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)

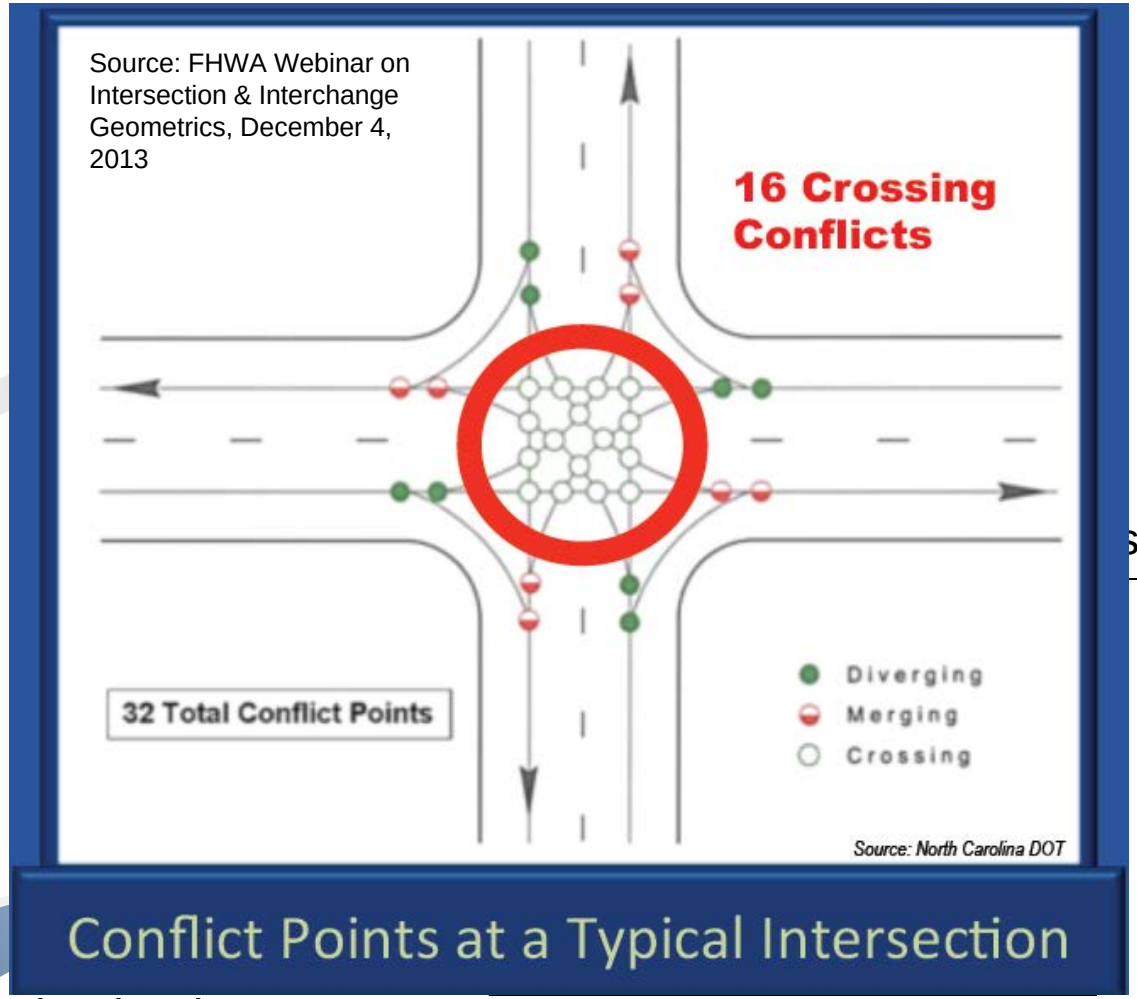
Design and operational strategies

Splitting the Intersection Plane

Intersection Plane

Conflict Points

Reduction in Conflict Points



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

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

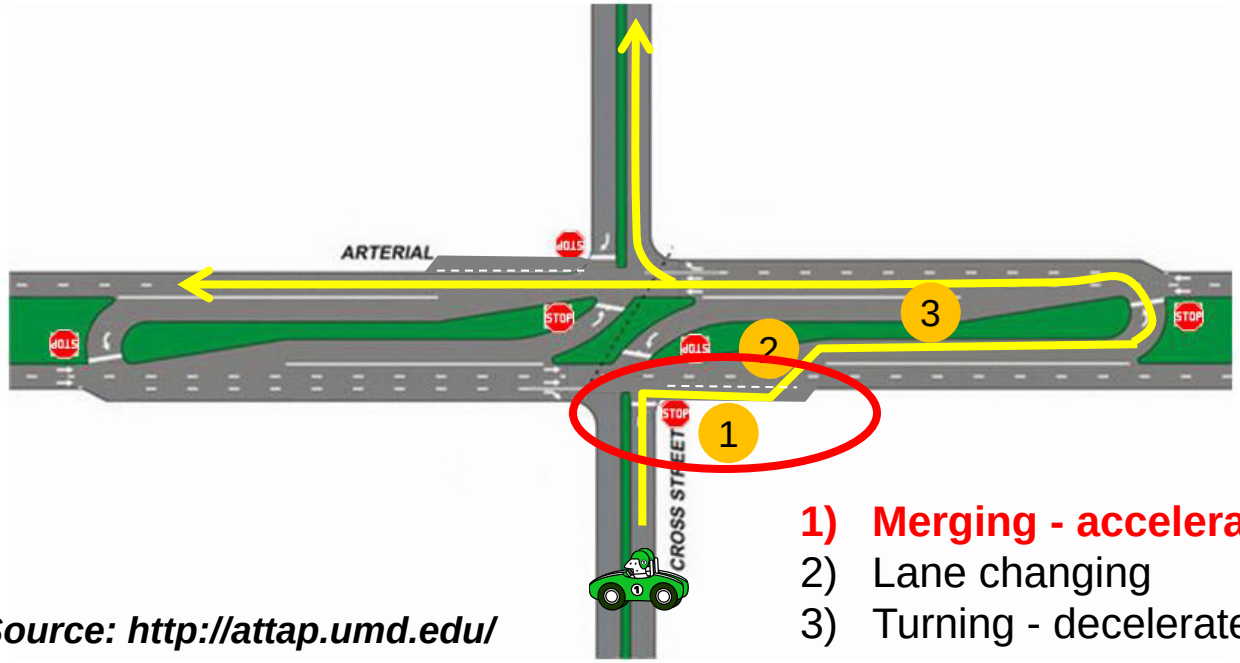
Unconventional Designs In Maryland

Locations of Selected Unconventional Interchanges

Category	Design	Locations
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.



1) **Merging - accelerate**
2) Lane changing
3) Turning - decelerate

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

Maryland J-turn

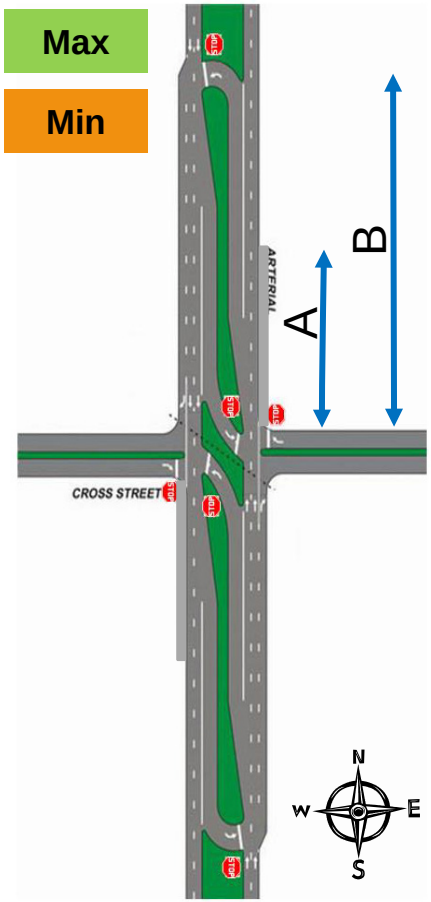
- US 15 Corridor in Frederick County (6 locations)

- US 301 Corridor in Eastern Shore (6 locations)

Maryland J-turn

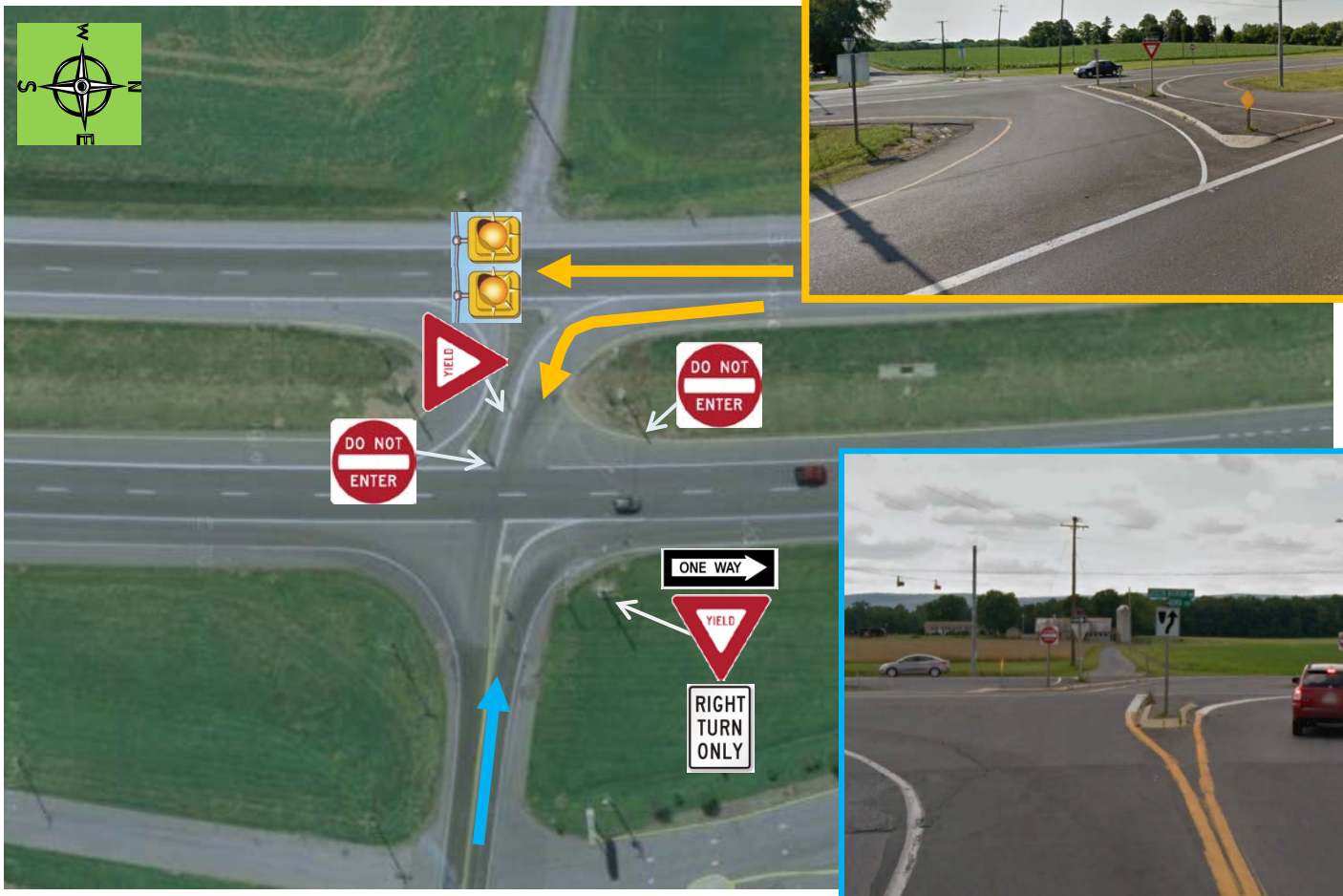
❖ Acceleration Lane Length & U-Turn Crossover Spacing

