2015 Design Training Expo

Diverging Diamond Interchange Design

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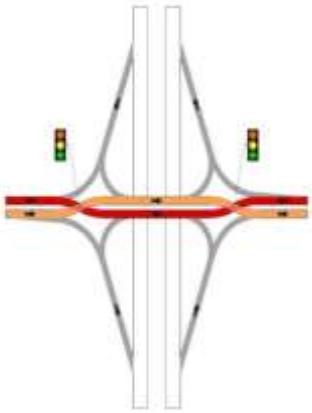
Wednesday June 10, 2015 / 9am

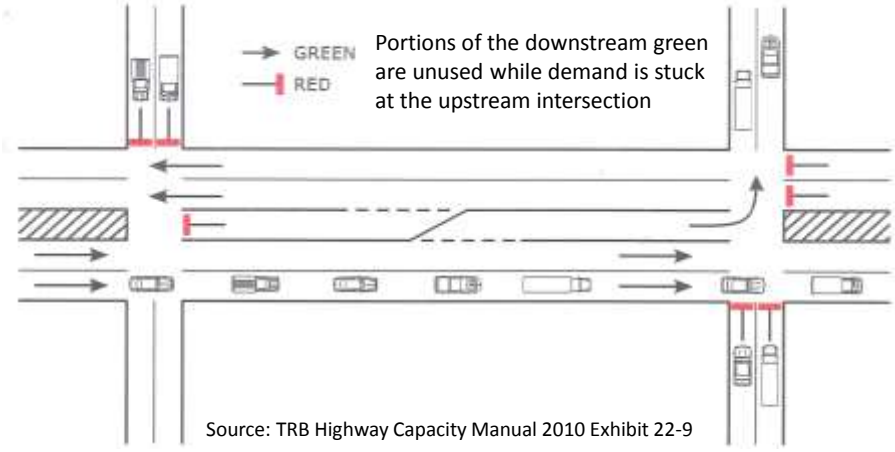
What is a Diverging Diamond Interchange (DDI)?



A diamond interchange form that allows the two directions of traffic on the crossroad to temporarily divide and cross to the opposite side to provide easier left-turns to and from the freeway

Traditional Diamond vs. DDI

Demand Starvation



Source: TRB Highway Capacity Manual 2010 Exhibit 22-9

What Are the Benefits of a DDI?

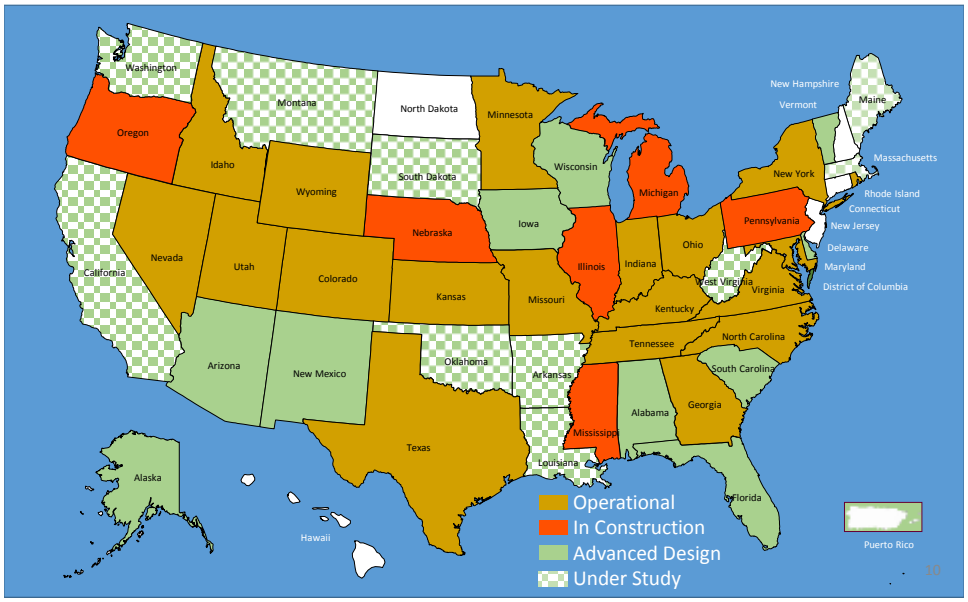
- Operations
  - Improves capacity with two-phase signals
    - Eliminates left turn phases to get traffic to/from the freeway
- Safety
  - Fewer conflict points
- Lower cost
  - Small footprint
  - Short construction timeframe
  - May salvage bridge

