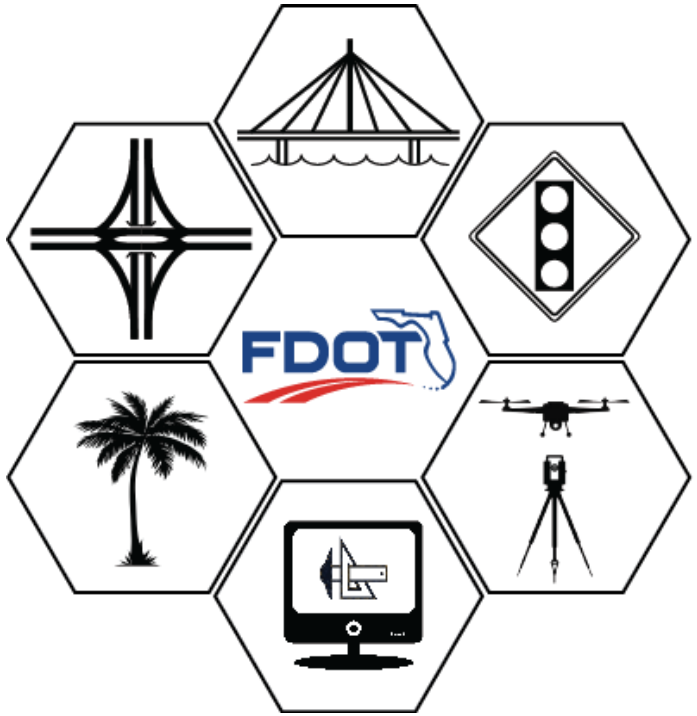
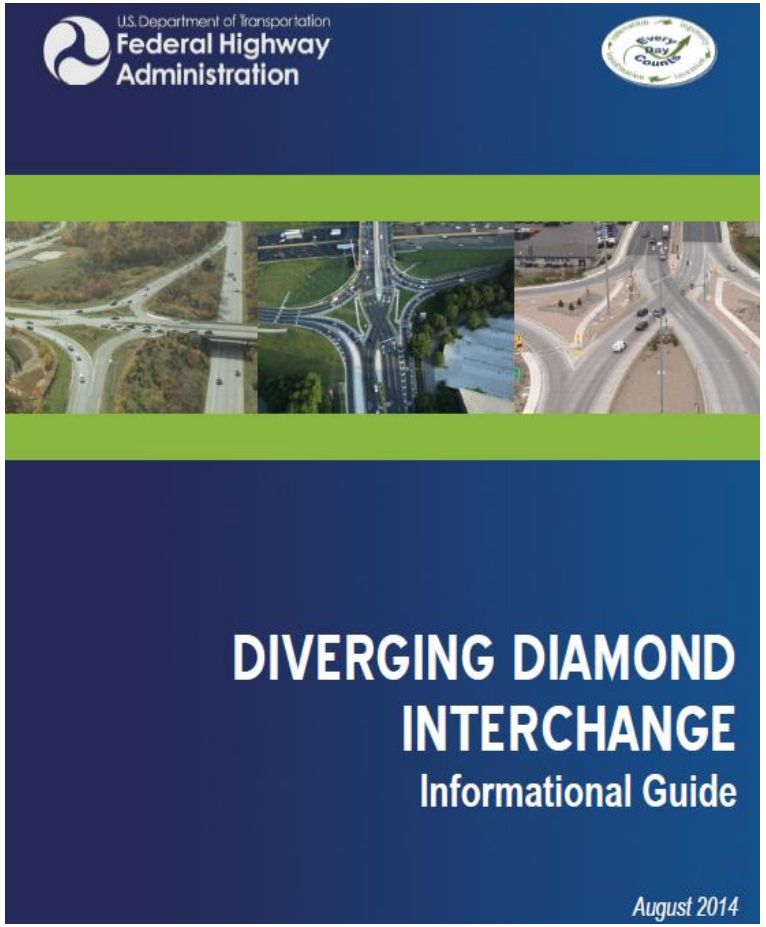


FDOT TRANSPORTATION SYMPOSIUM 2019

Diverging Diamond Design Considerations

Mark Doctor, FHWA Resource Center

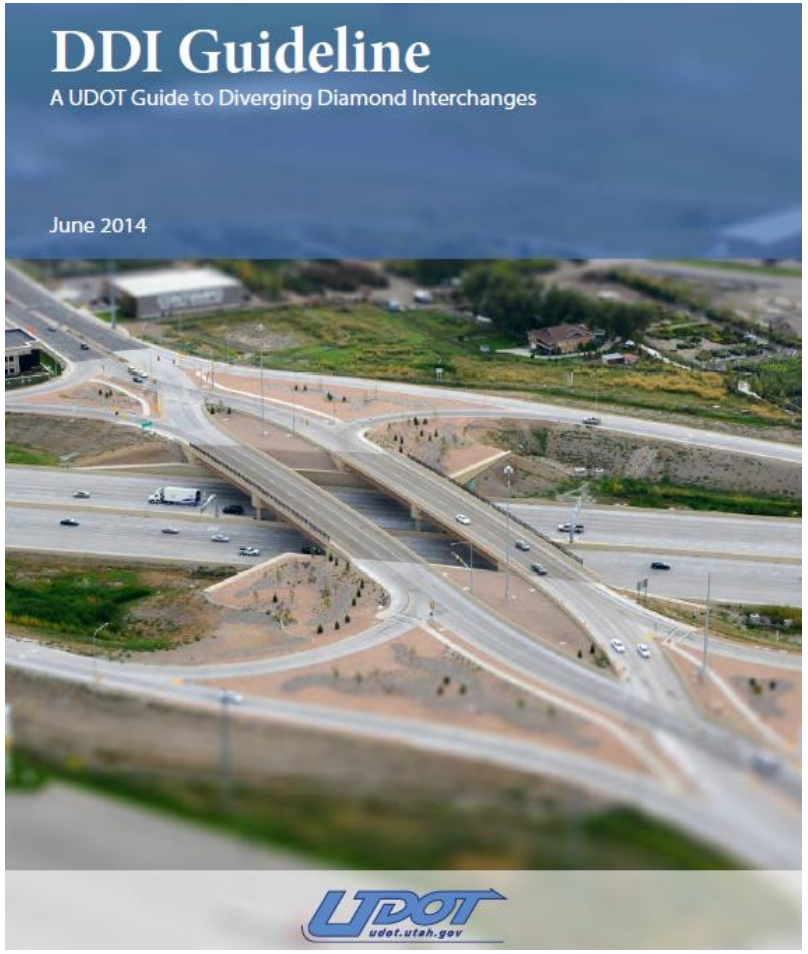
KEY REFERENCES



FHWA DDI INFORMATIONAL GUIDE

safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14067_ddi_infoguide.pdf

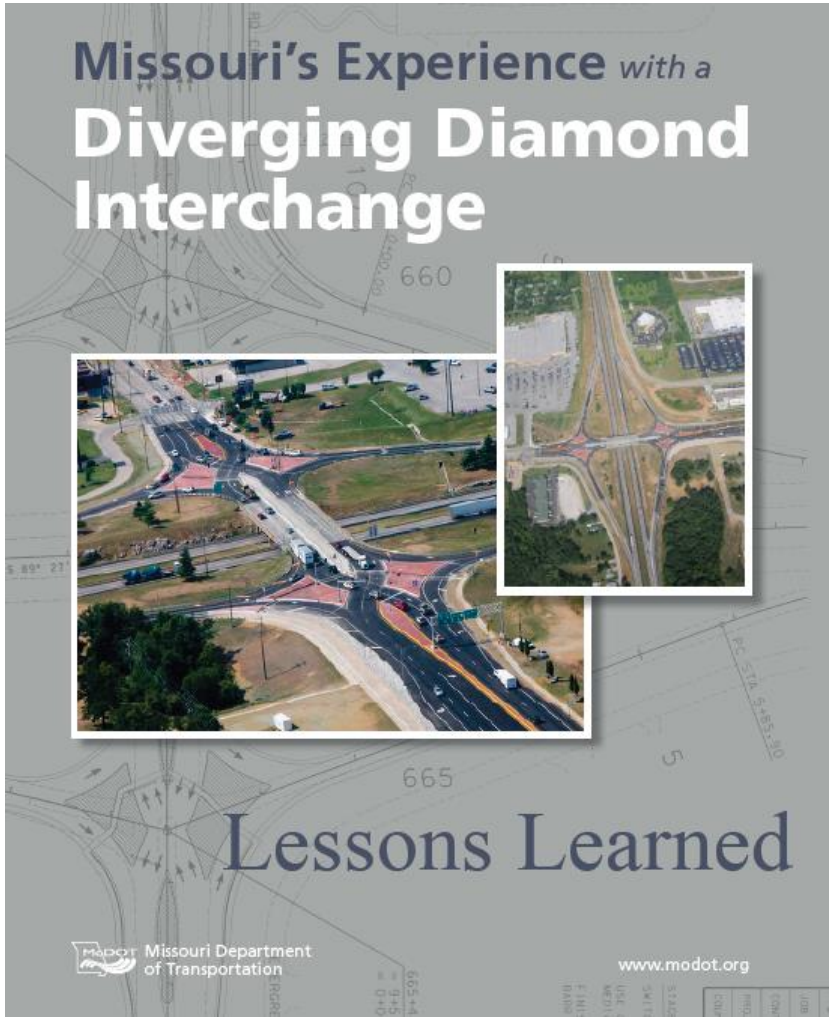
KEY REFERENCES



Available at:
www.udot.utah.gov/main/uconowner.gf?n=14769524027177477

Utah DOT DDI Guidelines

KEY REFERENCES



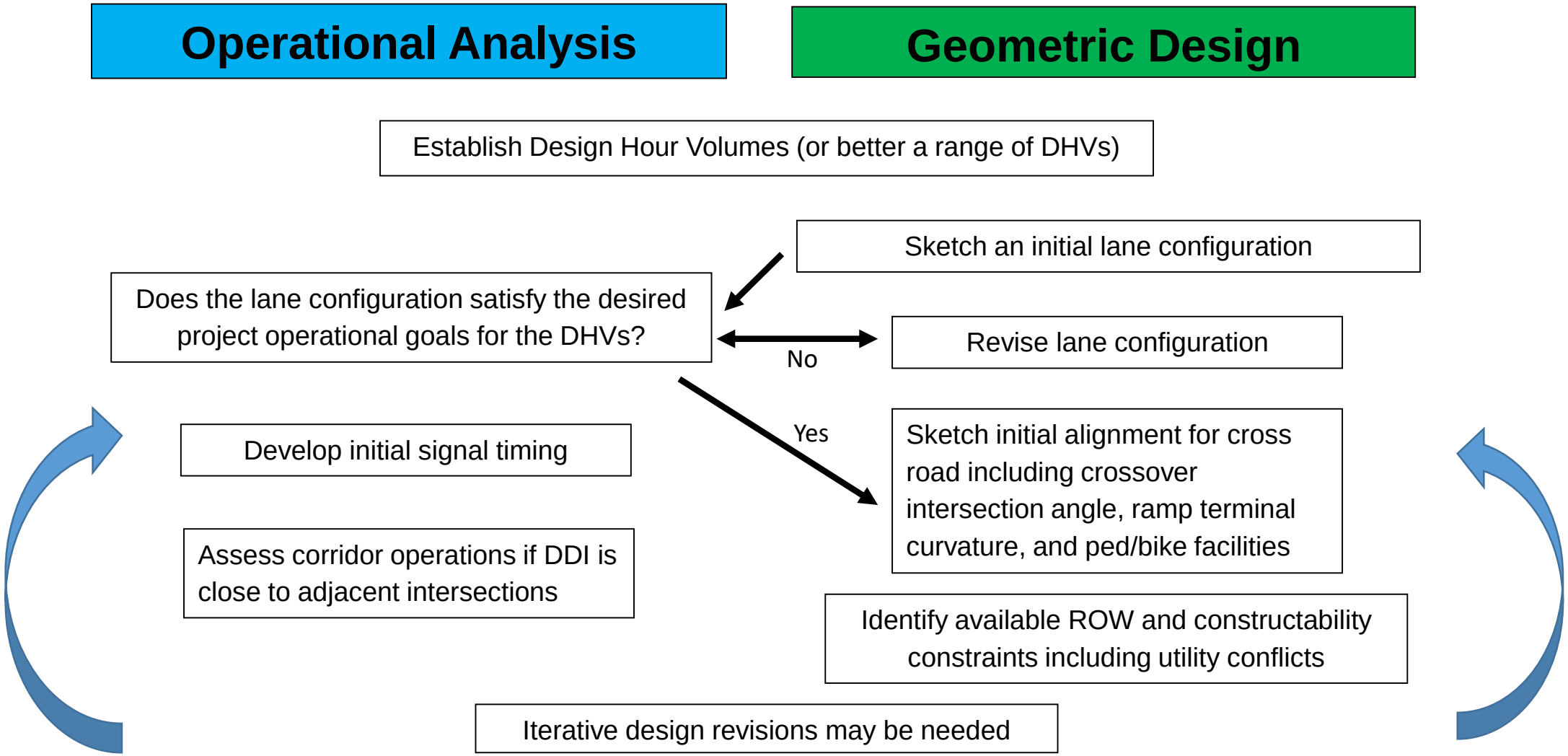
https://library.modot.mo.gov/rdt/reports/unnumbrd/or10021rpt.pdf

MISSOURI DOT DDI LESSONS LEARNED

The traffic operations at a DDI will greatly influence the appropriate geometric design choices.