Location	Length of Acceleration Lane (ft) (A)		U-Turn Crossover spacing(ft) (B)	
	Southbound	Northbound	S. Crossover	N. Crossover
US 15 @ Hayward Rd.	1,160	n/a	1,860	n/a
US 15 @ Willow Rd.	520	n/a	2,900	4,920
US 15 @ Biggs Ford Rd.	n/a	466	4,920	1,618
US 15 @ Sundays Ln.	510	n/a	1,618	2,804
US 15 @ College Ln.	537	663	1,900	2,166
US 15 @ Old Frederick Rd.	556	470	1,945	2,358
US 301 @ Main St.	106	521	3,990	2,530
US 301 @ Del Rhodes Ave.	350	320	2,530	1,337
US 301 @ Ruthsburg Rd.	480	930	1,500	2,590
US 301 @ Sudlersville Rd.	210	270	1,480	1,470
US 301 @ McGinnes Rd.	250	460	1,470	1,470
US 301 @ Galena Rd	222	248	1,475	1,327
Average	**450**	**480**	**2,320**	**2,248**



Maryland J-turn

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



Maryland J-turn

Safety Benefits - Crash data

Location	At Intersection			Intersection and Adjacent Segments		
	Before	After	Decrease (percent)	Before	After	Decrease (percent)
U.S. 15 at Hayward Road	4.33	3.33	23	9.00	5.33	41
U.S. 15 at Willow Road	1.67	0.33	80	4.67	7.67	-64
U.S. 15 at Biggs Ford Road	4.33	1.33	69	7.00	6.33	10
U.S. 15 at Sundays Lane	0.33	1.33	-300	3.33	5.00	-50
U.S. 15 at College Lane	3.67	0.33	91	5.00	1.33	73
U.S. 15 at U.S. 15 Business	3.67	1.67	55	4.33	2.33	46
U.S. 301 at Main Street	3.33	1.33	60	8.00	7.00	13
U.S. 301 at Del Rhodes Avenue	7.00	1.00	86	7.67	3.33	57
U.S. 301 at Galena Road	5.00	0.67	87	8.33	1.67	80
Total	**33.33**	**11.33**	**66**	**57.33**	**40.00**	**30**

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

- Before-after covers 3 years of crashes before the Maryland J-turn deployment and 3 years of crashes after the Maryland J-turn deployment

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

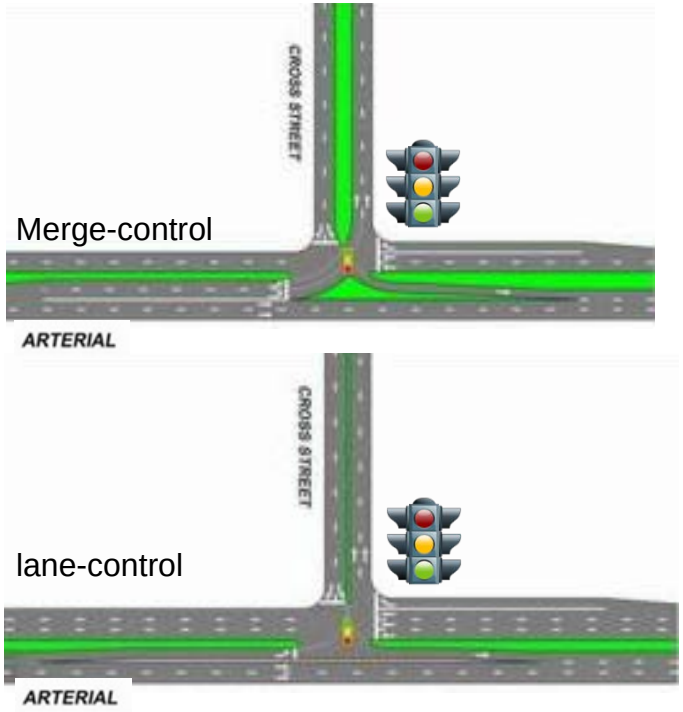
- Before period: 1985-1987
- After period: 1995-1997
- PDO: Property damage only

Location	Before Period			After Period		
	PDO	Fatal	Injury	PDO	Fatal	Injury
U.S. 15 at Hayward Road	32	1	41	36	0	59
U.S. 15 at Willow Road	29	1	22	27	0	22
U.S. 15 at Biggs Ford Road	38	1	46	21	1	10
U.S. 15 at Sundays Lane	13	0	12	17	0	9
U.S. 15 at College Lane	21	0	28	6	0	5
U.S. 15 at Old Frederick Road	23	1	21	23	1	16
U.S. 301 at Main Street	26	2	24	29	0	14
U.S. 301 at Del Rhodes Avenue	20	1	28	7	0	7
U.S. 301 at Galena Road	16	3	30	7	1	3
Total	**218**	**10**	**252**	**173**	**3**	**145**

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



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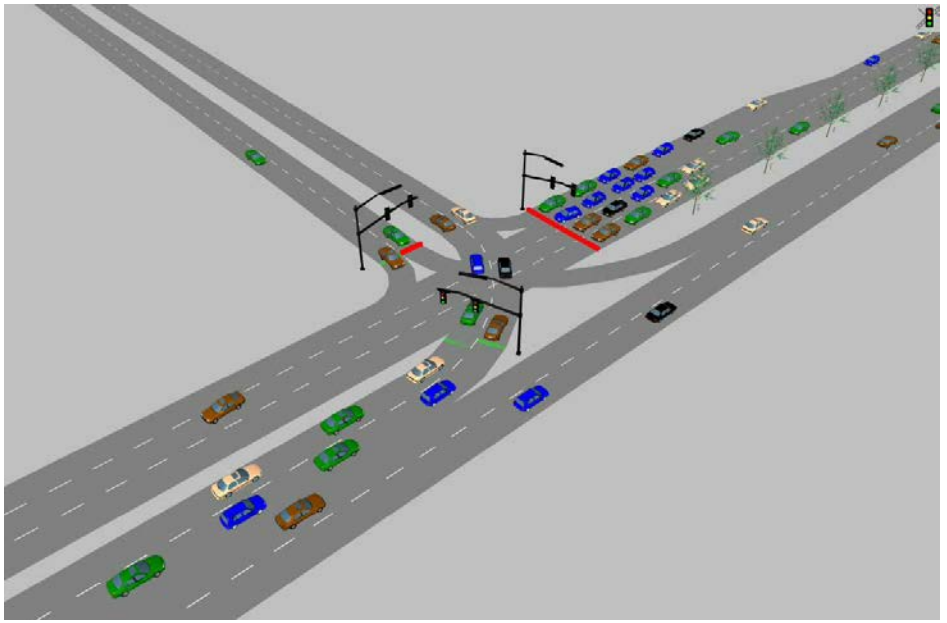

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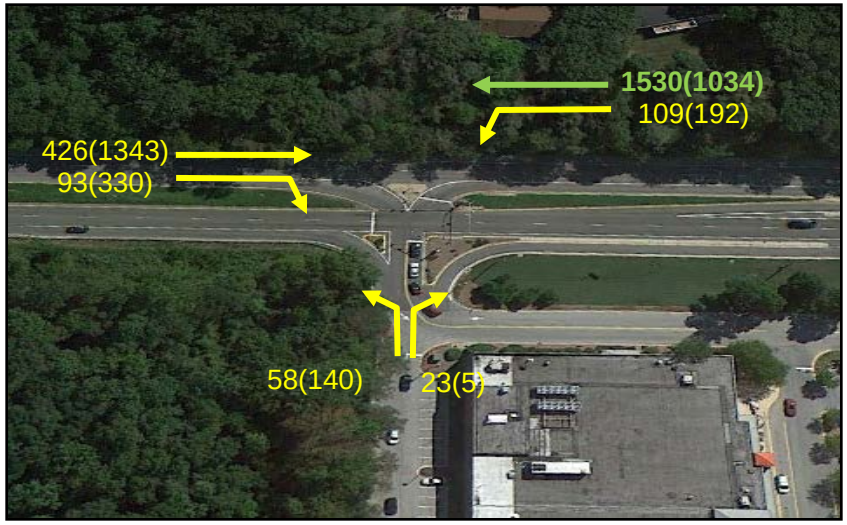
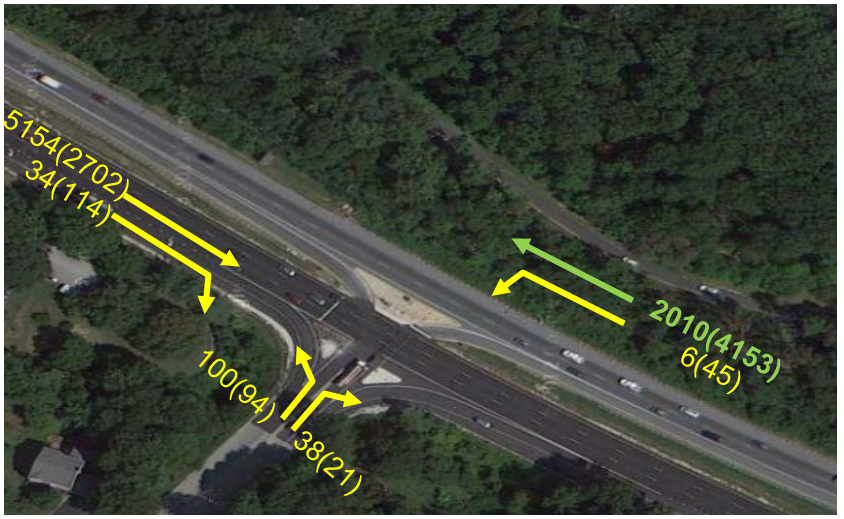
Source: attap.umd.edu

