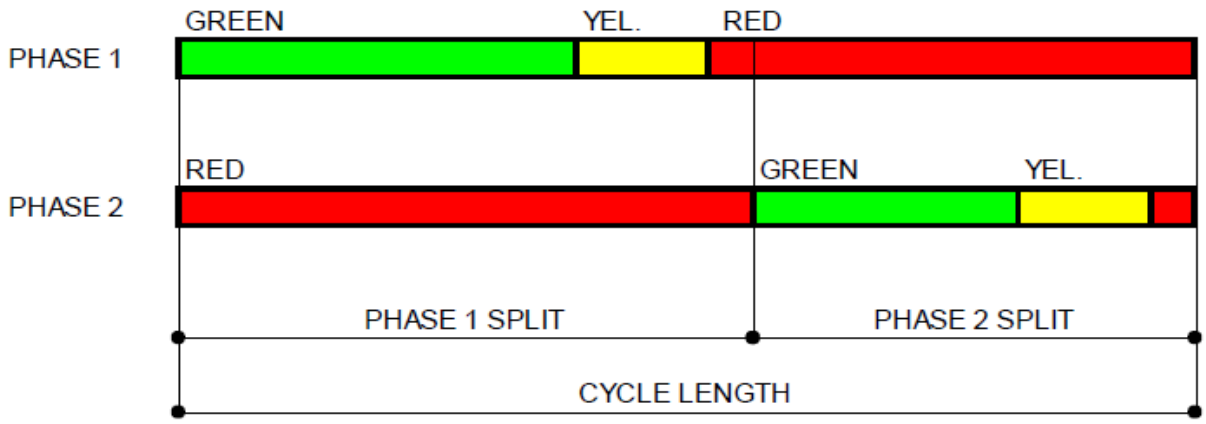
WHY INNOVATIVE INTERSECTIONS & INTERCHANGES?

Intersections are a safety concern, with the highest percentage of crashes and severity than any other roadway element.

Photo Source: Mark Doctor, FHWA

SIGNAL PHASING

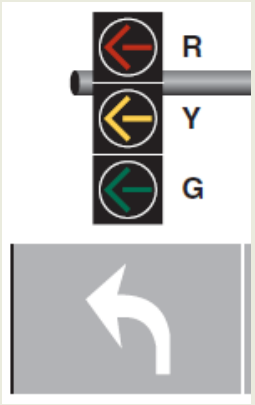




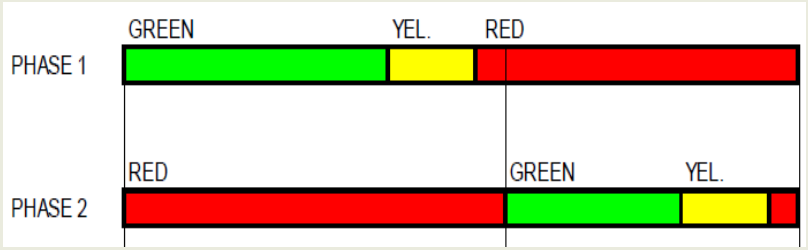
Basic two-phase signal operation

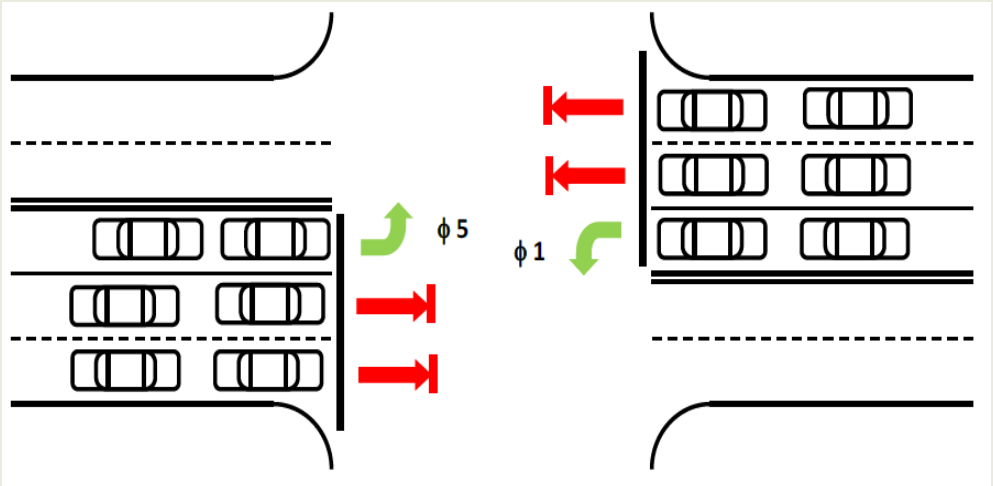
Source: MnDOT Traffic Signal Timing and Coordination Manual

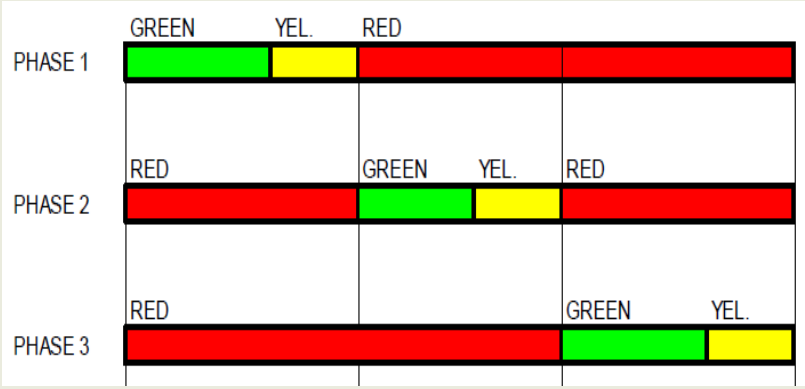
SIGNAL PHASING



Adding "protected" left-turn phases is common as volumes increase

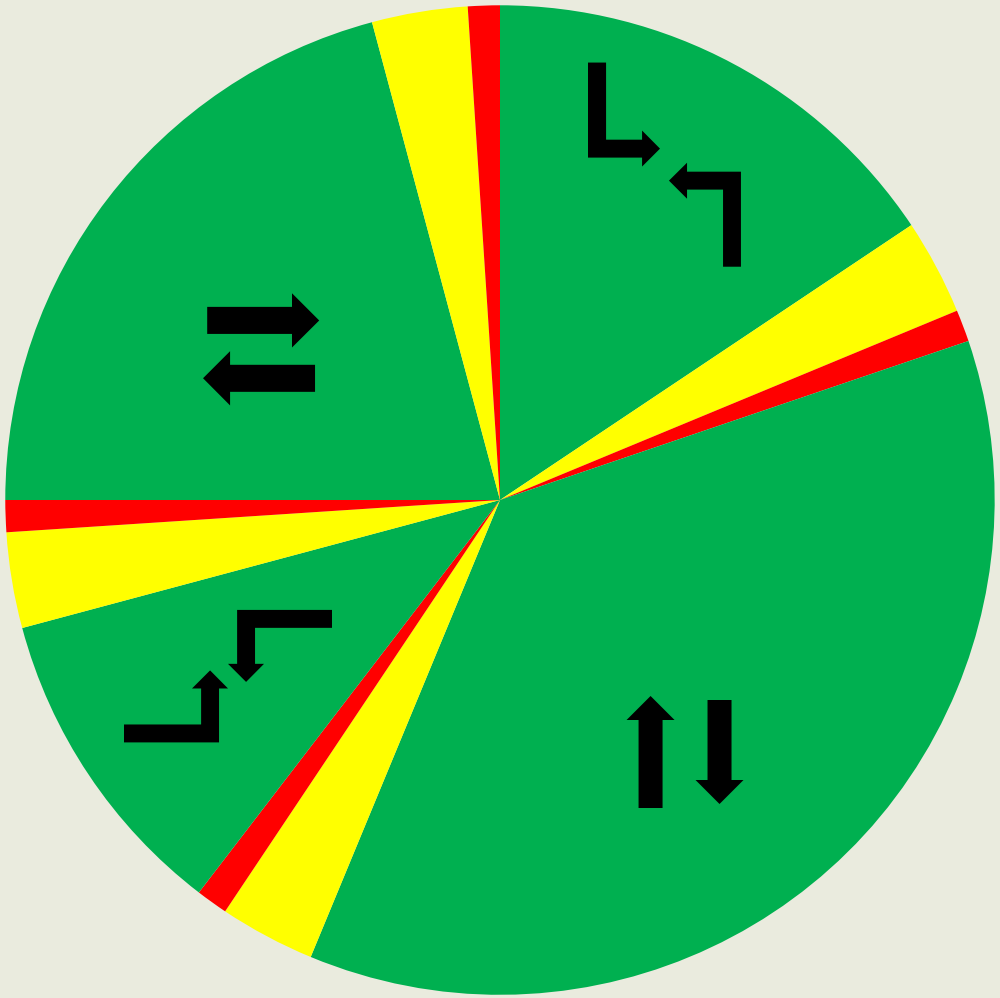






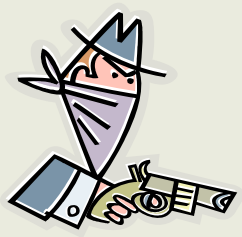
Source: MnDOT Traffic Signal Timing and Coordination Manual

COMMON PHASING WITH PROTECTED LEFTS ON MAJOR AND MINOR ROADS

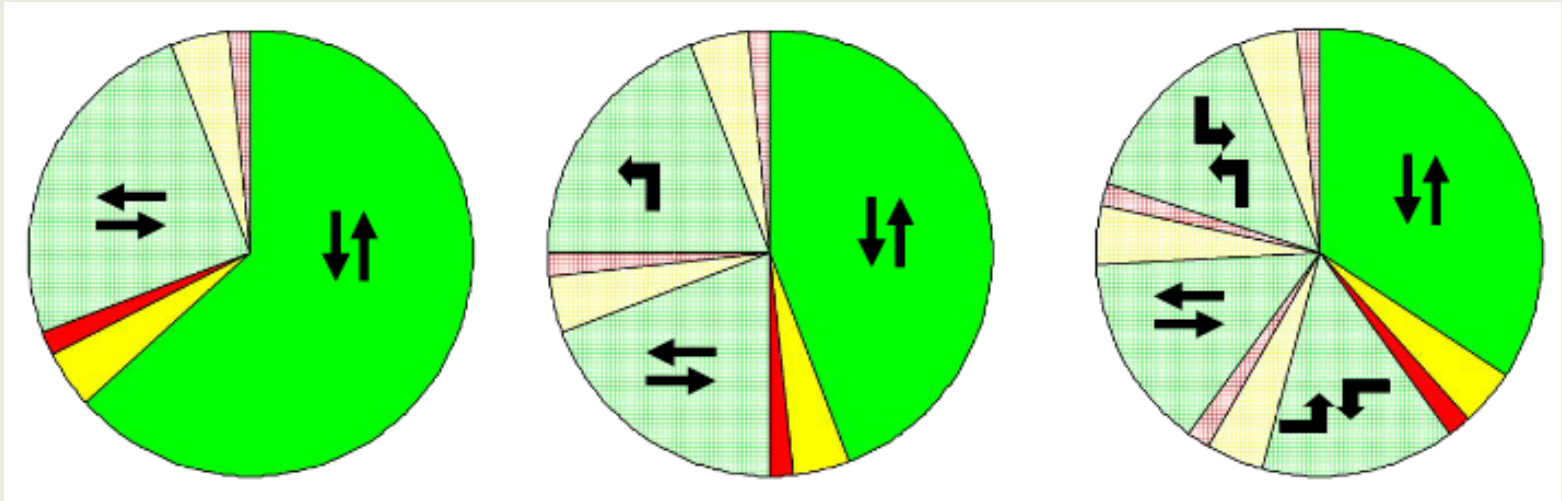


SIGNAL PHASING

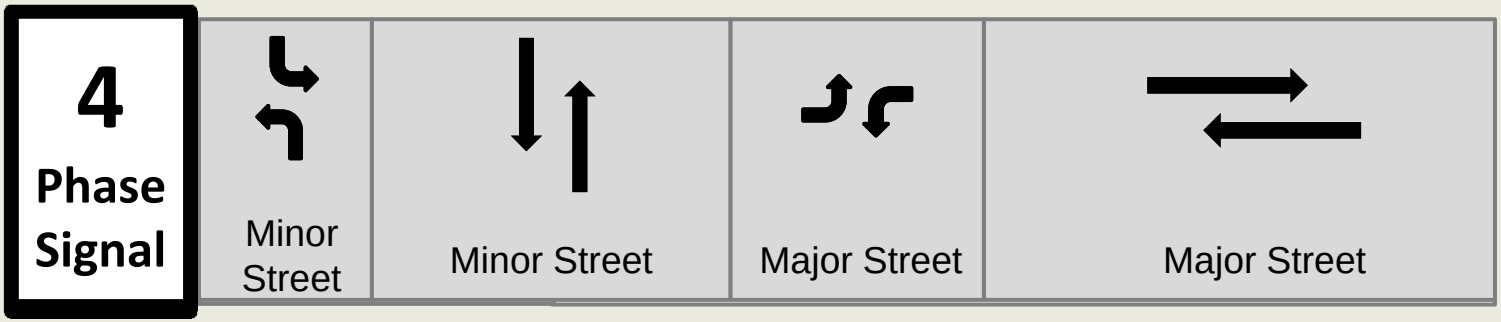
Adding more phases “steals” time away from the major through movement and can increase intersection delays



- More phases also add more “lost time”



SIGNAL PHASING



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

BENEFITS OF INNOVATIVE DESIGNS

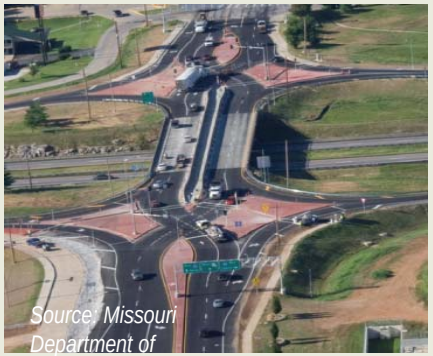
SAFER – they can improve the way traffic makes certain movements by eliminating, relocating or modifying conflict points

LESS DELAY – reducing the number of signal phases

LOWER COST – $$$

Source: Mark Doctor, FHWA

Source FHWA



Source: Missouri Department of Transportation

IN SUMMARY …

Fewer phases – GOOD / Left turns - BAD

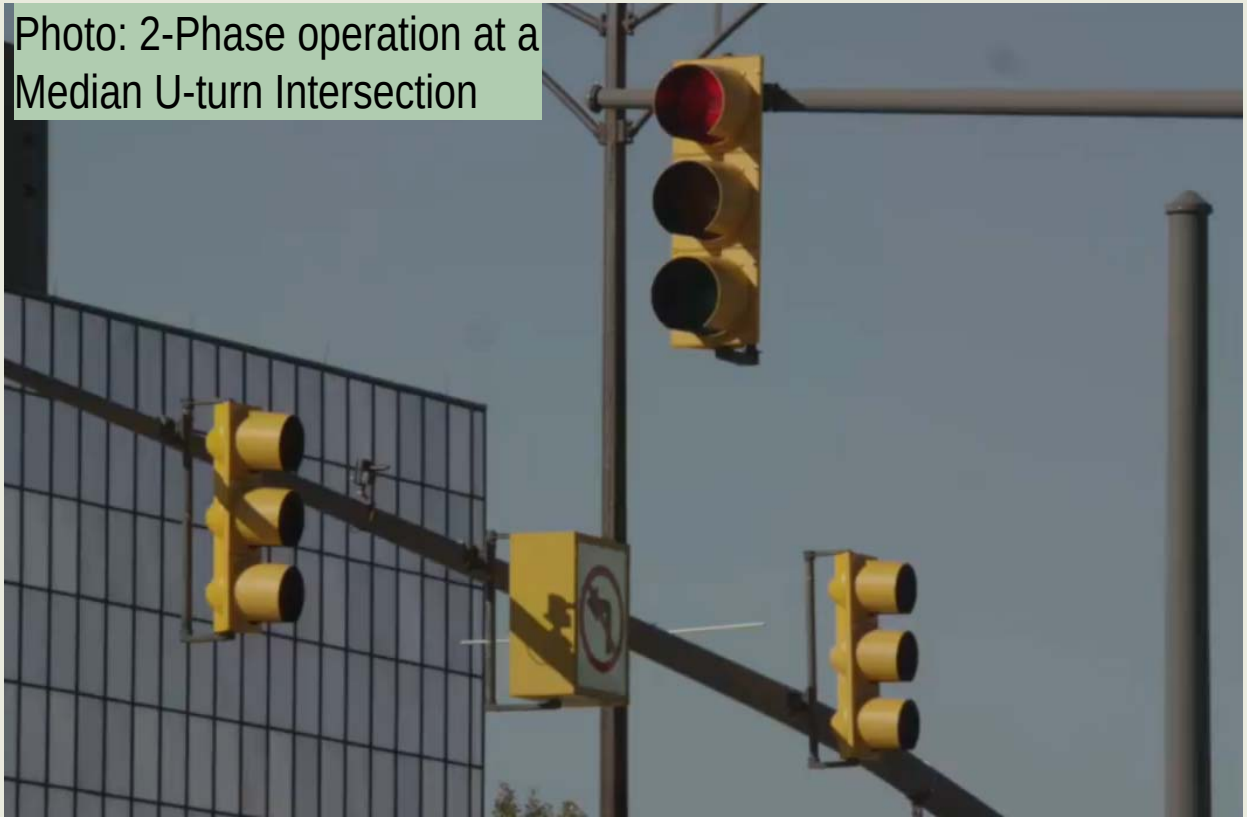
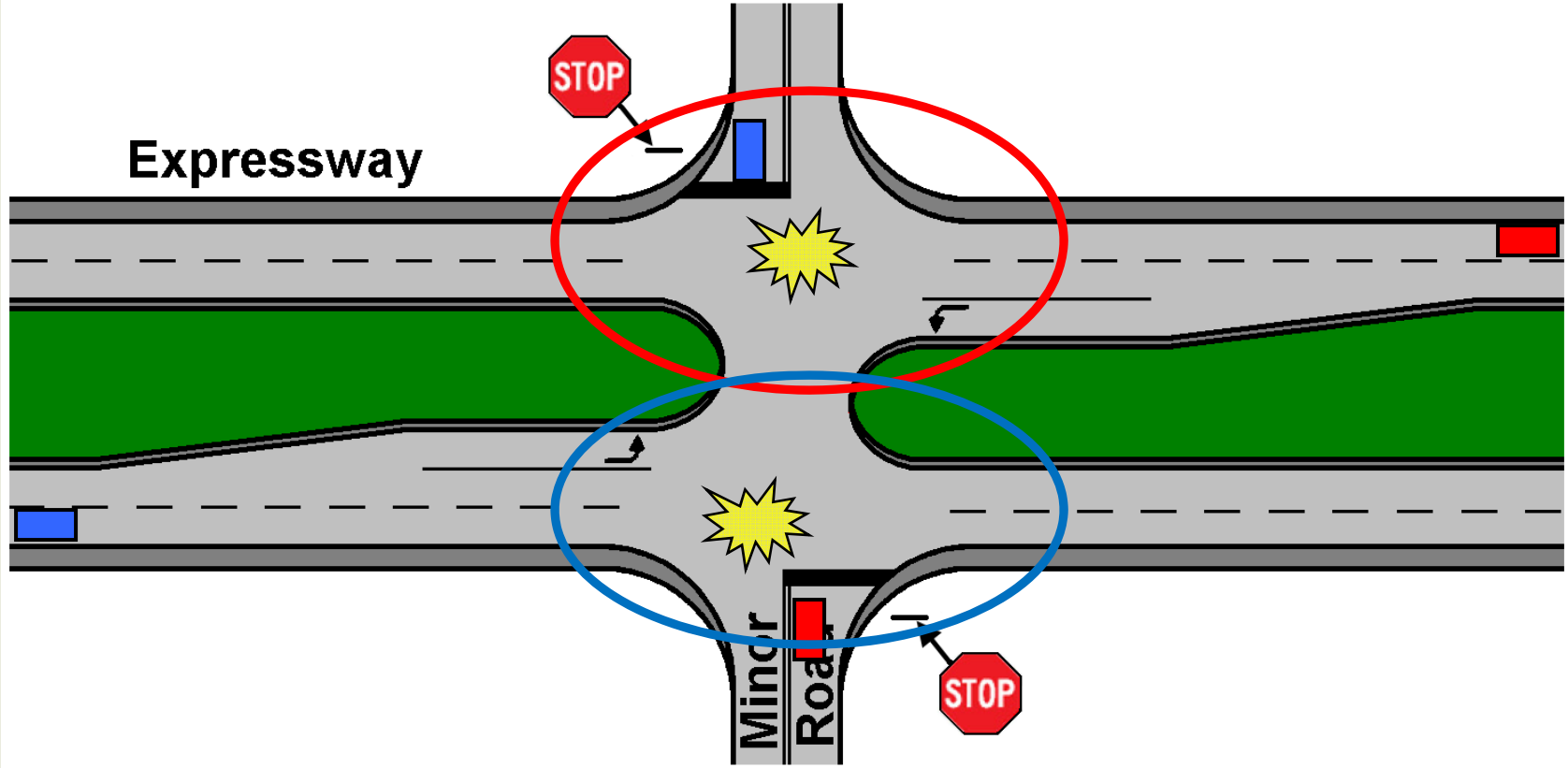


