



# TRANSPORTATION SYMPOSIUM

2019

## Pedestrian and Bicycle Treatments at Alternative Intersections and Interchanges

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# Outline

- ✓ Current research on pedestrian and bicycle treatments
- ✓ Restricted crossing U-turn (RCUT) intersection
- ✓ Median U-turn intersection (MUT)
- ✓ Quadrant roadway (QR) intersection
- ✓ Displaced left-turn (DLT) intersection
- ✓ Diverging diamond interchange (DDI)

# Current Research on Pedestrian and Bicycle Treatments

## **NCHRP 07-25: Guide for Pedestrian and Bicycle Safety at Alternative Intersections and Interchanges**

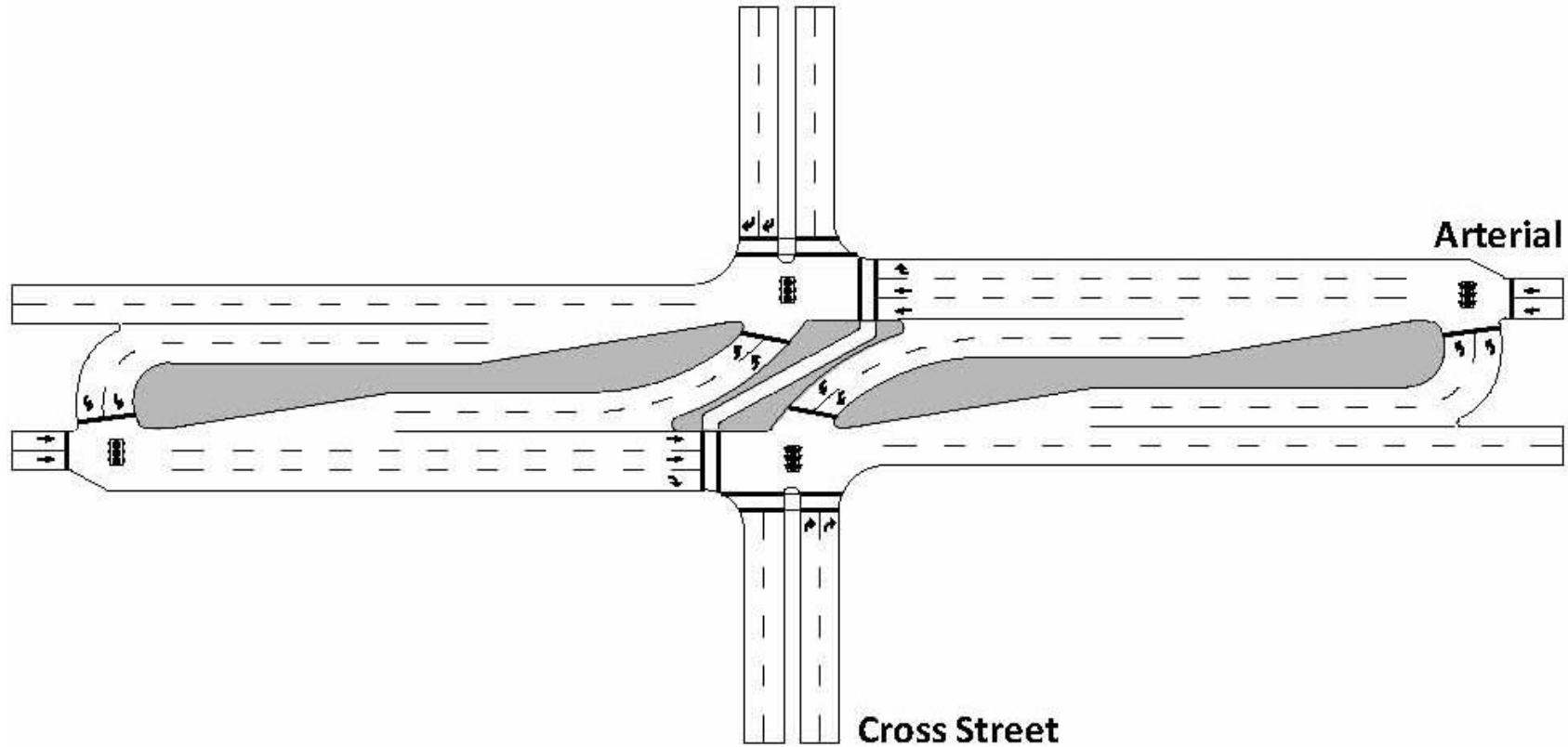
- Completion date: 9/20/2019

## **Background**

- New alternative intersection/interchange designs being built in US
- Safety issues to pedestrian/bicyclists by reversing traffic lanes

## **Research objectives**

- Develop a guide to improve pedestrian/bicycle safety at alternative intersections and interchanges
- Include planning, design, and operational treatments



# Restricted Crossing U-turn Intersection

# Restricted Crossing U-Turn (RCUT) Intersections



*RCUT intersection in Emmitsburg, MD*

- ▶ Redirects left-turn and through movements from side street approaches
  - Right turn followed by U-turn maneuver at median opening
  - Median opening 1,000 feet to 1,500 feet downstream
- ▶ Can be signalized, stop, or yield controlled



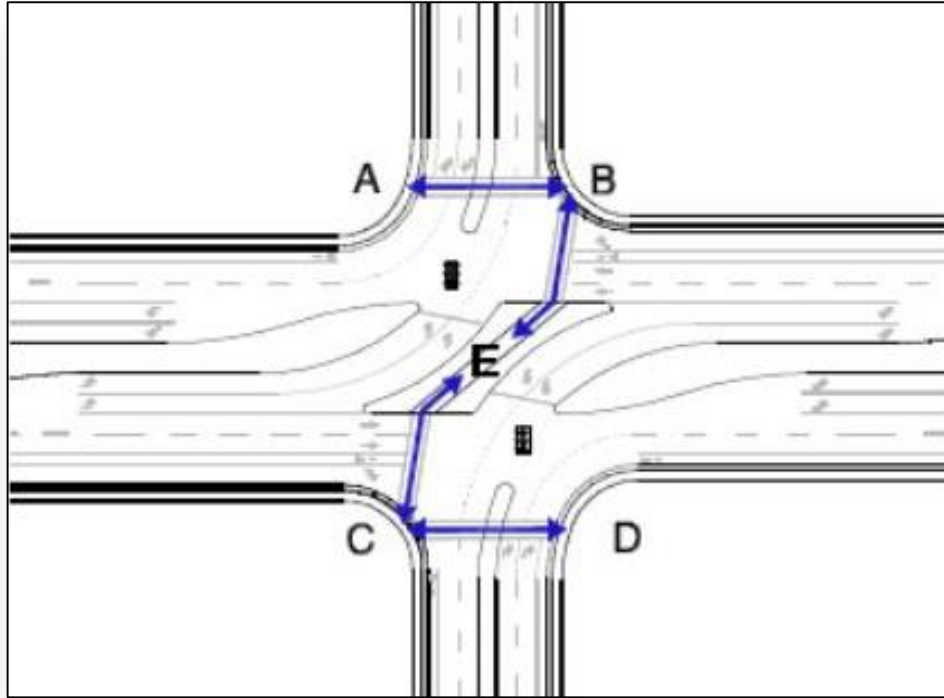
# Suitable Location for RCUTs

- ▶ On median divided highways
- ▶ Suitable intersections for RCUT
  - Moderate through and/or left-turn volumes on major street
  - Low through and left-turn traffic volumes on side street
  - Three or four legs



*RCUT intersection in Troy, MI*

# Pedestrian Movements at RCUTs



*Pedestrian movements in a  
RCUT intersection*

- ▶ Major street crossing is generally one diagonal path
  - Longer than conventional intersection
- ▶ Allows pedestrians to cross the main street between one (B to C) but not both pairs of opposing corners (not A to D)
- ▶ Median islands can provide pedestrian refuge

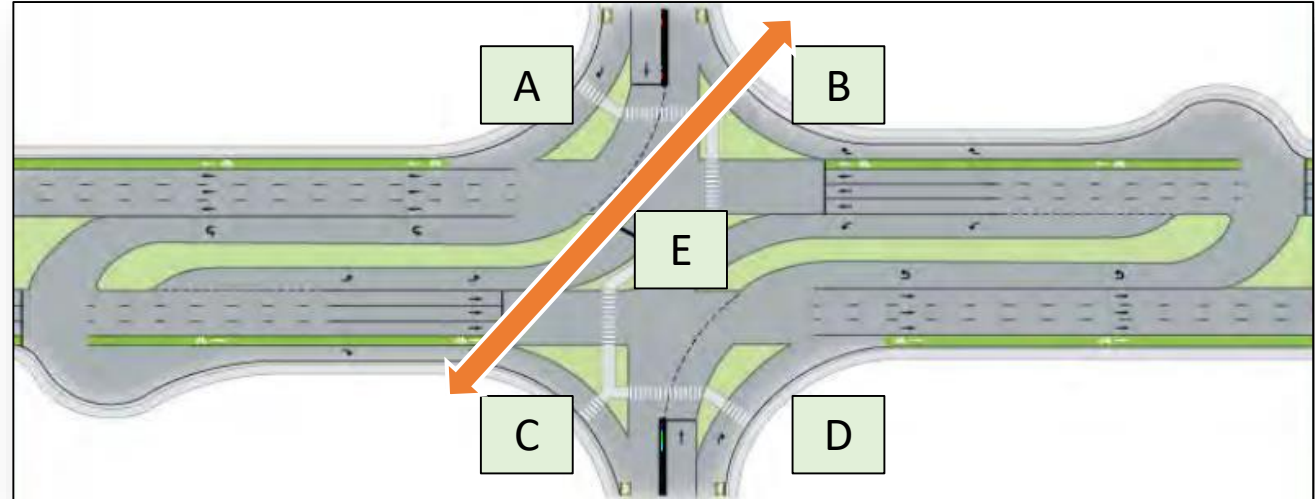
# Accommodation for Pedestrians and Bicyclists at RCUTs

## ► Apply RCUT design in areas that favor preferred pedestrian movements (B to C)

- Suitable for suburban environment with separated lane use and low pedestrian traffic

