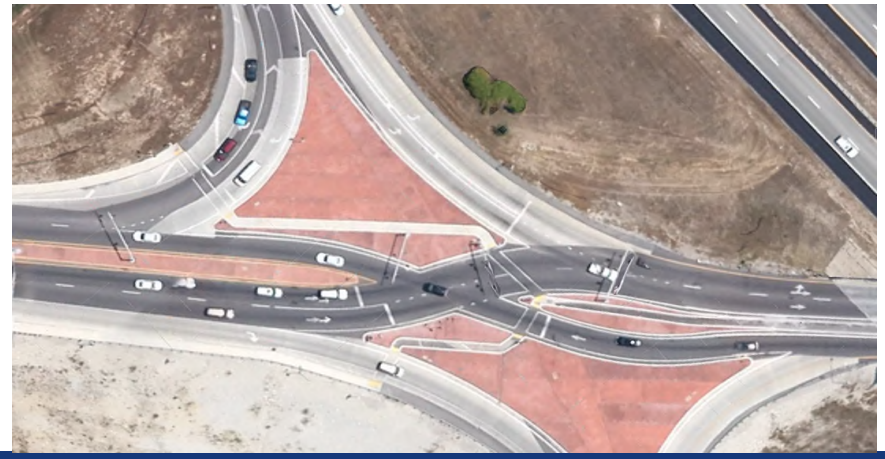
FDOT DDI Design Webinar Series
DDI Geometric Design

June 29, 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 and Pavement Marking	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



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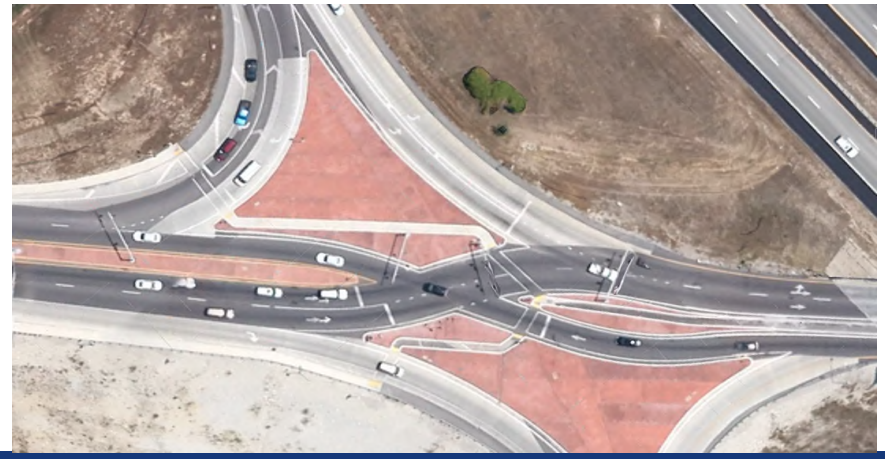

DDI Overview – Webinar Instructors

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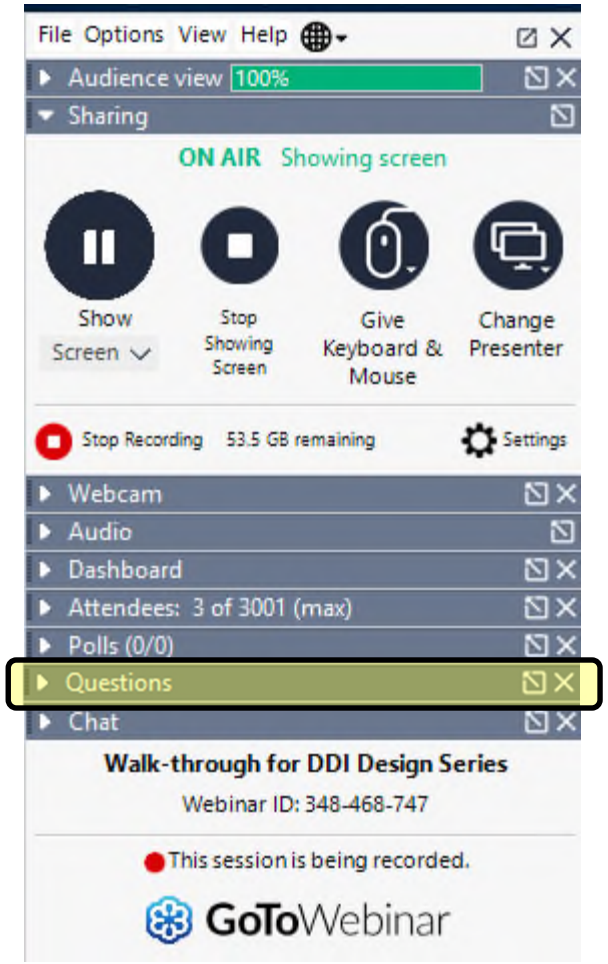
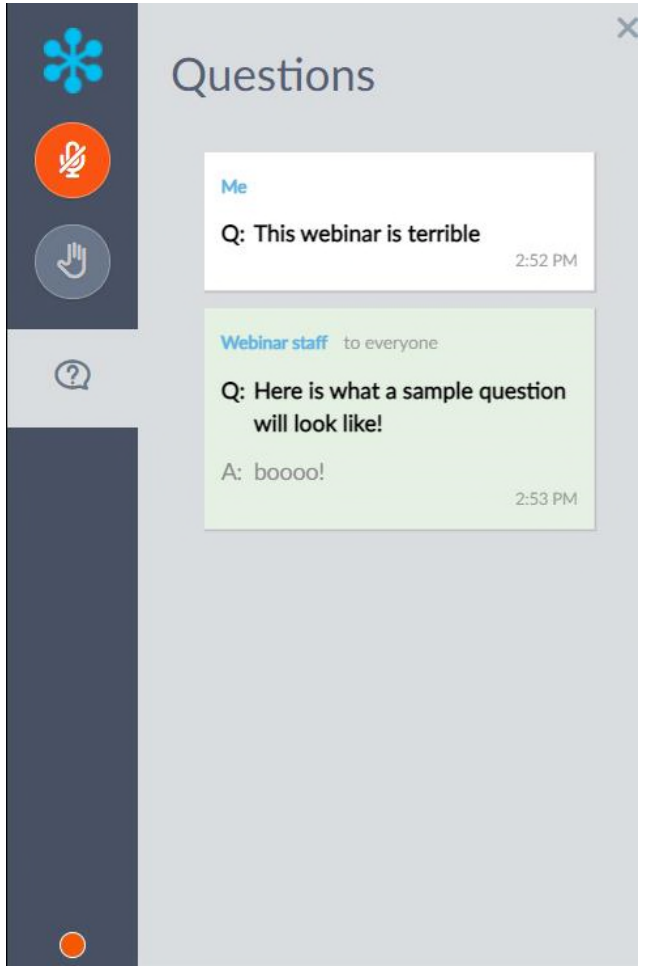
DDI Overview – Webinar Logistics

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



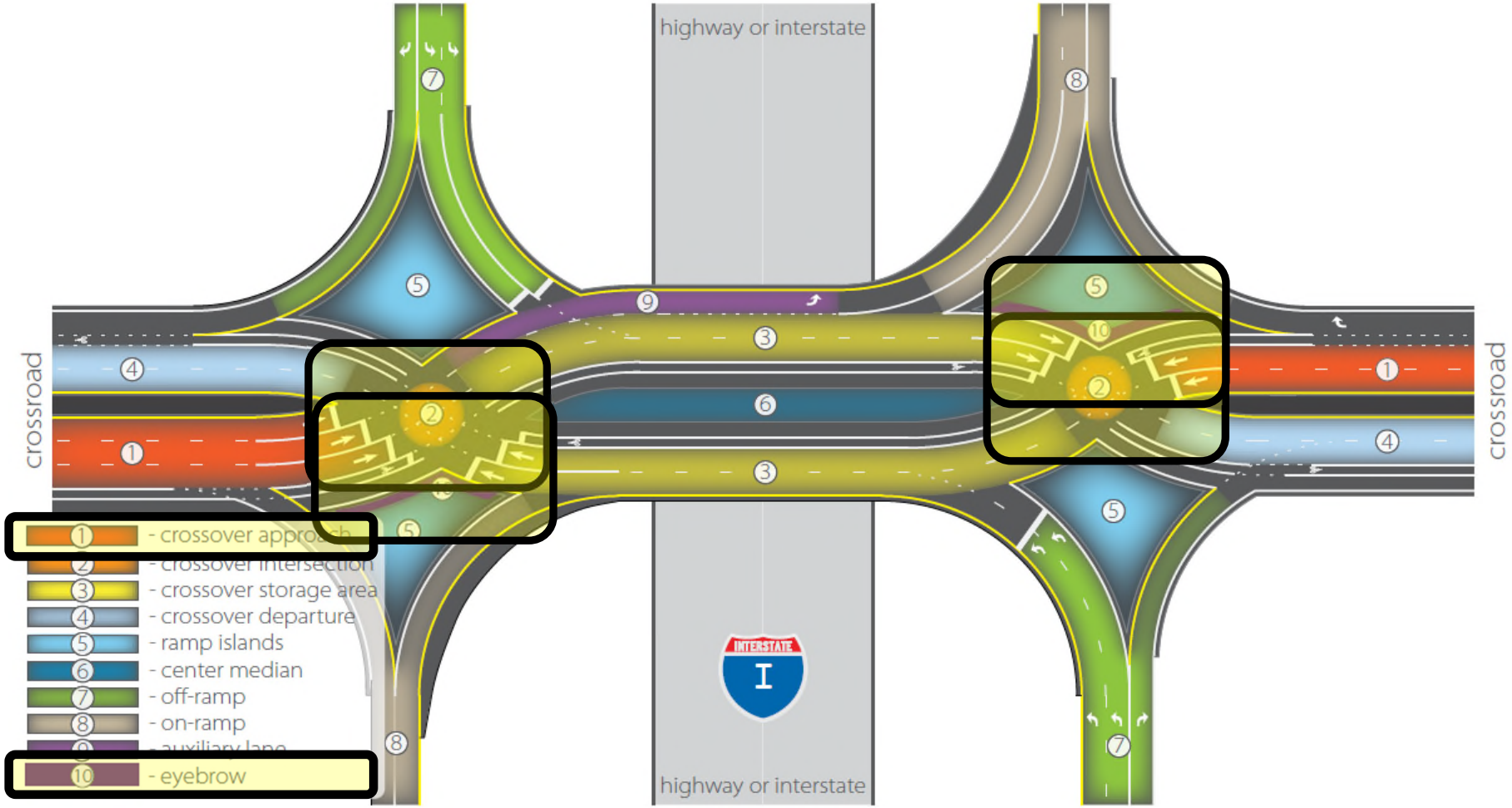


DDI Geometric Design - AGENDA

- **DDI Criteria**
  - Common DDI Terms
  - Design Speed
  - Design Vehicle
- **Horizontal Alignment**
  - Crossover Intersection
- **Vertical Alignment**
- **DDI Resources**

DDI Criteria

DDI Terminology



DDI Terminology

- **Eyebrow**
  - Physical impediment to discourage wrong-way movement thru the crossover intersection

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DDI Terminology

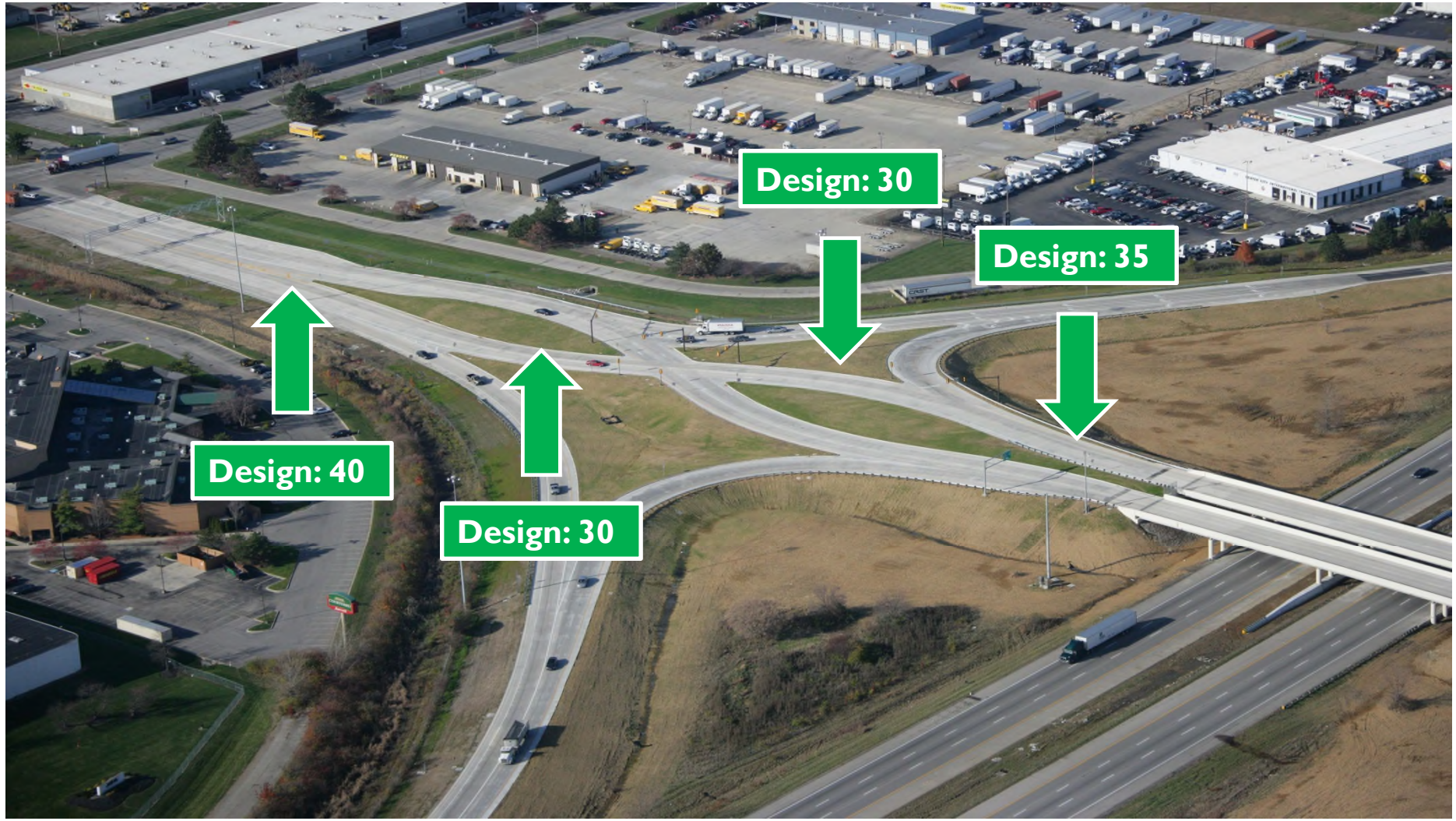
- **Eyebrow**
  - Physical impediment to discourage wrong-way movement thru the crossover intersection
  - Function of intersection angle and number of lanes
  - Angle of crossover intersection (as a function of the establishment of the eyebrow) directly impacts R/W, spacing between crossover intersections, and radii for right and left turns

DDI Terminology

- **Q-Tip**
  - Introduction of reverse curvature within the crossover storage area to improve crossover angle, reduce path overlap, control speeds, and improve left turn geometry
  - Isn't required – many DDIs have been constructed without the Q-tip design

DDI Criteria

- **Design Speed**
  - Provide geometry that gradually slows traffic prior to the crossover intersections and promotes slow, consistent speeds thru interchange
  - Provide adequate sight distance and clear sight lines for all conflict points within interchange



DDI Criteria

Table 217.3.1 Minimum Crossover Radius

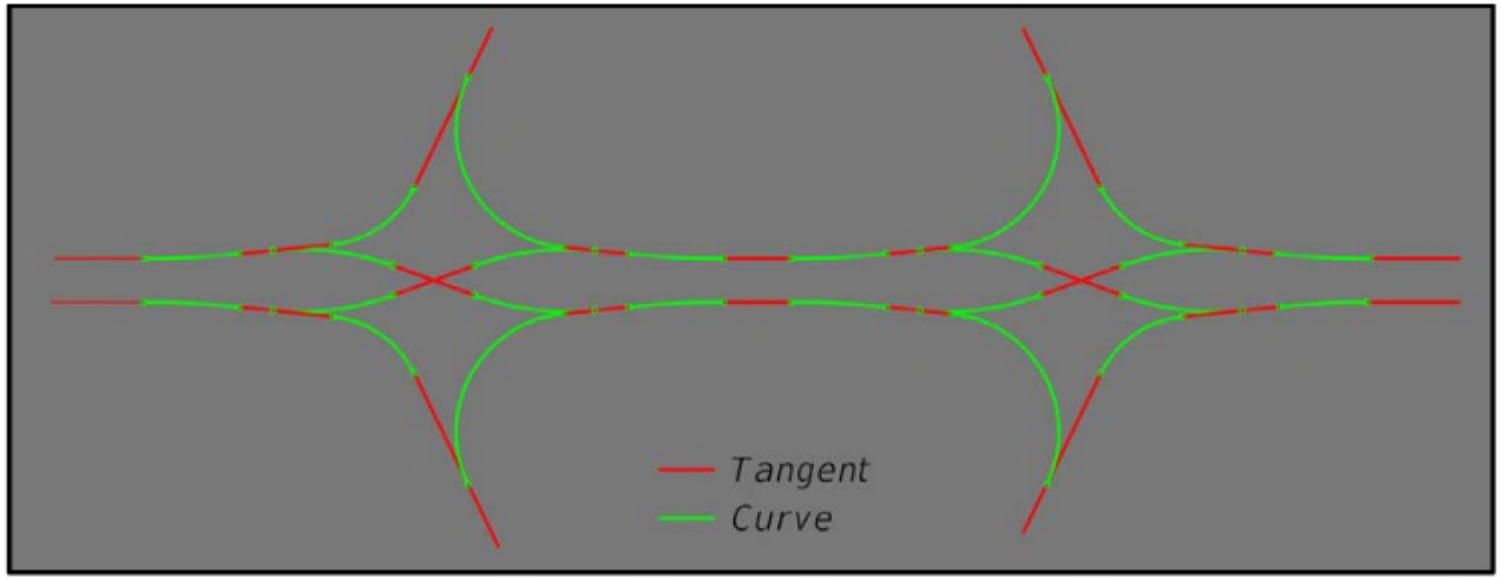
Design Speed (mph)	25	30	35	40	45
Min. crossover radius (ft)	250	350	500	650	900