Photo: 2-Phase operation at a Median U-turn Intersection

SAFETY CONCERNS AT TRADITIONAL DIVIDED HIGHWAY INTERSECTIONS

Far-Side Right-Angle Collisions



RCUT – RESTRICTED CROSSING U-TURN

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

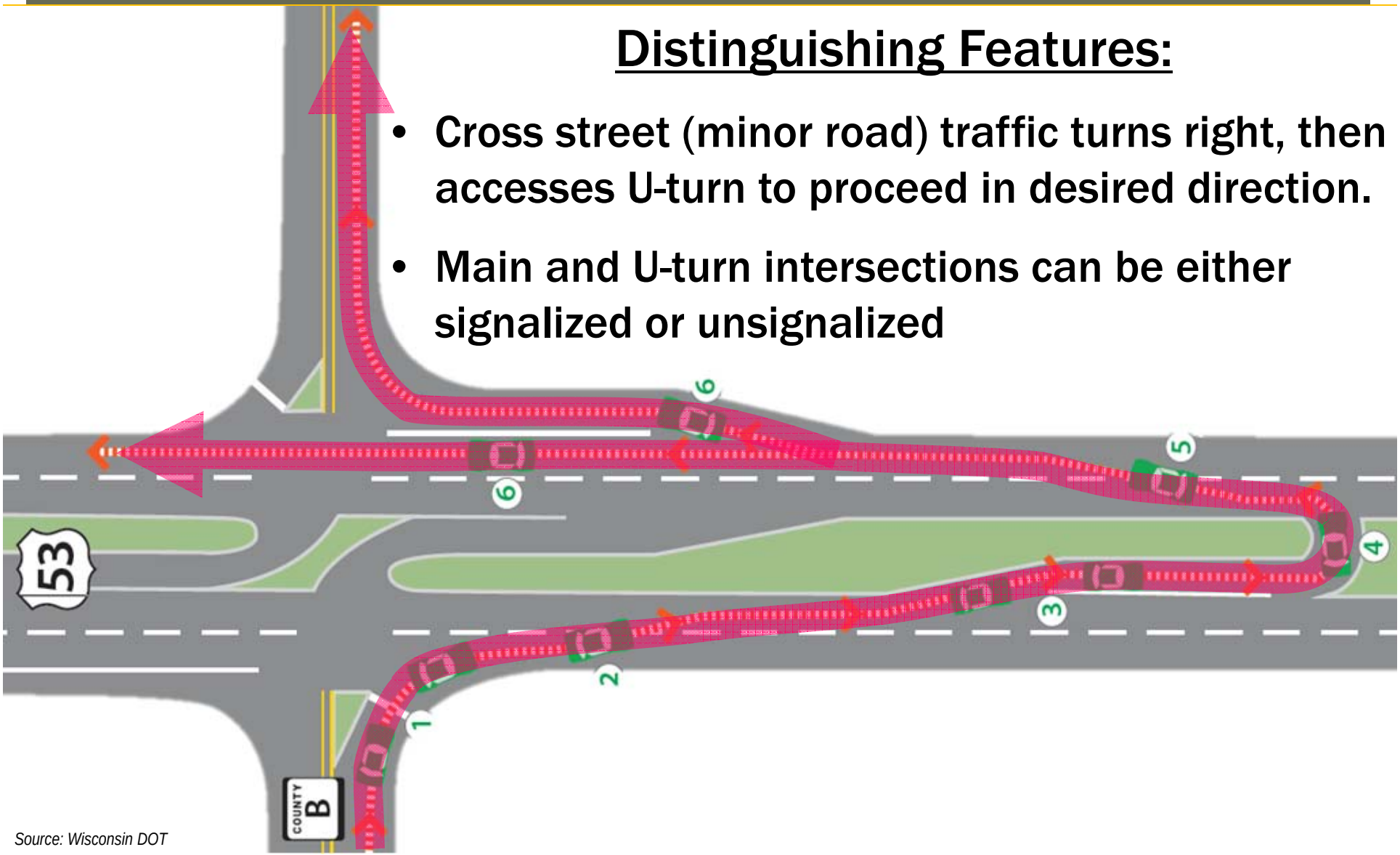
At-grade intersections with directional medians so minor road traffic must turn right and make a U-turn to cross or make the left-turn maneuver.

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

U-TURN INTERSECTIONS: 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 signalized or unsignalized



Source: Wisconsin DOT

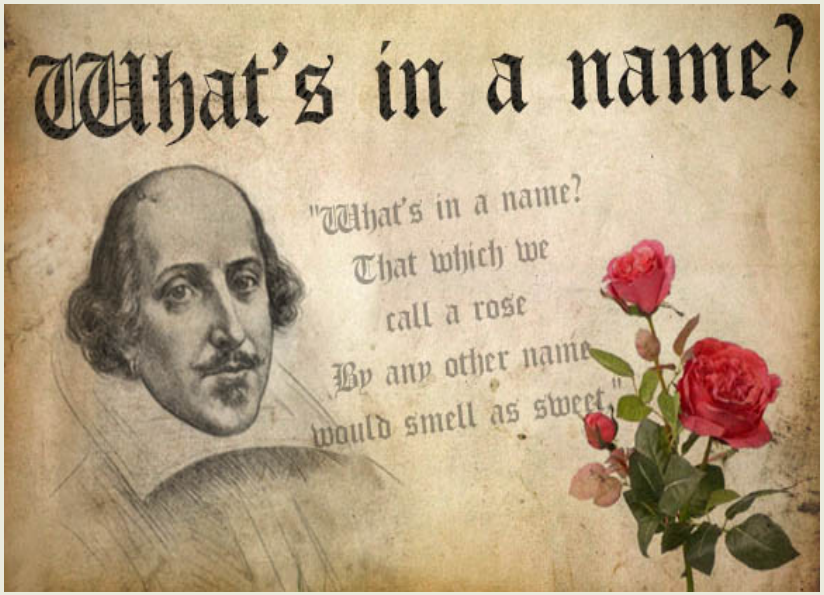
RCUT INTERSECTION MOVEMENTS

Vehicle Movement	Same as Traditional Intersection	Made with Indirect Movement
Major Hwy Thru	✓	
Major Hwy Right Turn	✓	
Major Hwy Left Turn	✓	
Minor Street Thru		✓
Minor Hwy Right Turn	✓	
Minor Hwy Left Turn		✓

RCUT INTERSECTION – APPLICATIONS

Context or Attribute	General Applicability	Context or Attribute	General Applicability
Unsignalized	✓	Four-Leg	✓
Signalized	✓	Three-Leg	✓
		Offset T	✓
Rural	✓		
Suburban	✓	Two-lane	?
Urban core	?	Multi-Lane	✓
High Speed	✓	Multi-modal	✓
Low Speed	?		

Restricted Crossing U-Turn (RCUT)



Also known as:

- Superstreets (AL, OH)
- Synchronized streets (NC)
- J-turn Intersections (many)
- Reduced conflict intersections (MN)

The intersection formerly known as RCUT:

RCUT Intersection Field Evaluations

Maryland:

Crashes decreased 28%-44%

North Carolina:

Fatal & injury crashes decreased by 58%-85%

Tennessee (4 sites)

Before: 54 crashes (2 fatalities, 8 injuries)

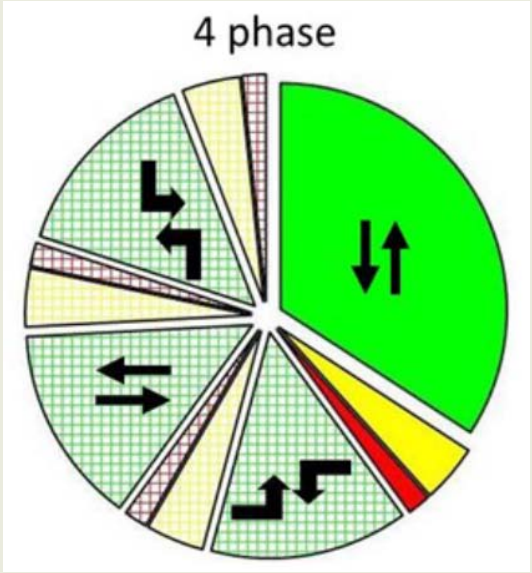
After: 10 crashes (0 fatalities, 0 injuries)

TDOT

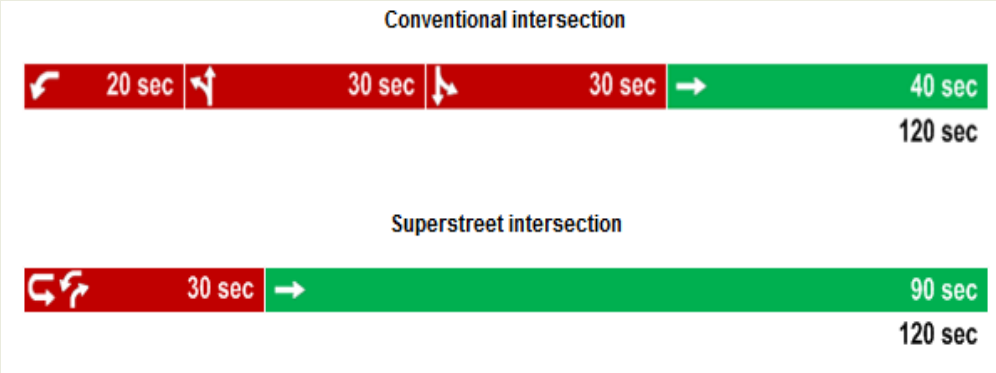
SIGNALIZED RCUT -“SUPERSTREET”

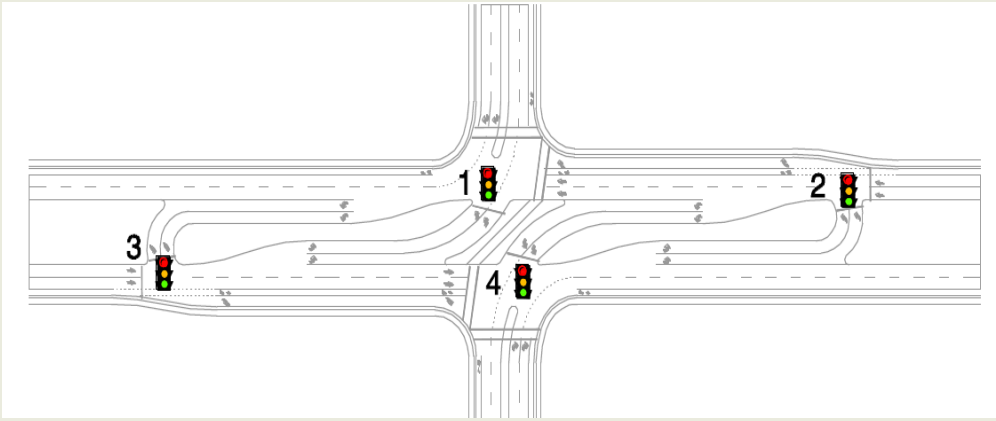
NEW DEVELOPMENT ALONG ARTERIAL

Problem: Proliferation of Four-Phase Signals



SIGNAL OPERATIONS



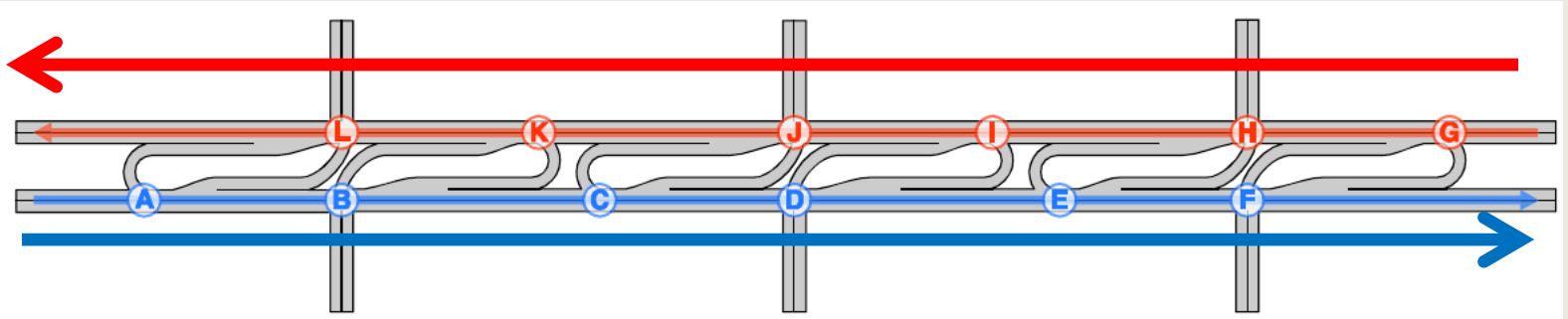


- RCUTs may operate with shorter cycle lengths than comparable conventional intersections because each signal will typically have only two phases
    - Shorter cycles reduce delay for most vehicles and for pedestrians

- RCUTs allow the ability to have different cycle lengths in each direction of the major street