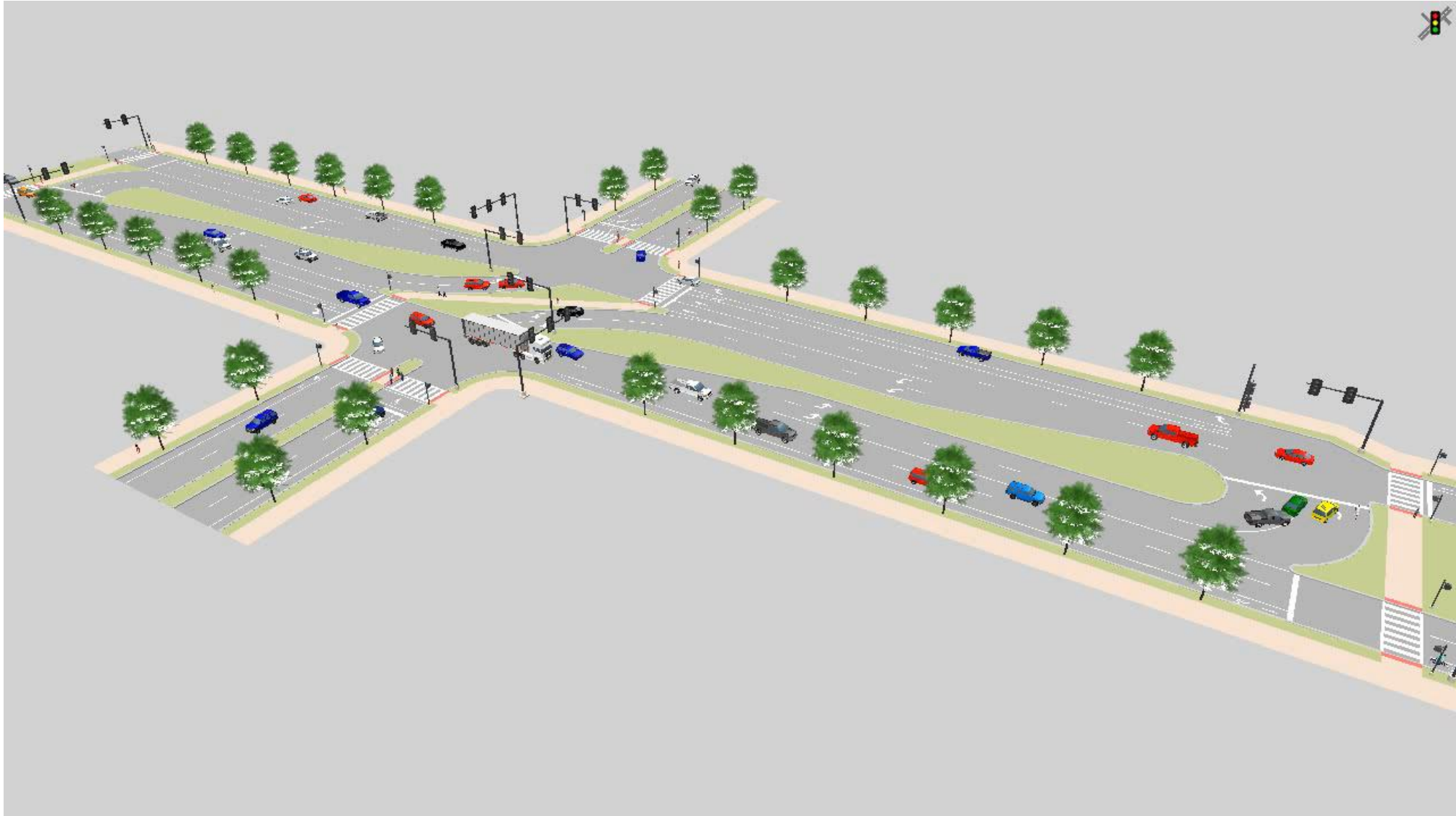
## ► Provide wayfinding signing for pedestrians

- Install barriers to channelize pedestrians
- Provide accessible devices to assist disabled pedestrians





# Pedestrian and Bicycle Movements at RCUTs

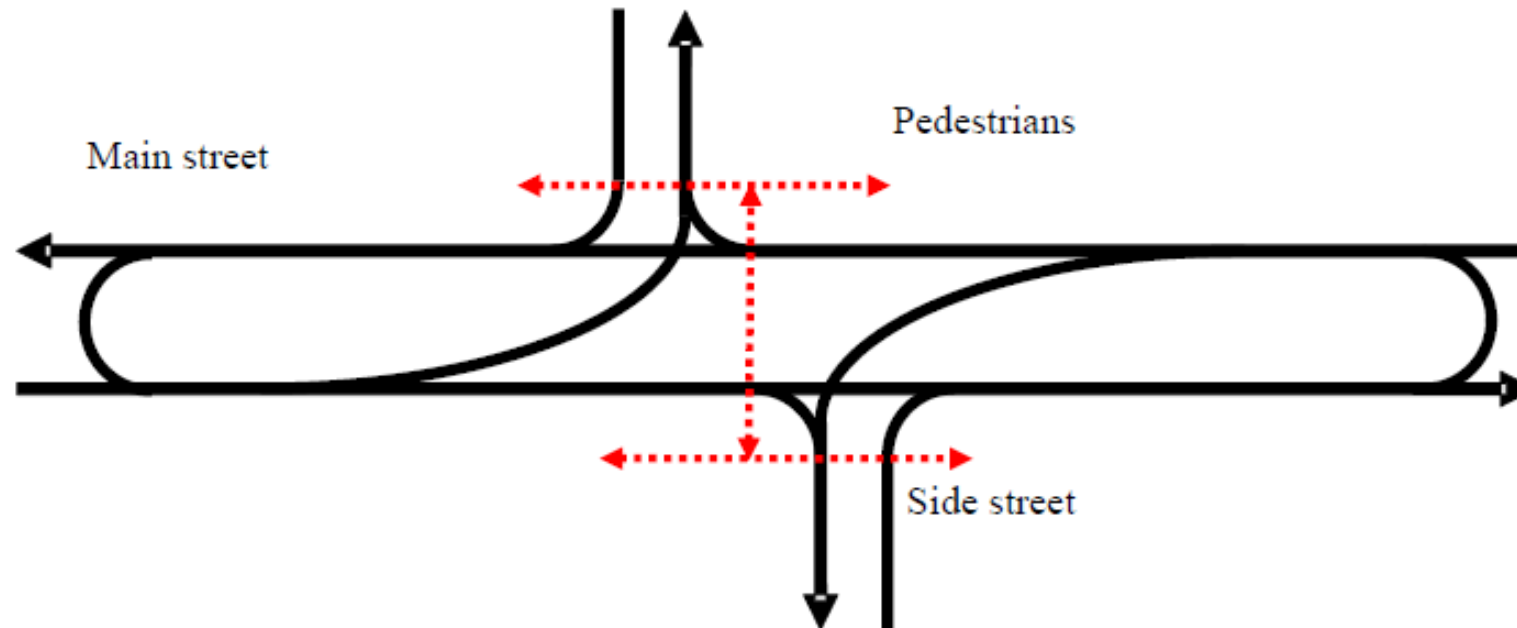


# Ped & Bicycle Movements at RCUTs W/Cycle Track



# Alternative Pedestrian Movements at RCUTs

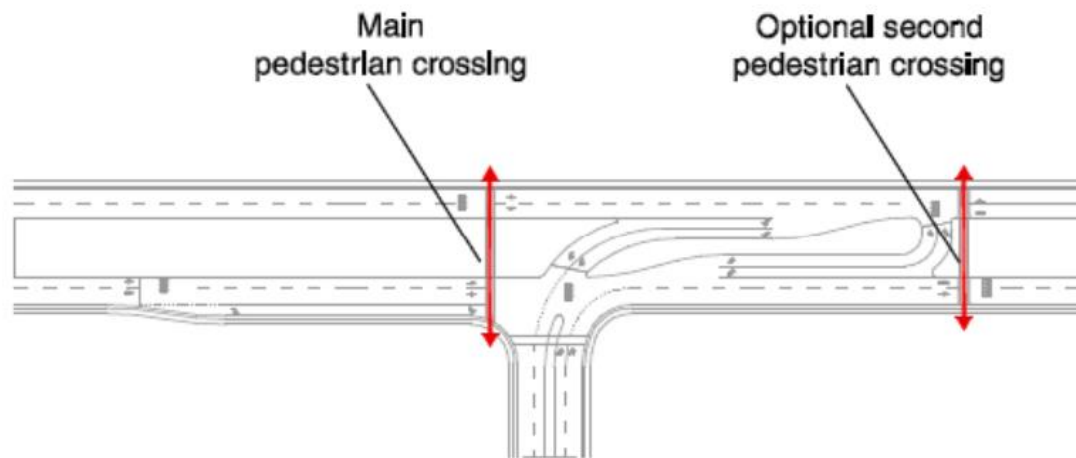
- ▶ Shorten the path to cross the arterial
- ▶ Decrease pedestrian exposure to moving vehicles on main street



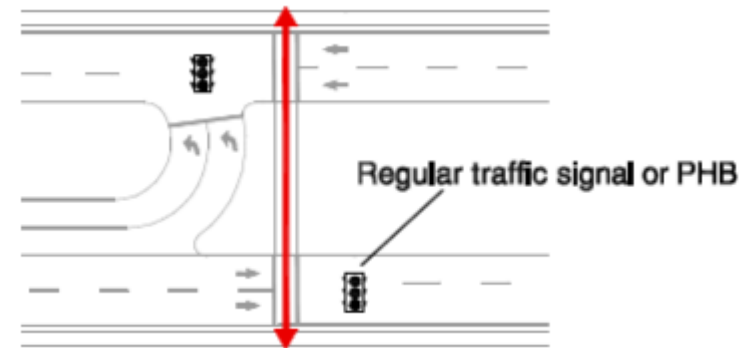
*RCUT with minor street approaches offset*

# Alternative Pedestrian Movements at RCUTs

## *Pedestrian Movements at Three-leg Intersection*



## *Pedestrian Crossing at U-Turn*



- ▶ Require additional signal on mainline to stop through traffic
- ▶ Decrease pedestrian exposure
- ▶ PHB Can also be used

# Bicycle Movements at RCUT Intersections

## ► Option 1 (blue line)

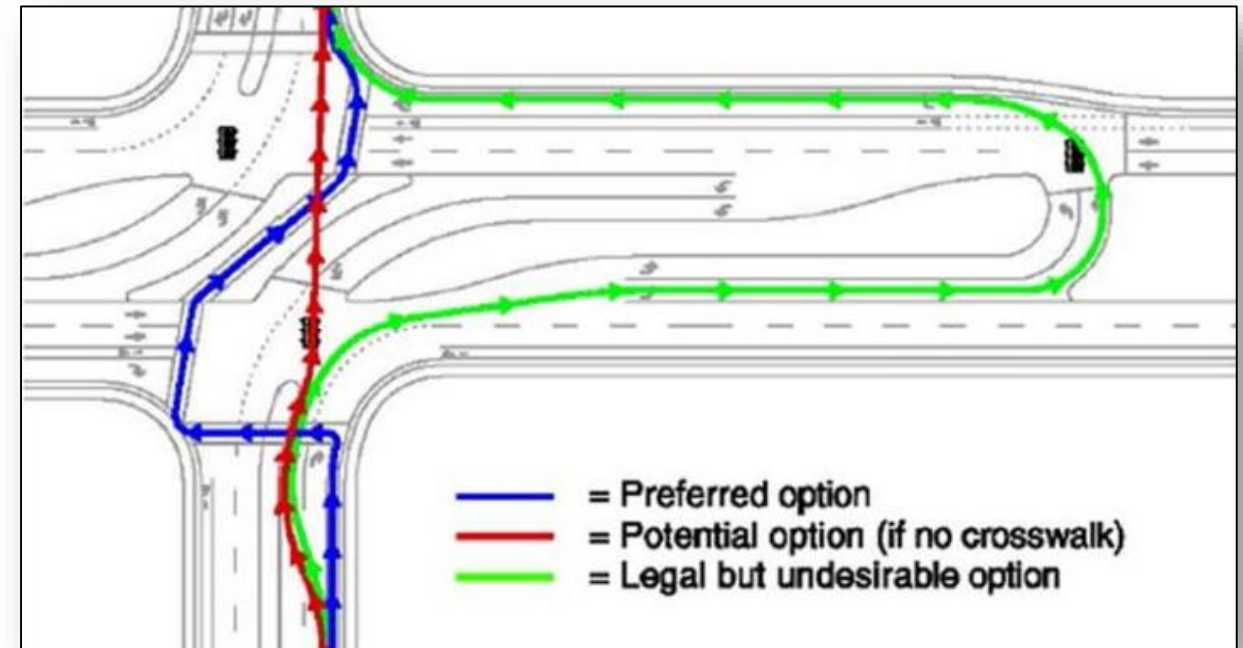
- Cross the major road with the pedestrians on the sidewalks of the “Z” crossing
- Preferred option for bicycle movements

