FDOT DDI Design Webinar Series
Traffic Operations

August 10, 2021

FDOT DDI Design Webinar Series

- **Florida Department of Transportation (FDOT) will be hosting a webinar series focused on design and analysis of Diverging Diamond Interchanges (DDI). This series will present guidance on the major elements of DDI project development, including Geometric Design, Signing and Pavement Markings, Traffic Operations, Signalization, Plan Detailing, and Public Involvement.**
- **FDOT Developmental Design Criteria, D217 Diverging Diamond Interchanges, will be covered as well as national design guidance and industry best practices.**
- **Intended Audience: The intended audience for this training includes transportation professionals involved in the planning, design, and review of Diverging Diamond Interchanges.**
- **Schedule:**

DDI Overview	June 15, 2021	2p-5p
DDI Geometric Design	June 29, 2021	2p-3p
DDI Signing & Marking and Signals	July 16, 2021	2p-3p
DDI Traffic Operations	August 10, 2021	2p-3p
DDI Multimodal Accommodations	August 24, 2021	2p-3p
DDI Plans Detailing & Public Involvement	September 7, 2021	2p-3p

DDI Traffic Operations – Webinar Instructors

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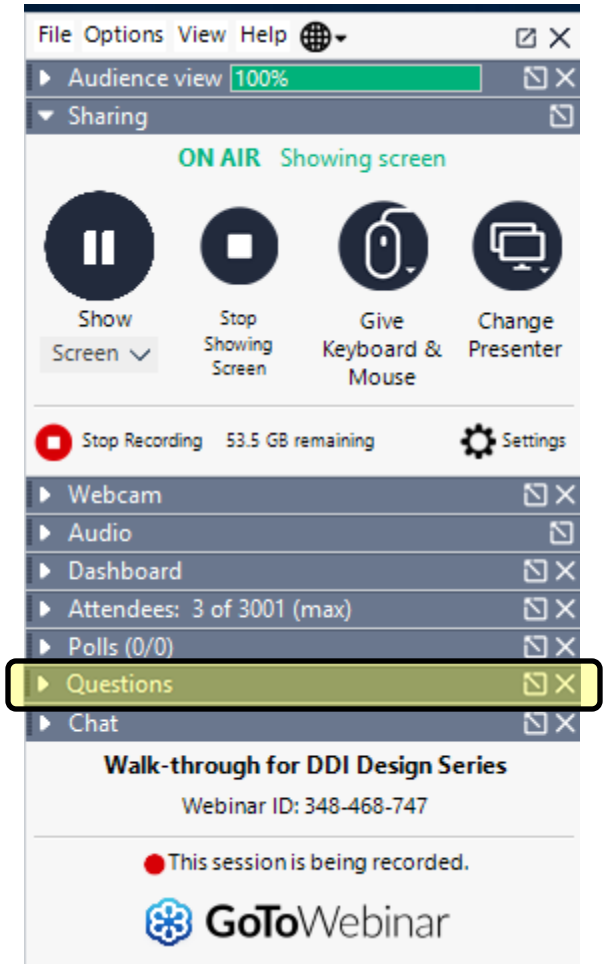
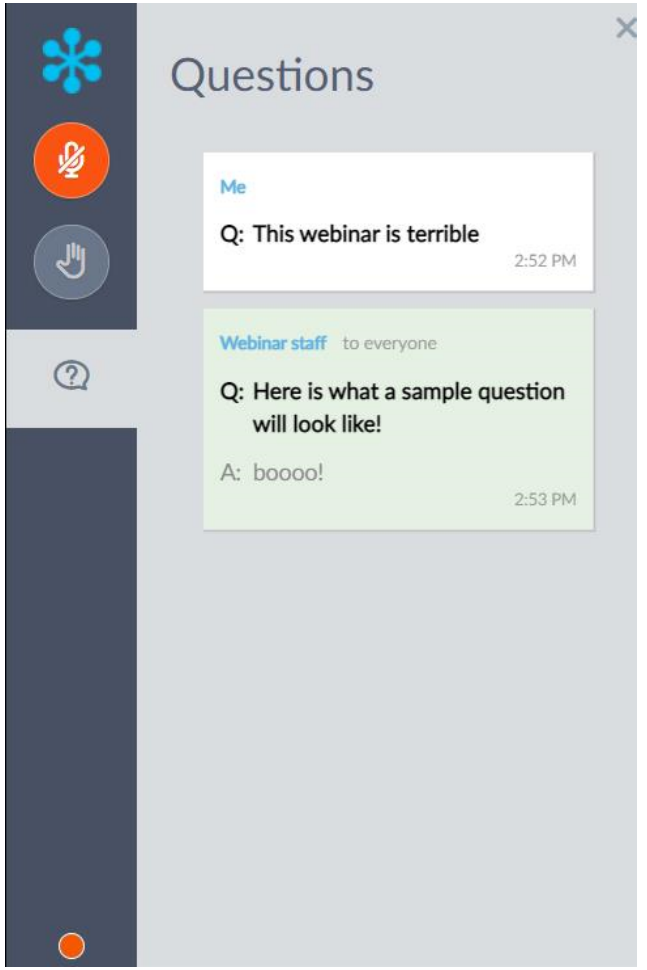
DDI Traffic Operations – Webinar Logistics

- You are MUTED upon entry
- Please ask questions via *Questions* dialogue box





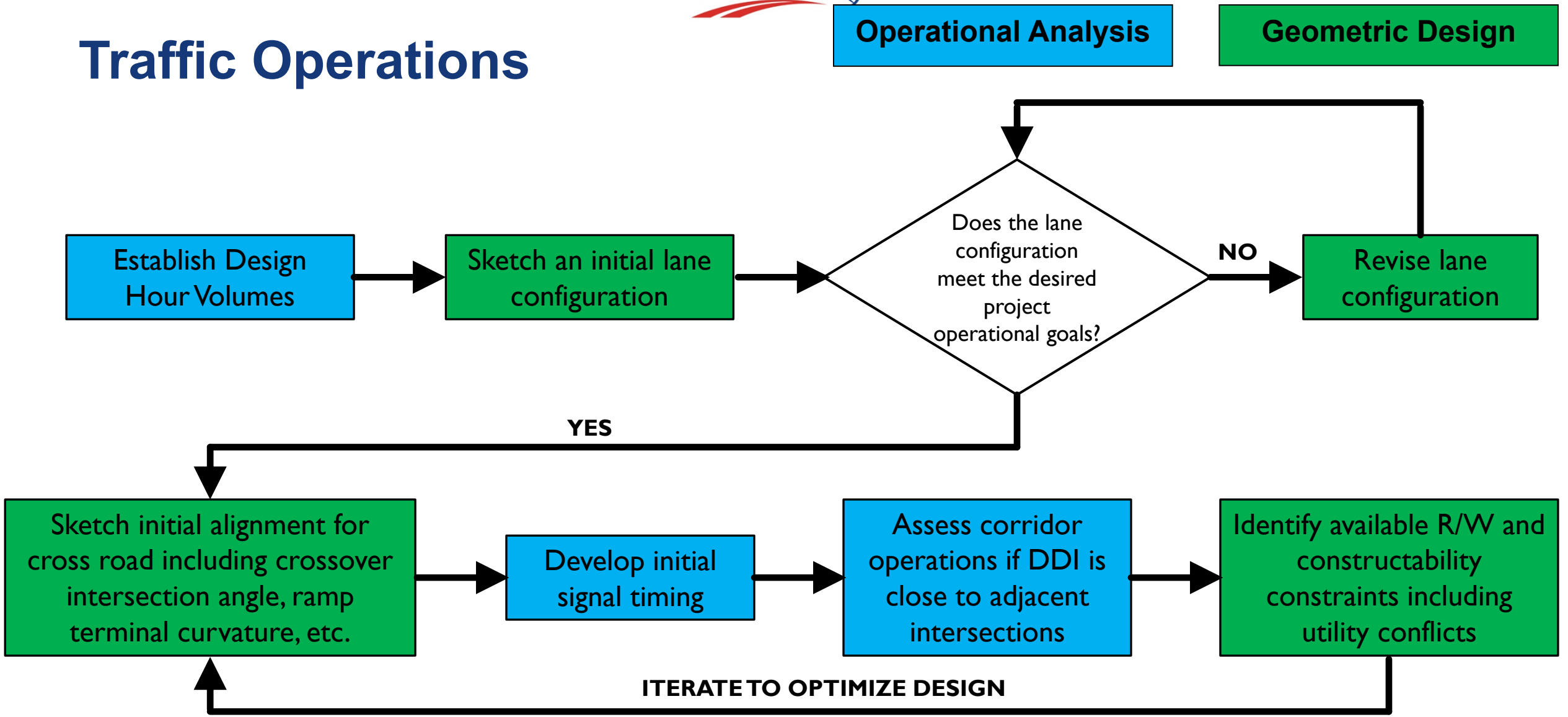
DDI Traffic Operations - AGENDA

- Traffic and Safety Benefits
- Signal Timing and Phasing
- Other Signal Operations Considerations
- Closely Spaced Adjacent Intersections
- Capacity Analysis

Key considerations

Several key operational & safety considerations need to be evaluated early in the analysis process since they may greatly influence geometric design, signal design, and impact how to properly model traffic

Traffic Operations



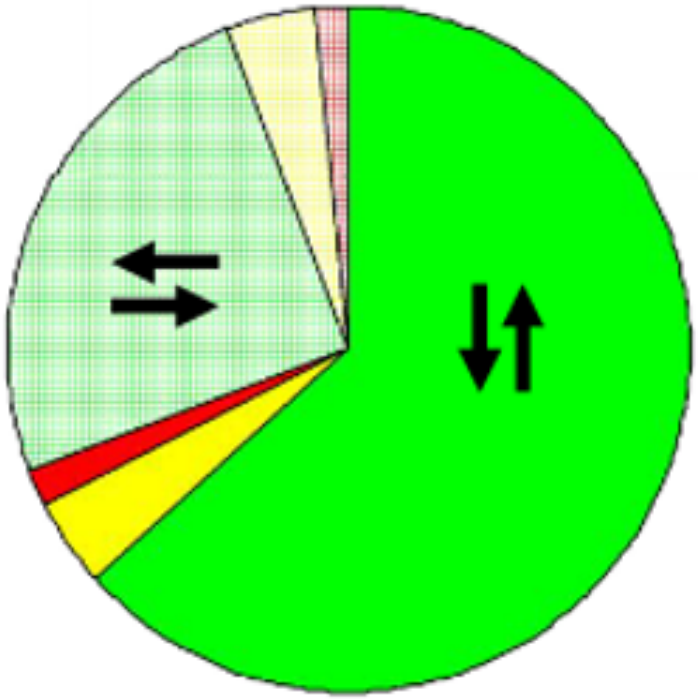
DDI Traffic and Safety Benefits

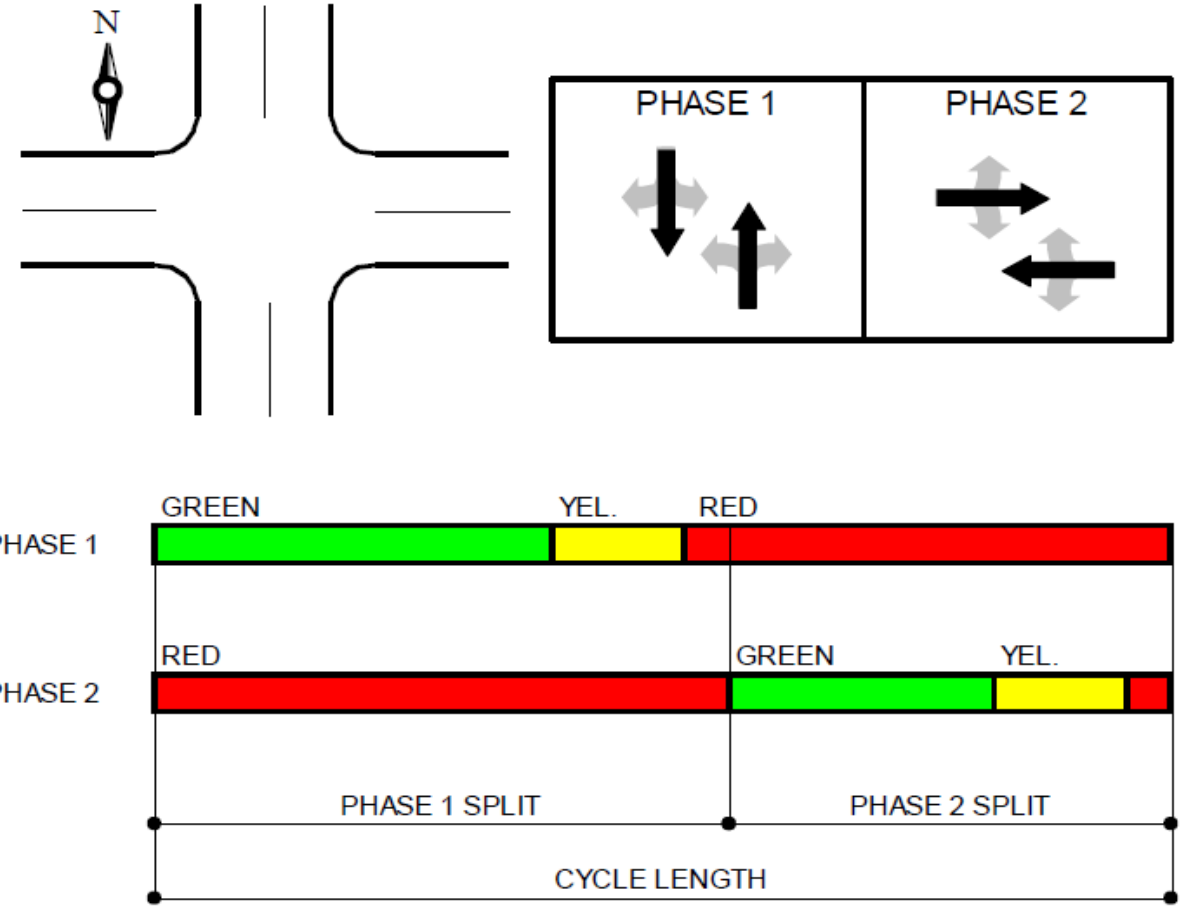
Benefits of a DDI

- **Better Traffic Operations**
  - Reduced Intersection Delay
  - Eliminates the need for left turn signal phases
- **Lower Cost**
  - Retrofit – Possibility to keep existing bridge structure
  - New Construction – Smaller structure footprint due to fewer lanes; less width on the approach to the interchange due to fewer lanes
- **Improved Safety**
  - Fewer conflict points for vehicles and pedestrians
  - Lower travel speeds

Better Traffic Operations

- Basic two-phase signal operation

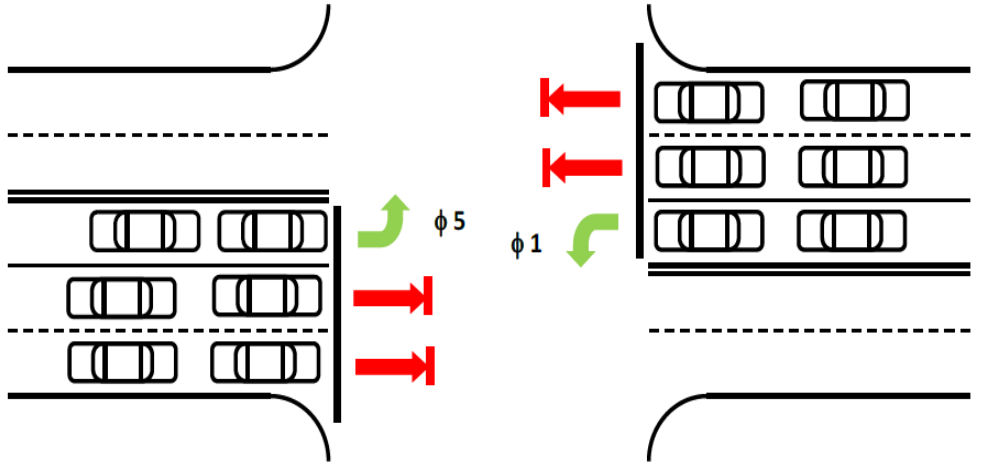


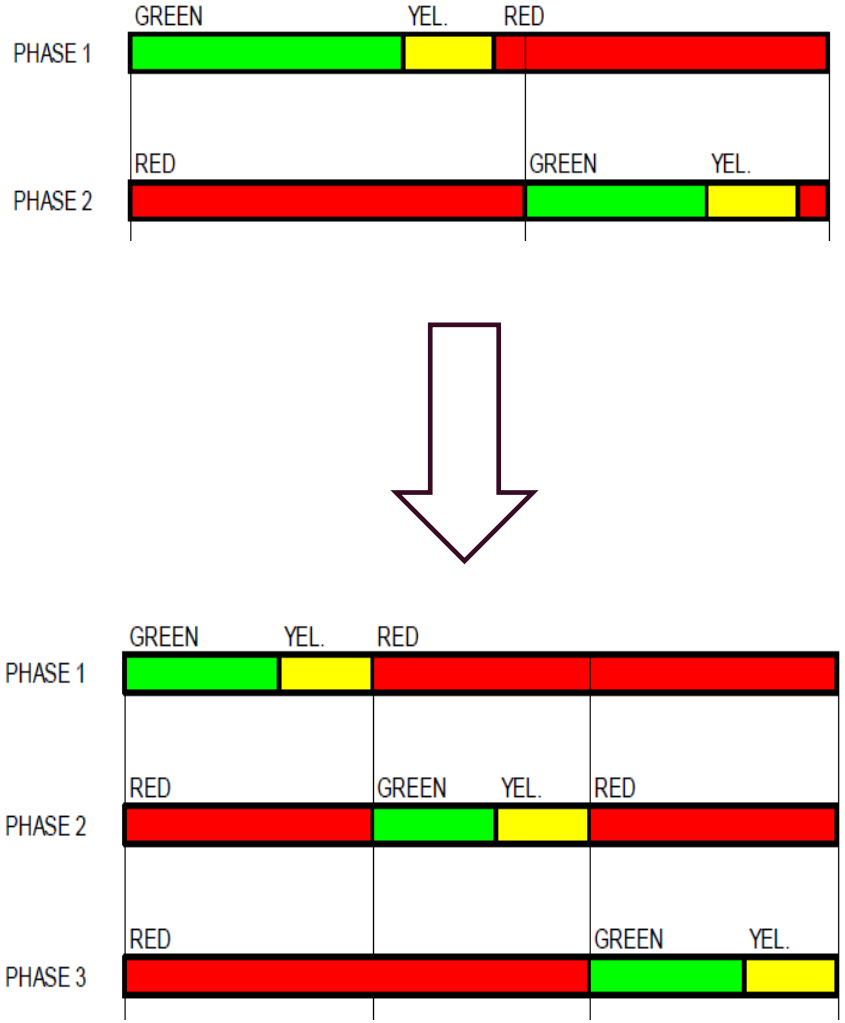


Source: MnDOT Traffic Signal Timing and Coordination Manual

Better Traffic Operations

- **When left turn phases are added….**
  - Adding “protected” left-turn phases is common as traffic volumes increase