DDIs are particularly advantageous if the existing structure can remain in-place

"Before" – Traditional Diamond

Before Condition
Traditional Diamond

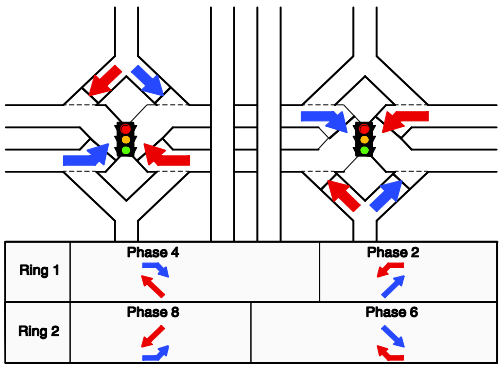
Where Do They Exist in the USA?



Signals at a DDI

- Two signalized "crossover" intersections establish the right-of-way for each "parallel" direction of traffic
  - Two phases at each
  - No separate left-turn phase
  - Can signalize the left or right turns onto the surface street, but the timings mimic the crossover signals

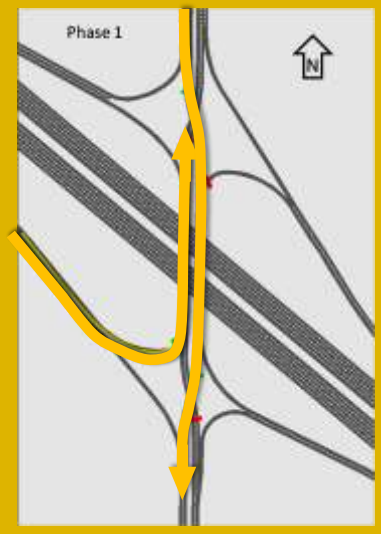
Simplified Signal Phasing of a DDI



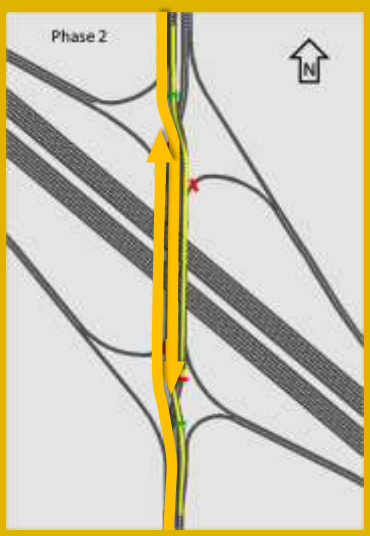
Note that the transition from Φ4 to Φ2 does not need to happen at the same time as the transition from Φ8 to Φ6

