Diverging Diamond Interchange 101

14th Annual ACEC-KY FHWA KYTC Partnering Conference

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Presented By:

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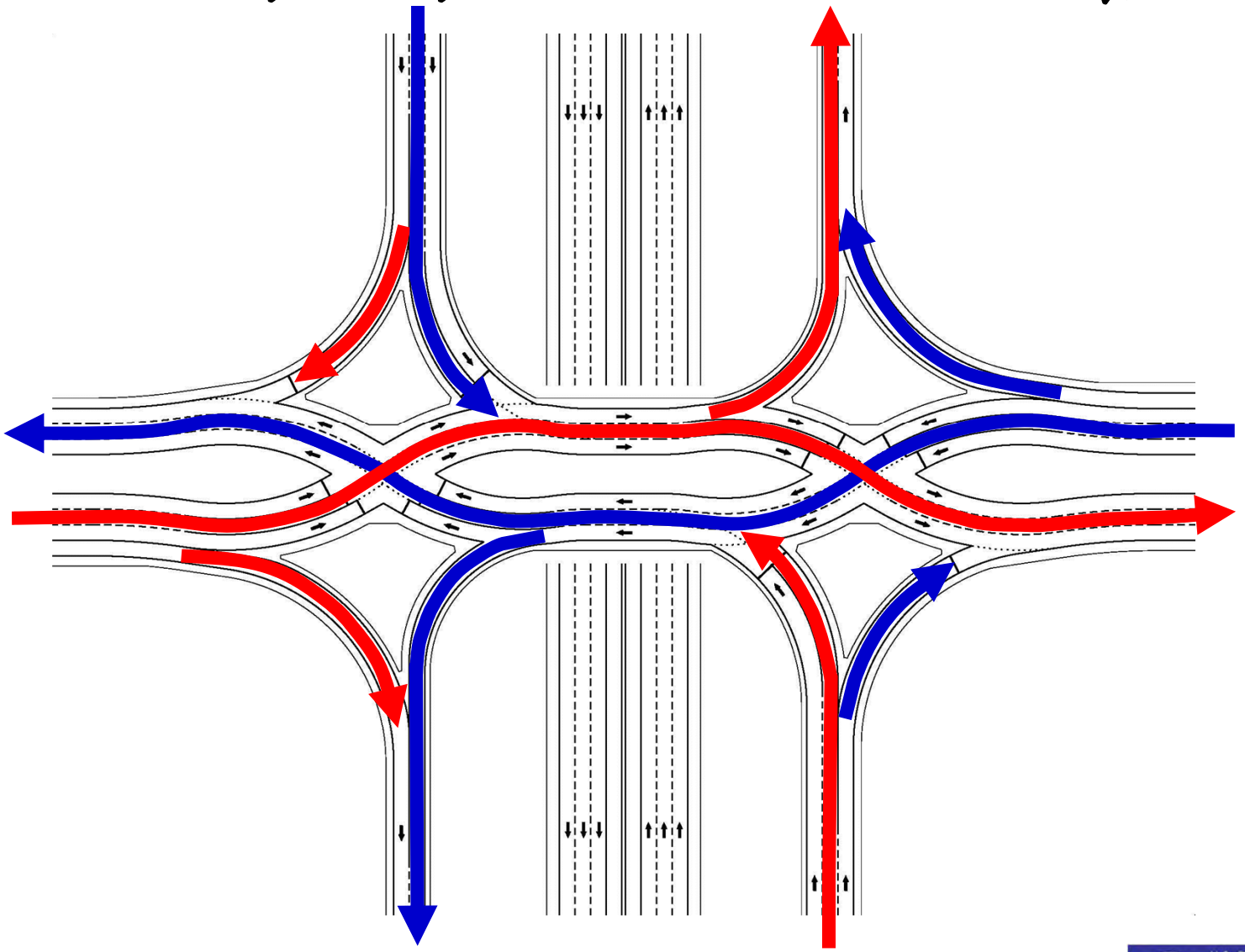
What is a Diverging Diamond Interchange (DDI)?

- It's a non-traditional design to accommodate left-turning movements at signalized, grade separated interchanges while eliminating the need for left-turn phasing of the traffic signals

- Also known as a Double Crossover Diamond (DCD)

What is a DDI? (Continued)



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Where did the DDI come from?