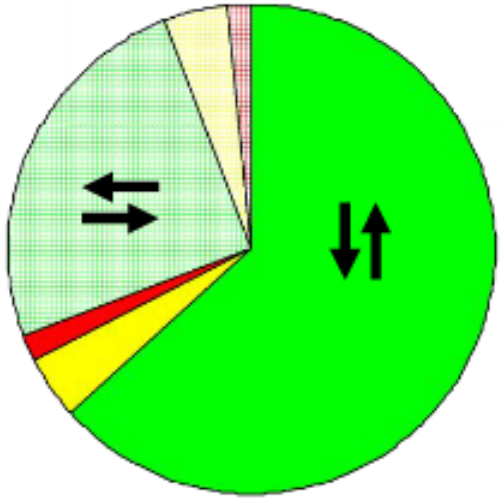


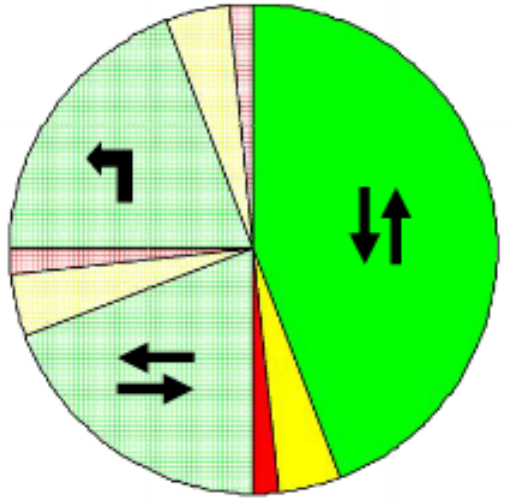


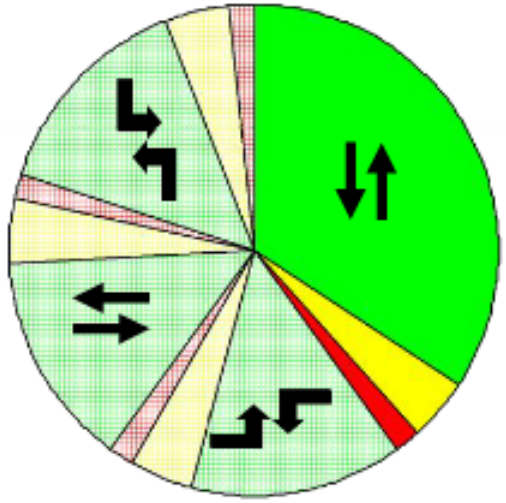
Source: MnDOT Traffic Signal Timing and Coordination Manual

Better Traffic Operations

- **When more phases are added….**
  - Adding more phases “steals” time away from the major through movement and can increase intersection delays
  - More phases also add more “lost time” (clearance intervals)

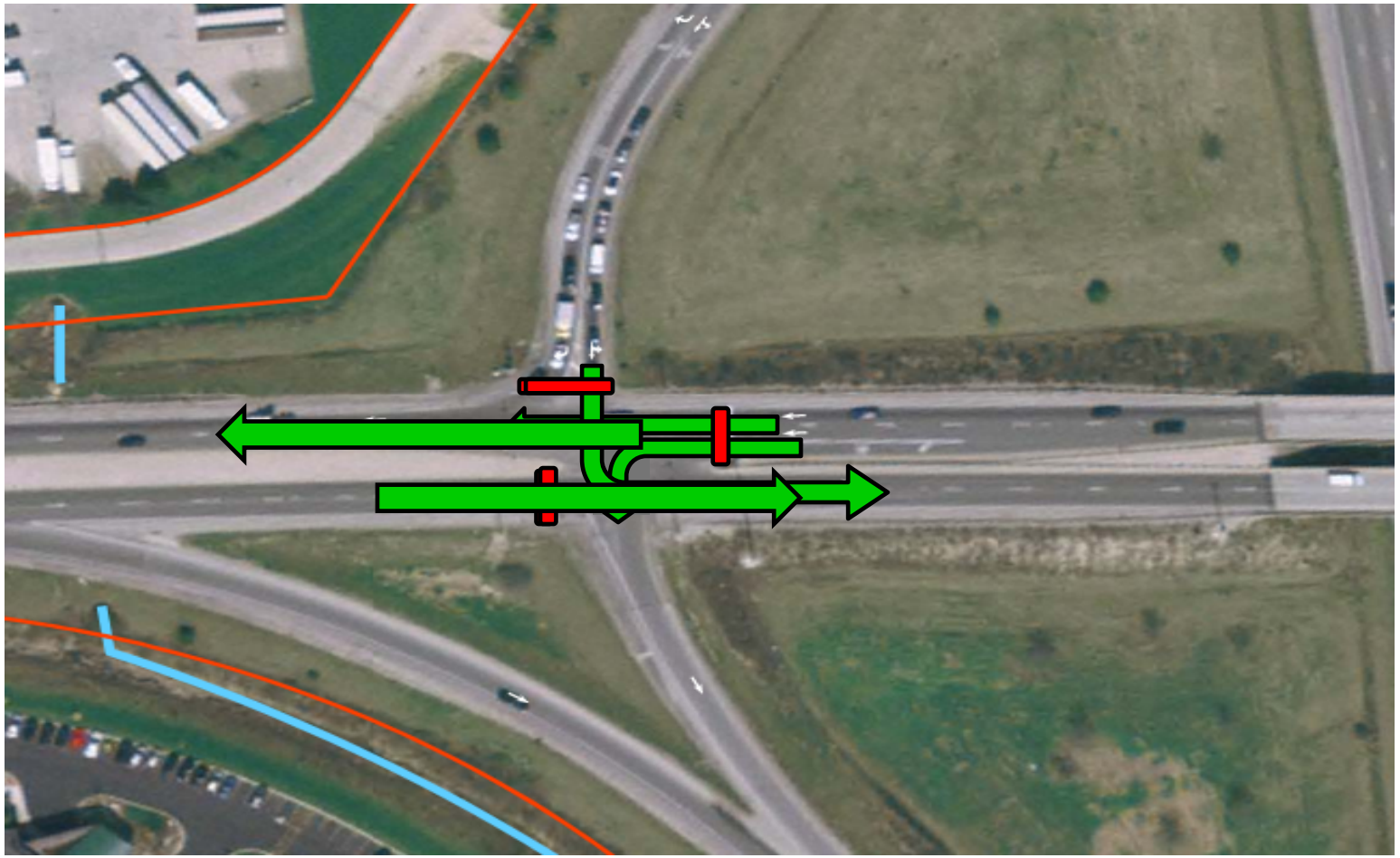






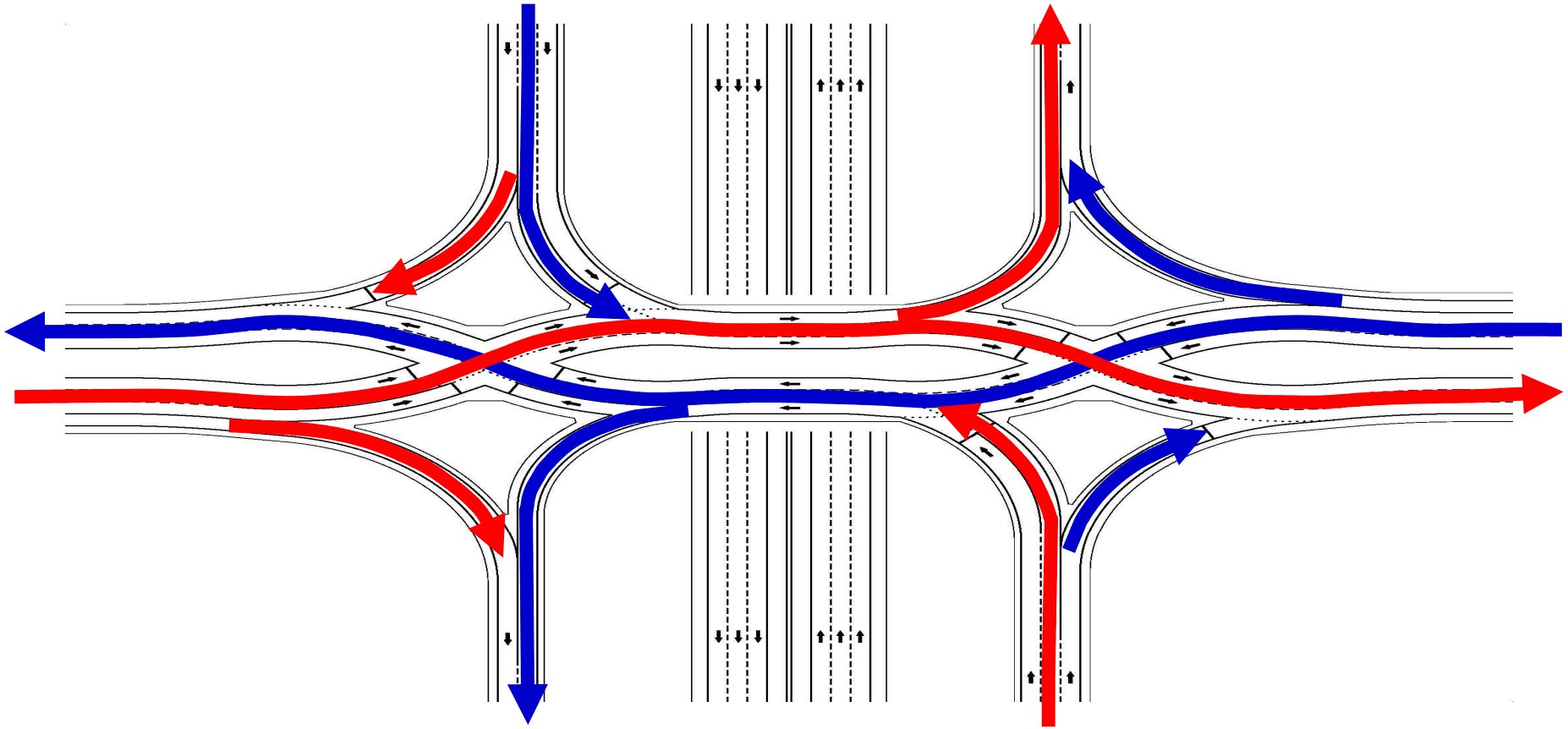
Better Traffic Operations

- Signalization of a Traditional Diamond



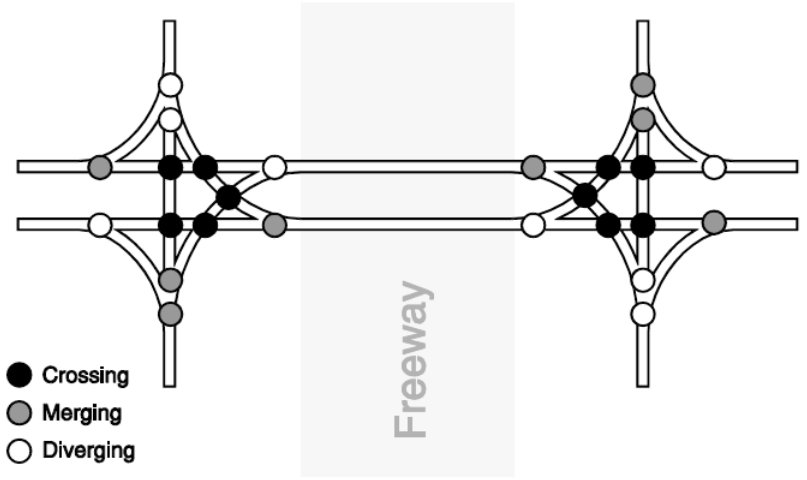
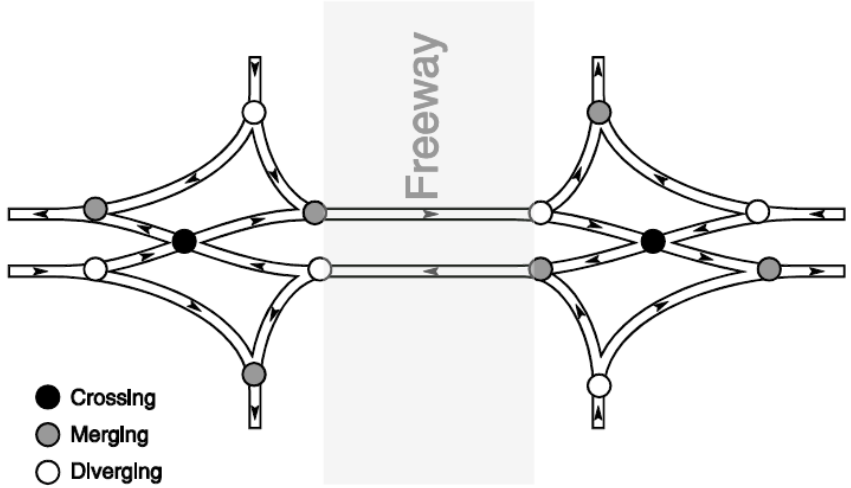
Better Traffic Operations

- Two Phase Signal



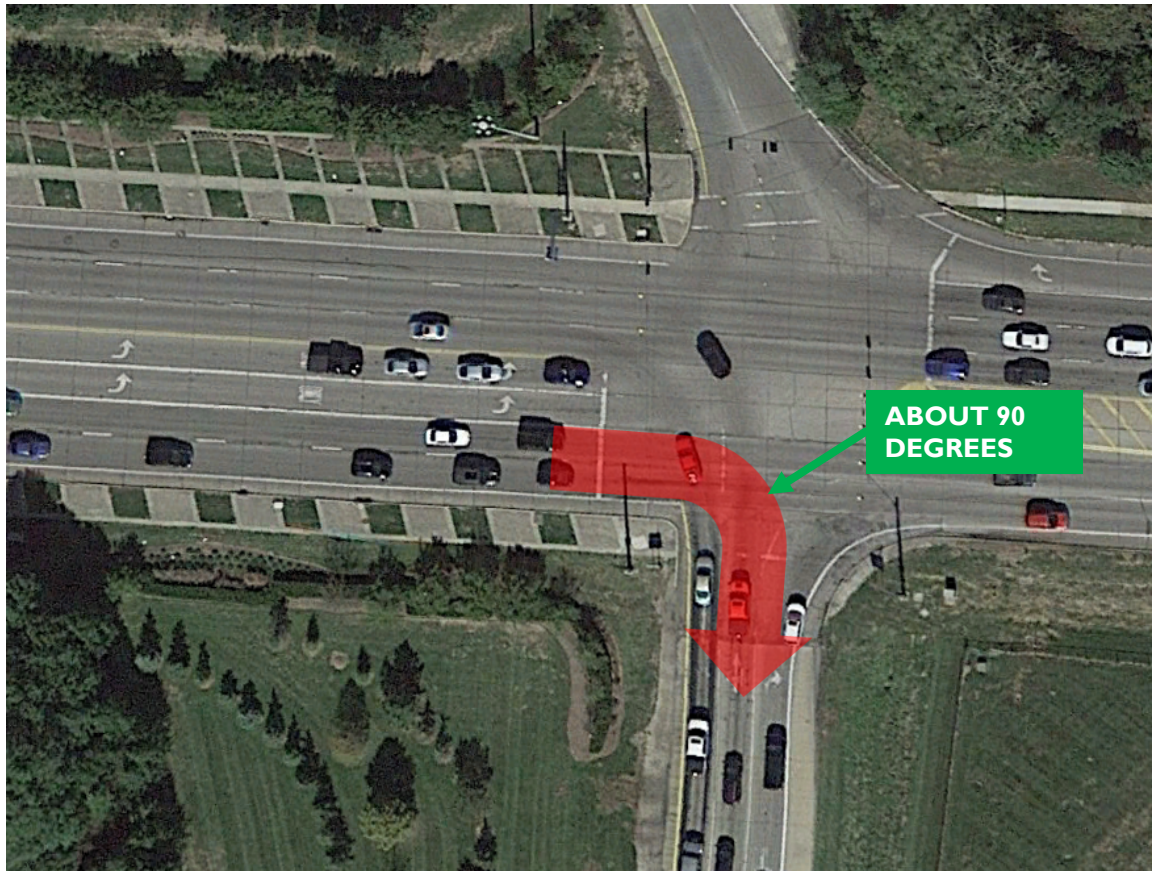
Improved Safety

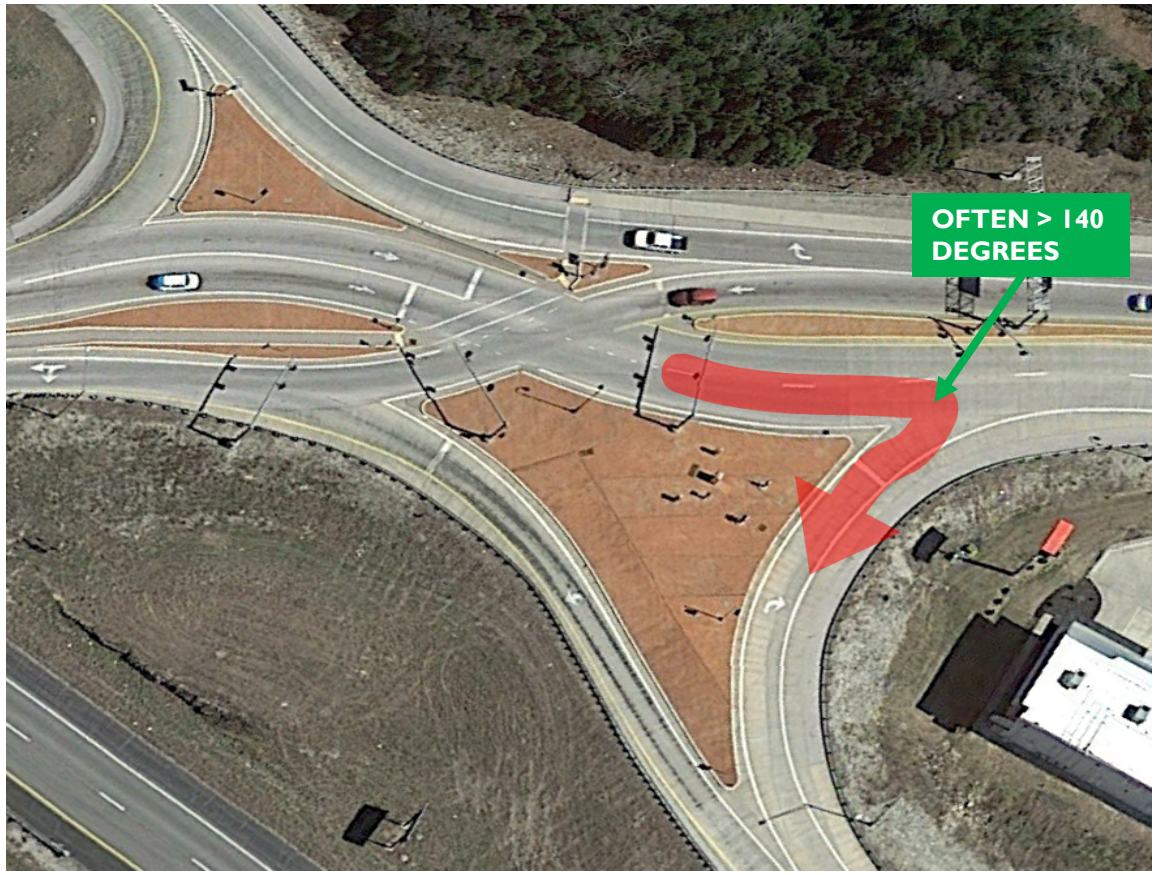
- Intersection Conflict Points

Conventional Diamond	Diverging Diamond
	
10 Crossing Conflicts (most severe) 26 Total Conflict Points	2 Crossing Conflicts (most severe) 14 Total Conflict Points

Improved Safety

- Discouraging Wrong-Way Movements





Improved Safety

- **FHWA Field Evaluation (2015)**
  - Evaluated 7 of the earliest DDI conversions in the United States
    - 4 in Missouri
    - 1 in Kentucky
    - 1 in Tennessee
    - 1 in New York
  - Collected 4 years of “before” and 3 years of “after” DDI conversion crash data
  - Recommended CMF = 0.68 for Total Crashes
  - Recommended CMF = 0.61 for Injury/Fatal Crashes