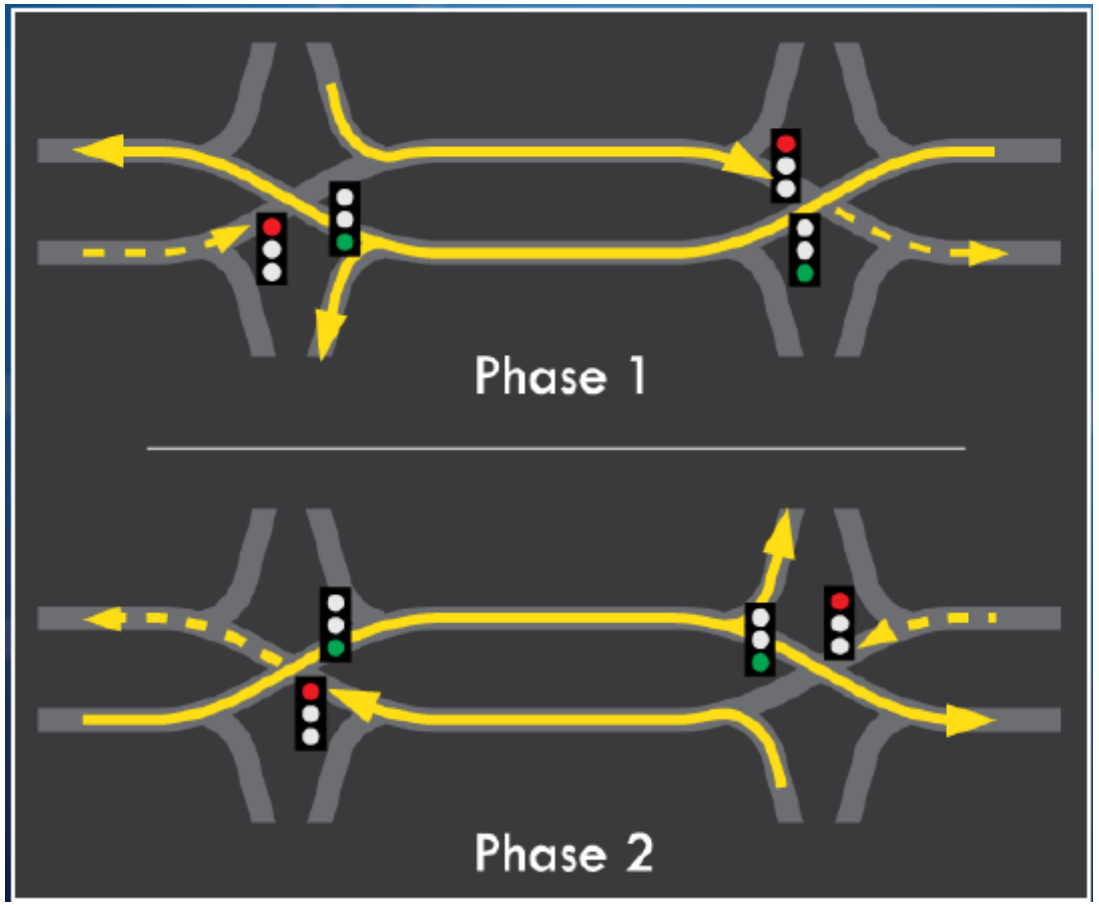
Although this is not unique to DDIs, it is of critical importance that the geometric design choices be integrated into considerations of how the signals will be operated.

Design Development Process

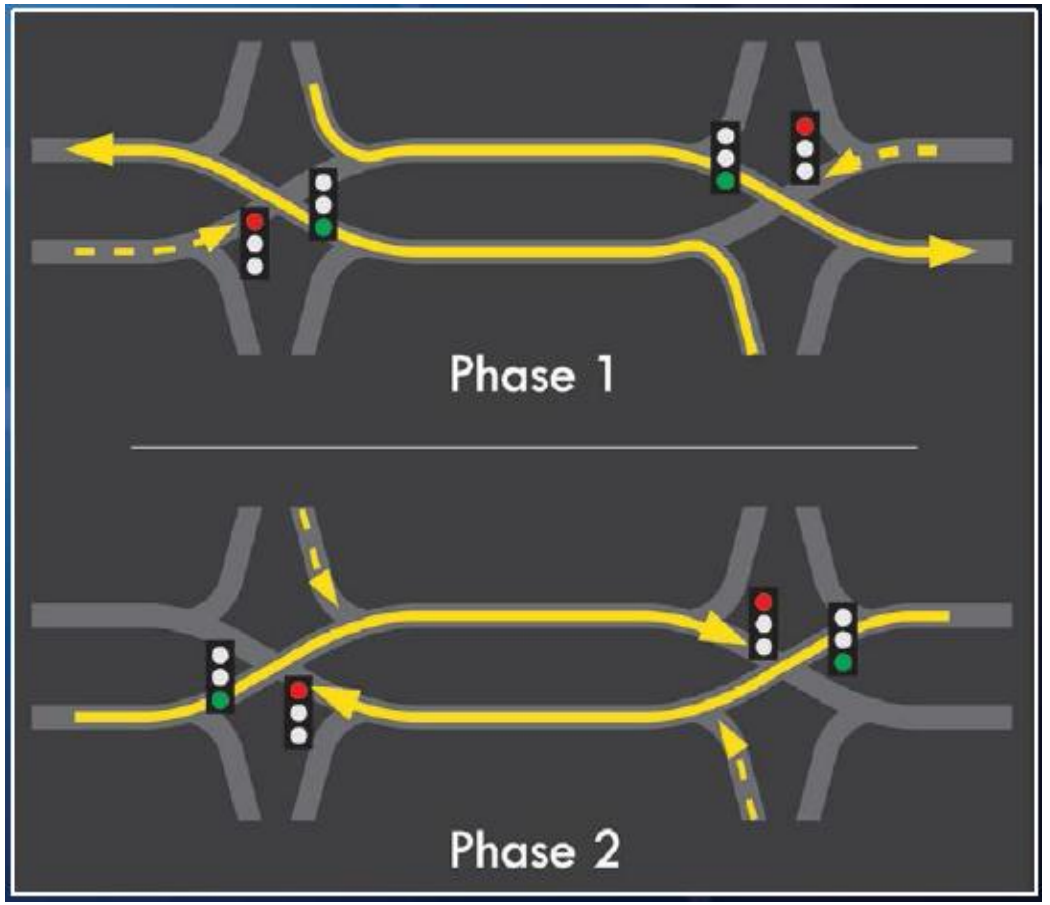


FDOT TRANSPORTATION SYMPOSIUM

Basic DDI Signal Phasing



Option 1 – Alternating Progression on Crossroad

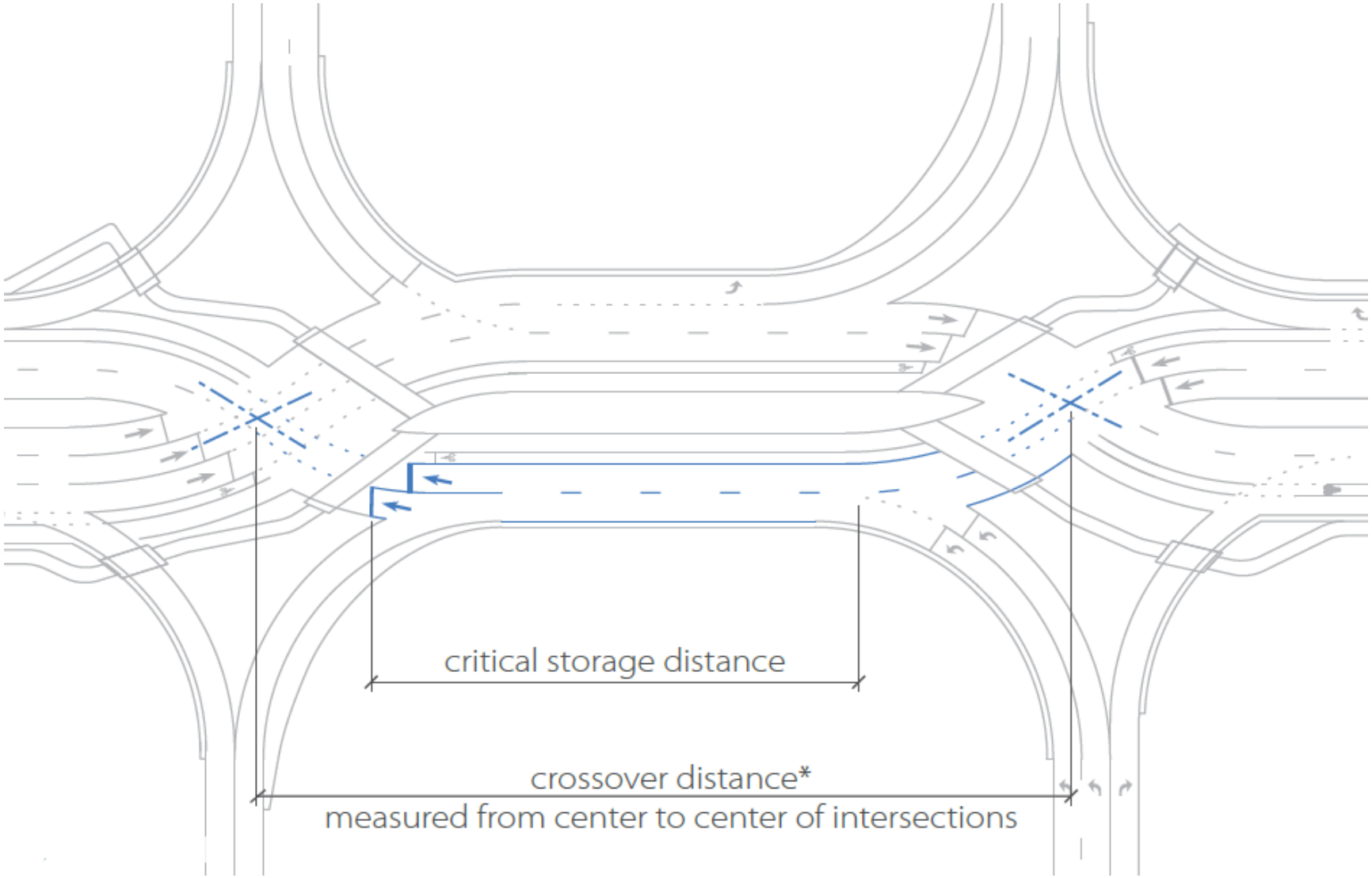


Option 2 – Progression for Exit Ramp Left-Turns

Key Operational Considerations for Design

- Queue Storage Between Crossovers
- Queue Spillback from Adjacent Intersections
- Lane Utilization / Shared Thru & Turn Lanes

Queue Storage Between Crossovers



Queue Spillback

Queue spillback may occur into the DDI and block the departure zone if the downstream signalized intersection cannot handle the increased traffic throughput from the more efficient upstream DDI

Queue spillback into DDI from downstream adjacent signal

Mitigation strategies

Strategies to mitigate queue spillback risk:

- Remove adjacent signal (grade separate or make right-in/right-out only)
- Move the intersection farther away
- Improve the adjacent intersection (add storage lanes and/or reduce number of signal phases)

Grade Separate

The left turn (into a hospital) was modified to take a right, followed by another immediate right turn that loops under the cross road

Grade Separate

I-35 at 95th St
Lenexa, KS

FDOT TRANSPORTATION SYMPOSIUM

Relocate Intersection Farther Away

Relocate the intersection farther away.
This treatment was used at Dorsett Road in Maryland Heights, MO.

Relocate Intersection Farther Away

Dorsett Road in Maryland Heights, MO.

