FDOT DDI Design Webinar Series
Traffic Operations
August 10, 2021
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**
  - Date: June 15, 2021
  - Time: 2p-5p

- **DDI Geometric Design**
  - Date: June 29, 2021
  - Time: 2p-3p

- **DDI Signing & Marking and Signals**
  - Date: July 16, 2021
  - Time: 2p-3p

- **DDI Traffic Operations**
  - Date: August 10, 2021
  - Time: 2p-3p

- **DDI Multimodal Accommodations**
  - Date: August 24, 2021
  - Time: 2p-3p

- **DDI Plans Detailing & Public Involvement**
  - Date: September 7, 2021
  - Time: 2p-3p
DDI Traffic Operations – Webinar Instructors

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DDI Traffic Operations – Webinar Logistics

- You are MUTED upon entry
- Please ask questions via Questions dialogue box
DDI Traffic Operations - AGENDA

- Traffic and Safety Benefits
- Signal Timing and Phasing
- Other Signal Operations Considerations
- Closely Spaced Adjacent Intersections
- Capacity Analysis
Key considerations

Several key operational & safety considerations need to be evaluated early in the analysis process since they may greatly influence geometric design, signal design, and impact how to properly model traffic.
Traffic Operations

Operational Analysis

Does the lane configuration meet the desired project operational goals?

YES

Sketch initial alignment for cross road including crossover intersection angle, ramp terminal curvature, etc.

Develop initial signal timing

Assess corridor operations if DDI is close to adjacent intersections

Identify available R/W and constructability constraints including utility conflicts

NO

Revise lane configuration

Iterate to optimize design

Establish Design Hour Volumes

Sketch an initial lane configuration
DDI Traffic and Safety Benefits
Benefits of a DDI

- Better Traffic Operations
  - Reduced Intersection Delay
  - Eliminates the need for left turn signal phases

- Lower Cost
  - Retrofit – Possibility to keep existing bridge structure
  - New Construction – Smaller structure footprint due to fewer lanes; less width on the approach to the interchange due to fewer lanes

- Improved Safety
  - Fewer conflict points for vehicles and pedestrians
  - Lower travel speeds
Better Traffic Operations

- Basic two-phase signal operation

Better Traffic Operations

- When left turn phases are added....
  - Adding “protected” left-turn phases is common as traffic volumes increase

Better Traffic Operations

- When more phases are added....
  - Adding more phases “steals” time away from the major through movement and can increase intersection delays
  - More phases also add more “lost time” (clearance intervals)
Better Traffic Operations

- Signalization of a Traditional Diamond

1st Phase
Thru Movements

2nd Phase
Exit Ramp

3rd Phase
Left Turns

Florida Department of Transportation
Better Traffic Operations

- Two Phase Signal
Improved Safety

- Intersection Conflict Points

**Conventional Diamond**

- 10 Crossing Conflicts (most severe)
- 26 Total Conflict Points

**Diverging Diamond**

- 2 Crossing Conflicts (most severe)
- 14 Total Conflict Points

Source: Ohio DOT
Improved Safety

- Discouraging Wrong-Way Movements

ABOUT 90 DEGREES

OFTEN > 140 DEGREES
Improved Safety

**FHWA Field Evaluation (2015)**
- Evaluated 7 of the earliest DDI conversions in the United States
  - 4 in Missouri
  - 1 in Kentucky
  - 1 in Tennessee
  - 1 in New York
- Collected 4 years of “before” and 3 years of “after” DDI conversion crash data
- Recommended CMF = 0.68 for Total Crashes
- Recommended CMF = 0.61 for Injury/Fatal Crashes

Objective
This TechBrief provides results from the second year of a major study commissioned by the Federal Highway Administration (FHWA) to evaluate the first few double crossover diamond (DCD) interchange installations in the United States (U.S.). This research is (1) evaluating the operational and safety impacts of converting an existing diamond interchange into a DCD and (2) investigating how accurately field-observed traffic conditions at DCIs can be replicated in the microscopic simulation model VISSIM.

This research studied the following seven recently constructed and operated DCD interchanges:
- Bessemer Street at US 129, Alcoa, TN;
- MO 13 at I-44, Springfield, MO;
- National Avenue at US 60, Springfield, MO;
- Dorsett Road at I-270, Maryland Heights, MO;
- Harrodsburg Road at KY 4, Lexington, KY;
- Front Street at I-435, Kansas City, MO;
- Winton Road at I-590, Rochester, NY.

