Diverging Diamond Interchanges

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About Horrocks Engineers

Horrocks Engineers is a full service Civil Engineering Firm with Offices In 5 States:

- Utah
- Idaho
- Nevada
- Arizona
- New Mexico

Involved with the Development of:

- 6 Constructed DDIs
- Numerous Studies Considering DDIs
- UDOT’s DDI Recommended Practices Publication
- UDOT’s DDI Observations and Experience Publication
• Diverging Diamond Interchanges in the US

• What is a Diverging Diamond Interchange?

• Recommended Practices
  ▪ Traffic Operations Analysis
  ▪ Signalization
  ▪ Geometric Design

• Benefits of DDI/Why Consider Using One

• Conclusions & Lessons Learned
• 64 Completed DDIs in the US

• Number of Operational DDIs Growing Exponentially
The main goal of the DDI is to reduce delay by accommodating the left turn movements, and reducing the number of phases in the signal cycle. Only two signal phases are required, compared with three for a SPUI, or four with a diamond.
Option for signalized right turns (with no RTOR)

Directional crossover for through movements functions as a two-phase signal

Left turns do not conflict with opposing traffic

Option to carry downstream left turn through upstream crossover

Reverse curvature upstream of crossover

Right turns typically yield to lefts on on-ramp

Left turns from freeway are yield- or signal-controlled

Option for right turn with acceleration lane

FHWA, DDI Informational Guide, Report No. FHWA-SA-14-067
• Interchange Developed as Part of I-15 CORE Design-Build Project
  • Concept Originally Proposed in 2008

  ▪ UDOT Operational and Geometric Design of DDIs
    ▪ Operational Thresholds and Sensitivity Analysis
    ▪ Geometric Design Recommendations
• Operational Failure when:
  • A + B > 1900 vph
• Operational Failure when:
  • A + B > 1900 vph
  • A + C > 1900 vph
Operational Thresholds

• Operational Failure when:
  • $A + B > 1900$ vph
  • $A + C > 1900$ vph
  • $B + C > 1900$ vph
Operational Thresholds

- Operational Failure when:
  - $A + B > 1900 \text{ vph}$
  - $A + C > 1900 \text{ vph}$
  - $B + C > 1900 \text{ vph}$
  - $A + B + C > 2100 \text{ vph}$
• Operational Failure when:
  • A + B > 1900 vph
  • A + C > 1900 vph
  • B + C > 1900 vph
  • A + B + C > 2100 vph

• Transition from LOS D to LOS F is very short. For this reason, UDOT defines LOS C as a minimum for acceptable operation.
• Considerations:
  • Weaving and merging behavior
  • Signal timing
  • Driver behavior
  • Closely spaced intersections

• Requires use of micro-simulation software
  • UDOT requires use of VISSIM (PTV America) for analysis
Signalization of Ramp Movements

• Considerations:
  
  • Significant Traffic & Pedestrian Volumes
  
  • Multi-Lane Turning Movements
  
  • Merging & Weaving Operations within the interchange
  
  • Requires a non-traditional signal warrant analysis
Favoring Cross-street Signal Phasing – Option 1
Typical Signalization Layout

(Signalization of right turn optional)

(Optional near side signal)
Typical Signalization Layout

(Signalization of right turn optional)

(Optional near side signal)
• Design Speed
• Ramp terminal separation distance.
• Lane and Shoulder Widths.
• Roadway Cross-Section.
• Crossover intersection layout and grading.
• Glare Reduction.
• Signing and Striping.
• Design speed through the crossovers is reduced at least 10 mph, with a minimum speed through the curves of 25 mph.

• Recommended Design Speed is 25-35 mph

• Utilize reverse curves with tangents to minimize length of crossover zones.
Crossover intersections should be spaced 850’ apart, with adjacent signalized intersections 1000’ from the crossover intersections.

Right-in/Right-out access points may be placed according to Access Management rules.

Placement of accesses closer than 1000’ should be analyzed using VISSIM to determine potential operational effects.
• Shoulder widths should NOT be reduced across structure.

• Lane widths should be at least 12 feet.

• Turning templates for side by side WB-67 or other appropriate design vehicle should be applied.
Roadway Cross Section

NOTES:

1. ROADWAY CROSS-SLOPE TO BE GRADED AS SHOWN IN AREAS WHERE SNOW REMOVAL IS ANTICIPATED.

2. SHOULDER DIMENSIONS TO BE DETERMINED FROM PROJECT DESIGN CRITERIA. 5' MIN. SHOULDER WHEN USED AS BIKE LANE.

3. SHOULDER DIMENSIONS TO BE DETERMINED FROM PROJECT DESIGN CRITERIA.
UDOT

30° Minimum

FHWA

45° Minimum
Cross-Over Development

FHWA, DDI Informational Guide, Report No. FHWA-SA-14-067
Placement of glare screen is specific to each DDI design, and may affect horizontal alignments.

Line-of-sight calculations should be used.

Additional study required to identify appropriate design parameters.
Optional Glare Screen Placement
Pedestrians and Bicycle Treatments
Pedestrians and Bicycle Treatments
Pedestrians and Bicycle Treatments
• Proximity of side streets, railroads, etc.

• Accommodation of pedestrians.

• Existing geometric constraints in retrofit projects.
• 500 East, American Fork
  • Why a DDI?
  • Crossover geometry & glare reduction
  • Side street & ramp terminal separation
Case Study – 500 East Interchange
When compared with SPUI or Diamond interchanges:

**ADVANTAGES**
- Higher left-turn capacity.
- No exclusive left-turn lanes.
- Smaller structures.
- Two-phase signal provides flexibility in timing.
- Smaller ROW footprint at the interchange.

**CHALLENGES**
- Contrary to driver expectation.
- Operation sensitive to signal and street spacing.
- Rapid transition from LOS D to LOS F.
- ROW impacts at crossover intersections.
- Integration of pedestrian traffic.
Conclusions and Lessons Learned

• Design/Build contractors may submit the DDI interchange type as an alternate concept; RFP should be written to address the possibility.

• Operational analysis of a DDI requires specific software and requires more review time.

• Retrofit of existing structures may extend the operational life of the interchange for much less than reconstruction.
Questions

THAT CONCLUDES MY TWO-HOUR PRESENTATION. ANY QUESTIONS?

DID YOU INTEND THE PRESENTATION TO BE INCOMPREHENSIBLE, OR DO YOU HAVE SOME SORT OF RARE "POWER-POINT" DISABILITY?

ARE THERE ANY QUESTIONS ABOUT THE CONTENT?

THERE WAS CONTENT?
Horrocks Engineers DDI Experience

I-86/US-91 - Chubbuck, ID
Idaho’s First DDI
I-15/US 91 – Brigham City, UT
DDI Experience

I-15/SR-92 - Lehi, UT
Utah’s First Diamond to DDI Retrofit
DDI Experience

I-15/Pioneer Crossing - American Fork, UT
Utah’s First DDI
DDI Experience

I-15/St George Blvd. – St George, UT