- **Design Speed**
  - Design speed governing reverse curvature at crossover intersections may be reduced by up to 10 mph below the design speed of the approaching roadway
  - Design speed of less than 25 mph shall not be used
  - High speed facilities with R/W or other constraints may use speeds of 35 mph or less – need to gradually slow approaching traffic using reverse curvature

DDI Criteria

- **Reverse Curvature**
  - Avoid back-to-back reverse curves
    - Minimize abrupt change in direction
    - Reduce path overlap and load shift
  - Place a **minimum 75-foot tangent** section between curves
    - Allows smooth transition from one direction to the other
    - Applies to all crossroads, ramp and turning roadway alignments

Figure 217.3.2 Tangents Between Reverse Curves



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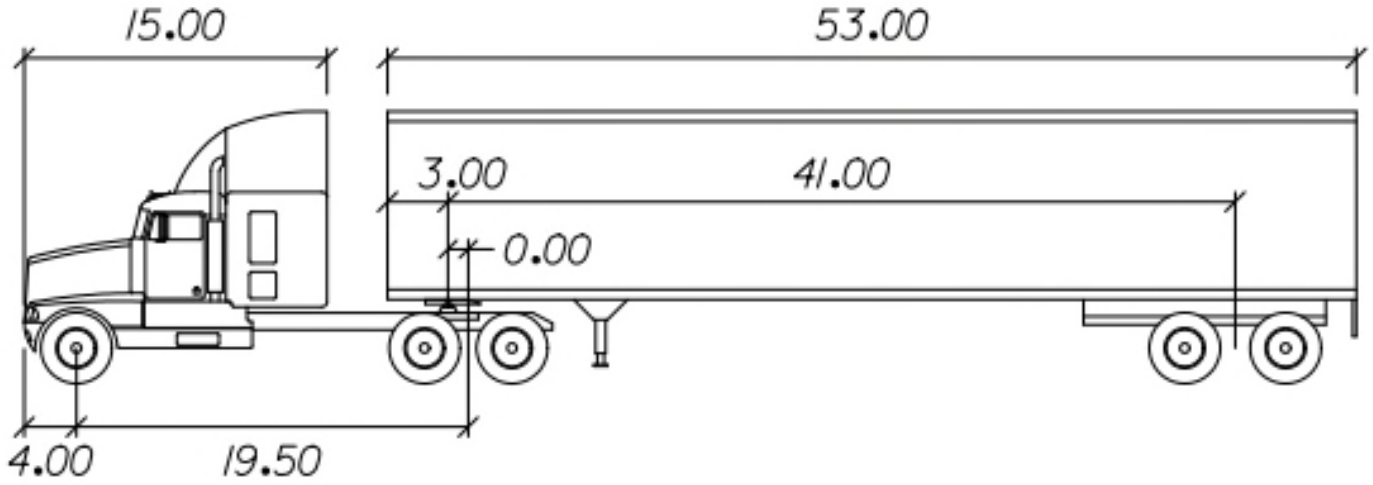
  - Avoid abrupt reverse curvature

DDI Criteria

- **Design Vehicle**
  - DDI design governed by WB-62 FL
  - Consider oversize vehicle needs

Figure 201.6.1 WB-62FL

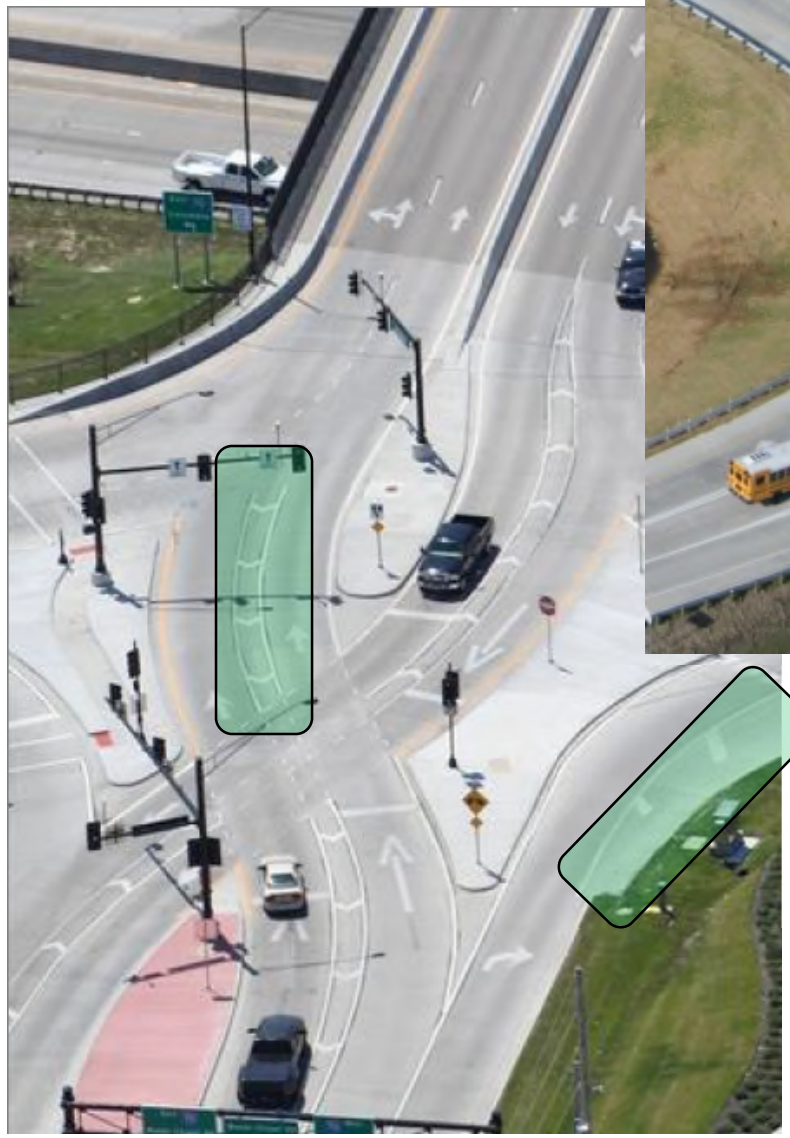


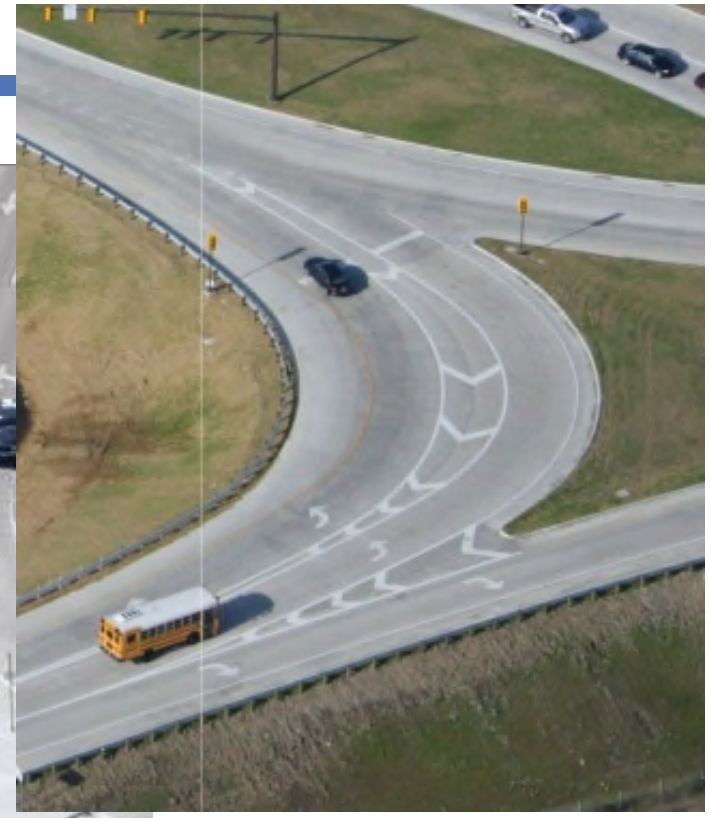
WB-62FL feet

Tractor Width :	8.00	Lock to Lock Time:	6.00 seconds
Trailer Width :	8.50	Steering Angle :	28.40 degrees
Tractor Track:	8.00	Articulating Angle:	70.00 degrees
Trailer Track :	8.50		

DDI Criteria

- **Design Vehicle**
  - Through lanes and auxiliary lanes on crossroad must be sized to provide no over-tracking into adjacent lanes, gutters, or shoulders for the design vehicle
  - Single lane turning roadways – standard 15-foot wide lane with additional striped out pavement adjacent to inside lane edge line as necessary
  - Two-lane turning roadways – provide 12-foot wide lanes separated by gore striping as necessary





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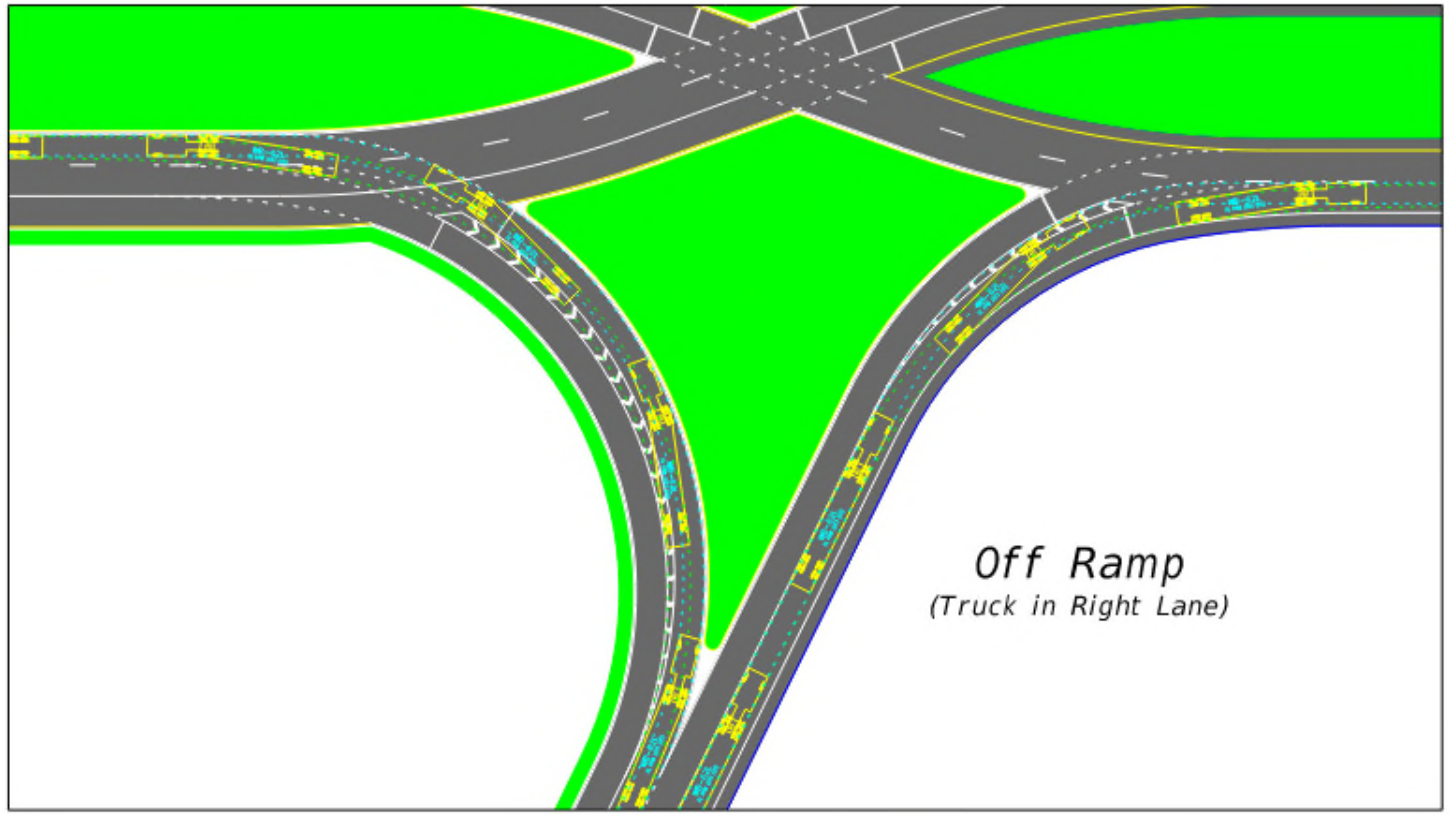
  - Two-lane turning roadways – provide 12-foot wide lanes separated by gore striping as necessary

DDI Criteria

- **Design Vehicle**
  - Three-lane turning roadways – must allow for passage of design vehicle through either the right or middle lane with no encroachment into adjacent lanes, gutter, or shoulders. Provide 12-foot wide lanes with gore striping separating the right and middle lanes as necessary.
  - Under constrained conditions, multi-lane turning roadways can be designed to allow encroachment into adjacent lanes with the **approval of the District Design Engineer**



Design Vehicle Accommodation at Multi-Lane Ramp Terminals

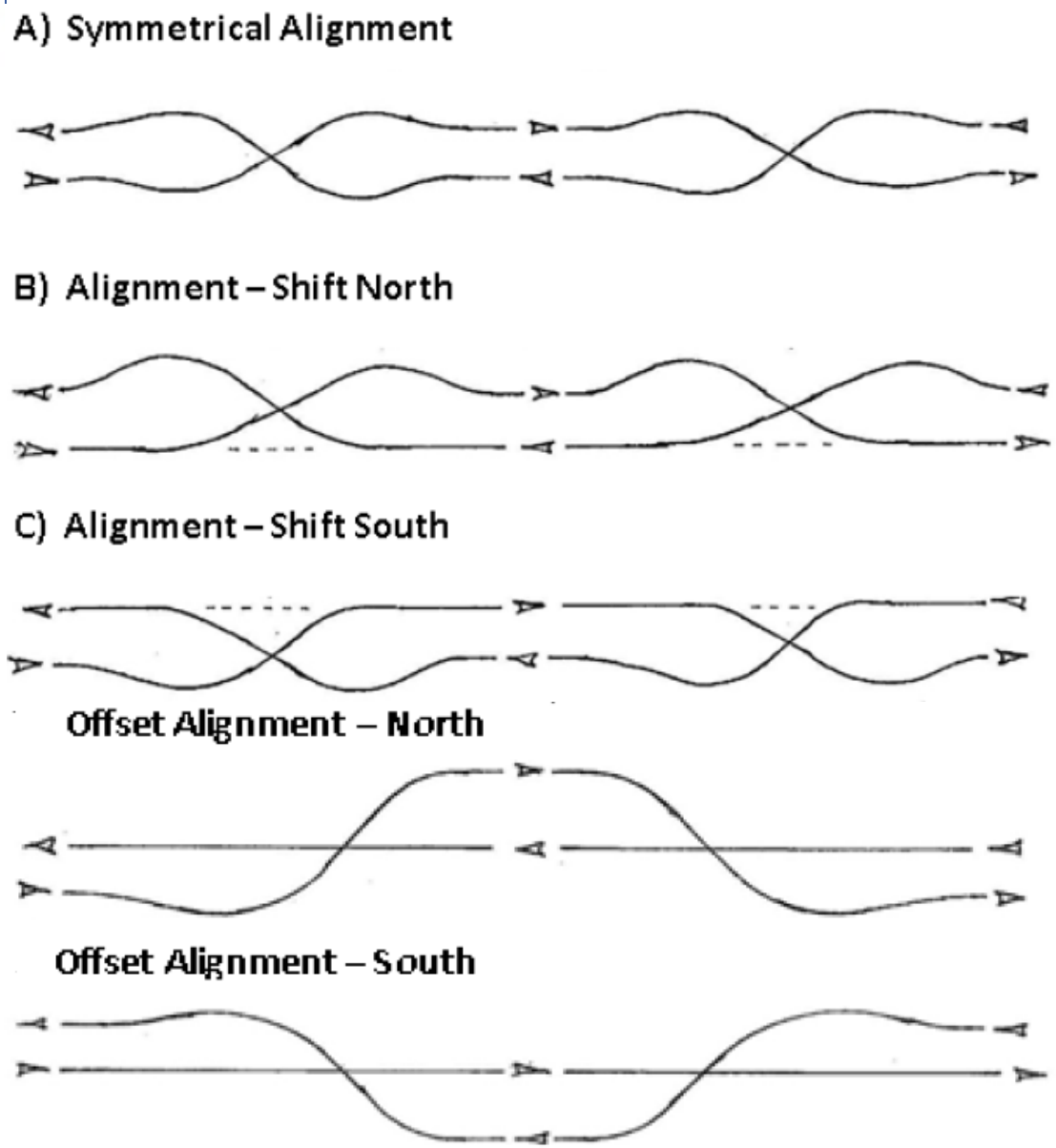
NOT TO SCALE

EXHIBIT 217-1
07/27/2020

HORIZONTAL ALIGNMENT

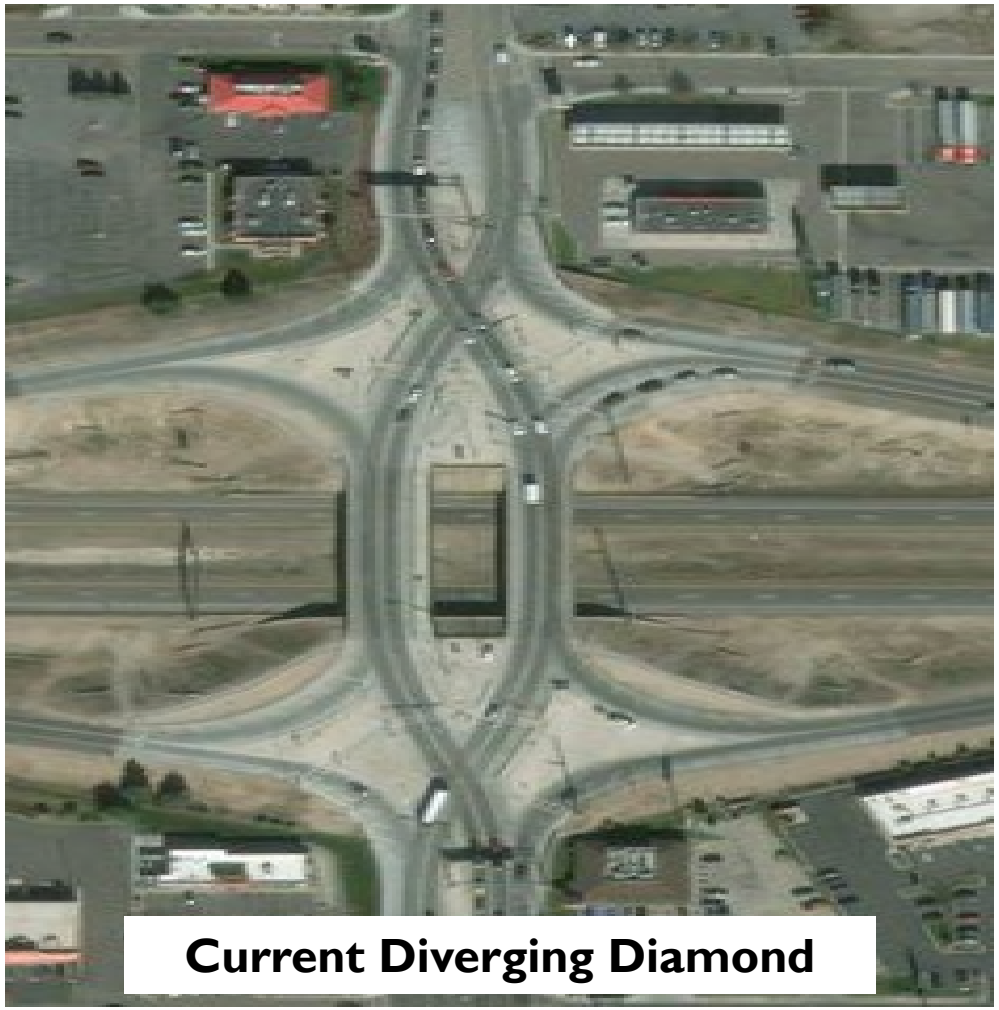
Horizontal Alignment

- **Alignment Alternatives**
  - Although the symmetrical alignment is most common, other options can be advantageous where:
    - The existing structure can remain in place while a parallel one is constructed
    - There are ROW constraints on one side of the cross road
    - There are ROW constraints in opposite quadrants on either side of the freeway
    - One direction on the crossroad has much higher volumes and would benefit from less driver “work load” of traversing the reverse curvature