- The DDI originated in France in the 1970's
- Until recently, the only known DDIs were located in France:
  - Versailles
  - Le Perreux sur Marne
  - Seclin

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A13 & RD182
Versailles, France

Only 11 light injury crashes reported in 5 years compared to an average of 23 fatal/injury crashes of a typical DI in the USA

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D45 & A4
Le Perreux sur Marne, France

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A1 & D549
Seclin, France

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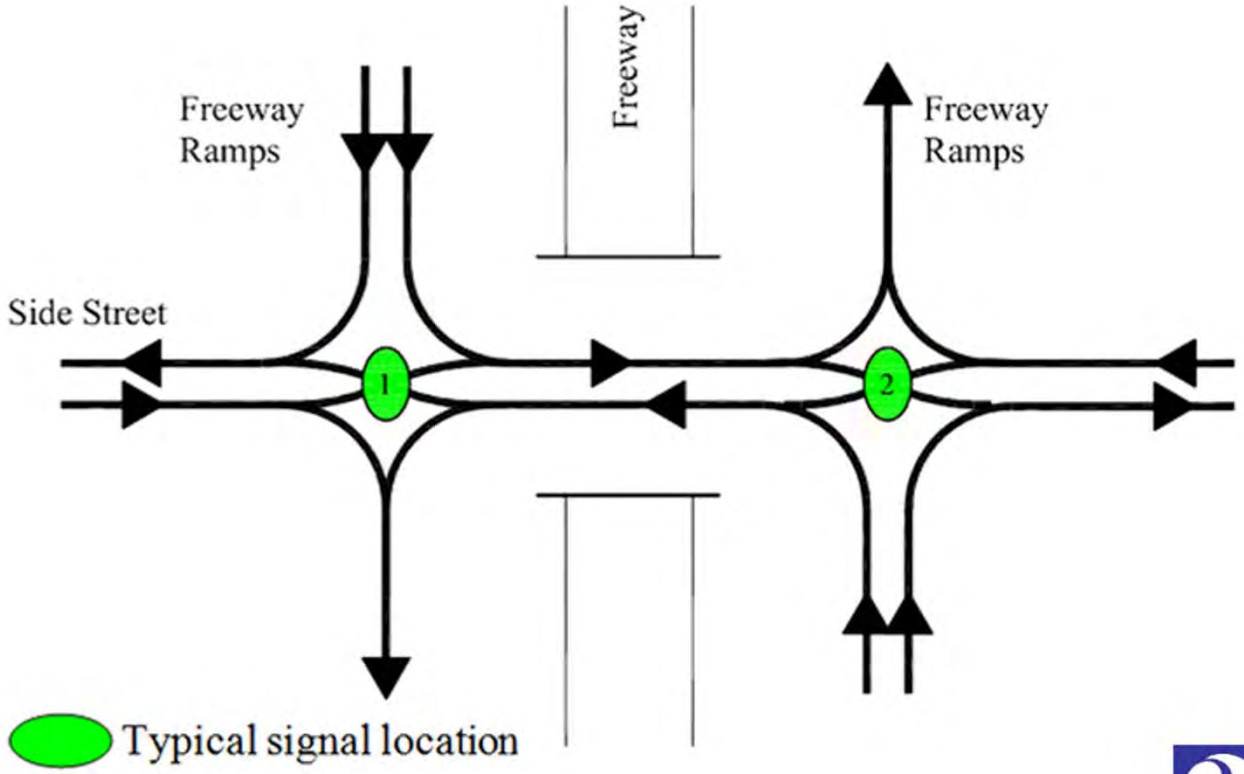
Why a Diverging Diamond?

- Improved operational benefits with two phase signal operation since left-turn phase is eliminated