## ► Option 2 (red line)

- Cross the major road near the left-turn lanes if no crosswalk is available

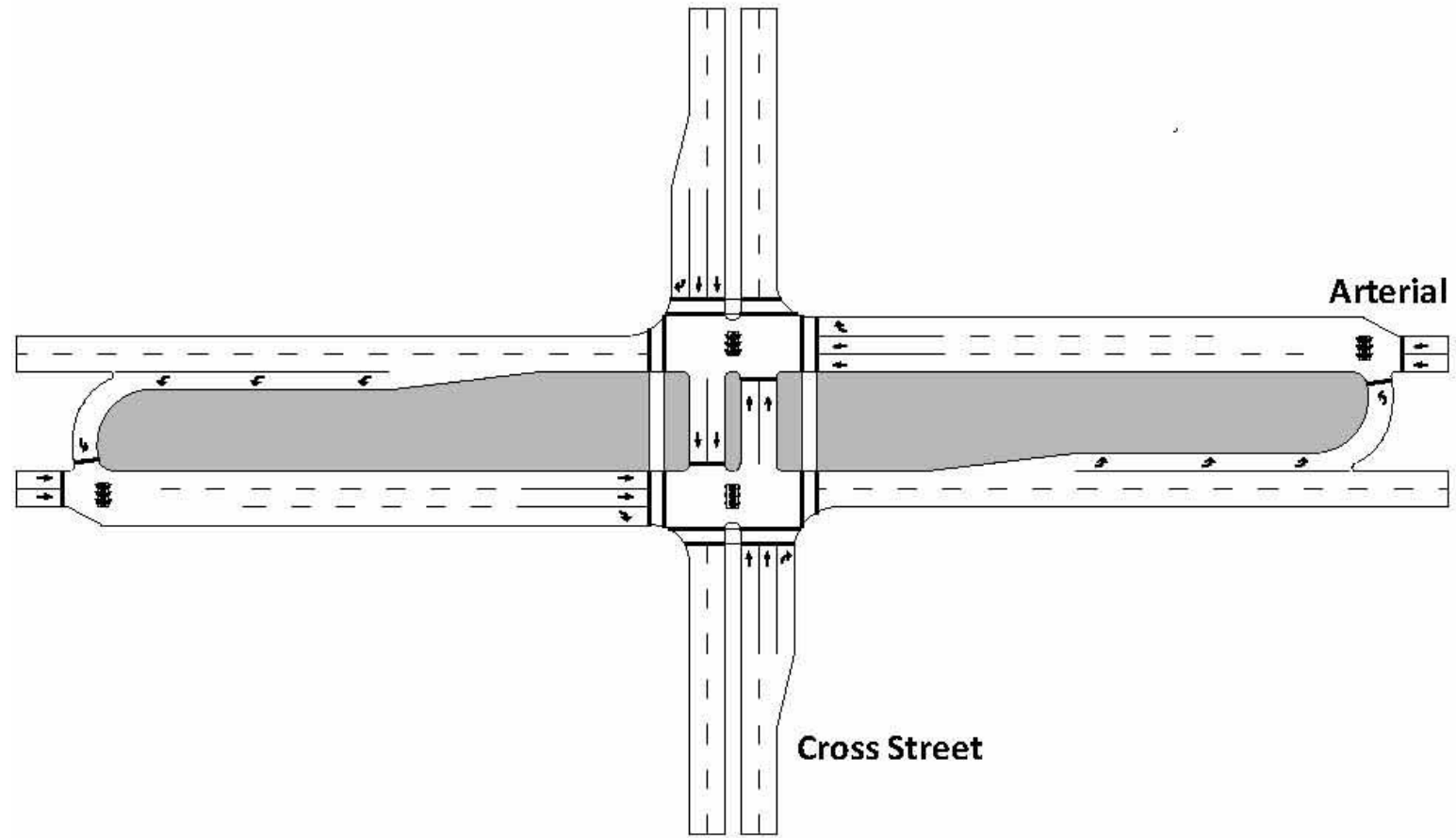
## ► Option 3 (green line)

- Cross by moving with the vehicle traffic
- Makes a right turn, a U-turn, and then a right turn onto the minor road



*Bicycle Route Options for Minor Road*

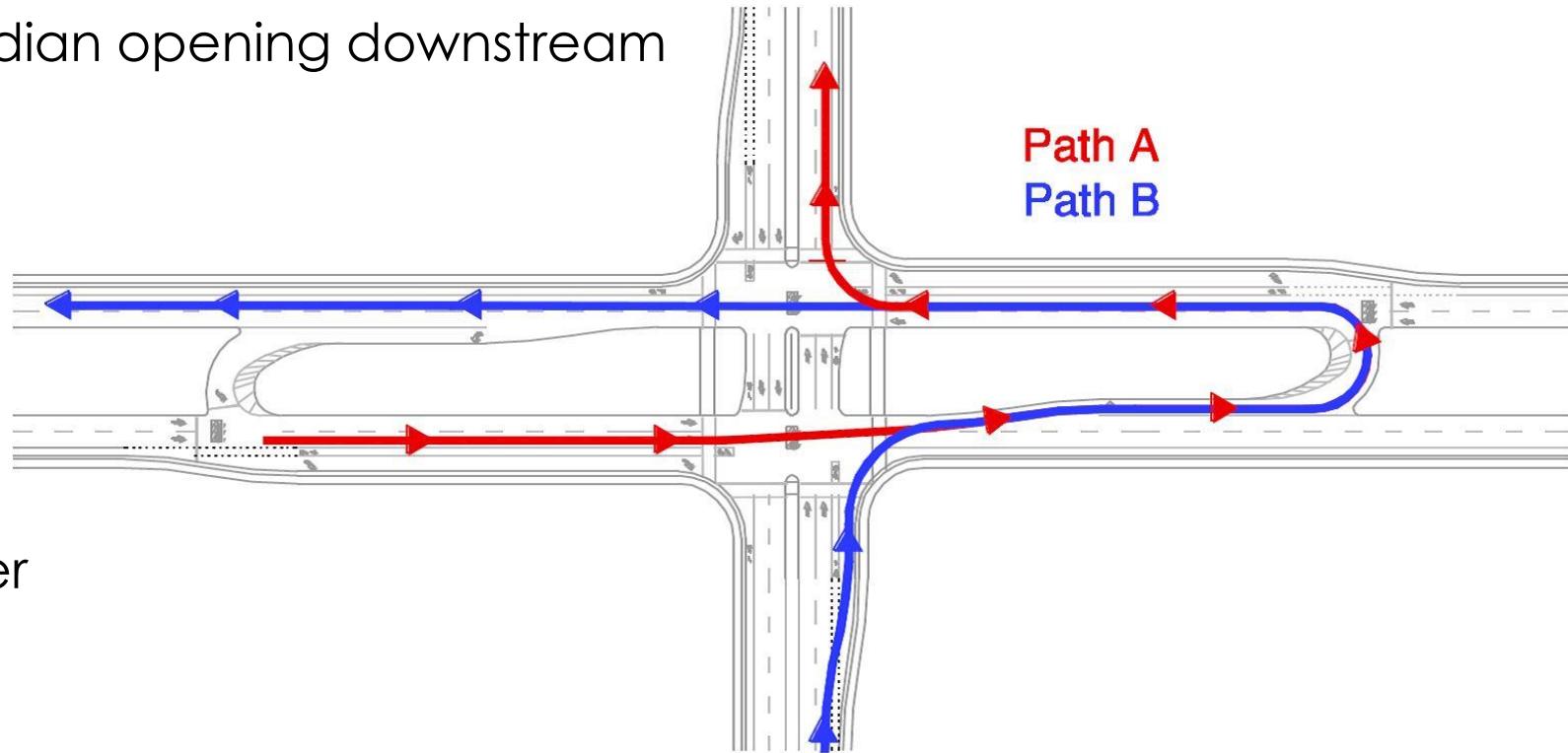




# Median U-turn Intersection

# Median U-Turn (MUT) Intersections

- ▶ Eliminate direct left-turns from major and minor approaches
- ▶ Two-step for left-turn maneuver
  - Turn right onto the main road
  - Make a U-turn at a median opening downstream
- ▶ Traffic control for MUT
  - Signalized
  - Stop controlled
  - Yield controlled
- ▶ Other name for MUT
  - Michigan left-turn
  - Median U-turn crossover
  - Boulevard turnaround
  - Michigan loon



# Suitable Location for MUTs

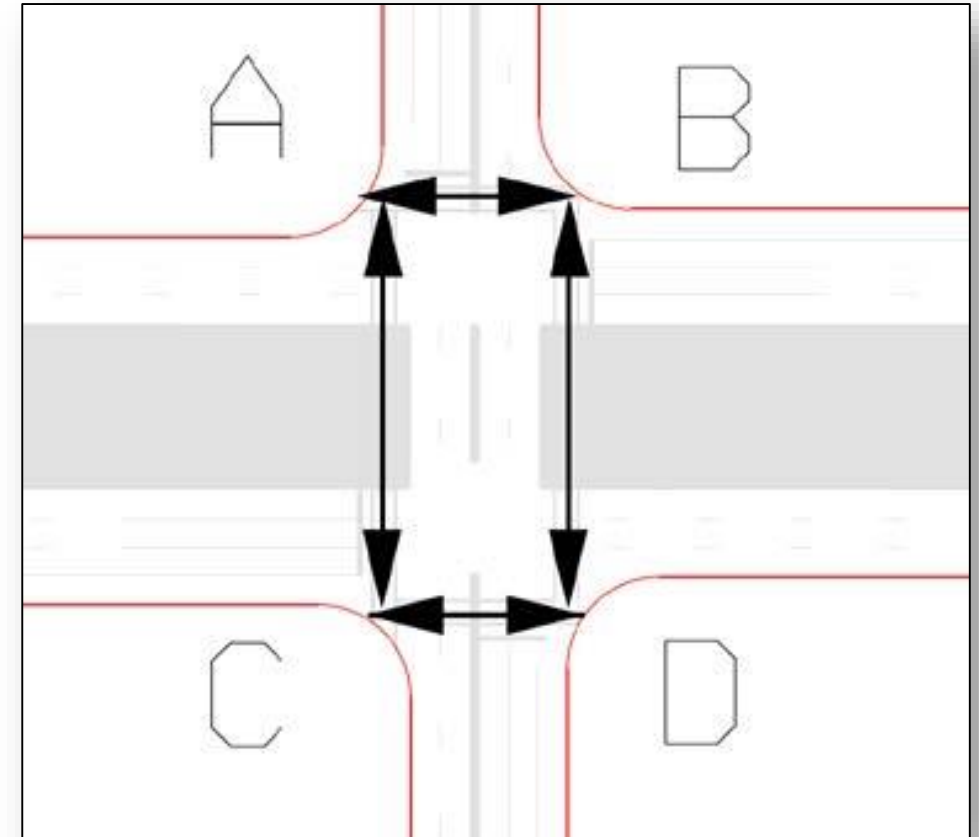


*MUT intersection in a corridor in Michigan*

- ▶ On median divided highways
- ▶ Intersections suitable for MUT
  - Moderate to heavy through traffic volumes
  - Low to moderate left-turn traffic volumes
  - Three or four legs
  - Minor road volume to total intersection volume less than or equal to 1/4
- ▶ Typically a corridor treatment is applied at signalized intersections
- ▶ Also used at isolated intersections to alleviate specific traffic operational and safety problems

