State of the Practice, Case Studies and Analysis Tools on Unconventional Intersection & Interchange Designs in Maryland

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What we have done & will keep doing

**Informing, educating and sharing unconventional design concepts for interchanges and intersections**

- Established the Applied Technology and Traffic Analysis Program (ATTAP)
  - Work in partnership with the University of Maryland to conduct in-depth research on highway design and traffic control
  - Provide internship opportunities to graduate students to obtain practical and technical knowledge in traffic engineering
- Propose and initiate other unconventional concepts to be studied during our planning and preliminary engineering alternative selection phases
What we have done & will keep doing

**Informing, educating and sharing unconventional design concepts for interchanges and intersections**

- Coordinate/conduct frequent workshops within our organization at Maryland State Highway Administration for our highway engineers.
- Conduct regular meetings to inform and share updates on unconventional design concepts.
- Engage senior leadership at Maryland State Highway Administration and conduct presentations for regional, out of state & international visitors.
- Reach out and work with engineering consulting firms.
- Developed and maintain an interactive and informative website (http://attap.umd.edu)
Design and operational strategies

- Splitting the Intersection Plane
- Intersection Plane
- Conflict Points
- Reduction in Conflict Points

Source: FHWA Webinar on Intersection & Interchange Geometrics, December 4, 2013

16 Crossing Conflicts
32 Total Conflict Points

Source: North Carolina DOT
PROMINENT UNCONVENTIONAL DESIGNS IN MARYLAND

1. Unconventional Designs in Maryland
2. Maryland J-turn Intersection
3. Continuous Green-T(CGT) Intersection
## Unconventional Designs in Maryland

### Locations of Selected Unconventional Intersections

<table>
<thead>
<tr>
<th>Category</th>
<th>Design</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>At-grade &amp; Signalized</td>
<td>Jughandle Intersection</td>
<td>1. Hanover St. / Cromwell St., Baltimore</td>
</tr>
<tr>
<td></td>
<td>Superstreet Intersection</td>
<td>1. MD 3 &amp; Waugh Chapel Rd., Odenton</td>
</tr>
<tr>
<td></td>
<td>Continuous Flow Intersection</td>
<td>1. MD 210 &amp; MD 228, Accokeek</td>
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<tr>
<td></td>
<td></td>
<td>2. US 1 &amp; MD 200 (to be opened in 2014)</td>
</tr>
<tr>
<td></td>
<td>Continuous Green-T Intersection</td>
<td>1. US 40 &amp; Enchanted Forest, Ellicott City</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. US 29 &amp; Rivers Edge Rd., Columbia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. MD 139 &amp; Chestnut Ave., Towson</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. MD 100 &amp; US 1, Elkridge</td>
</tr>
<tr>
<td>At-grade &amp; Unsignalized</td>
<td>Maryland J-turn Intersection</td>
<td>1. US 15 &amp; Hayward Rd., Frederick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. US 15 &amp; Willow Rd., Frederick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. US 15 &amp; Biggs Ford Rd., Frederick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. US 15 &amp; Sundays Ln., Frederick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. US 15 &amp; College Ln., Emmitsburg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. US 15 &amp; Old Frederick Rd., Emmitsburg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. US 301 &amp; Main St. Queenstown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. US 301 &amp; Del Rhodes Ave., Queenstown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. US 301 &amp; Ruthsburg Rd., Centreville</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. US 301 &amp; Sudlersville Rd., Sudlersville</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11. US 301 &amp; McGinnes Rd., Millington</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. US 301 &amp; Galena Rd., Galena</td>
</tr>
<tr>
<td></td>
<td>Modern Painted Roundabout</td>
<td>1. MD 235 &amp; MD 6, Mechanicsville</td>
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<tr>
<td></td>
<td></td>
<td>2. US 50 &amp; Carmichael Rd., Queenstown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. MD 5 &amp; Gallant Green Rd., Hughesville</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. MD 5 &amp; Old Leonardtown Rd., Hughesville</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Arundel Mills Circle &amp; Mills Dr., Hanover</td>
</tr>
<tr>
<td></td>
<td>Maryland T Intersection</td>
<td>1. US 50 &amp; Thompson Creek Rd., Stevensville</td>
</tr>
</tbody>
</table>
## Unconventional Designs In Maryland

