Downstream Intersection and Ramp Terminal Considerations to Improve DDI Corridor Performance

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Background and Motivation

NCHRP 3-113 *Guidance for Traffic Signals at Diverging Diamond Interchanges and Adjacent Intersections*

- Geometric Limitations
- Safety Concerns
- Operational Concerns

DDI Schematic for Reference

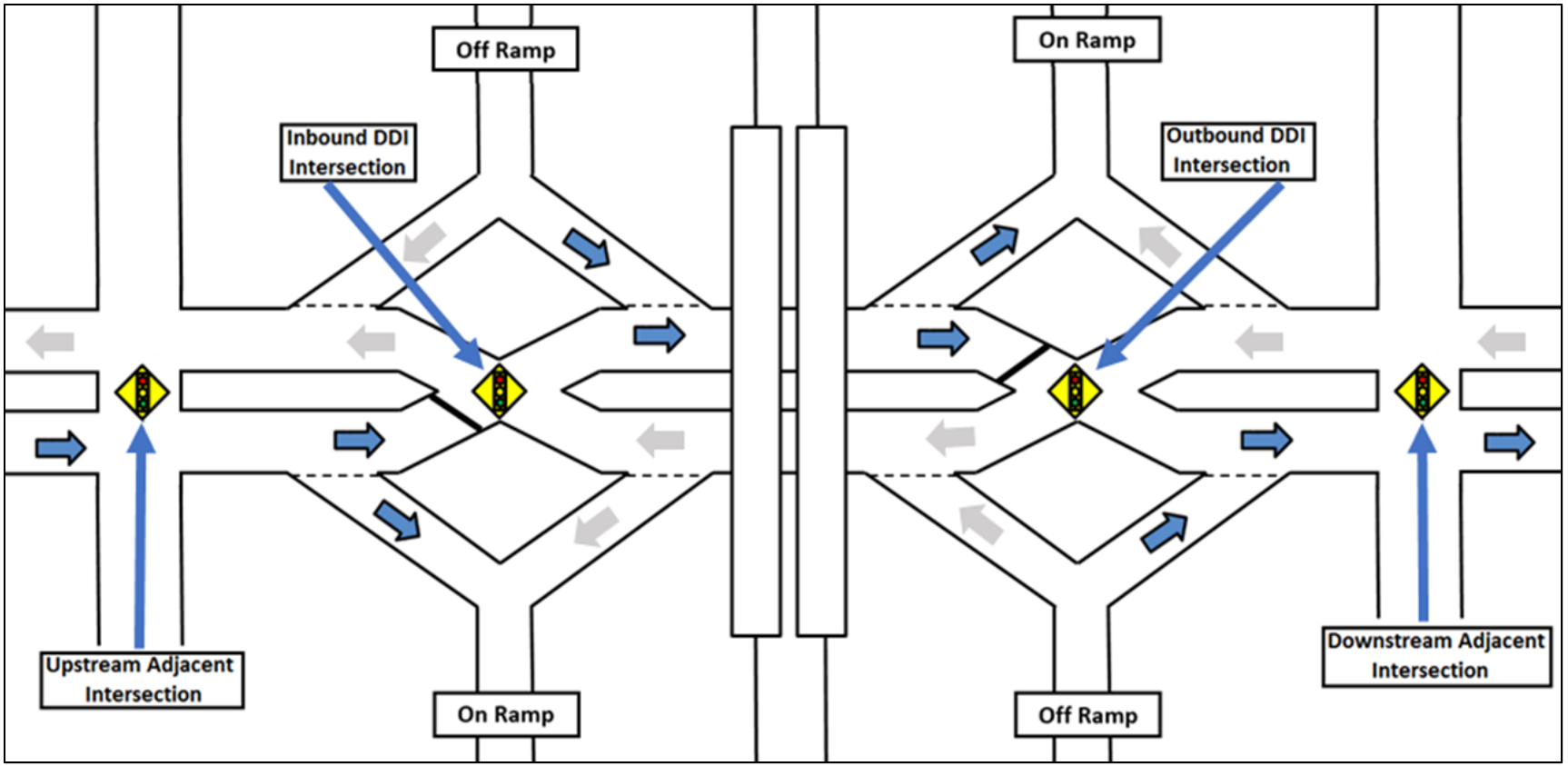


Figure 1 DDI Intersection Naming Schematic

Strategies to Improve DDI Corridor

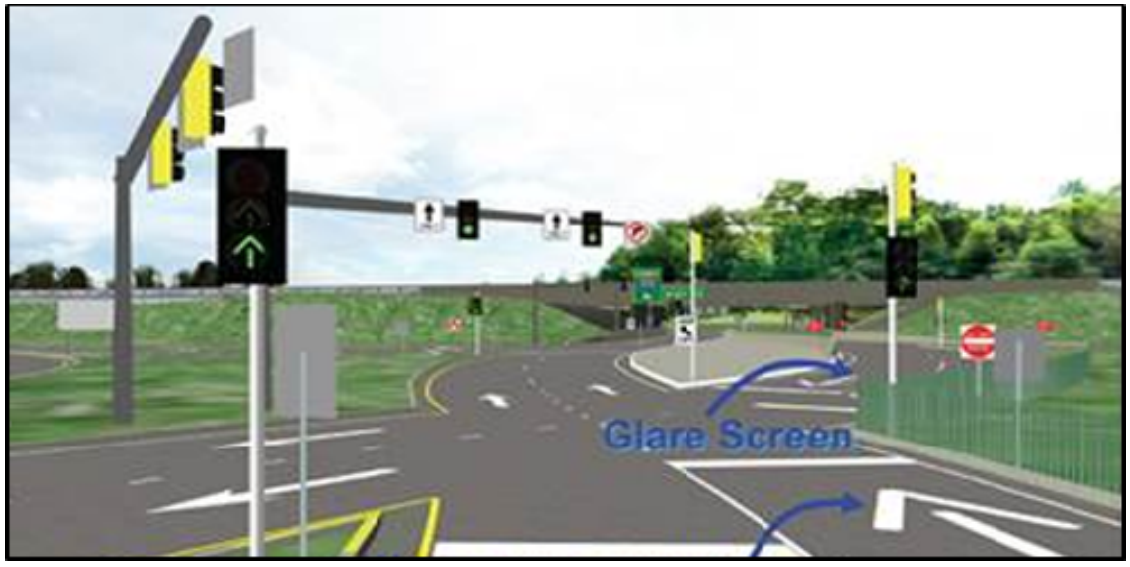
- Optimize Timing and/or Meter Traffic
- Eliminate Phases at Adjacent Intersections
- Lead/Lag Phasing
- Twice per Cycle Left at Adjacent Intersection
- Alternate Side-Street Phases
- Free/Uncoordinated
- Half Cycling
- RTOR Allowed at Off-Ramp
- Vehicle/Transit Preemption
- Dedicated Phase for Concurrent Left and Right Turn
- Dynamic Overlap Phasing
- Signalize Left On-Ramp
- Access Management
- Dual or Triple Off-Ramp Turn Lanes
- Relocate Right Turn at Off-Ramp
- CTL with Acceleration Lane
- Right Turn Slip Lane
- Sight Distance Improvement for Right Turn at Off-Ramp
- Glare Screen
- General Design Considerations
- Signing and Pavement Marking
- Guidance on When/Where to Add/Drop Lanes
- Add Lanes to Side Street at Adjacent Intersection
- Add Storage Capacity of On-Ramp

General Design Considerations

- Trucks and Wrong Way
  - Crossover Angle
  - Tangent between Reverse Curves
  - Slow down Trucks for Crossover without Superelevation
  - Crossover Lane Width
- Exit Ramp Turns
  - Prevent Tipping
  - Multiple Lanes + Wide Truck Turns

Glare Screens/Tall Barriers

- Glare from oncoming vehicles at crossover not significant
- Can help channelize the sight line to the correct crossover approach for RTOR