Relocate Intersection Farther Away

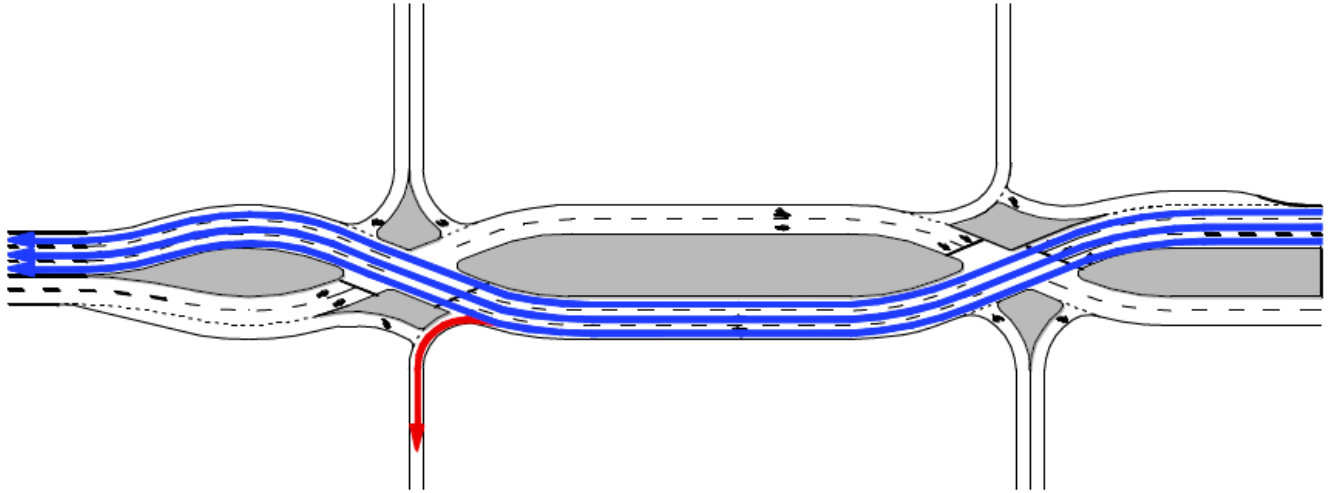
I-70 at Woods Chapel Road in Blue Springs, MO.

I-85 at Poplar Tent Road – Concord, NC (north of Charlotte)

Corridor of “2-Phase” Signals (Signalized RCUTs)

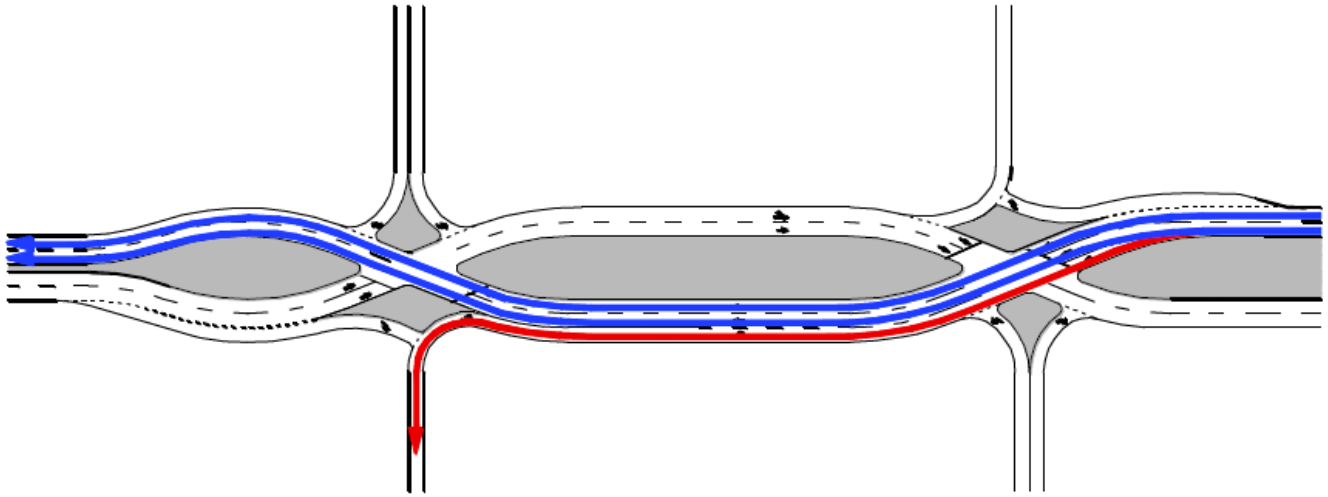
FDOT TRANSPORTATION SYMPOSIUM

Lane Utilization



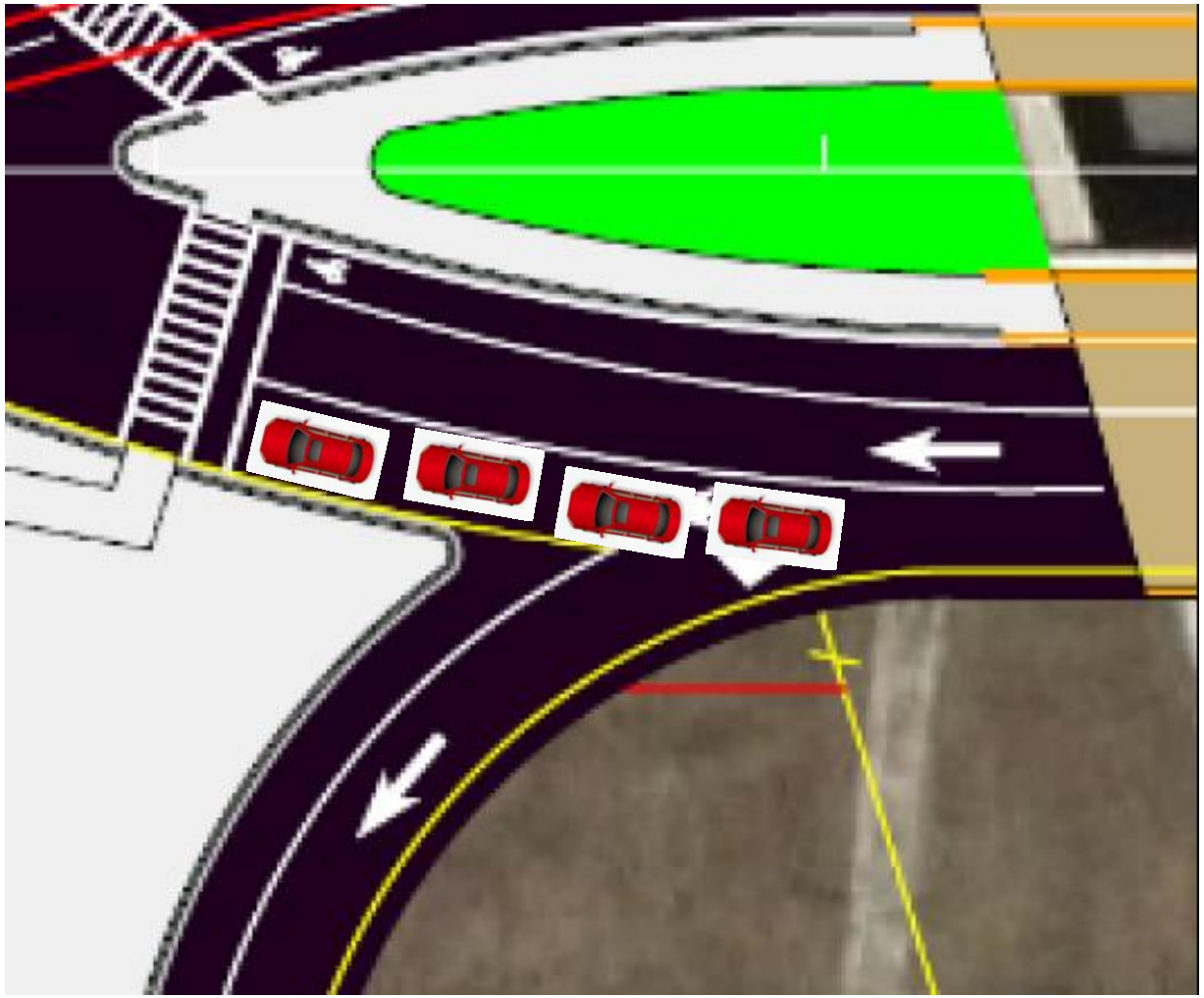
3 Thru Lanes w/
shared Left

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



2 Thru Lanes w/
Exclusive Left

Shared Left/Thru lane



When considering the left turn capacity for a shared Left/Thru lane, traffic can turn left only until the queue blocks the turn

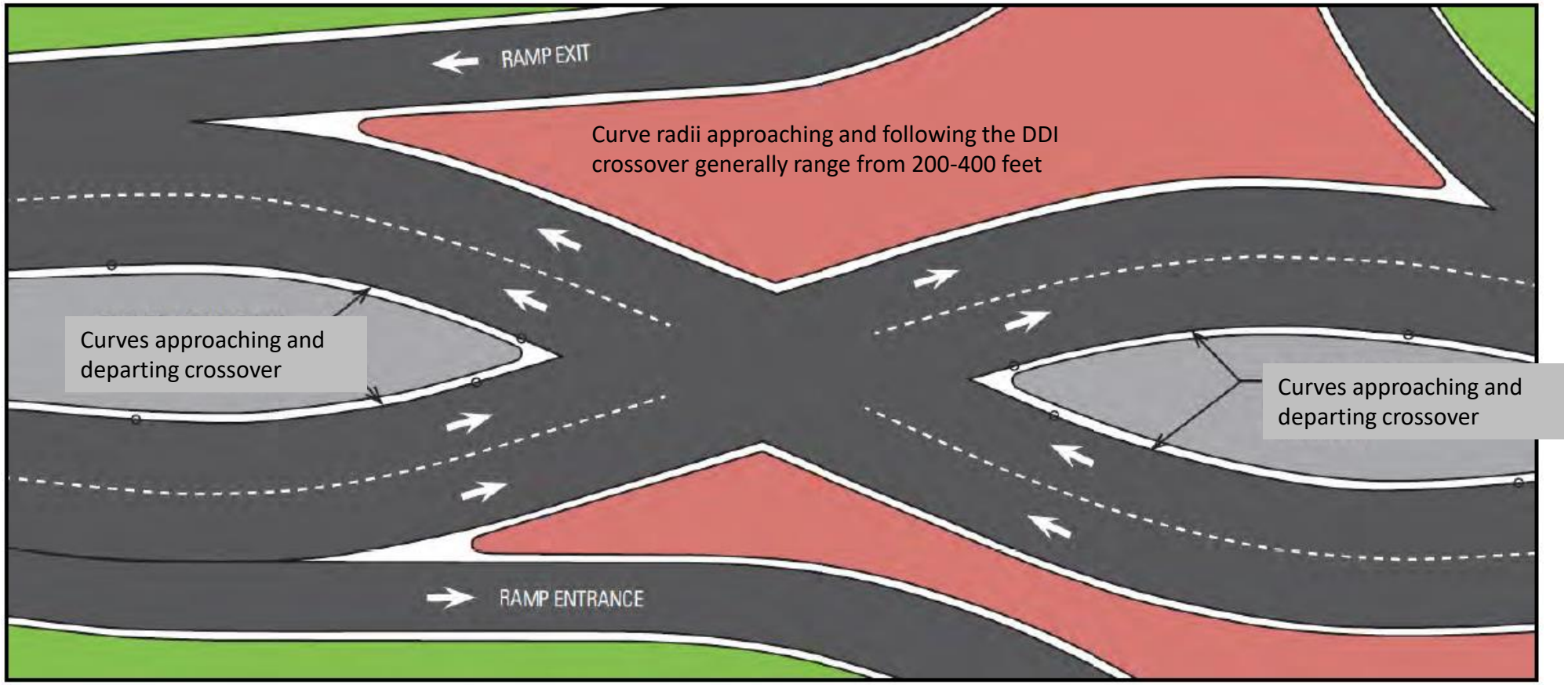
Lane utilization

Key Considerations for Design

- Design Speed
- Tangent Through Crossover / Natural Path
- Crossover Angle
- Direct Pass-Through Distance (Eyebrow Offset)