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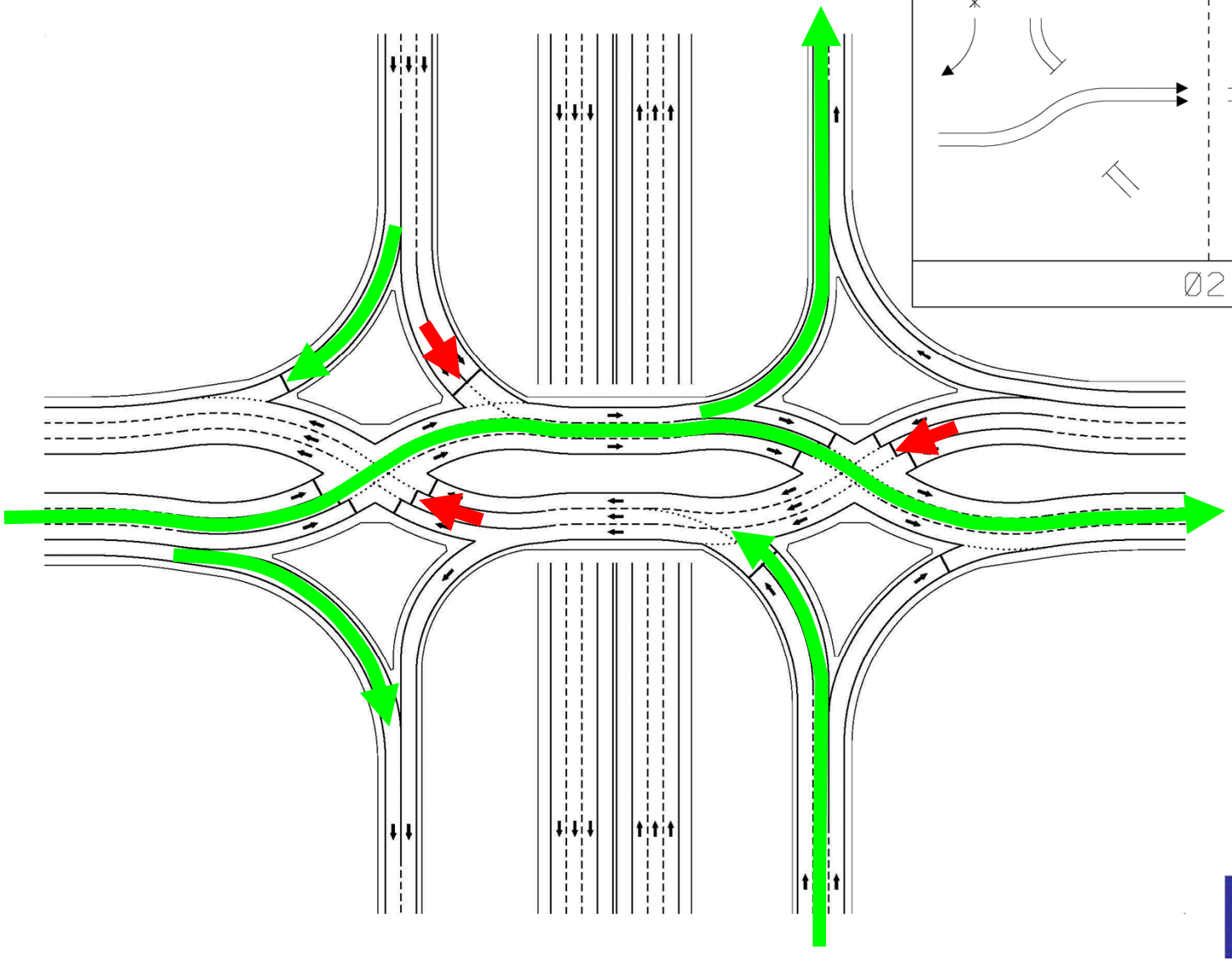
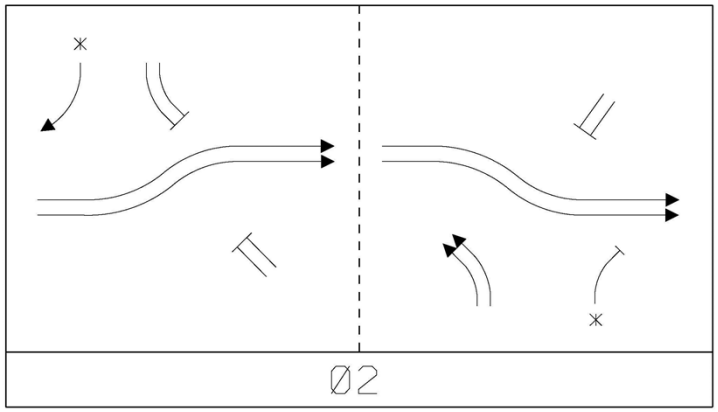
DDI Signal Phasing