Horizontal Alignment

Original Compressed Diamond

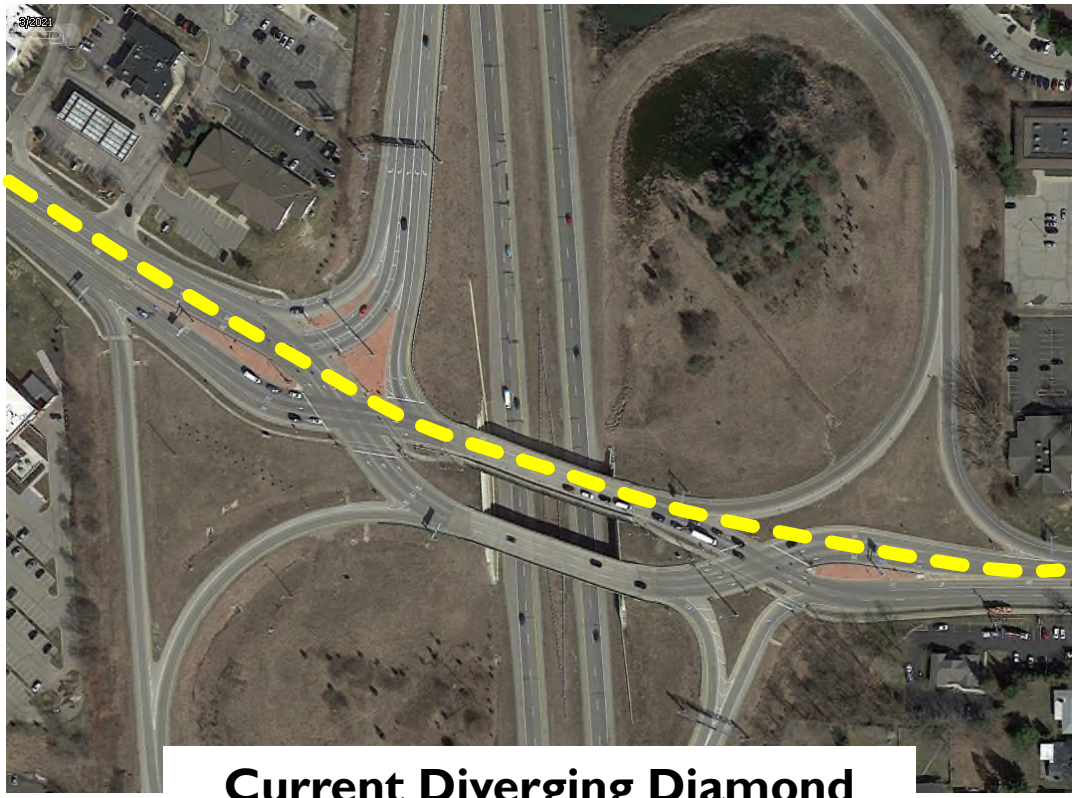


Current Diverging Diamond

Horizontal Alignment

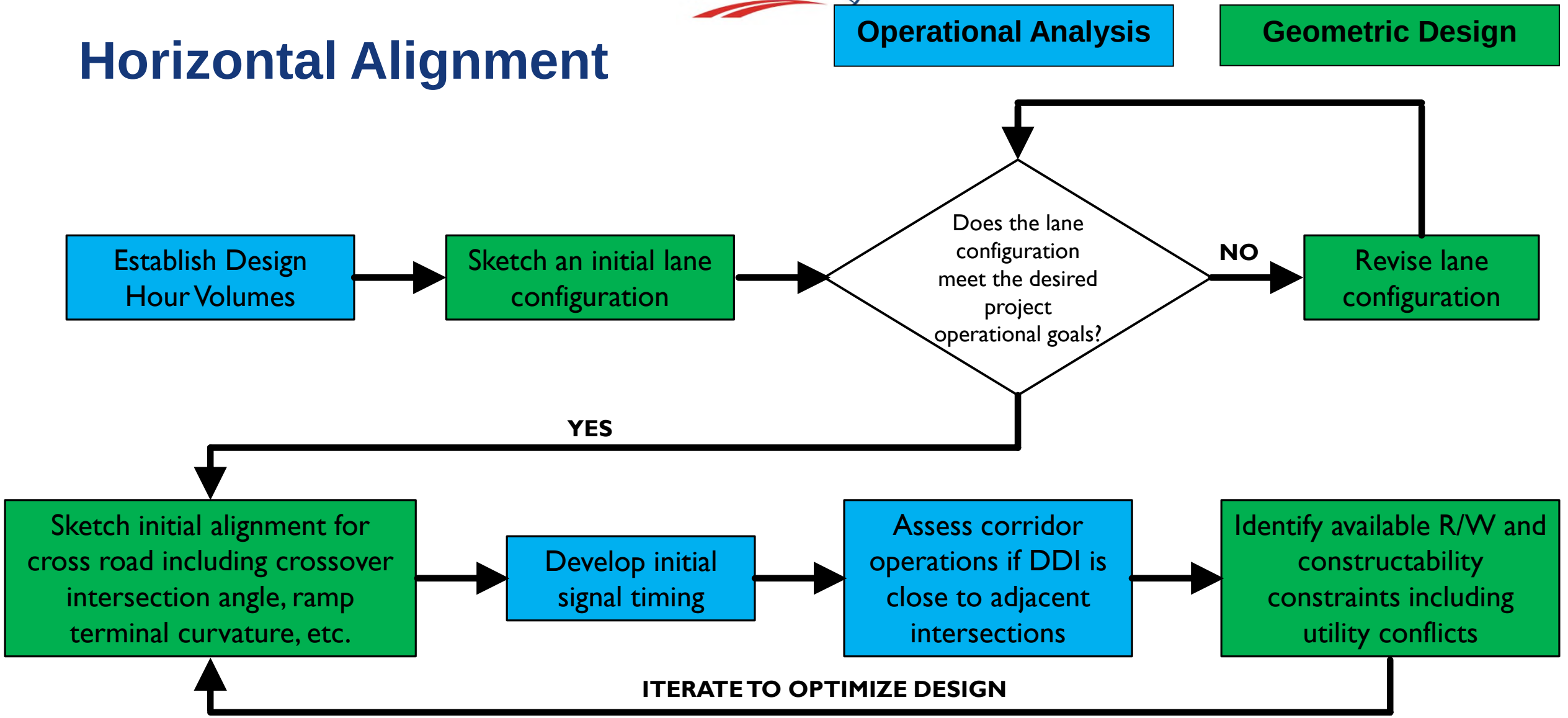
- **Alignment Alternatives**

Original Partial Cloverleaf



Current Diverging Diamond

Horizontal Alignment

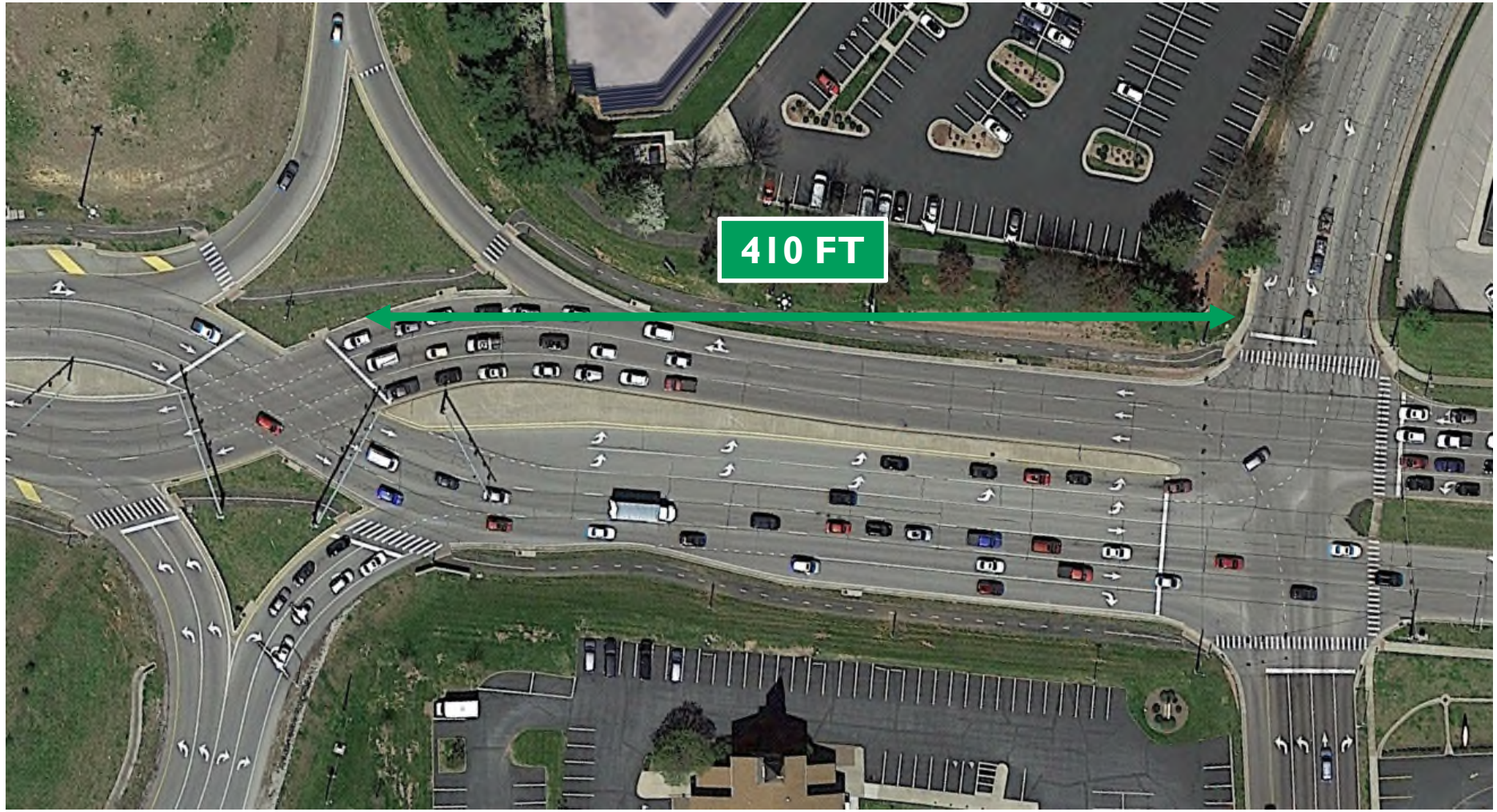


Horizontal Alignment

- **Position the Crossover Intersections**
  - Closely spaced signalized intersections

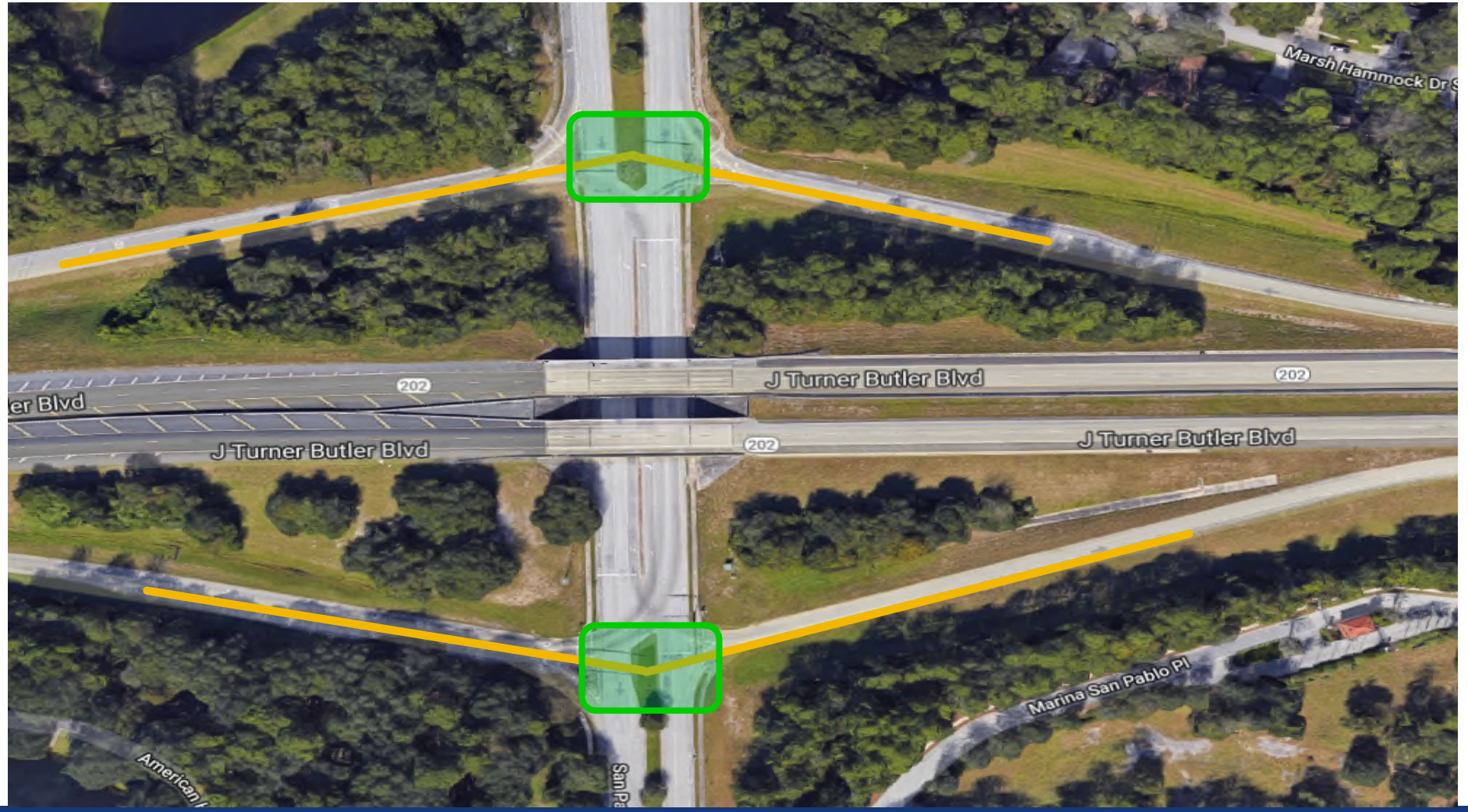
Horizontal Alignment

- **Position the Crossover Intersections**
  - Closely spaced signalized intersections
  - **No “magic dimension”**



Horizontal Alignment

- **Position the Crossover Intersections**
  - Closely spaced signalized intersections
  - **No “magic dimension”**
  - Close to existing intersections to minimize R/W impacts and signal inefficiencies

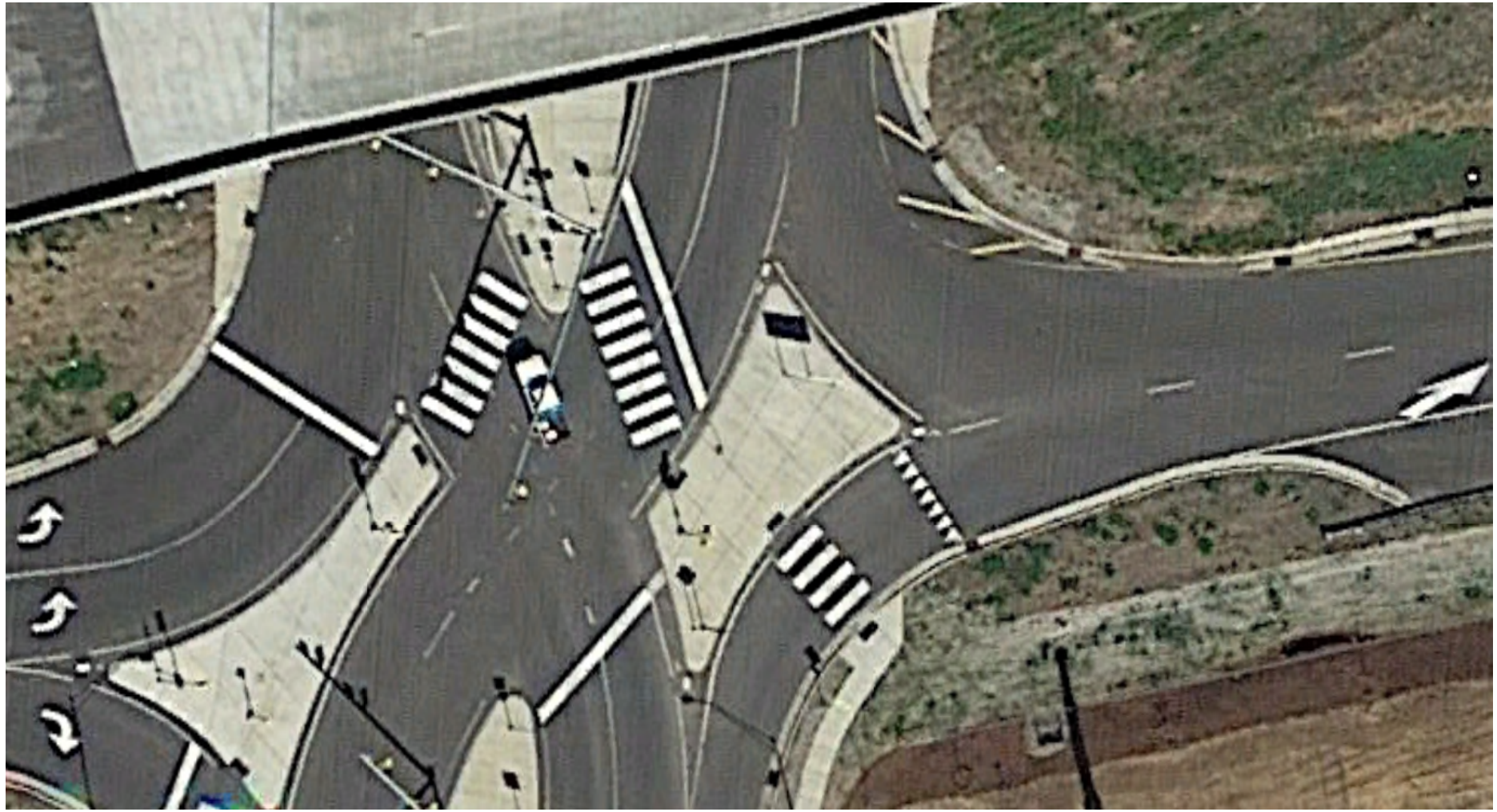


Horizontal Alignment

- **Critical Criteria**
  - **Lane Configuration**
    - Tied to Traffic Operations
    - Number of lanes
    - Length of storage at crossover intersections
    - Use of option lanes at the ramps
    - Need for auxiliary lanes
    - Lane utilization outside DDI