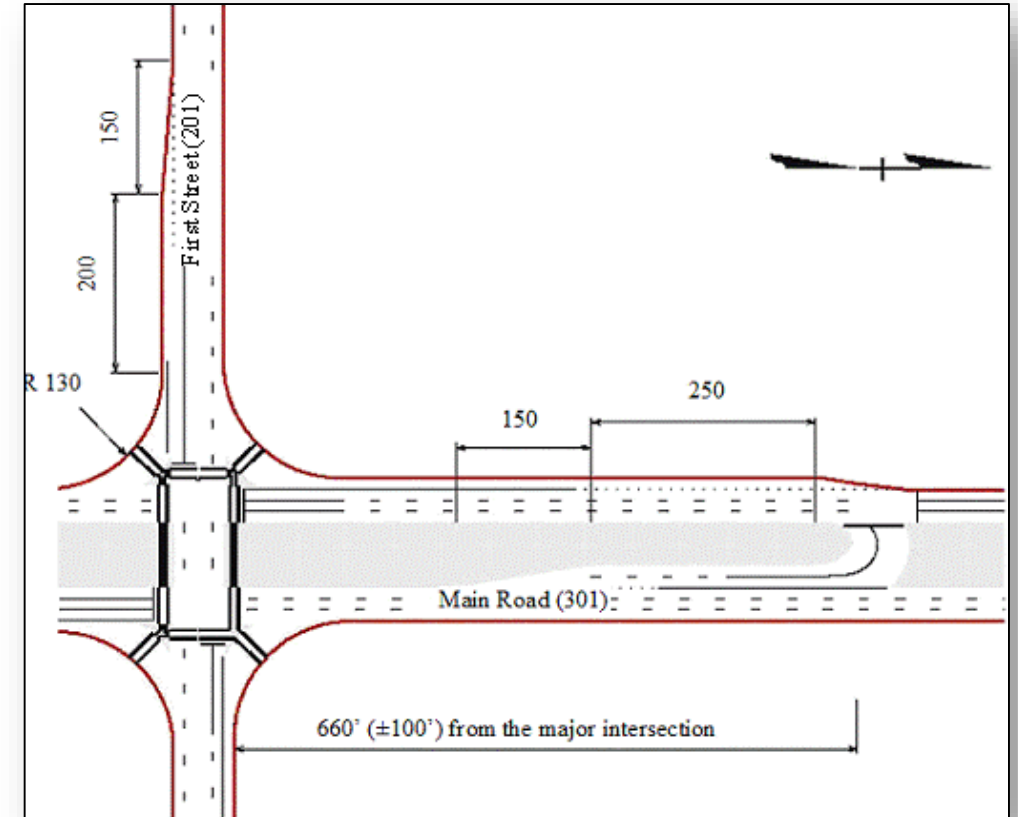
# Pedestrian Movements at MUT Intersections

- ▶ Two-phase pedestrian crossing
  - Pedestrian crosses one direction of the major street during the first signal phase
  - Pedestrian crosses the other direction during a second signal phase
  - Usually some delay between the phases
- ▶ Median islands can provide pedestrian refuge
- ▶ Small delay to pedestrians because of only two signal phase and short cycle length



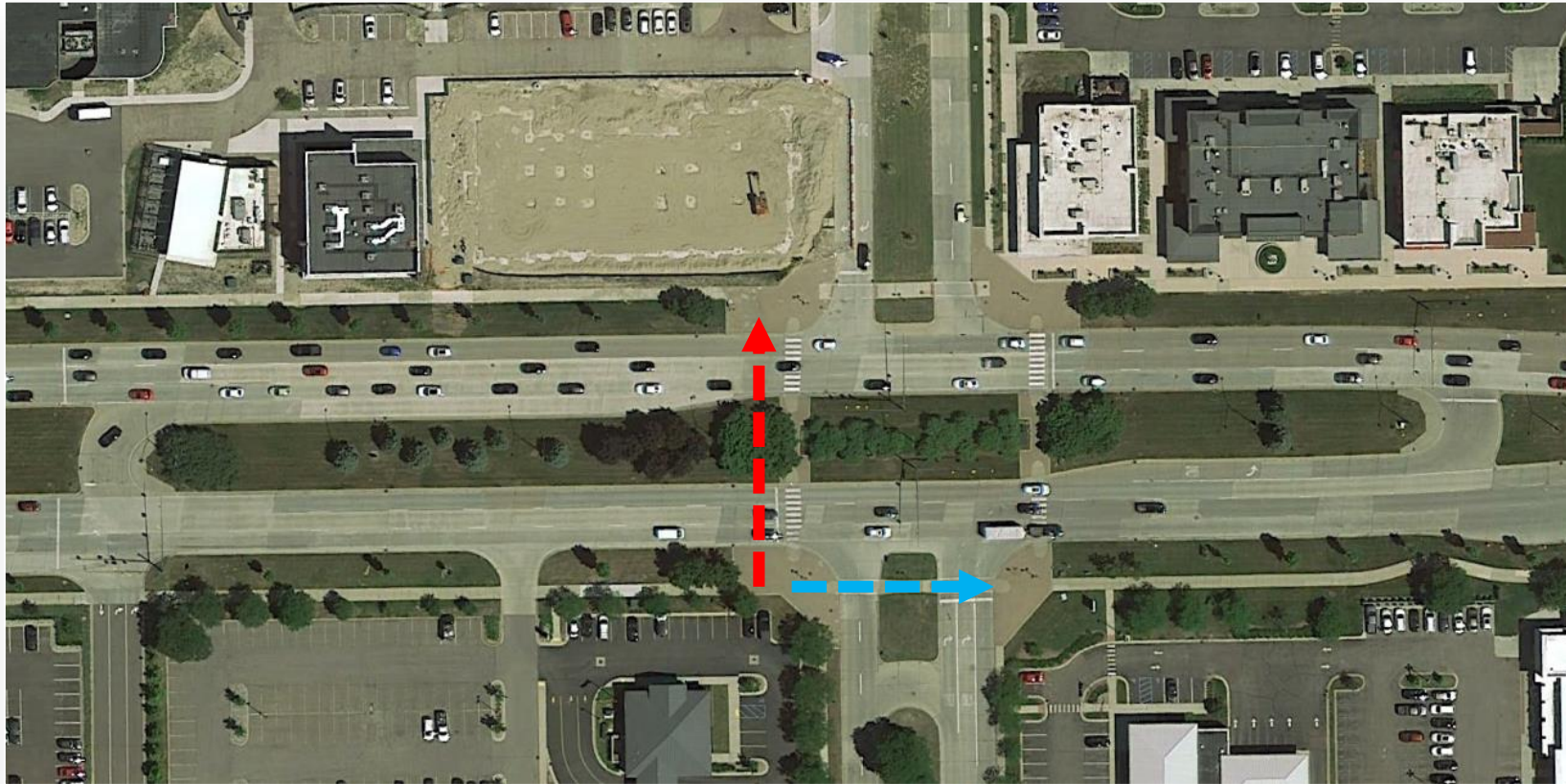
# Accommodation for Pedestrians and Bicyclists at MUTs

- Allows pedestrians to cross major street during minor street through and right-turn signal phase
- Pedestrians encounter fewer conflicting traffic streams than at a conventional intersection
- Two-phase signal create a shorter signal cycle length
  - Allow more pedestrian phases per hour
  - Allow less wait times between walk signals
- Through and right-turning bicyclists navigate the same as a conventional intersection