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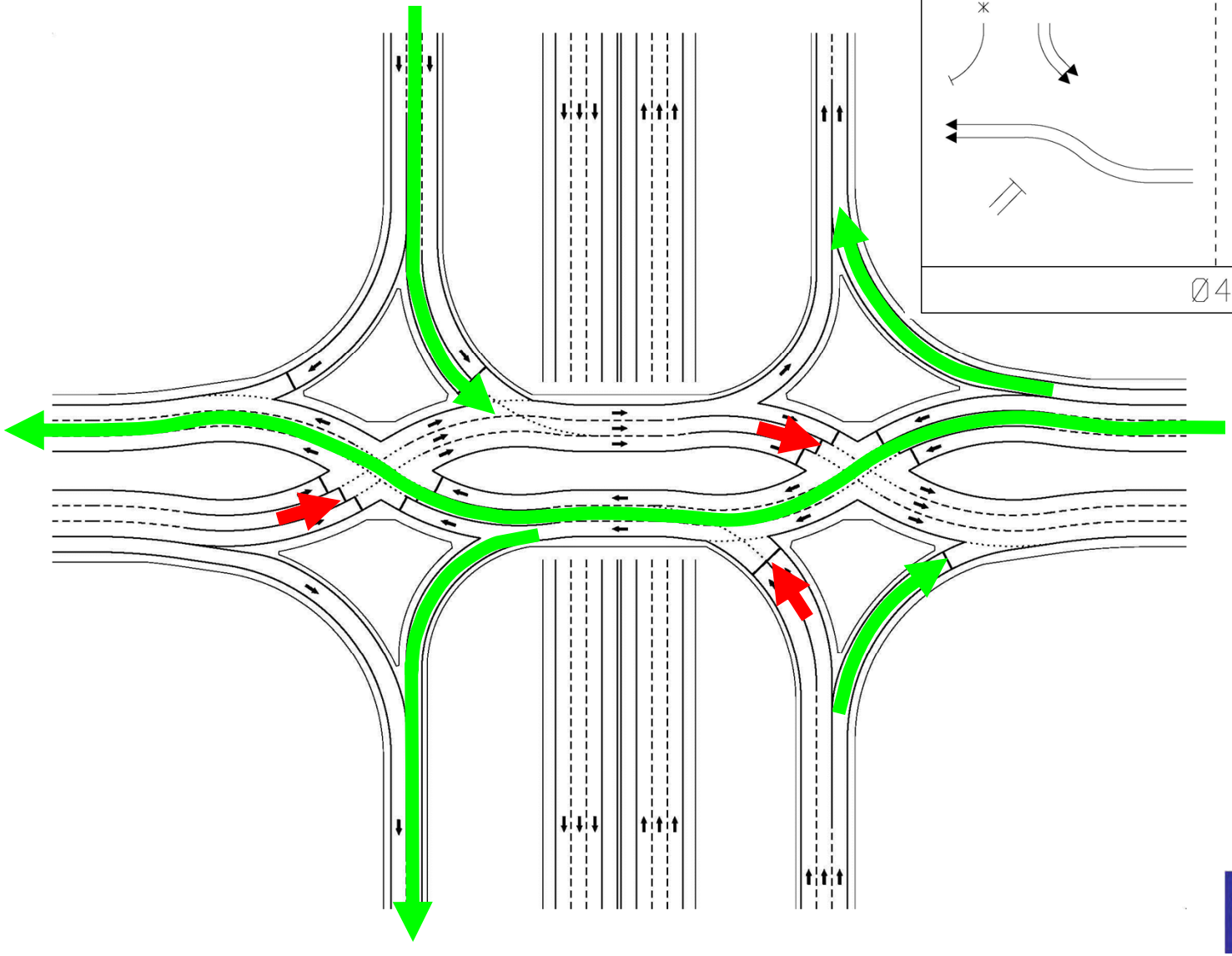
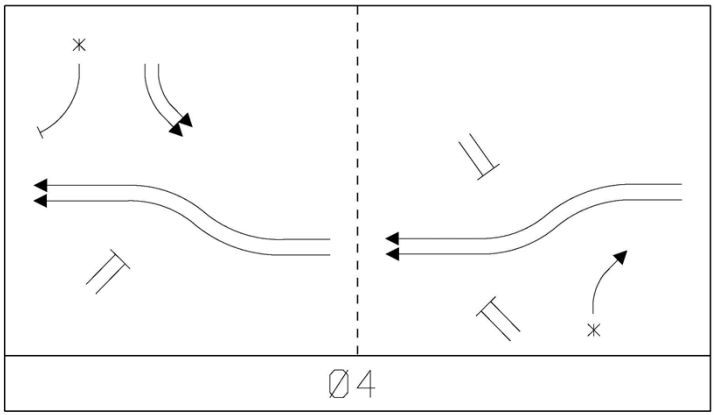
DDI Signal Phasing (Cont.)





