INNOVATIVE DESIGNS FOR IMPROVING INTERSECTION CAPACITY

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AT GRADE INTERSECTIONS

- Continuous Flow Intersections (CFI)
- Parallel Flow Intersection
- Offset Left-turns
- Jug Handles
- Median Crossovers
- Split Intersections
- Quadrant Connectors
GRADE SEPARATED

- Single Point Interchanges (SPUI)
- Tight Urban Diamond
- Diverging Diamond
- Echelon Interchange
- Grade Separated Intersections
- Queue Jumping for Transit Vehicles

AT GRADE INTERSECTIONS
Continuous Flow Intersections

Source: Fehr and Peers, Salt Lake City
This design includes crosswalks but very long if timed as single phase.

Source: KOA Corporation

Design is patented: US 5049000

Left turns move across opposing lanes at half signal before the intersection.

Source: Fehr and Peers, Salt Lake City
CONTINUOUS FLOW INTERSECTION

- Left-turns moved to the far left
- Left-turns at same time as through movements
- Eight phases reduced to four
- Reduces conflicts at the main intersection
- Improves capacity by up to 70%

Left-turns move to far left using a half signal so they can turn with thru-traffic.

http://www.abmb.com/cfi-testdrive.html
CONTINUOUS FLOW INTERSECTION

- Four additional traffic signals needed – one on each approach
- Access to adjacent properties severely limited
- Right of way larger
- Pedestrians may need to be grade separated
- More complex for bicyclists

Right-of-way impacts
Source: KOA Corporation
Locations in USA

- Baton Rouge, Louisiana
- Maryland – Hwy 210
- Ohio State Route 125/Five Mile Road, Hamilton County
- Bangerter Hwy and 3500 South, Salt Lake City Area
- “Continuous Flow Intersections”: ITE Journal, July 2004
- Patent Holders: Francisco D. Mier and Belisario H. Romo,

Baton Rouge, Louisiana

- Congestion Reduced by 40%
- Volume thru intersection increased by 10%
- Crashes reduced by 27%
Baton Rouge, Louisiana (2006)

For more info: ABMB Engineering (www.abmb.com)

Four-way example in Mexico

Left-turns/thru movements move together

Opposing traffic!
Parallel Flow Intersections

Left-turns are on this side of the median

Design is patented: US 7135989

Simulation may be viewed at: www.quadranteng.com

Source: Urban Transportation Monitor
PARALLEL FLOW INTERSECTION

- Left-turns made ahead of the intersection
- No left turn movements at the intersection
- Eight phases reduced to four
- Reduces conflicts at the main intersection
- Improves capacity by up to 70%

PARALLEL FLOW INTERSECTION

- Up to at least additional traffic signals needed – one on each approach
- Access to adjacent properties severely limited
- Right of way larger
- Pedestrians crosswalks at intersection
- Not as complex for bicyclists
PARALLEL FLOW INTERSECTION

- Gregory F. Parsons is the Patent Holder
- Article published in the ITE Journal October 2007
- Additional information in the Urban Transportation Monitor
- No known operational intersections to date

OFFSET LEFT-TURNS

- Best suited for wide medians
- Reduces left-turn maneuver travel distance
- Improves visibility of on-coming traffic
- Conversion to dual left-turns possible
Median Crossover
(Michigan Left-Turns)

U-turns median crossovers

Source: Signalized Intersection Information Guide
FHWA-HRT-04-091
MICHIGAN LEFT-TURN

- Requires wide medians
- Remove left-turns from intersection
- Improves capacity and reduces collisions at the intersection
- Vehicles have to go through intersection twice

Example in Michigan

No left-turns are allowed at the signal
Capacity Gains from Michigan U-Turns v. Dual Lefts


Super Street Median Crossover
Super Street Median Crossover

Source: Signalized Intersection Information Guide
FHWA-HRT-04-091

No through movements allowed from side street
Left turns made as U-turns

Signalized left-turns and right-turns only
Limited movement intersection near RR Xing

Pre-signal U-turns
Pre-signal U-turn

**PRESIGNAL U-TURNS**

- Requires wider medians
- Remove U-turns from intersection
- Improves capacity and reduces collisions
- Most effective where heavy U-turns present
Pre-signal left-turn

Offset Left-Turns
Example in Albuquerque

Left-turn lanes

JUG HANDLES
JUGHANDLES

- Near side
- Far side
- U-Turn
- Indirect left-turns

Forward
Figure 30. Design layout of near-side jug-handle (adapted from 14).