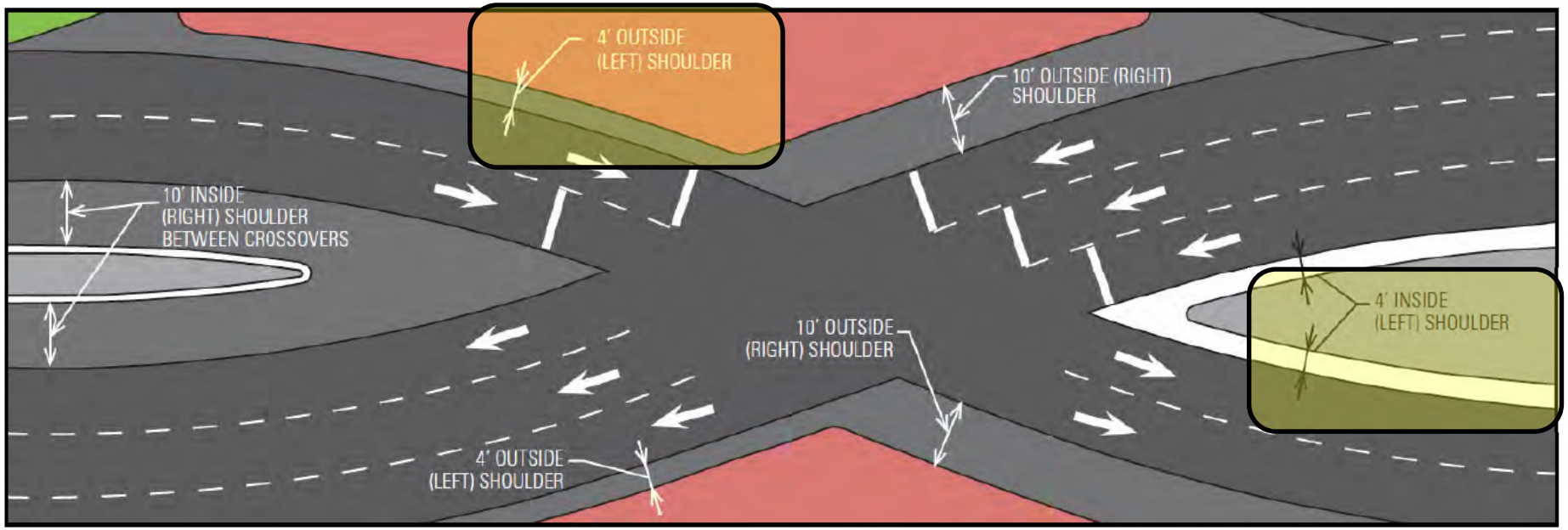
Horizontal Alignment

- **Critical Criteria**
  - Lane Configuration
  - **Lane Width**
    - Identify appropriate Design Vehicle, especially for multiple turn lanes
    - No encroachment into adjacent lanes, gutter or shoulder
    - Impacts overall roadway width on both arterial and ramps



Horizontal Alignment

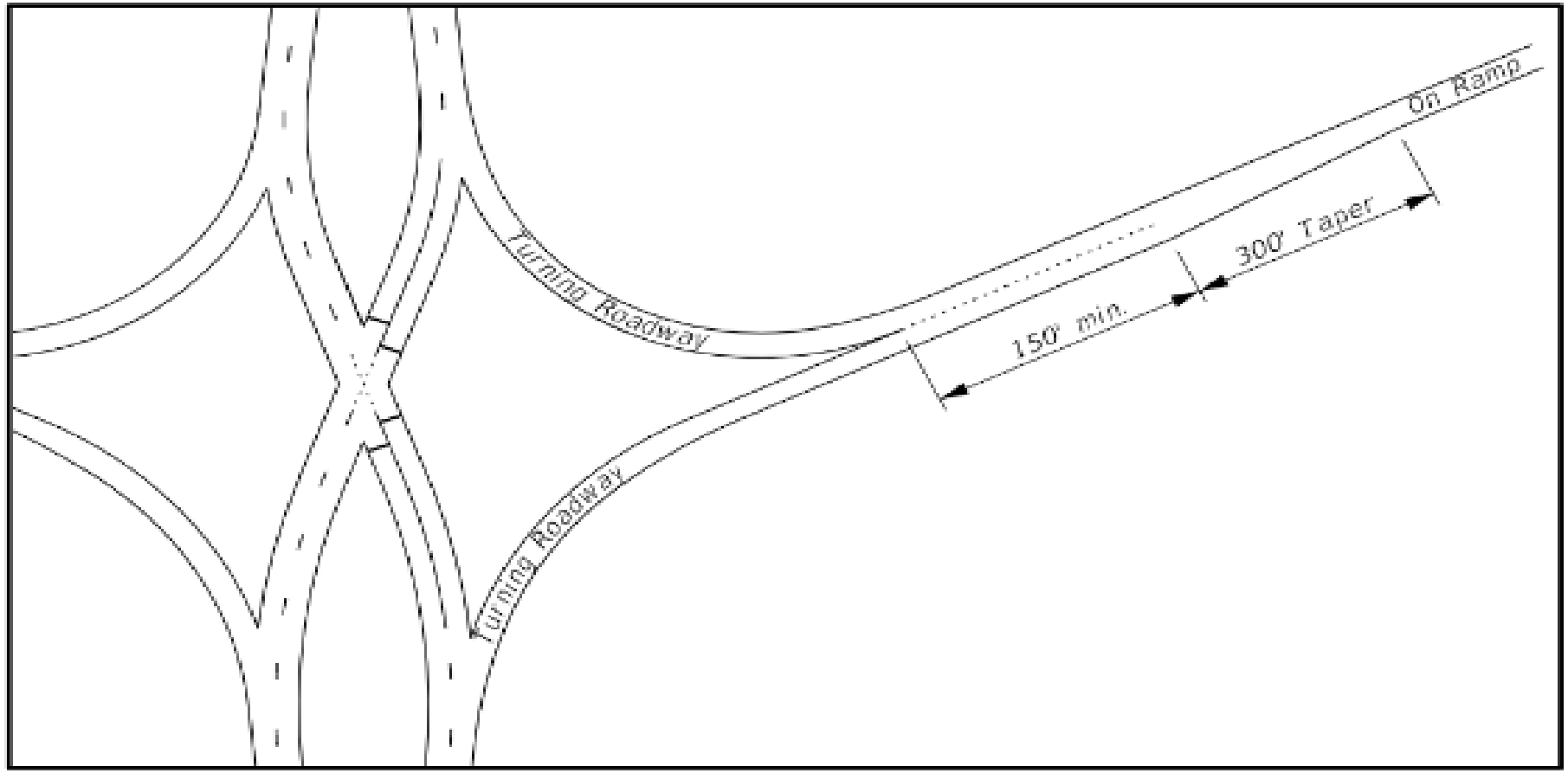
- **Critical Criteria**
  - Lane Configuration
  - Lane Width
  - **Use of Shoulders**
    - If shoulders are provided, it is recommended to maintain consistency in the right and left side shoulder widths even if contrary to what is “inside” and “outside” shoulders



Horizontal Alignment

- **Critical Criteria**
  - Lane Configuration
  - Lane Width
  - Use of Shoulders
  - **Merging Ramp Junctions**
    - When turning roadways merge together to form a single lane, provide acceleration length beyond the merge point

Figure 217.3.4 Merging Ramp Lanes



CROSSOVER INTERSECTION

Crossover Intersection

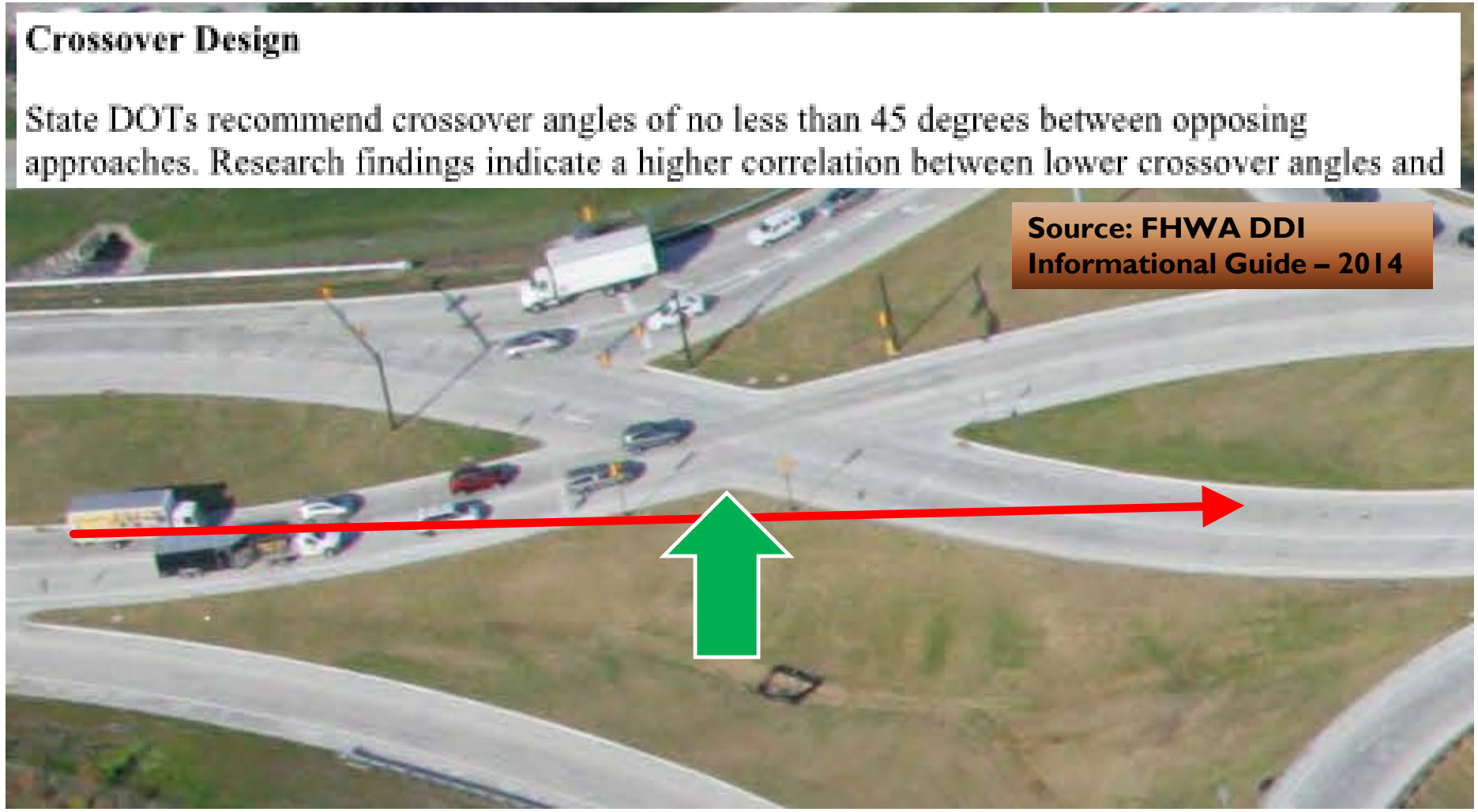
- Intuitive to Drivers

Crossover Intersection

- **Critical Criteria**
  - Eyebrow vs Crossover Angle
  - Barrier along eyebrow
  - Vehicle path alignment
  - Cross slope
  - Sight lines

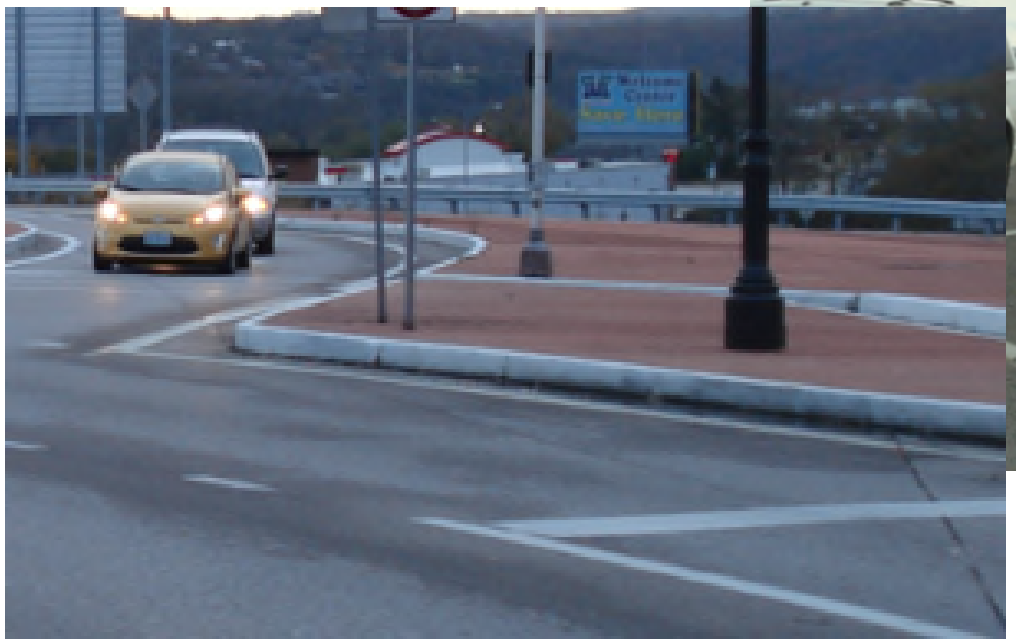
Crossover Intersection

- **Critical Criteria**
  - **Eyebrow vs Crossover Angle**
    - Dependent on several factors, including number of lanes, approach curvature, R/W constraints
    - The larger the DDI (more lanes) often the larger the crossover angle
    - Tradeoffs exist with signal operations



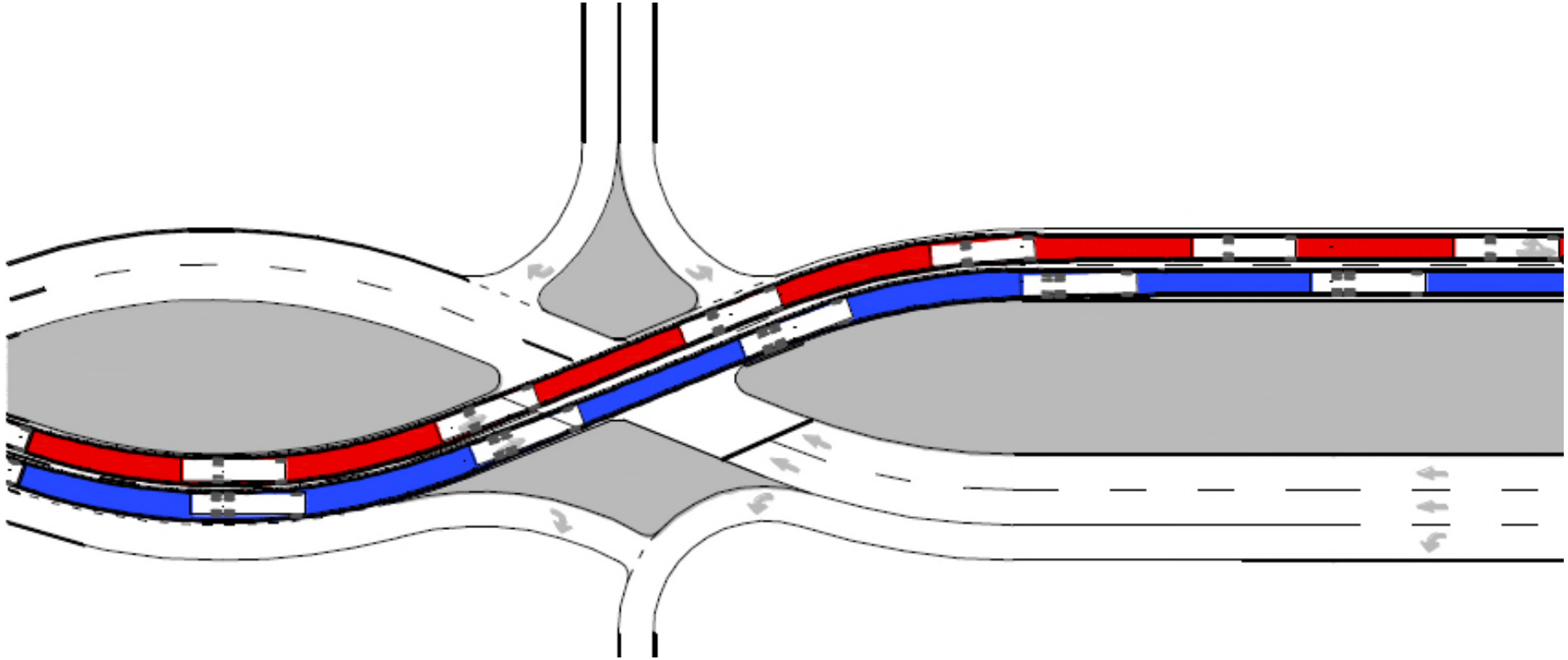
Crossover Intersection

- **Critical Criteria**
  - **Barrier along eyebrow**
    - Doesn’t need to be substantial height
    - Needs to be visible – use of contrasting color between pavement and island