TECHBRIEF

Field Evaluation of Double Crossover Diamond Interchanges

FHWA Publication No.: FHWA DTFH61-10-R-00030

FHWA Contact: Dr. Wei Zhang, HRDA-10, (202) 493-3317, Wei.Zhang@dot.gov

This document is a technical summary of the Federal Highway Administration Year Two Summary Report, Field Evaluation of Double Crossover Diamond Interchanges (DTFH61-10-C-00029)

Objective

This TechBrief provides results from the second year of a major study commissioned by the Federal Highway Administration (FHWA) to evaluate the first few double crossover diamond (DCD) interchange installations in the United States (U.S.). This research is (1) evaluating the operational and safety impacts of converting an existing diamond interchange into a DCD and (2) investigating how accurately field-observed traffic conditions at DCDs can be replicated in the microscopic simulation model VISSIM.

This research studied the following seven recently constructed and operated DCD interchanges:

- Bessemer Street at US 129, Alcoa, TN;
- MO 13 at I-44, Springfield, MO;
- National Avenue at US 60, Springfield, MO;
- Dorsett Road at I-270, Maryland Heights, MO;
- Harrodsburg Road at KY 4, Lexington, KY;
- Front Street at I-435, Kansas City, MO; and
- Winton Road at I-590, Rochester, NY.

Figure 1. Harrodsburg Road at KY 4 DCD Interchange, Lexington, KY

Source: © 2014 Google

Operational Characteristics

The DCD interchange, also known as a diverging diamond interchange, is an alternative to other service interchange forms, such as conventional diamond interchanges and partial cloverleaf interchanges. The primary difference between a DCD and a conventional diamond interchange occurs at the directional crossovers along the cross-street on

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Improved Safety

- **Missouri DOT Evaluation Study (2015)**
  - Evaluated 6 early DDI implementations in the state of Missouri
  - Compared these to 6 comparable Diamond interchanges
  - Collected average of 2.5 years of “before” and 2.5 years of “after” DDI conversion crash data
  - Reduction of Total Crashes by over 40%
  - Reduction of Injury/Fatal Crashes by over 60%

Safety Evaluation of Diverging Diamond Interchanges in Missouri

Prepared by
Praveen Edara, Ph.D., P.E., PTOE
Carlos Sun, Ph.D., P.E., J.D.
Boris R. Claros, MSCE, Research Assistant
Henry Brown, MSCE, P.E., Research Engineer
Department of Civil and Environmental Engineering, University of Missouri-Columbia

MoDOT
Final Report Prepared for Missouri Department of Transportation
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“In summary, the DDI offers significant crash reduction benefits over conventional diamond interchanges.”

Safety Evaluation of Diverging Diamond Interchanges in Missouri

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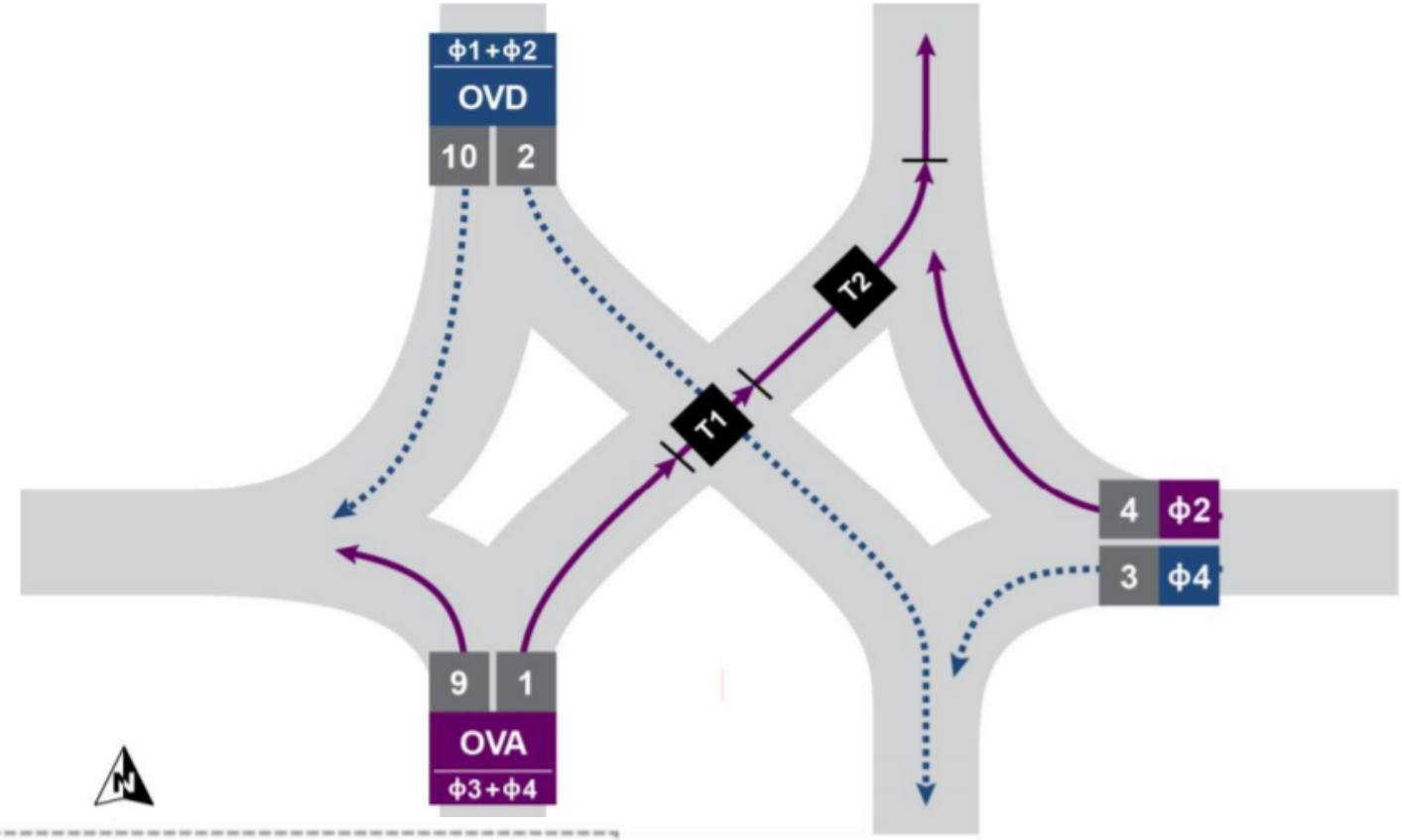
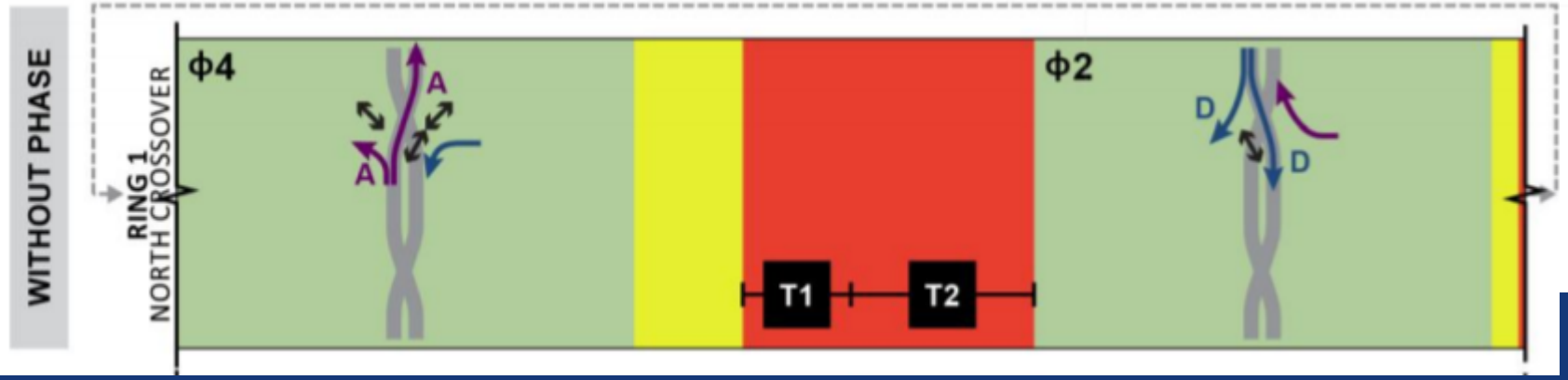
DDI Signal Timing and Phasing

Signal Overlaps

- Thru movements at crossovers should have enough red clearance time to clear the conflicting ramp movement
- Depending on DDI geometry, this can be a lengthy interval

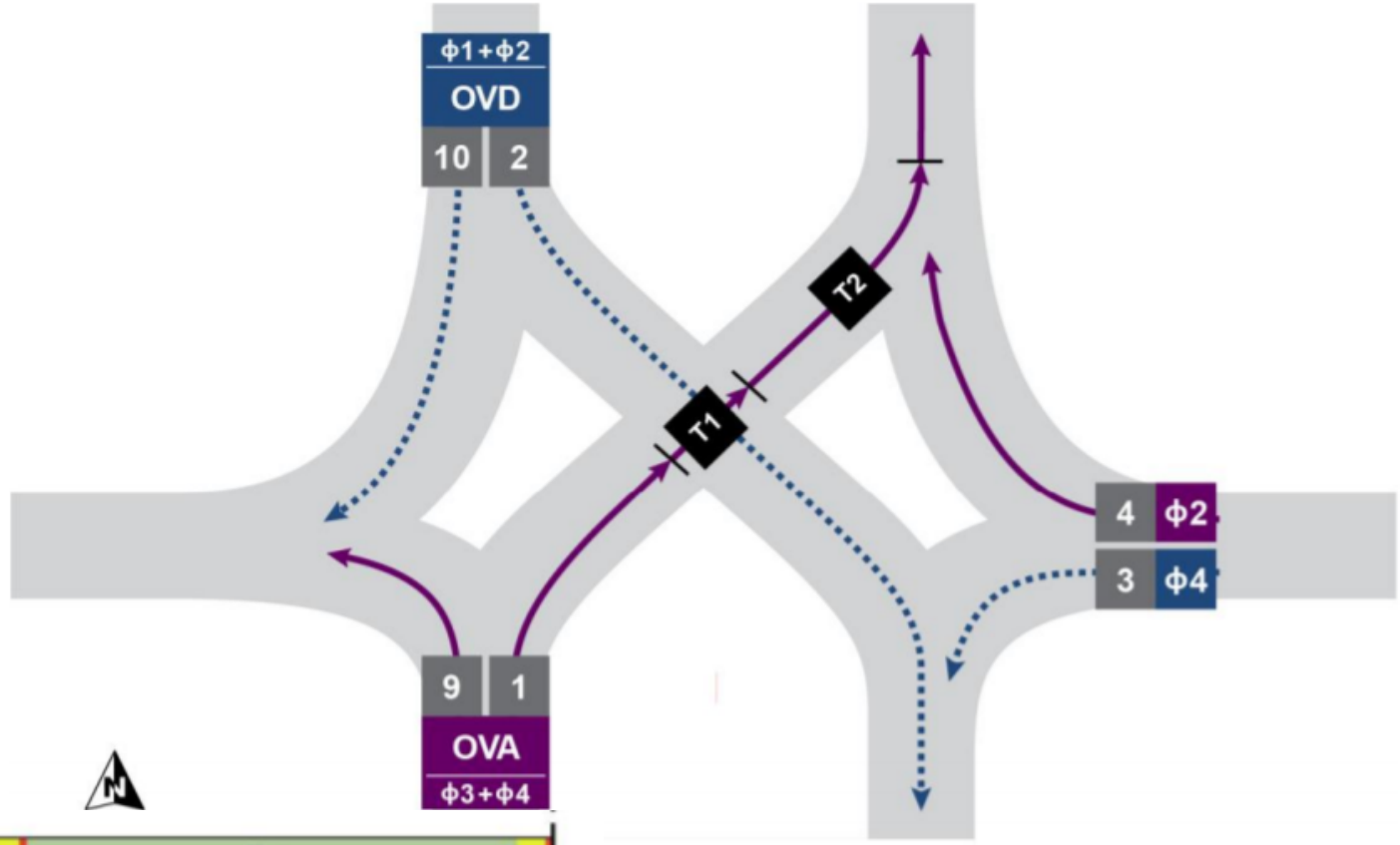


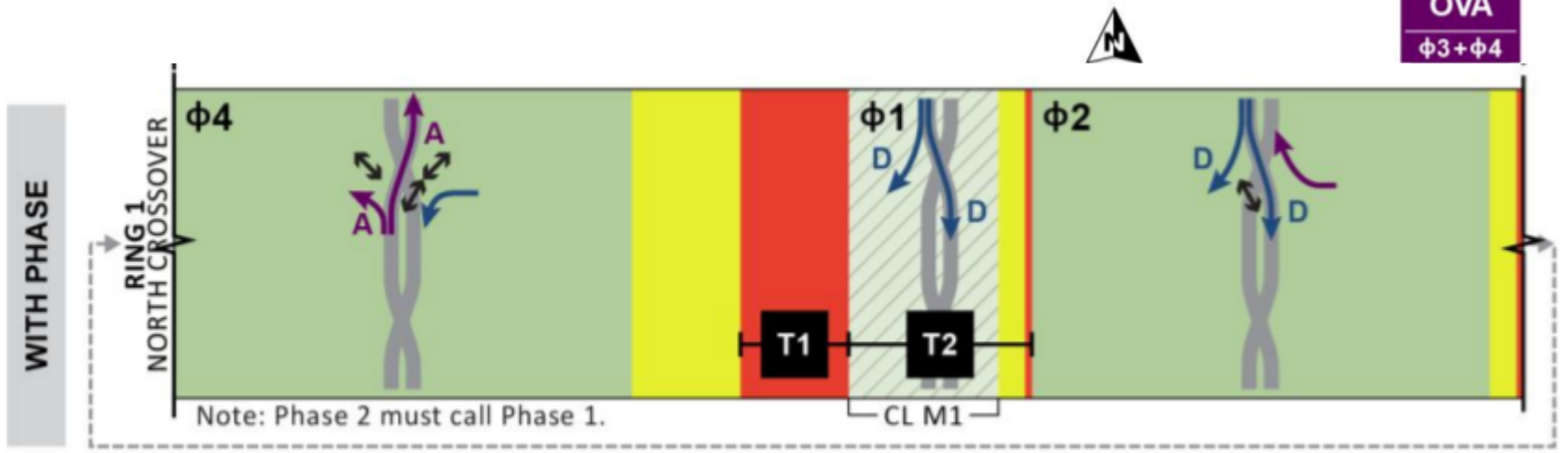


Source: NCHRP 959

Signal Overlaps

- Use overlaps or short, fixed-time phases following thru movements
- Minimizes driver frustration