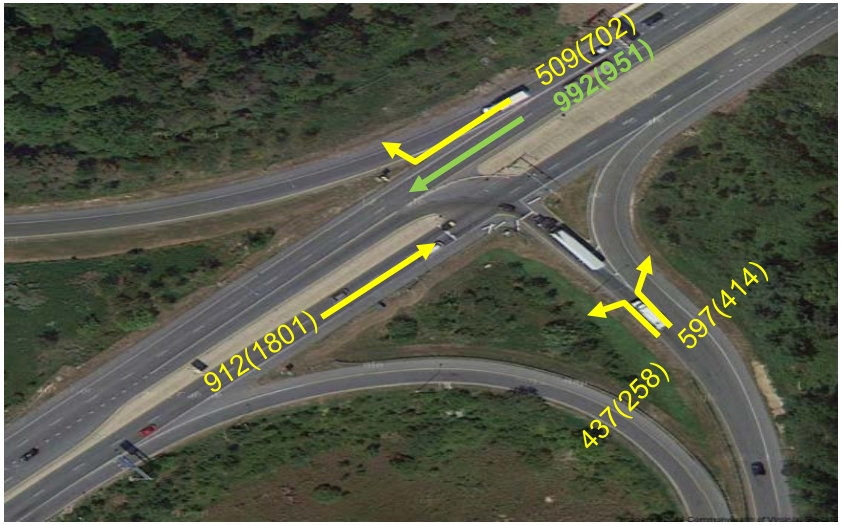
Continuous Green “T”



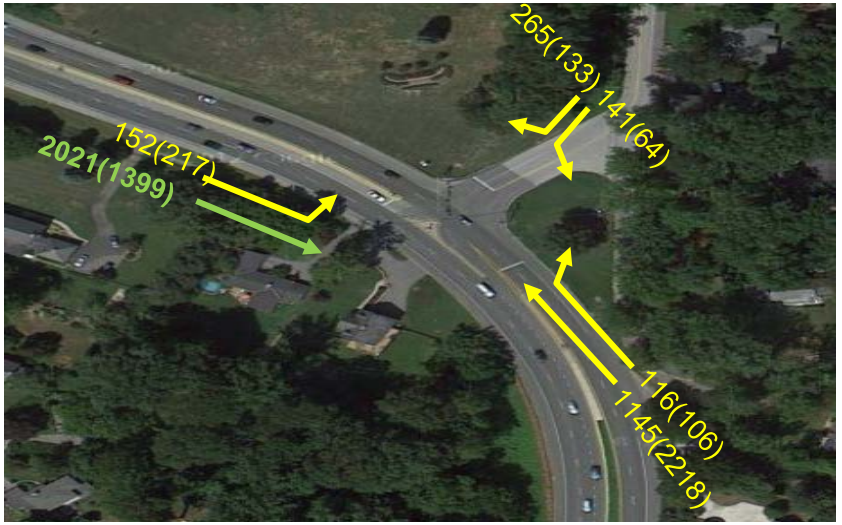
- US 40 & Enchanted Forest, Ellicott City



- US 29 & Rivers Edge Rd., Columbia



- MD 100 & US 1, Elkridge



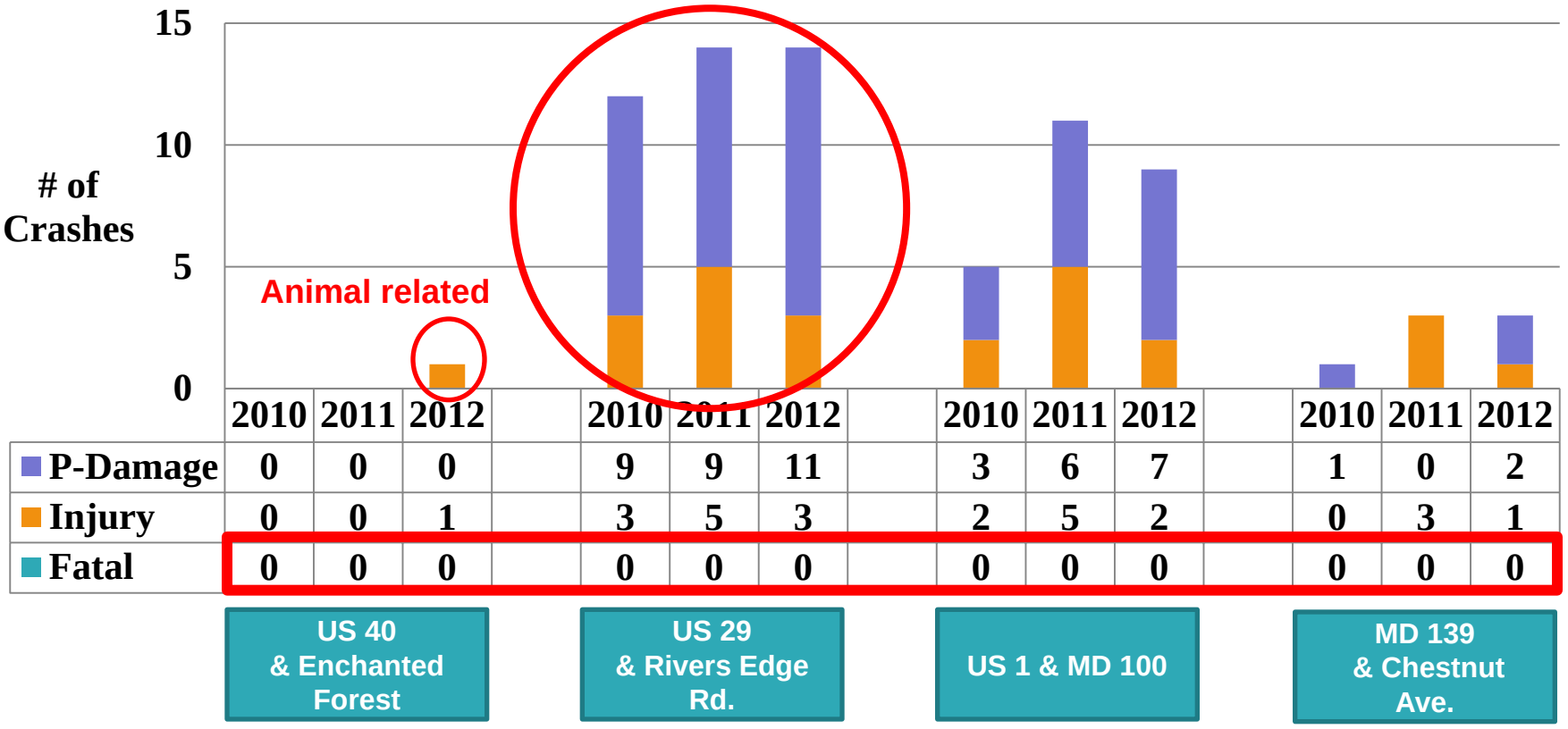
- MD 139 & Chestnut Ave., Towson

Continuous Green "T"

- US 40 @ Enchanted Forest, Ellicott City, MD

Continuous Green "T"

- Safety Analysis for the four locations
  - Using recent three-year(2010-2012) crash data
    - By severity

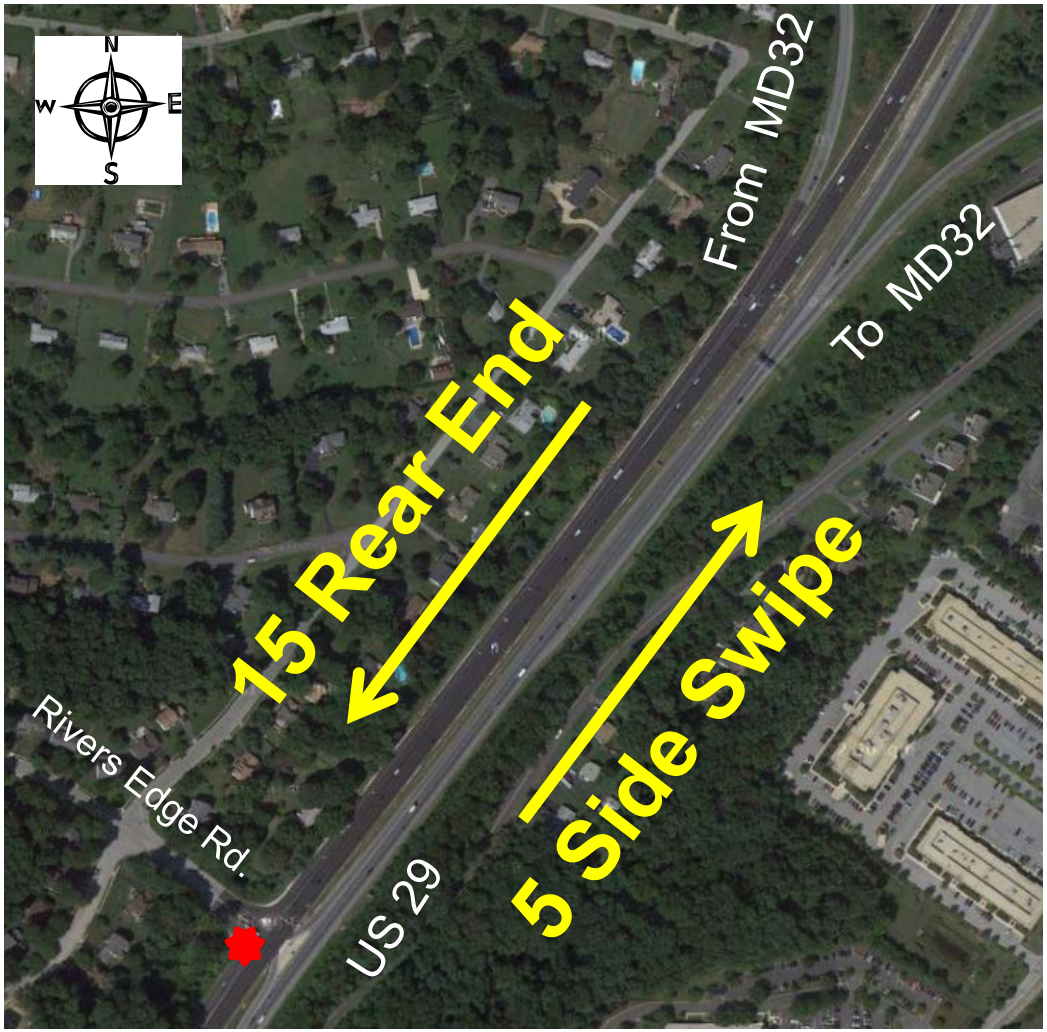


	US 40 & Enchanted Forest			US 29 & Rivers Edge Rd.			US 1 & MD 100			MD 139 & Chestnut Ave.		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
P-Damage	0	0	0	9	9	11	3	6	7	1	0	2
Injury	0	0	1	3	5	3	2	5	2	0	3	1
Fatal	0	0	0	0	0	0	0	0	0	0	0	0

Continuous Green "T"

US 29 @ Rivers Edge Rd.