BI-DIRECTIONAL PROGRESSION

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

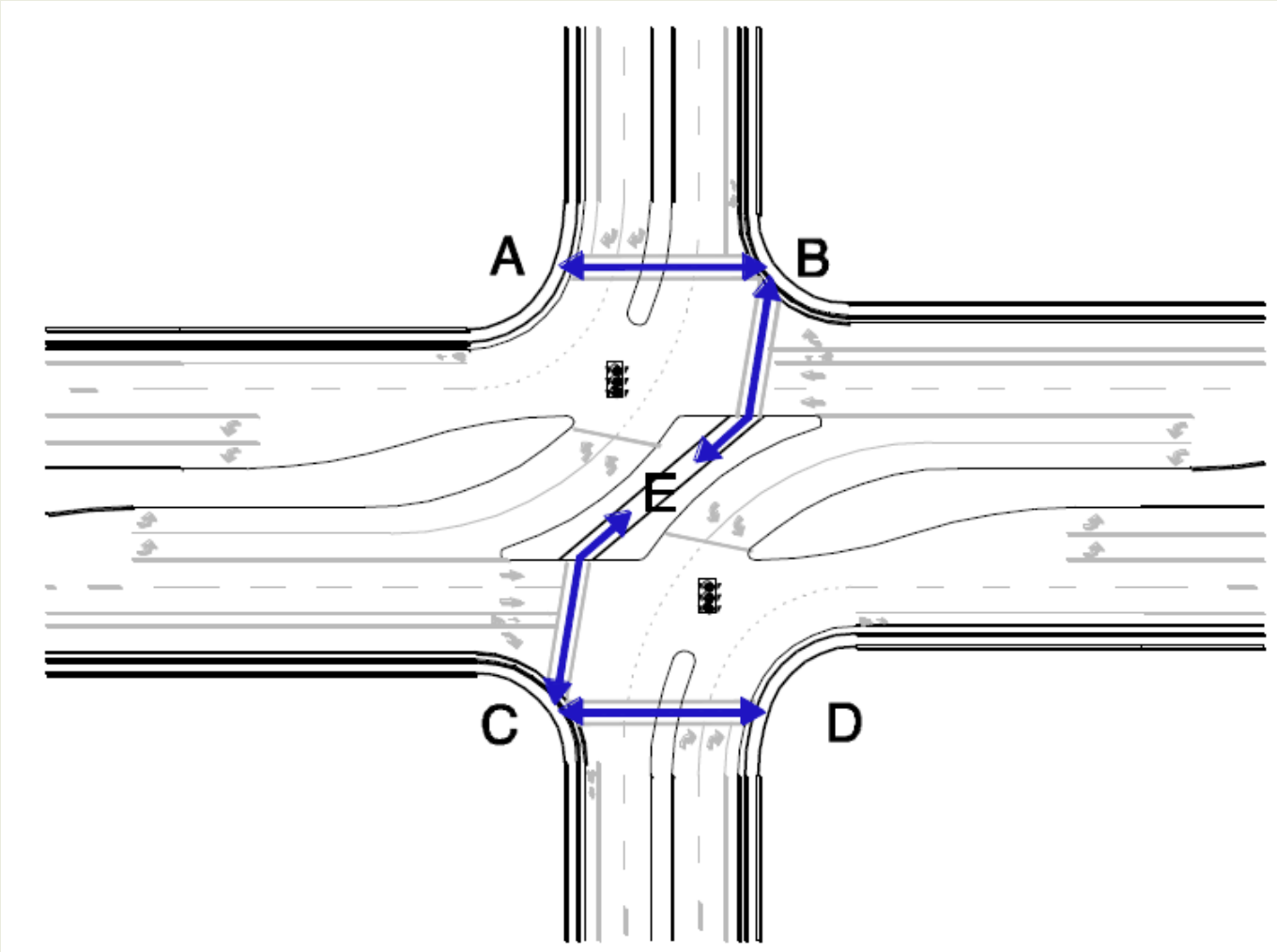


Direction	Parameter						
Right to left	Signal	F	E	D	C	B	A
	Distance from previous signal, ft	750	650	1000	700	600	Not applicable
	Offset to start of green, sec	74	59	46	26	12	0
Left to right	Signal	G	H	I	J	K	L
	Distance from previous signal, ft	Not applicable	600	850	1050	600	600
	Offset to start of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

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

PEDESTRIAN CROSSWALKS

Pedestrian crosswalks and pathways in a signalized RCUT



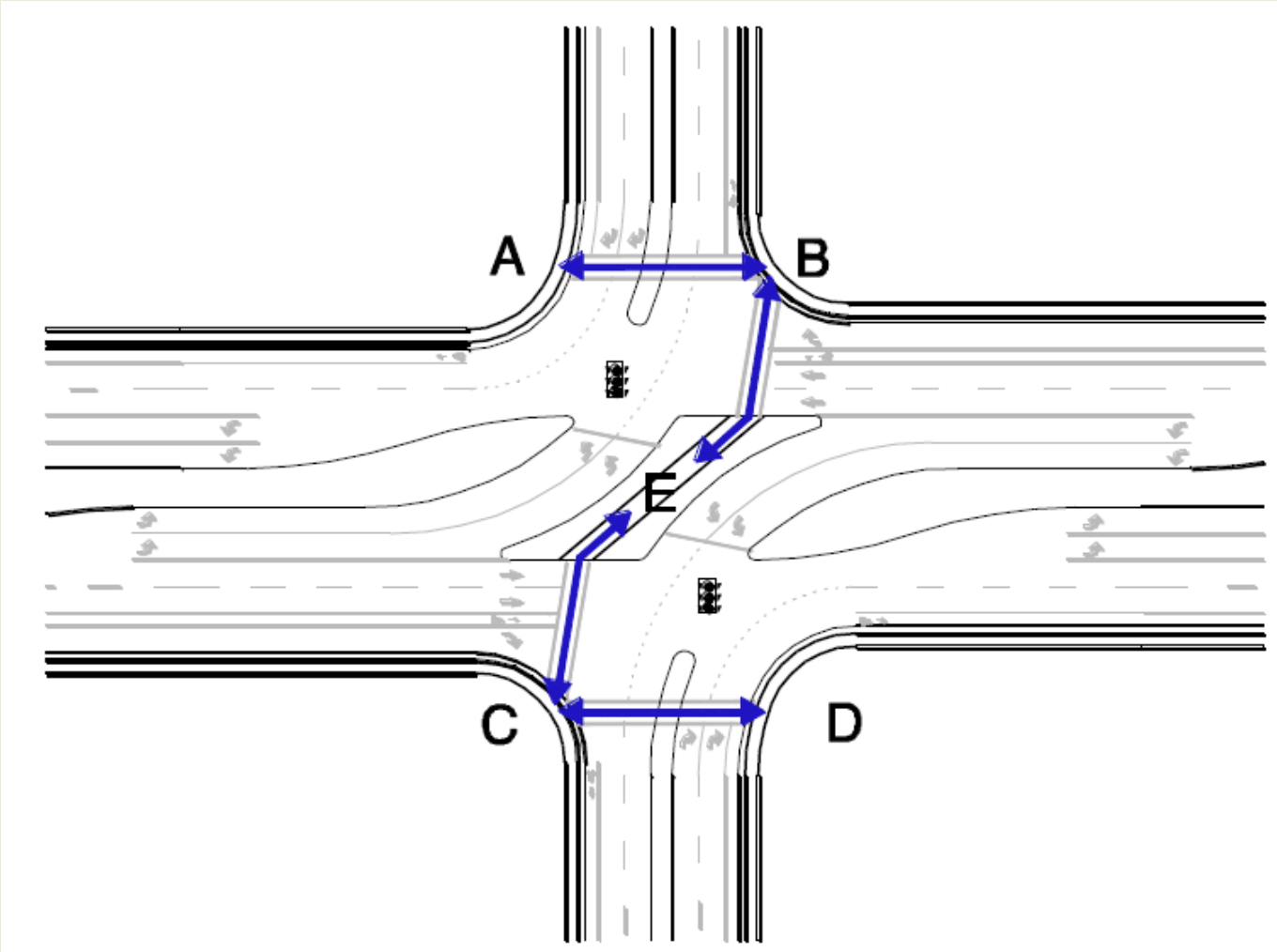
Question: Will pedestrian crossings take longer in an RCUT?

PEDESTRIAN CROSSWALKS

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

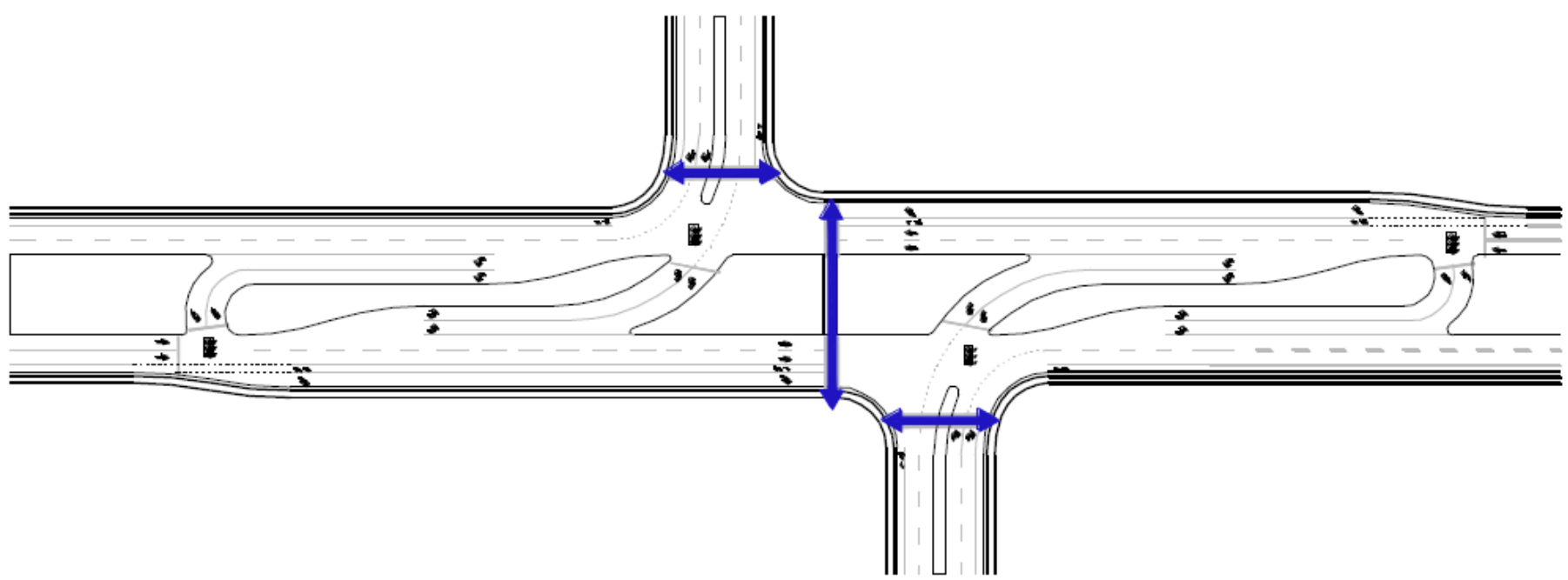
B-E-C could be shorter if cycle length is reduced

A-D
Likely Longer
(extra crossing)



PEDESTRIAN CROSSING

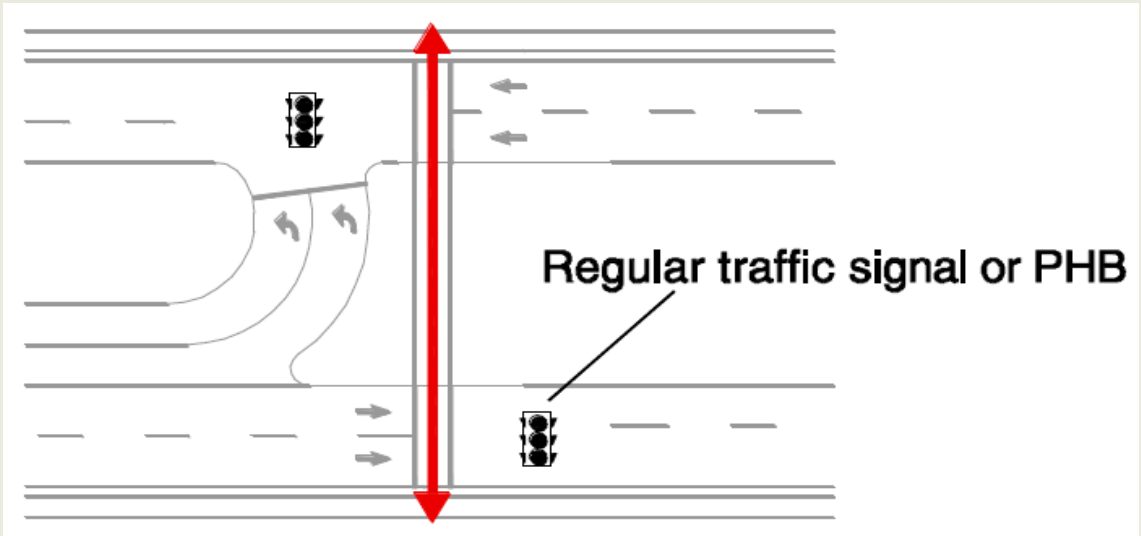
OFFSET APPROACHES OPTION



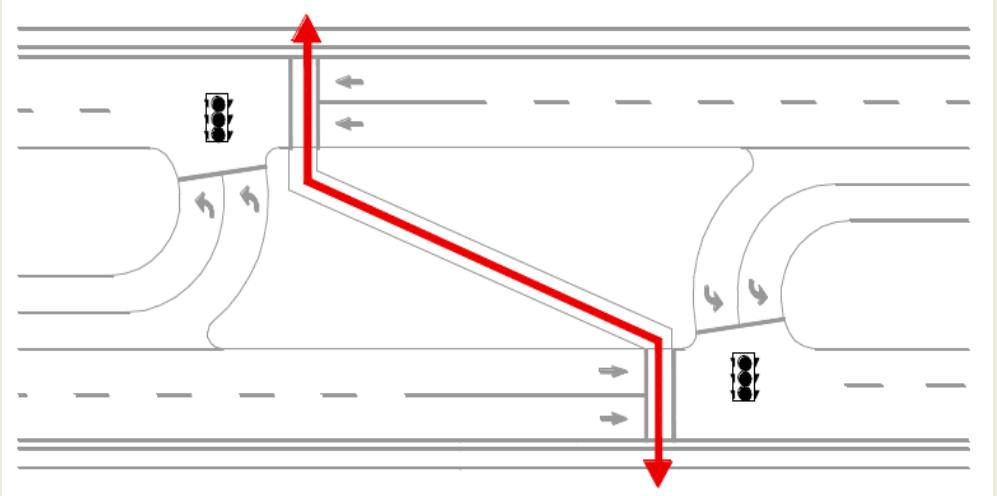
This variation should be strongly considered in developing areas where the minor street or driveway locations have not yet been established.