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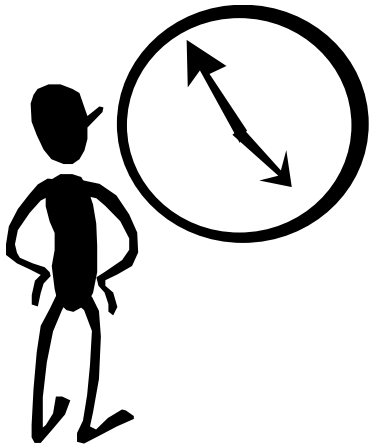
DDI Operational Benefits

- Research has shown that compared to a traditional diamond interchange, the DDI:
  - Reduces intersection delay by 15% – 60%
  - Increases throughput by 10% – 30%
  - Increases overall capacity by 15% - 25%



- A DDI accommodates heavy left-turn volumes onto ramps and from off-ramps
- A DDI accommodates moderate or unbalanced through volumes

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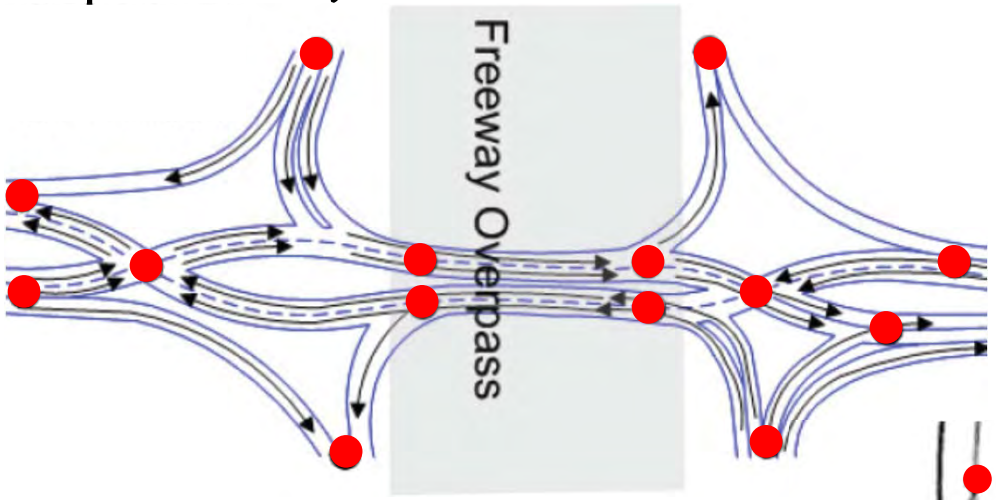
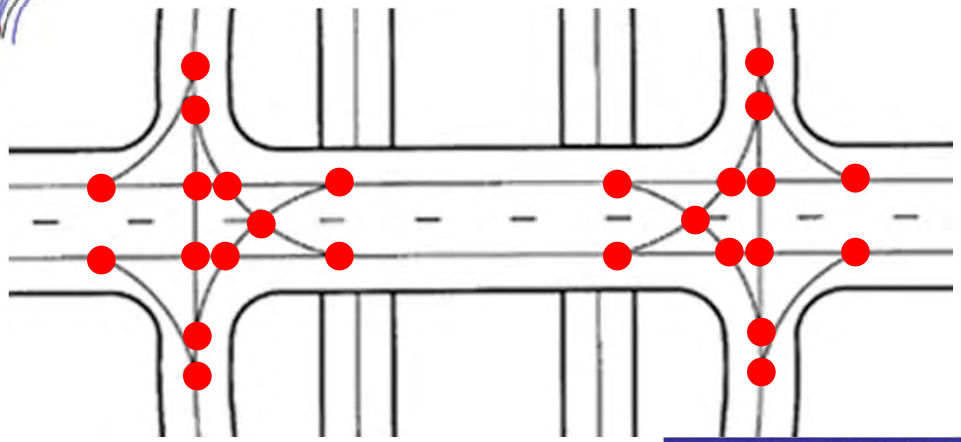
Why a Diverging Diamond?

- Theoretical safety benefit from reduction in potential vehicle-vehicle conflict points



- DDI: 14 Conflict Points



- Traditional Diamond Interchange: 26 Conflict Points
- Single Point Urban Interchange: 18 Conflict Points

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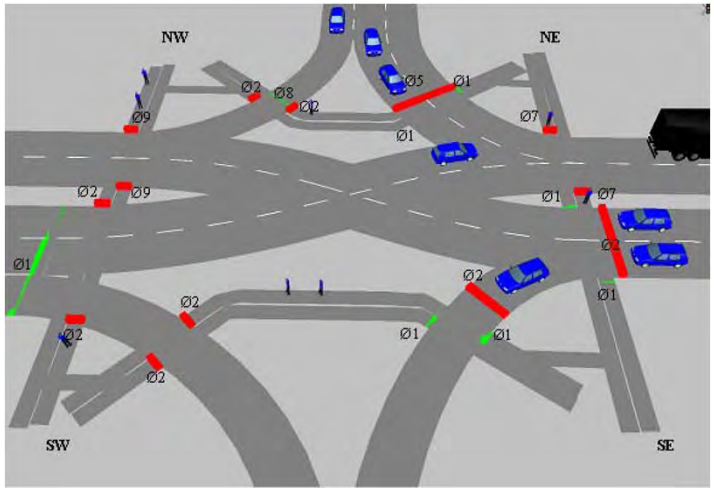
Why a Diverging Diamond?