Crossover Intersection

- **Critical Criteria**
  - **Vehicle path alignment**
    - Should direct vehicles into the proper receiving lane
    - Drivers should be able to drive “straight” thru the crossover intersection



Crossover Intersection

- **Critical Criteria**
  - **Vehicle path alignment**
    - Should direct vehicles into the proper receiving lane
    - Drivers should be able to drive “straight” thru the crossover intersection
    - Insufficient tangent makes an awkward driving path

Crossover Intersection

- **Critical Criteria**
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    - Should direct vehicles into the proper receiving lane
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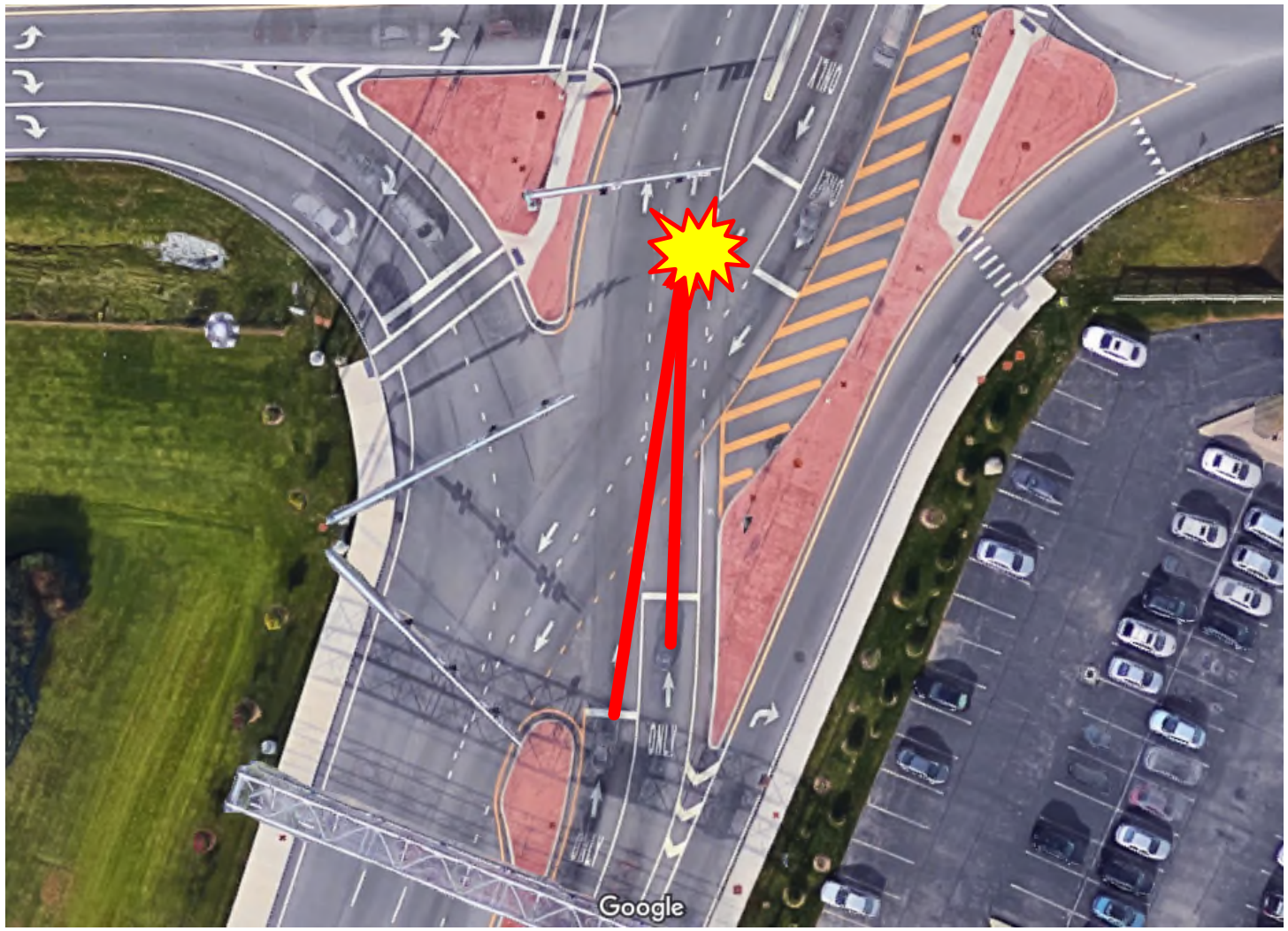


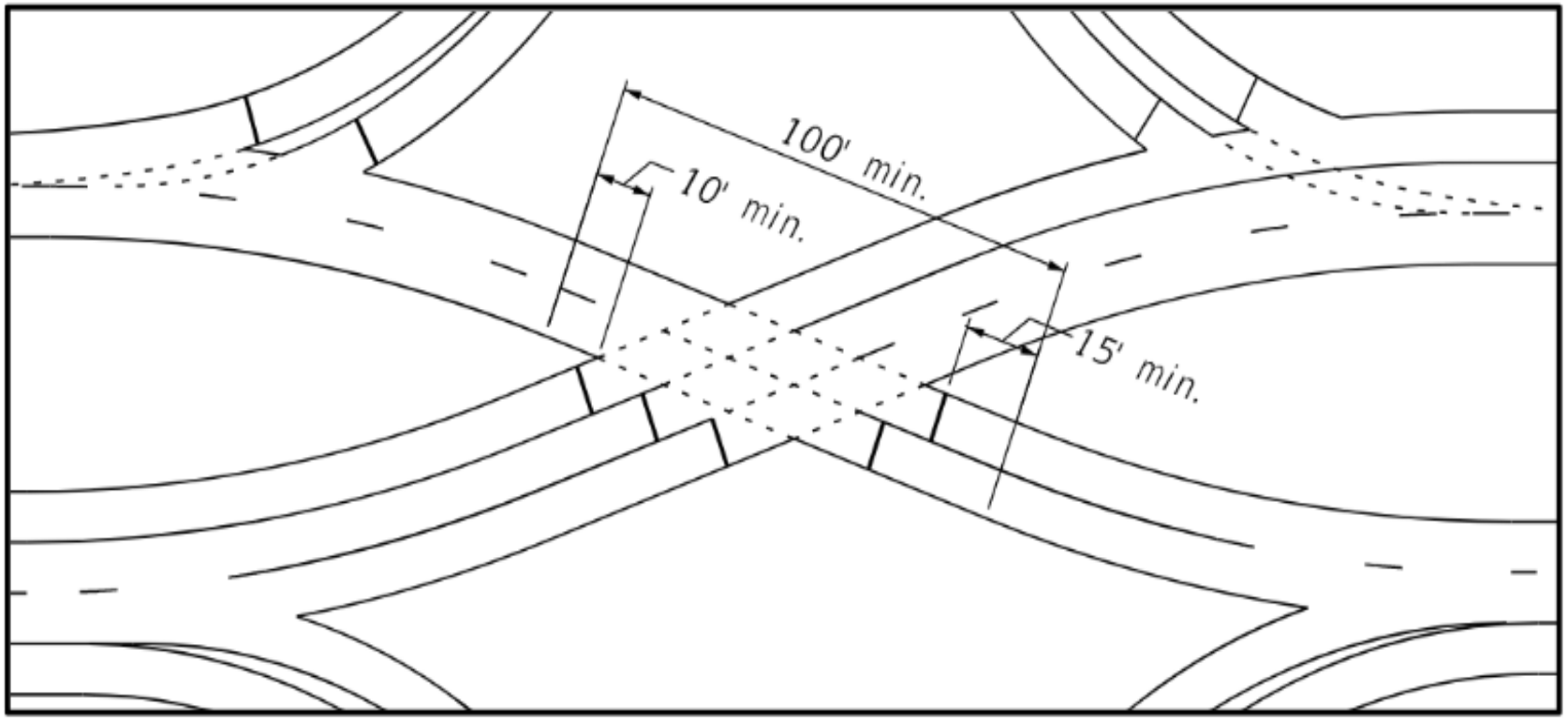
Crossover Intersection

- **Critical Criteria**
  - **Vehicle path alignment**
    - Should direct vehicles into the proper receiving lane
    - Drivers should be able to drive “straight” thru the crossover intersection
    - Insufficient tangent makes an awkward driving path

Crossover Intersection

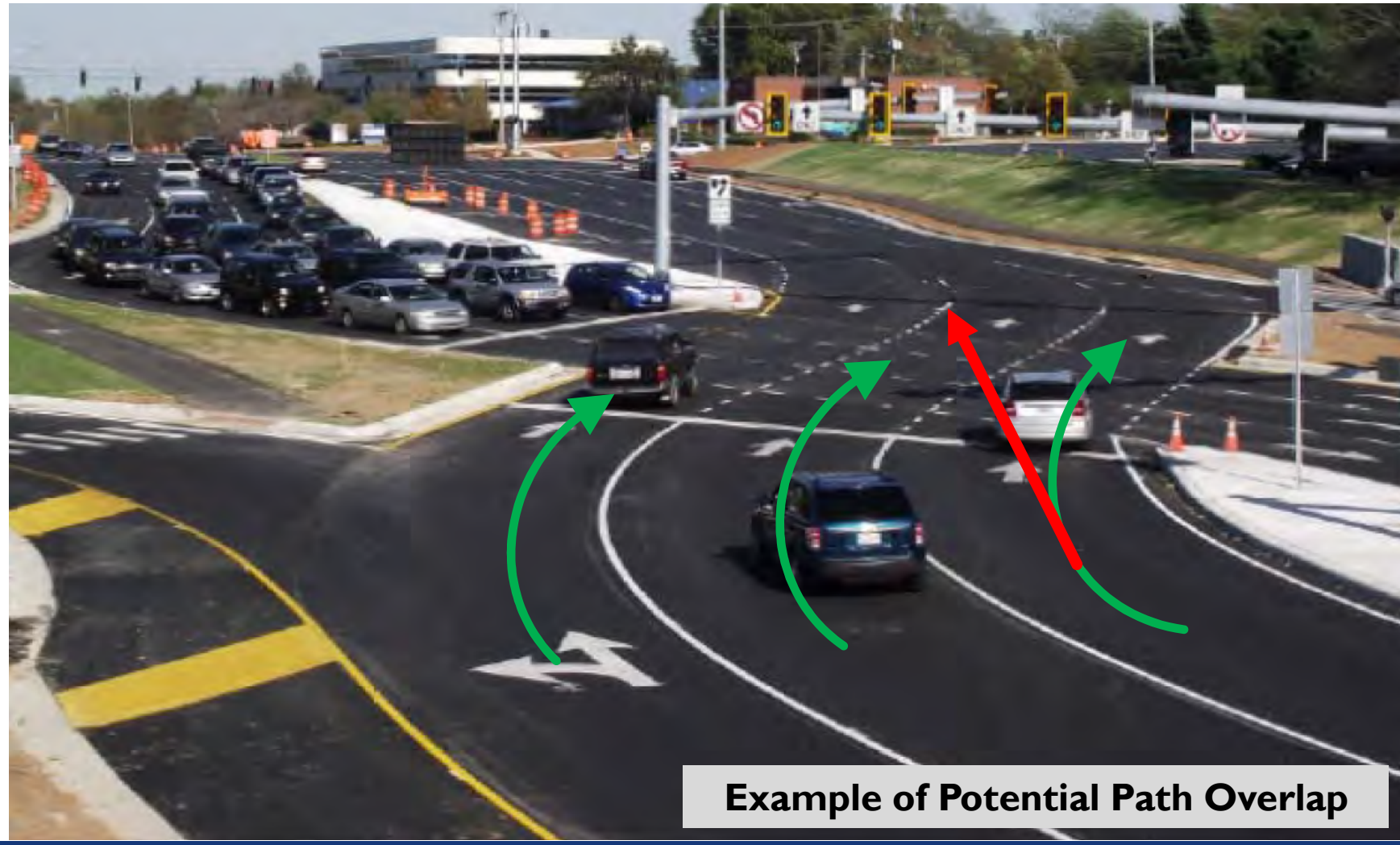
- **Critical Criteria**
  - **Vehicle path alignment**
    - Don’t introduce curvature within the crossover intersection
    - Give drivers a target straight ahead on the other side of the intersection to aim for

Figure 217.3.3 Tangents at Crossover Intersections



Crossover Intersection

- **Critical Criteria**
  - **Vehicle path alignment**
    - Driver's "natural path" is also influenced by the sharpness of curvature
    - Designers should try to "balance" the tangent length and degree of curvature



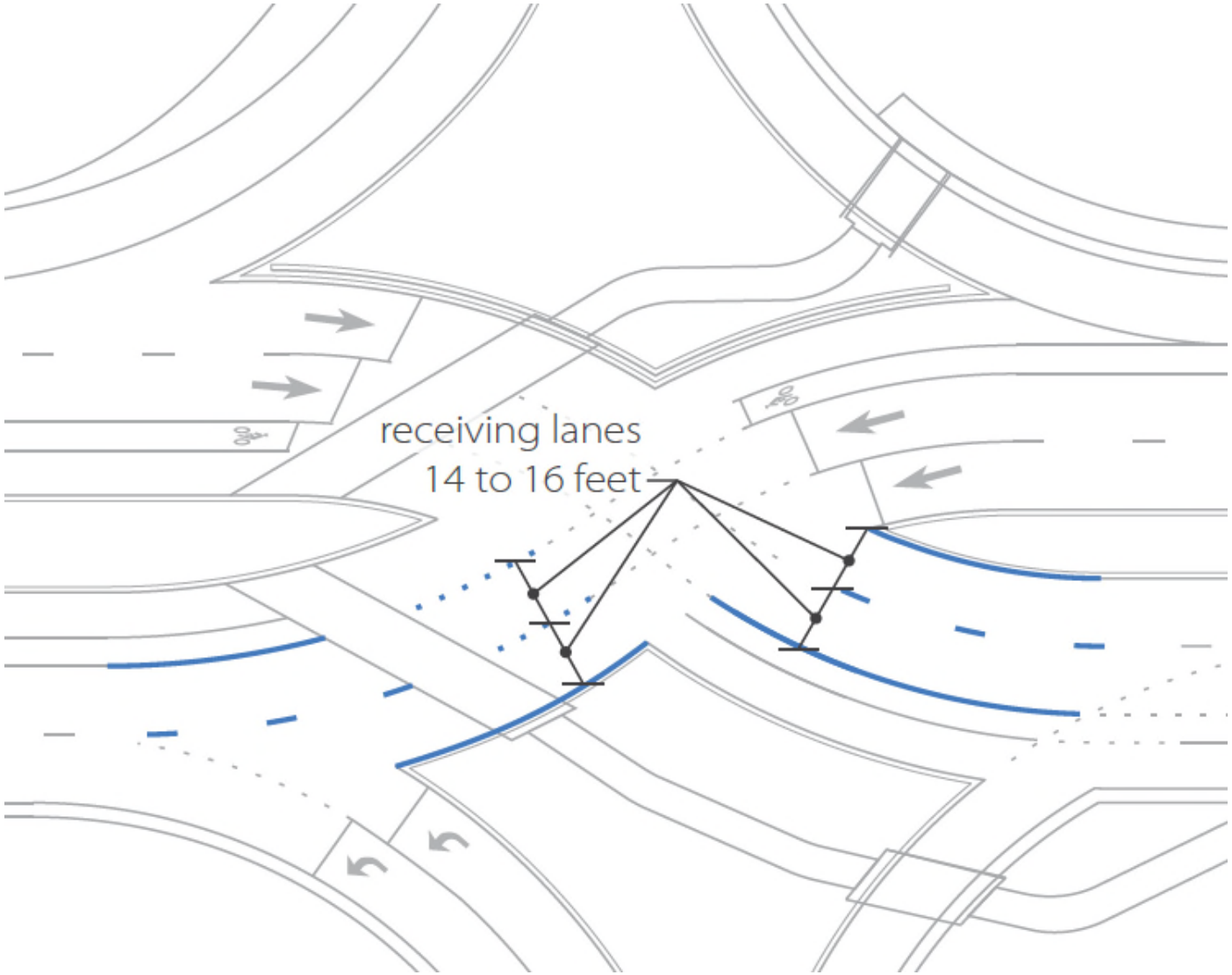
Example of Potential Path Overlap

Crossover Intersection

- **Critical Criteria**
  - **Vehicle path alignment**
    - Driver's "natural path" is also influenced by the sharpness of curvature
    - Designers should try to "balance" the tangent length and degree of curvature
    - Consider "Q Tip" Design

Crossover Intersection

- **Critical Criteria**
  - **Vehicle path alignment**
    - Lane widths can be widened to 14-16 feet to accommodate off tracking of the design vehicle