- **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

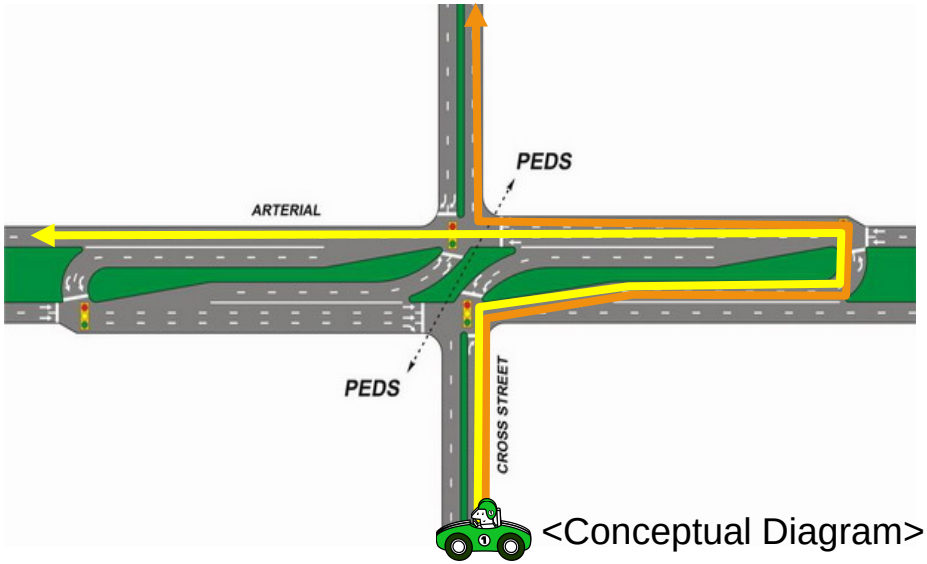


CASE STUDIES

1. Signalized Superstreet Intersection
2. Diverging Diamond Interchange
3. Continuous Flow Intersection

Signalized Superstreet

- 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.



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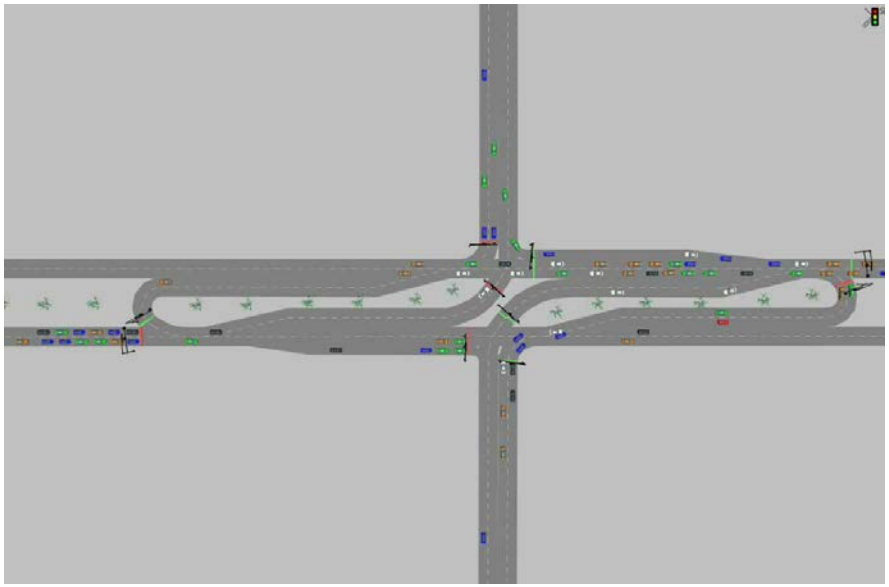
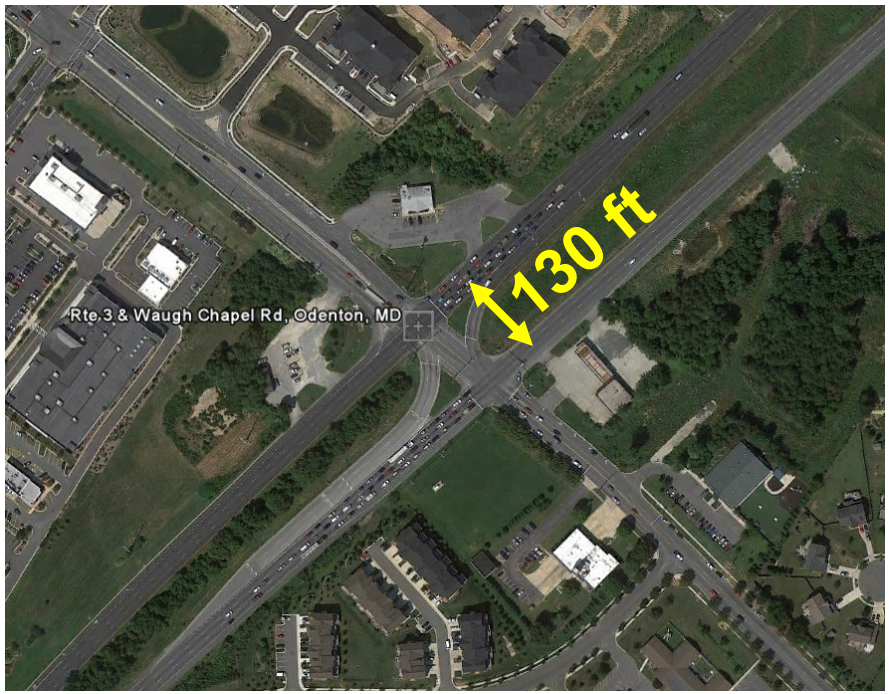


<Simulation Demo>

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)

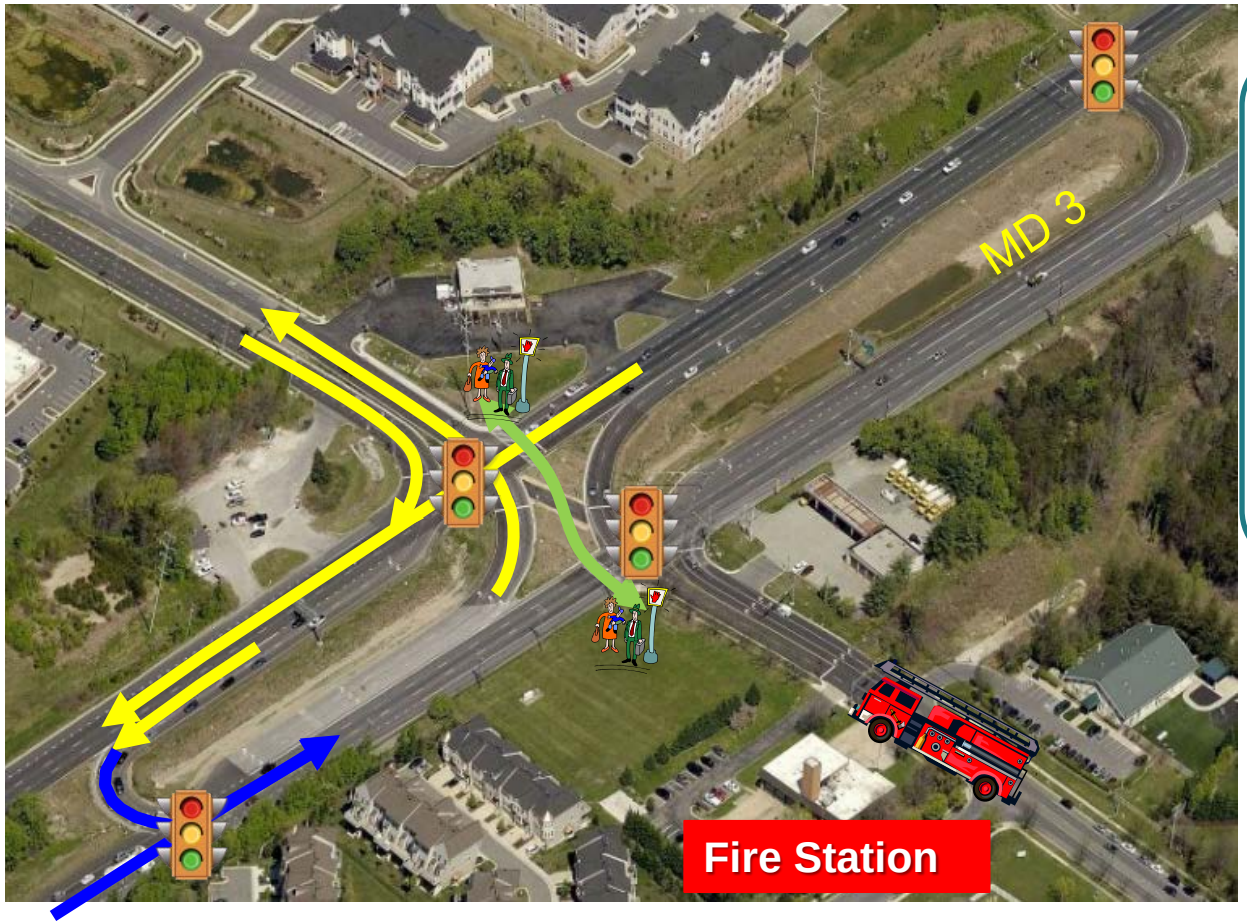


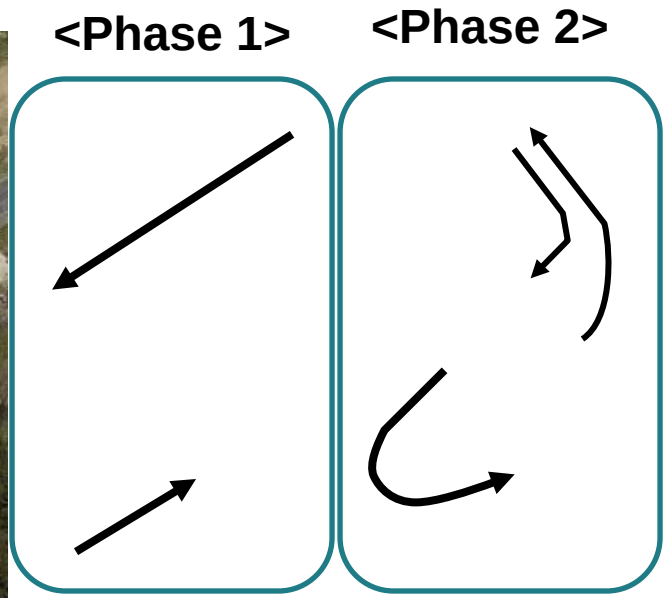
<Before>

<After>

Signalized Superstreet

- Signal Phasing





Signalized Superstreet

Network/System Performance

Network/System Performance	2025 AM			2025 PM		
	Before	After	Change (%)	Before	After	Change (%)
Total Delay(hr)	1,693.1	1,158.2	-32	2,426.3	695.1	-71
Delay/veh(s)	773.3	484.2	-37	1,202.0	245.8	-80
Total Stops	14,406	14,815	3	11,680	18,042	54
Vehicles Served	7,326	8,194	12	6,812	9,594	41
Travel Distance (mi)	4,901.4	5,595.6	14	4,360.1	6,411.4	47
Travel Time(hr)	1,793.7	1,279.7	-29	2,527.1	836.8	-63