Innovative Solutions for tomorrow's transportation needs

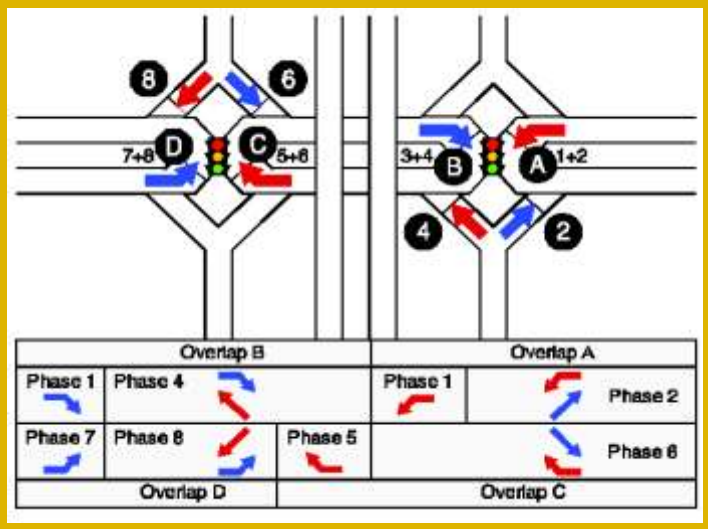
Signal Phasing: Favoring Cross-Street



Signal Phasing: Favoring Off-Ramps



"Dummy" and "Overlap" Phases



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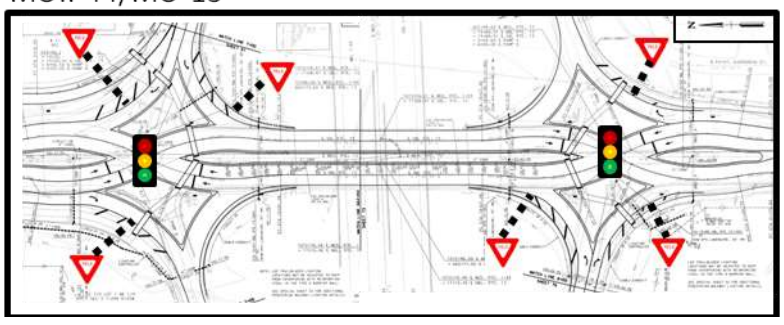
Should the Ramp Turning Movements be Signalized?

MO:I-44/MO-13



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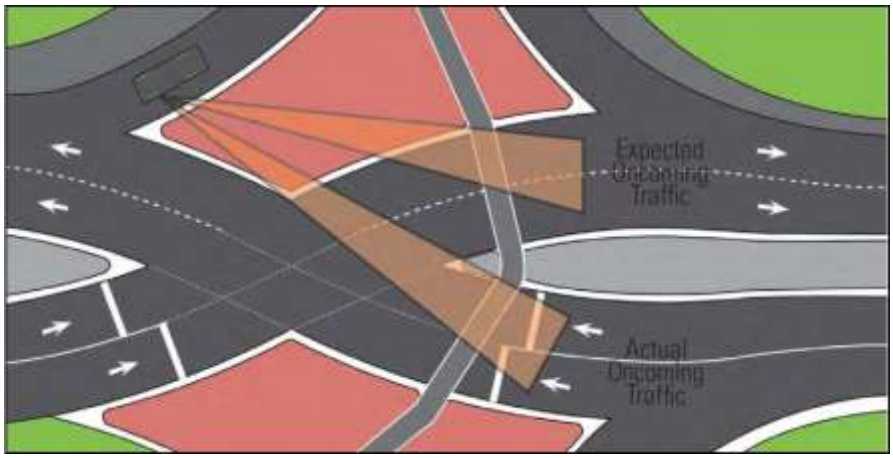
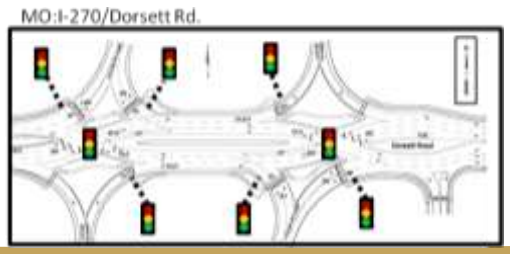
Right Turn from Freeway: Signalize or Yield?



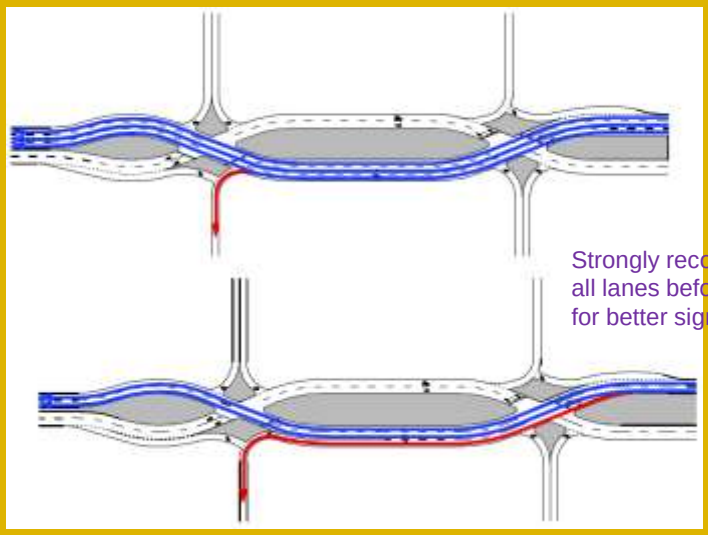
Source: MoDOT

More signals can be better!