# Alternative Pedestrian Movements at MUTs



*Median U-Turn with No Through Movement*

# Pedestrian and Bicycle Treatments at MUTs

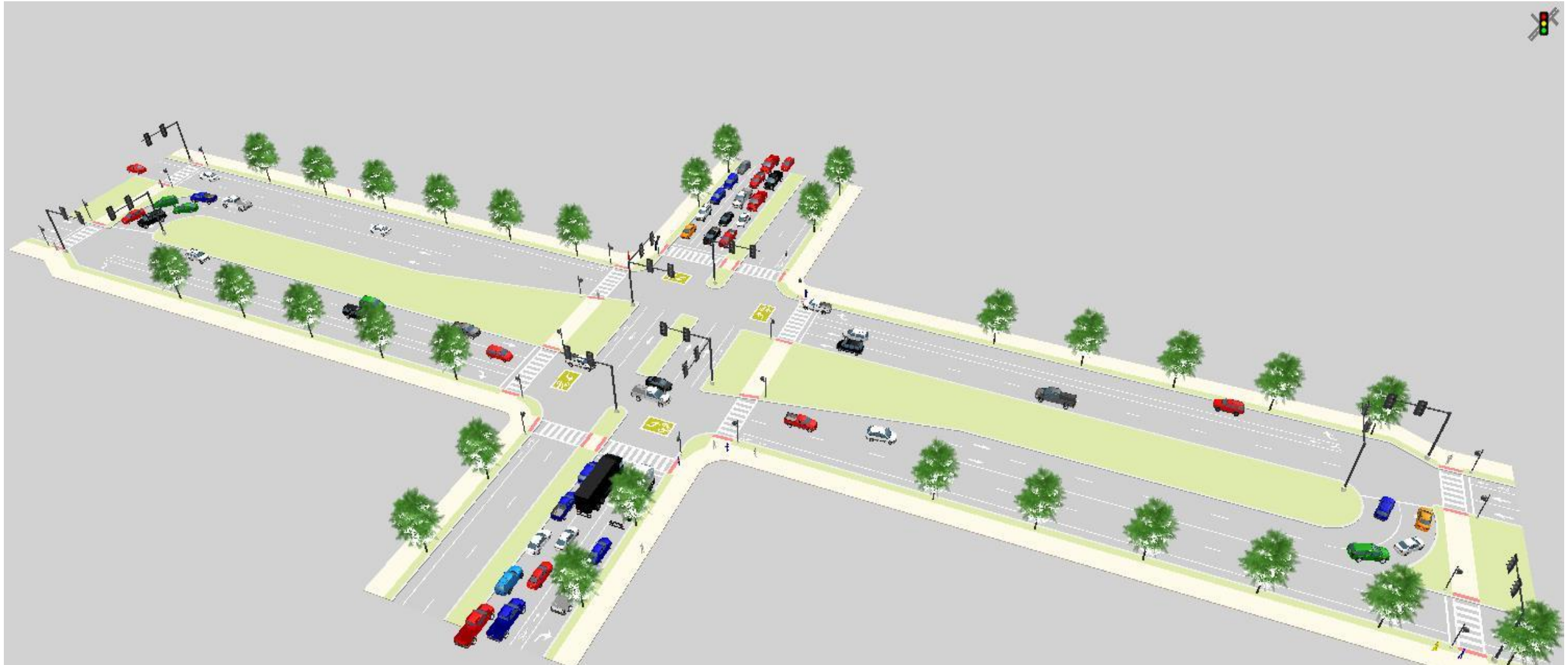




# Pedestrian and Bicycle Treatments at MUTs W/Cycle Track



# Pedestrian and Bicycle Treatments at MUTs W/Left-turn Boxes



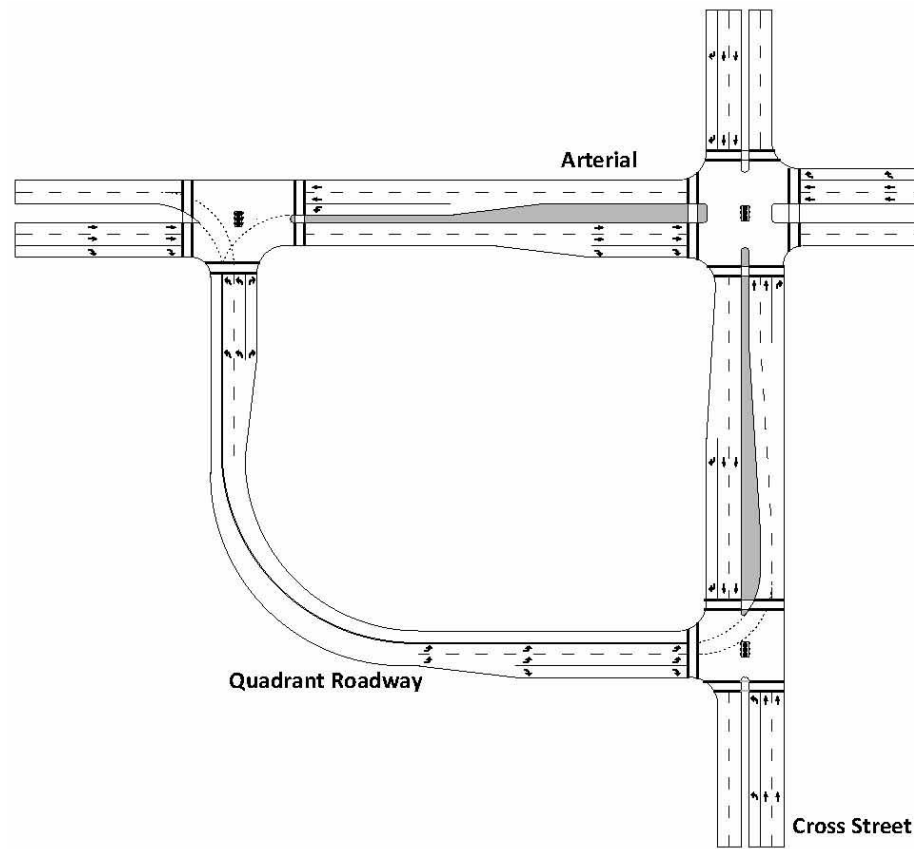
# Bicycle Movements at MUT Intersections

- ▶ Through and right-turning bicyclists from a side street
  - Encounter high green time percentages for their movements
- ▶ Left-turning bicyclists from the side street
  - Can use pedestrian crosswalks to cross the major street and then cross the far side street
  - Use the U-turn crossovers
- ▶ Cyclists wanting to turn left from the main street
  - Can use pedestrian crosswalks to cross side street leg and then the far major street leg
  - Continue down to U-turn crossover



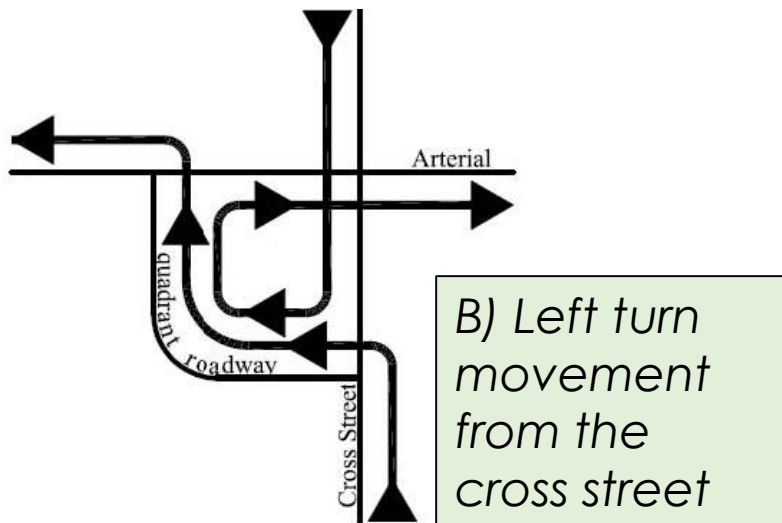
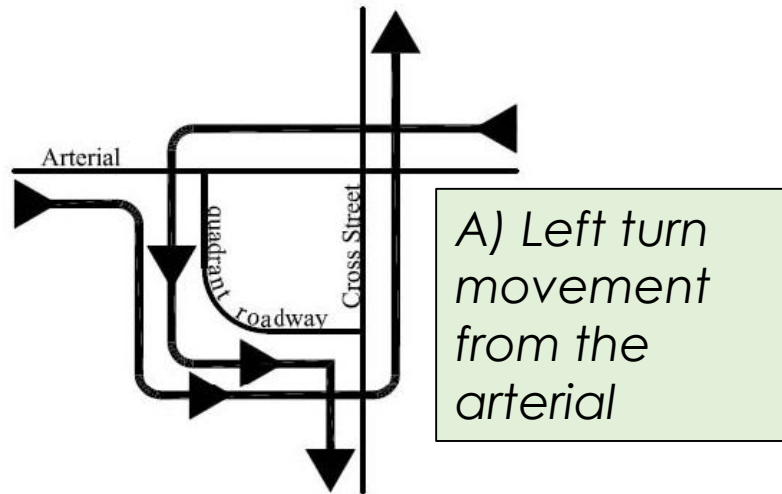
*MUT intersection in Draper, Utah*





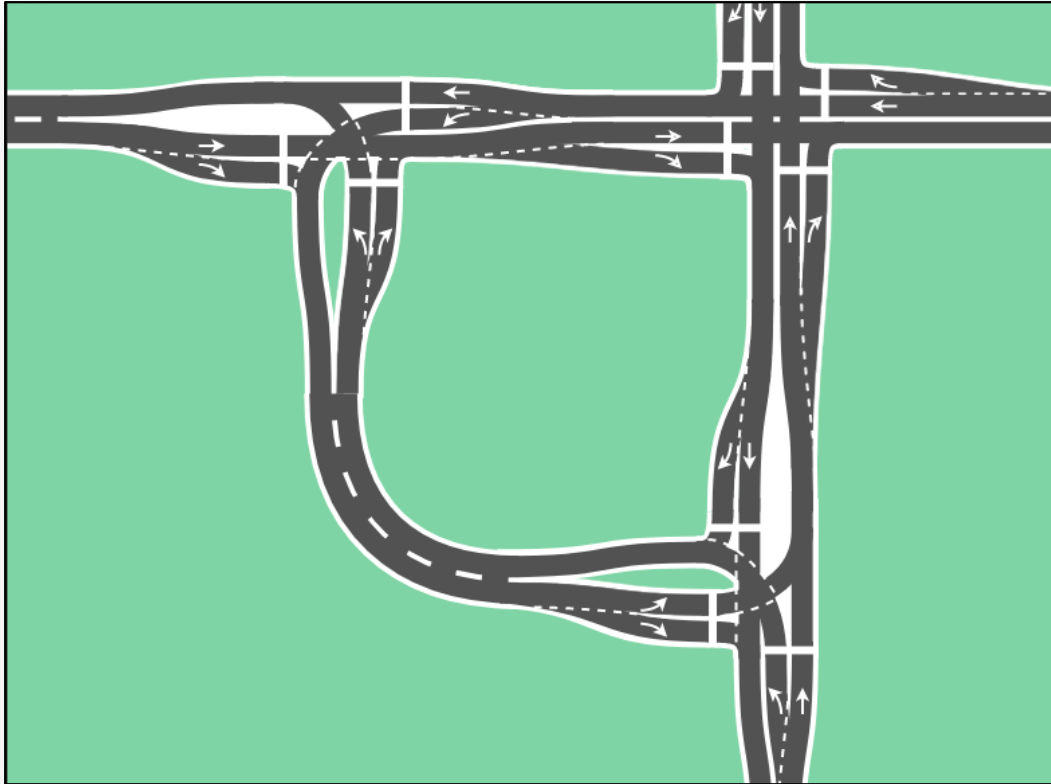
# Quadrant Roadway Intersection

# Quadrant Roadway (QR) Intersections



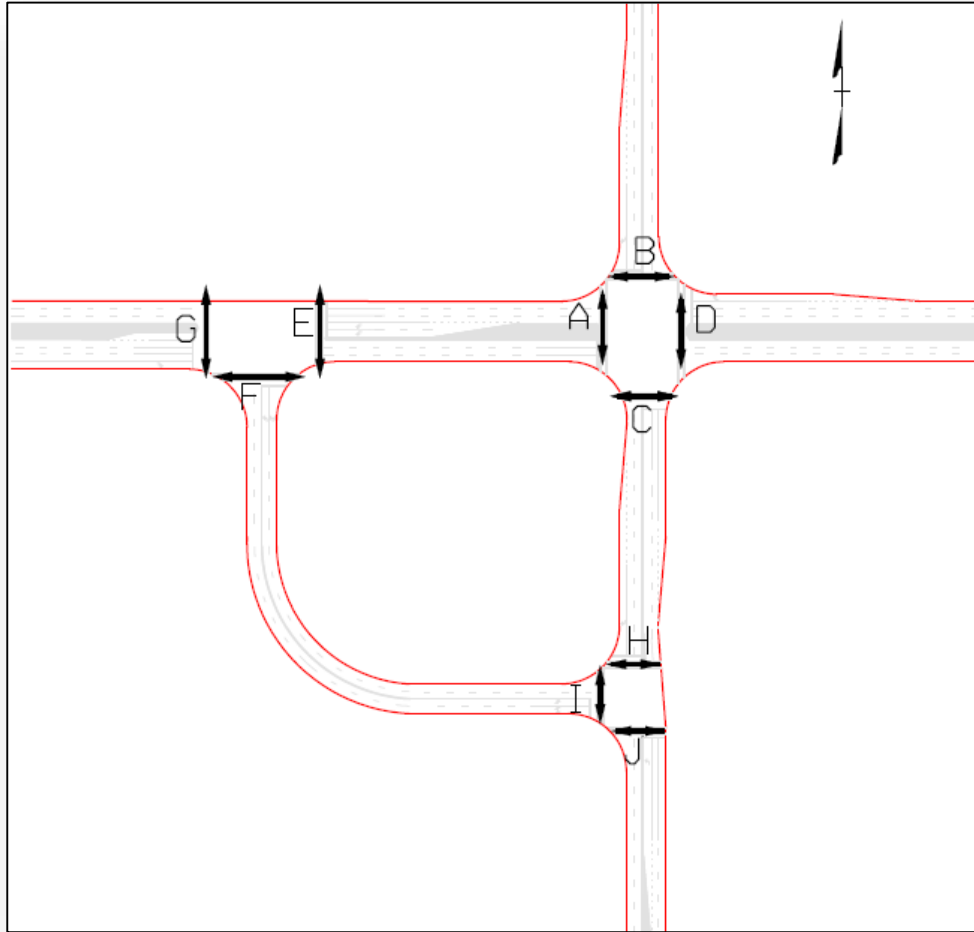
- ▶ One main intersection and two secondary intersections linked by a connector street in any quadrant of the intersection
- ▶ Reroutes all four left-turn movements onto a street that connects the two intersecting streets
- ▶ Secondary intersections are typically signalized, but can also be unsignalized

# Location for Quadrant Roadway (QR) Intersections



- ▶ At locations with an existing roadway that can be used as the connector roadway
- ▶ Intersections suitable for QR
  - Heavy through and left-turn volumes on the major and minor streets
  - Four-leg intersection

# Pedestrian Movements at QRs



- ▶ Extra crossings for pedestrians
  - East and westbound pedestrians crossing at crossing F
  - North and southbound pedestrians crossing at crossing I
- ▶ Pedestrians conflict with right-turn vehicle
  - Similar to the conflicts at conventional intersections