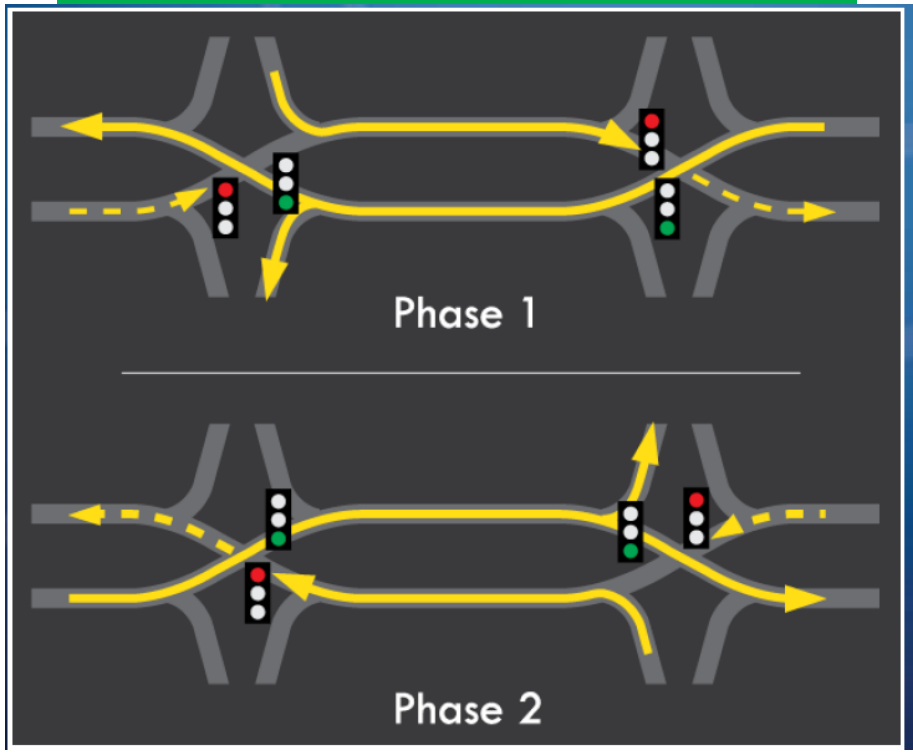


Source: NCHRP 959

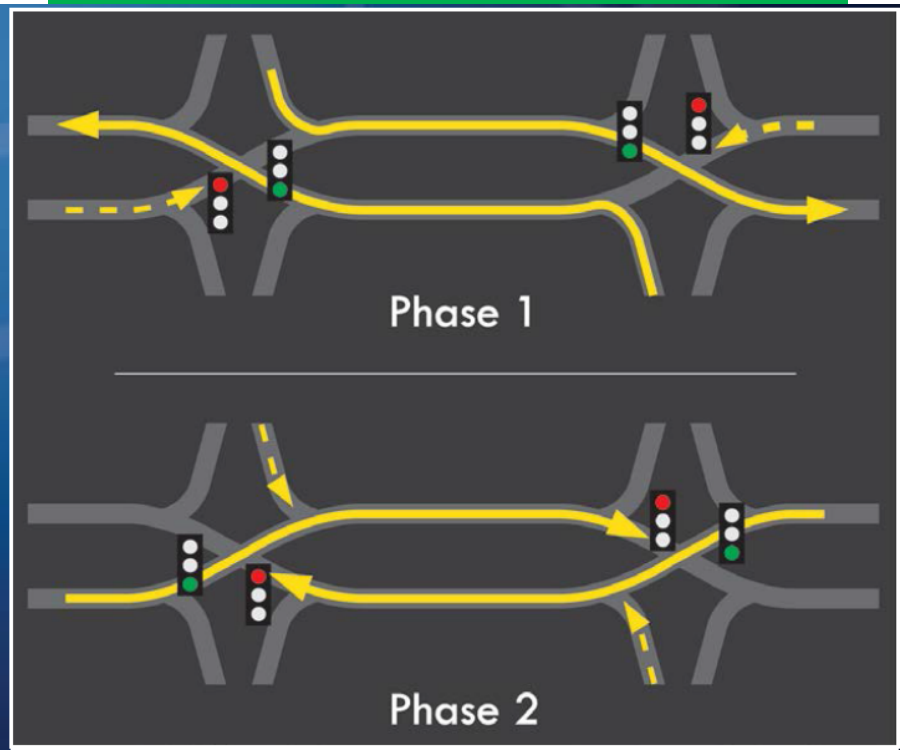
Signal Progression

- Two Critical Movements

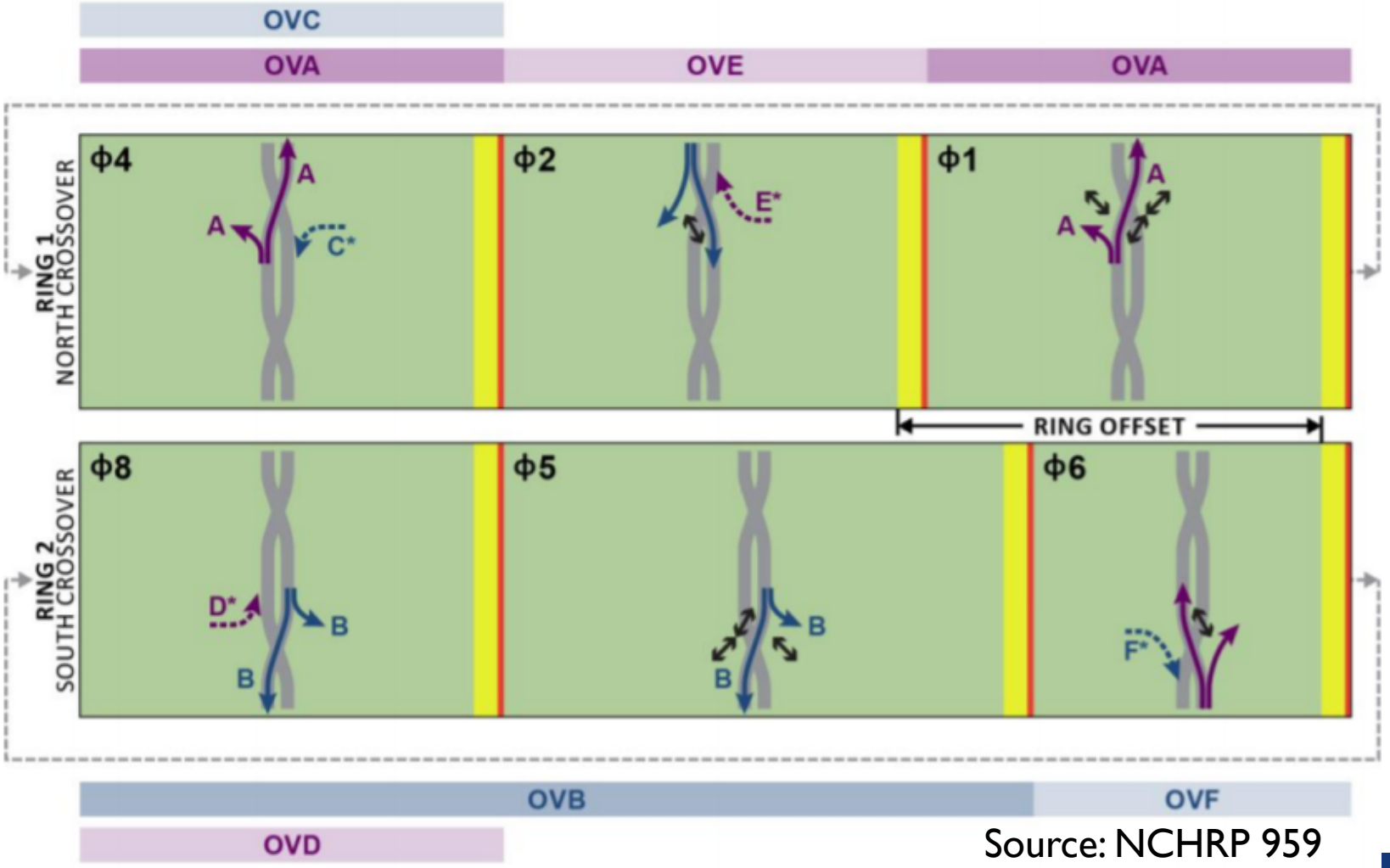
Alternating Directional Progression for Crossroad

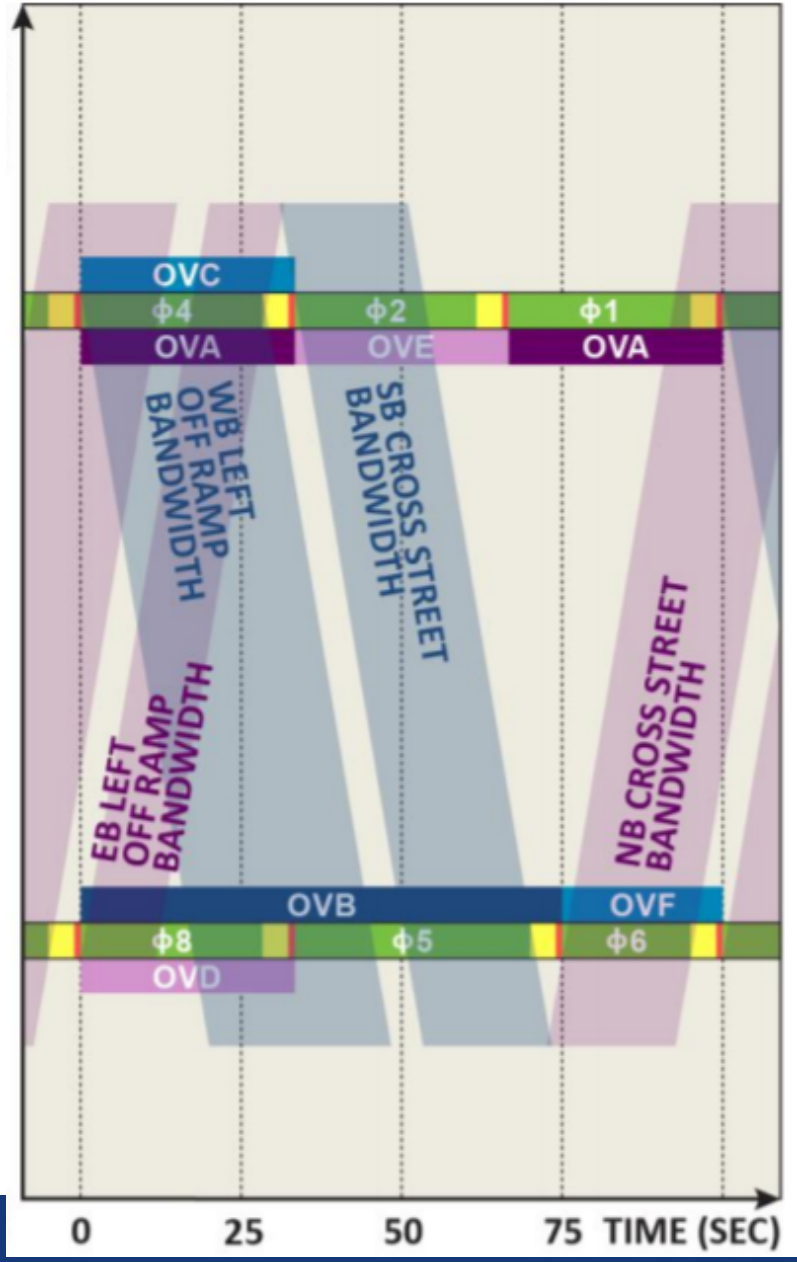


Progression for Left-Turns from the Exit Ramps



Three Critical Movements





Source: NCHRP 959

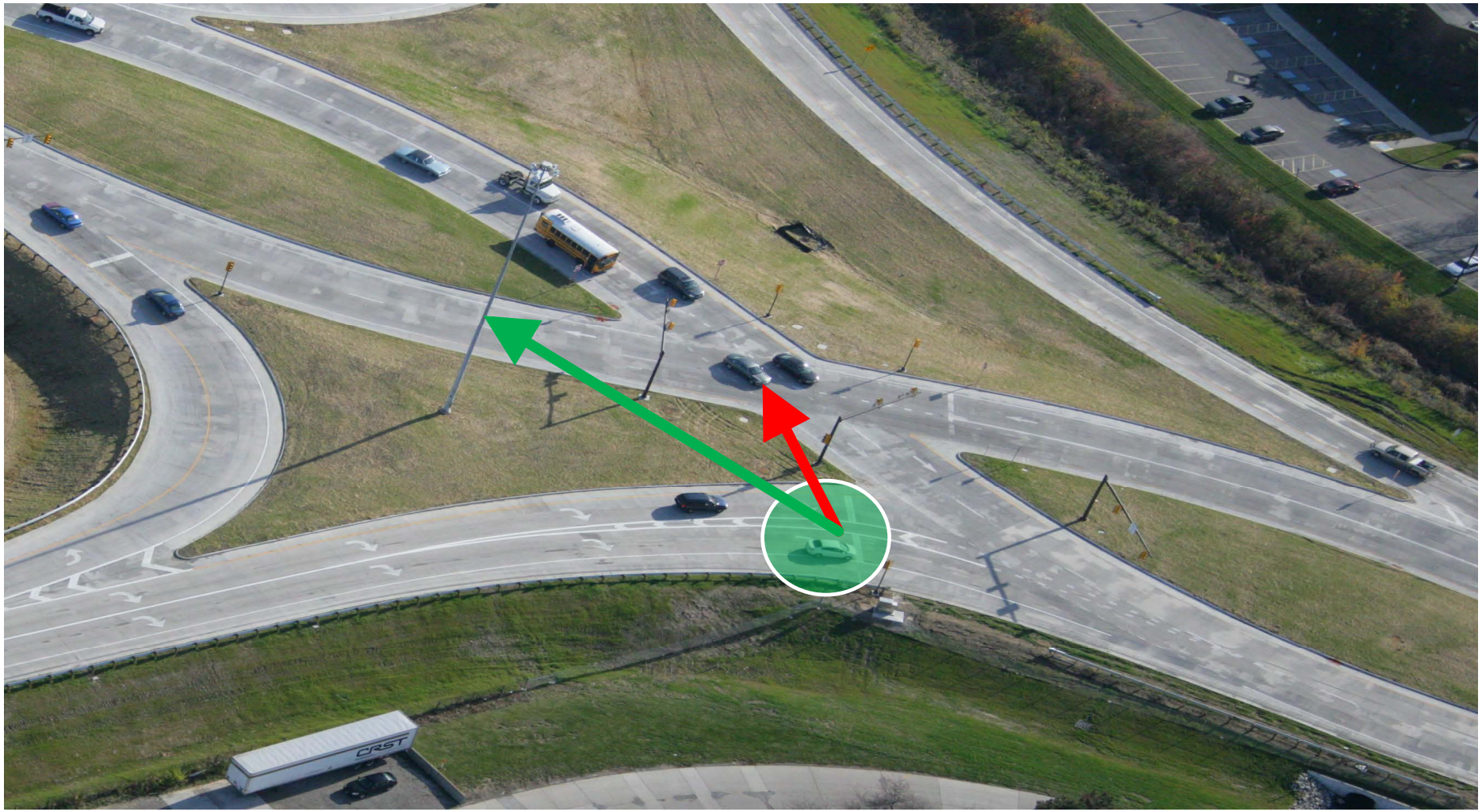
DDI Other Signal Operations Considerations

Other Signal Operations Considerations

- Signalized Right Turns

Other Signal Operations Considerations

- **Signalized Right Turns**
  - Poor sight lines can lead to driver error
  - Dual turn lanes can cause sight line obstructions



Other Signal Operations Considerations

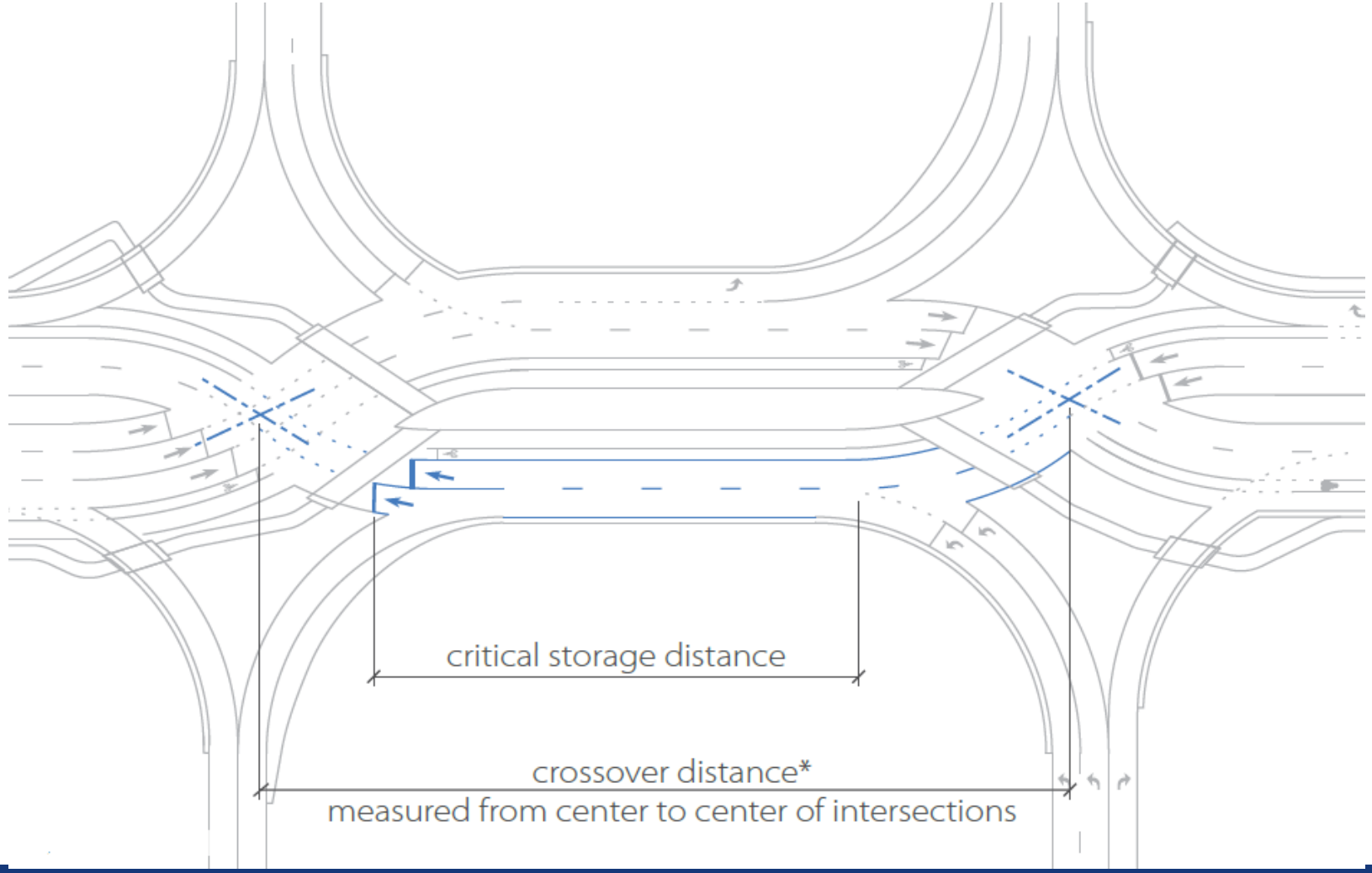
- **Signalized Right Turns**
  - Poor sight lines can lead to driver error
  - Dual turn lanes can cause sight line obstructions
  - Movements with downstream weaving
  - No turns on red