- Especially where conflicts may cause problems:
  - Right turn from off-ramp
  - Left turn to on-ramp
  - All turns regarding pedestrians
  - All ramp movements with downstream weaving and merging



Lane utilization



3 Thru Lanes w/ shared Left

Strongly recommend forming all lanes before first crossover for better signing purposes

2 Thru Lanes w/ Exclusive Left

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Design Vehicle

- Typically WB-67
- Lane width: 12’ widened to 14’ in the crossover reverse curves and turning movements (especially on outside lanes)
  - Examine truck turning radii for acceptable operation
  - Consider curb choice and possible mountable curb in turning areas

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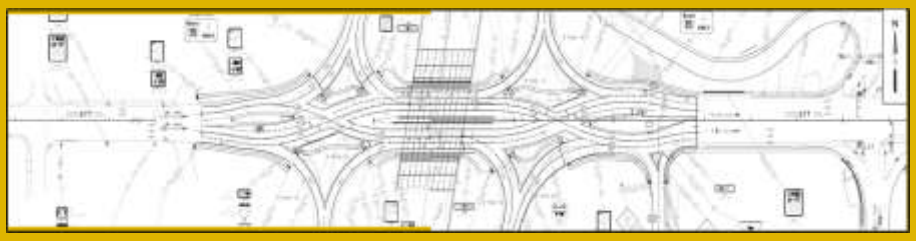
Innovative Solutions for tomorrow’s transportation needs

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
  - Typical crossover angles of 40-50 degrees
  - The crossover angle is dictated by right-of-way constraints and available cross-section over or under the bridge



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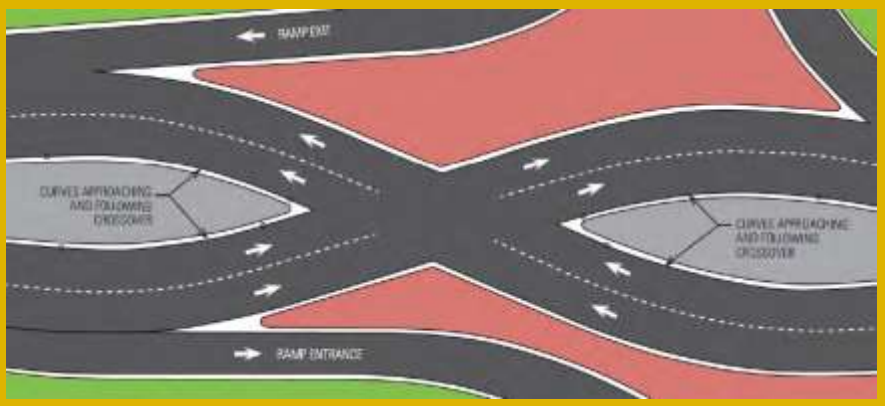
Crossover Geometry

Curve radii approaching and following the DDI crossover generally range from 150-300 feet



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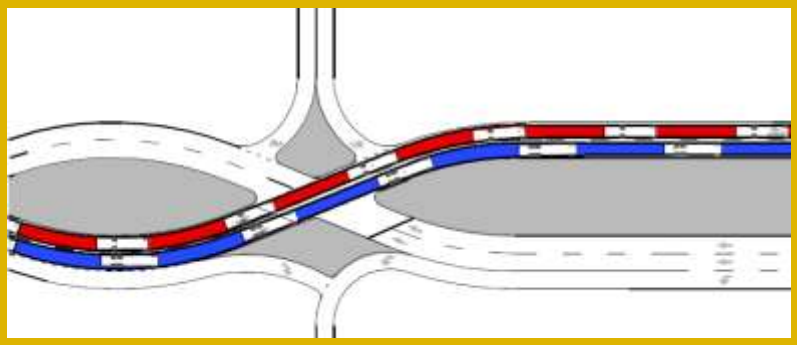
Vehicle paths through crossover



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). If the curve radii extends into the crossover (i.e. insufficient tangent), it makes for an awkward driving path and can lead to vehicle path overlap (encroachment into adjacent lane).