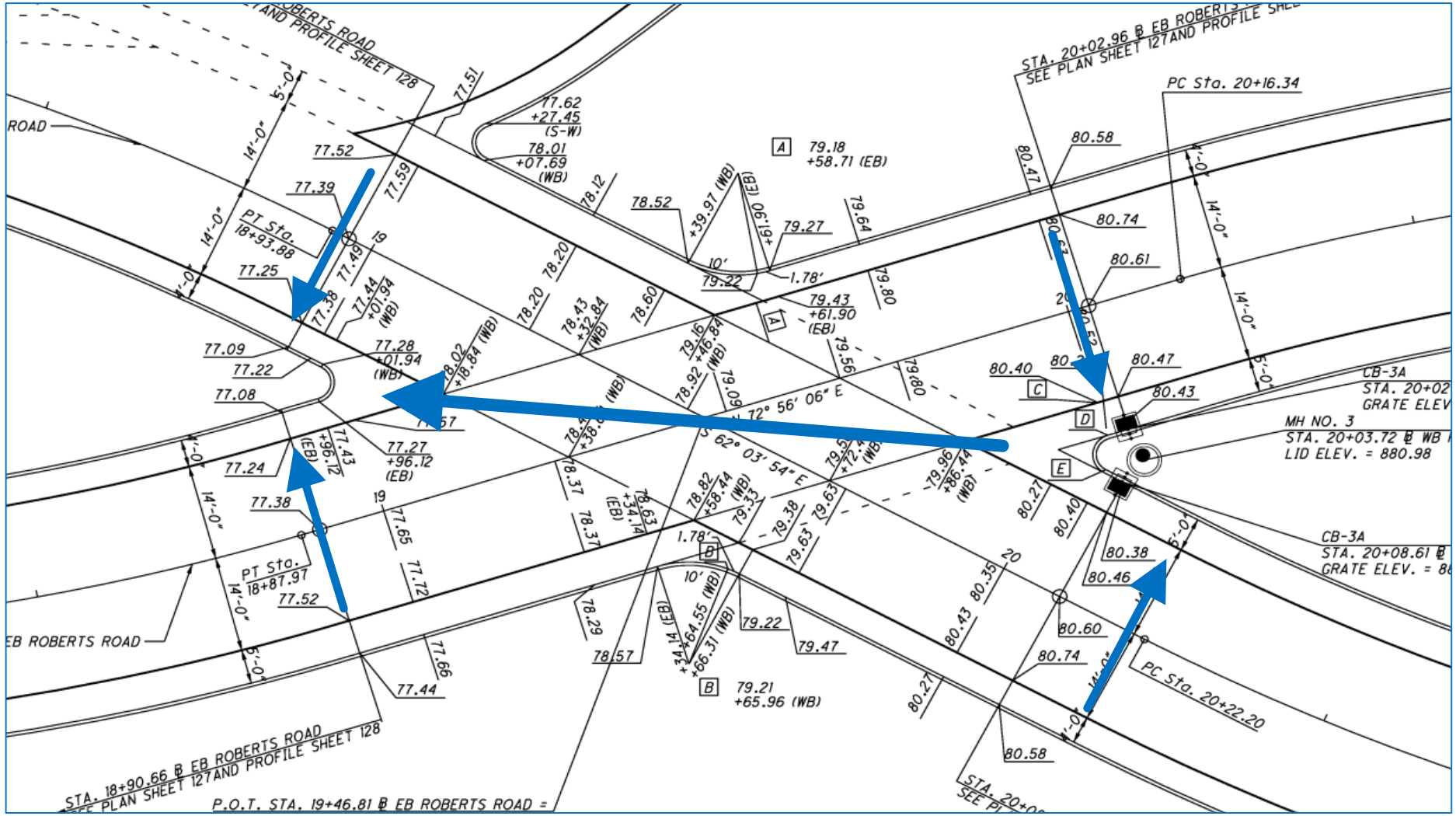


Crossover Intersection

- **Critical Criteria**
  - **Vehicle path alignment**
    - Lane widths can be widened to 14-16 feet to accommodate off tracking of the design vehicle
    - If curvature is sharp, consider 16 feet or a marked buffer area between lanes

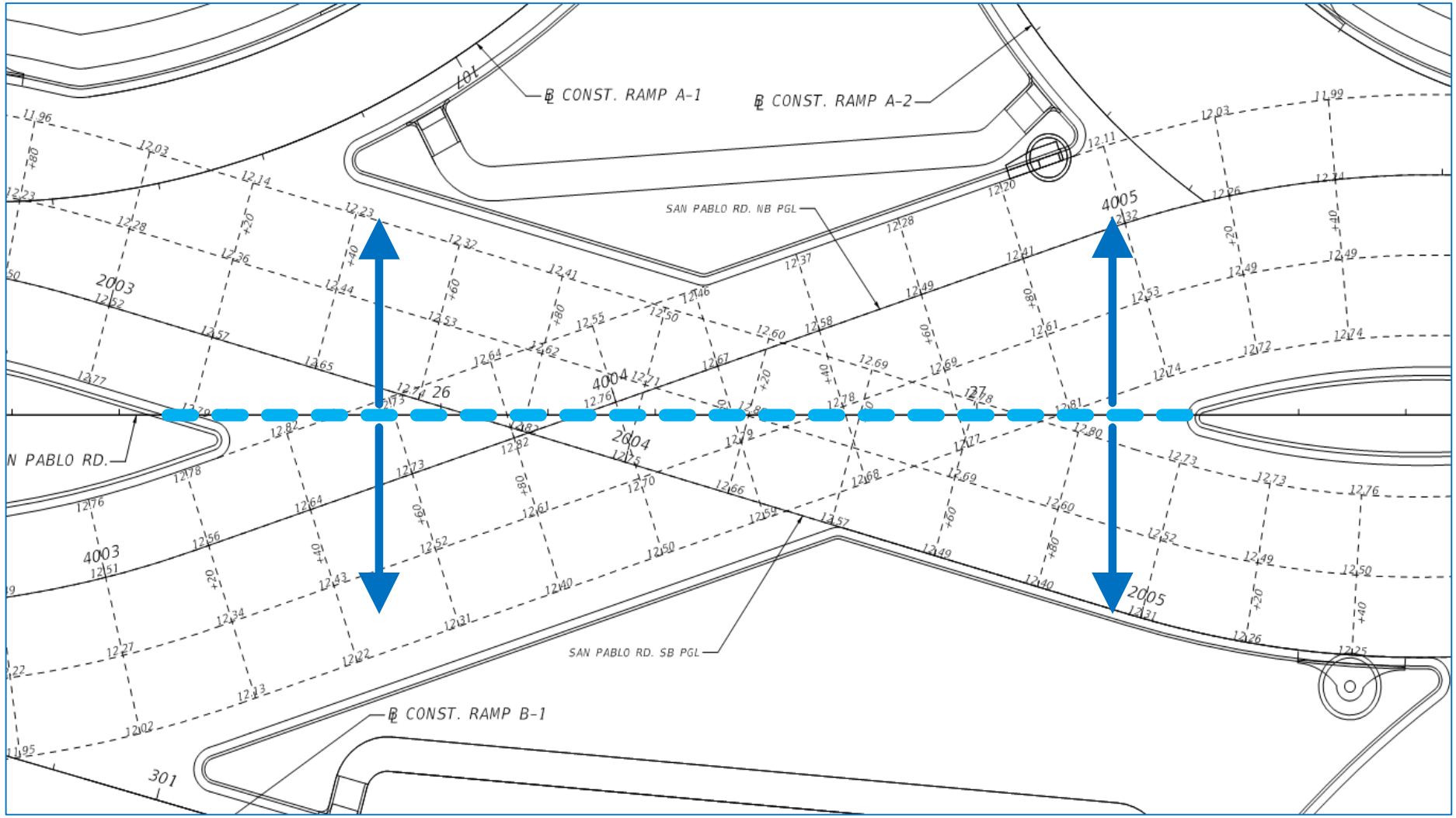
Crossover Intersection

- **Critical Criteria**
  - **Cross slope**
    - Crossover roadway surfaces should result in smooth, continuous pavement edge profiles
    - Providing positive drainage is critical, especially due the large size the intersections can be



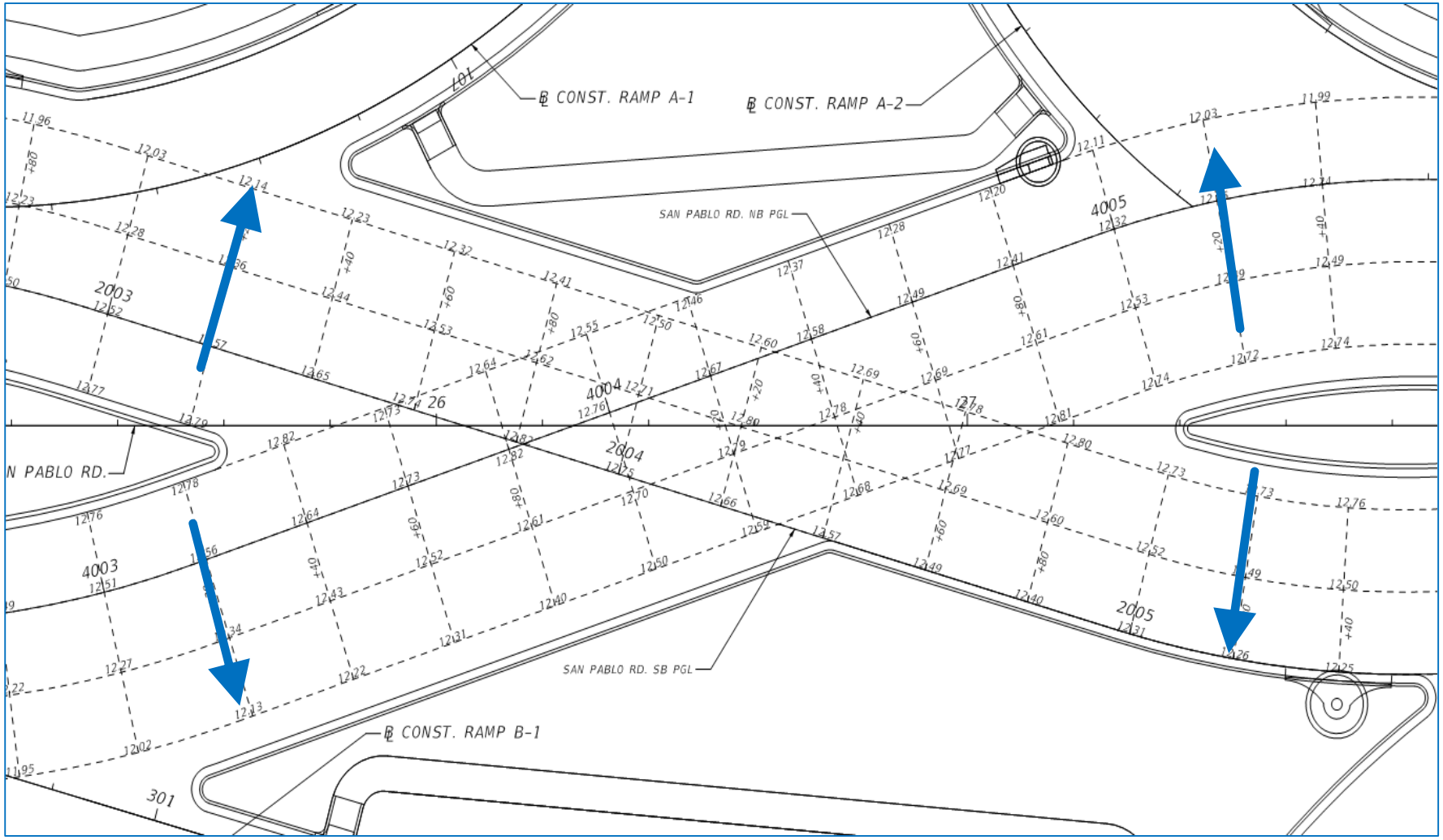
Crossover Intersection

- **Critical Criteria**
  - **Cross slope**
    - The maximum algebraic difference in cross slopes at crossover lines should be limited to 4%



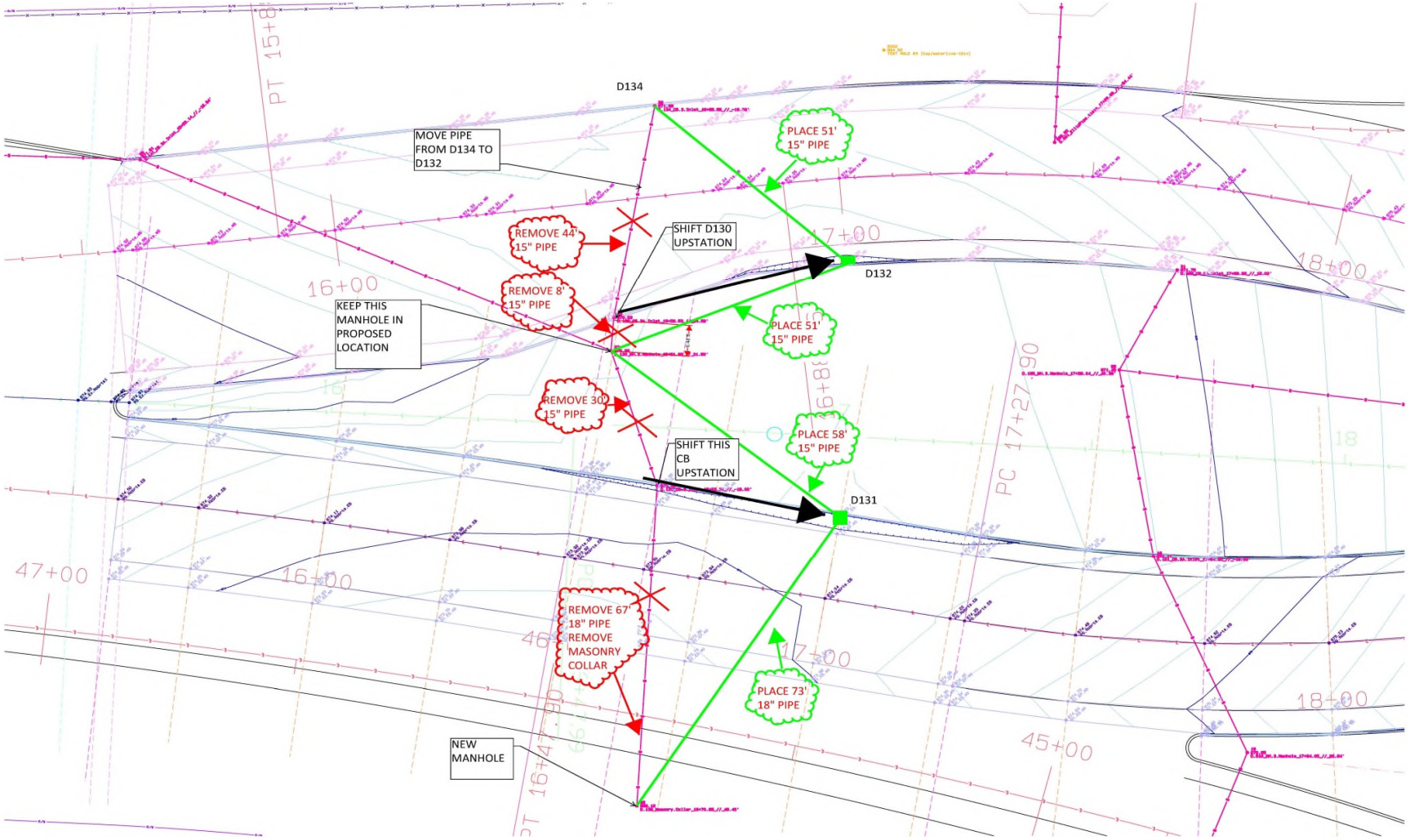
Crossover Intersection

- **Critical Criteria**
  - **Cross slope**
    - The maximum algebraic difference in cross slopes at crossover lines should be limited to 4%
    - Crossover regions do not represent a typical roadway situation and typical superelevation criteria for open road conditions do not apply.



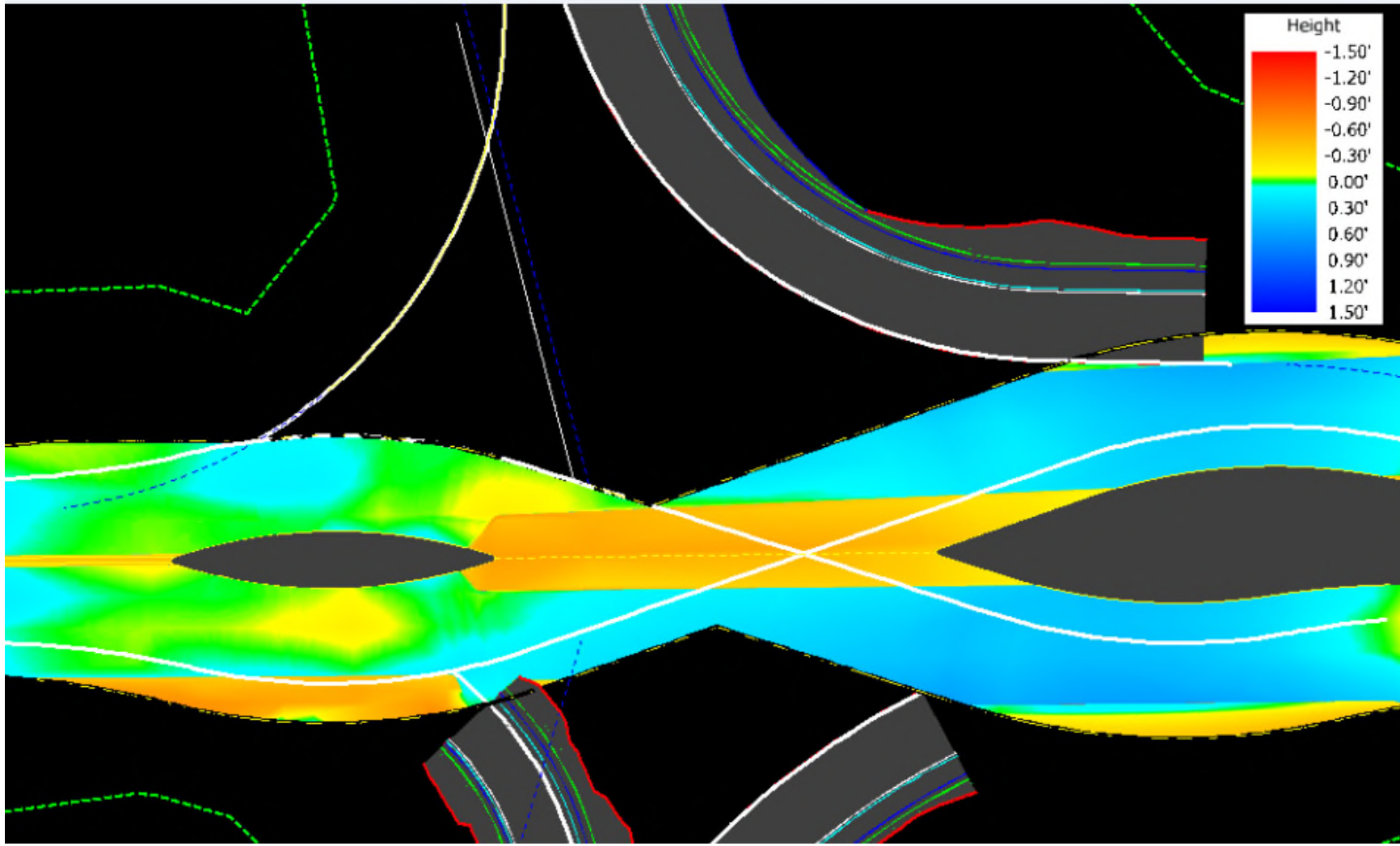
Crossover Intersection

- **Critical Criteria**
  - **Cross slope**
    - The cross slope and vertical profiles of each roadway through the intersection are interdependent. Development of the roadway surfaces requires a 3D approach.
    - Roadway surfaces should be developed to provide effective drainage. Avoid low points and flat slopes that do not drain properly.