Design Speed and Reverse Curvature

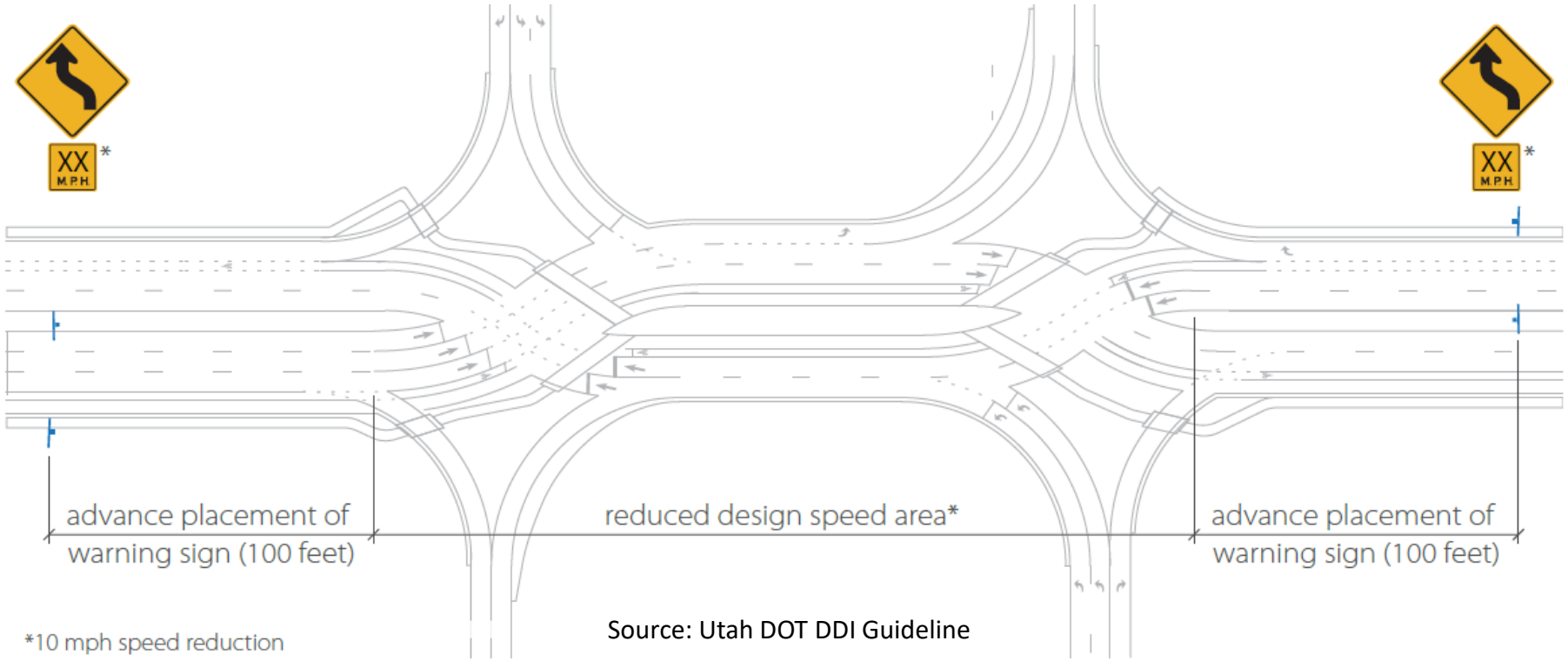
- Design speed at a DDI affects the reverse curve radii through the two intersection crossovers
  - Typically ranging from 25 to 35 mph



Utah DOT Guidance

- The design speed of the curves in the crossover areas is **at least 10 mph less** than the design speed of the approaching crossroad unless the reduction results in a design speed of less than 25 mph

- UDOT has designed crossover areas for travel speeds of 25 to 40 mph

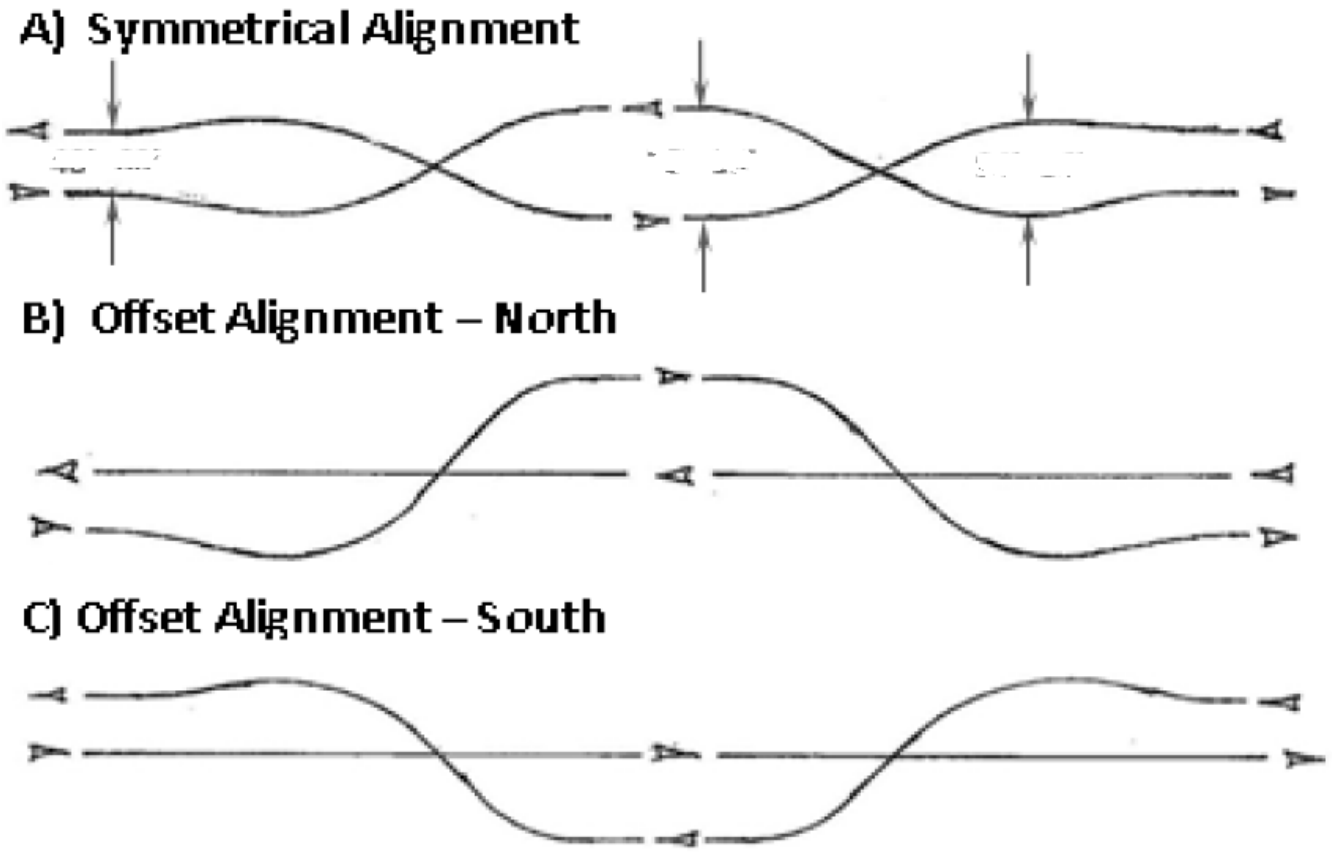


Source: Utah DOT DDI Guideline

Avoid abrupt reverse curvature

If the radius leading into the crossover is less than 150 feet, it may cause drivers to take the “fastest path” and encroach into adjacent lanes.

Alignment Alternatives



Although the symmetrical alignment is most common, other options can be advantageous where:

1) The existing structure can remain in place while a parallel one is constructed

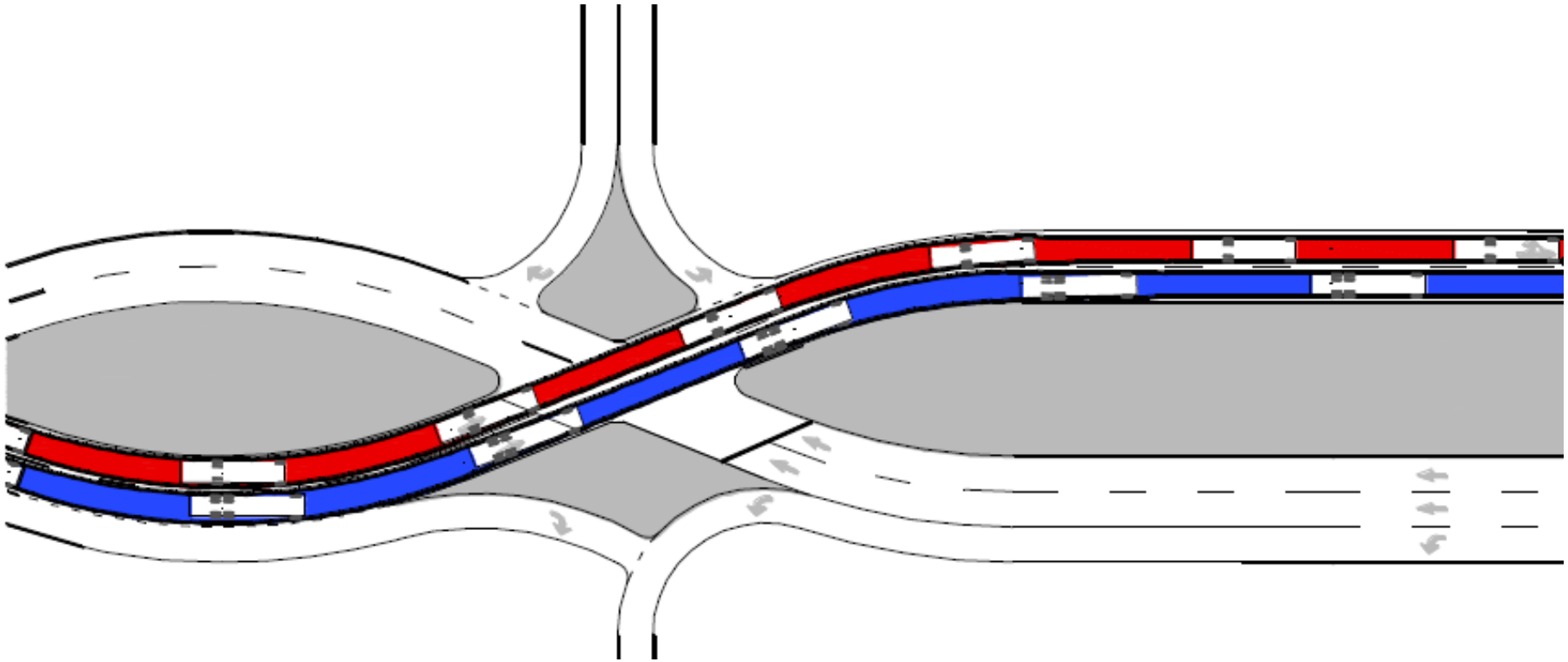
2) there are ROW constraints on one side of the cross road

3) There are ROW constraints in opposite quadrants on either side of the freeway

4) One direction on the crossroad has much higher volumes and would benefit from less driver “work load” of traversing the reverse curvature

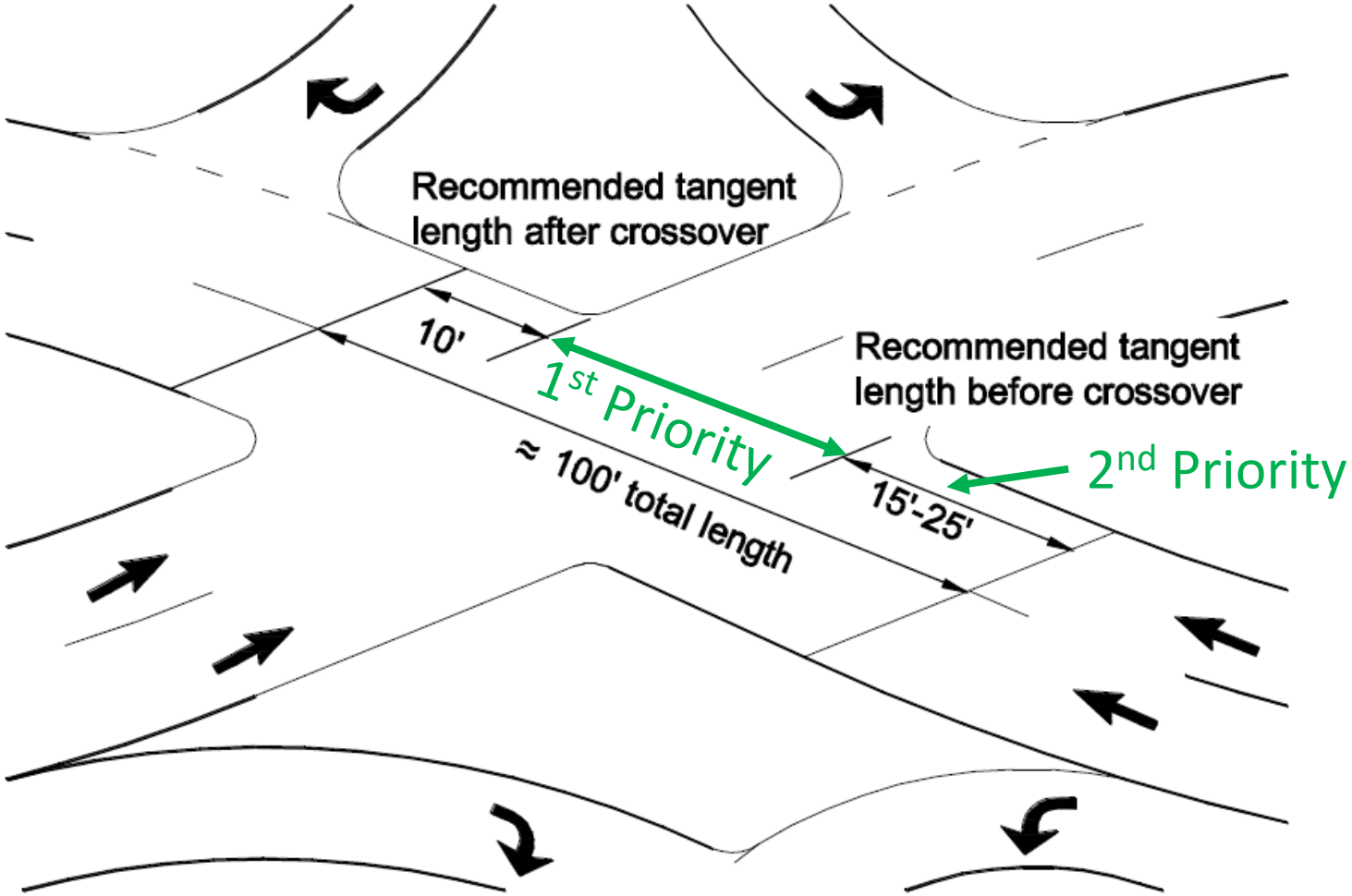
“Natural Path” Through Crossover

Vehicle path alignment at the crossovers should direct vehicles into the proper receiving lane. Drivers should be able to drive “straight” through the crossover intersection (tangent between the reverse curves). An insufficient tangent (or no tangent), makes for an awkward driving path that can lead to vehicle path overlap (encroachment into adjacent lane).