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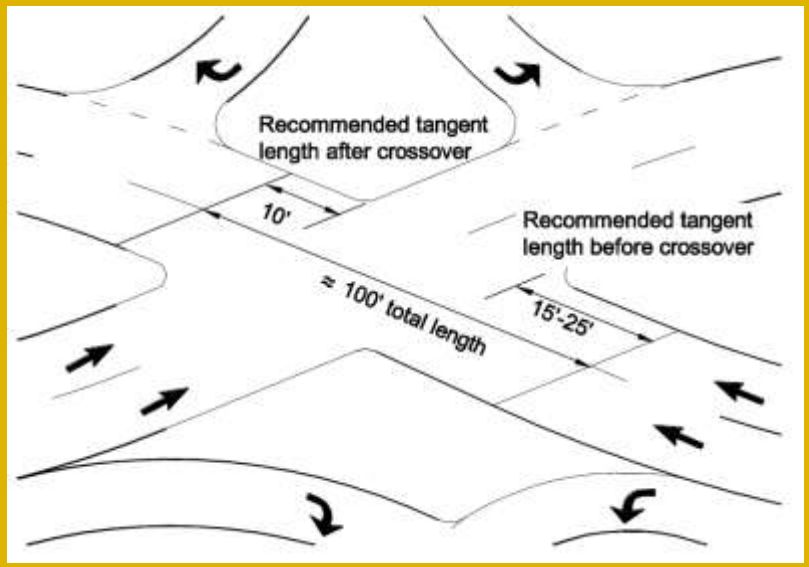
Tangent Before and After Crossover



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Potential path overlap

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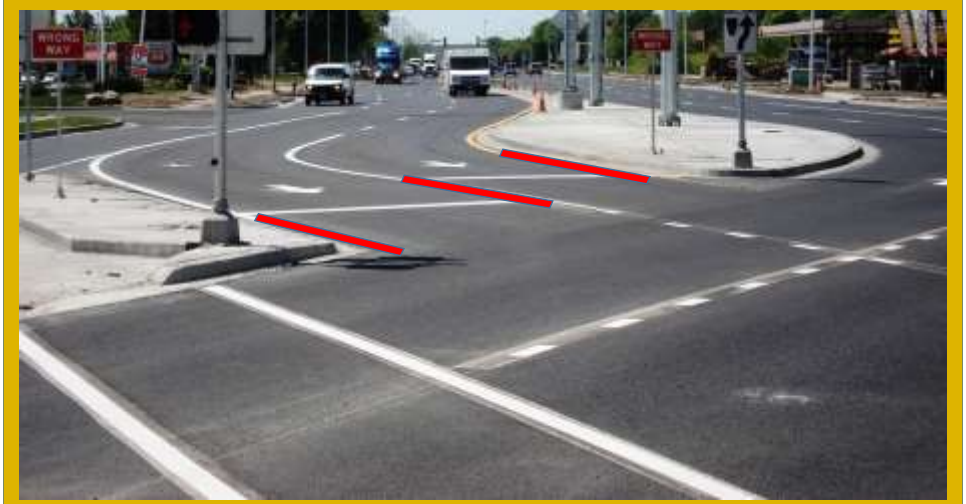
Short Tangent Before Crossover



Woods Chapel Road / I-70 DDI – Blue Springs, MO

Crossover Geometry

- The greater the crossing angle, the less "different" the intersection will seem
  - Recommended crossover angles of 40-50 degrees (or more)
    - Existing DDIs have angles as low as 28 degrees
  - Low crossover angles may increase the likelihood for wrong-way maneuvers into opposing lanes
  - Low angles increase crossing distances and increase signal clearance time