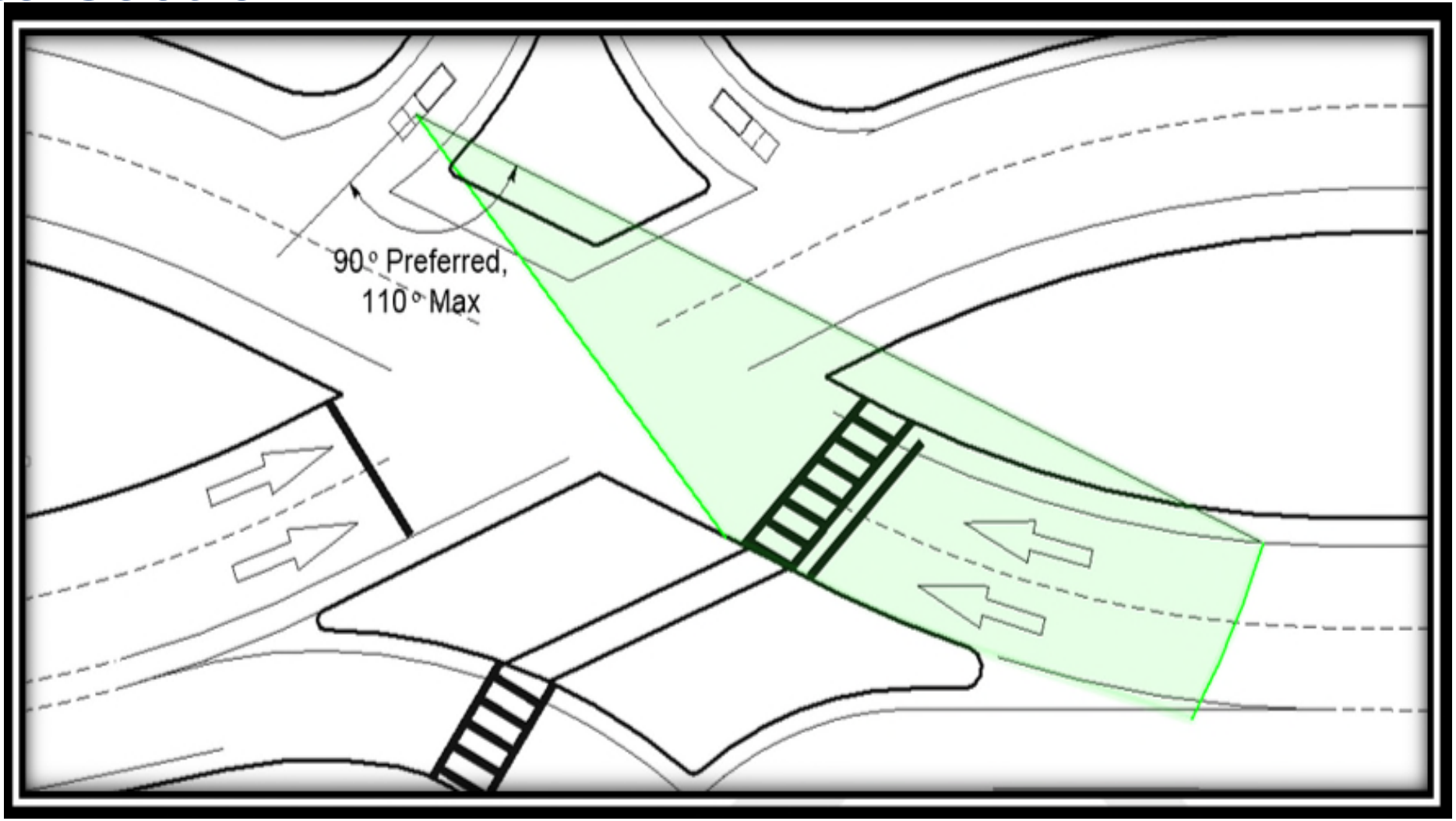
Crossover Intersection

- **Critical Criteria**
  - **Proposed Surfaces**
    - Heat maps can be created to compare proposed surface to the existing to maximize cross slope correction/pavement resurfacing and minimize the need for full-depth pavement reconstruction.



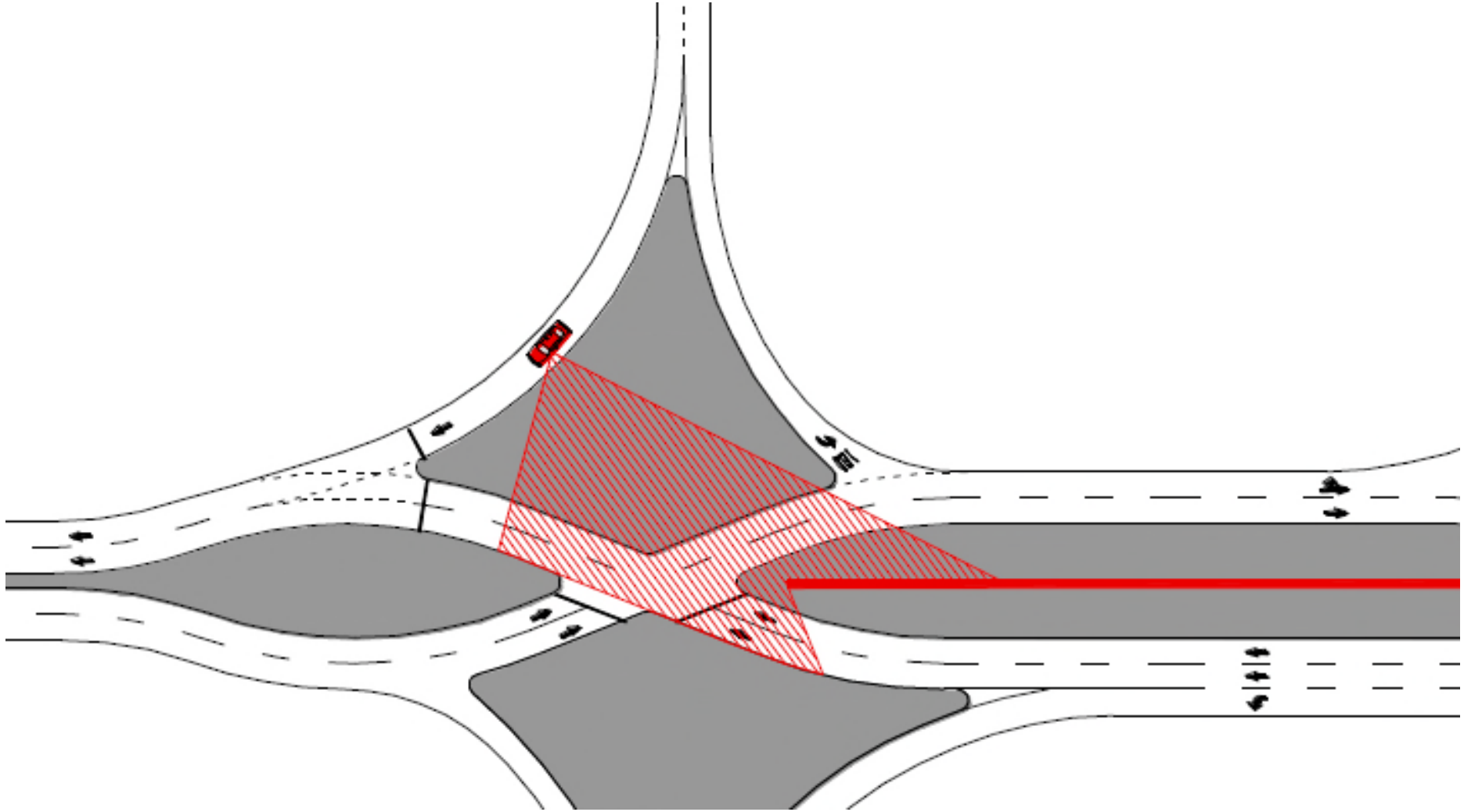
Crossover Intersection

- **Critical Criteria**
  - **Sight Line**
    - An angle close to 90 degrees for the “look back angle” from the exit ramp is preferable, with a maximum of 110 degrees in consideration of drivers having difficulty turning their necks



Crossover Intersection

- **Critical Criteria**
  - **Sight Line**
    - Median barrier can block driver sight lines
    - Consider truncating the end of the barrier wall or lower the wall height to increase sight distance



Crossover Intersection

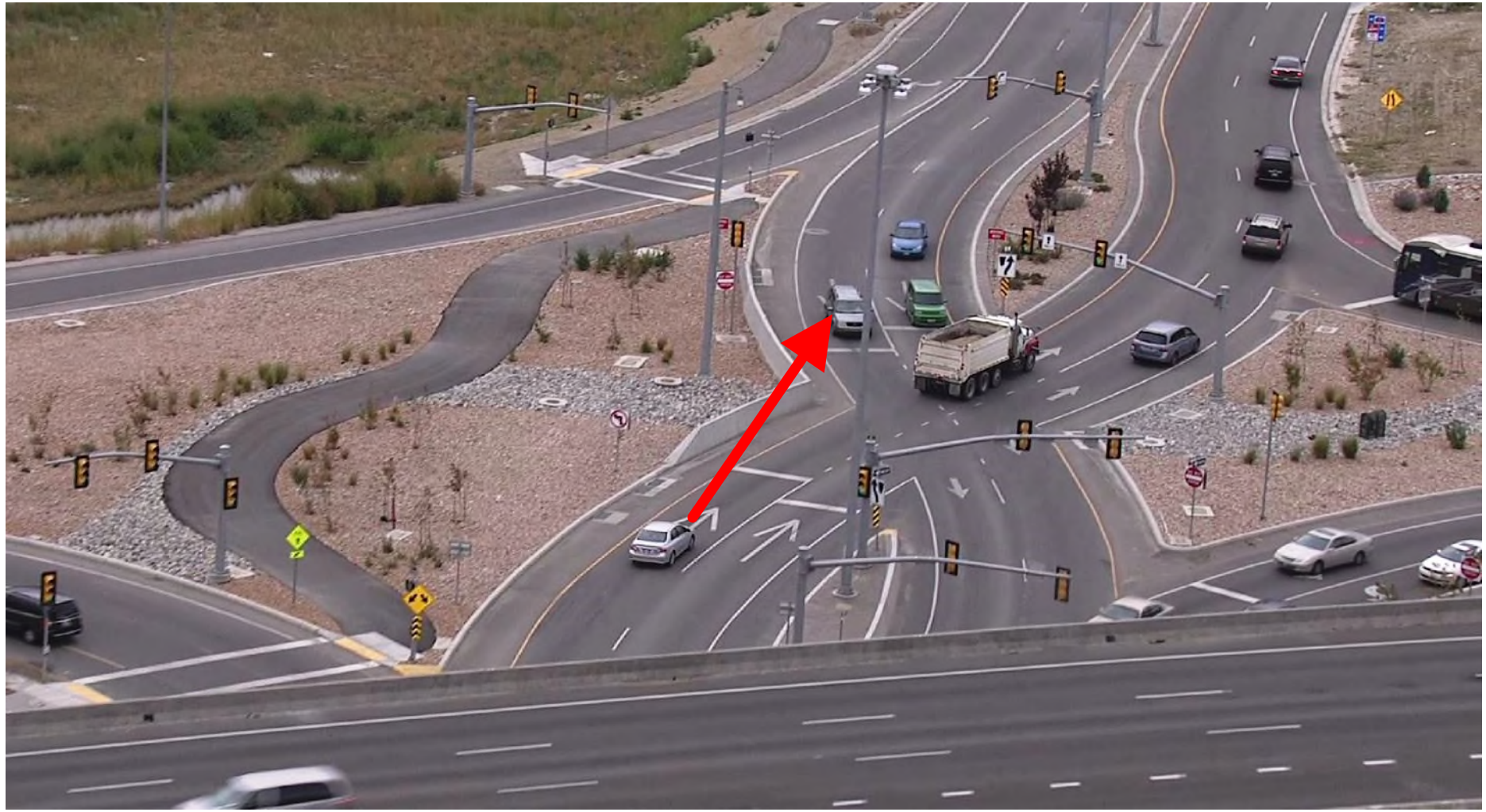
- **Critical Criteria**
  - **Sight Line**
    - The red line shows how the barrier wall could be altered to provide better sight distance

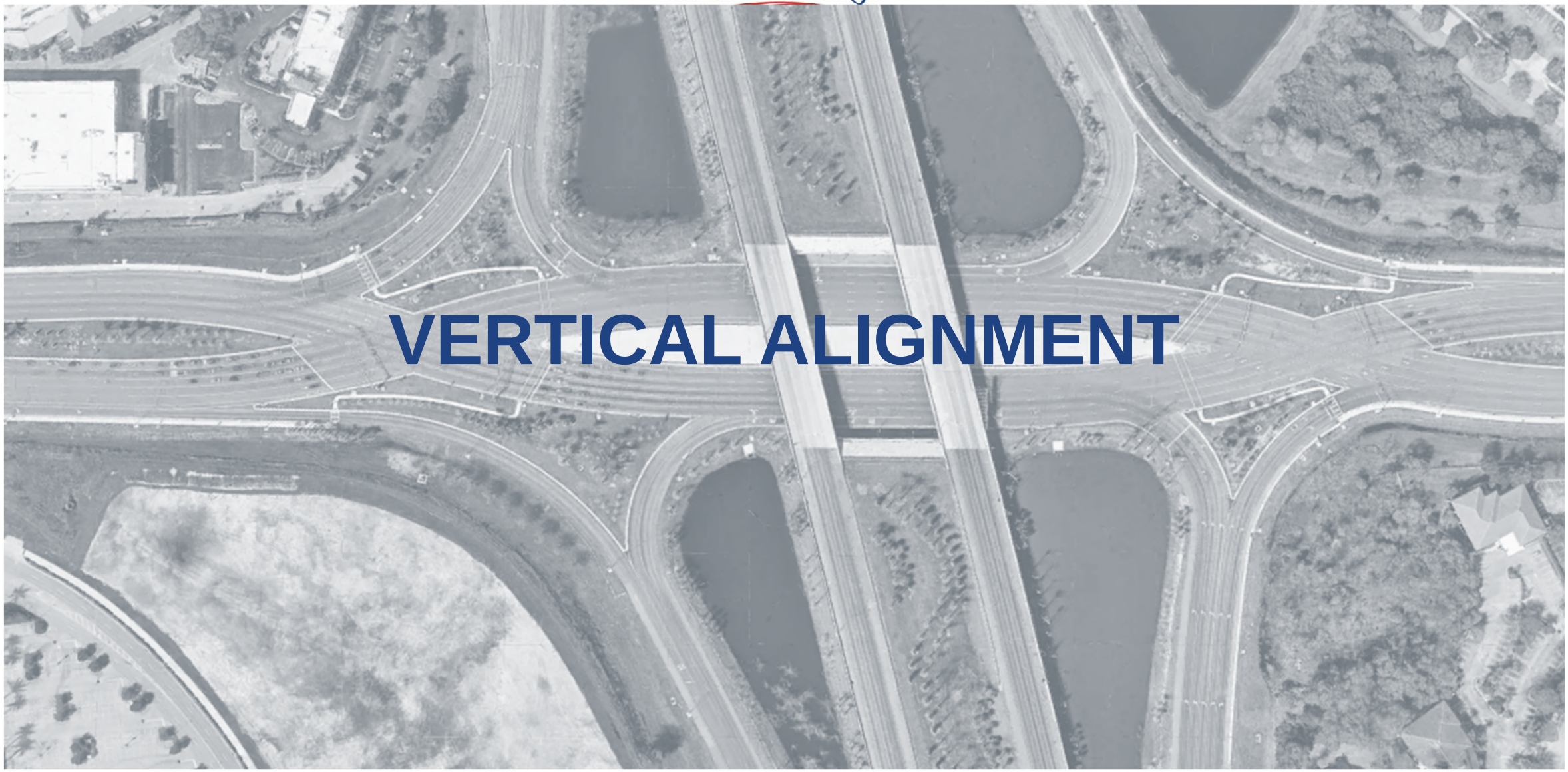
Crossover Intersection

- **Critical Criteria**
  - **Sight Line**

Crossover Intersection

- **Critical Criteria**
  - **Sight Line**
    - When using barrier along the eyebrow, make sure sight line is still available for drivers to see oncoming vehicles approaching the crossover intersection





VERTICAL ALIGNMENT

Vertical Alignment

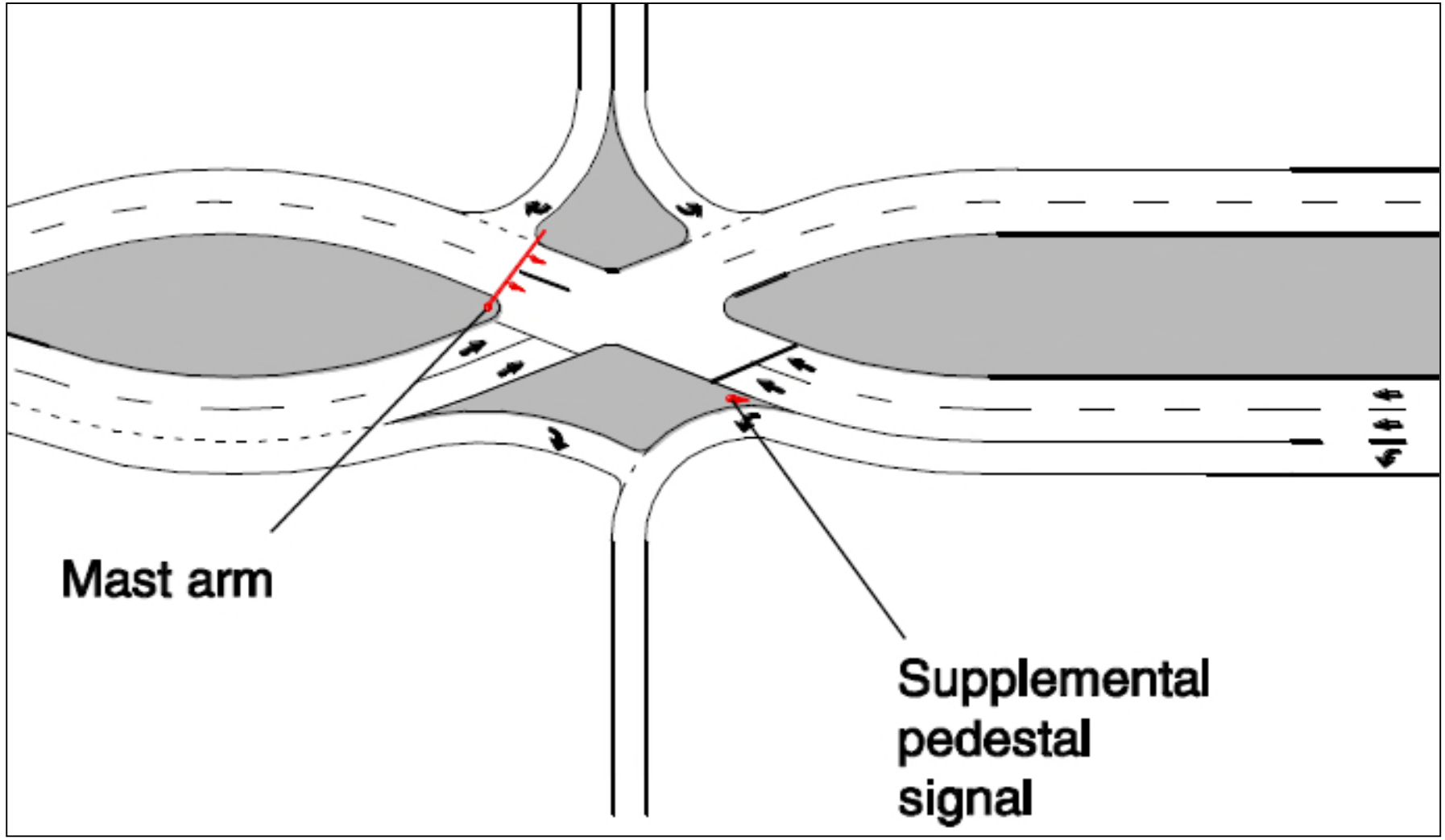
- **Vertical Sight Distance**
  - **Profiles**
    - DDI profiles should be relatively flat to increase driver sight distance