- 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

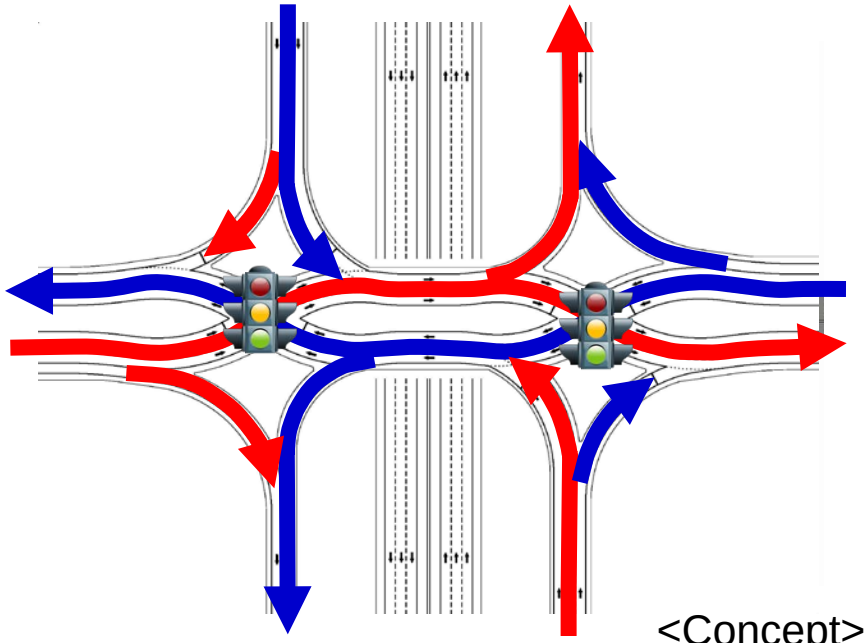
Signalized Superstreet

- Safety Benefits – Crash data at the intersection

	Before							After						
	Jan. 01, 2008 ~ Dec. 31, 2010 (3 years)							Jan.01, 2012 ~ Mar. 31, 2013 (1 year and 3 months)						
Total Crashes	58							26						
Severity	Fatal		PDO		Injury			Fatal		PDO		Injury		
	0		29		29			0		17		9		
Collision Type	Rear End	Side swipe	Left Turn	Angle	Parked Veh.	Fixed Object	Other	Rear End	Side swipe	Left Turn	Angle	Parked Veh.	Fixed Object	Other
	34	5	2	12	1	3	1	17	5	2	1	0	1	0

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.



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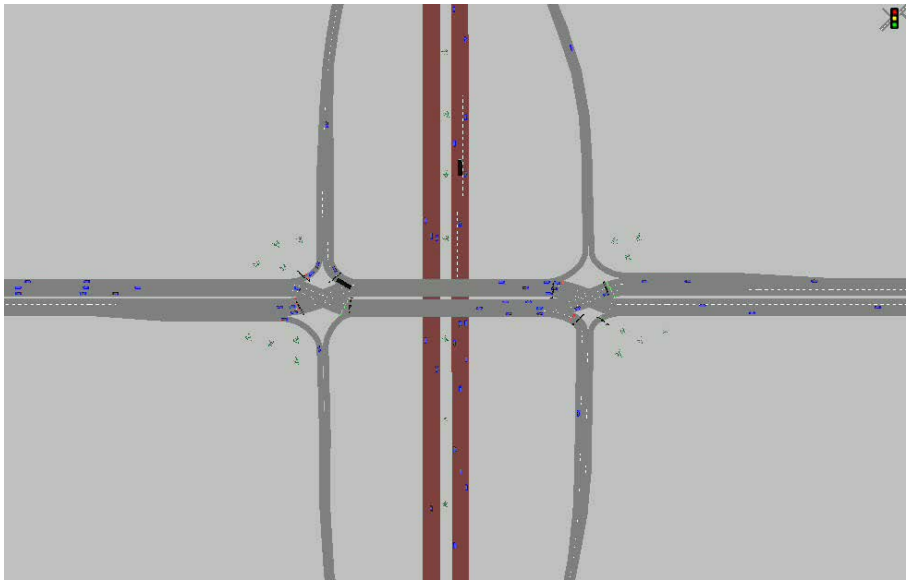


<Simulation>

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)

<Before>

<After>

Source: http://baltimore.cbslocal.com/

Diverging Diamond Interchange

- MD 295 & Arundel Mills Blvd., Anne Arundel County
  - Before condition with projected volume

Approach	PM Peak				Saturday Peak			
	Delay (s/veh)	LOS	Avg. Queue (ft)	Max. Queue (ft)	Delay (s/veh)	LOS	Avg. Queue (ft)	Max. Queue (ft)
WB Arundel Mills Blvd	3.3	A	25	50	2.6	A	25	75
SB off-ramp from MD 295	**267.7**	**F**	**5,050**	**6,000**	**393.5**	**F**	**5,300**	**6,000**
EB Arundel Mills Blvd	6.5	A	25	75	5.4	A	25	75
NB off-ramp from MD 295	**52.1**	**F**	**450**	**2,375**	**61.3**	**F**	**475**	**2,675**

* 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

Diverging Diamond Interchange

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

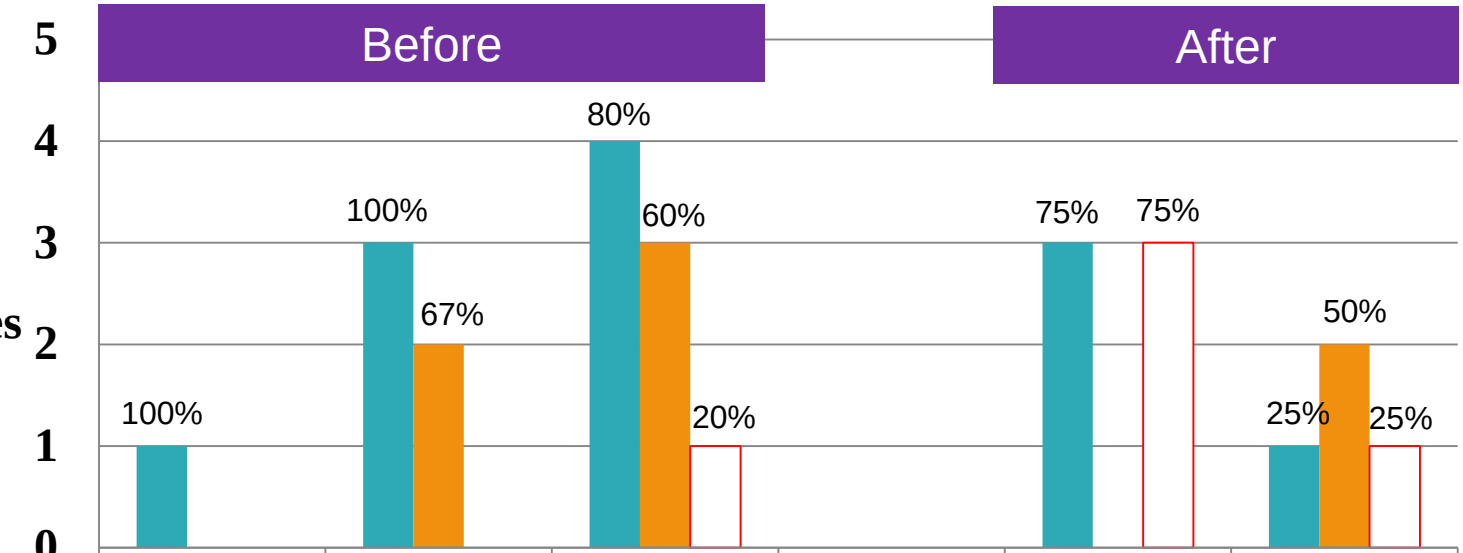
- Provides acceptable operations upon build out of Maryland Live!
- May **address EB weaving along Arundel Mills Blvd.** to Dorchester Blvd.
- No confusion to motorists in choosing correct lanes for turning movements
- **Eliminates conflicts at SB off-ramp** intersection

Approach	LOS: PM(SAT)
WB Arundel Mills Blvd	N/A(N/A)
MD 295 SB off-ramp	N/A(N/A)
EB Arundel Mills Blvd	C(C)
MD 295 NB off- ramp	B(B)

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

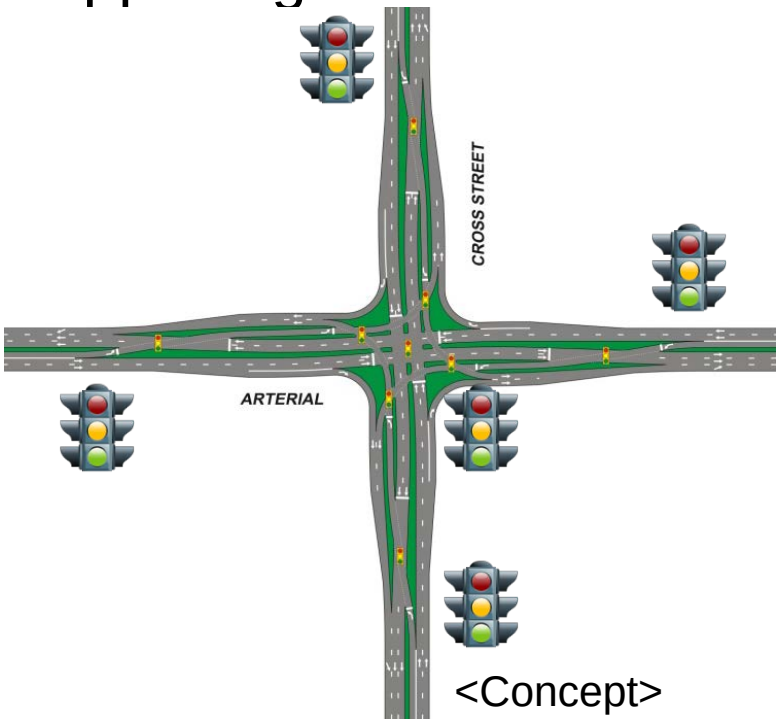
- Safety Analysis at MD 295 & Arundel Mill Blvd.
  - By Conditions



	2008	2009	2010		2012	2013
NightTime	1	3	4		3	1
Wet Surface	0	2	3		0	2
Alcohol	0	0	1		3	1

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.