FDOT TRANSPORTATION SYMPOSIUM

Before, Through & After Crossover



Example of Potential Path Overlap

Source: Kentucky Transportation Cabinet, US 68 DDI

Tangent Before Crossover

Case Study: Pleasant Hill Rd, Gwinnett GA

Originally a “Compressed Diamond” Interchange

Case Study: Pleasant Hill Rd, Gwinnett GA

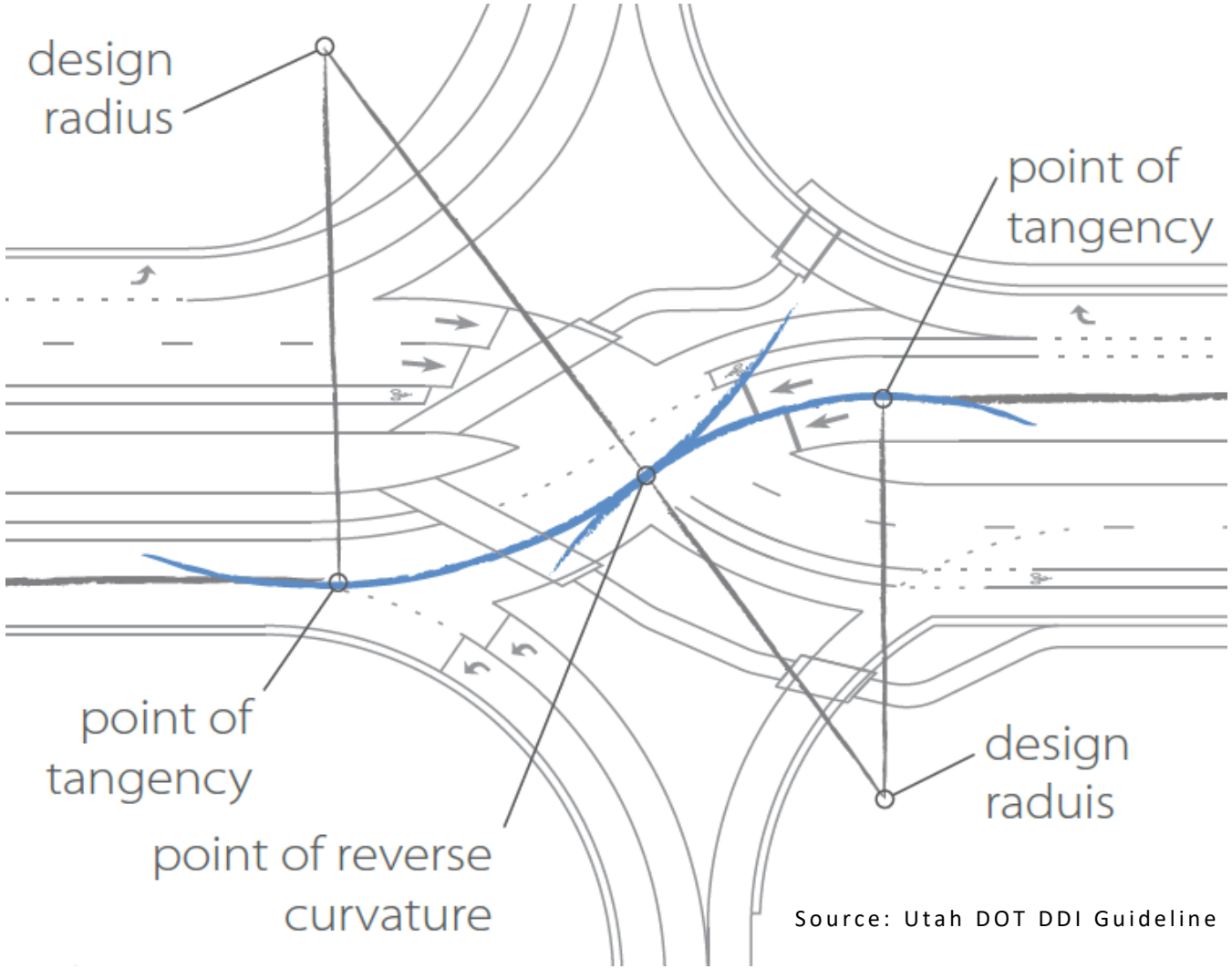
POTENTIAL PATH OVERLAP

Case Study: Pleasant Hill Rd, Gwinnett GA

The “Natural Path” is also influenced by the sharpness of curvature
Designers should try to “balance” the tangent length and degree of curvature

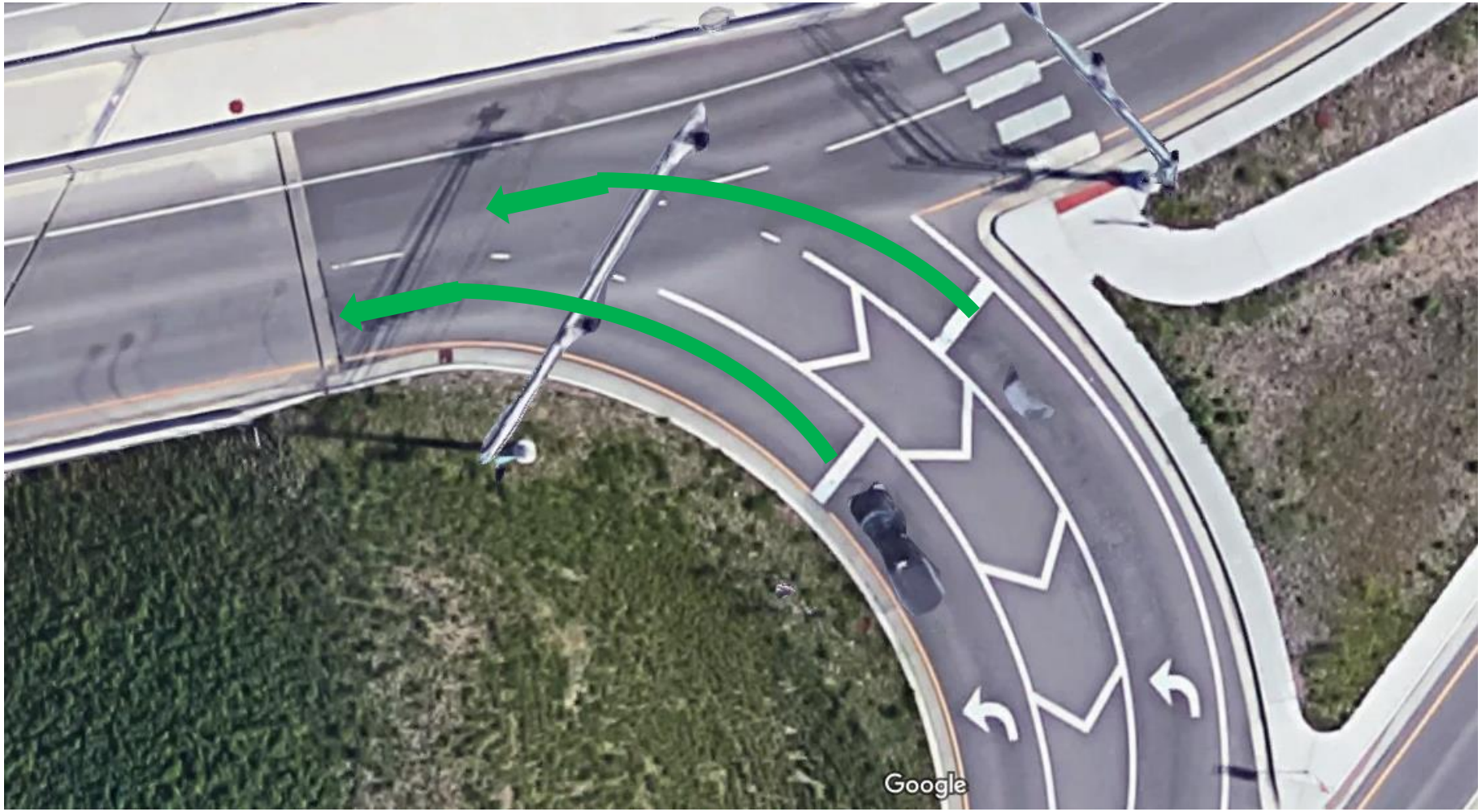
Example of Potential Path Overlap

Reverse Curve Option



Source: Utah DOT DDI Guideline

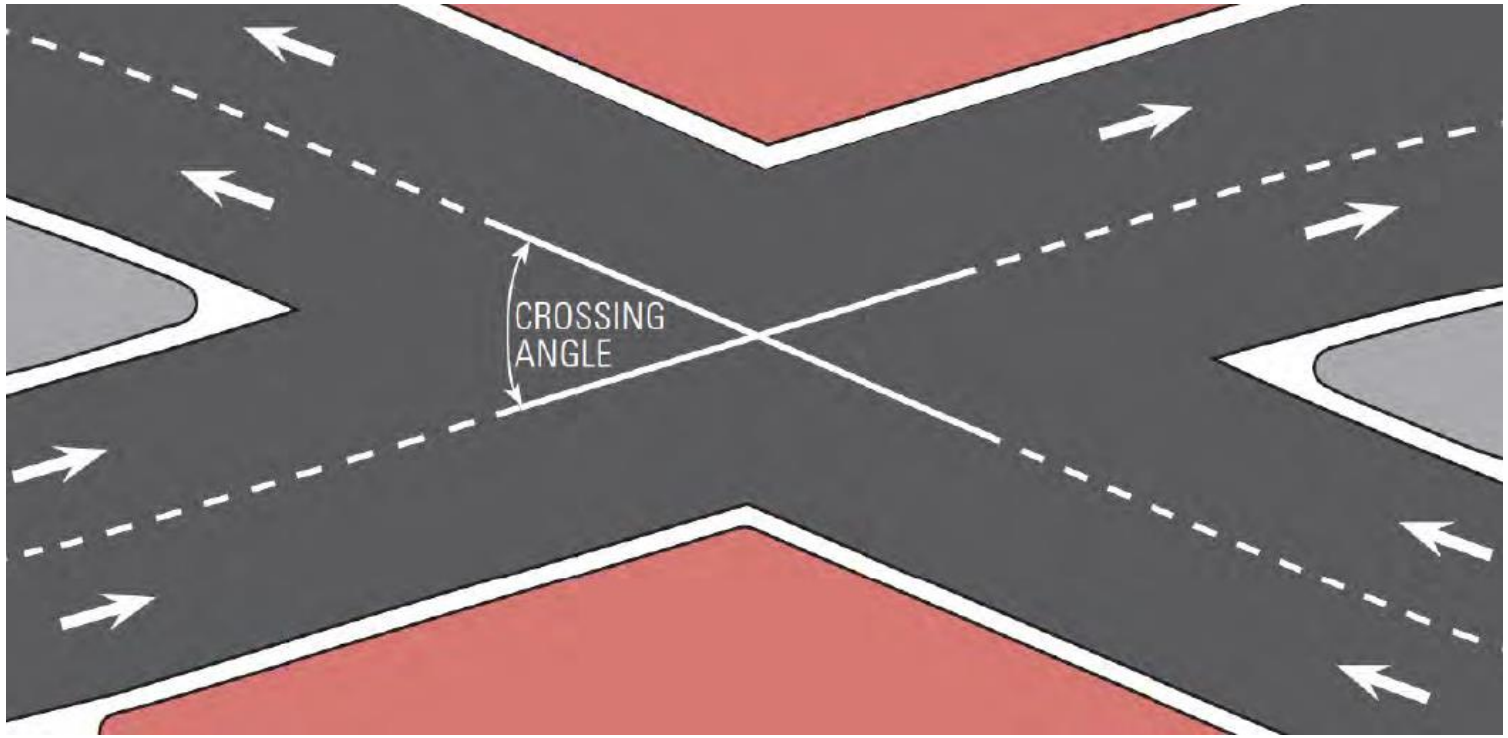
Although not desirable, if developing the tangent is not possible, try to balance the reverse curvature by having the point of reverse curvature near the center of the crossover.