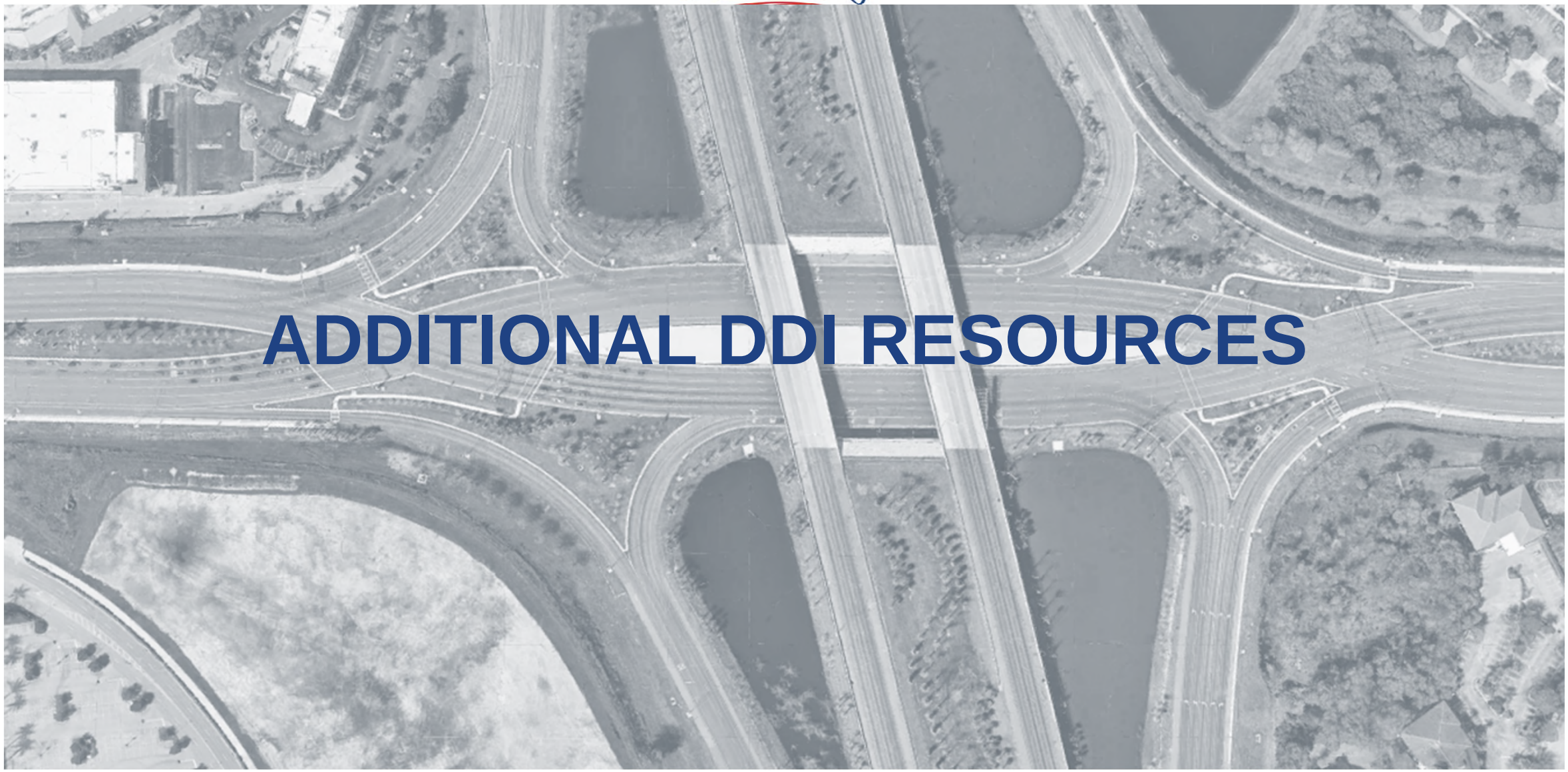
Vertical Alignment

- **Vertical Sight Distance**
  - **Profiles**
    - DDI profiles should be relatively flat to increase driver sight distance
    - Consider visibility of downstream crossover intersection

Vertical Alignment

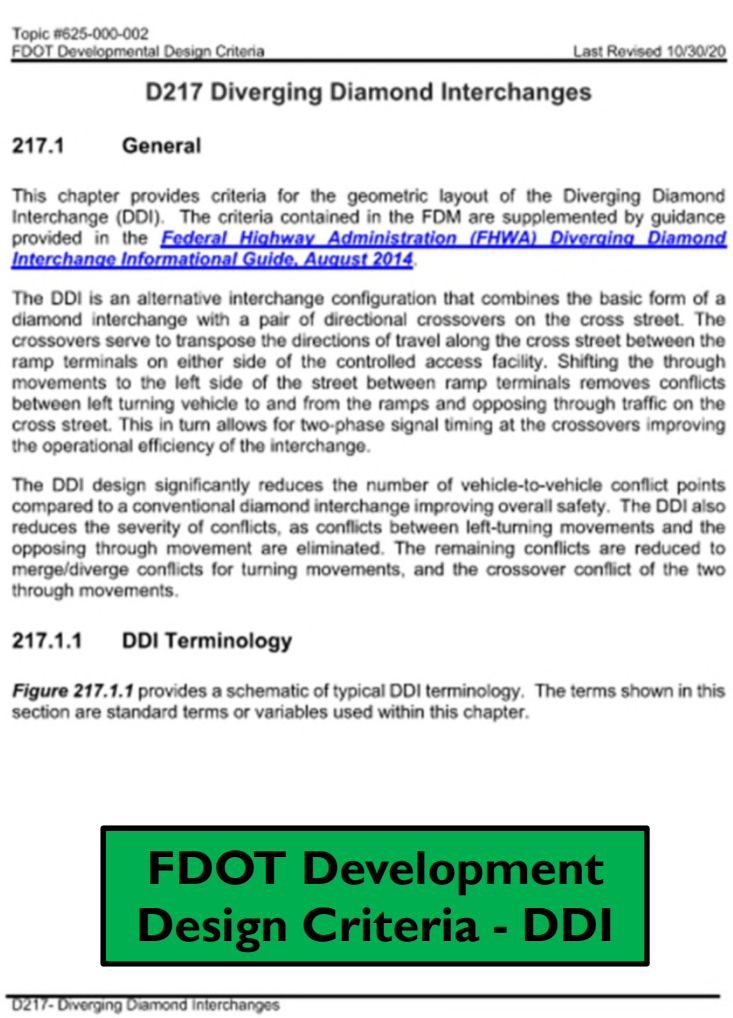
- **Vertical Sight Distance**
  - **Profiles**
    - DDI profiles should be relatively flat to increase driver sight distance
    - Consider visibility of downstream crossover intersection
    - When traffic signals are not visible, consider supplemental advance signals





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.

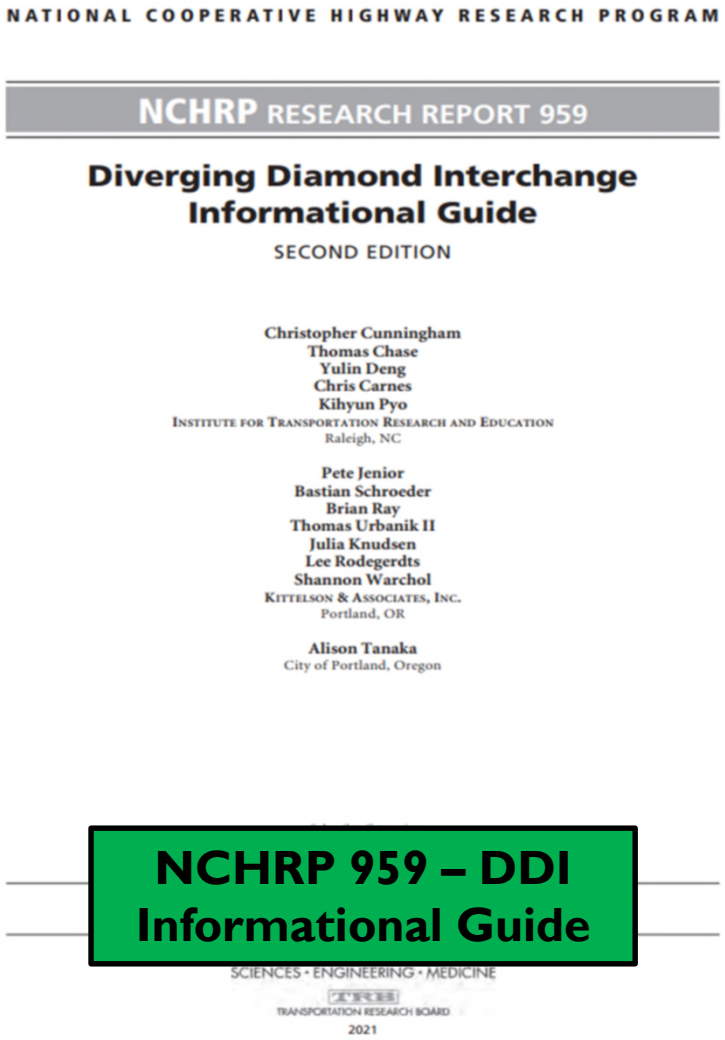
The DDI design significantly reduces the number of vehicle-to-vehicle conflict points compared to a conventional diamond interchange improving overall safety. The DDI also reduces the severity of conflicts, as conflicts between left-turning movements and the opposing through movement are eliminated.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



NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP RESEARCH REPORT 959

Diverging Diamond Interchange Informational Guide

SECOND EDITION

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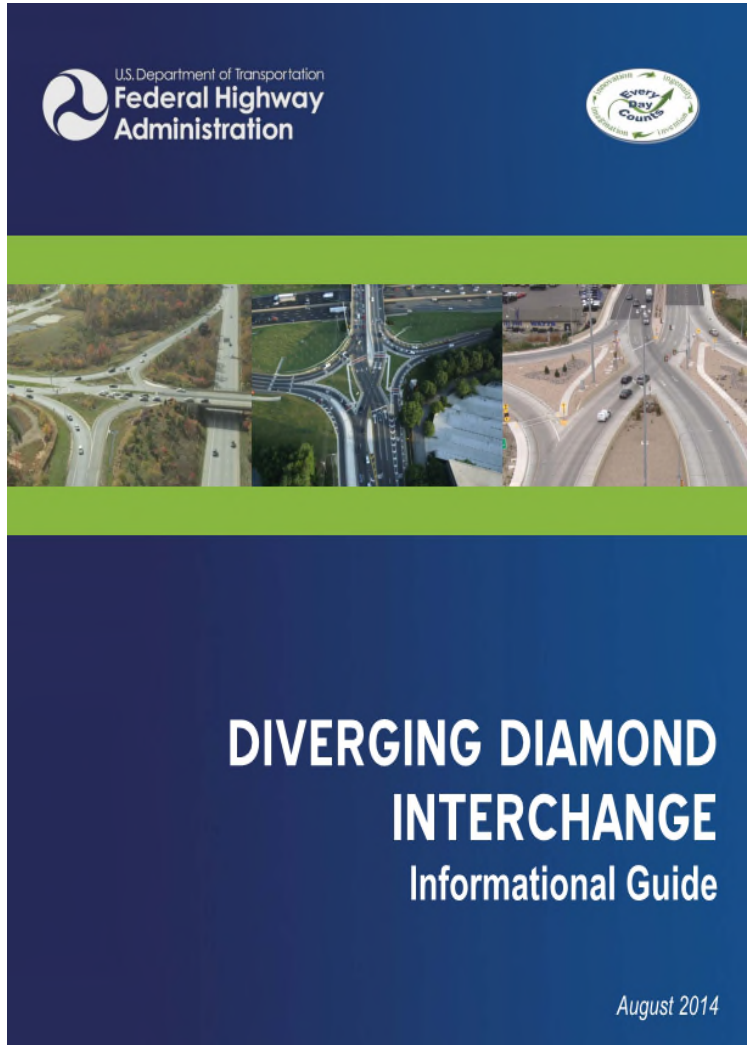
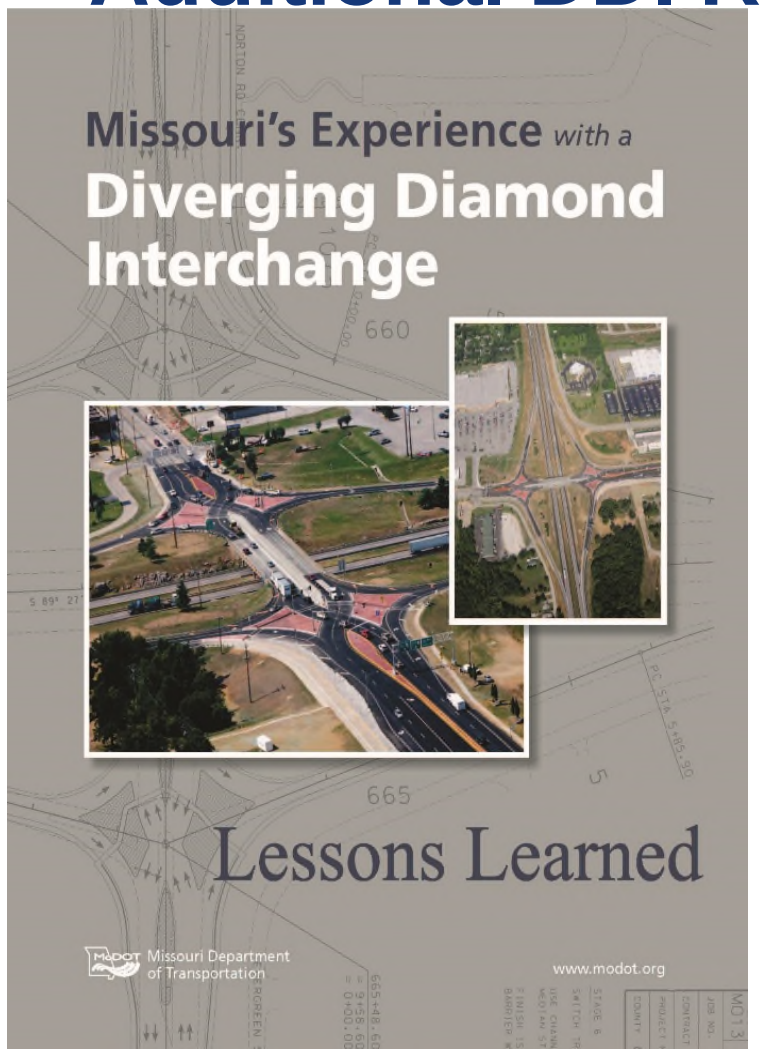


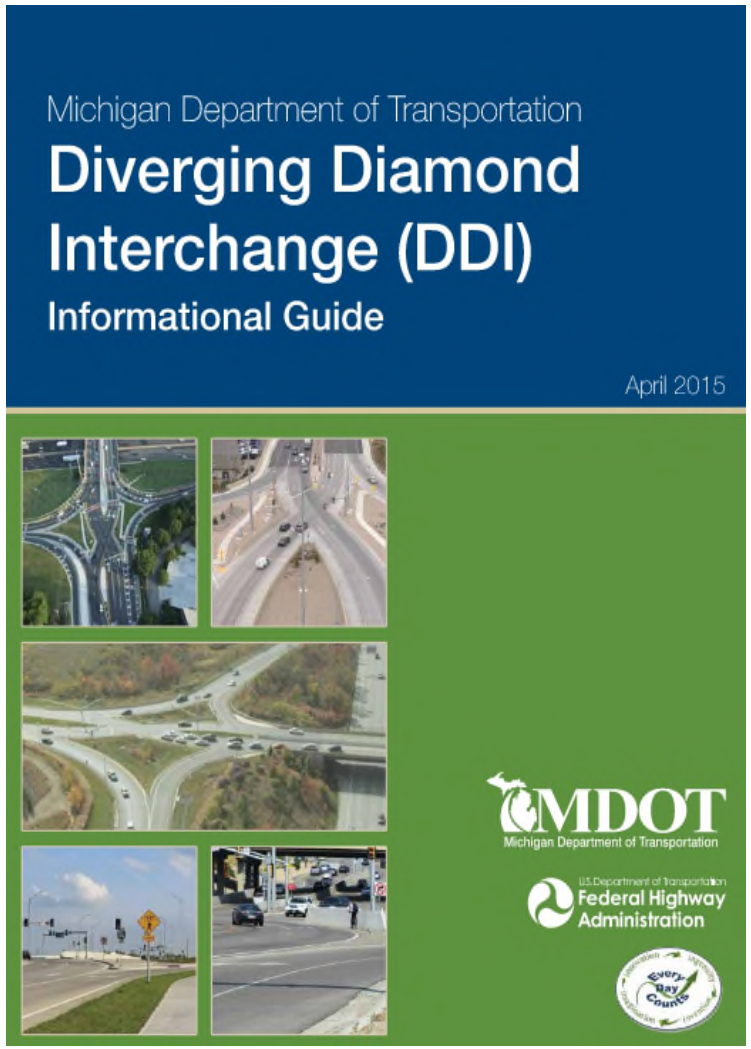
U.S. Department of Transportation
Federal Highway Administration

DIVERGING DIAMOND INTERCHANGE
Informational Guide

August 2014

Additional DDI Resources





FDOT DDI Design Webinar Series

- **Schedule:**

DDI Overview	June 15, 2021	2p-5p
DDI Geometric Design	June 29, 2021	2p-3p
DDI Signing and Pavement Marking	**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

Questions?

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