Near Side

Source: Signalized Intersection Information Guide
FHWA-HRT-04-091

Source: KOA Corporation
Source: Signalized Intersection Information Guide FHWA-HRT-04-091

Forward near side
Reverse

Source: Signalized Intersection Information Guide
FHWA-HRT-04-091
REVERSE

- Traffic circulation more circuitous
- Right of way needed for connector
- Removes left-turns from the intersection
- Merge distance needs to be greater than 500 feet.

U-Turn
U-Turn crossover

U-turn crossovers
U-turn

U-turn
New regulatory signs for jughandles

- All turns from right lane
- U turn from right lane
- U turn

All turns

U and left turns

U and left turns

ALTERNATIVE INTERSECTION TREATMENTS
Quadrant Roadway

Quadrant roadway intersection

Source: KOA Corporation
CONNECTOR ROADS

- Pedestrian traffic more circuitous
- Significant impact on transit operations
- Right of way needed for connector
- Significant construction impacts
- Most often used in conjunction with railroad crossing improvements

Split Intersections/Frontage Roads
SPLIT INTERSECTION

- Space between roads should be about 300 to 500 feet
- Minimal impact on peds and transit operations
- No impacts to adjacent land uses
- Significant construction impacts
- Can be first phase of grade separation project
Frontage road alignment shifted to increase spacing

Source: Signalized Intersection Information Guide
FHWA-HRT-04-091
Variable Lane Sign

Variable lane sign allows dual rights during peak hours
Queue Jumping for Transit Vehicles

Queue Jump Applications at Intersections Increase in North America

Queue jump applications have been used at many intersections in the U.S. and cities in Europe. They are particularly useful to improve efficiency of bus, taxi, and paratransit service. In Troy, NY, a new queue jump implementation improved efficiency by 15 percent. The traffic engineers responsible for this project have identified several benefits of queue jumping. The implementation reduced travel times, increased bus and taxi frequencies, and increased passenger satisfaction. The success of the project led to further improvements, which have been summarized in the table below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Reason for Implementation</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troy, NY</td>
<td>Traffic Engineering</td>
<td>Increased efficiency</td>
<td>Improved travel times</td>
</tr>
<tr>
<td>City of NY</td>
<td>Traffic Engineering</td>
<td>Increased efficiency</td>
<td>Increased passenger satisfaction</td>
</tr>
</tbody>
</table>

The data table above shows the results of the project in Troy, NY. The implementation of queue jumping has led to significant improvements in travel times and passenger satisfaction. Further research into the benefits of queue jumping is ongoing, and the results will be presented at the next conference.
**Bus priority lane in the Netherlands**

**QUEUE JUMPING**

- By pass lane requires additional right of way
- Significant reduction in delay on transit operations
- More complex signal operations
- Best suited for short headway services
GRADE SEPARATED INTERSECTIONS

Viaducts with Connector Roads
CONNECTOR ROADS

- Pedestrian traffic more circuitous
- Significant impact on transit operations
- Right of way needed for connector
- Significant construction impacts
- Most often used in conjunction with railroad crossing improvements
Viaduct with connector roadways

Movements between arterials made Via connector roadways

Elevated Left-turns
GRADE SEPARATED INTERSECTIONS

- Can be constructed within existing right-of-way
- Visual impacts to adjacent land uses
- Merging movements from the left
- Addition ice and snow removal impacts
GRADE SEPARATED INTERSECTIONS

- Structure costs significant
- No significant impacts on peds or transit
- Little impacts on access to adjacent land uses
- Construction impacts are minimal

INTERCHANGES
Single Point Urban Interchanges

SINGLE POINT URBAN INTERCHANGE (SPUI)

- One intersection (above freeway better)
- Signals on overhead gantry
- All turns handled in three movements
- More expensive (BIG retaining walls)
- Reduced right of way
Single Point Urban Interchange

Source: KOA Corporation

SINGLE POINT URBAN INTERCHANGE

- Requires the same area as a tight diamond
- Requires longer structure
- Significant impact on pedestrian traffic
- Significant impact on transit stop locations
- Can be confusing to unfamiliar drivers
- Freeway underneath is preferred option
SPUI with freeway overhead

View of SPUI from underneath the freeway (limits signal head visibility)
One signal processes three movements:
Off-ramps/on-ramps/thru traffic

SPUI in Phoenix with freeway underneath
(Preferred Design)
Tight Urban Diamond Interchange (TUDI)