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

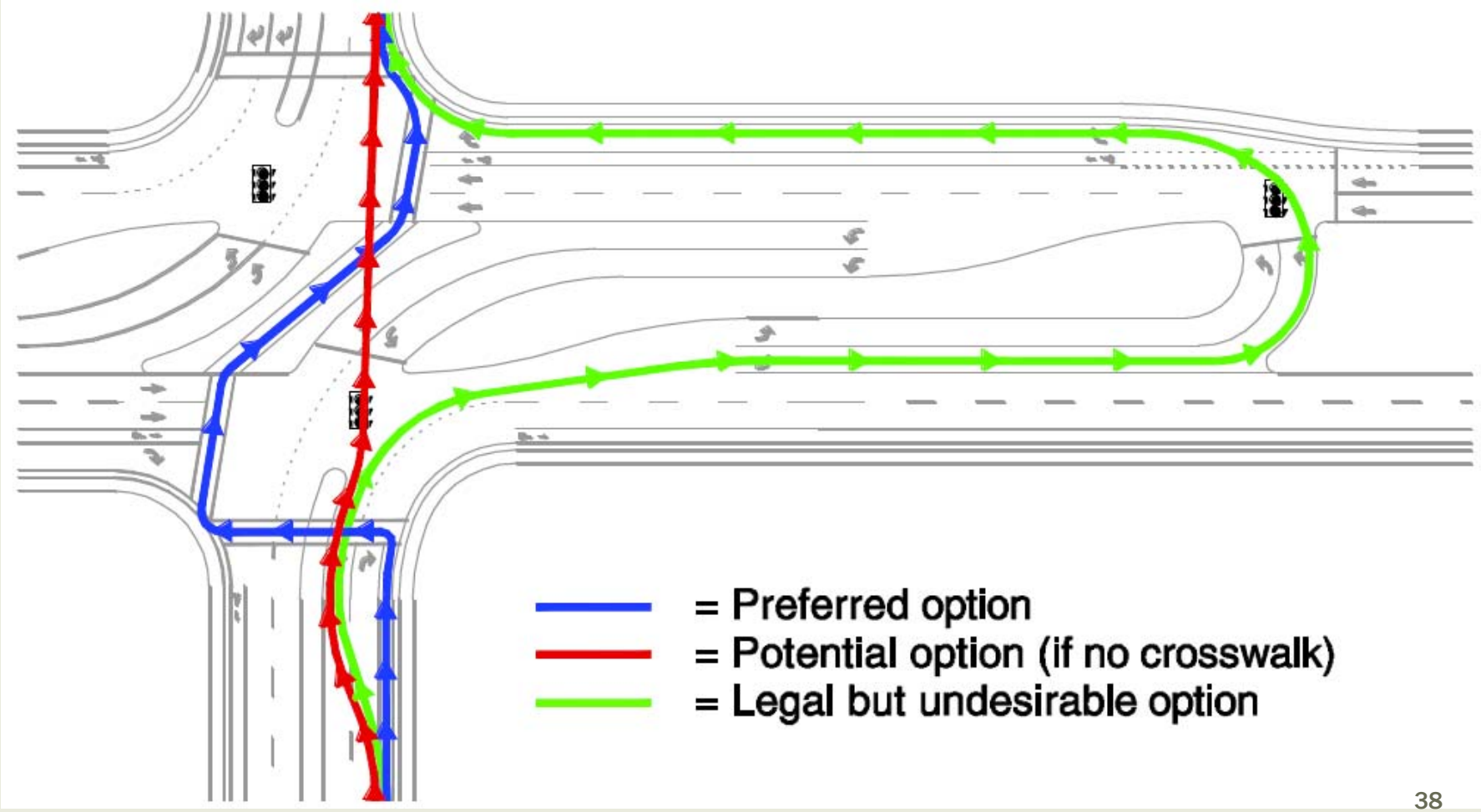
MID-BLOCK PED CROSSING OPTION



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



BICYCLE – MINOR STREET THROUGHS

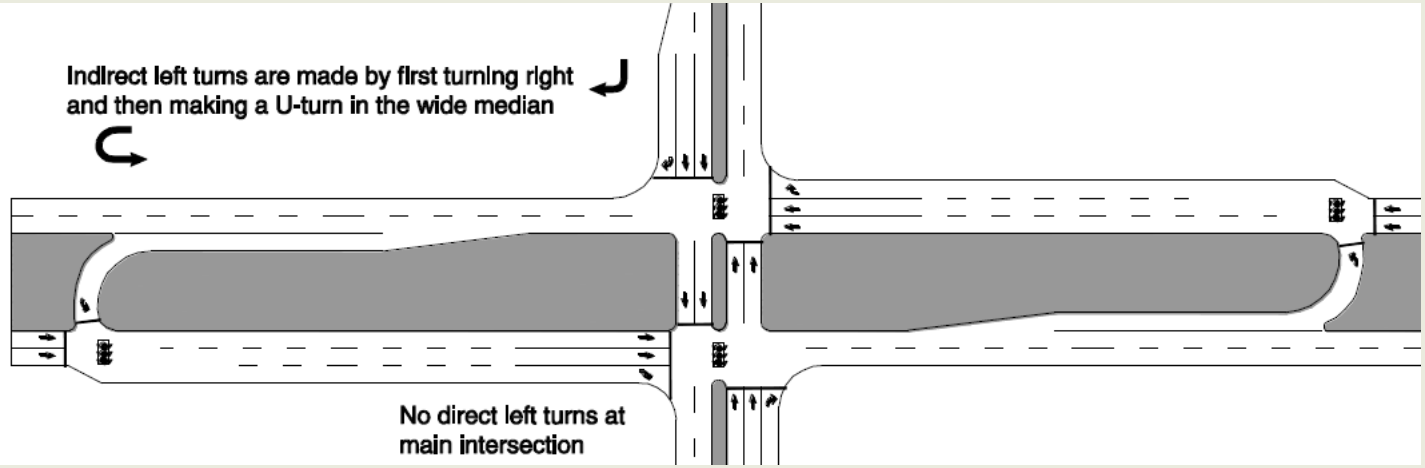


North Carolina

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

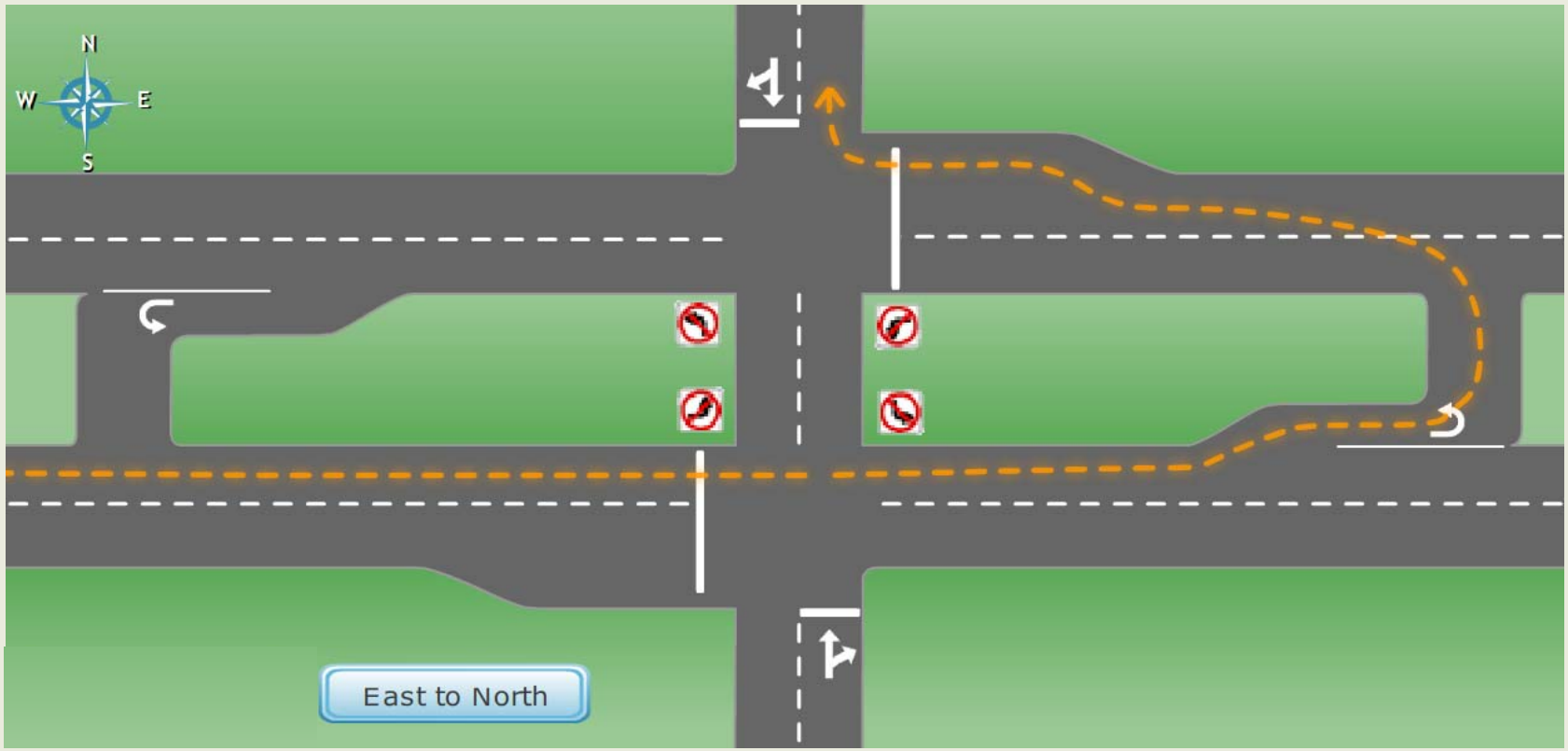
MUT – Median U-Turn

(aka Michigan Left)



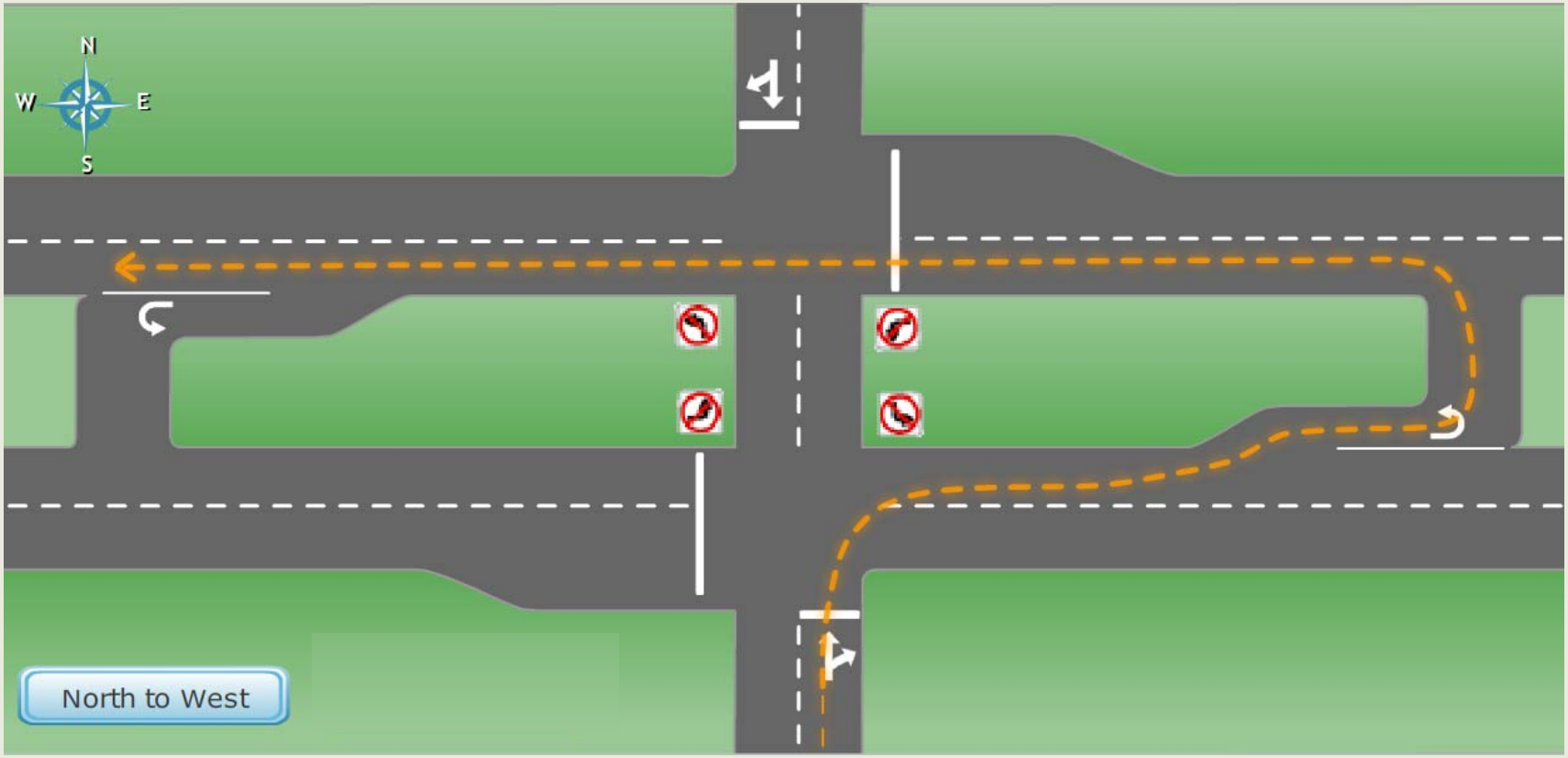
- At-grade intersections with *indirect* left turns using a U-turn movement in a wide median and/or loon
- The MUT eliminates direct left turns on both intersecting streets, reducing the number of signal phases and conflict points at the main intersection

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.

MUT INTERSECTION MOVEMENTS

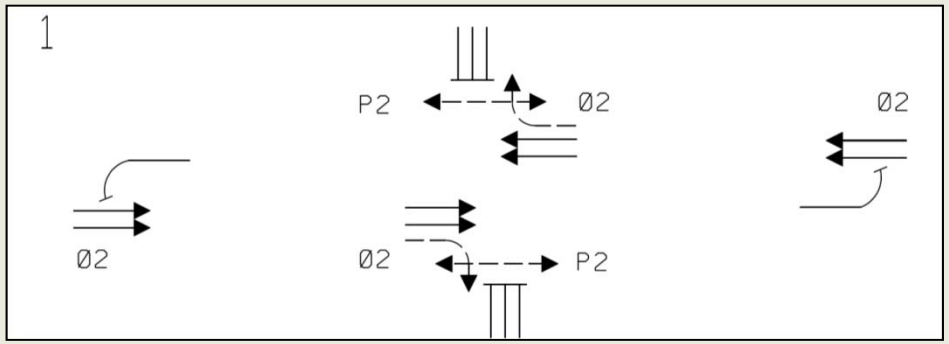
Vehicle Movement	Same as Traditional Intersection	Made with Indirect Movement
Major Hwy Thru	✓	
Major Hwy Right Turn	✓	
Major Hwy Left Turn		✓
Minor Street Thru	✓	
Minor Hwy Right Turn	✓	
Minor Hwy Left Turn		✓

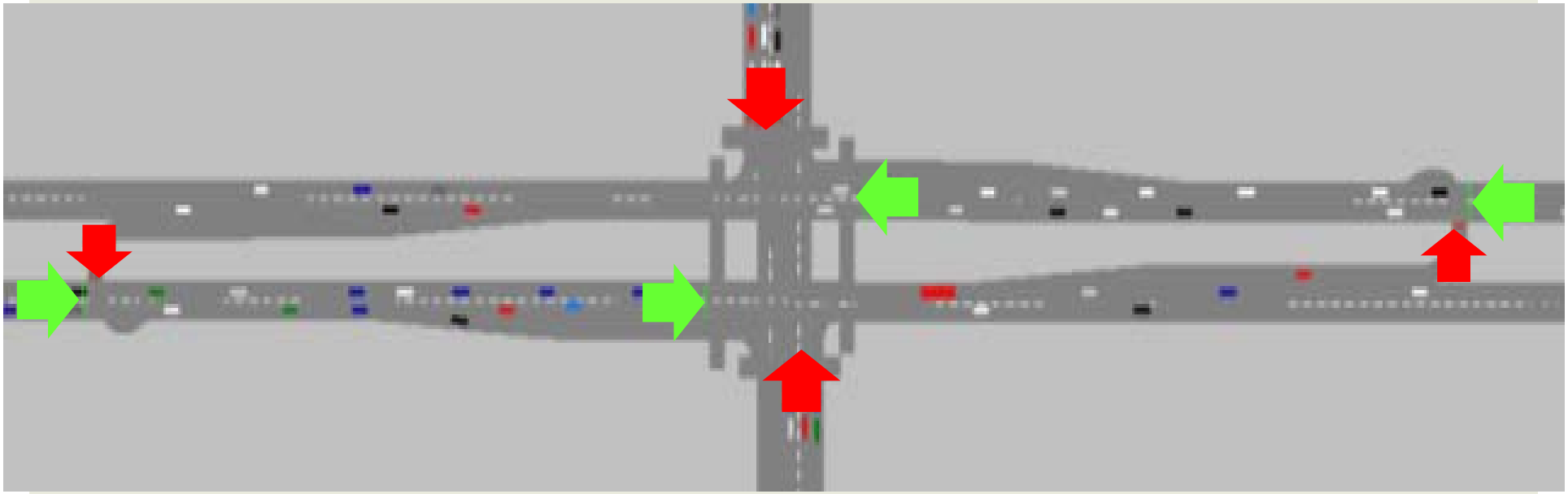
MUT INTERSECTION – APPLICATIONS

Context or Attribute	General Applicability	Context or Attribute	General Applicability
Unsignalized		Four-Leg	✓
Signalized	✓	Three-Leg	
		Offset T	
Rural	?		
Suburban	✓	Two-lane	
Urban core	✓	Multi-Lane	✓
High Speed	✓	Multi-modal	✓
Low Speed	✓		

BASIC SIGNAL PHASING

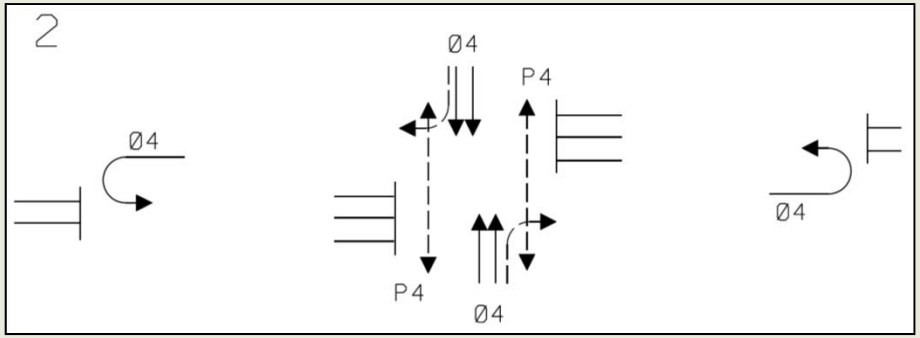
Phase 1 – Major Street Through

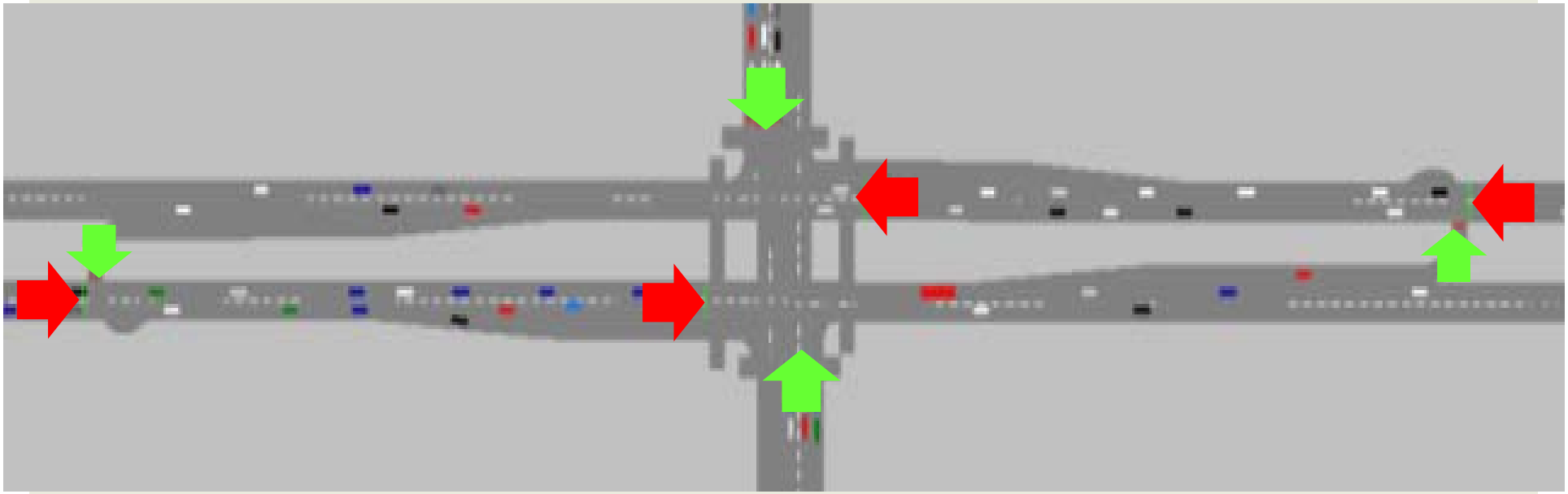




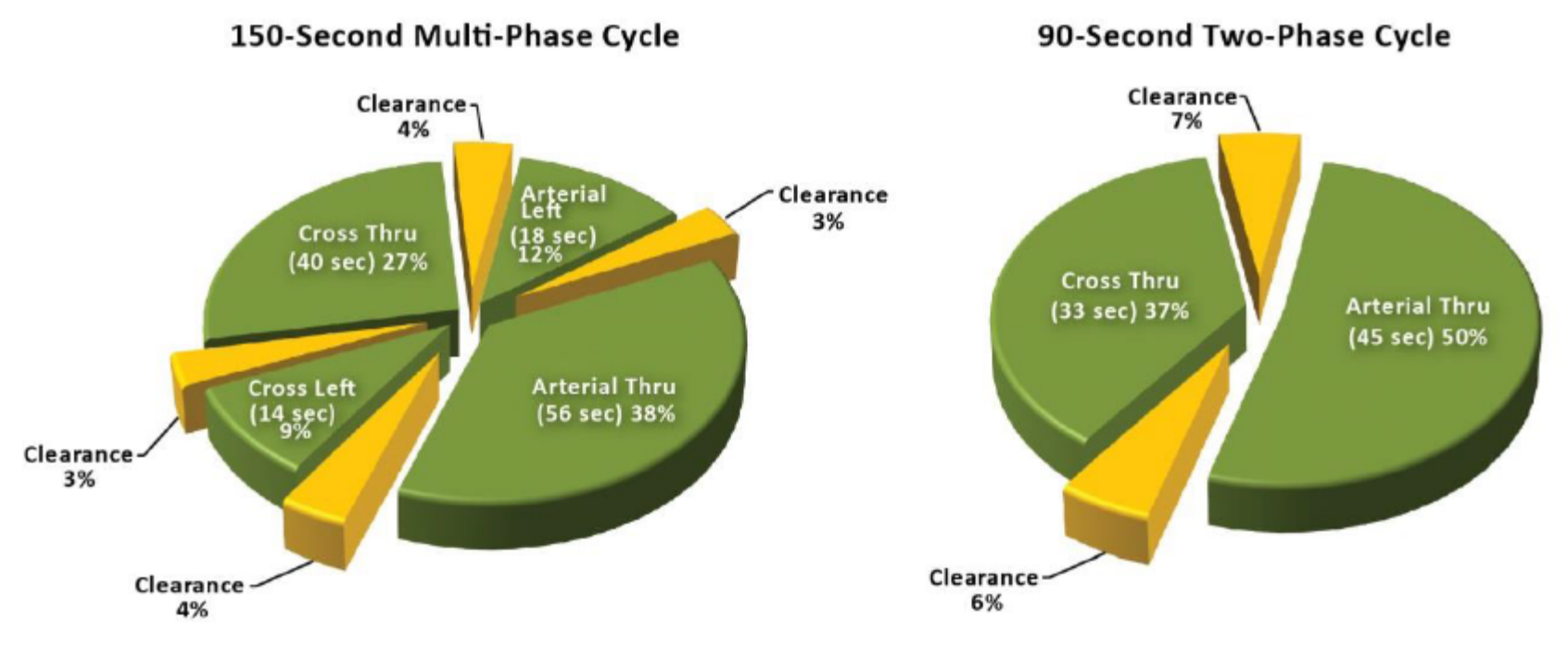
SIGNAL PHASING

Phase 2 – Minor Street Through and U-turns





SIGNAL OPERATIONS



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

SAFETY PERFORMANCE STUDIES

Dataset	Rate Type	Group	Mean Crash Rates (Crashes/MVE)
Corridor	All	MUT (Reduction)	1.554 (14%)
		Conventional	1.806
Intersection Related	All	MUT (Reduction)	1.388 (16%)
		Conventional	1.644
	PDO	MUT (Reduction)	0.982 (9%)
		Conventional	1.077
	Injury	MUT (Reduction)	0.407 (30%)
		Conventional	0.58