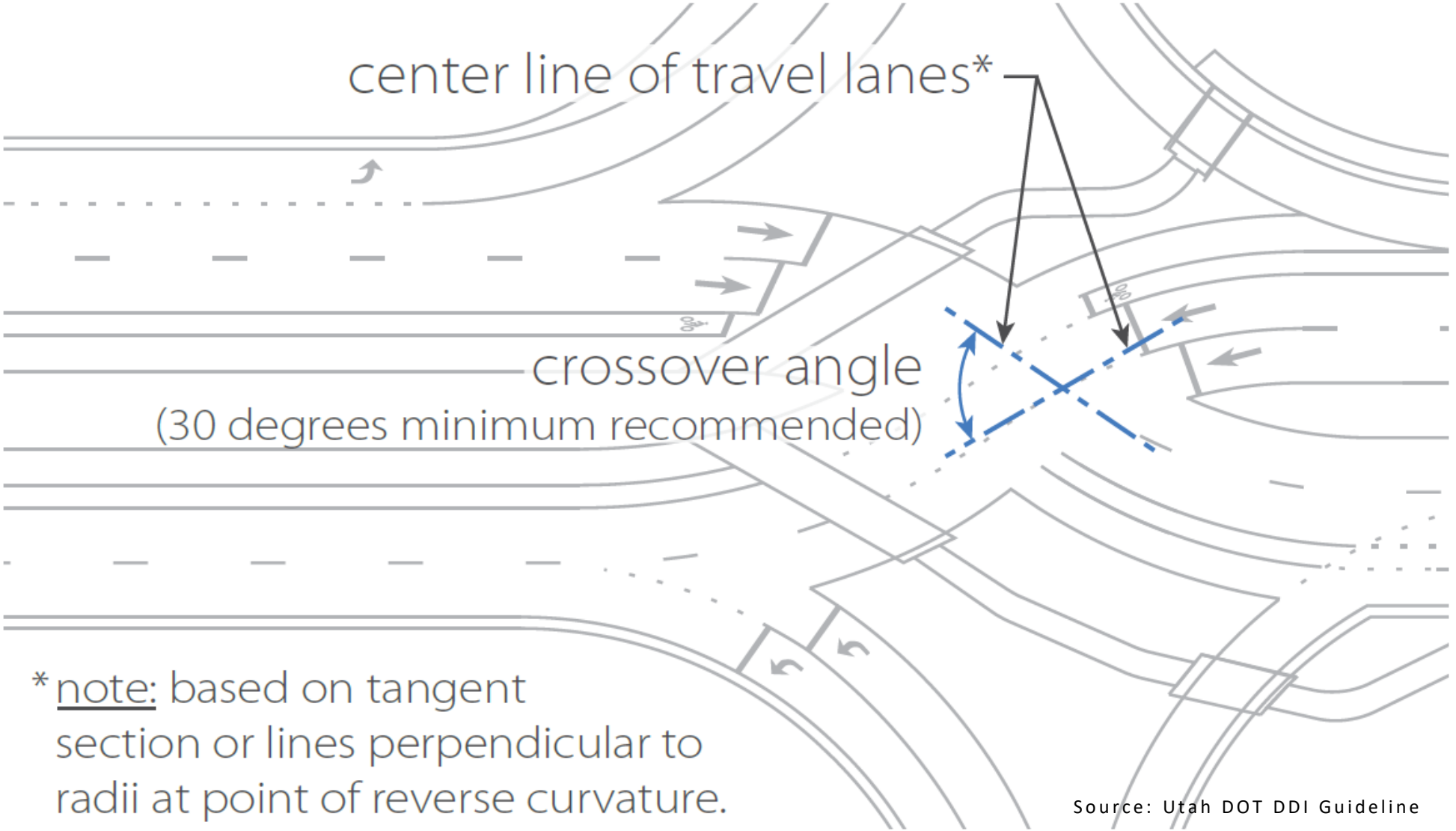
A consideration for using a wider lane width between the crossovers is whether there is a single- or dual-left turn into those lanes and the truck volumes making that turning maneuver. Many truck drivers are instructed to use the right-most lanes when there are multiple left-turn lanes.

Crossover Angle

- The greater the crossing angle, the less “different” the intersection will seem and reduce risk of wrong-way movements
  - Recommended crossover angles of 30-50 degrees
    - Several DDIs have angles of 30 degrees or less (and work OK)
    - Low angles increase crossing distances and increase signal clearance time



Crossover Angle



Source: Utah DOT DDI Guideline

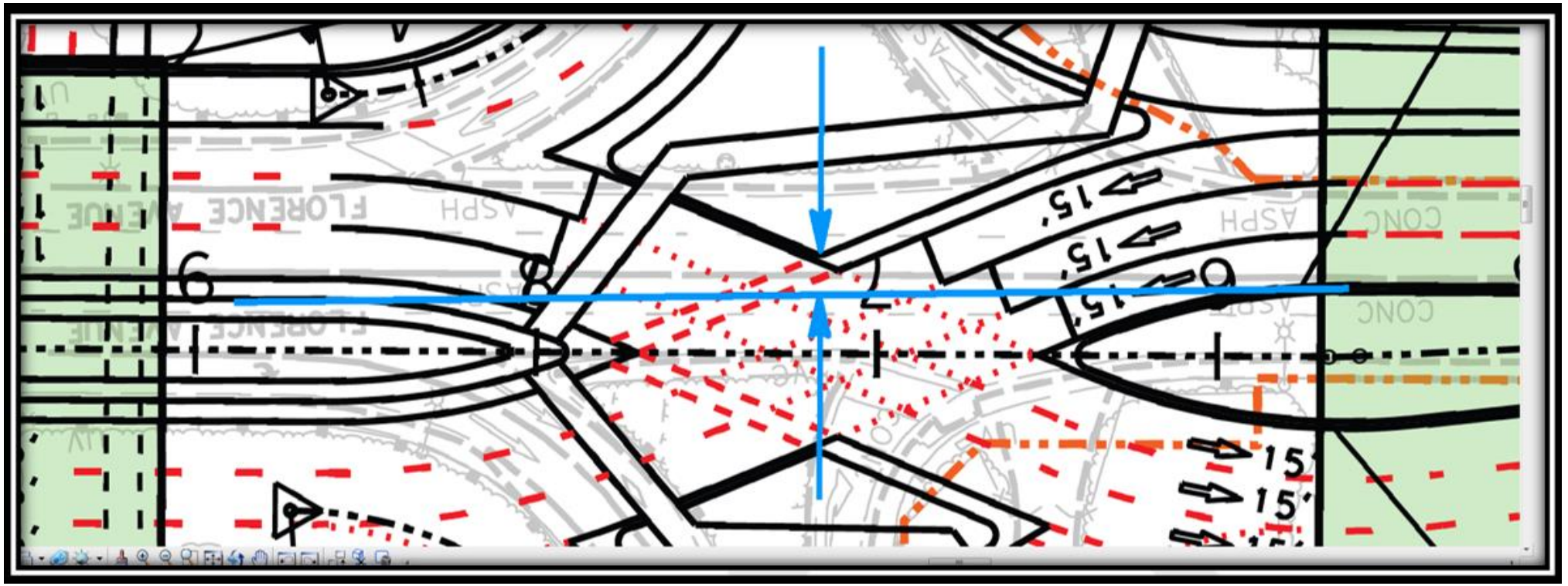
FDOT TRANSPORTATION SYMPOSIUM

Eyebrows

Q-Tips

Wrong Way Direct Path Test

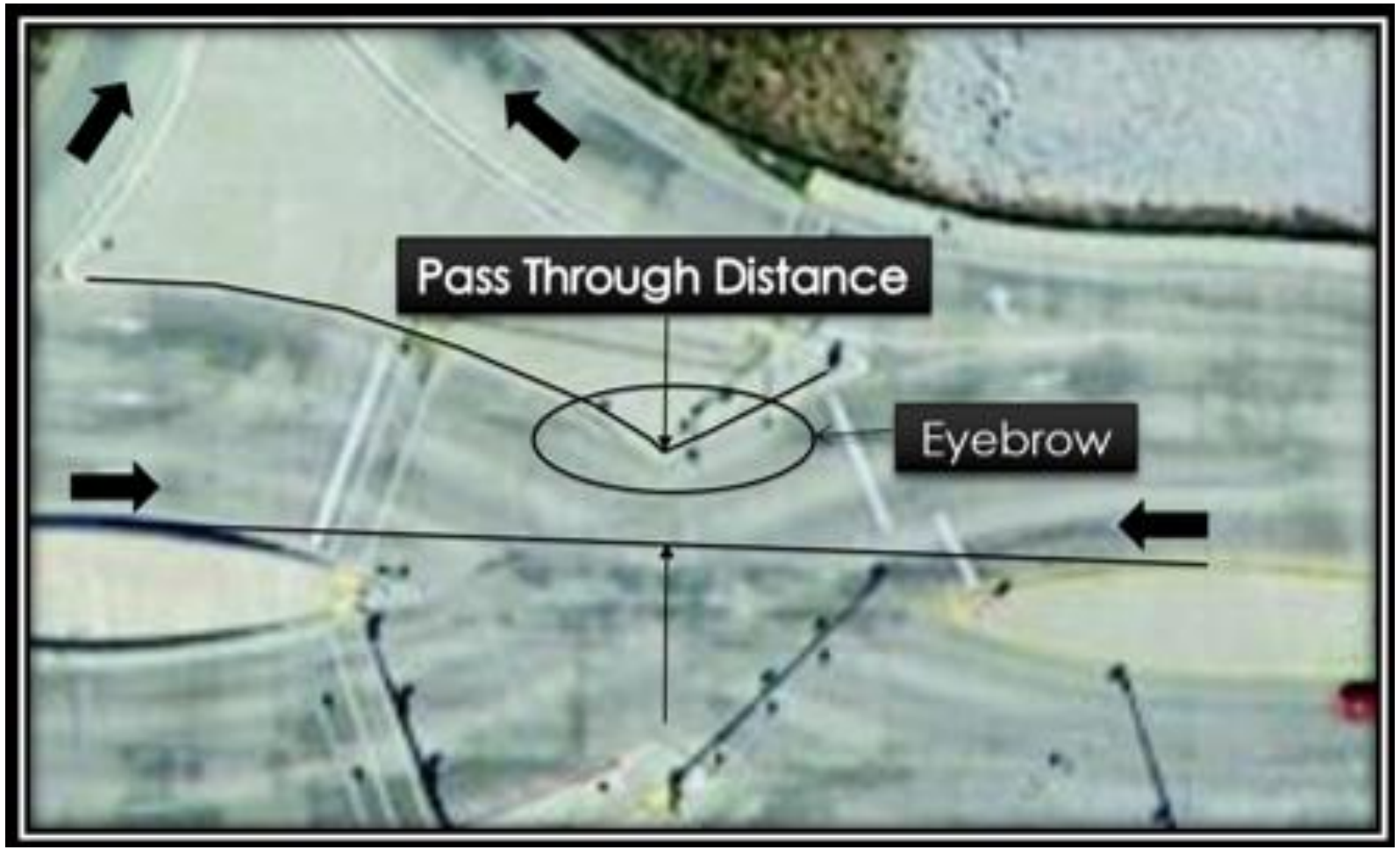
Figure below shows a narrow gap (less than a car width) for a wrong way pass through – GOOD DESIGN