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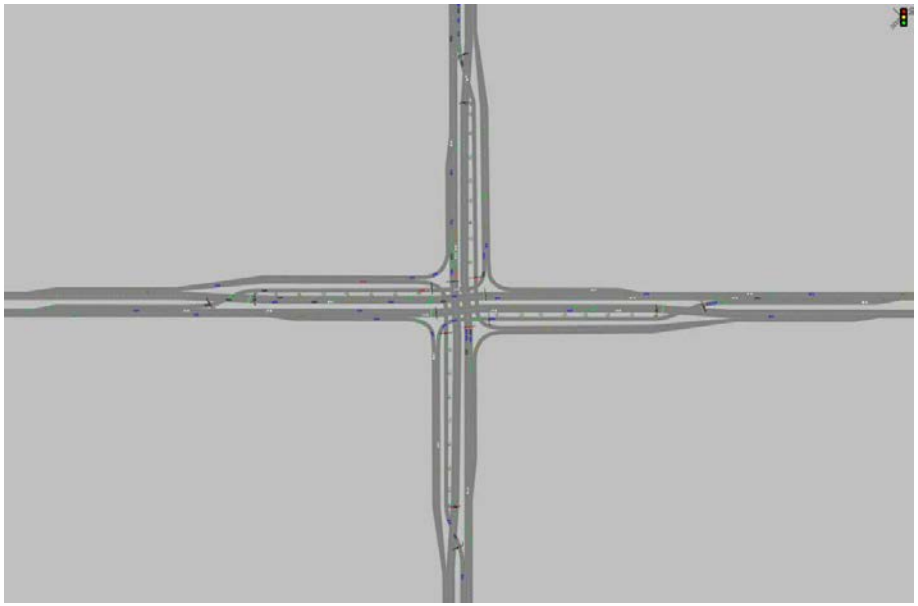

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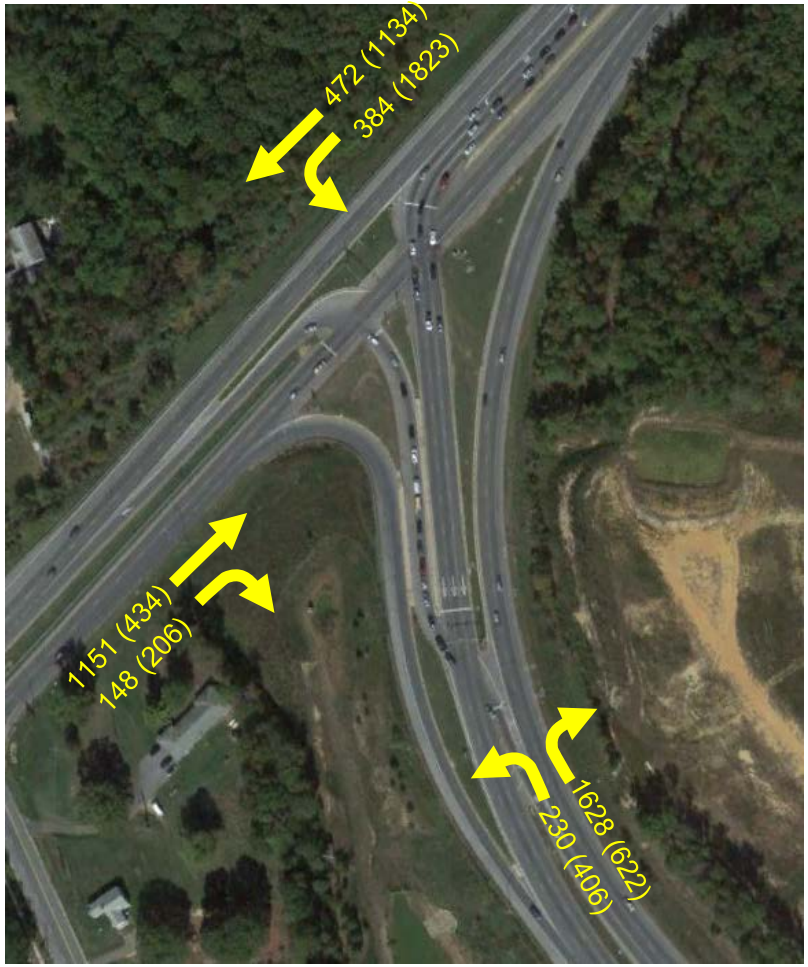
Source: http://attap.umd.edu/

Continuous Flow Intersection(CFI)

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



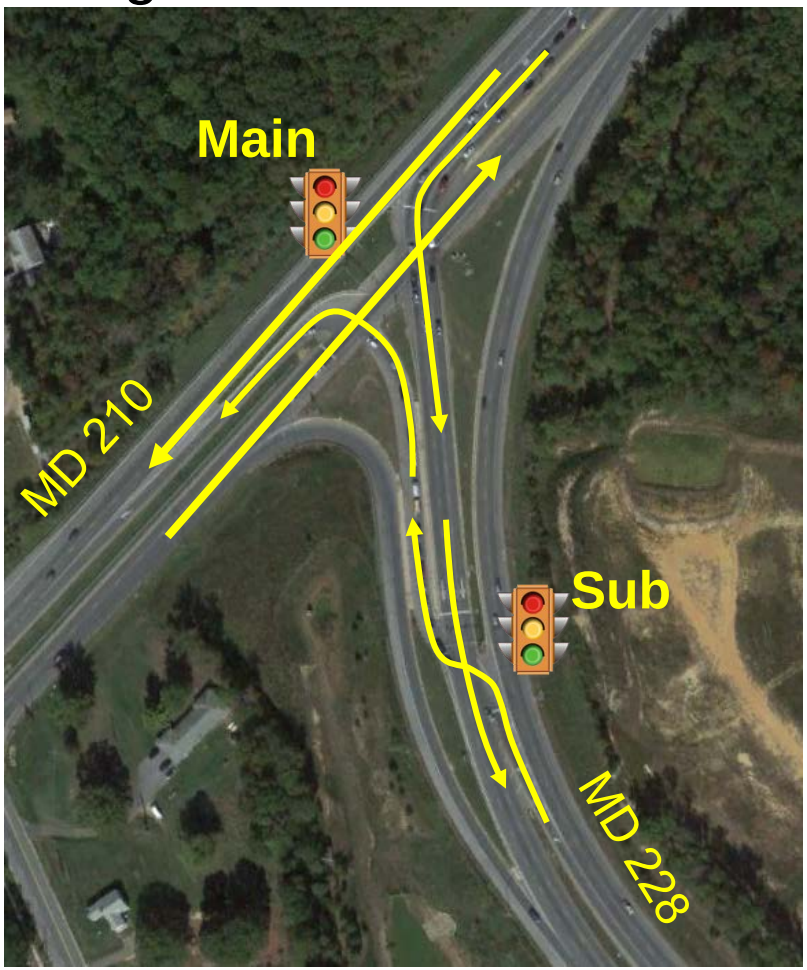
Flyover: $30 Million

CFI: $5.3 Million

- **Existing Peak Hour volume(2005)**
- **AM(PM)**

Continuous Flow Intersection(CFI)

- CFI-T of MD 210 and MD 228
  - Signalization



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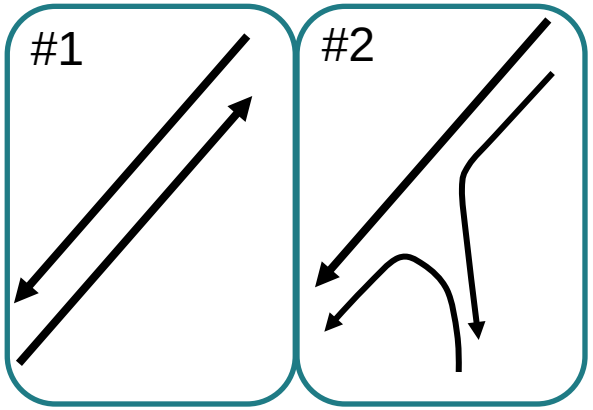
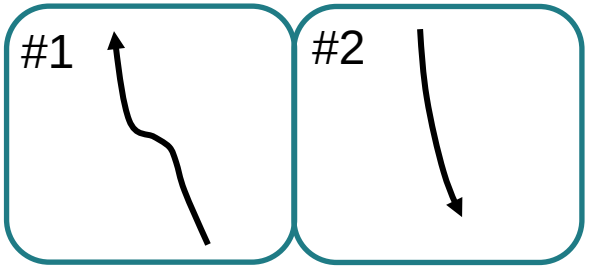
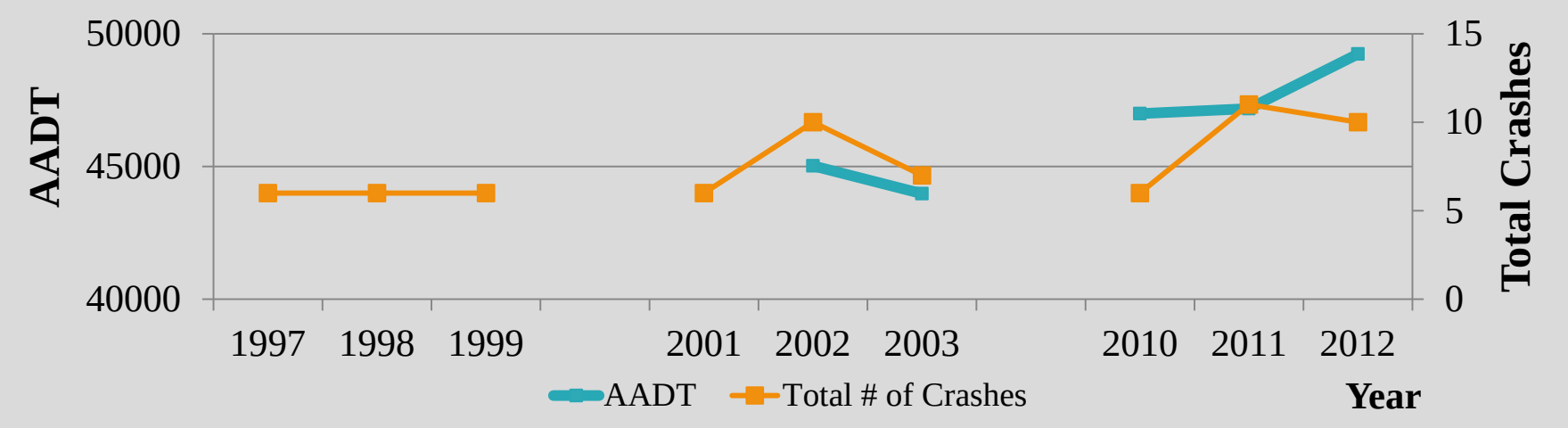