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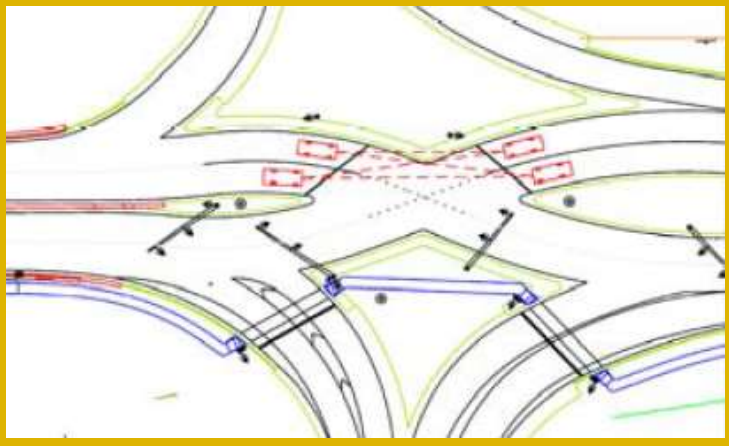
Crossover Geometry

- Greater crossing angles promote better lines of sight to signals and less concern with driver confusion on appearance of opposing traffic



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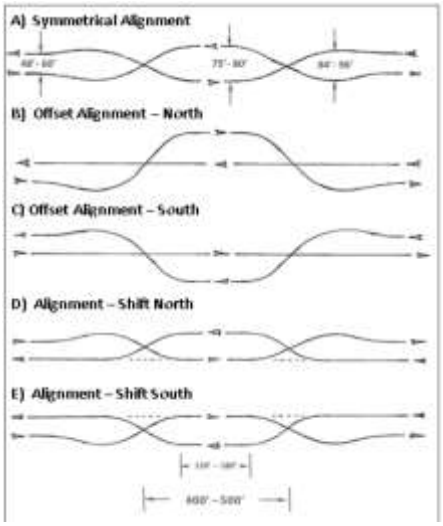
"To ∞ and beyond …"

Source: Brian Toombs, P.E. – Burgess & Niple

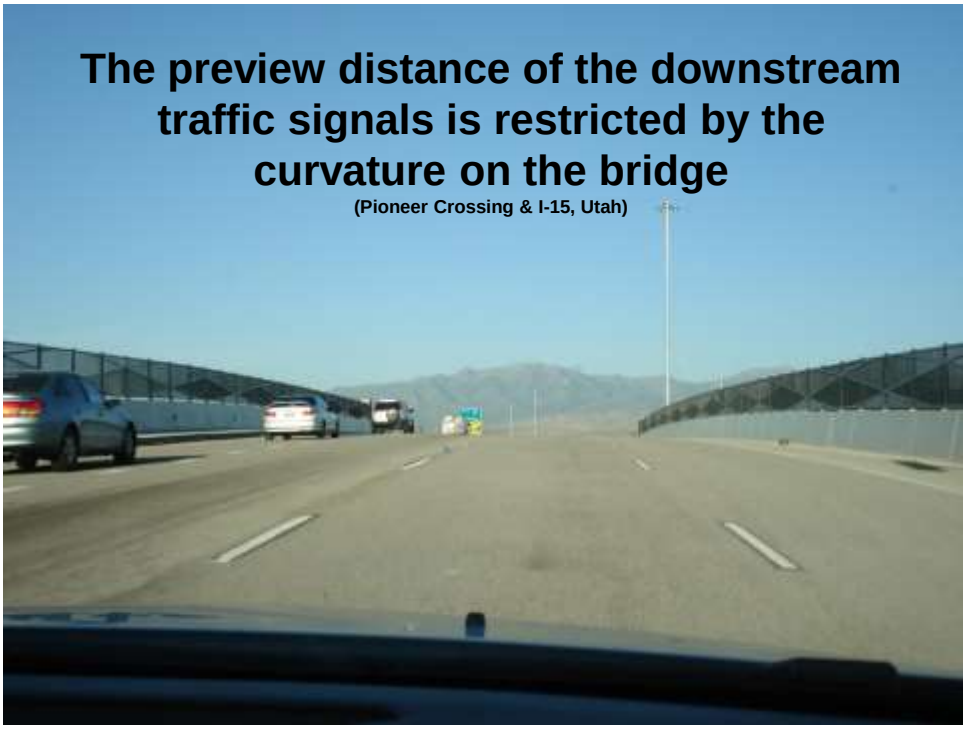


Alignment Alternatives

Various alignment alternatives should be considered with respect to the distance between crossovers and the amount of reverse curvature