### Locations of Selected Unconventional Interchanges

<table>
<thead>
<tr>
<th>Category</th>
<th>Design</th>
<th>Locations</th>
</tr>
</thead>
</table>
| Grade-separated & Signalized                | Single Point Urban Interchange | 1. I-695 & MD 140, Pikesville  
2. MD 100 & MD 170, Severn  
3. US 29 & Cherry Hill Rd., Silver Spring  
4. MD 337 & MD 5, Camp Springs  
5. MD 200 & MD 650, Colesville |
|                                             | Single Loop Interchange       | 1. MD 140 & MD 940, Owings Mills                                         |
|                                             | Tight Diamond Interchange     | 1. MD 32 & MD 108, Columbia  
2. MD 100 & Coca Cola Dr., Hanover                                        |
|                                             | Diverging Diamond Interchange | 1. MD 295 & Arundel Mills Blvd, Hanover                                  |
| Grade-separated & Unsignalized              | Double Roundabout Interchange | 1. MD 100 & MD 103, Elkridge  
2. US 29 & MD 216, Scaggsville                                           |
Maryland J-turn

- Maryland J-Turn is an **unsignalized superstreet** design controlled by **Stop or Yield** signs.
- Left turns from the arterial can make direct left turns onto the cross street, but the cross-street thru and left turn movements must use the directional U-turn crossovers.

Source: [http://attap.umd.edu/](http://attap.umd.edu/)
Maryland J-turn

- US 15 Corridor in Frederick County (6 locations)

- US 301 Corridor in Eastern Shore (6 locations)
## Maryland J-turn

### Acceleration Lane Length & U-Turn Crossover Spacing

<table>
<thead>
<tr>
<th>Location</th>
<th>Length of Acceleration Lane (ft) (A)</th>
<th>U-Turn Crossover spacing(ft) (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Southbound</td>
<td>Northbound</td>
</tr>
<tr>
<td>US 15 @ Hayward Rd.</td>
<td>1,160</td>
<td>n/a</td>
</tr>
<tr>
<td>US 15 @ Willow Rd.</td>
<td>520</td>
<td>n/a</td>
</tr>
<tr>
<td>US 15 @ Biggs Ford Rd.</td>
<td>n/a</td>
<td>466</td>
</tr>
<tr>
<td>US 15 @ Sundays Ln.</td>
<td>510</td>
<td>n/a</td>
</tr>
<tr>
<td>US 15 @ College Ln.</td>
<td>537</td>
<td>663</td>
</tr>
<tr>
<td>US 15 @ Old Frederick Rd.</td>
<td>556</td>
<td>470</td>
</tr>
<tr>
<td>US 301 @ Main St.</td>
<td>106</td>
<td>521</td>
</tr>
<tr>
<td>US 301 @ Del Rhodes Ave.</td>
<td>350</td>
<td>320</td>
</tr>
<tr>
<td>US 301 @ Ruthsburg Rd.</td>
<td>480</td>
<td>930</td>
</tr>
<tr>
<td>US 301 @ Sudlersville Rd.</td>
<td>210</td>
<td>270</td>
</tr>
<tr>
<td>US 301 @ McGinnes Rd.</td>
<td>250</td>
<td>460</td>
</tr>
<tr>
<td>US 301 @ Galena Rd</td>
<td>222</td>
<td>248</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>450</strong></td>
<td><strong>480</strong></td>
</tr>
</tbody>
</table>
Maryland J-turn

- Traffic Control, Signing and Marking
  - US 15 & Biggs Ford Rd.
Maryland J-turn

Safety Benefits - Crash data

Table 30. Before-After Average Annual Crash Summary for Maryland J-turn in the 3-year short period (number of crashes/year)

Table 39. Observed Crash by Severity Before and After the Maryland J-turn treatment (number of crashes)

Source: Field evaluation of a restricted crossing U-turn intersection, FHWA, FHWA-HRT-11-067, June 2012
Continuous Green “T”

- Continuous Green-T provides **free-flow operations for the through movement in one direction**, and the **channelized left turn movement from** the stem of the **minor street** to the mainline.
PROMINENT DESIGNS IN MARYLAND

Continuous Green “T”

- US 40 & Enchanted Forest, Ellicott City
  - Traffic Volume: 426(1343) 93(330)
  - 1530(1034) 109(192)
- US 29 & Rivers Edge Rd., Columbia
  - Traffic Volume: 515(2702) 34(114)
  - 2010(4153) 6(45)
- MD 100 & US 1, Elkridge
  - Traffic Volume: 912(1801)
  - 509(702) 93(531)
  - 43(258) 597(414)
- MD 139 & Chestnut Ave., Towson
  - Traffic Volume: 152(217)
  - 2021(1399)
  - 146(106) 1145(218)
Continuous Green “T”