Spread Diamond
Source: KOA Corporation
Tight Urban Diamond

Source: KOA Corporation

TIGHT DIAMOND INTERCHANGE

- Reach capacity much sooner than SPUIs because of special signal phasing
- Space between ramps about 100 feet vs. 300 feet for spread diamonds
- Reduces conflicts at the main intersection
- Can have some impacts on transit operations
Diverging Diamond Interchange (DDI)


DIVERGING DIAMOND INTERCHANGE

- Unopposed left Turns
- Closely Spaced Intersection
- Separate Over crossings
- Crossover Intersections
Diverging Diamond Interchange Concept Gains Attention Nationally

Kansas City, MO: Planning the Nation's First Diverging Diamond Interchange

The Diverging Diamond Interchange (DDI) is a new type of interchange in the United States. The innovative design allows for safer and more efficient traffic flow compared to traditional interchange designs. The Kansas Department of Transportation (KDOT) is exploring the implementation of the DDI concept as an alternative to traditional interchanges.

The DDI design is characterized by two diverging diamond configurations, providing a unique solution to improve traffic flow and safety. This design is expected to reduce weaving and merging conflicts, which is a common issue in traditional interchanges.

The Kansas City DDI project is part of the KDOT's efforts to improve transportation systems and enhance safety. The implementation of the DDI concept is expected to provide significant benefits, including reduced congestion and improved travel times.

The Drivers' Evaluation of the Diverging Diamond Interchange

Objective

In recent years, the Federal Highway Administration (FHWA) has been actively encouraging innovative designs in the transportation sector. One such innovation is the Diverging Diamond Interchange (DDI), which offers significant benefits in terms of safety and efficiency.

The FHWA is conducting an evaluation of the DDI concept to gather insights from drivers and assess its practicality. This evaluation is expected to provide valuable information for future implementations.

Figure 1: Aerial view of a simulated DDI, showing the divergence of traffic flows.
Source: Bared J. et al., “Design and Operational Performance of Double Crossover Intersection and Diverging Diamond Interchange”
I-590 and Winton Road, NYDOT
Video Link:
https://www.nysdot.gov/portal/page/portal/regional-offices/region4/projects/590winton/diverging-diam

I-40/San Mateo Boulevard Interchange in Albuquerque, NM
Source: NMDOT
http://www.youtube.com/watch?v=NaNacKPO0Q4

DIVERGING DIAMOND INTERCHANGE

- 21 conflict points v. 45 with TUDI
- Smaller ramp intersections – reduced clearance intervals
- Un opposed left turns eliminates need for triple lefts
- Eliminates need for retain walls
- Better sight distance
DIVERGING DIAMOND INTERCHANGE

- Need public education campaign because of unusual configuration

- Pedestrians have to cross free flowing ramps – merging may require more than two manes in each direction between the ramps

- More intense level of signing, striping and lighting

- Limited accident history available

Echelon Interchange
Echelon Interchange

Source: KOA Corporation

ECHELON INTERCHANGE

- Needs wide right-of-way
- For heavy turning movement locations
- Limits access to adjacent land uses in some quadrants
- Appears confusing but all travel patterns are intuitive
- Construction impacts can be severer
Roundabouts

ROUNDABOUT INTERCHANGE

- Shorter Structure
- Efficient Operation
- Frontage Road Impacts Minimized
- Minimal Delays
Roundabouts at an Interchange
PEDESTRIAN ACCESSIBILITY ISSUES

US Access Board Concerns about free flowing intersections such as roundabouts

http://www.teachamerica.com/RAB08/RAB08S9AThibault/index.htm

INTERCHANGE COMPARISON
Interchanges Types Included

- Single Point Diamond (SPUI)
- Roundabout Diamond
- Diverging Diamond

Source: “Innovative Diamond Interchange Designs: How to Increase Capacity” and Minimize Cost – David Stanek
**When to Consider Innovative Interchange**

**Single Point Diamond (SPUI)**
- High left-turn volumes > 300 vph at ramp terminals
- Signal progression on cross street important
- Adjacent signalize intersections closely spaced

**Roundabout Diamond**
- Low left-turn volumes < 300 vph at ramp terminals
- Need to minimize structure widening
- Need to accommodate peds and bikes
- Adjacent signalize intersections closely spaced
When to Consider Innovative Interchange

Diverging Diamond

- High left-turn volumes > 300 vph at ramp terminals
- Need to minimize structure widening (potentially)
- Signal progression on cross street not important

OVERVIEW OF INNOVATIVE DESIGNS
Visit http://attap.umd.edu/UAID.php for an excellent overview of alternative designs

REFERENCE LIST FOR SOURCES OF INFORMATION
QUESTIONS ?