# Bicycle Movements at QRs

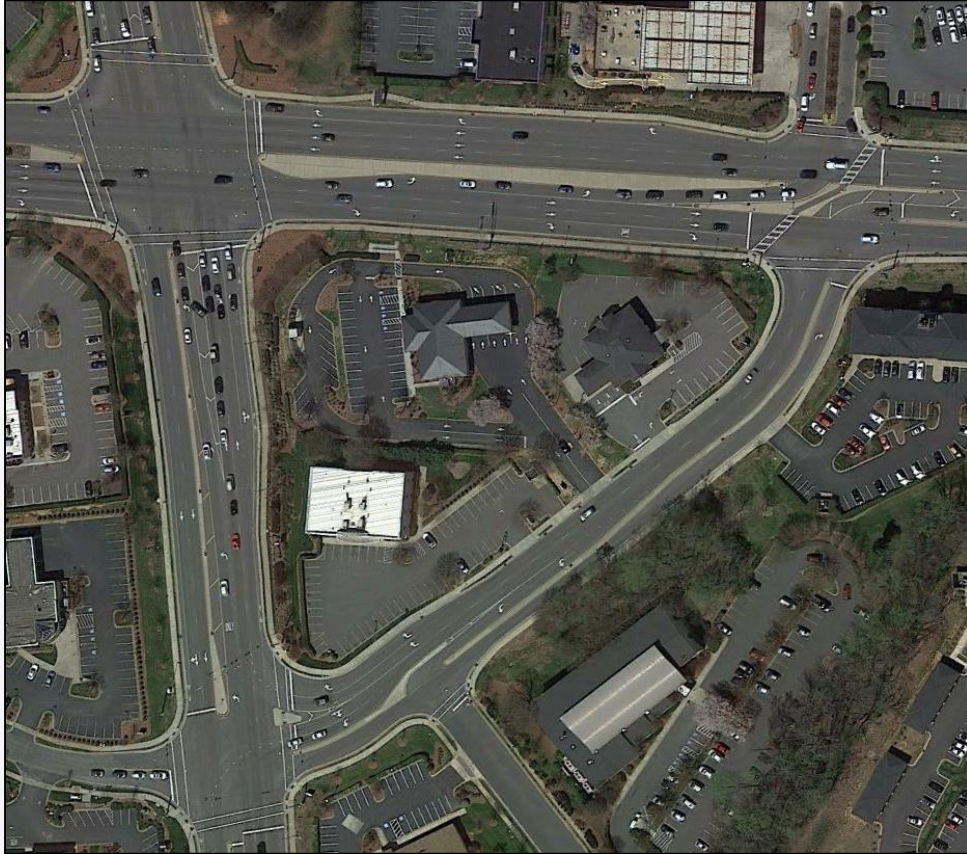
- ▶ Through bicyclists on both intersecting streets
  - Relatively longer green times
  - Favorable progression
- ▶ Right-turning movements
  - Three not affected
  - The fourth has a shorter travel distance
- ▶ Choices for left-turning cyclists
  - Follow the vehicular paths
  - Follow the crossing paths of pedestrians at the main intersection



*QR intersection in Huntersville, NC*

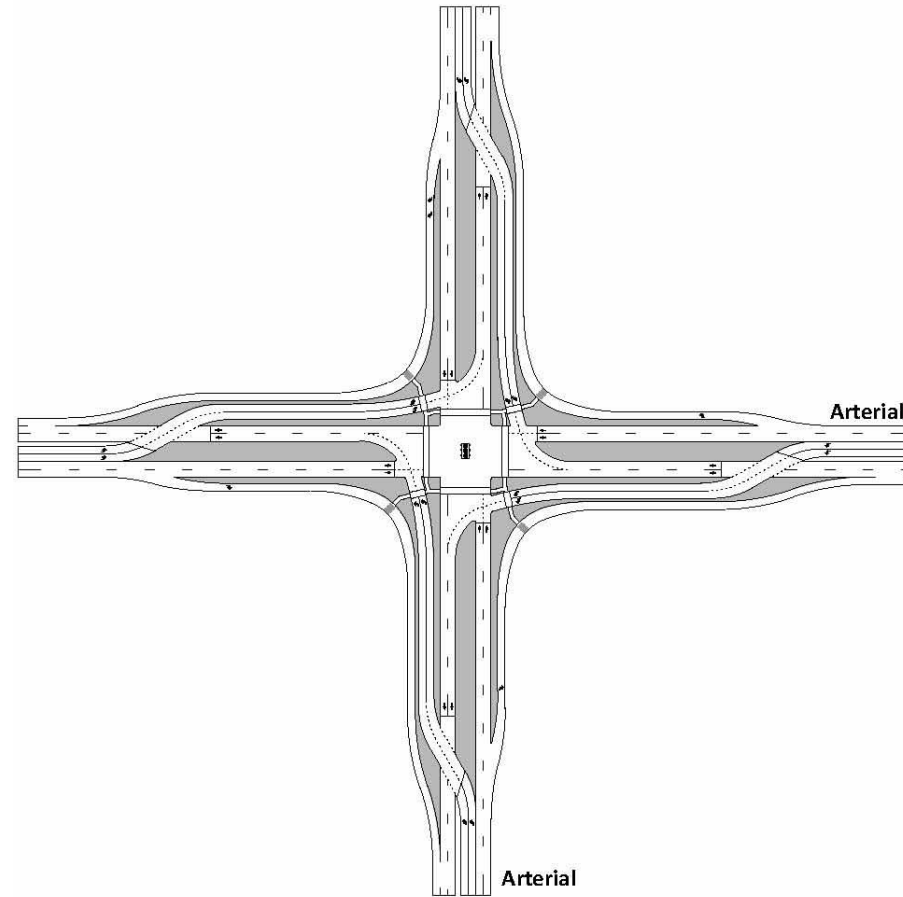


# Accommodation for Pedestrians and Bicyclists at QRs



*QR intersection in Huntersville, NC*

- ▶ No left-turn pedestrian/vehicle conflicts at the main intersection
- ▶ Only two or three signal phases at the intersection
  - Shorter cycle length reduce pedestrian delay
- ▶ Potentially shorter walking distance due to curved connecting roadway



# Displaced Left-turn Intersection

# Displaced Left-turn Intersections

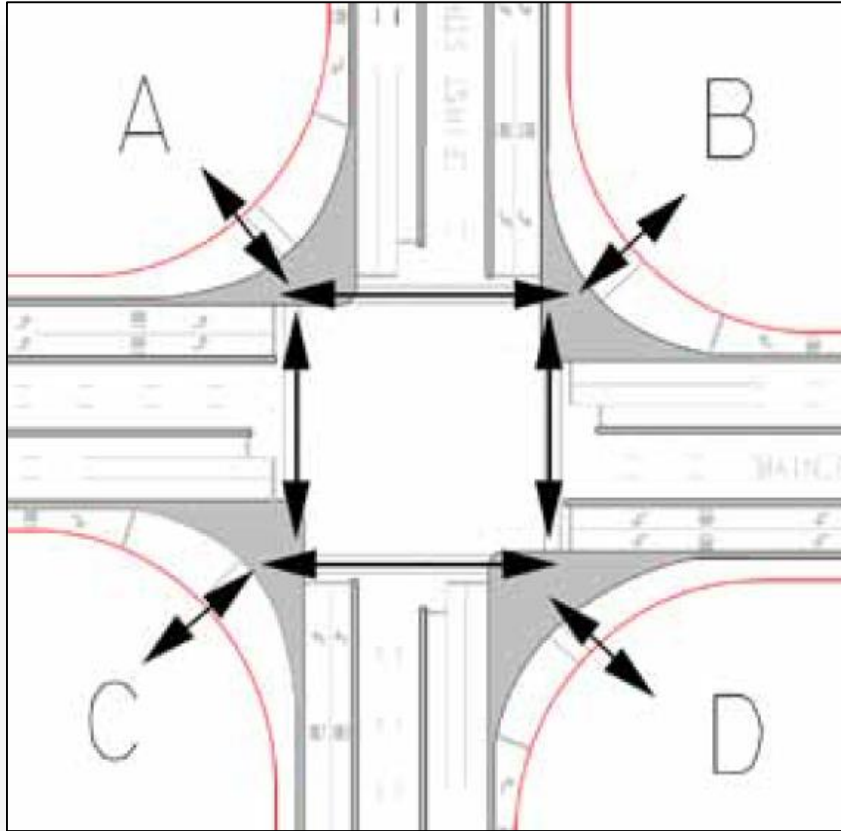


*Displaced left-turn intersection in Shirley, NY*

## ► DLT Features

- Relocate the left-turn movement to the other side of the opposing roadway
- Eliminate the left-turn phase for this approach
- Reduce numbers of traffic signal phases and conflict points
- Improve traffic operations and safety

# Pedestrian Movements at DLT Intersections

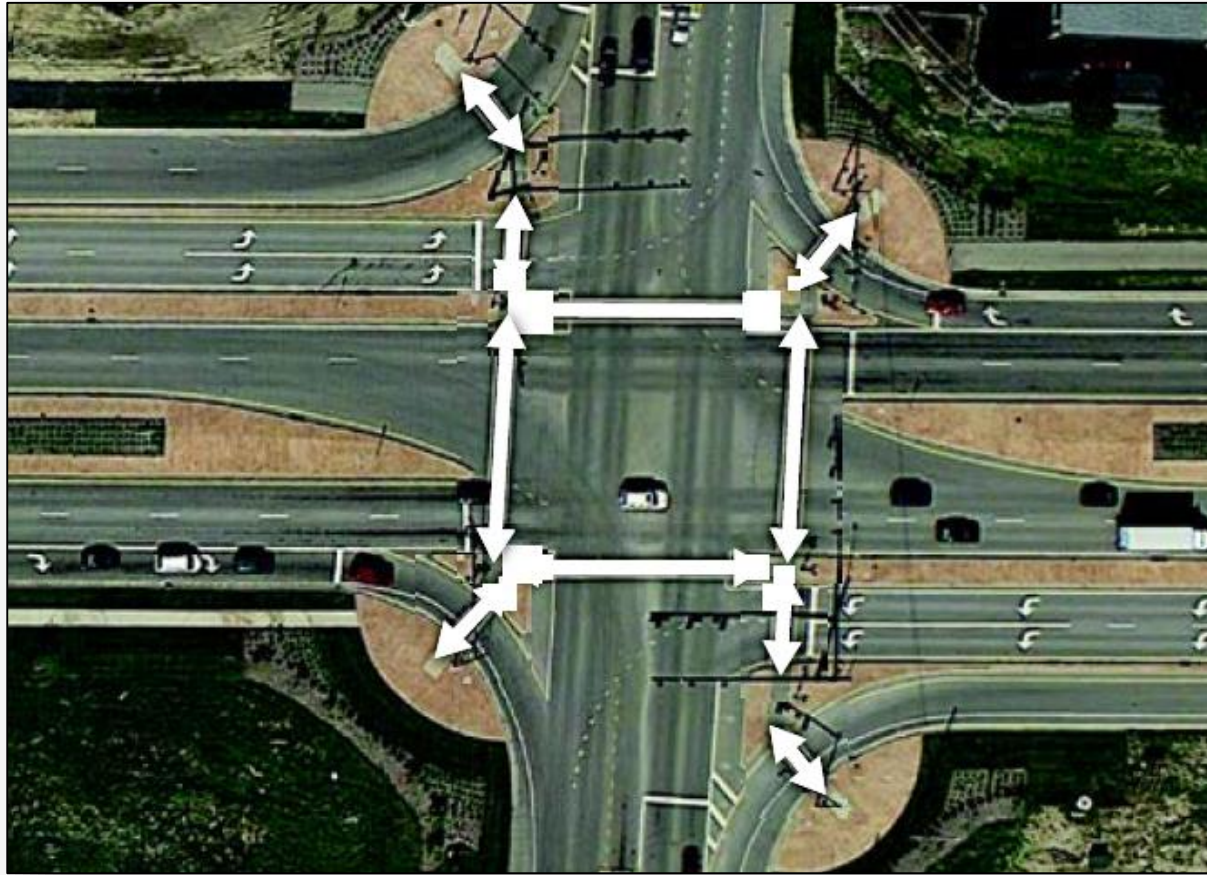


*Possible Pedestrian Movements at DLT*

- ▶ Left-turn lanes at DLT
  - between opposing through lanes and right-turn lanes
  - Counterintuitive to pedestrians
- ▶ DLT design to accommodate pedestrian crossing
  - Wide geometric footprint
  - Short signal cycle length
- ▶ Median islands provide pedestrian refuge