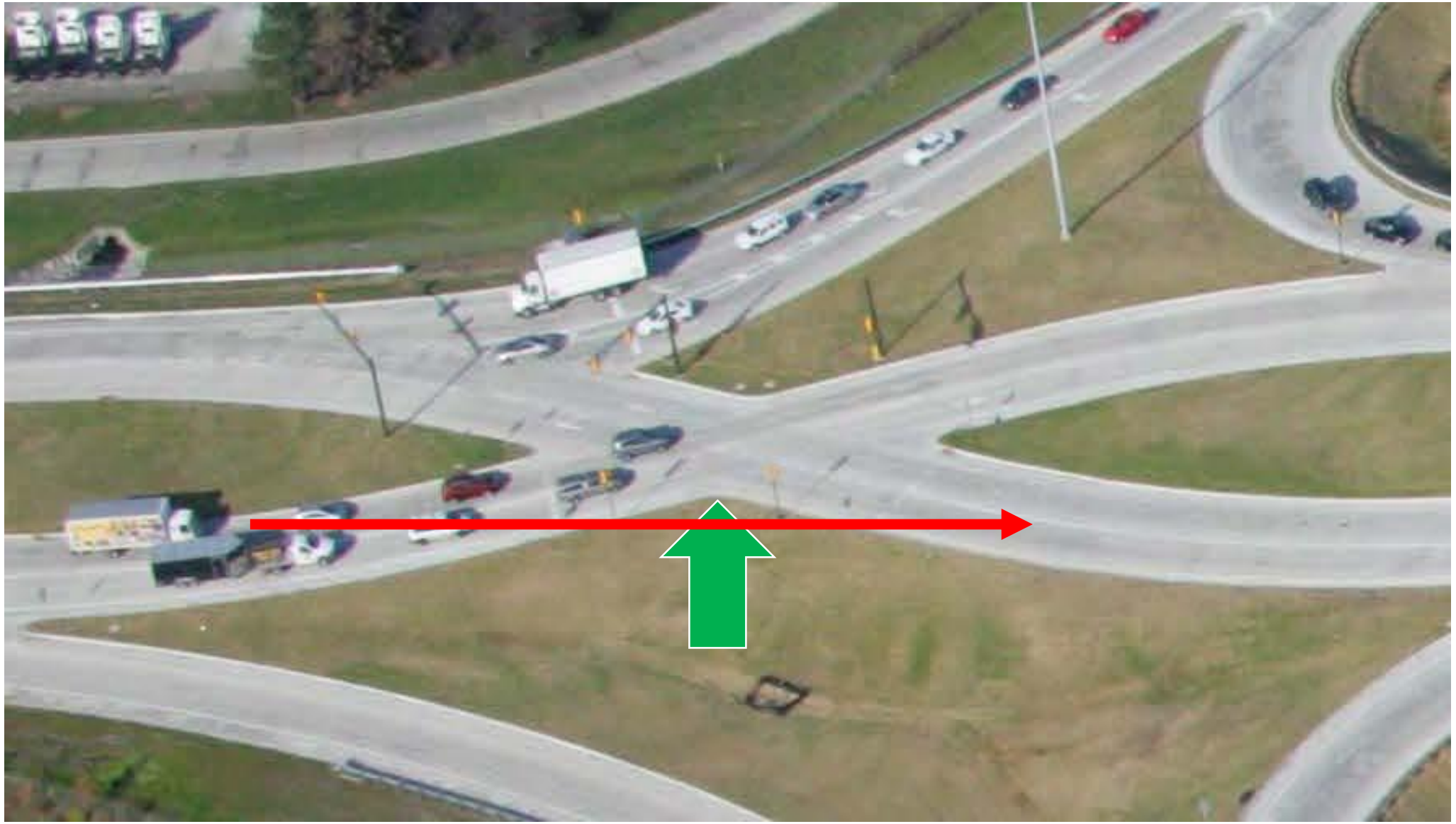
Example Check

Wrong Way Direct Path Test

Figure below shows a pass through gap greater than a car width (not desirable)



Example Check



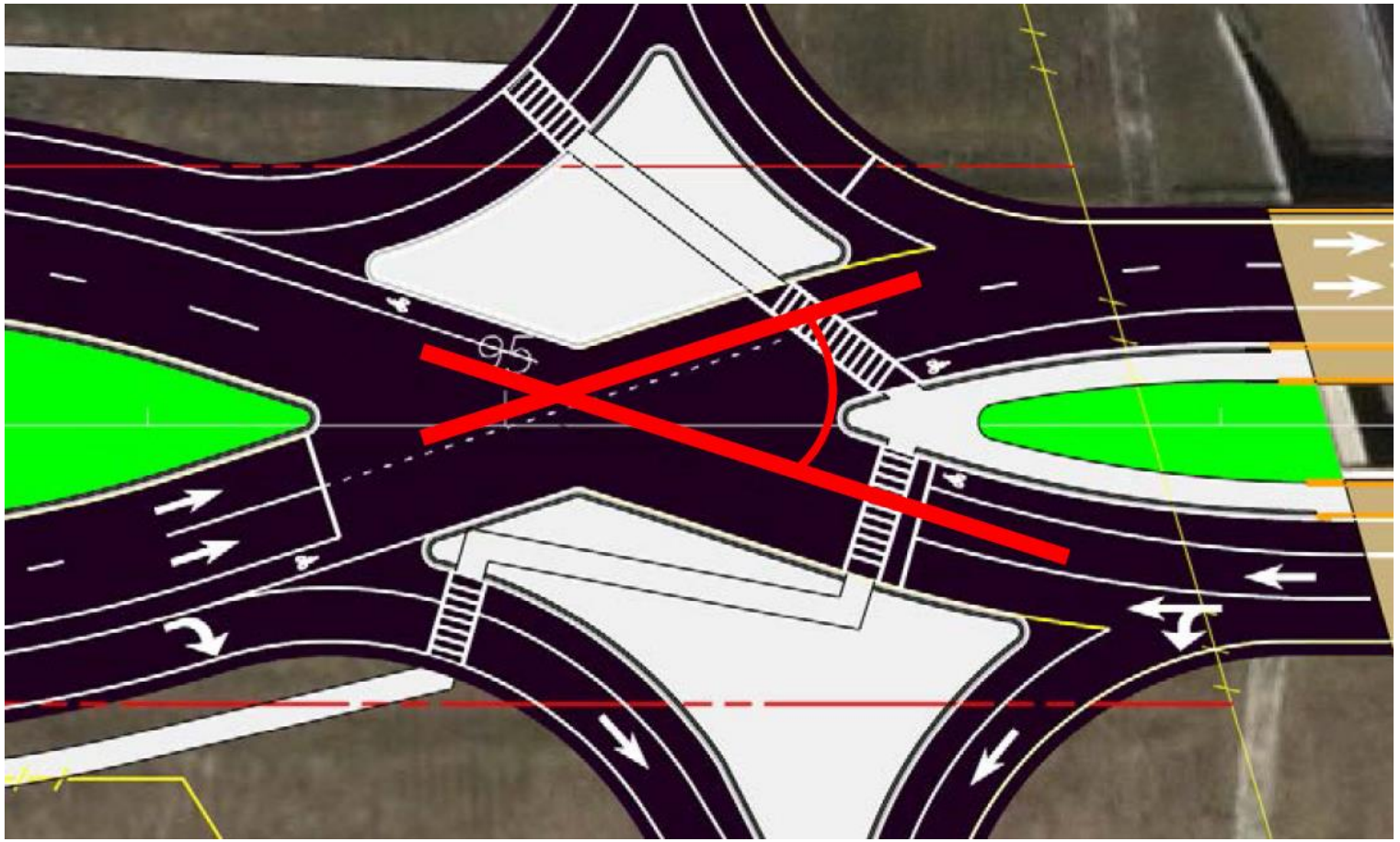
Barrier wall along eyebrow

Eyebrow enhancement options

Vertical curb painted white immediately adjacent to travel lane (no shoulder or bike lane) set against contrasting color of raised channelization island

Be careful “shaving your eyebrows”

Consider the “Sum of the Parts”

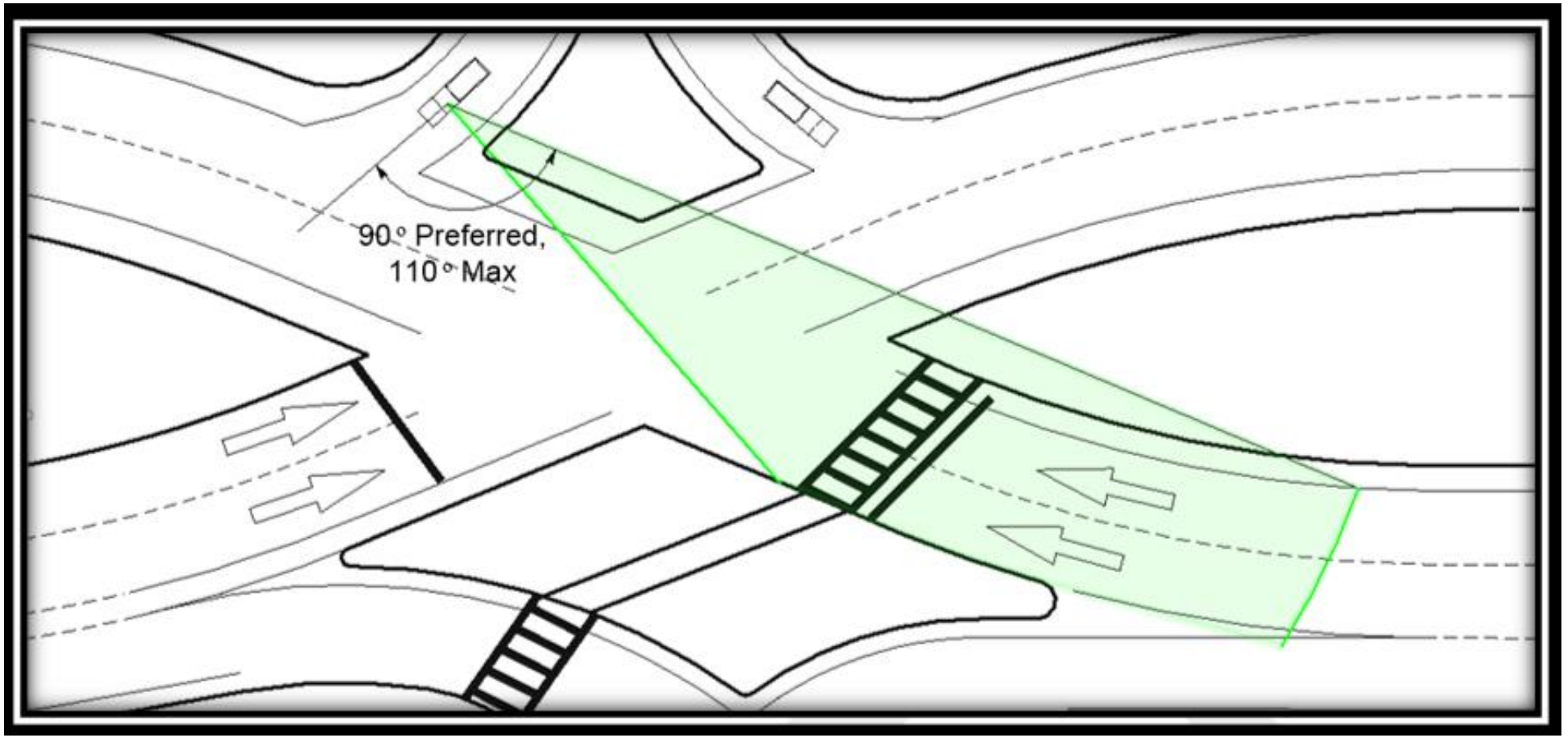


Consider collectively:

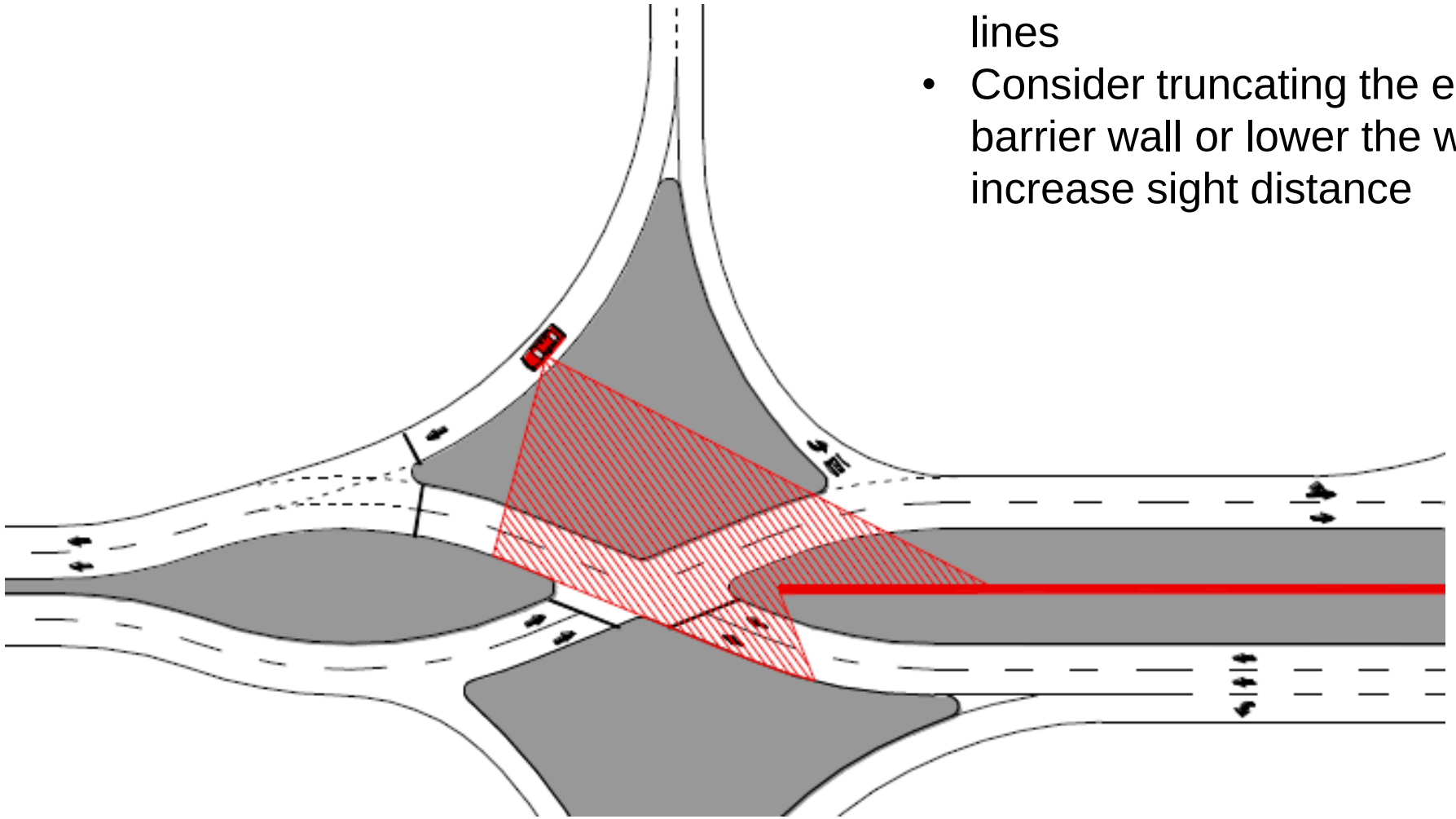
- Crossing Angle
- Length of Tangent
- Setback Distance
- Eyebrow Design
- Pass Through Test

Look back angle

An angle close to 90 degrees is preferable, with a maximum of 110 degrees in consideration of drivers having difficulty turning their neck.