Other Signal Operations Considerations

- **Signalized Left Turns**
  - Same sight line issues for left turns as with right turns
  - No turns on red

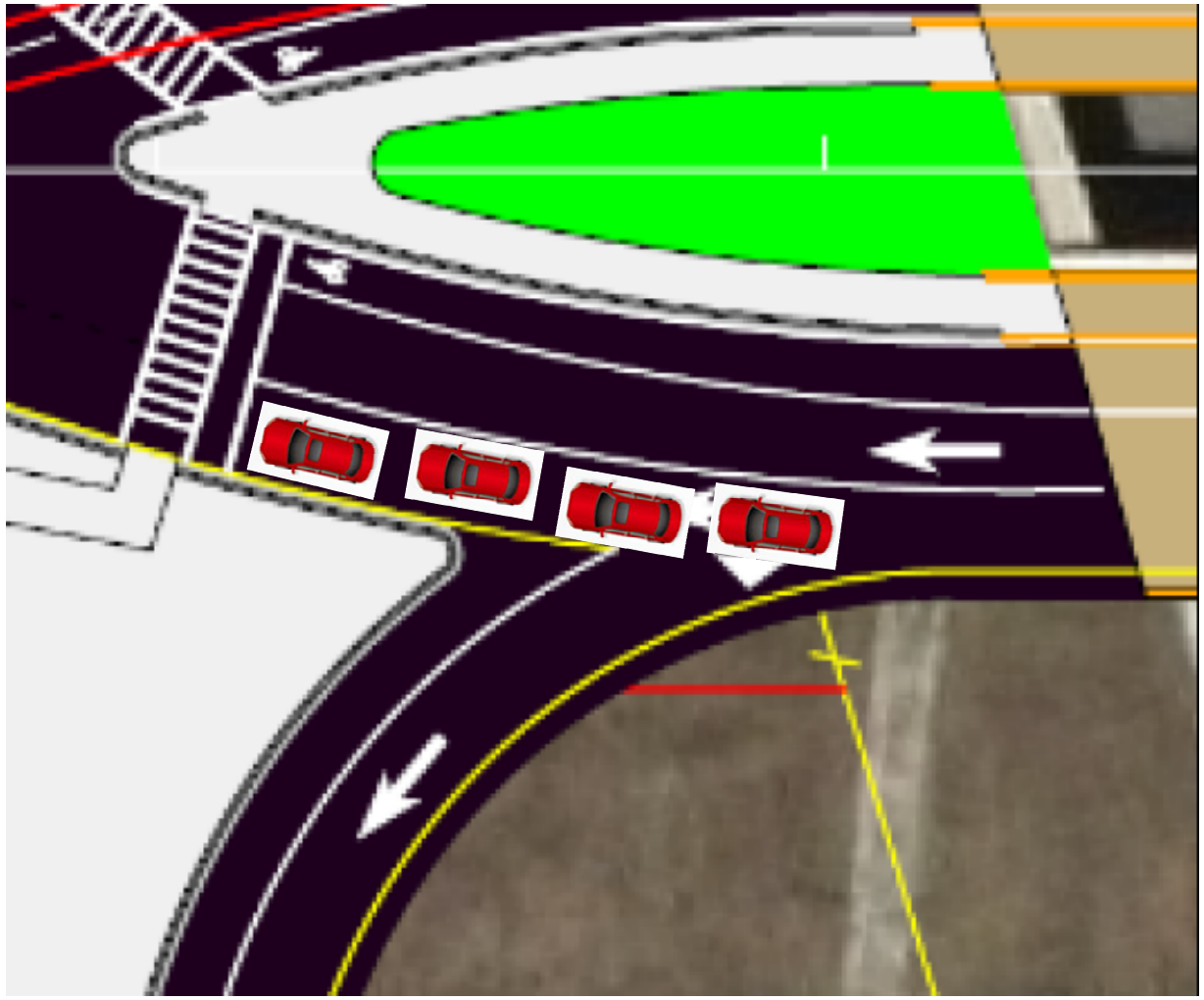
Other Signal Operations Considerations

- Queue Storage Between Crossovers



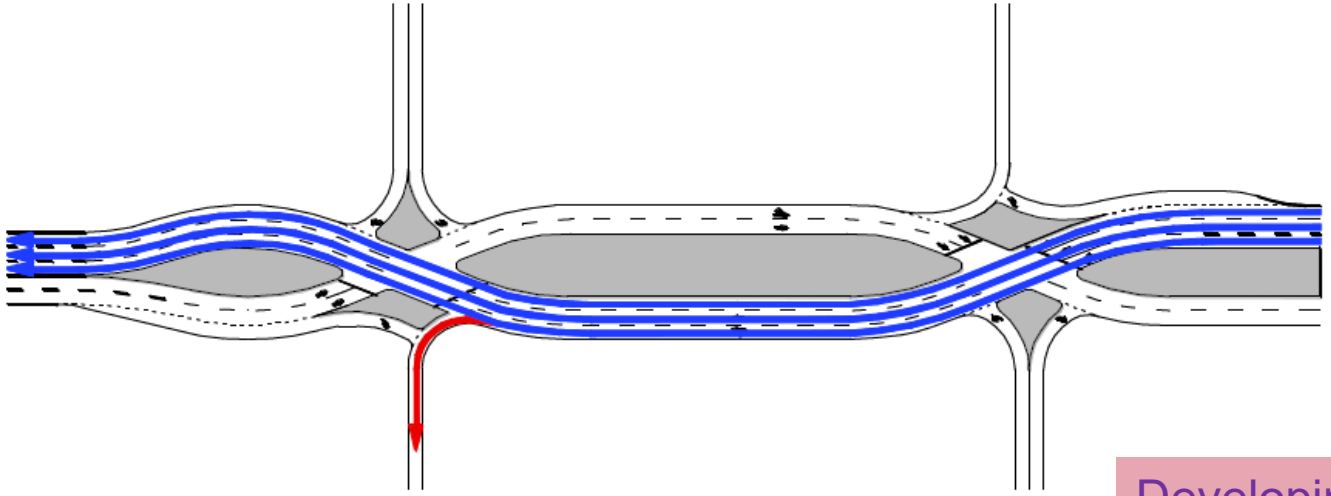
Other Signal Operations Considerations

- **Shared Left/Thru Lane**
  - Left turn capacity can be significantly reduced if the thru queue routinely blocks the entrance to the turn lane



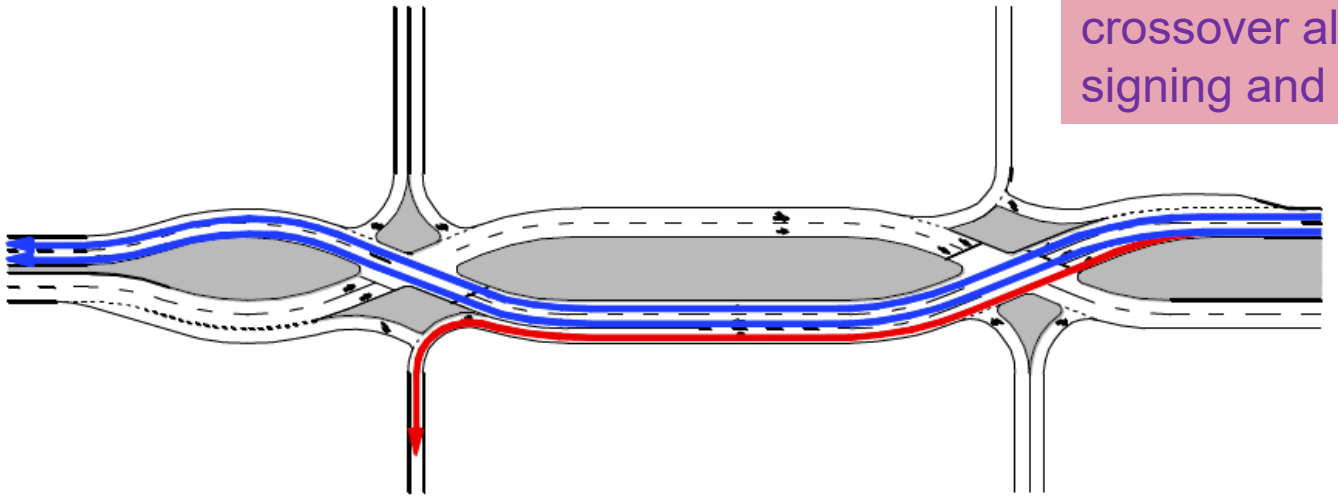
Other Signal Operations Considerations

- Lane Utilization/Lane Balance



3 Thru Lanes w/ shared Left

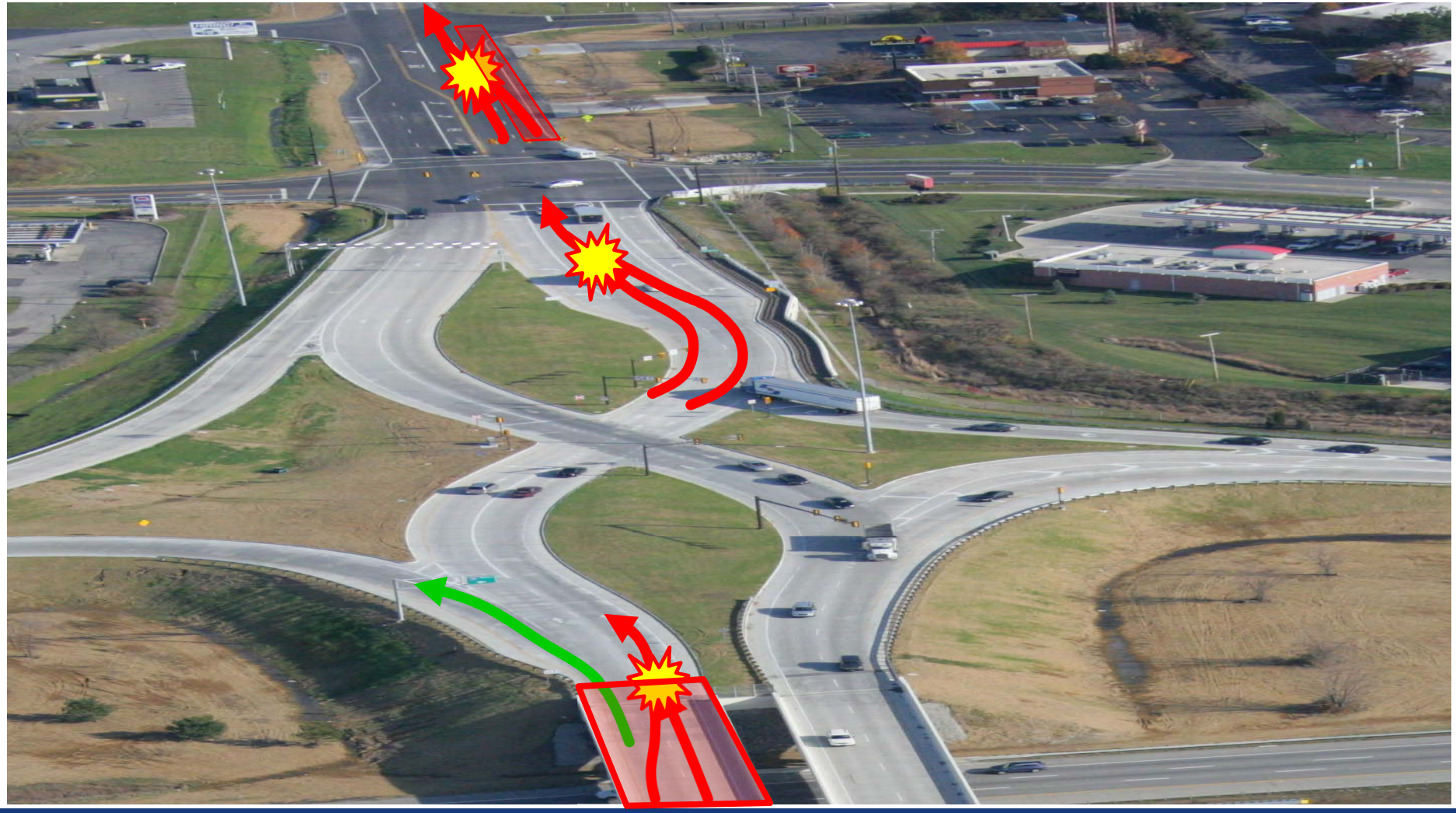
Developing lanes before the crossover allows for better signing and higher capacity

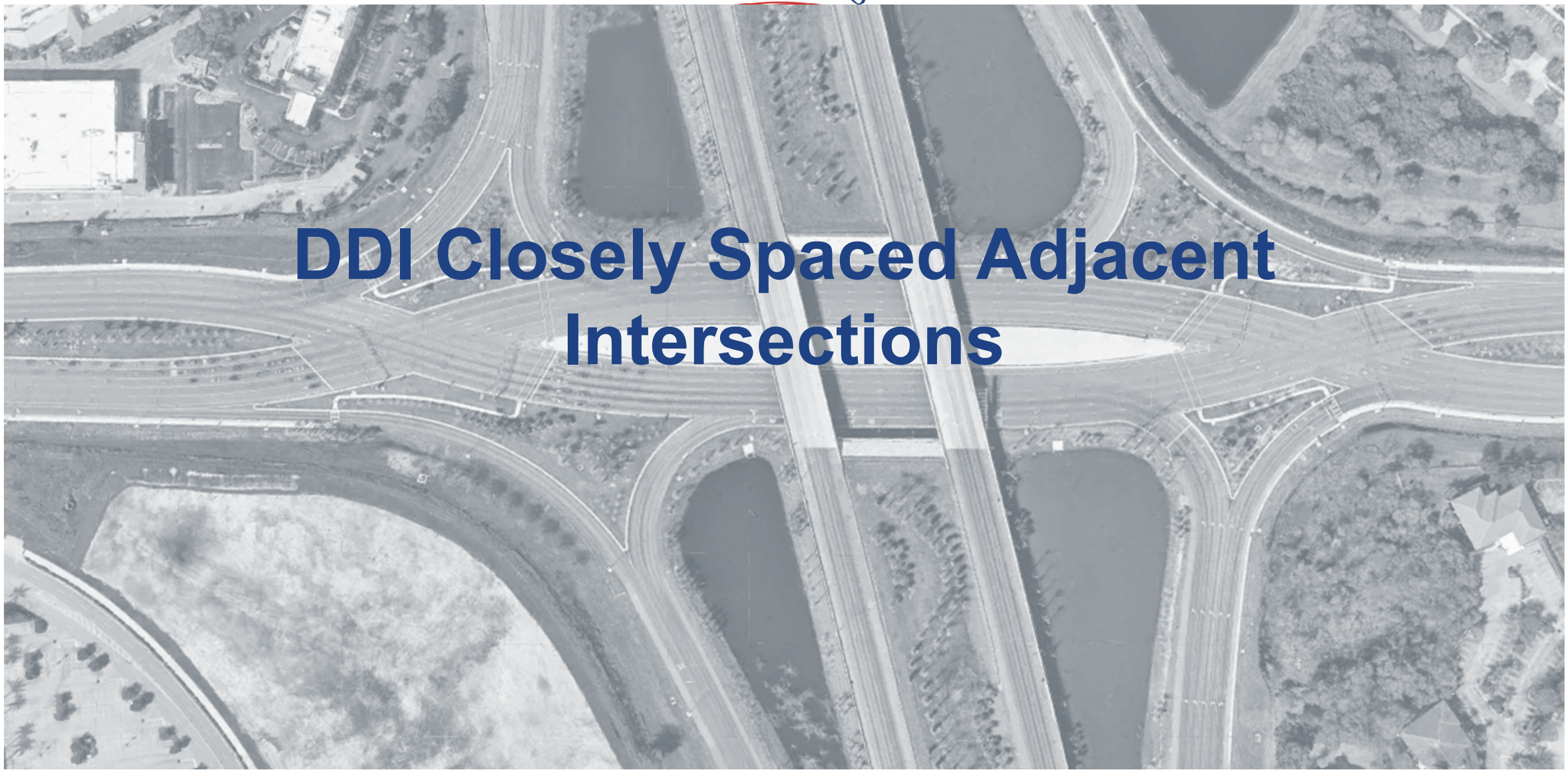


2 Thru Lanes w/ Exclusive Left

Other Signal Operations Considerations

- **Lane Utilization through a DDI**
  - Think about how lane assignments affect traffic flow
  - Minimize turbulence within the DDI





DDI Closely Spaced Adjacent Intersections

Traffic Operations

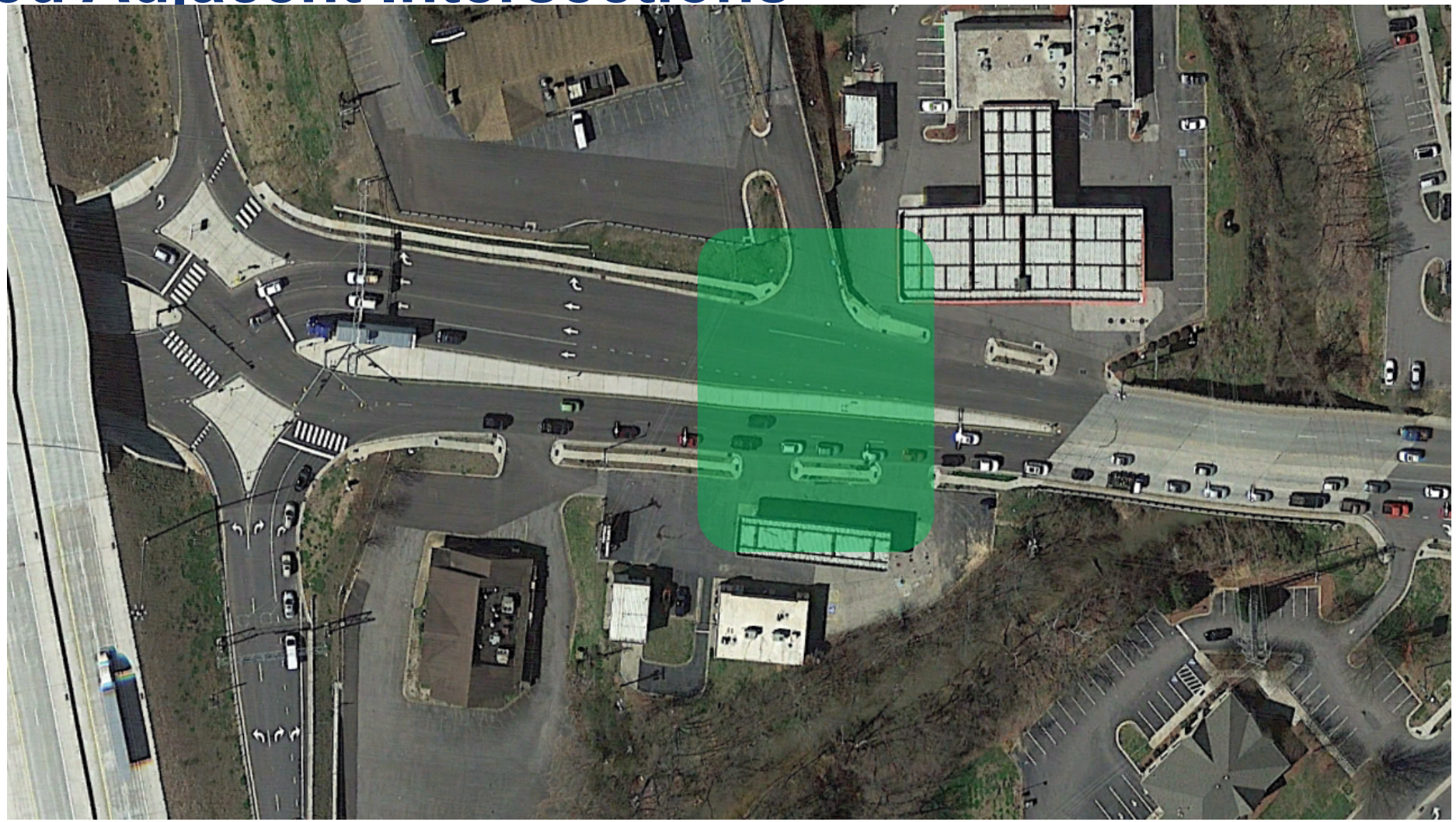
- **Closely spaced signalized intersections**
  - Common myth of how to “break a DDI”
  - **No “magic dimension”**

Closely Spaced Adjacent Intersections

- **Queue Spillback**
  - Queue spillback from an adjacent signal can block the crossover intersection if it cannot handle the increased throughput from the DDI

Closely Spaced Adjacent Intersections

- **Queue Spillback**
  - Can the adjacent signal be eliminated?