# Accommodation for Pedestrians and Bicyclists at DLTs



*Displaced left-turn intersection in Dayton, OH*

- ▶ Provide pedestrian refuges between opposing through lanes
  - Increase pedestrian safety
  - minimize vehicular delay
- ▶ Design right-turn channelized islands to accommodate pedestrians



# Accommodation for Pedestrians and Bicyclists at DLTs (cont'd)



*Displaced left-turn  
intersection in Shirley, NY*

## ***Provide wayfinding signing for pedestrians***

- ▶ Direct pedestrians through the intersection to desired destinations
- ▶ Reduce pedestrian confusion
- ▶ Encourage pedestrians to use designated travel paths through the intersection

# Accommodation for Pedestrians and Bicyclists at DLTs (cont'd)

***Provide accessible devices to assist pedestrians with disabilities***

- ▶ Use locator tones at the pedestrian signals
- ▶ Install specialized surface treatments at the quadrants and median refuges
- ▶ Accessible Pedestrian Signals (APS) recommended



*DLT intersection in West Valley City, Utah*



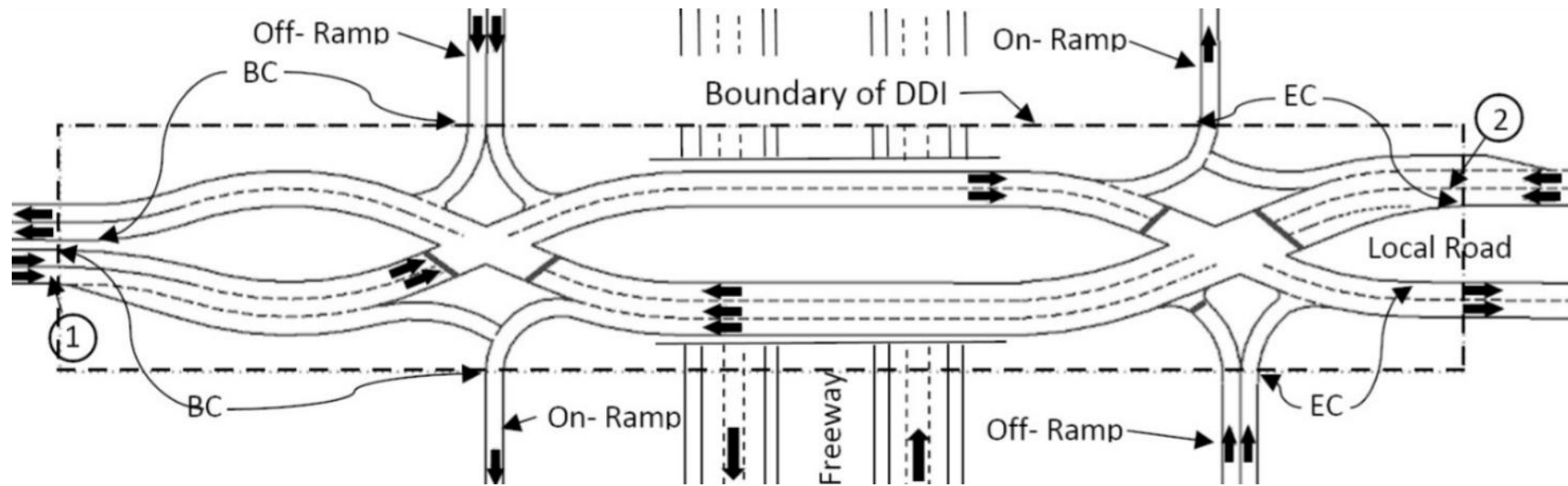
# Pedestrian and Bicycle Treatments at DLT



# Pedestrian and Bicycle Treatments at DLT W/Cycle Track



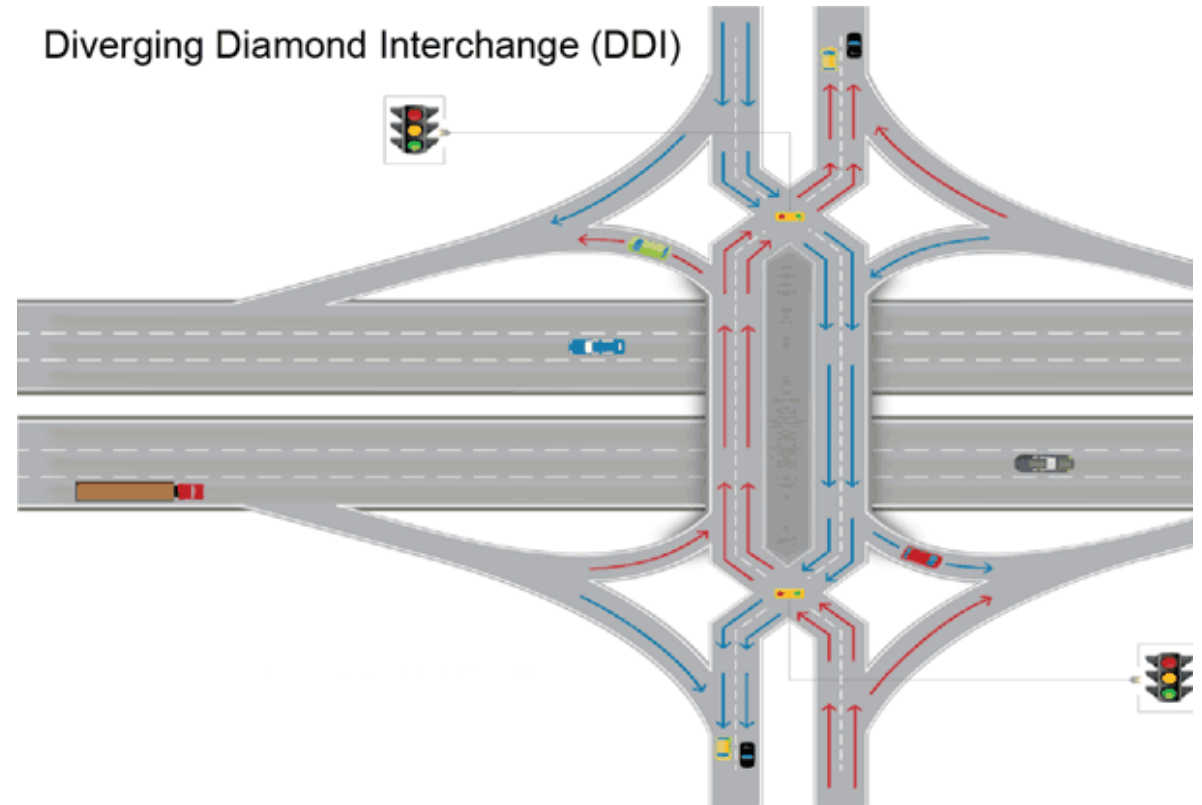




# Diverging Diamond Interchange

# Diverging Diamond Interchanges (DDI)

- ▶ Arterial traffic crosses to the other side of the roadway between the freeway ramps
- ▶ Vehicles can turn left onto/off freeway ramps without stopping or crossing opposing lanes of traffic
- ▶ Can be designed as an overpass or underpass
- ▶ Also known as a Double Crossover Diamond



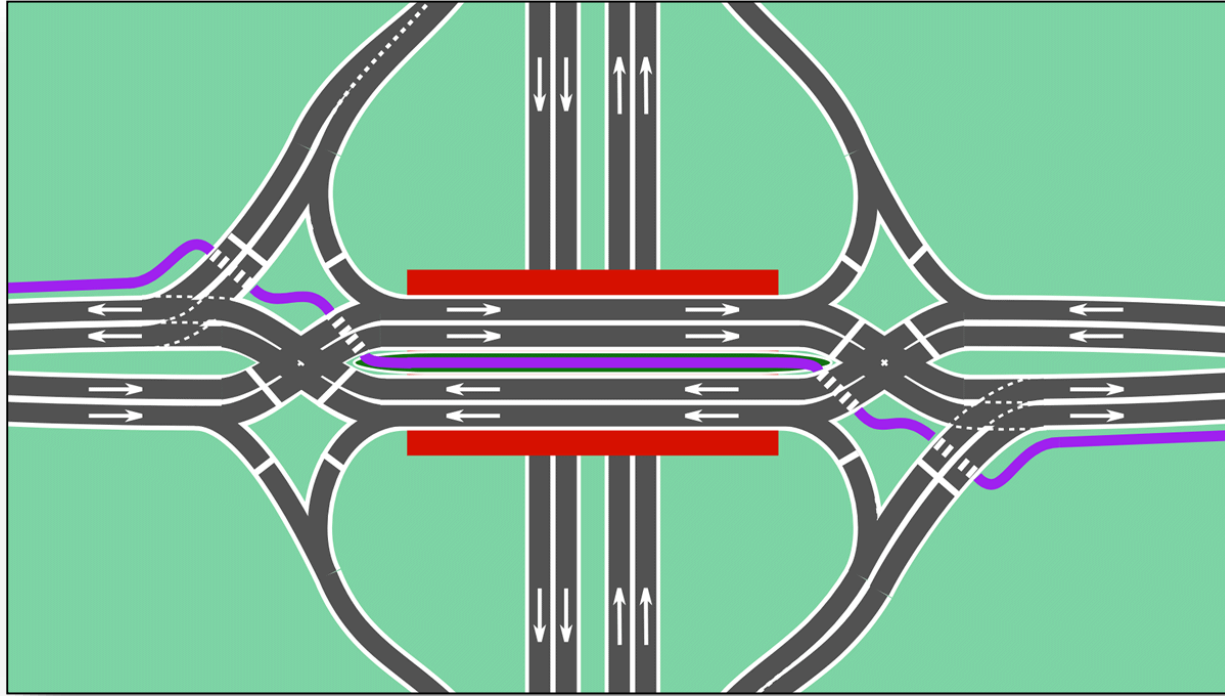
# Location Suitable for DDIs

- ▶ Heavy left-turn traffic volumes onto/off freeway ramps
- ▶ Limited roadway width for left-turn lanes between ramp intersections
- ▶ Limited right-of-way area to expand
- ▶ Without adjacent traffic signals or nearby driveways