Sight line obstructions



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

Sight line obstructions

Source: Missouri DOT

The red line shows how the barrier wall could be altered to provide better sight distance

Curb to Barrier Transition at Throat of Q-Tip

US 65 at SR 248
Branson , MO

FDOT TRANSPORTATION SYMPOSIUM


Missouri
US 60 and Kansas Expwy


Kansas Expwy
East South
Rogersville
East South
PriceCutter

FDOT TRANSPORTATION SYMPOSIUM


49
44
EAST
Springfield

FDOT TRANSPORTATION SYMPOSIUM


SCHOOL BUS
DEF


435 SOUTH
Front St
Front St
20 MPH


Corrington Ave

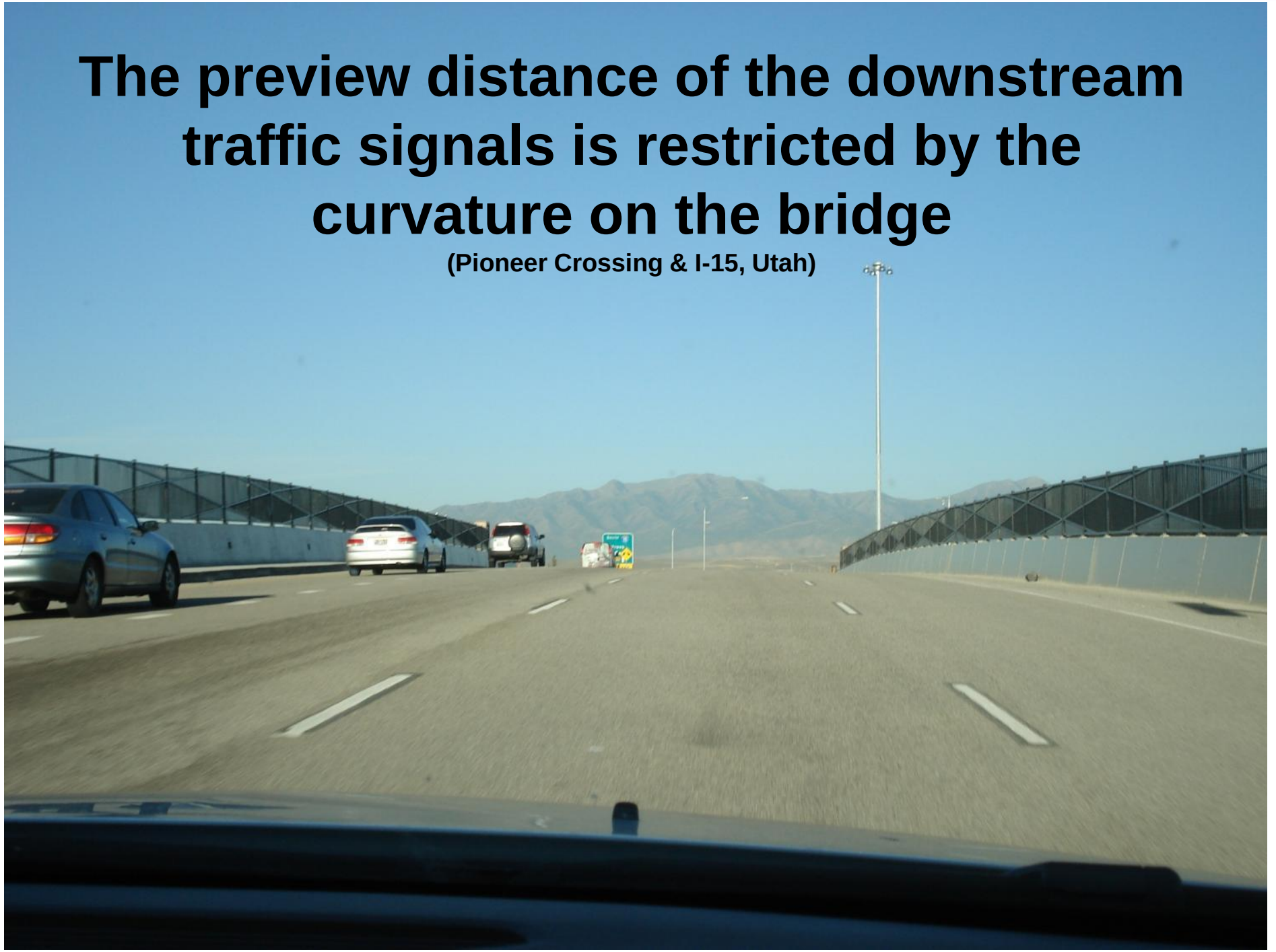

Innovators in Power Wheelchairs

Vertical Geometry

- DDI profiles should be relatively flat
  - Increases driver sight distance
- Crest vs. Sag profile of cross-road
  - Consider visibility of downstream cross-over intersection
  - Drivers don’t like surprises

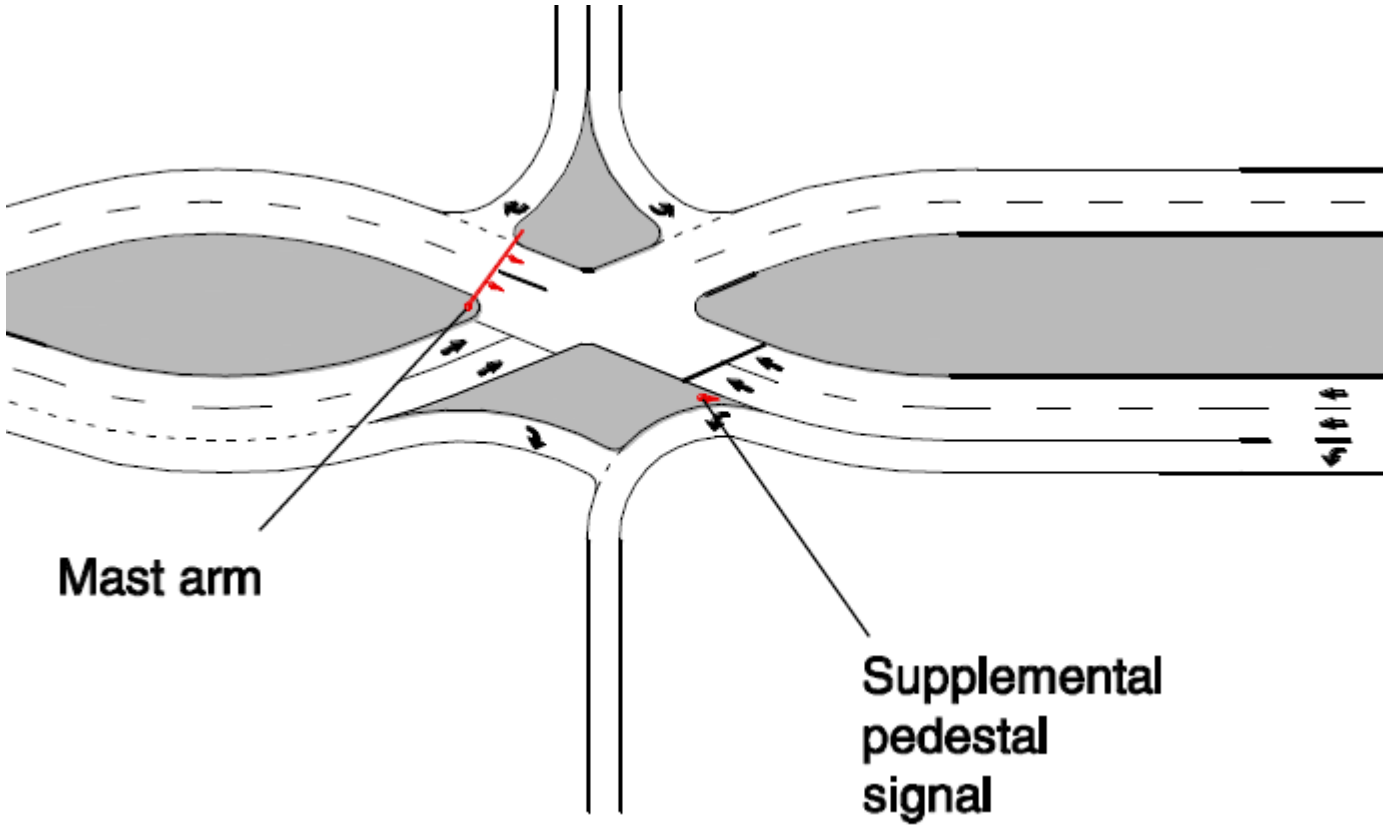
The preview distance of the downstream traffic signals is restricted by the curvature on the bridge

(Pioneer Crossing & I-15, Utah)

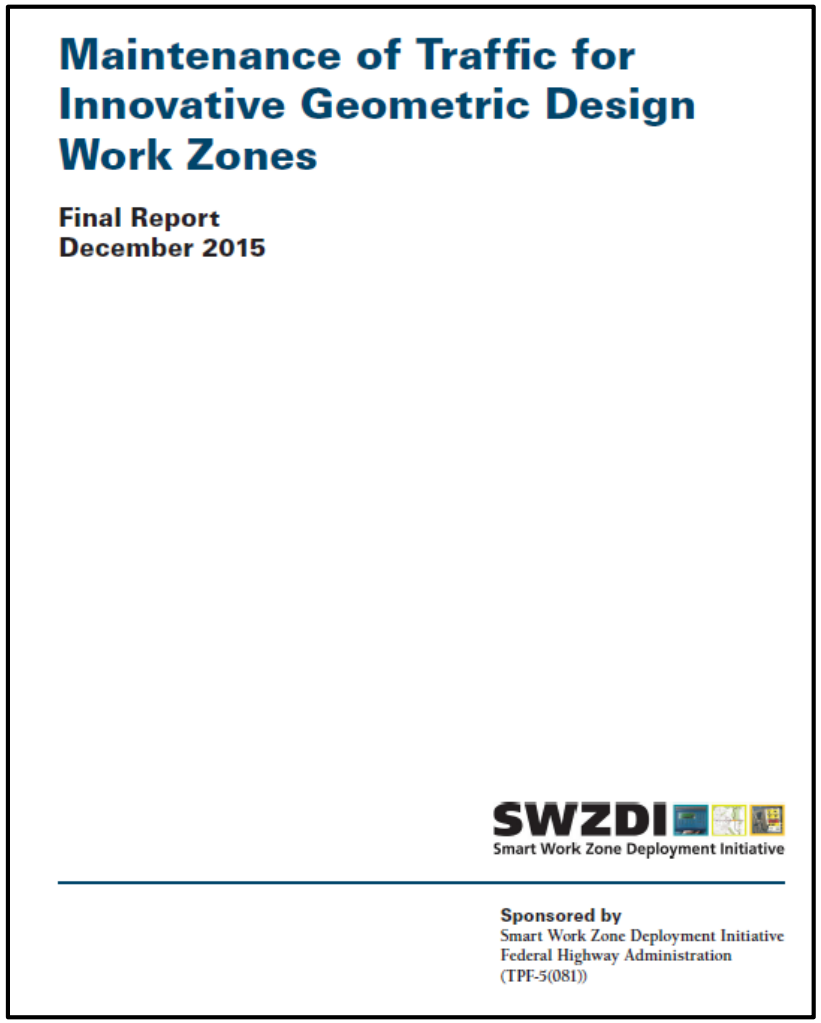


Crest curvature & signal placement

Where traffic signals are not visible to oncoming drivers, supplemental advance signals should be considered



Key Reference



Survey of industry experts with knowledge on current practices pertaining to Maintenance of Traffic at innovative geometric design intersection work zones

www.intrans.iastate.edu/smartwz/documents/project_reports/innovative_geometric_design_work_zones_w_cvr.pdf

QUESTIONS

FDOT TRANSPORTATION SYMPOSIUM