- US 40 @ Enchanted Forest, Ellicott City, MD

Existing AM (PM) Volumes

- 1530 (1034)
- 109 (192)
- 426 (1343)
- 93 (330)
- 58 (140)
- 23 (5)
Safety Analysis for the four locations

Using recent three-year (2010-2012) crash data

- By severity

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P-Damage</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Injury</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Fatal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Animal related

US 40 & Enchanted Forest
US 29 & Rivers Edge Rd.
US 1 & MD 100
MD 139 & Chestnut Ave.
Continuous Green “T”

- **Rear end** Collision
  - 20 Crashes
    - 50% of total crashes
  - 15 in SB & 5 in NB

- **Sideswipe** Collision
  - 6 Crashes
    - 15% of total crashes
  - 5 in NB & 1 in SB
CASE STUDIES

1. Signalized Superstreet Intersection
2. Diverging Diamond Interchange
3. Continuous Flow Intersection
Superstreet design is similar to the Median U-turn (MUT) concept but different in that an MUT intersection allows through movements from the cross street.

Superstreet usually allows left turns from the arterial to make direct left turns onto the cross-street.

Source: http://attap.umd.edu/
Signalized Superstreet

- MD 3 & Waugh Chapel Rd., Anne Arundel County
  - The 1st signalized superstreet in Maryland
    (Opened on Oct. 19, 2011)
Signal Phasing

Signalized Superstreet

<Phase 1>

<Phase 2>

Fire Station
## Network/System Performance

<table>
<thead>
<tr>
<th>Network/System Performance</th>
<th>2025 AM</th>
<th>2025 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Total Delay (hr)</td>
<td>1,693.1</td>
<td>1,158.2</td>
</tr>
<tr>
<td>Delay/veh(s)</td>
<td>773.3</td>
<td>484.2</td>
</tr>
<tr>
<td>Total Stops</td>
<td>14,406</td>
<td>14,815</td>
</tr>
<tr>
<td>Vehicles Served</td>
<td>7,326</td>
<td>8,194</td>
</tr>
<tr>
<td>Travel Distance (mi)</td>
<td>4,901.4</td>
<td>5,595.6</td>
</tr>
<tr>
<td>Travel Time (hr)</td>
<td>1,793.7</td>
<td>1,279.7</td>
</tr>
</tbody>
</table>

- With the projected traffic volume for 2025, assume that the shopping mall would be open in 2011.
- Using SimTraffic to simulate for one hour and for three replications.
## Signalized Superstreet

**Safety Benefits – Crash data at the intersection**

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Crashes</strong></td>
<td><strong>58</strong></td>
<td><strong>26</strong></td>
</tr>
<tr>
<td><strong>Severity</strong></td>
<td><strong>Fatal</strong></td>
<td><strong>PDO</strong></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td><strong>Collision Type</strong></td>
<td><strong>Rear End</strong></td>
<td><strong>Side swipe</strong></td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>5</td>
</tr>
</tbody>
</table>
Diverging Diamond Interchange

- DDI is a revised diamond interchange with one cross-over intersection at each ramp terminal.
- The **through lanes are crossed** over a short section between two diamond ramp intersections, and then cross back to the normal (right) side of the roadway.

Source: http://attap.umd.edu/
Diverging Diamond Interchange

- MD 295 & Arundel Mills Blvd, Anne Arundel County
  - The first diverging diamond interchange in Maryland
    (Opened on June 11, 2012)

Source: http://baltimore.cbslocal.com/
## Diverging Diamond Interchange

**MD 295 & Arundel Mills Blvd., Anne Arundel County**

- Before condition with projected volume

<table>
<thead>
<tr>
<th>Approach</th>
<th>PM Peak</th>
<th>Saturday Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Delay (s/veh)</td>
<td>LOS</td>
</tr>
<tr>
<td>WB Arundel Mills Blvd</td>
<td>3.3</td>
<td>A</td>
</tr>
<tr>
<td>SB off-ramp from MD 295</td>
<td>267.7</td>
<td>F</td>
</tr>
<tr>
<td>EB Arundel Mills Blvd</td>
<td>6.5</td>
<td>A</td>
</tr>
<tr>
<td>NB off-ramp from MD 295</td>
<td>52.1</td>
<td>F</td>
</tr>
</tbody>
</table>

