Diverging Diamond Interchange 101

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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)
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
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
D45 & A4
Le Perreux sur Marne, France
A1 & D549
Seclin, France
Why a Diverging Diamond?

- Improved operational benefits with two phase signal operation since left-turn phase is eliminated
DDI Signal Phasing
DDI Signal Phasing (Cont.)
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
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
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
MoDOT Proposes DDI

- I-435 & Front Street
  Kansas City, MO
  - Gateway to Northeast Industrial District
I-435 & Front Street Alternatives
TUDI vs. DDI

- **Estimated Costs**

<table>
<thead>
<tr>
<th></th>
<th>TUDI</th>
<th>DDI</th>
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<tbody>
<tr>
<td>Construction</td>
<td>$6,866,000</td>
<td>$4,918,000</td>
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<tr>
<td>Right of Way</td>
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<tr>
<td>Utilities</td>
<td>$600,000</td>
<td>$391,000</td>
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<tr>
<td>Total Costs</td>
<td>$11,354,000</td>
<td>$6,754,000</td>
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- **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
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
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
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)
I-435 & Front Street DDI Simulation
I-435 & Front Street DDI Simulation
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:
I-15 & American Fork in Sarasota Springs, UT

Under Construction – Project is 25% Complete
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
I-44 & Route 13 in Springfield, MO
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Contact Information

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