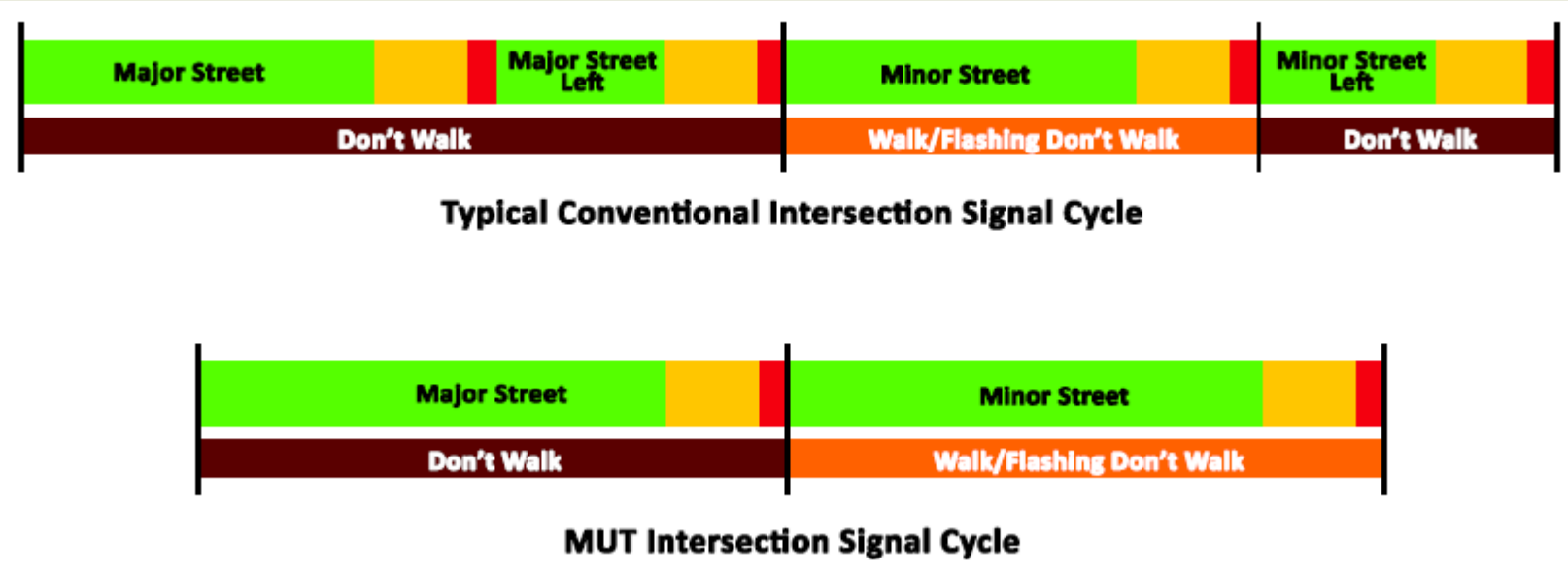
MUT intersections show safety performance improvements compared to conventional intersections for most crash types and injury severities.

Source: FHWA Median U-Turn Informational Guide

PEDESTRIAN CROSSINGS

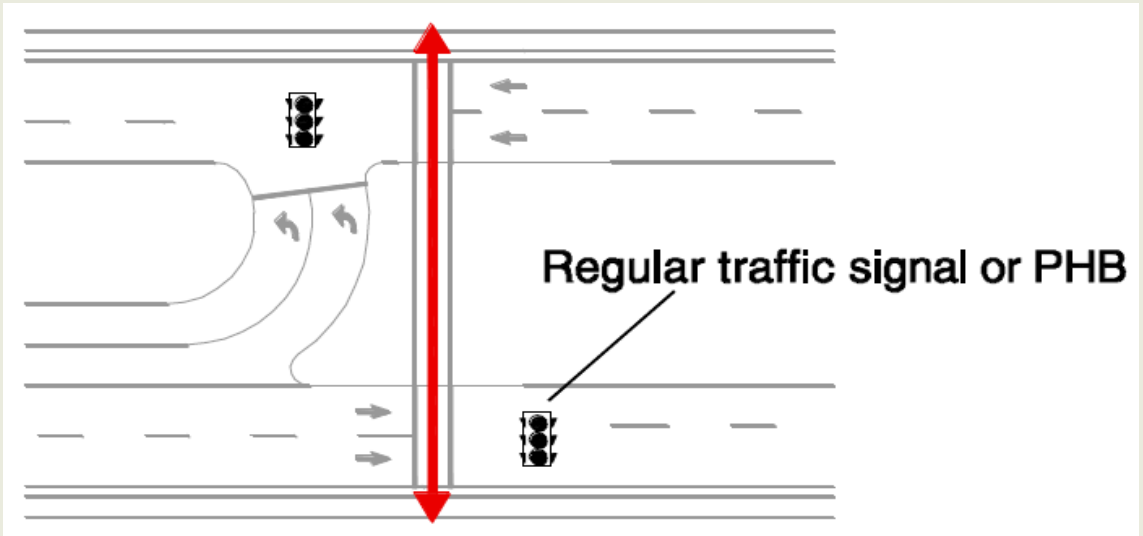
- Major Road Crossing
  - 1 or 2 Stages
  - Median Refuge
- Minor Road Crossing
  - 1 Stage

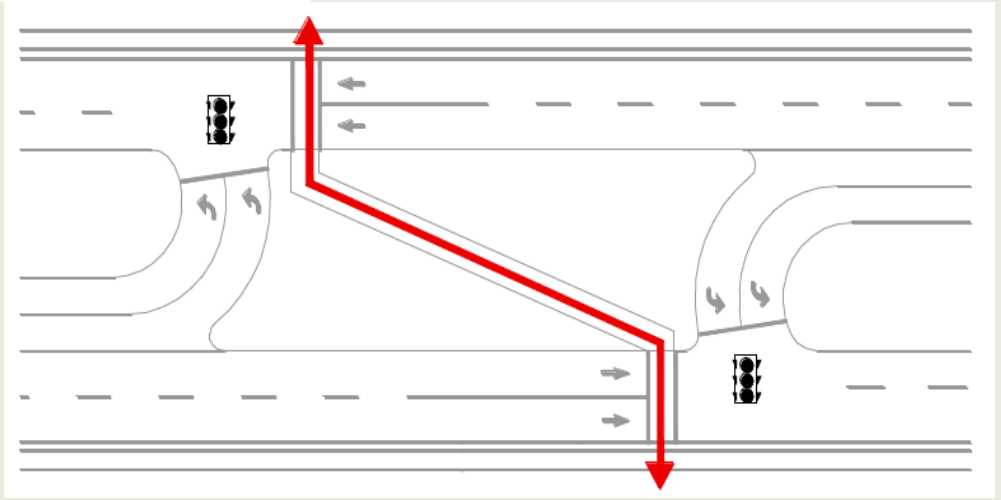
PEDESTRIAN WALK PHASES



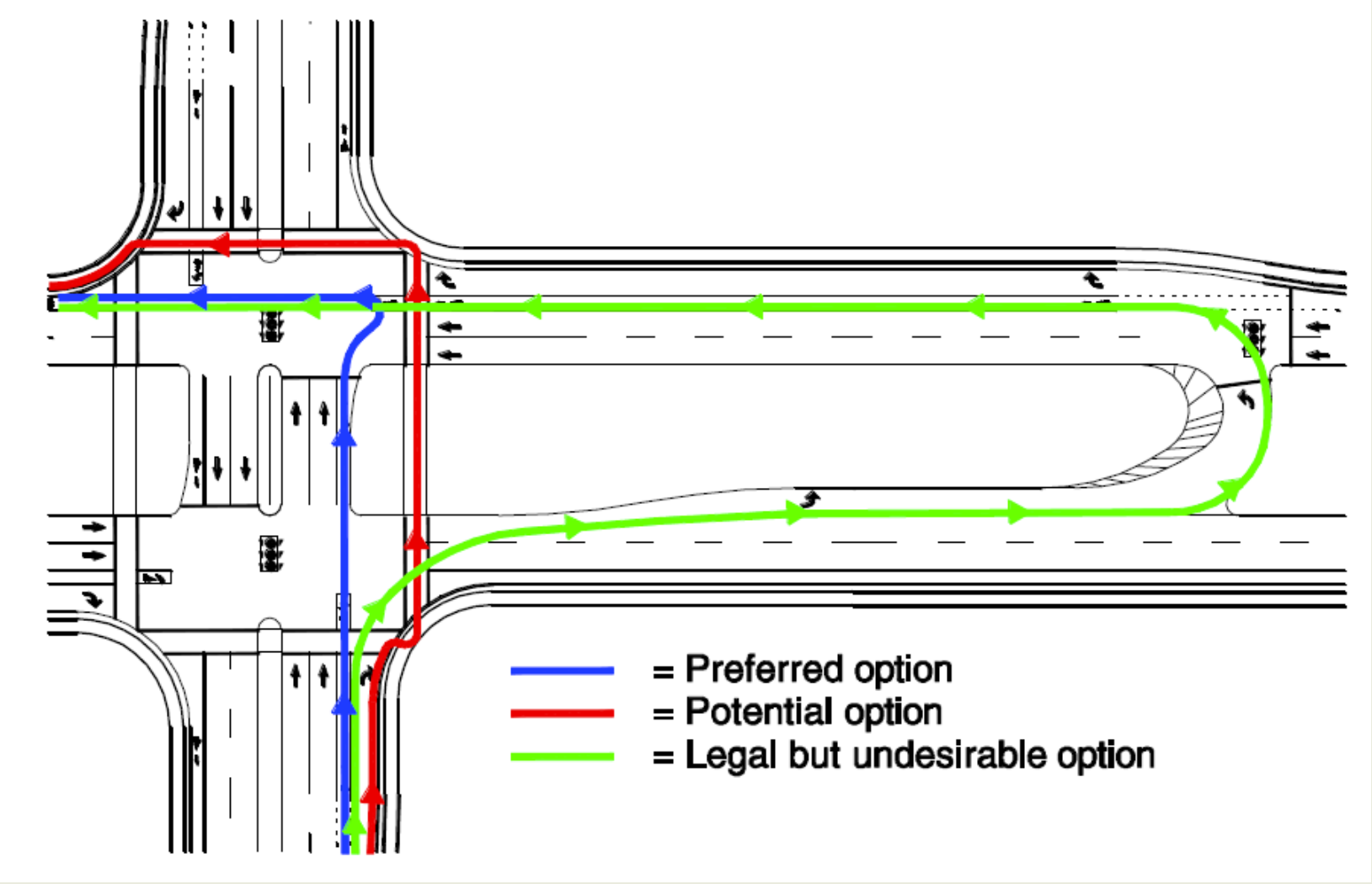
The two-phase signal at a MUT typically allows a shorter signal cycle length compared to a comparable conventional intersection, but with similar green times for pedestrians and vehicles. This benefits pedestrians by creating more pedestrian phases per hour along with less “don’t walk” time between “walk”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

MID-BLOCK PED CROSSING OPTION





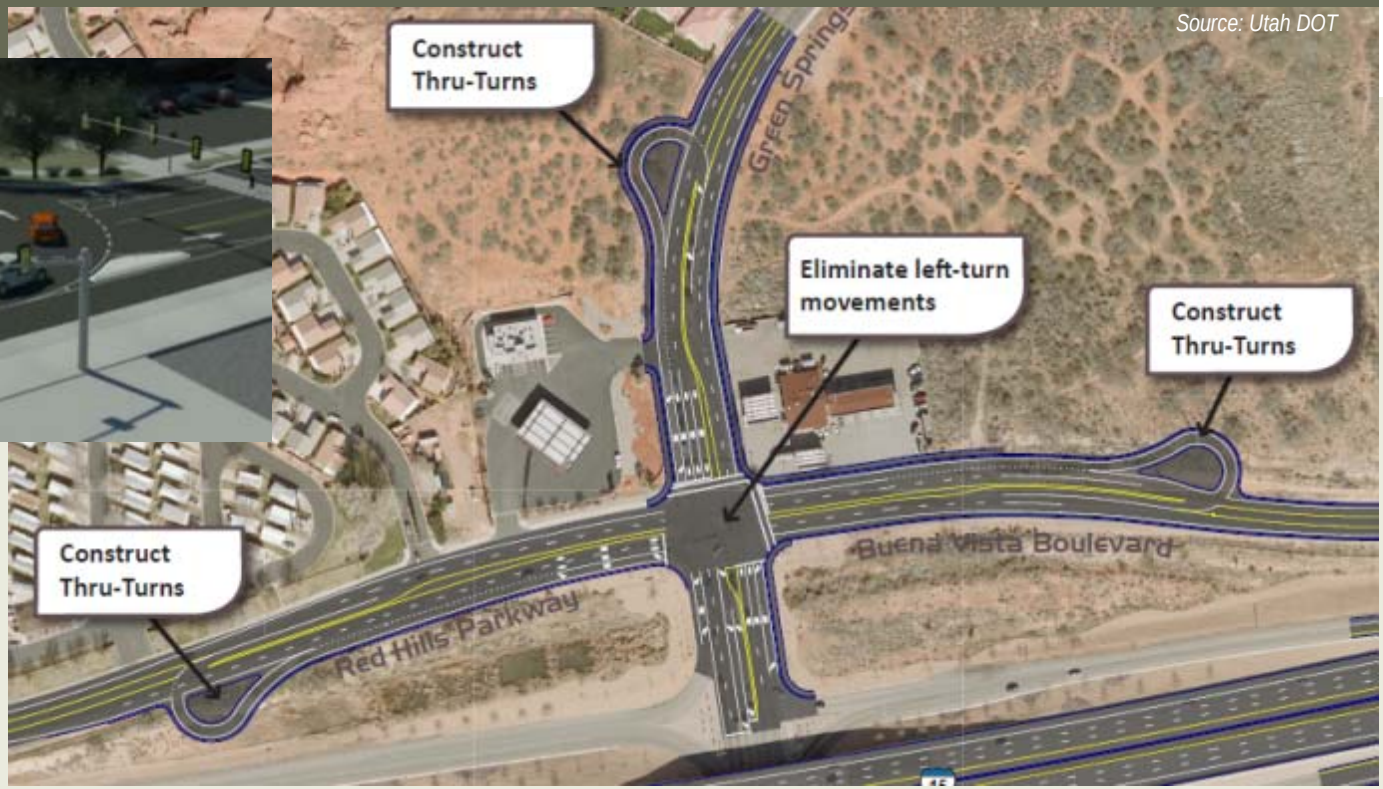
BICYCLE – LEFT TURN OPTIONS



OK – but …
What if I'm dealing with an existing arterial that doesn't have a median?