*DDI on I-75 in Sarasota, FL*

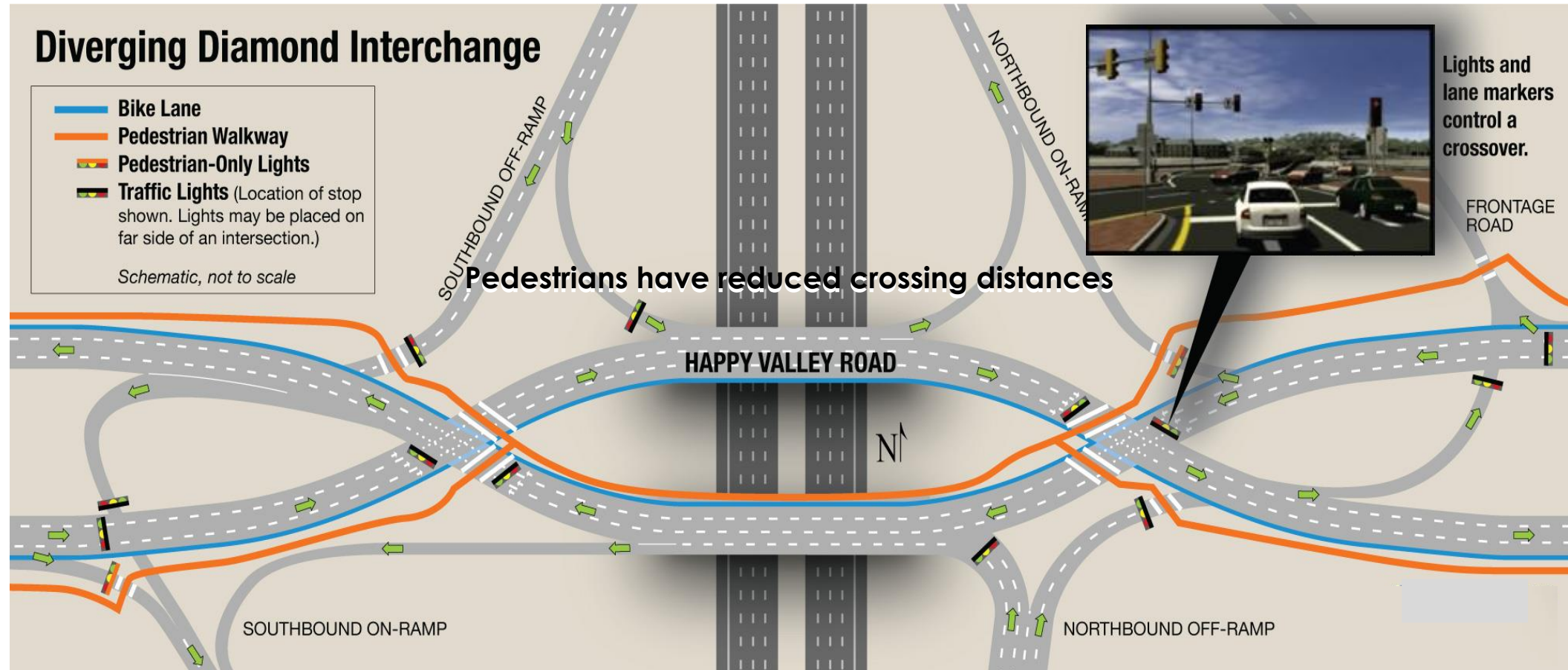
# Accommodation for Pedestrians and Bicyclists at DDIs



- ▶ Fewer conflicting traffic streams
- ▶ Central island serves as refuge between each stage or signal phase
- ▶ Bicycles can utilize pedestrian paths or vehicle paths with bike lanes

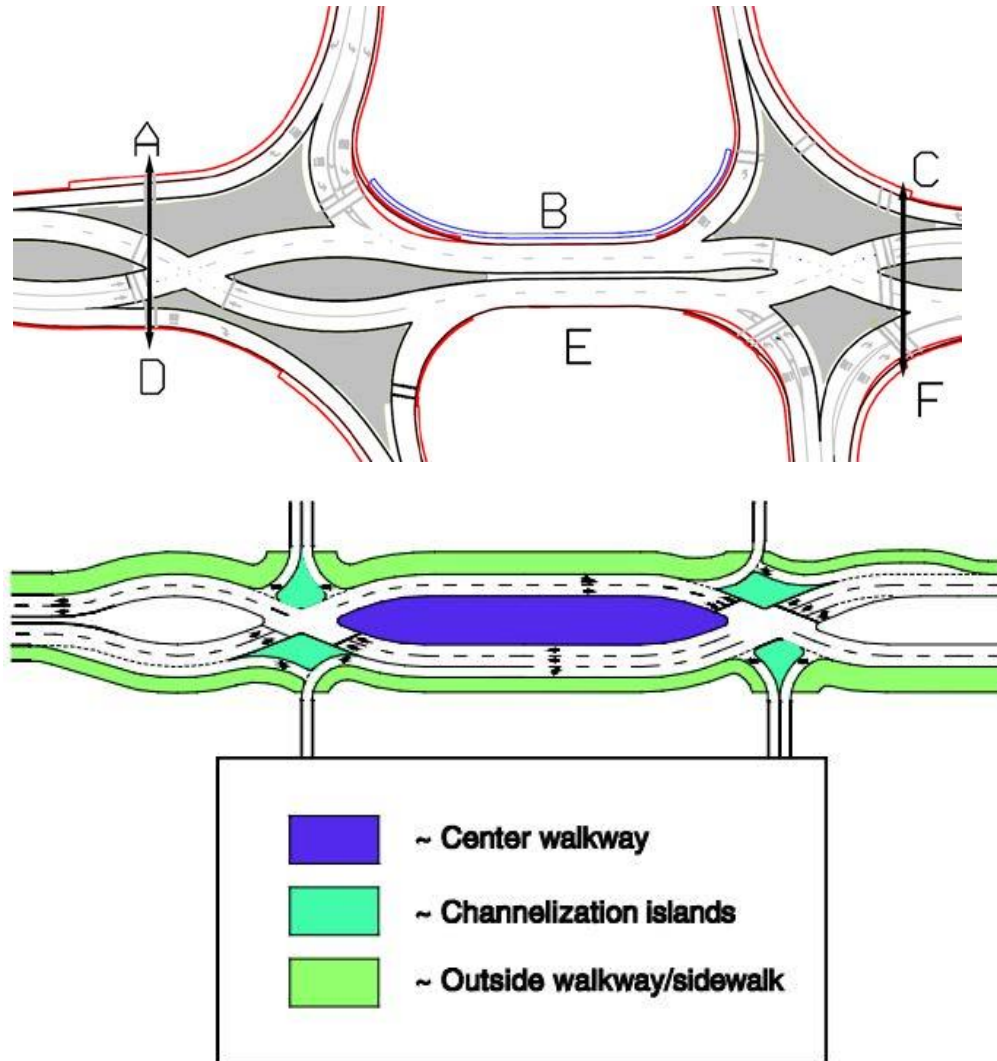


# Accommodation for Pedestrians and Bicyclists at DDIs



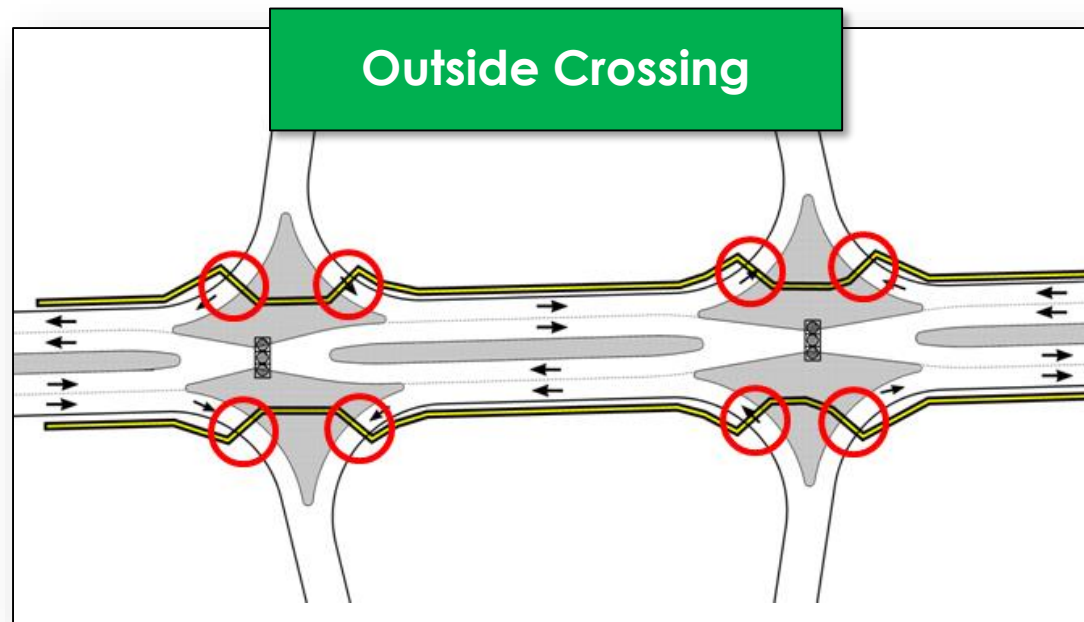


# Pedestrian Movements at DDIs

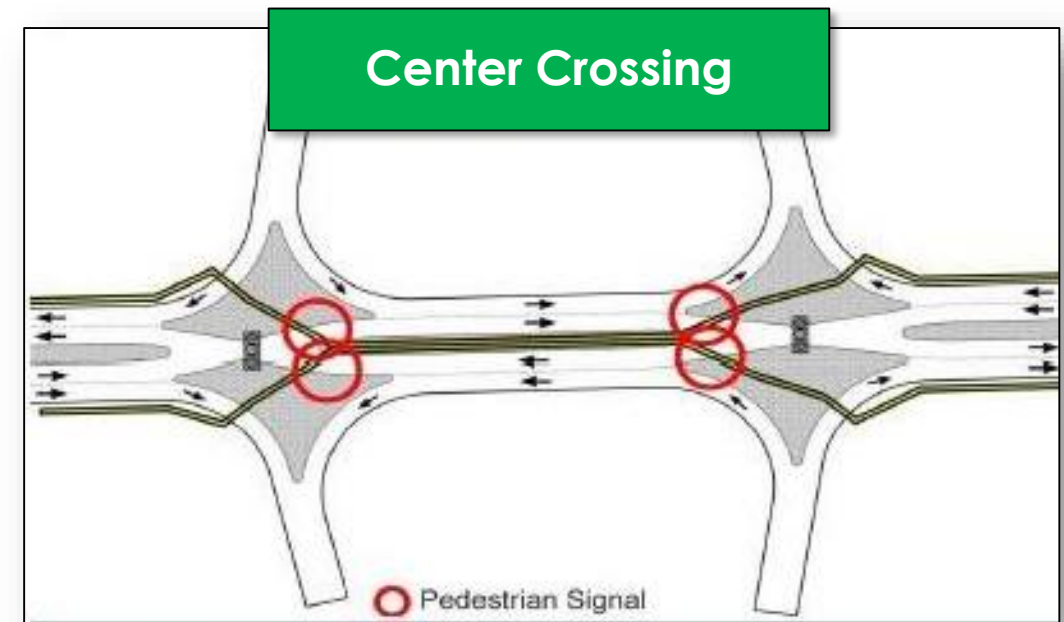


- ▶ Can cross freeway ramps and/or main street
- ▶ Cross on outside or through interchange
- ▶ Only cross one direction of traffic is allowed at a time
- ▶ Pedestrians have reduced crossing distances

# Alternative Pedestrian Movements at DDIs



- ▶ Pedestrians have shorter conflict times
- ▶ More traditional and familiar path



- ▶ Crossing at signalized locations
- ▶ Crossing movement is controlled by signals

# Questions?

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