* Operational Analysis was performed with VISSIM

* Source: Venu Nemani, MD 295(Baltimore Washington pkwy.) at Arundel Mills Blvd. The Story Behind Maryland's First DDI, 2013 MdQi Conference
CASE STUDIES

Diverging Diamond Interchange

MD 295 & Arundel Mills Blvd., Anne Arundel County
- Diverging Diamond Interchange with projected volume

- Provides acceptable operations upon build out of Maryland Live!
- May **address EB weaving along Arundel Mills Blvd.** to Dorchester Blvd.
- No confusion to motorists in choosing correct lanes for turning movements
- **Eliminates conflicts at SB off-ramp intersection**

<table>
<thead>
<tr>
<th>Approach</th>
<th>LOS: PM(SAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB Arundel Mills Blvd</td>
<td>N/A(N/A)</td>
</tr>
<tr>
<td>MD 295 SB off-ramp</td>
<td>N/A(N/A)</td>
</tr>
<tr>
<td>EB Arundel Mills Blvd</td>
<td>C(C)</td>
</tr>
<tr>
<td>MD 295 NB off-ramp</td>
<td>B(B)</td>
</tr>
</tbody>
</table>

Source: Venu Nemani, MD 295(Baltimore Washington pkwy.) at Arundel Mills Blvd.
The Story Behind Maryland's First DDI, 2013 MdQi Conference
Diverging Diamond Interchange

Safety Analysis at MD 295 & Arundel Mill Blvd.

- By Conditions

<table>
<thead>
<tr>
<th>Year</th>
<th>NightTime</th>
<th>Wet Surface</th>
<th>Alcohol</th>
</tr>
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<tbody>
<tr>
<td>2008</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2012</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2013</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Before | After
---|---
50% 25% 25% | 50% 25% 25%
Continuous Flow Intersection (CFI)

- CFI allows *left-turning vehicles* to begin their turns several hundred feet ahead of the main intersection at a signalized "crossover" intersection, and move into separated lanes to the right of the opposing thru movement.

Source: http://attap.umd.edu/
CASE STUDIES

Continuous Flow Intersection (CFI)

- CFI-T of MD 210 and MD 228
  - Opened in 2000

Flyover: $30 Million

CFI: $5.3 Million

- Existing Peak Hour volume (2005)
- AM (PM)
CASE STUDIES

Continuous Flow Intersection (CFI)

- CFI-T of MD 210 and MD 228

  - Signalization

<Main Intersection>

<Sub Intersection>
CASE STUDIES

Continuous Flow Intersection (CFI)

Safety Analysis at MD 210 and MD 228

- CFI-T design opened in 2000
- Crash data collection time
  - (Before) 01/01/1997 ~ 12/31/1999
  - (After 1) 01/01/2001 ~ 12/31/2003
  - (After 2) 01/01/2010 ~ 12/31/2012

* AADT is collected at MD 210 -.20 mi south of MD 373, which is located to the north of the intersection of MD 210 & MD 228
ANALYSIS TOOLS

1. MIDCAP
2. MUID
MIDCAP

- **Maryland Intersection Design & Capacity Analysis Program**
- Capacity analysis program developed by MDSHA and the University of Maryland, College Park
- Intersection & interchange analysis
  - v/c ratio
  - LOS
  - Queue length
  - 4 leg, 3 leg, CFI intersections
  - RDI, DDI, and SPUI
- Include signal warrant and shoulder bypass analysis
Critical Lane Volume (CLV)

- The sum of traffic volumes that cross at one point in an intersection (in veh/hr/lane);
MIDCAP

- Analyze the capacity of Regular Diamond Interchange design

Step 1: Choose the interchange type

Step 2: Set Lane Configurations

Step 3: Input Movement Volumes

Step 4: Choose Right Turn Control Type

Step 5: Calculate Critical Lane Volume

Step 6: Obtain Intersection LOS & V/C
Planning analysis using MIDCAP

- Summary
Maryland Unconventional Intersection Design Analysis Tool

Developed by MDSHA and the University of Maryland, College Park

Include two modules:

- **Planning evaluation model**
  - Delay and queue length
- **Signal optimization model**
  - Offset, cycle length, and g/C ratio

CFI, DDI and Superstreet
MUID

- Input: demand and geometric layout
Outputs: planning evaluation and signal optimization
Questions / Comments?

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Thank You!