- Theoretical pedestrian safety improvement with multi-stage crossing as pedestrians only cross one direction of traffic at a time



- Curvature reduces vehicle speeds through intersections
- Potential for reduction of infrastructure costs through reduction of needed lanes and underpass/overpass bridge width

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MoDOT Proposes DDI

- I-435 & Front Street
  Kansas City, MO
  - Gateway to Northeast Industrial District

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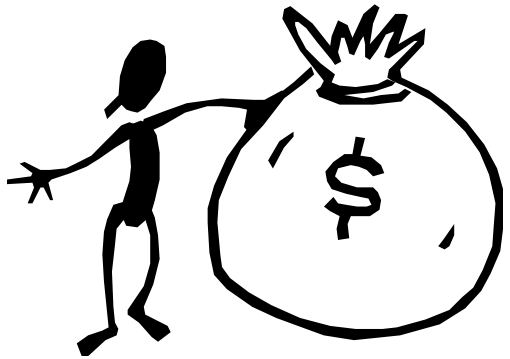
I-435 & Front Street Alternatives
TUDI vs. DDI

- Estimated Costs

	TUDI	DDI
Construction	$ 6,866,000	$ 4,918,000
Right of Way	$ 3,868,000	$ 1,445,000
Utilities	$ 600,000	$ 391,000
Total Costs	$11,354,000	$ 6,754,000



- Operations
  - TUDI – 8 lanes, LOS C-F, Capacity @ 95%
  - DDI – 4 lanes, LOS A-C, Capacity @ 60%
- Safety
  - TUDI – 45 Conflict Points
  - DDI – 21 Conflict Points

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Why Not Select a Diverging Diamond?

- The DDI is a new concept to drivers in the US
- The crossover maneuver is not intuitive because drivers travel on the opposite side of the road
- Concern that driver unfamiliarity will result in an increase in crashes

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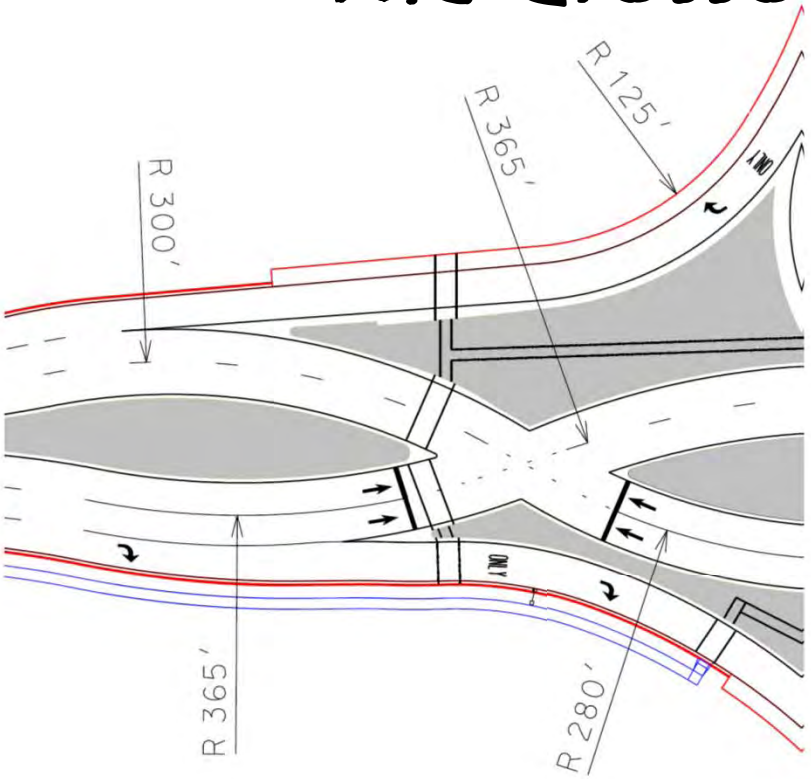
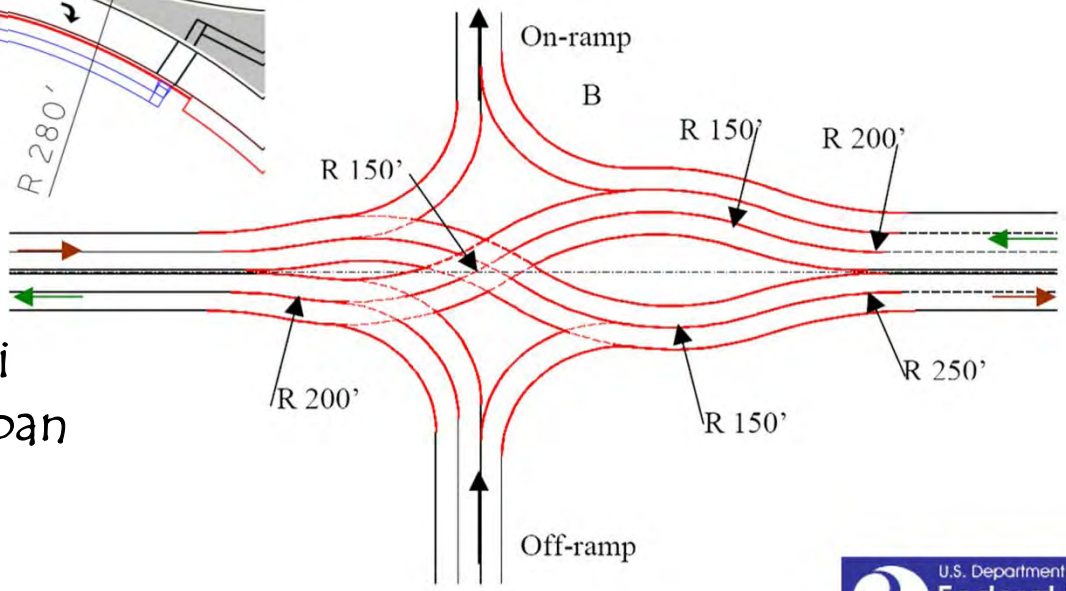
The Crossover Design