Right Turn at Exit Ramp

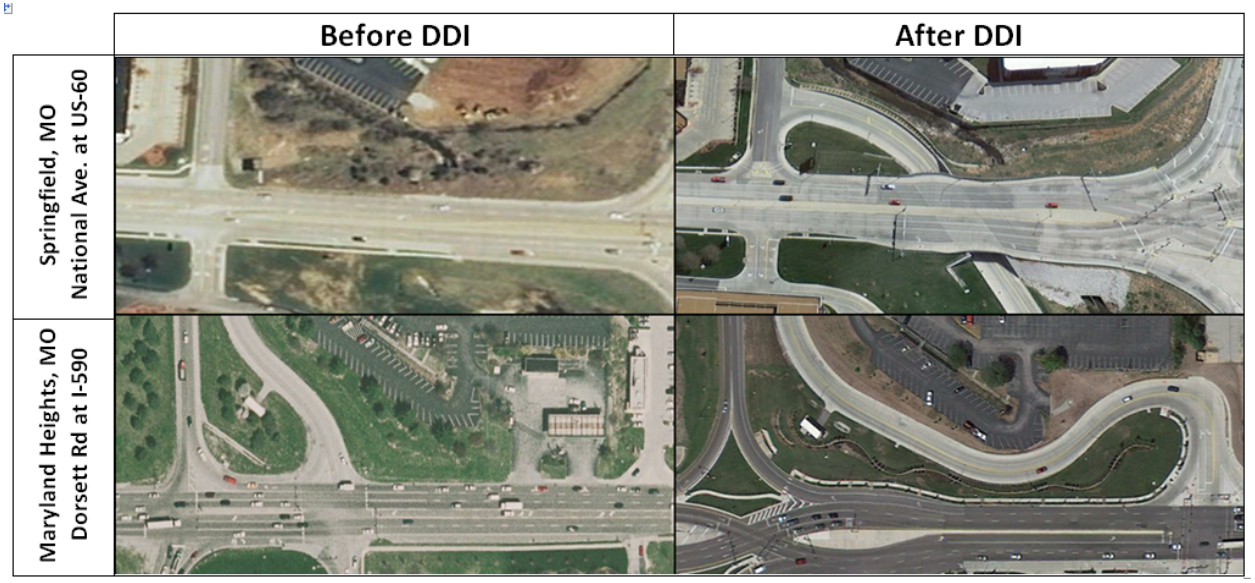
- Crossover Median Barrier Lowered/Shaved Down For Better Sight Distance
- Realign Right Turn Parallel To Inbound Traffic At The Mainline Crossover

Signing and Pavement Marking

- Identify lane assignments in advance
- Combine overhead signs with pavement markings
- Warn pedestrians of direction of oncoming vehicles

Access Management

- Adjacent Driveways or Signalized Intersections cause Safety and Operational Concerns
- U-turn, Grade Separation, Combine Approaches



Signal Timing Strategies

- 750’ Crossover Spacing
- 3 critical phase scheme
- 6 Volume Scenarios
  - Low
  - Heavy Through
  - Heavy Left Off
  - Heavy Right Off
  - Heavy Left On
  - Heavy Through and Right Off

Free and Half Cycle

- In low volume and highly variable conditions, free signal operations may be more effective
- In corridors with adjacent controlling intersections, the DDI may progress better at half cycle

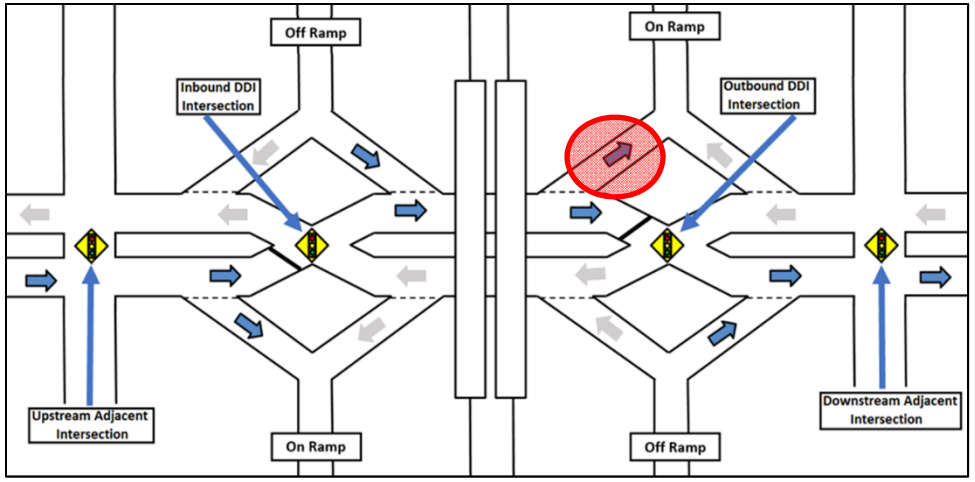
Simulation Results: Increased delay under simulated conditions

(Volumes not low/random enough)