U-TURN INTERSECTIONS: THRU TURN

Source: Utah DOT



Source: Utah DOT

- 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

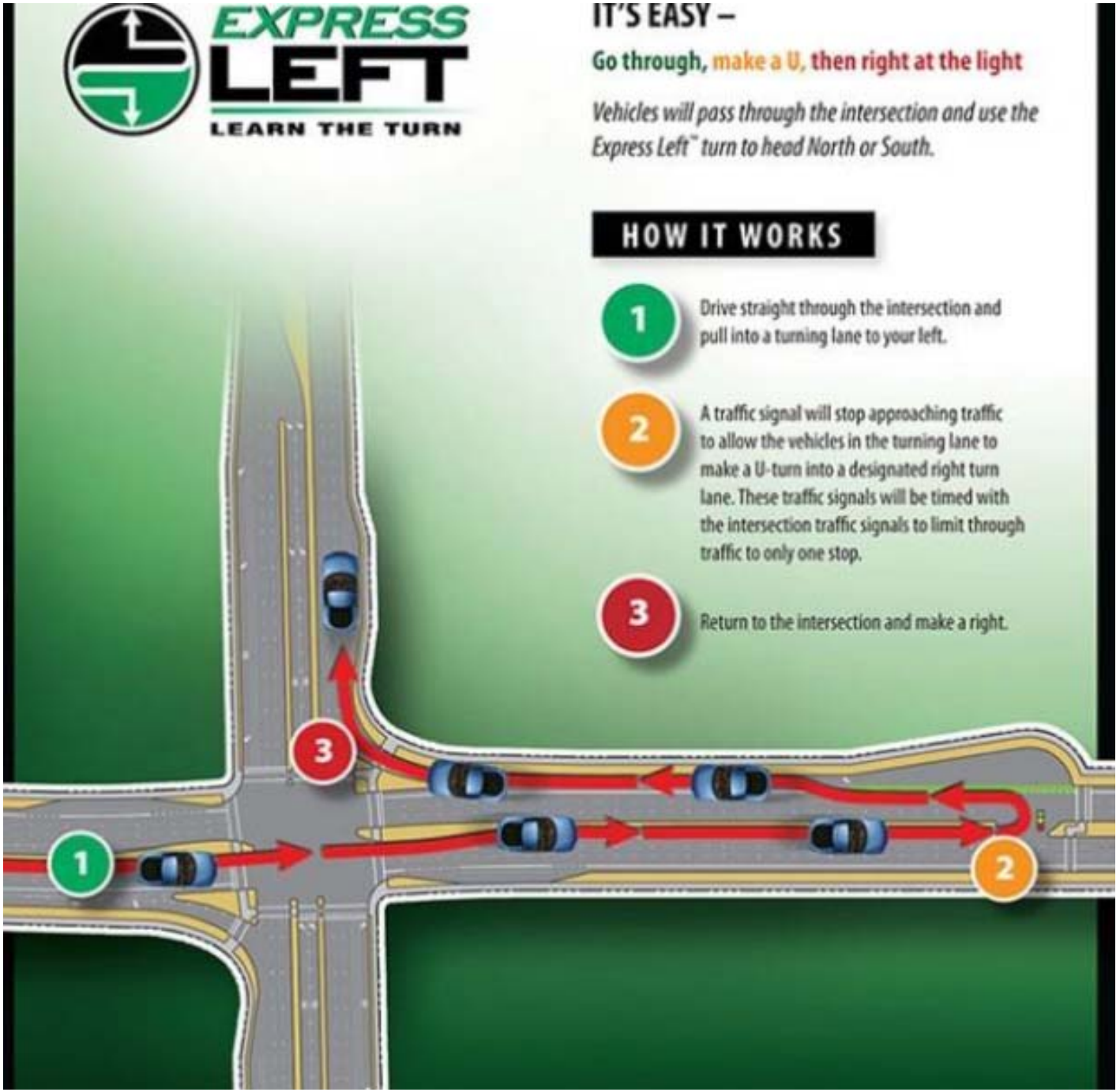
U-turn & T intersection

Draper, UT

Advance Signing at ThrU-turn

Draper, UT

Signing at U-turn

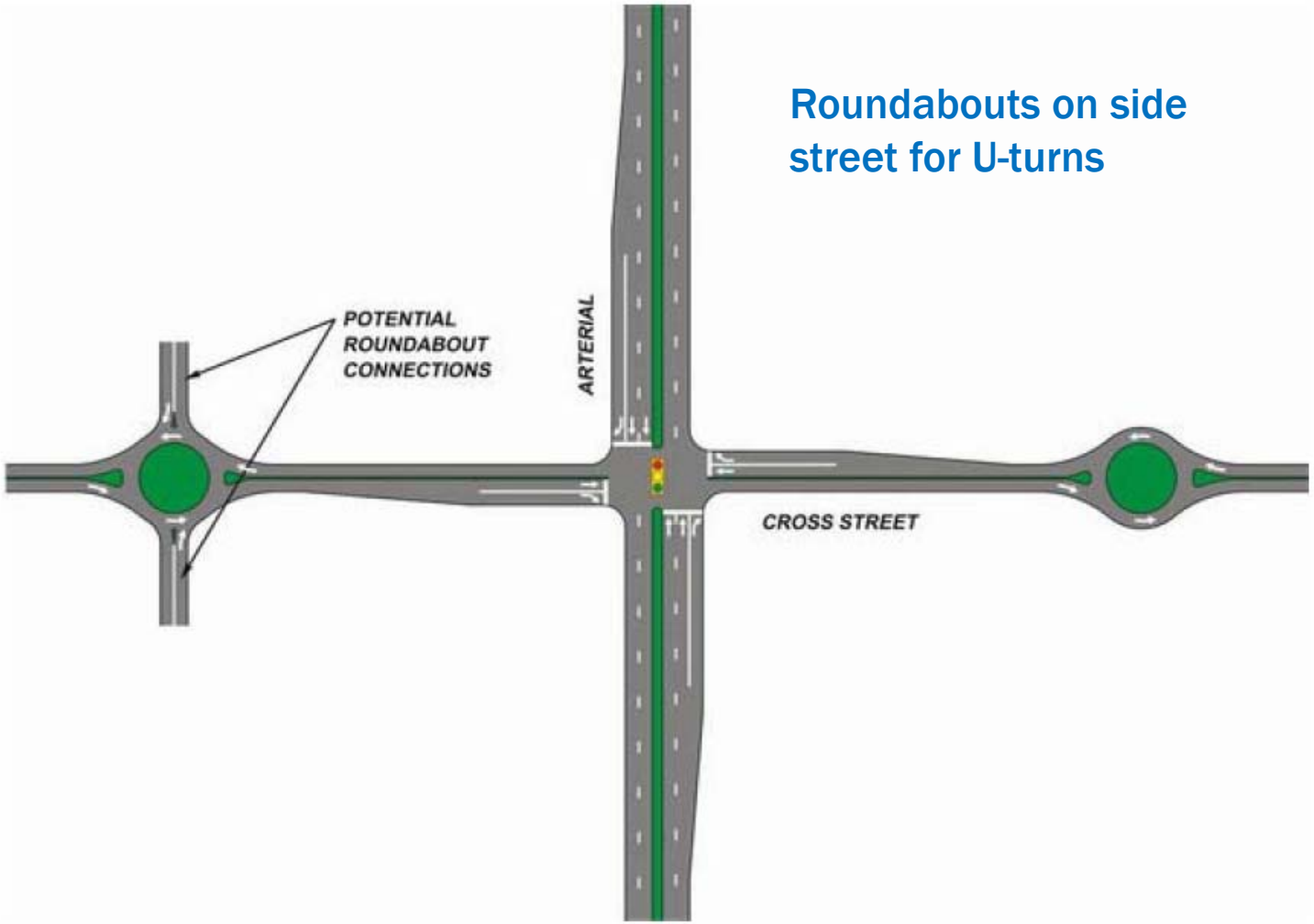


EXPRESS LEFT

Tucson, AZ

Tucson, AZ

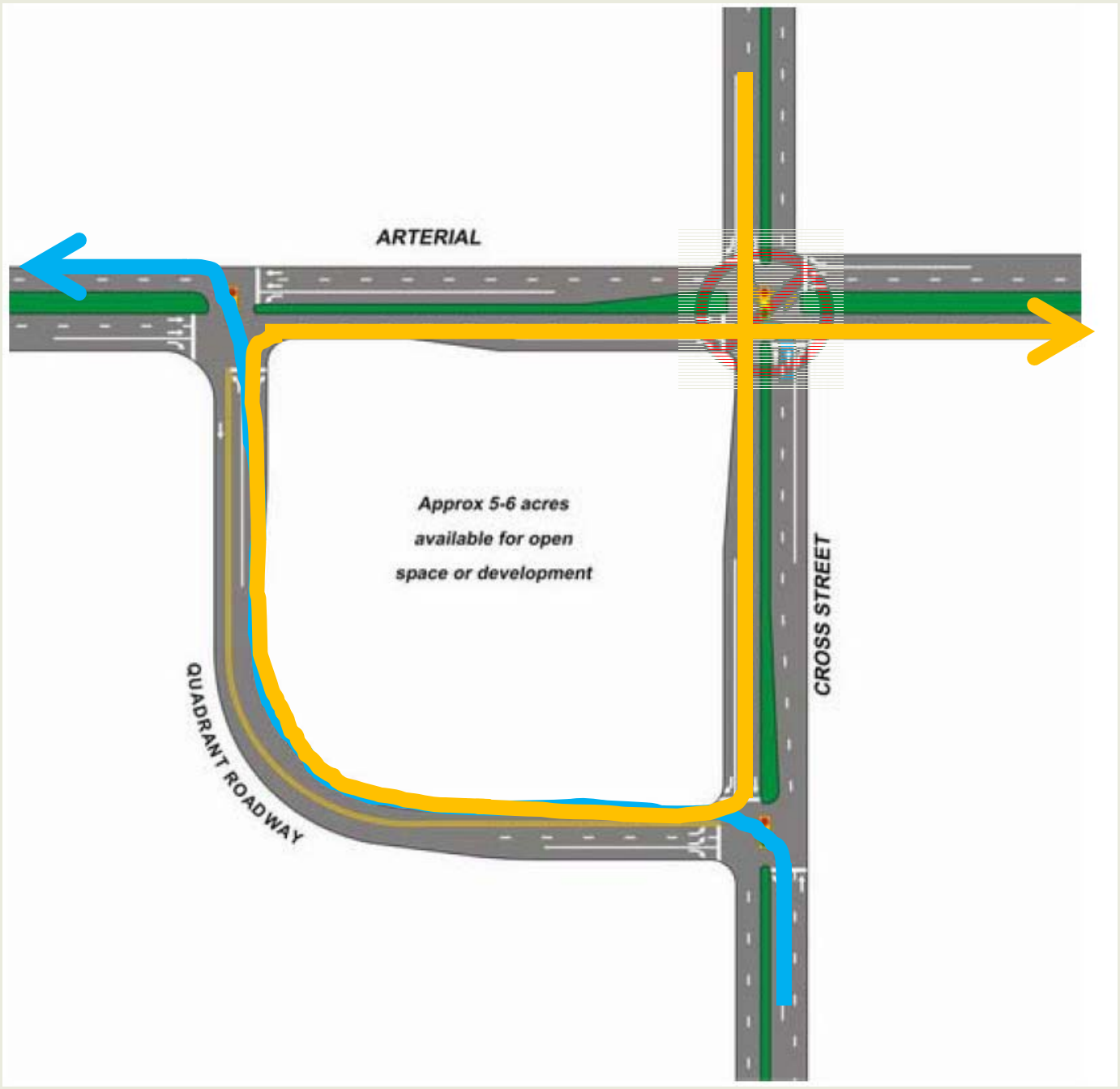
BOWTIE INTERSECTION



Roundabouts on side street for U-turns

QUADRANT ROADWAY INTERSECTION (QRI)

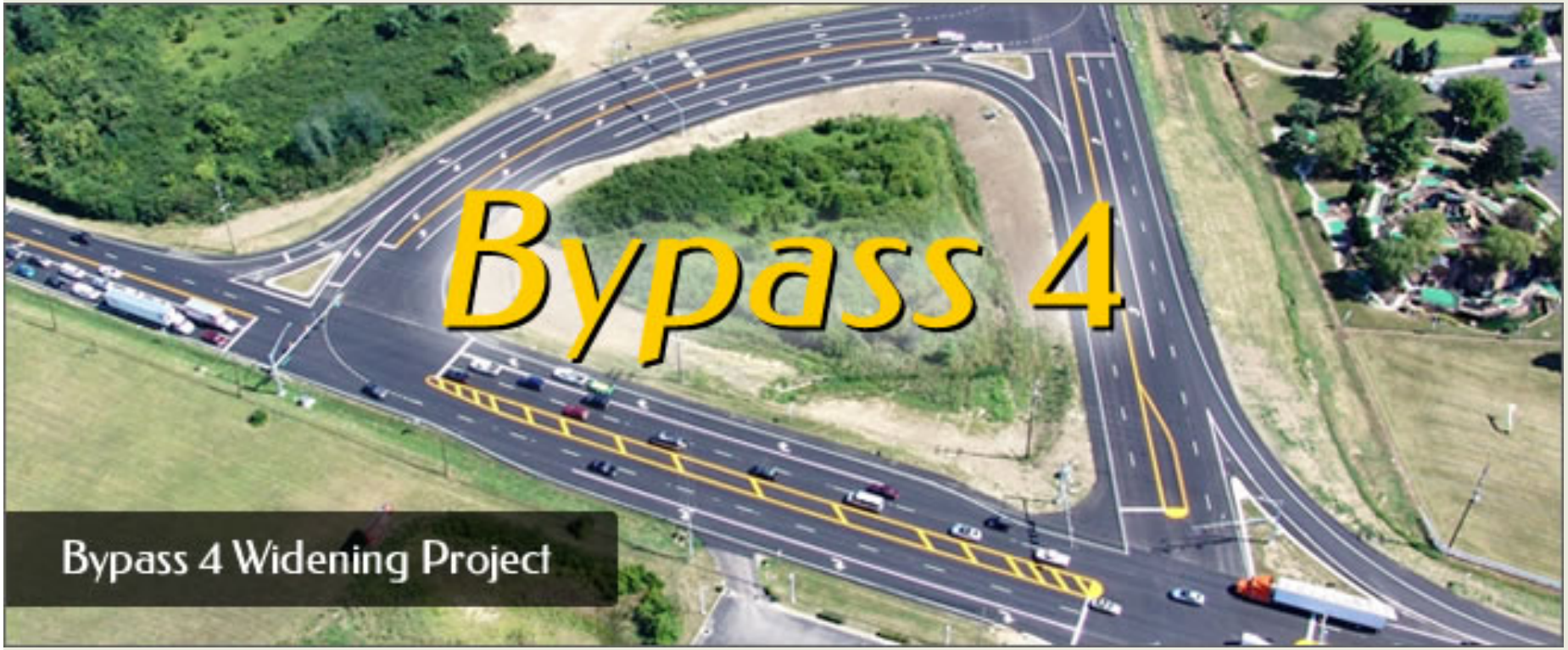
Eliminates some or all left turn movements at the main intersection by relocating the movements onto a connector (or quadrant) roadway


ARTERIAL
Approx 5-6 acres
available for open
space or development
QUADRANT ROADWAY
CROSS STREET

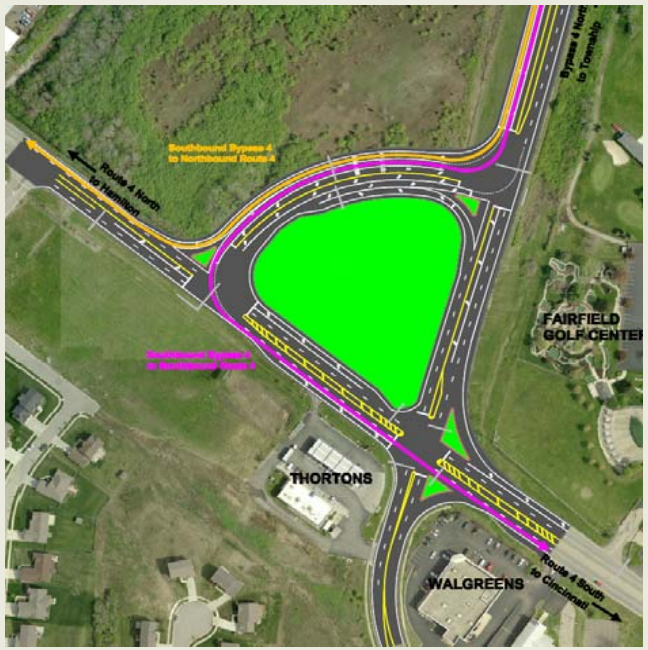

ARTERIAL
Approx 5-6 acres
available for open
space or development
CROSS STREET
QUADRANT ROADWAY

QUADRANT ROADWAY CASE STUDY

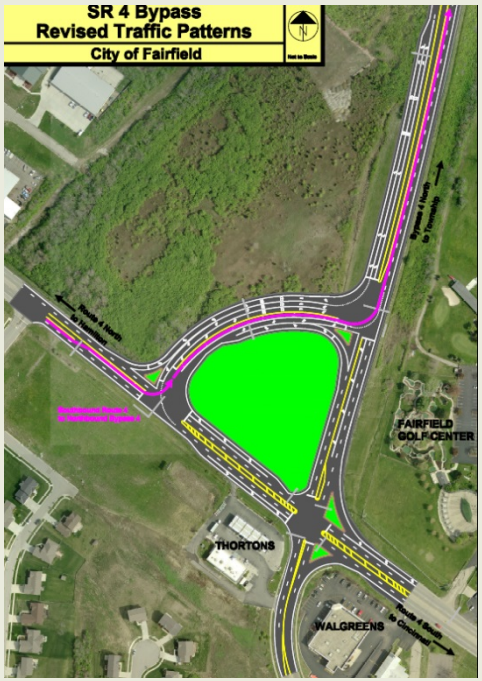
BYPASS 4 – FAIRFIELD, OH

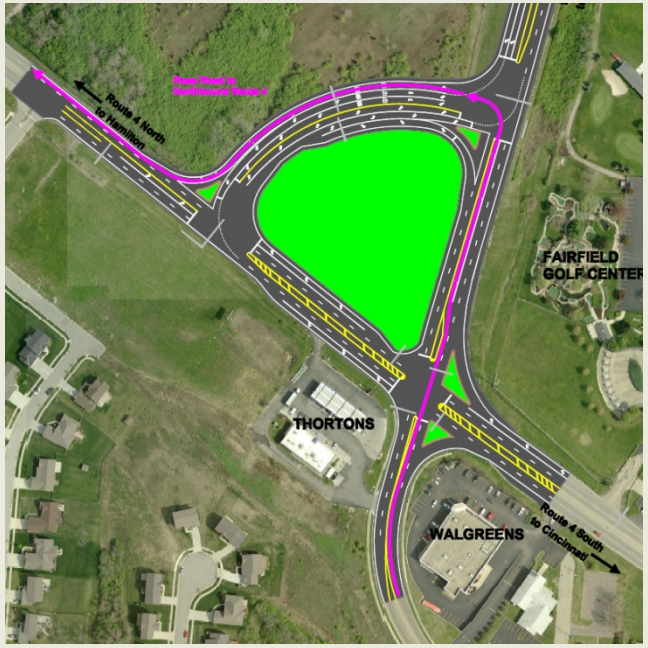


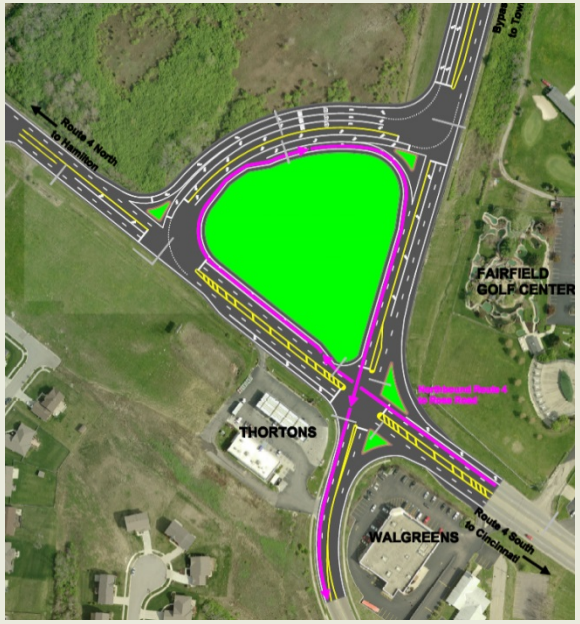

ass
ovements
field
Not to Scale
Bypass 4 North
to Township
Route 4 North
to Hamilton
FAIRFIELD
GOLF CENTER
THORTONS
WALGREENS
Route 4 South
to Cincinnati