<Sub Intersection>



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



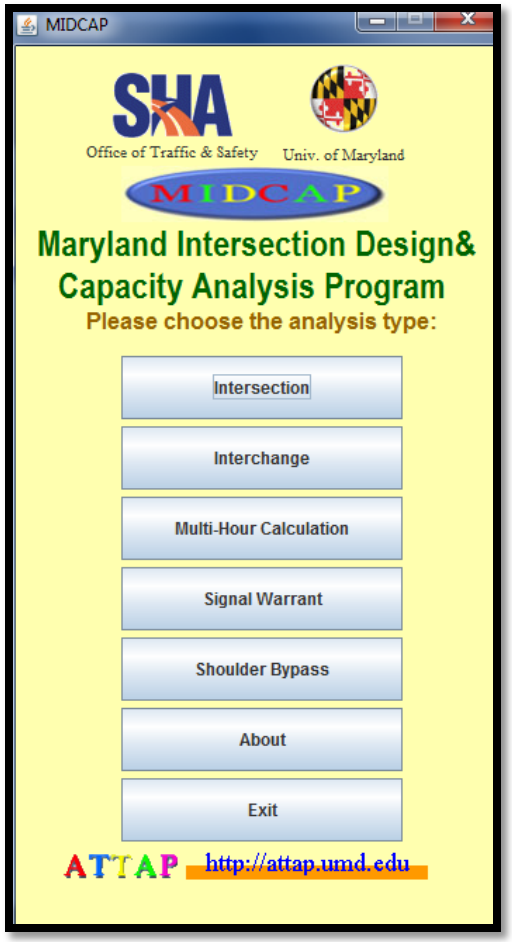
* AADT is collected at MD 210 -.20 mi south of MD 373, which is located to the north of the intersection of MD 210 & MD 228

ANALYSIS TOOLS

1. MIDCAP
2. MUID

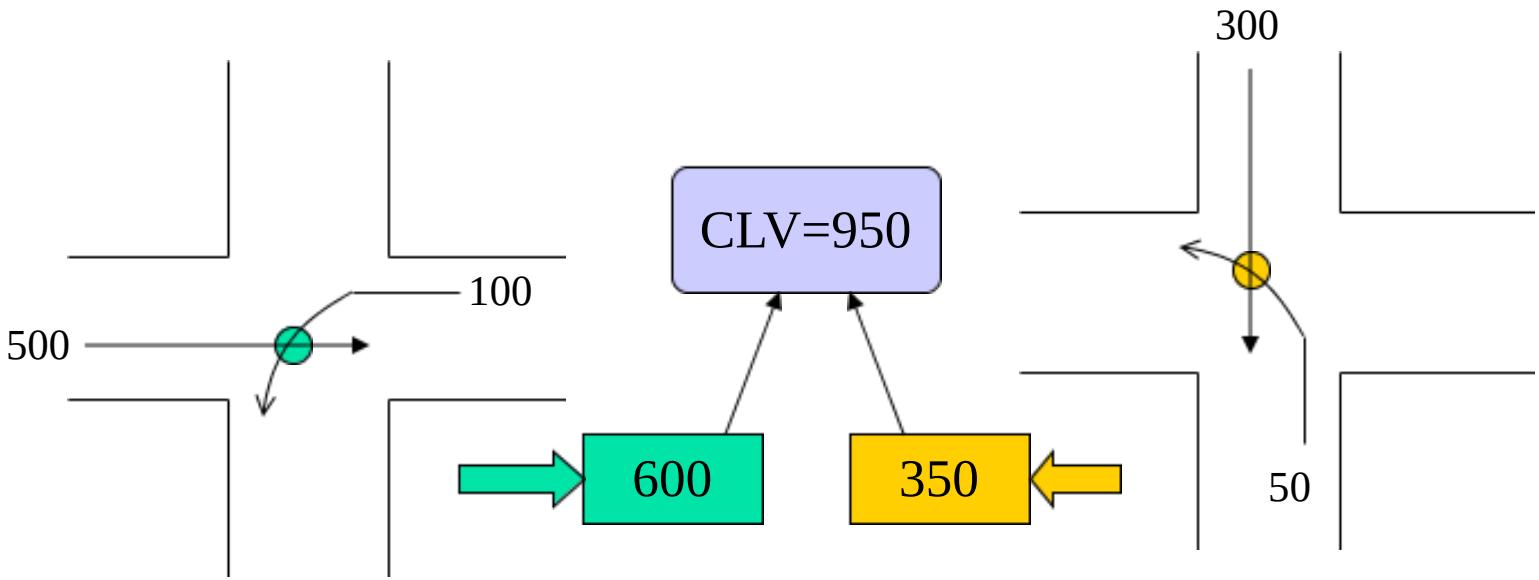
MIDCAP

- **M**aryland **I**ntersection **D**esign & **C**apacity **A**nalysis **P**rogram
- 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



MIDCAP

- 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

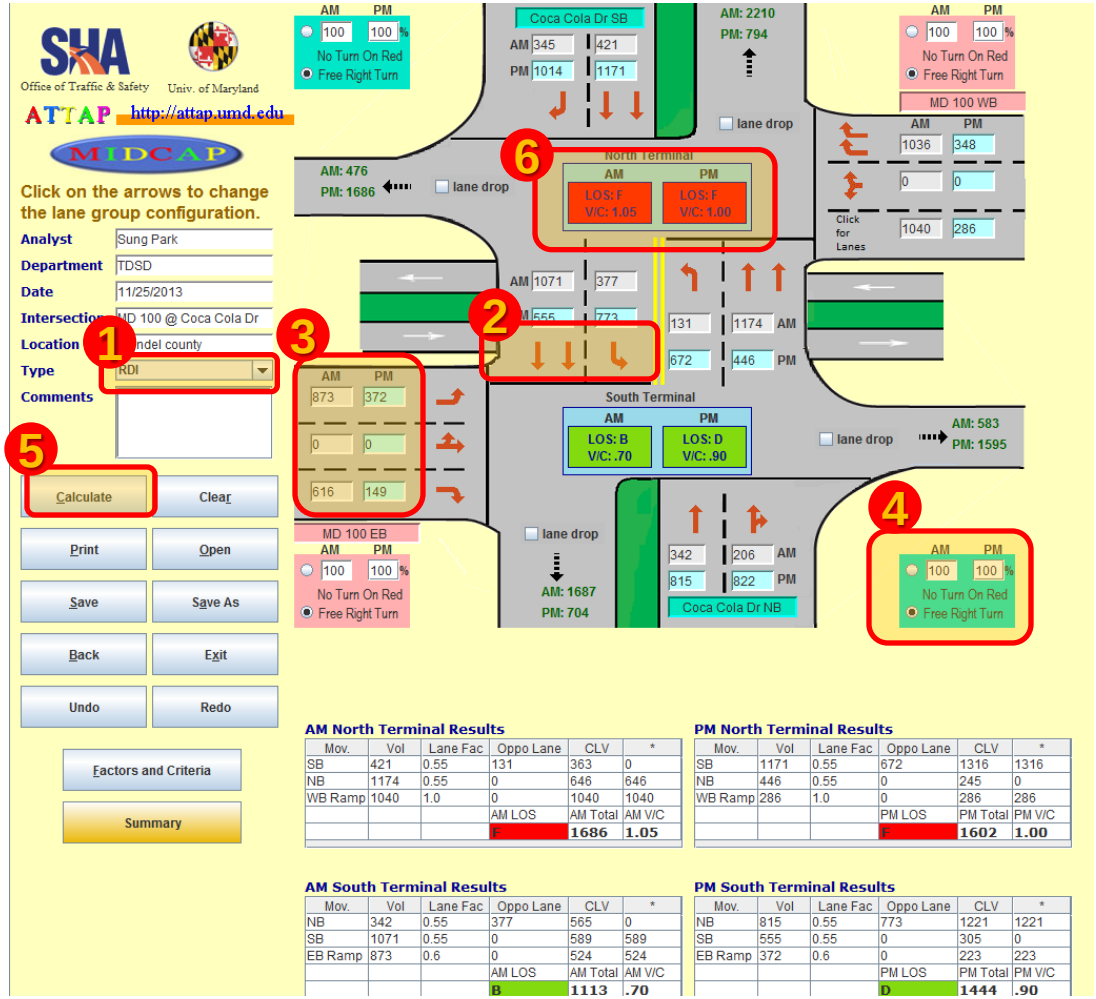
Step 2: Set Lane Configurations

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



AM North Terminal Results

Mov.	Vol	Lane Fac	Oppo Lane	CLV	*
SB	421	0.55	131	363	0
NB	1174	0.55	0	646	646
WB Ramp	1040	1.0	0	1040	1040
			AM LOS	AM Total	AM V/C
			F	1686	1.05

PM North Terminal Results

Mov.	Vol	Lane Fac	Oppo Lane	CLV	*
SB	1171	0.55	672	1316	1316
NB	446	0.55	0	245	0
WB Ramp	286	1.0	0	286	286
			PM LOS	PM Total	PM V/C
			F	1602	1.00

AM South Terminal Results

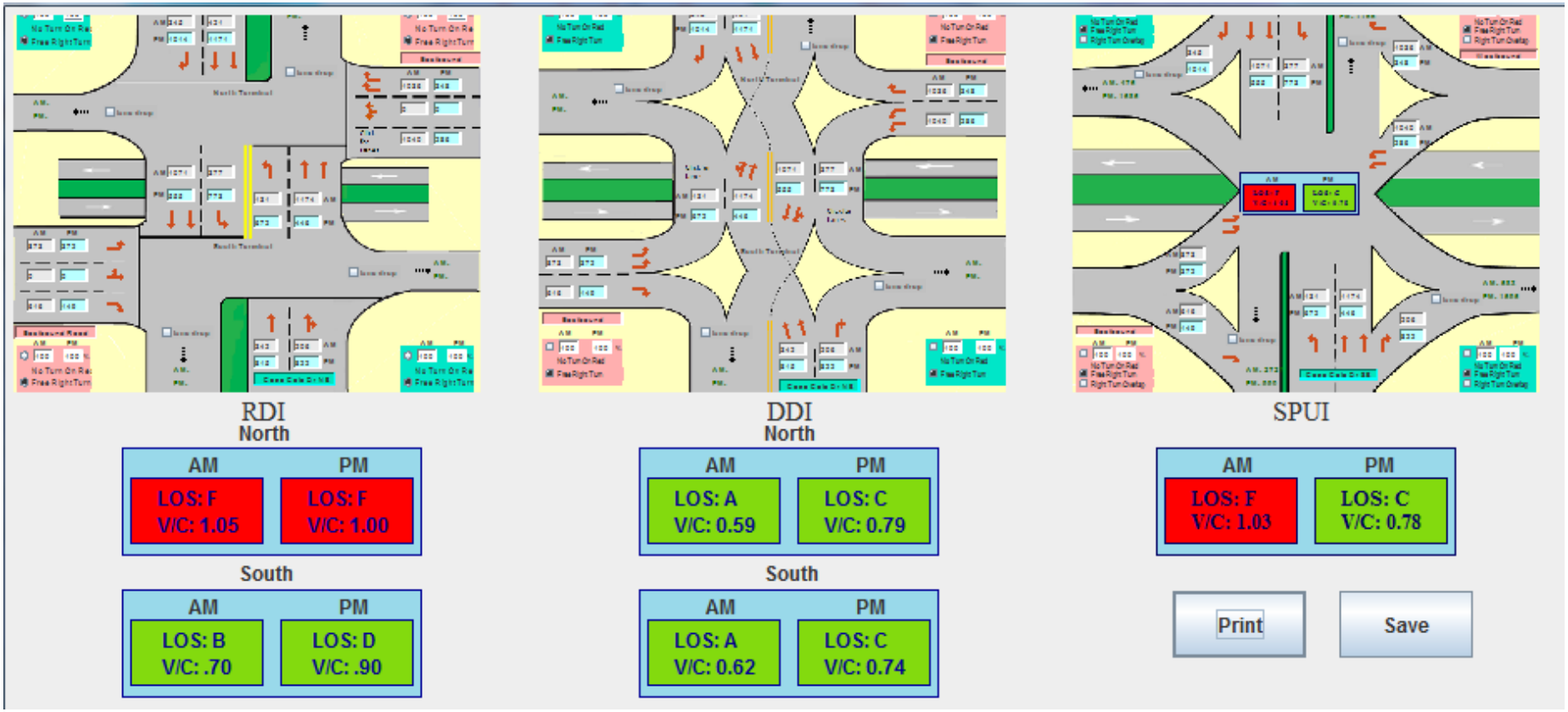
Mov.	Vol	Lane Fac	Oppo Lane	CLV	*
NB	342	0.55	377	565	0
SB	1071	0.55	0	589	589
EB Ramp	873	0.6	0	524	524
			AM LOS	AM Total	AM V/C
			B	1113	.70