Signalize On-Ramp Left Turn

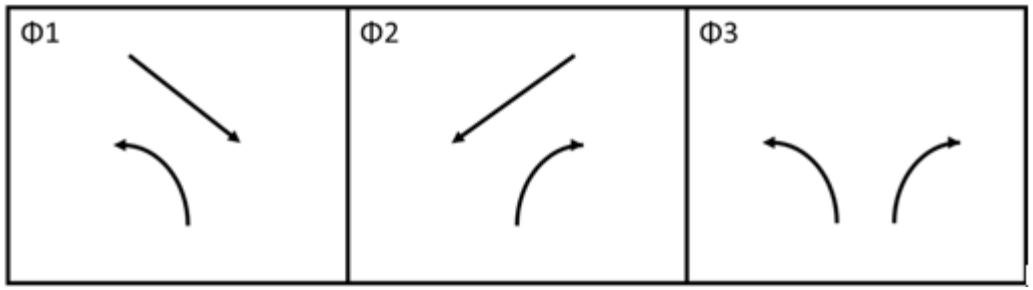
- In order to accommodate pedestrians, the left turn on ramps must be signalized
- Pedestrian hybrid beacon (PHB) or rectangular rapid flashing beacon (RRFB)
- Coordinate with the major DDI movements

Simulation Results: No net impact on delay



Dedicated Phase for Concurrent On-Ramp Left and Right Turns

- During peaks with continuous high exit ramp demands



- Can be preempted to act as a flush phase

Simulation Results: Off Ramp delay decrease, Through delay increase

Left Turn and Right Turn on Red

- RTOR and LTOR can be provided if proper sight distance is available and drivers can identify conflicting vehicles

Simulation Result: Most movement delays decrease

Dynamic Overlap Phasing

- Crossover is timed to allow crossing traffic to clear crossover in advance of right or left exit ramp green
- Dynamic overlaps use detection in the crossover to shorten clearance time when there are no vehicles present