Closely Spaced Adjacent Intersections

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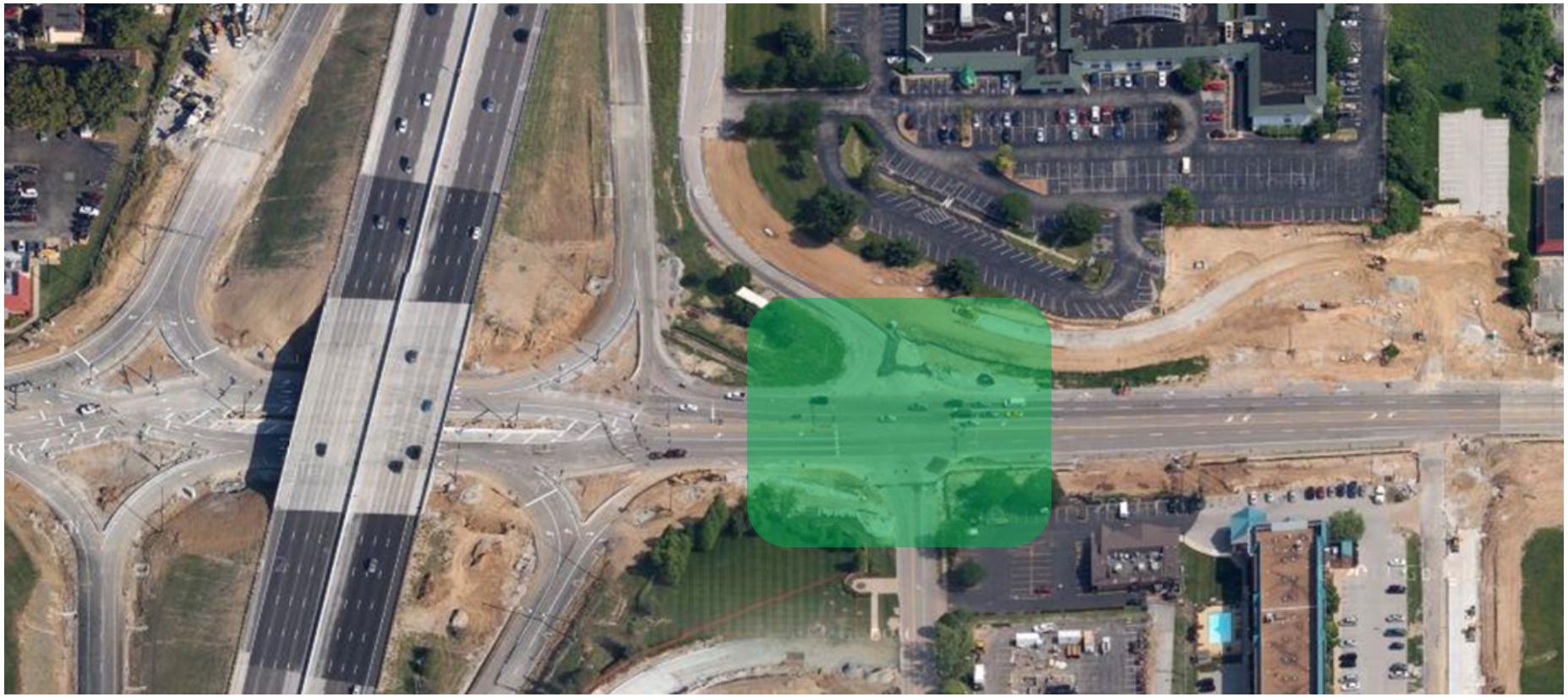
Closely Spaced Adjacent Intersections

- **Queue Spillback**
  - Can the adjacent signal be moved farther away?

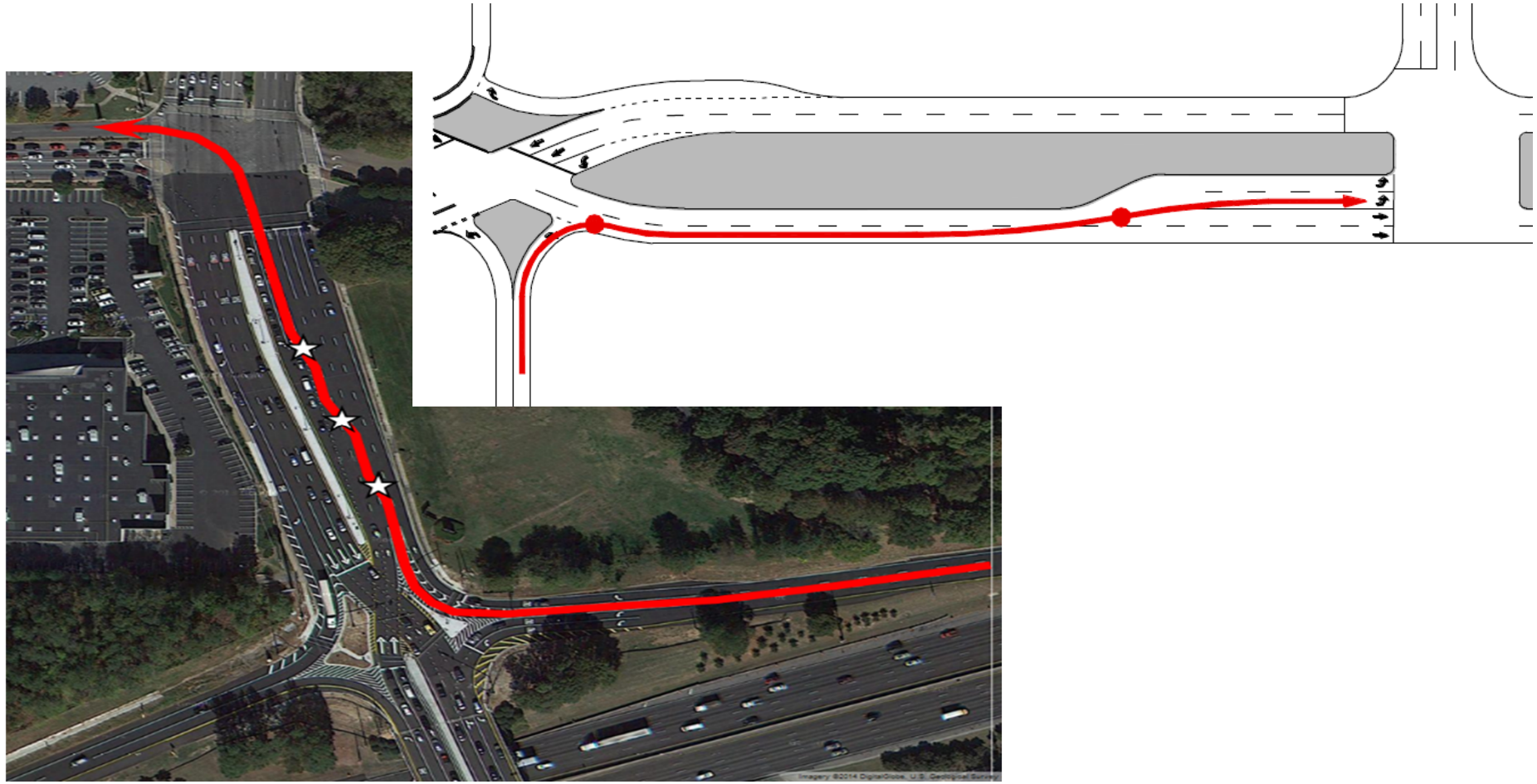


Closely Spaced Adjacent Intersections

- **Queue Spillback**
  - Can the adjacent signal be moved farther away?

Closely Spaced Adjacent Intersections

- **Weaving Conflicts**
  - Consider traffic volume weaving from exit ramp to adjacent left turn lane
  - Signalize the right turn from the ramp



Traffic Operations

- **Closely spaced signalized intersections**
  - Example

Existing Lane Configuration

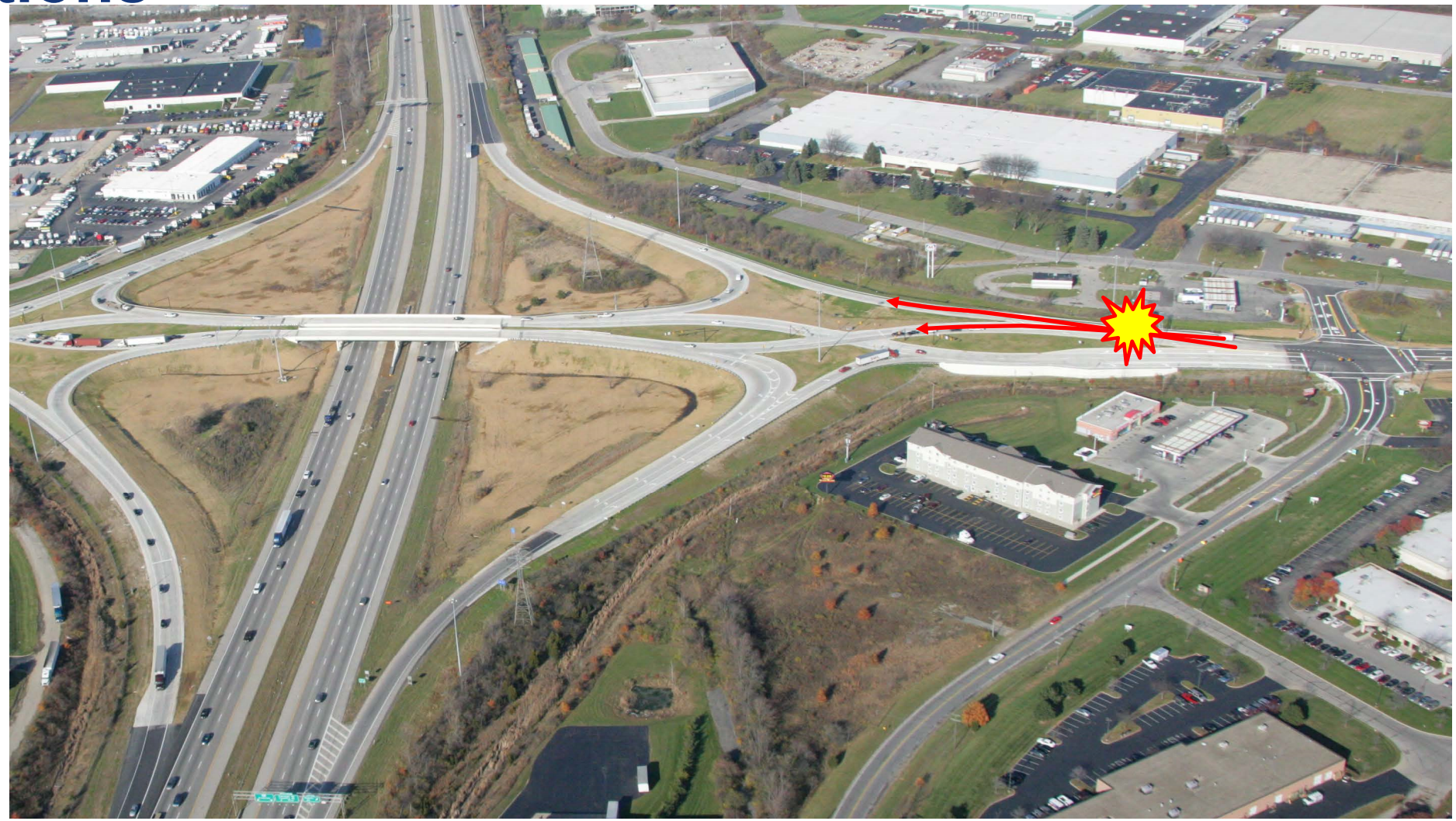
Traffic Operations

- **Closely spaced signalized intersections**
  - Adjust intersection to give more green time back to the primary road
  - Dual left from the secondary street

Proposed Lane Configuration

Traffic Operations

- **Closely spaced signalized intersections**
  - Don’t “blindly” trust your traffic simulation models!