◇Design of I-435 & Front Street DDI Crossover with larger radii to accommodate high truck/heavy vehicle %



◇More typical design radii values expected for an urban DDI Crossover

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FHWA Human Factors Driver Simulation Study

- Simulation of I-435 & Front Street DDI in Highway Driving Simulator at Turner-Fairbank Highway Research Center
- Three simulated interchanges – DDI, DDI (Mod), and Diamond
- 74 Drivers (Balance male/female & over/under 65)
- Results published in FHWA Tech Brief (www.tfhrc.gov)

TECHBRIEF

Drivers' Evaluation of the Diverging Diamond Interchange

Publication No. FHWA-HRT-07-048

FHWA Contacts: Joe G. Bared, Task Manager 202–493–3314; Tom Granda, 202-493-3365; or Abdul Zineddin, 202-493-3369

Objective

In recent years, the Federal Highway Administration (FHWA) has been advocating novel intersection designs as a way to promote intersection safety while meeting the often conflicting demands for increasing capacity, decreasing congestion, and minimizing the cost of new infrastructure. One of these novel designs is the diverging diamond interchange (DDI).[1] [2] [3]

The DDI design accommodates left-turning movements at signalized, grade-separated interchanges of arterials and limited-access highways while eliminating the need for left-turn phasing. On the arterial, traffic crosses over to the left side of the roadway between the nodes of the interchange. Two-phase traffic signals are installed at the crossovers. Once on the left side of the arterial roadway, vehicles can turn left onto limited-access ramps without stopping and without conflicting with through traffic. Figure 1 provides a bird's eye view of the DDI simulation used in this study. Colored arrows have been added to emphasize the direction of travel on the arterial.

Figure 1. Aerial view of a simulated DDI. Yellow and blue arrows indicate the direction of travel on the arterials.

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Research, Development, and Technology
Turner-Fairbank Highway Research Center
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McLean, VA 22101-2296

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I-435 & Front Street DDI Simulation

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I-435 & Front Street DDI Simulation