All movements are provided





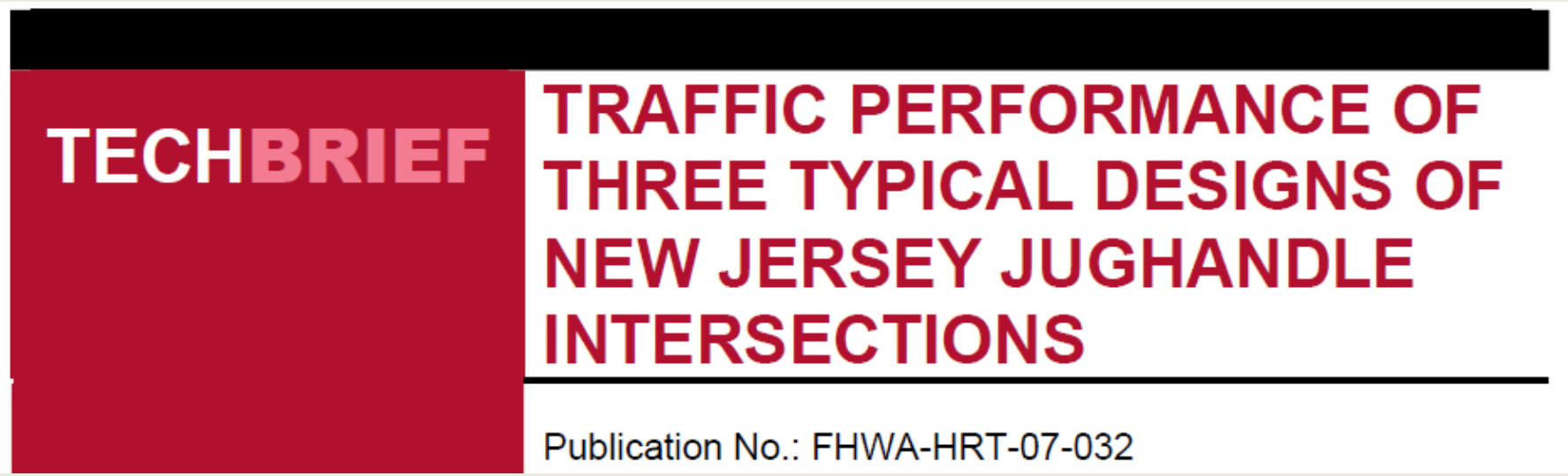


JUGHANDLE INTERSECTIONS

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

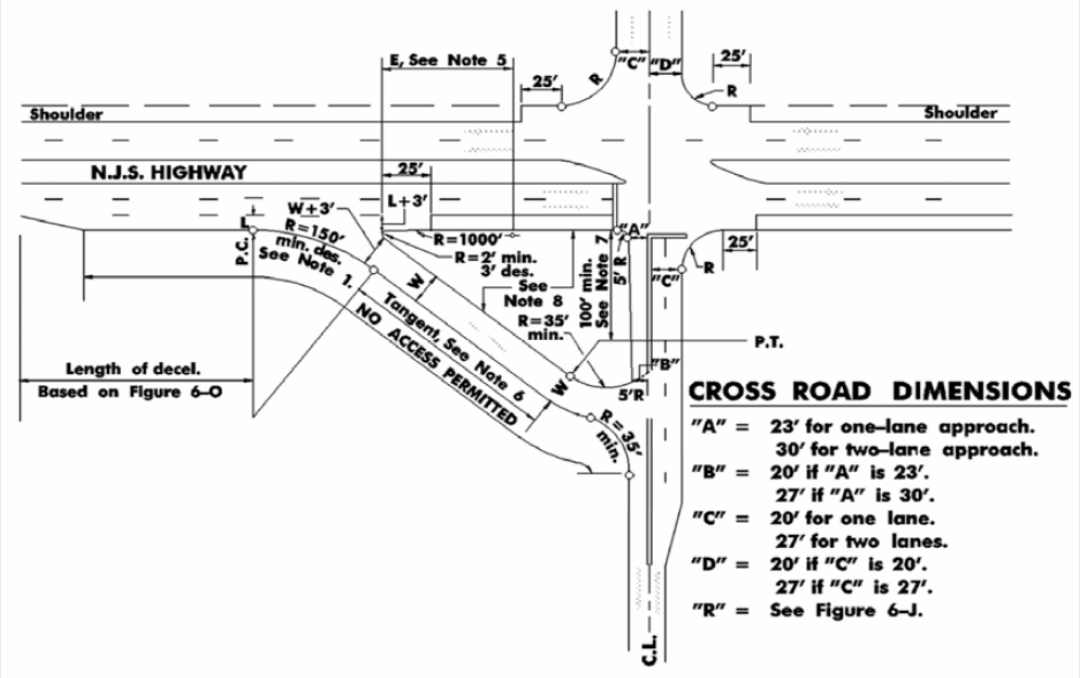
Main intersection of choice in New Jersey.

FHWA TECH BRIEF

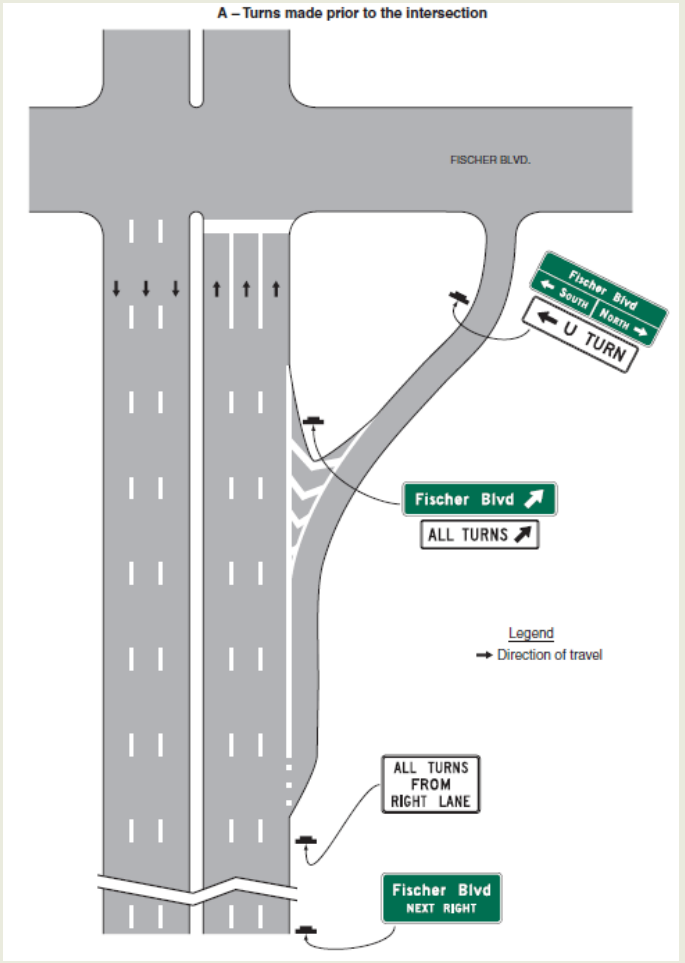


Available online at
www.tfhrc.gov/safety/intersect.htm

FORWARD RAMP STYLE

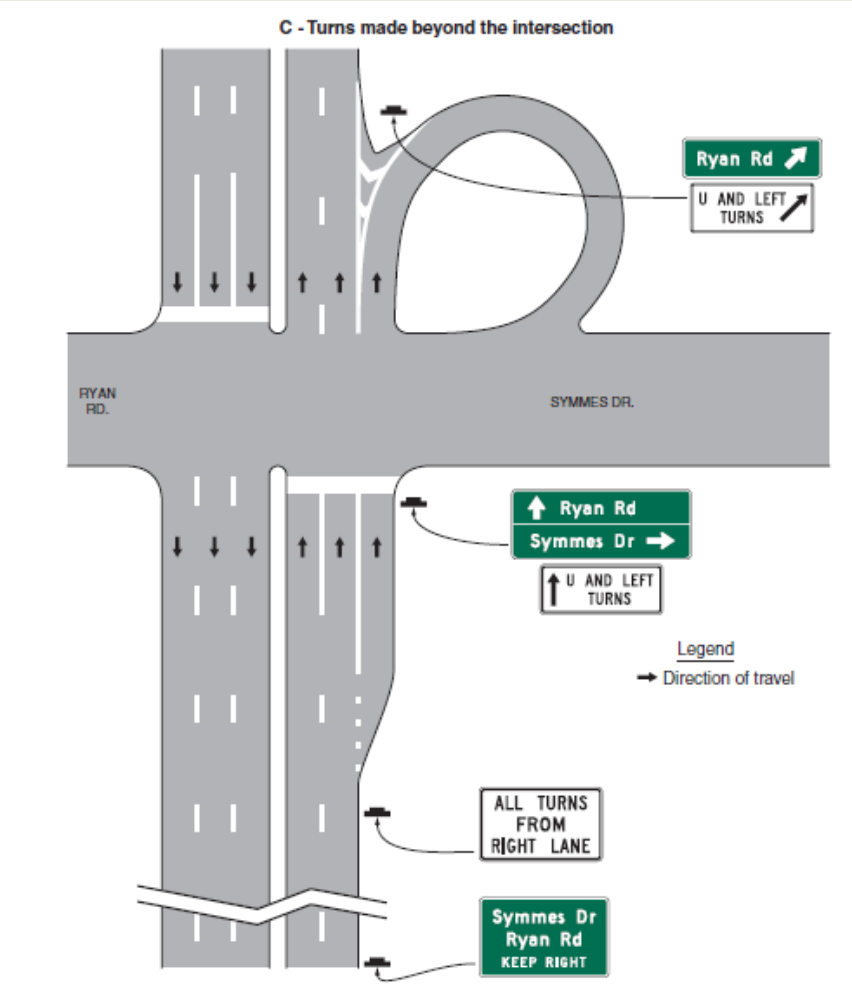


Source: NJDOT Design Manual



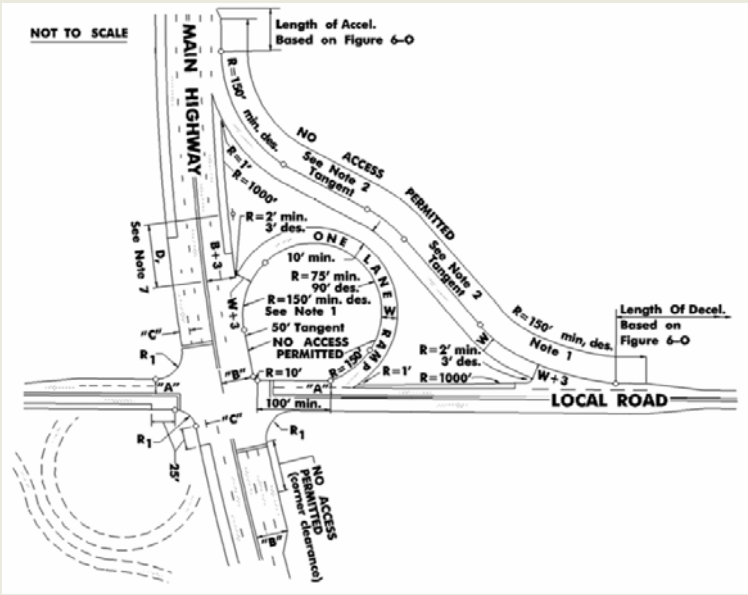
Source: 2009 MUTCD

REVERSE RAMP STYLE

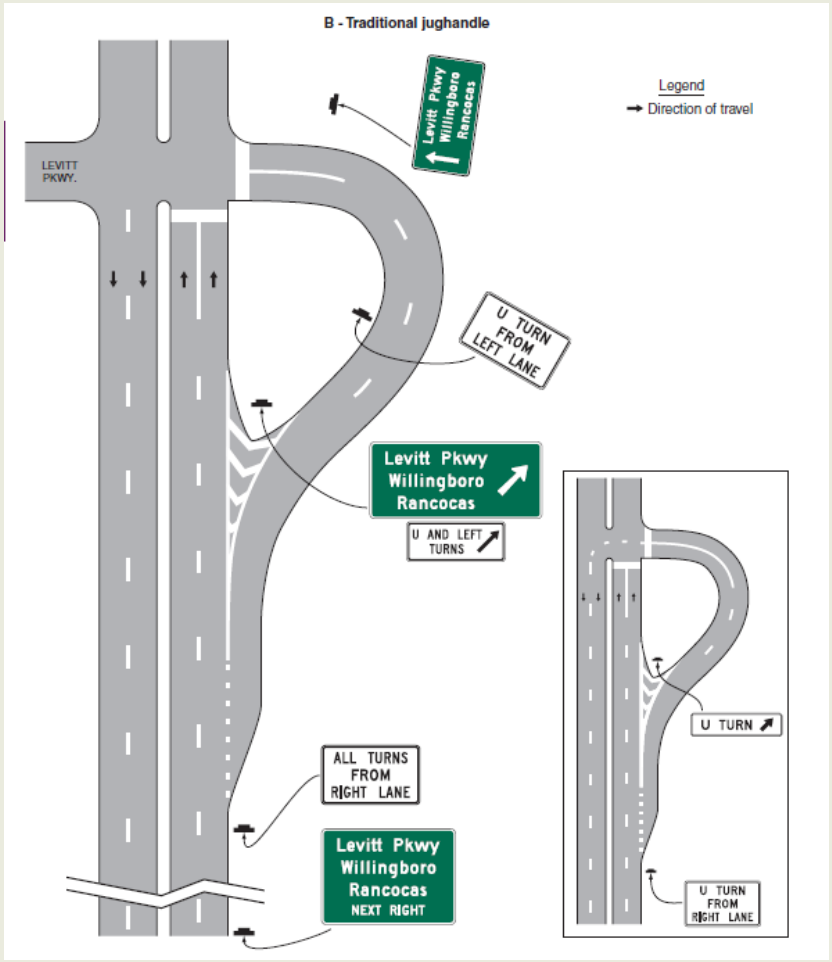


Left-turning traffic uses the rightmost lane downstream of the intersection into a loop ramp

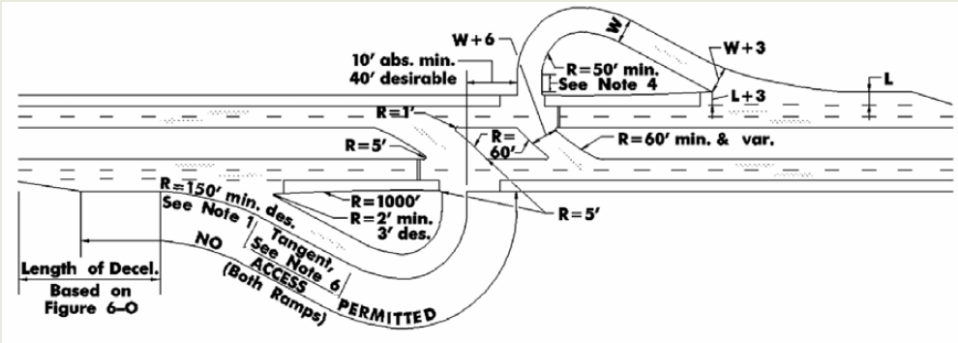
Right-turning traffic turns at the intersection in a traditional manner (not onto the loop ramp)



T-INTERSECTION & U-TURN RAMP



Source: 2009 MUTCD



Source: NJDOT Design Manual


ALL TURNS
FROM
RIGHT LANE
SAM WEINROTH ROAD
NEXT RIGHT


ALL TURNS
No Turns
NO TURNS


No Turns
No Turns

DISPLACED LEFT-TURN (DLT)

Distinguishing Feature:

Left-turn movement (on one or more approaches) strategically relocated to the far-side of the opposing roadway via interconnected signalized crossover in advance of the main intersection