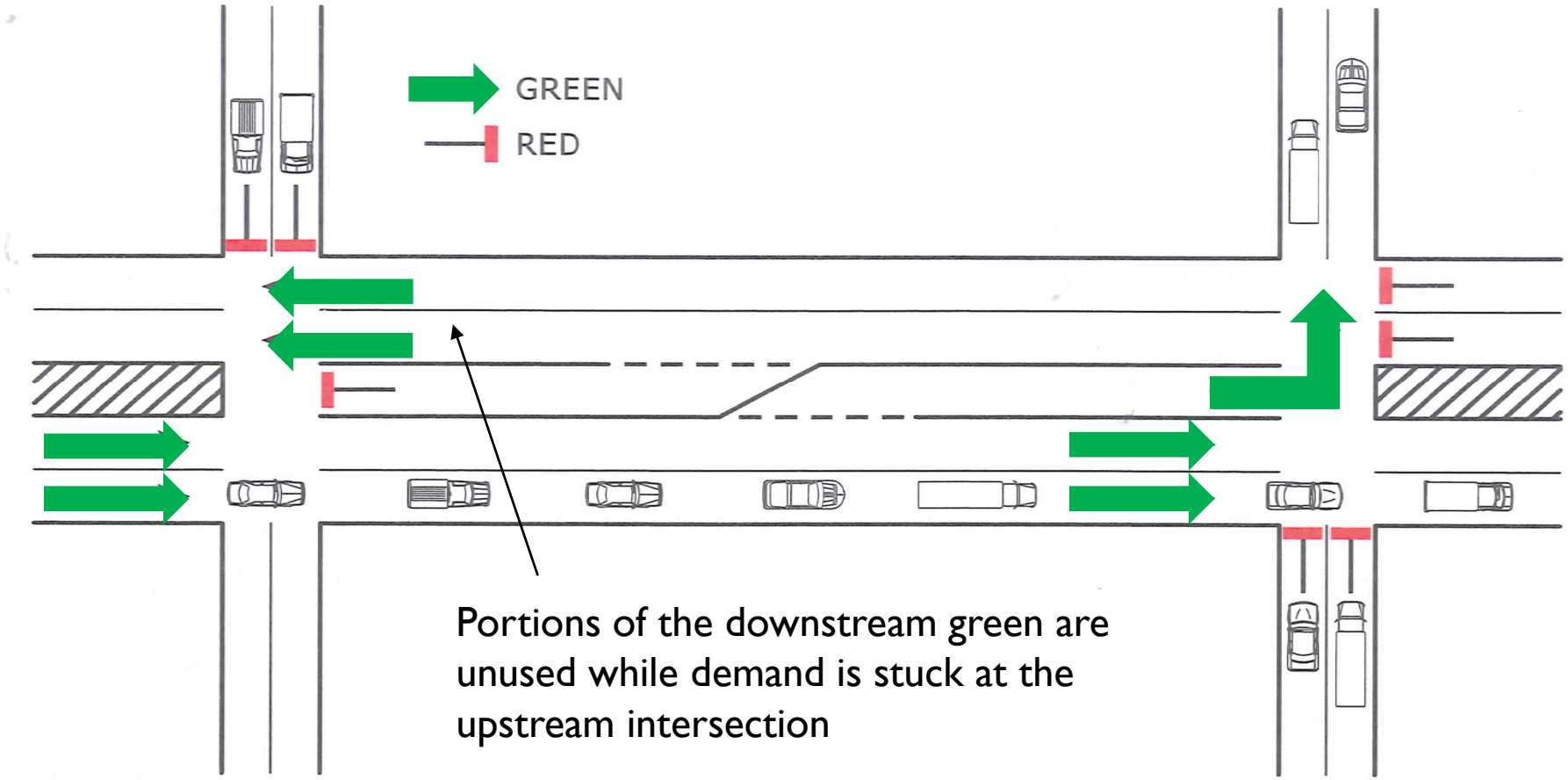
Traffic Operations

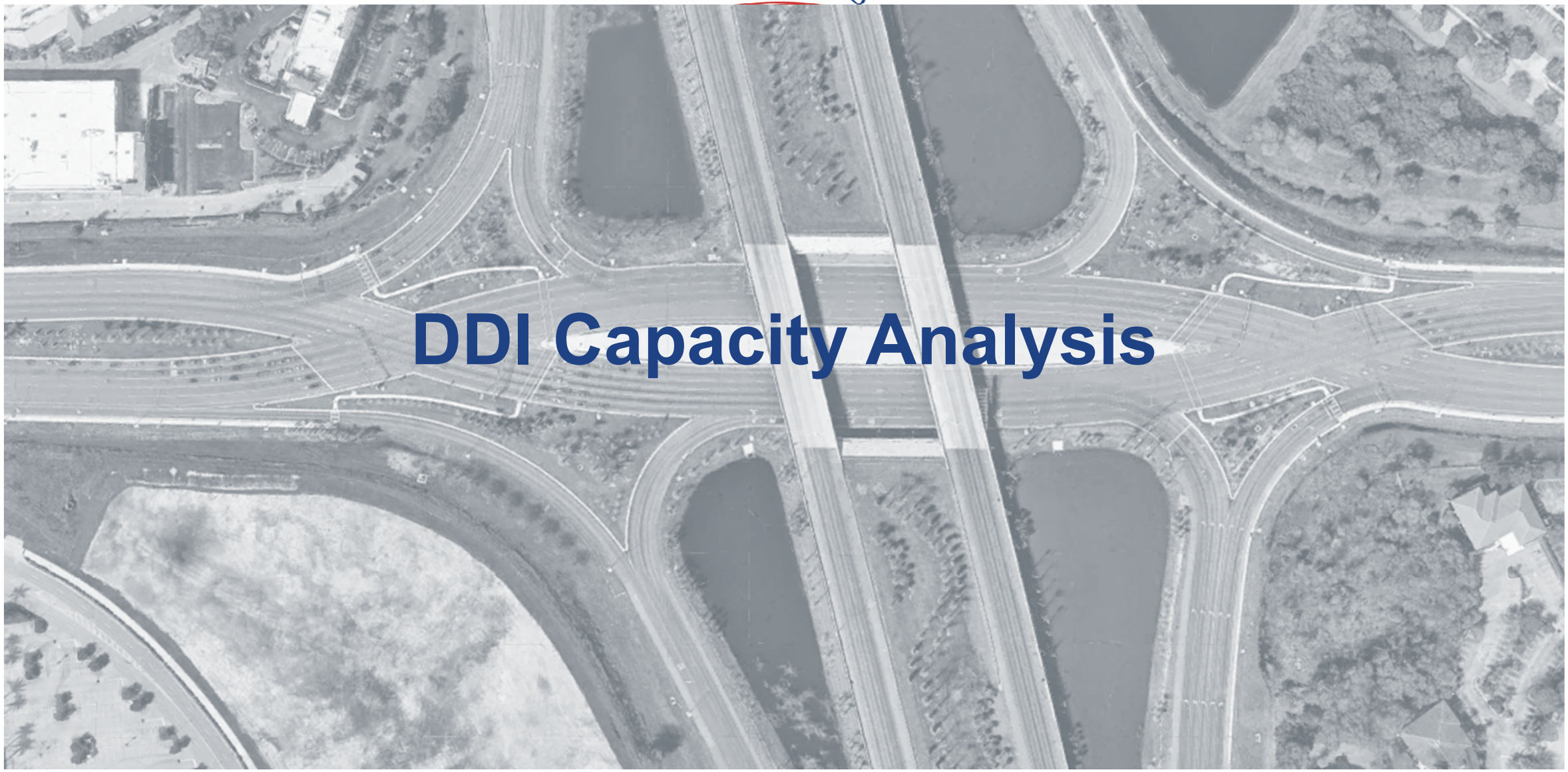
- **Closely spaced signalized intersections**
  - May need to make adjustments after construction is completed

Proposed Lane Configuration

Demand Starvation

- Vehicles blocked by the upstream intersection causes unused/ineffective green time at the downstream signal





DDI Capacity Analysis

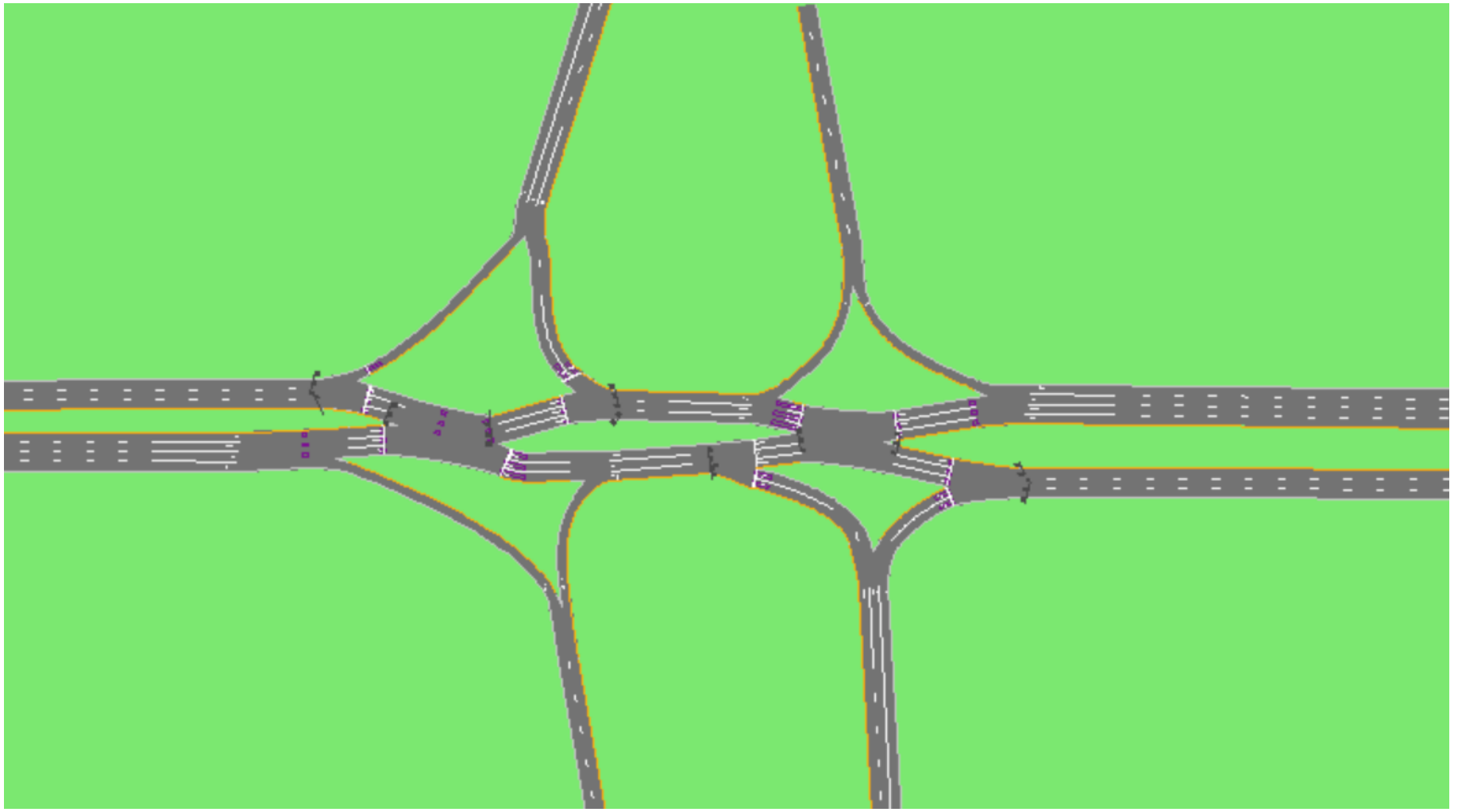
Capacity Analysis Software - SYNCHRO

- Easy to use
- Works well for corridor analysis
- Good planning level tool
- Difficult to use with non-traditional intersection geometry and signal phasing

Capacity Analysis Software - SYNCHRO

- **FDOT Traffic Engineering and Operations Office website has several Synchro templates, including a DDI**
  - https://www.fdot.gov/traffic/trafficservices/intersection-operations.shtm
  - Jughandle
  - Median U-Turn
  - Quadrant Roadway
  - Restricted Crossing U-Turn
  - Continuous Flow Intersection
  - Diverging Diamond
  - Continuous Green T-Section

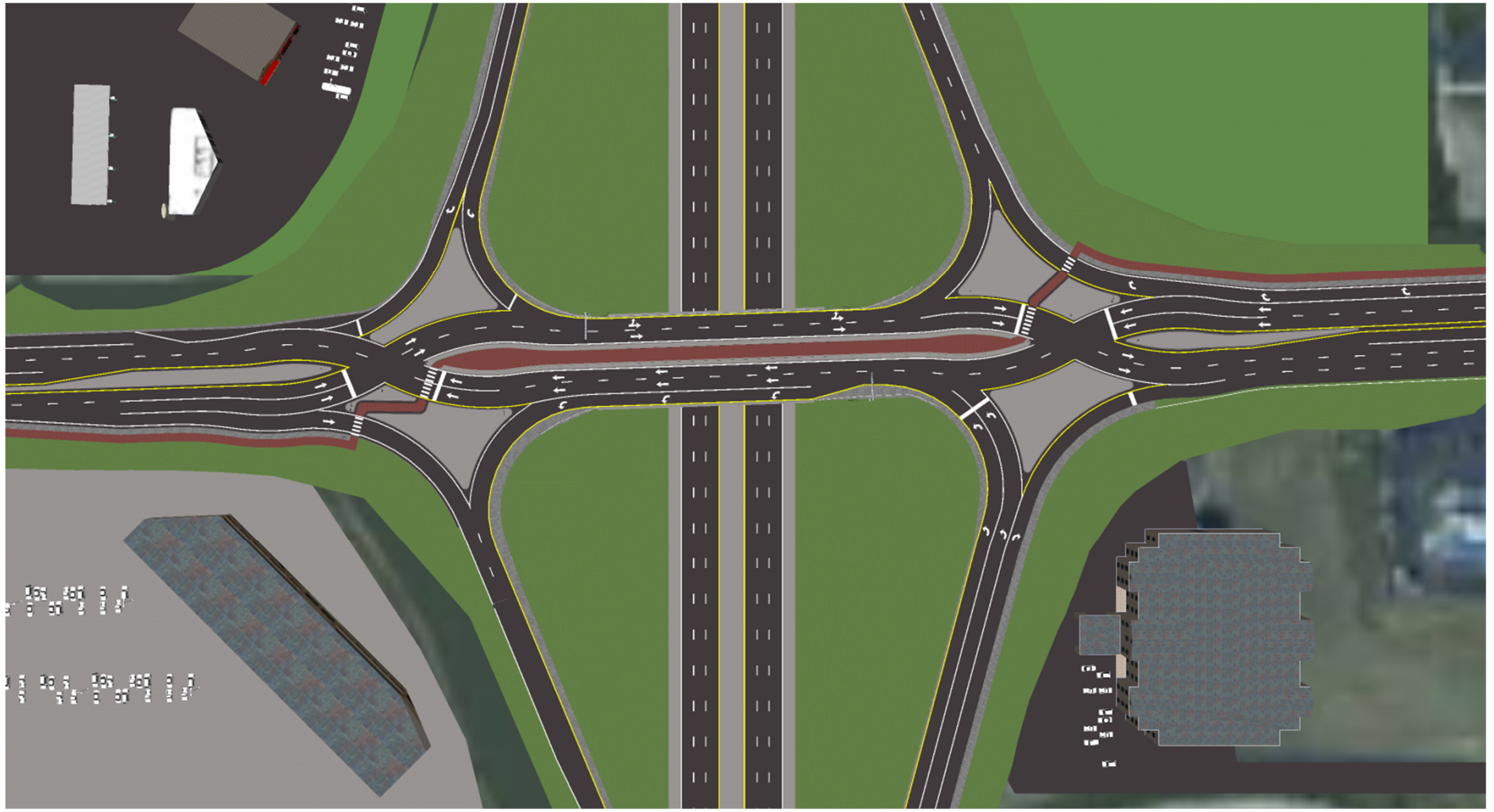
Capacity Analysis Software - SYNCHRO



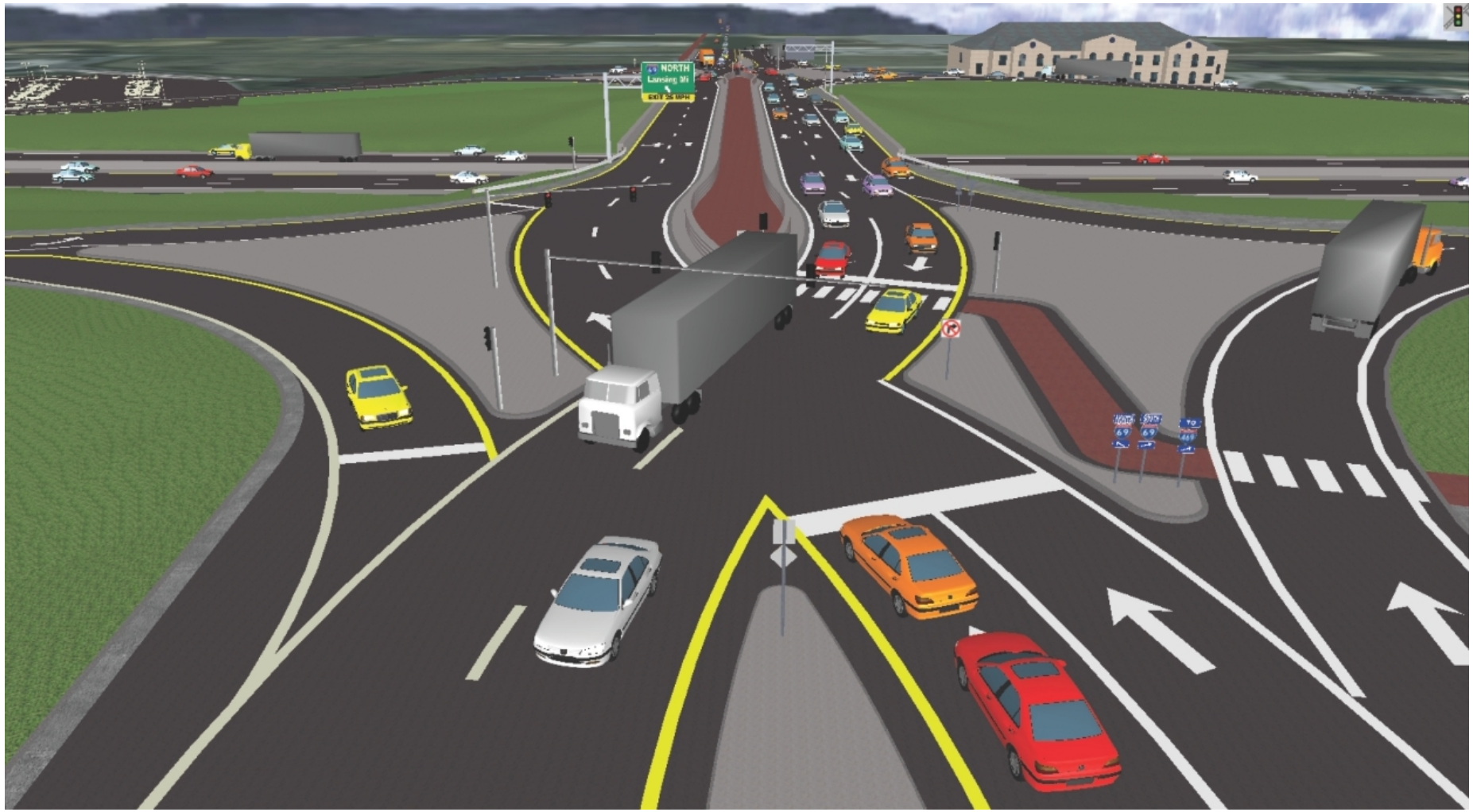
Capacity Analysis Software - VISSIM

- Can analyze nearly any geometric configuration and signal phasing
- Great visual display
- Helps the public understand how non-traditional geometry works
- Can get very labor intensive