Operational Characteristics
The DCD interchange, also known as a diverging diamond interchange, is an alternative to other service interchange forms, such as conventional diamond interchanges and partial cloverleaf interchanges. The primary difference between a DCD and a conventional diamond interchange occurs at the directional crossovers along the cross-street on...
Improved Safety

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    - 1 in New York
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- Recommended CMF = 0.61 for Injury/Fatal Crashes
Improved Safety

- **Missouri DOT Evaluation Study (2015)**
  - Evaluated 6 early DDI implementations in the state of Missouri
  - Compared these to 6 comparable Diamond interchanges
  - Collected average of 2.5 years of “before” and 2.5 years of “after” DDI conversion crash data
  - Reduction of Total Crashes by over 40%
  - Reduction of Injury/Fatal Crashes by over 60%

Source: Ohio DOT
Improved Safety

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  - Evaluated 6 early DDI implementations in the state of Missouri
  - Compared these to 6 comparable Diamond interchanges
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  - Reduction of Total Crashes by over 40%
  - Reduction of Injury/Fatal Crashes by over 60%

“In summary, the DDI offers significant crash reduction benefits over conventional diamond interchanges.”
DDI Signal Timing and Phasing
Signal Overlaps

- Thru movements at crossovers should have enough red clearance time to clear the conflicting ramp movement.
- Depending on DDI geometry, this can be a lengthy interval.

Source: NCHRP 959
Signal Overlaps

- Use overlaps or short, fixed-time phases following thru movements
- Minimizes driver frustration

Source: NCHRP 959
Signal Progression

Two Critical Movements

- Alternating Directional Progression for Crossroad
- Progression for Left-Turns from the Exit Ramps
Three Critical Movements

Source: NCHRP 959
DDI Other Signal Operations Considerations
Other Signal Operations Considerations

- Signalized Right Turns
Other Signal Operations Considerations

- **Signalized Right Turns**
  - Poor sight lines can lead to driver error
  - Dual turn lanes can cause sight line obstructions
Other Signal Operations Considerations

- **Signalized Right Turns**
  - Poor sight lines can lead to driver error
  - Dual turn lanes can cause sight line obstructions
  - Movements with downstream weaving
  - No turns on red
Other Signal Operations Considerations

- **Signalized Left Turns**
  - Same sight line issues for left turns as with right turns
  - No turns on red
Other Signal Operations Considerations

- Queue Storage Between Crossovers

*critical storage distance*
*crossover distance*
measured from center to center of intersections
Other Signal Operations Considerations

- **Shared Left/Thru Lane**
  - Left turn capacity can be significantly reduced if the thru queue routinely blocks the entrance to the turn lane
Other Signal Operations Considerations

- Lane Utilization/Lane Balance

3 Thru Lanes w/ shared Left

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

2 Thru Lanes w/ Exclusive Left
Other Signal Operations Considerations

- **Lane Utilization through a DDI**
  - Think about how lane assignments affect traffic flow
  - Minimize turbulence within the DDI
DDI Closely Spaced Adjacent Intersections
Traffic Operations

- Closely spaced signalized intersections
  - Common myth of how to “break a DDI”
  - No “magic dimension”
Closely Spaced Adjacent Intersections

- Queue Spillback
  - Queue spillback from an adjacent signal can block the crossover intersection if it cannot handle the increased throughput from the DDI.
Closely Spaced Adjacent Intersections

- **Queue Spillback**
  - Can the adjacent signal be eliminated?
Closely Spaced Adjacent Intersections

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  - Can the adjacent signal be eliminated?
Closely Spaced Adjacent Intersections

- **Queue Spillback**
  - Can the adjacent signal be moved farther away?
Closely Spaced Adjacent Intersections

- Queue Spillback
  - Can the adjacent signal be moved farther away?

Closely Spaced Adjacent Intersections

- **Weaving Conflicts**
- Consider traffic volume weaving from exit ramp to adjacent left turn lane
- Signalize the right turn from the ramp
Traffic Operations

- Closely spaced signalized intersections
  - Example
Traffic Operations

- Closely spaced signalized intersections
  - Adjust intersection to give more green time back to the primary road
  - Dual left from the secondary street
Traffic Operations

- Closely spaced signalized intersections
  - Don’t “blindly” trust your traffic simulation models!
Traffic Operations

- Closely spaced signalized intersections
  - May need to make adjustments after construction is completed
Demand Starvation

- Vehicles blocked by the upstream intersection causes unused/ineffective green time at the downstream signal.

Portions of the downstream green are unused while demand is stuck at the upstream intersection.
DDI Capacity Analysis
Capacity Analysis Software - SYNCHRO

- Easy to use
- Works well for corridor analysis
- Good planning level tool
- Difficult to use with non-traditional intersection geometry and signal phasing
Capacity Analysis Software - SYNCHRO

- FDOT Traffic Engineering and Operations Office website has several Synchro templates, including a DDI
  - https://www.fdot.gov/traffic/trafficservices/intersection-operations.shtm
  - Jughandle
  - Median U-Turn
  - Quadrant Roadway
  - Restricted Crossing U-Turn
  - Continuous Flow Intersection
  - Diverging Diamond
  - Continuous Green T-Section
Capacity Analysis Software - SYNCHRO
Capacity Analysis Software - VISSIM

- Can analyze nearly any geometric configuration and signal phasing
- Great visual display
- Helps the public understand how non-traditional geometry works
- Can get very labor intensive
Capacity Analysis Software - VISSIM
Capacity Analysis Software - VISSIM
ADDITIONAL DDI RESOURCES
Additional DDI Resources

FDOT Development Design Criteria - DDI

NCHRP 959 – DDI Informational Guide
Questions?

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