SR 30 and Summit Rd in Fenton, MO

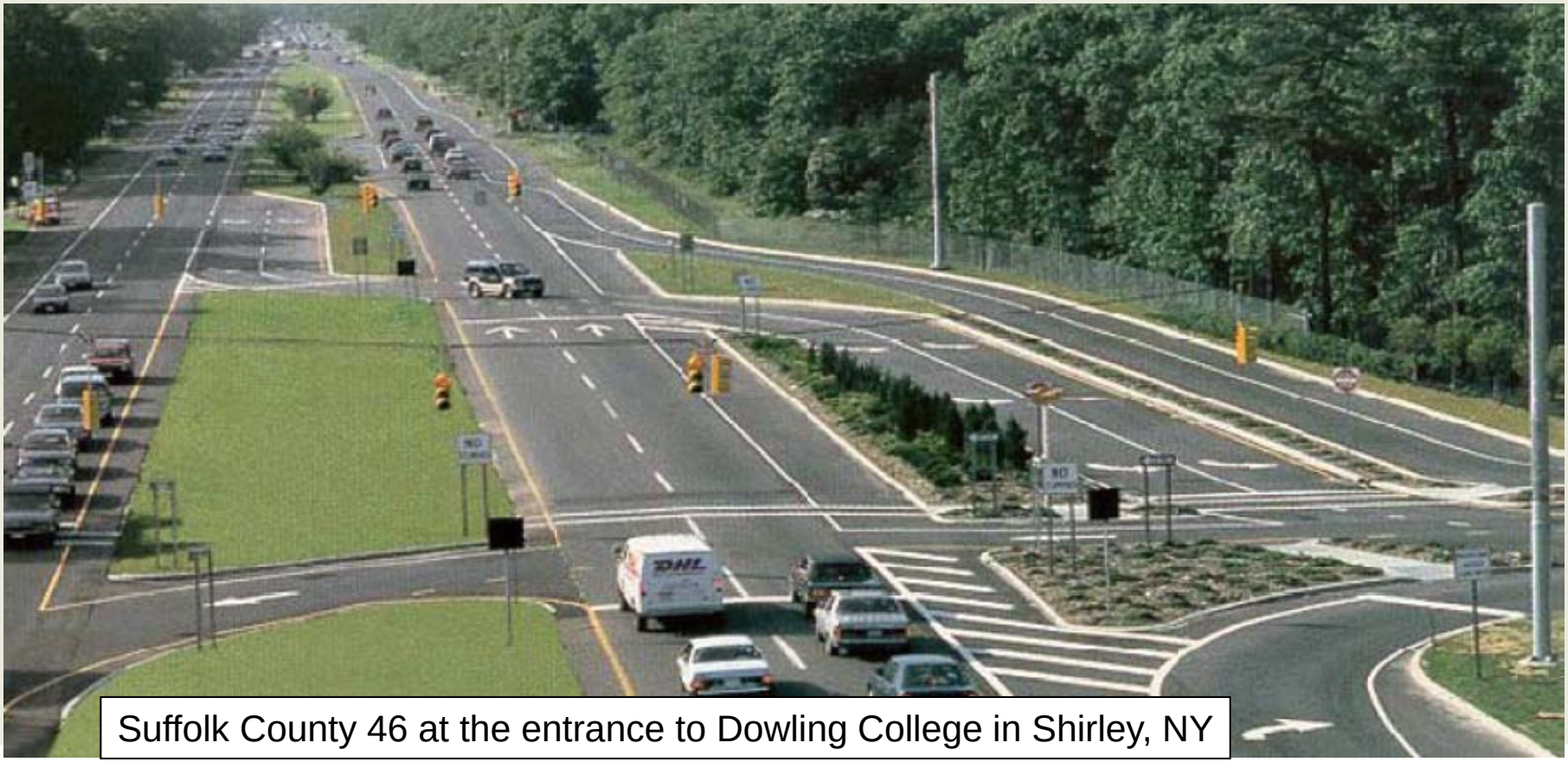
DISPLACED LEFT-TURN (DLT) INTERSECTION

Distinguishing Feature:

Relocation of the left-turn lanes to the other side of opposing traffic on one or more approach

DLT INTERSECTION

Allows left turns and opposing through movement to occur at the same time (eliminate left-turn signal phase)



Suffolk County 46 at the entrance to Dowling College in Shirley, NY

DLT INTERSECTION – APPLICATIONS

Context or Attribute	General Applicability	Context or Attribute	General Applicability
Unsignalized		Four-Leg	✓
Signalized	✓	Three-Leg	✓
		Offset T	
Rural	✓		
Suburban	✓	Two-lane	
Urban core	?	Multi-Lane	✓
High Speed	✓	Multi-modal	✓
Low Speed	?		

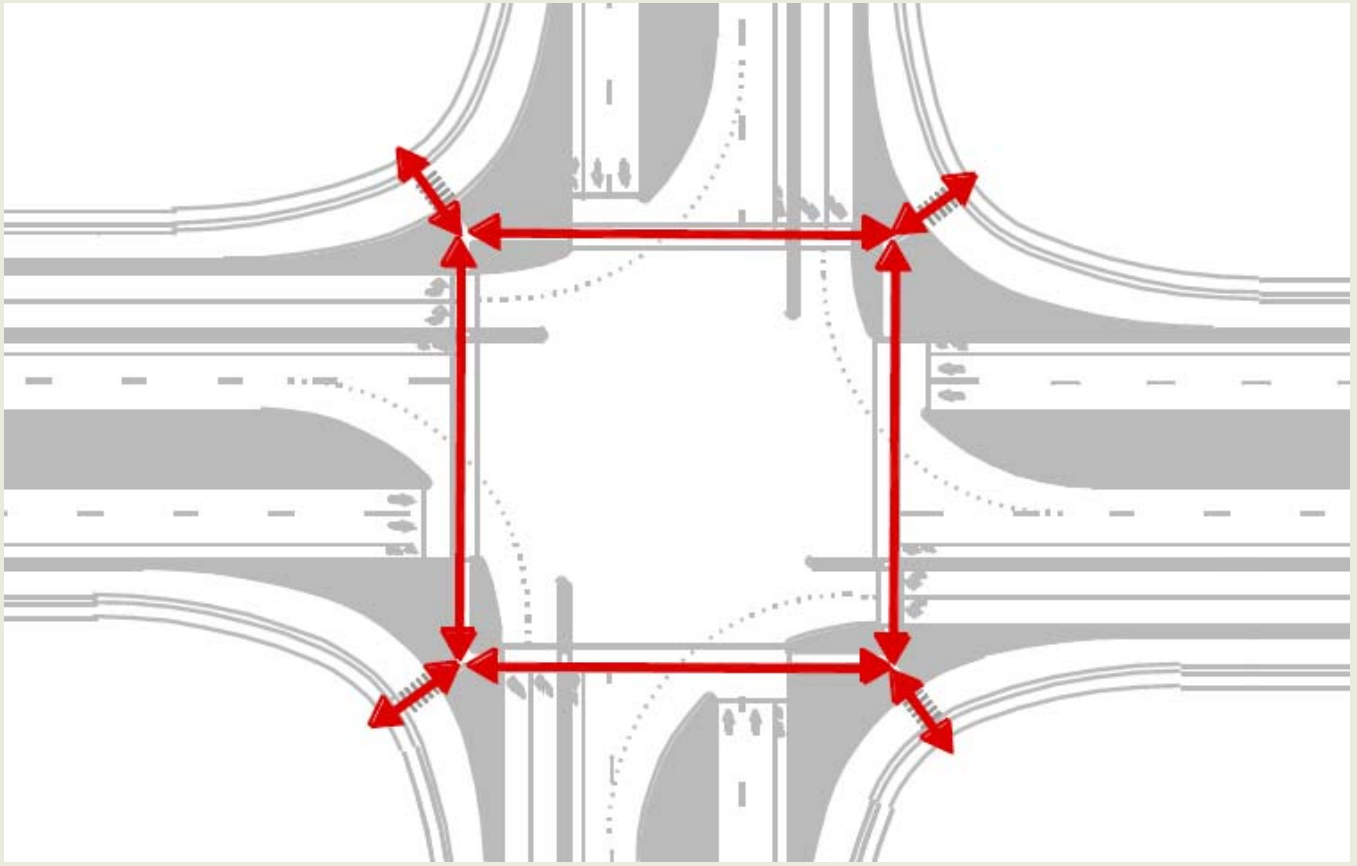
Access Management Issues

PEDESTRIAN CROSSINGS

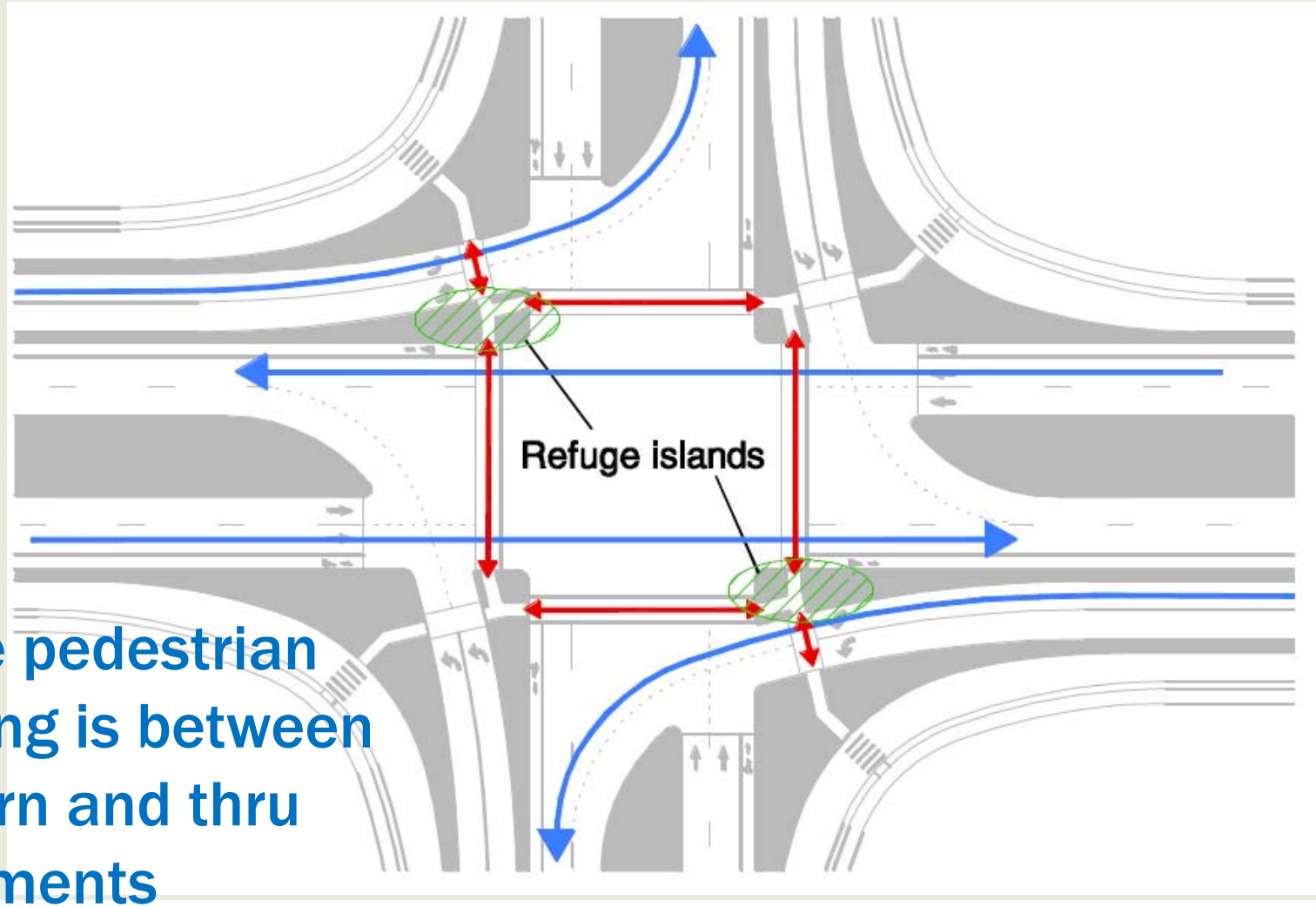
Sample configuration with direct pedestrian crossing paths and no conflict with free-flow right turn lanes

PEDESTRIAN CROSSINGS

- Potential for 1 Stage Ped Crossings

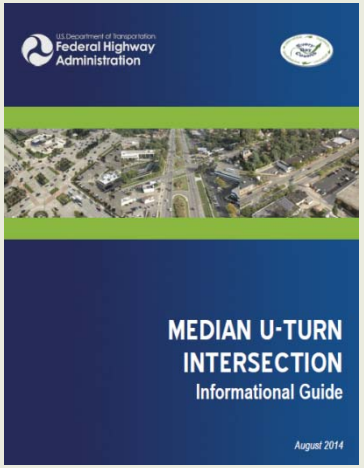


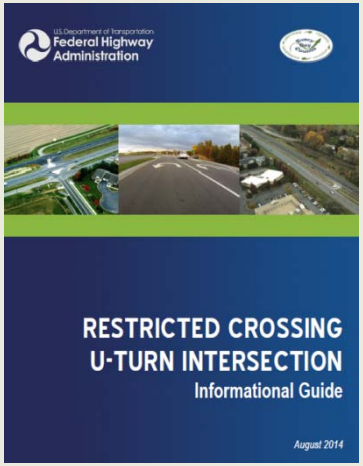
CROSSINGS WITH REFUGE ISLANDS



Notice pedestrian crossing is between left turn and thru movements

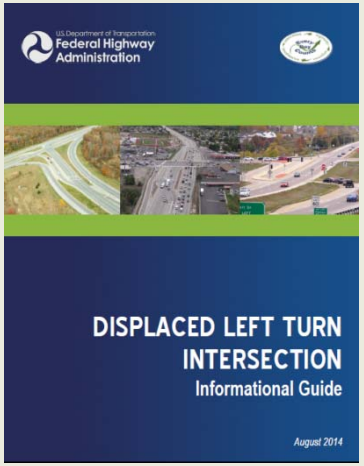
RESOURCES

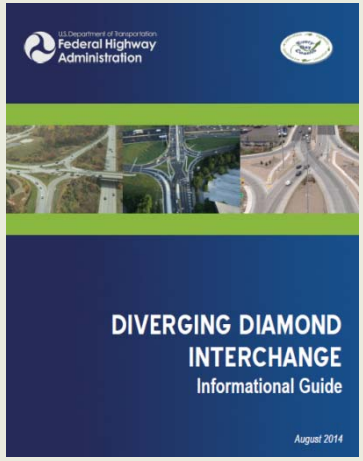


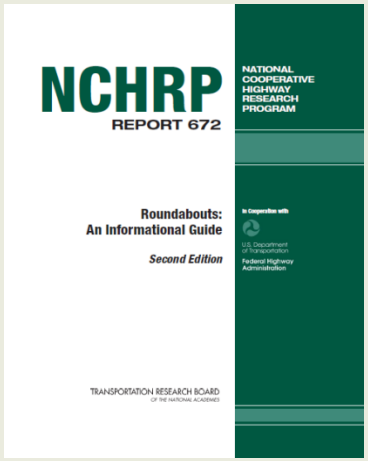


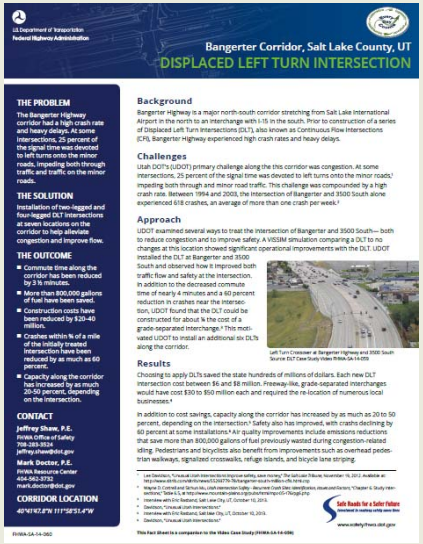
For easy access ...

safety.fhwa.dot.gov/intersection/



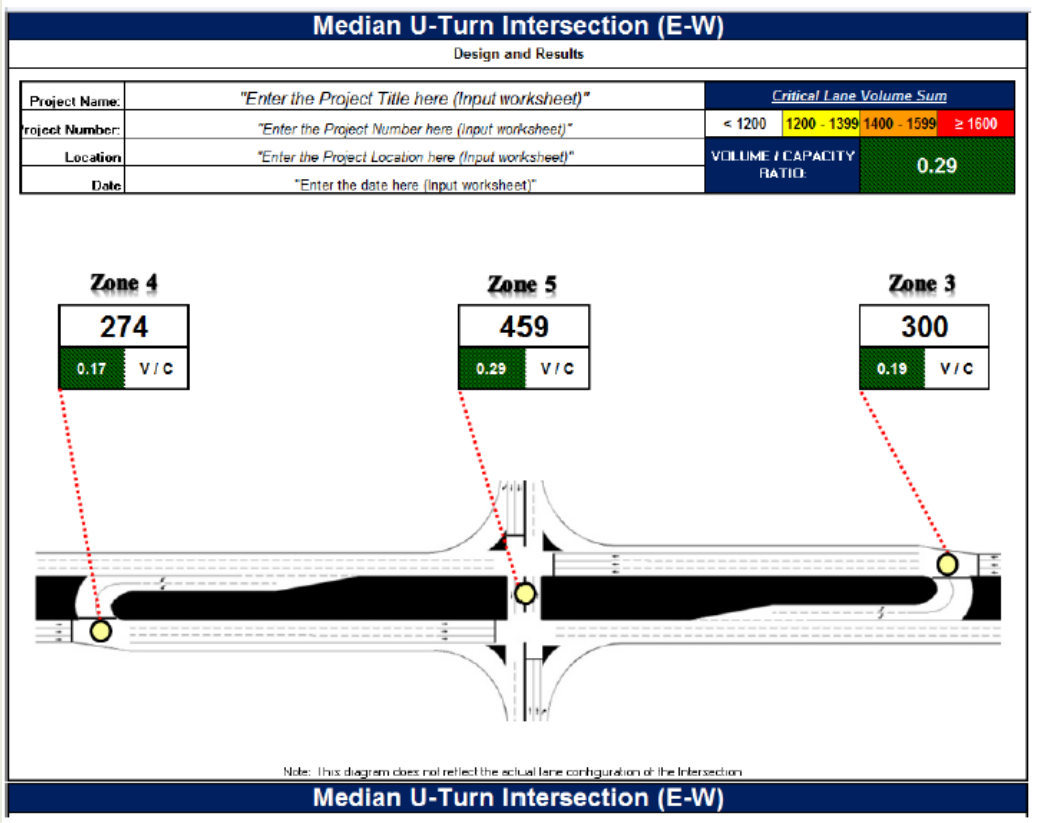






CAP-X SPREADSHEET

FHWA CAP-X Tool:
http://www.fhwa.dot.gov/software/research/operations/cap-x/



No charge, but user registration requested

THANK YOU !!!

QUESTIONS