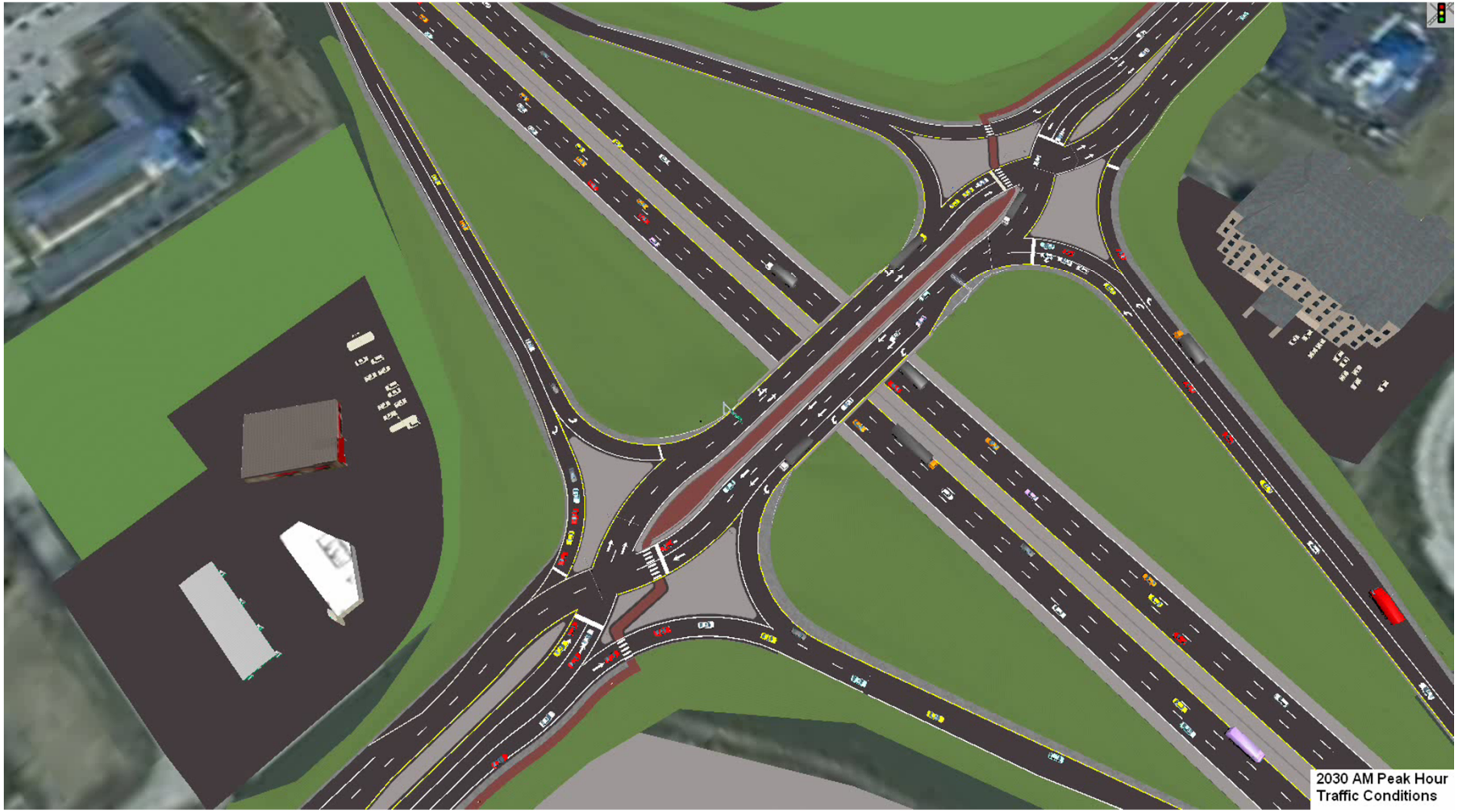
Capacity Analysis Software - VISSIM



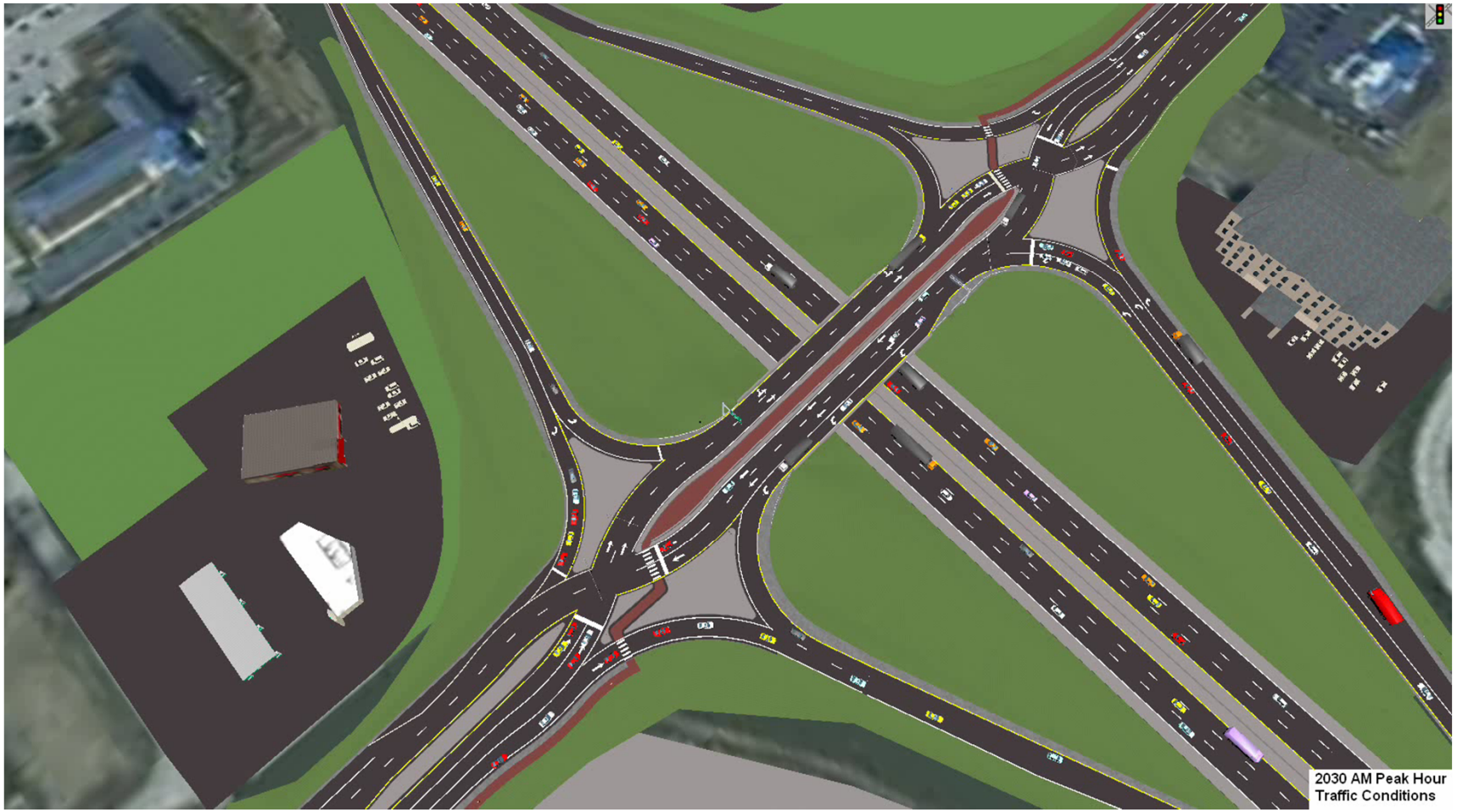
Capacity Analysis Software - VISSIM

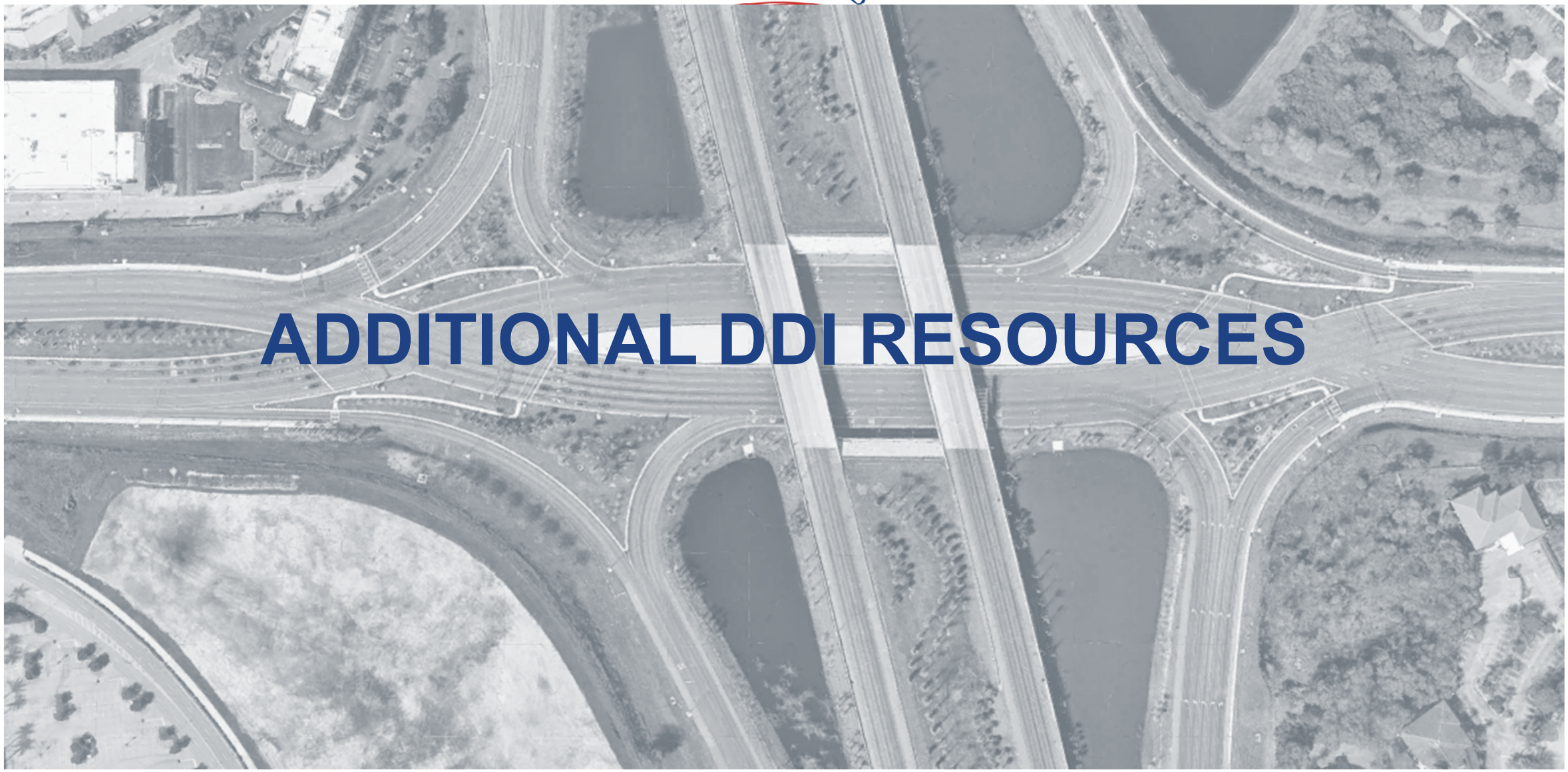


Capacity Analysis Software - VISSIM



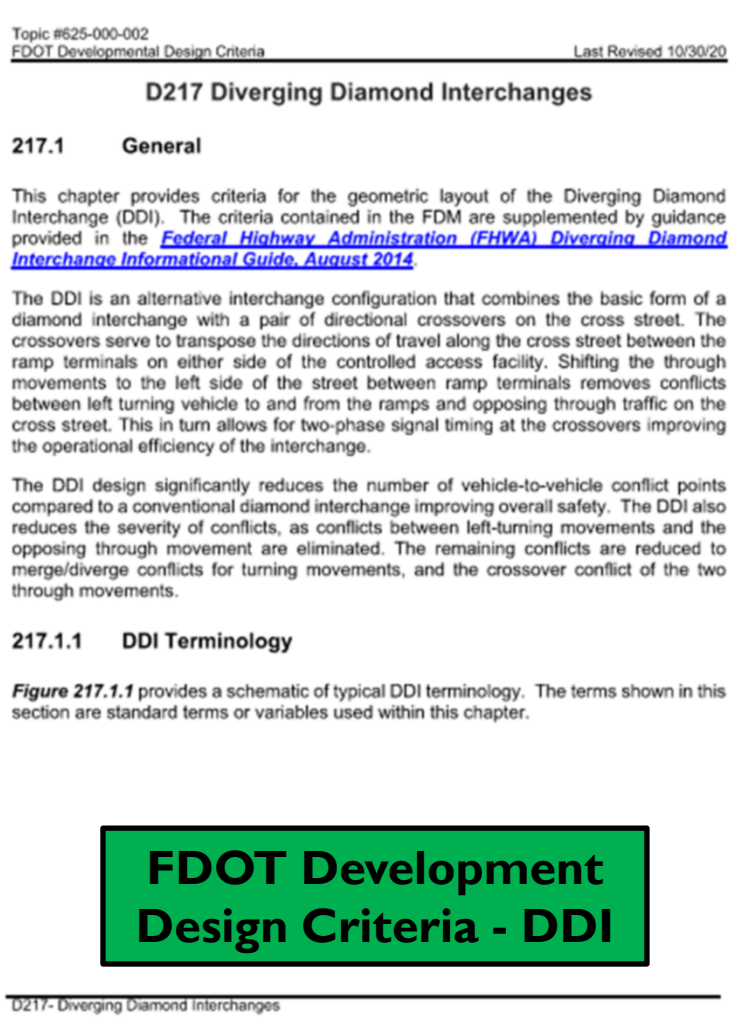
Capacity Analysis - VISSIM





ADDITIONAL DDI RESOURCES

Additional DDI Resources


Topic #625-000-002
FDOT Developmental Design Criteria Last Revised 10/30/20

D217 Diverging Diamond Interchanges

217.1 General

This chapter provides criteria for the geometric layout of the Diverging Diamond Interchange (DDI). The criteria contained in the FDM are supplemented by guidance provided in the *Federal Highway Administration (FHWA) Diverging Diamond Interchange Informational Guide, August 2014*.

The DDI is an alternative interchange configuration that combines the basic form of a diamond interchange with a pair of directional crossovers on the cross street. The crossovers serve to transpose the directions of travel along the cross street between the ramp terminals on either side of the controlled access facility. Shifting the through movements to the left side of the street between ramp terminals removes conflicts between left turning vehicle to and from the ramps and opposing through traffic on the cross street. This in turn allows for two-phase signal timing at the crossovers improving the operational efficiency of the interchange.

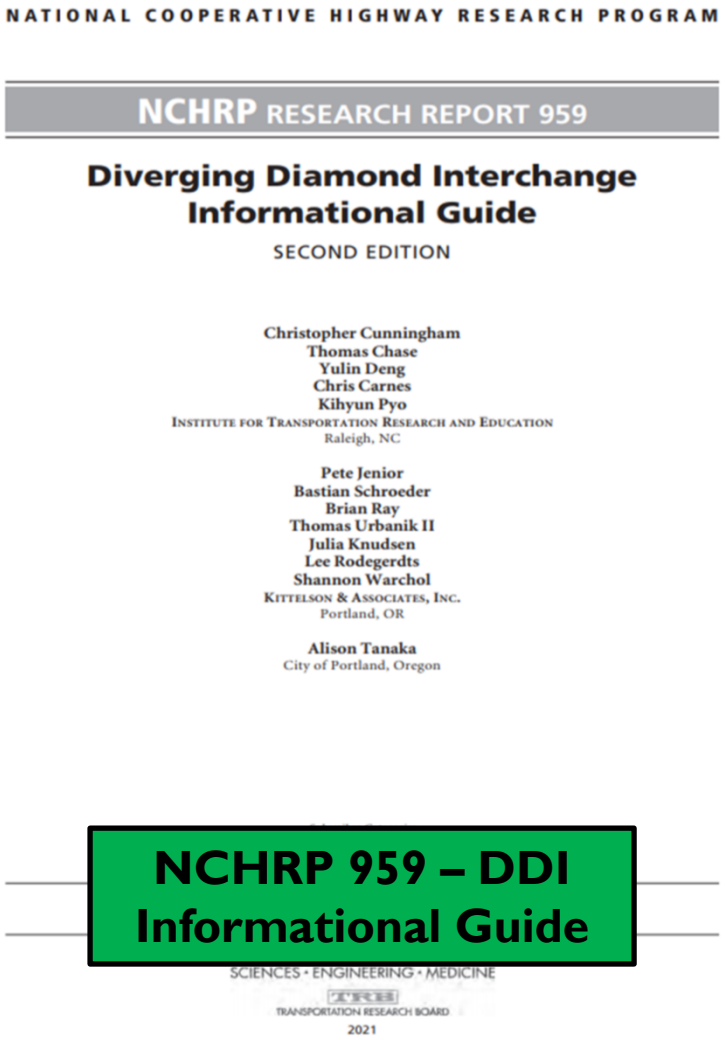
The DDI design significantly reduces the number of vehicle-to-vehicle conflict points compared to a conventional diamond interchange improving overall safety. The DDI also reduces the severity of conflicts, as conflicts between left-turning movements and the opposing through movement are eliminated. The remaining conflicts are reduced to merge/diverge conflicts for turning movements, and the crossover conflict of the two through movements.

217.1.1 DDI Terminology

Figure 217.1.1 provides a schematic of typical DDI terminology. The terms shown in this section are standard terms or variables used within this chapter.

D217- Diverging Diamond Interchanges

FDOT Development Design Criteria - DDI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NCHRP RESEARCH REPORT 959

Diverging Diamond Interchange Informational Guide

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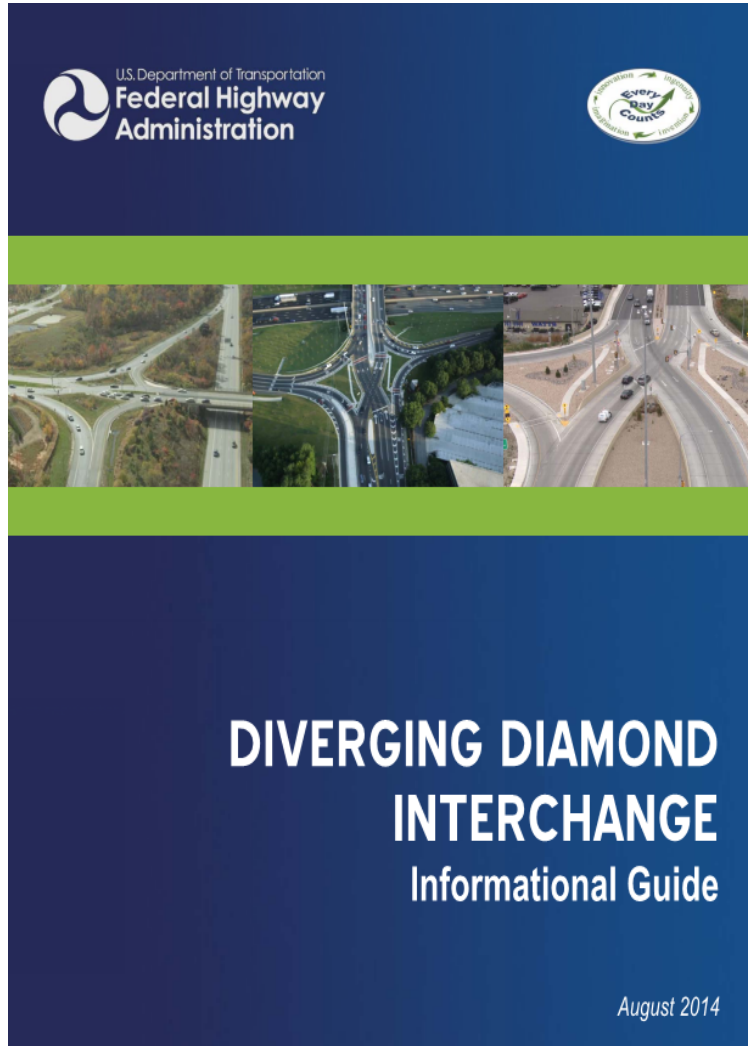

Questions?

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