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



Applicability of the DDI

- When might the DDI not be an appropriate alternative?
  - Close adjacent signalized intersections that are saturated and unable to be improved
    - Overall surface road corridor operations not significantly improved
  - Where existing driveways and a lack of ability to improve access control would reduce operational effectiveness
  - When there is substantial need to accommodate over-height vehicles with a exit ramp to entrance ramp "through"

Adjacent Intersection Spacing

- Key to ensuring quality of traffic flow along corridor
- Close spacing creates issues
  - Weaving conflicts
  - Merging conflicts with weaving traffic
  - Queue spillback/blocking of intersection
  - Crashes
  - Public disappointment
- Likely that the DDI will be more efficient than nearby signals
  - Therefore, nearby signals likely to control the capacity and progression of the corridor

Queue spillback

Since DDIs generally have fewer signal phases than adjacent intersections, they provide greater throughput and queue spillback may occur into the DDI departure zone if the downstream intersection cannot handle the traffic processed by the more efficient upstream DDI.

Queue spillback into DDI from downstream adjacent signal

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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

Relocate Intersection Farther Away

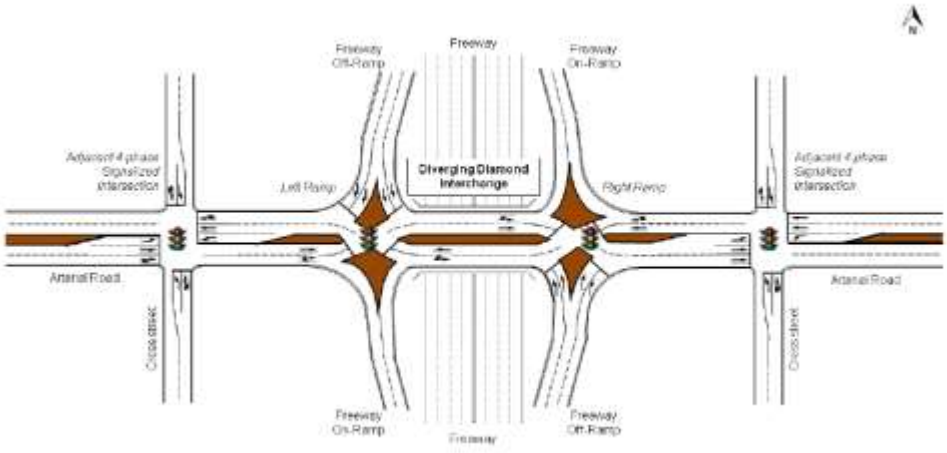
This treatment was used at Dorsett Road in Maryland Heights, MO

Relocate Intersection Farther Away

Dorsett Road in Maryland Heights, MO.

Reduce Signal Phases at Adjacent Intersection

Utilize innovative intersection designs to reduce the number of signal phases at adjacent intersections along the corridor



Reduce Signal Phases at Adjacent Intersection

Utah
ThrU Turn

Distinguishing Features

- Direct left-turns are eliminated from main intersection
- Bump-out or "loon" beyond the outside lane (or coinciding with a sidestreet tee intersection or driveway)

Reduce Signal Phases at Adjacent Intersection

Utilize innovative intersection designs to reduce the number of signal phases at adjacent intersections along the corridor

DDI Advantages for Pedestrians

- The two-phase DDI signal better serves pedestrian movements compared to three-phases
  - Typically allows more crossing time per phase to serve pedestrians
- With the separation and channelization of the two directions of vehicular traffic, pedestrians only have to cross one direction of traffic at a time

Pedestrian Guidance

Key issue for outside path: Signalized or Free Left

Bicycle Provisions

Four Basic Options:

1. Marked bicycle lane throughout the DDI
2. Marked bicycle lane on the approach to the DDI terminating upstream of the first crossover
3. Separated bicycle way or multi-use path
4. Bicyclists use the vehicular travel lane or pedestrian walkways (i.e. no specific bicycle provisions)

Questions