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Study MOEs and Results

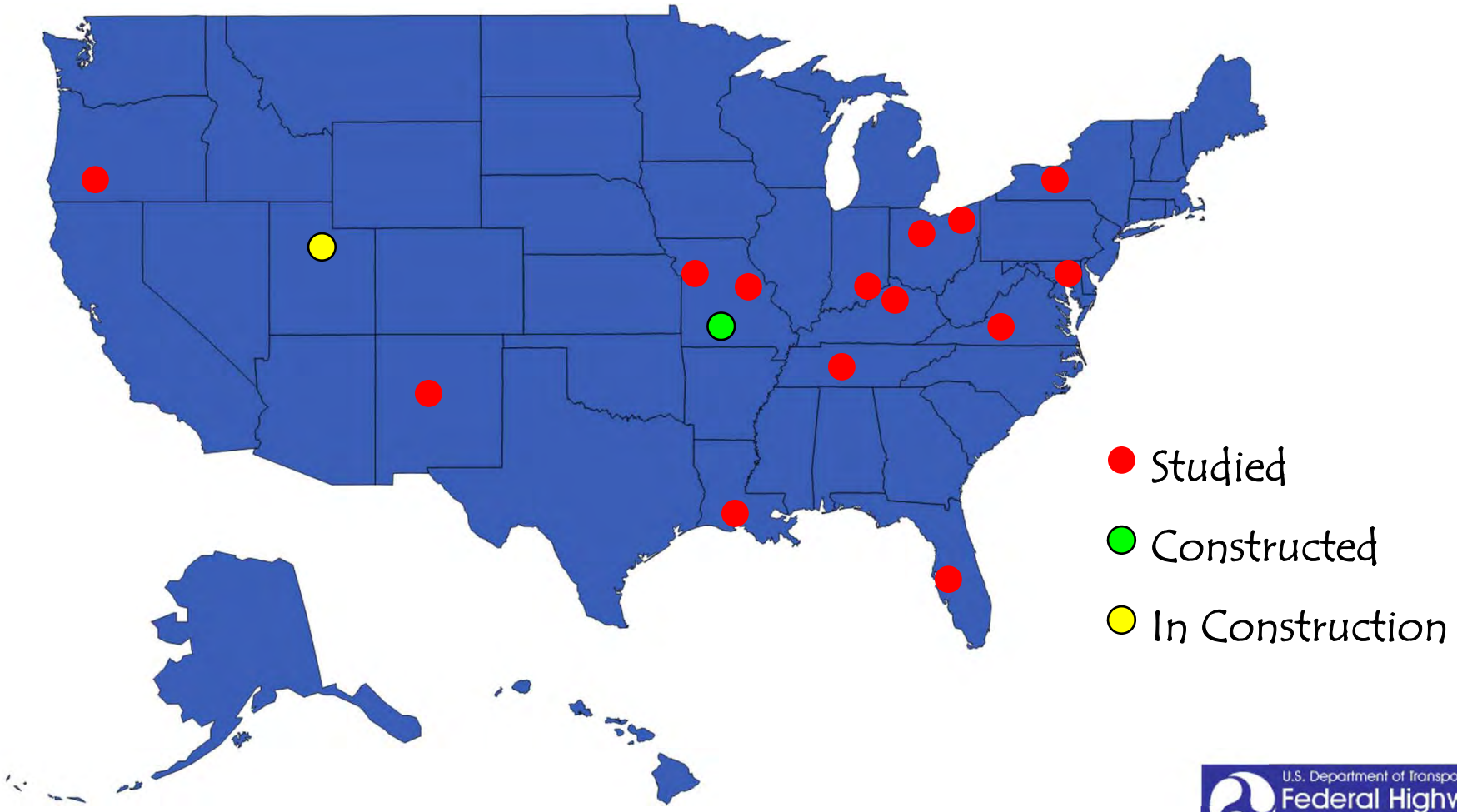
- Wrong-way Violations
  - No violations at crossover (1041 opportunities)
- Navigation Errors
  - Incorrect path on only 2.3% of opportunities
- Red-light Violations
  - Similar frequency although rare, but more violation opportunities with conventional diamond
- Speed @ Crossovers/Intersections
  - DDI – avg. 24 mph
  - Diamond – avg. 34 mph

DDI Conclusions/Recommendations

- The safety benefit combined with predicted operational benefits and reduced roadway width requirements make the DDI an attractive interchange alternative
- Simulation study suggests potential driver confusion not as significant of a concern and is mitigated with proper design (reverse curvature), signing, and markings

DDIs Under Consideration

- Status of DDIs in the following states:



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I-15 & American Fork in Sarasota Springs, UT

Under Construction – Project is 25% Complete

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MoDOT & DDIs

- June 21, 2009 the first DDI in the United States opened at I-44 & Route 13 in Springfield, MO
- I-435 & Front Street in Kansas City, MO to be constructed soon
- Planned:
  - US 65 & Chestnut Expressway in Springfield, MO
  - US 60 & National Avenue in Springfield, MO
  - Botts Road & Route 150 in Kansas City, MO
  - I-270 & Dorsett Road in St. Louis County, MO

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I-44 & Route 13 in Springfield, MO

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