Simulation Result: Lower delays on exit ramp movements

DDI Schematic for Reference

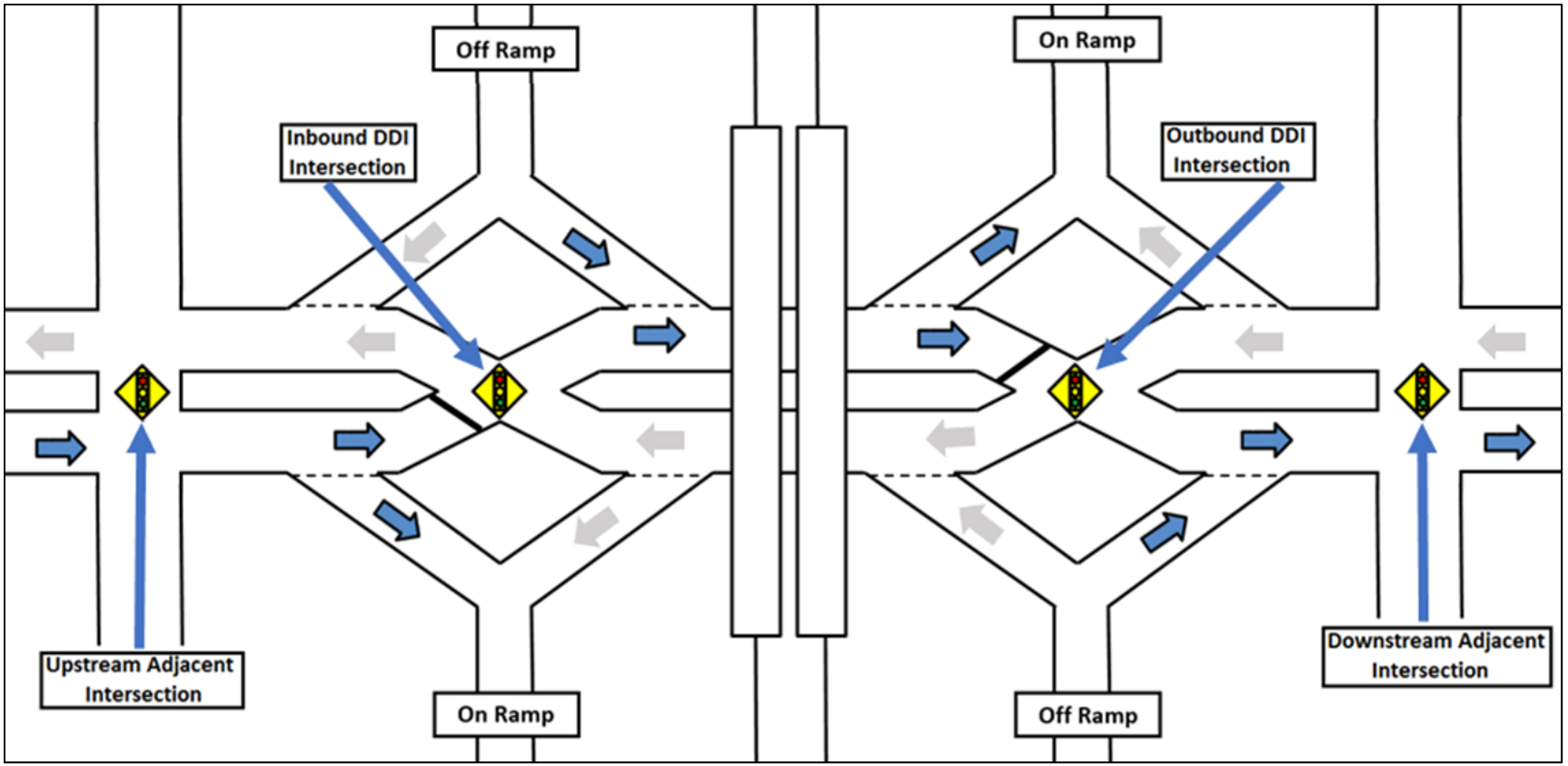


Figure 1 DDI Intersection Naming Schematic

Dynamic Overlap Phasing

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Simulation Result: Lower delays on exit ramp movements

Alternate Side-Street Phases at the Downstream Adjacent Intersection

- When adjacent intersection side street volumes are low, show green for one direction every other cycle
- Only used when capacity at this intersection is the critical issue on the corridor

Simulation Result: Minimal Net Impact on Delay

Lead/Lag Outbound Lefts at Downstream Signal

- In simulation base case, all lefts were leading
- Allowing lead/lag improved bi-directional coordination with DDI

Simulation Results: Net delay decrease for movements passing through downstream signal

Eliminate Phases at Adjacent Intersections

- Utilize alternative intersections at upstream and/or downstream intersections
- Superstreet, RCUT, MUT to increase mainline capacity
- Side street split phases may be skipped for very low demands

Simulation Results: Net decrease in delay for movements impacted by mainline capacity

Additional Signal/Intx Strategies

- Optimize Timing and/or Meter Traffic at Upstream Signalized Intersection
- Twice per Cycle Left at Adjacent Intersection
- Dual or Triple Right Turn Lanes
- Channelized Turn Lanes
- Right Turn Slip Lane
- Add Storage Capacity to Entrance Ramp (ramp meters)

Additional Signal/Intx Strategies

Strategy Selection in DDI Informational Guide

- Detailed Strategy Descriptions
- Use Cases and Examples
- Simulation Results

Strategy	Low Volume		Heavy Through		Heavy Left Off		Heavy Right Off		Heavy Left On		Heavy Through + Right	
	Heavy Movement	All Movements	Heavy Movement	All Movements	Heavy Movement	All Movements	Heavy Movement	All Movements	Heavy Movement	All Movements	Heavy Movement	All Movements
Half Cycle	++	-	++	++	o	--	--	++	++	o	-	o
Signalized On-Ramp Left Turn			o	o					o	o	o	o
Dedicated Phase for Concurrent Off-Ramp Left and Right Turns					o	o	o	++			++	o
Right-Turn-on-Red (RTOR) Allowed at Off-Ramp			o	-	o	o	--	--			-	o
Left-Turn-on-Red (LTOR) Allowed at Off-Ramp			-	--	o	o	--	--			o	-
LTOR & RTOR Allowed at Off-Ramp			-	--	o	+	o	--			o	--
Dynamic Overlap Phasing					o	o	-	o			o	o
Alternate Side-Street Phases at Downstream Signal			o	o	++	+	-	o			+	o
Lead/Lag Phasing for Outbound Lefts at Downstream Signal			o	o	--	o	+	o			--	-
Eliminate Phases at Adjacent Intersection					++	+	--	--	o	++	--	-
Free / Uncoordinated	++	+	++	++	++	o	++	++			++	+

++ High Delay Increase | + Low Delay Increase | o Minimal Delay Change | - Low Delay Decrease | -- High Delay Decrease

Conclusions

- Signals Chapter update to the DDI Informational Guide will be released as a white paper

- Once Geometry Chapter is updated, a new edition of the DDI Informational Guide will be published