PM South Terminal Results

Mov.	Vol	Lane Fac	Oppo Lane	CLV	*
NB	815	0.55	773	1221	1221
SB	555	0.55	0	305	0
EB Ramp	372	0.6	0	223	223
			PM LOS	PM Total	PM V/C
			D	1444	.90

MIDCAP

- Planning analysis using MIDCAP
  - Summary

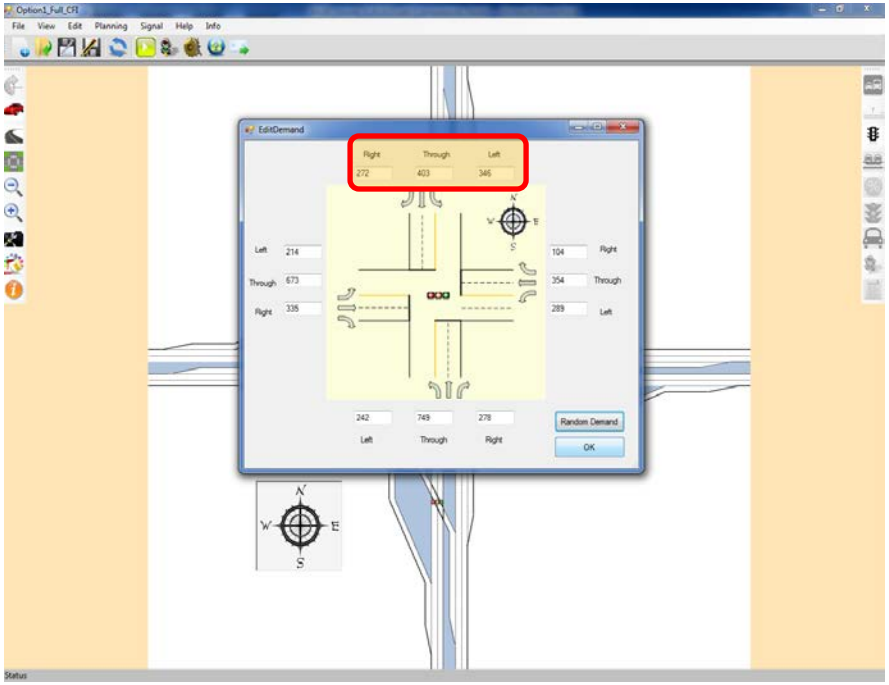


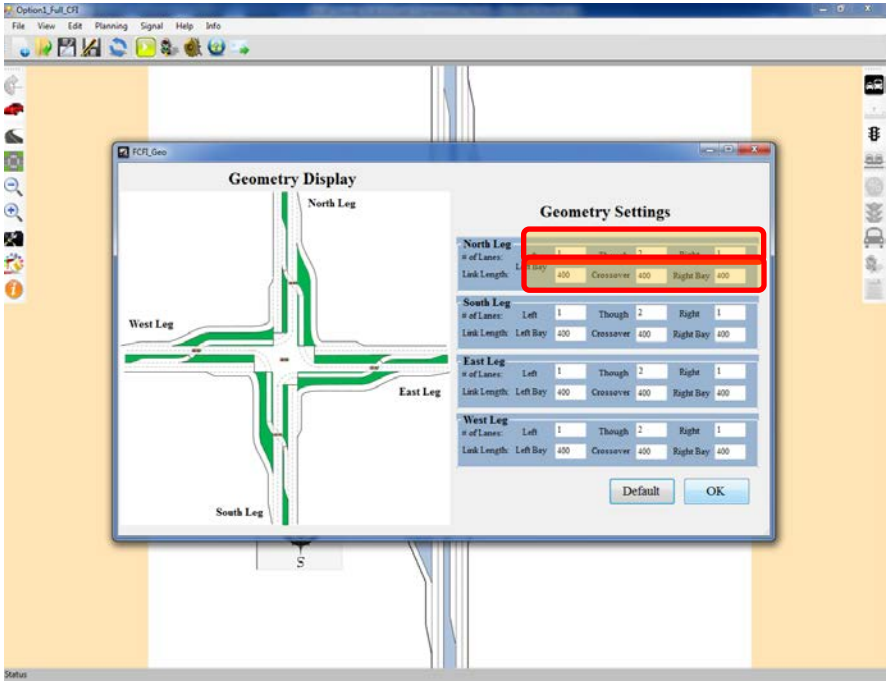
MUID

- **M**aryland **U**nconventional **I**ntersection **D**esign 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

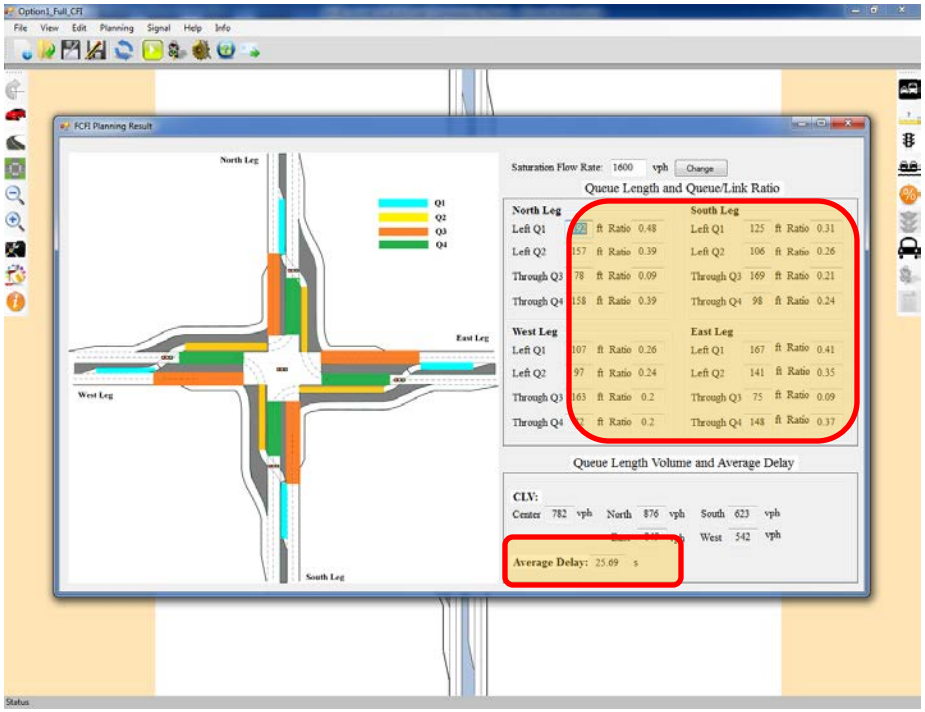
- Input: demand and geometric layout

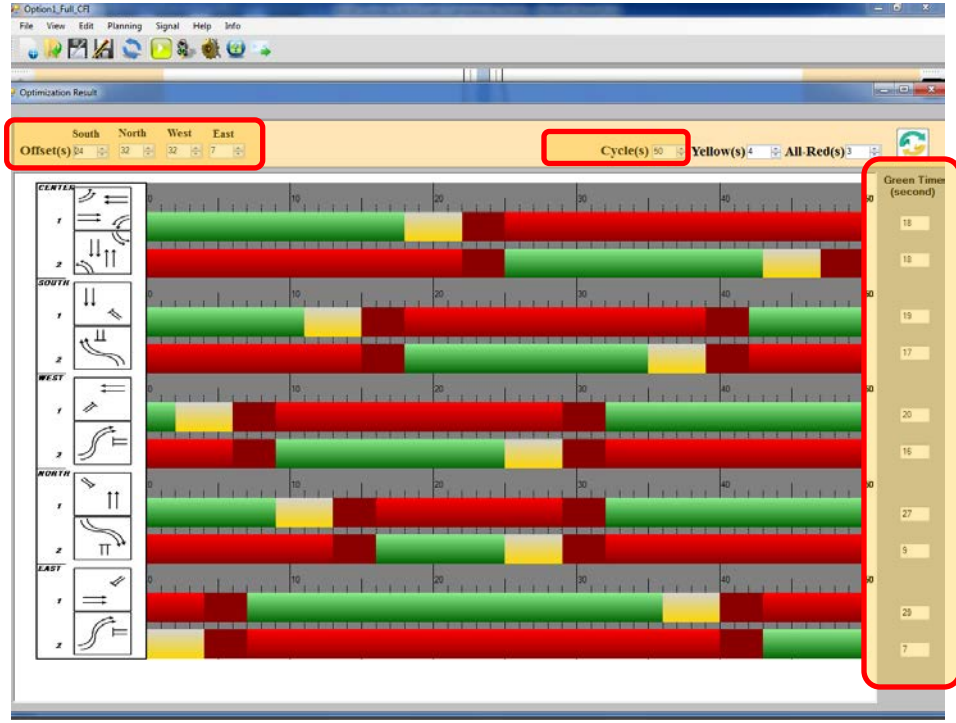




MUID

- Outputs: planning evaluation and signal optimization





Questions / Comments?

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Thank You !