

Signal Timing Strategies for Georgia's First In-House Designed DDI

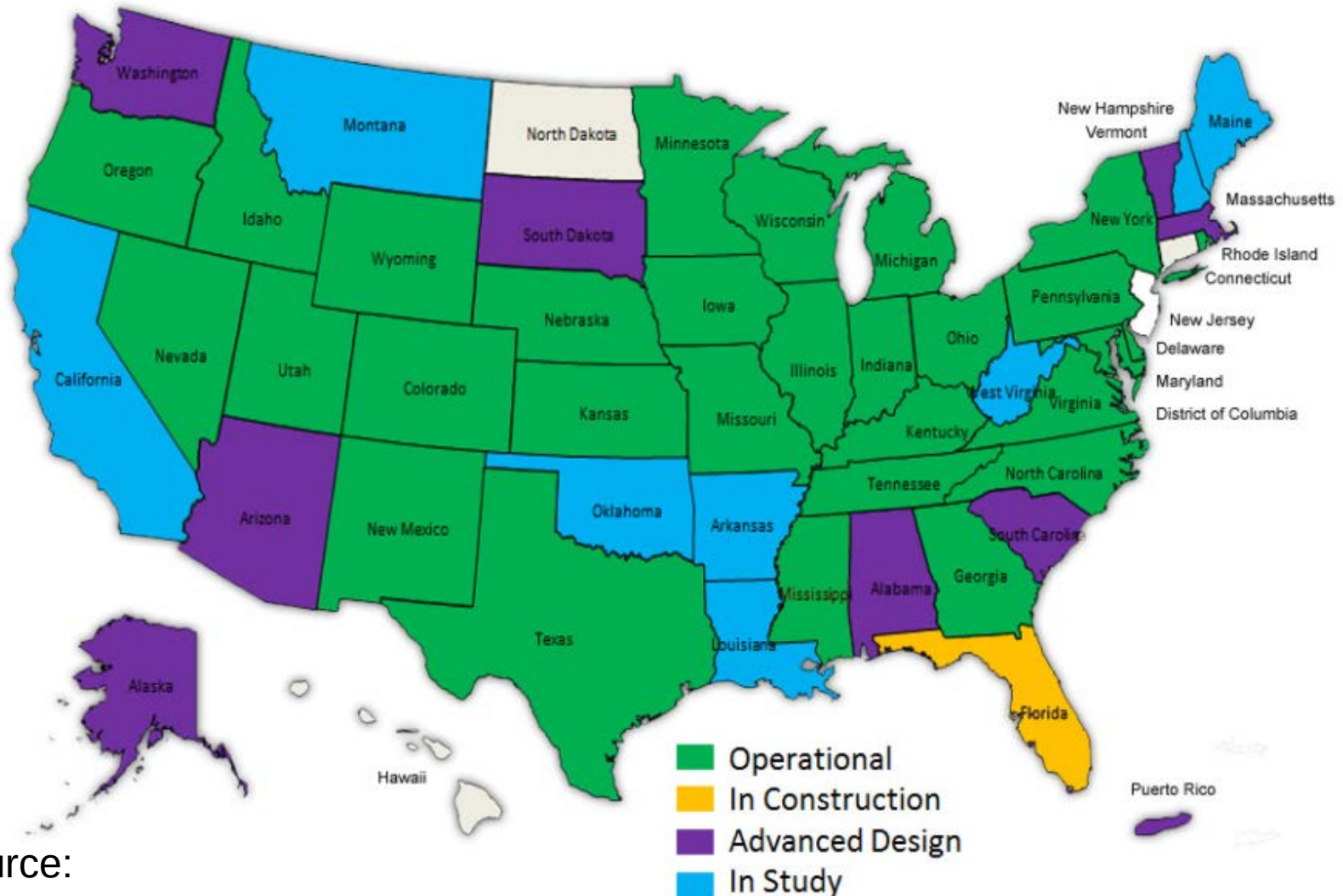
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**S05 Alternative Intersections - II
1:30 pm – 3:00 pm, May 22, 2017
5th Urban Street Symposium
Raleigh, NC**

Background

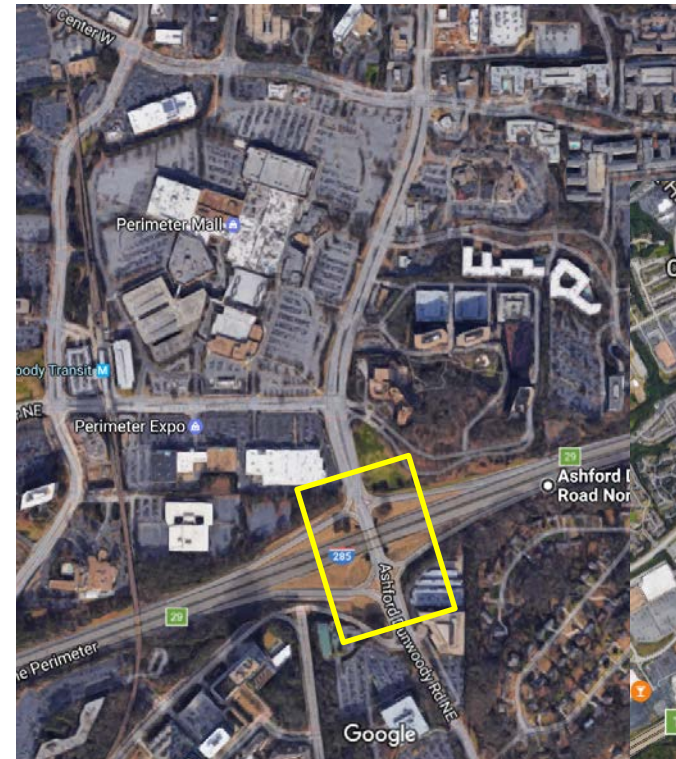
- 06/21/2009: 1st DDI opened in the U.S.
- As of 12/31/2016: 81 DDIs opened in the U.S.



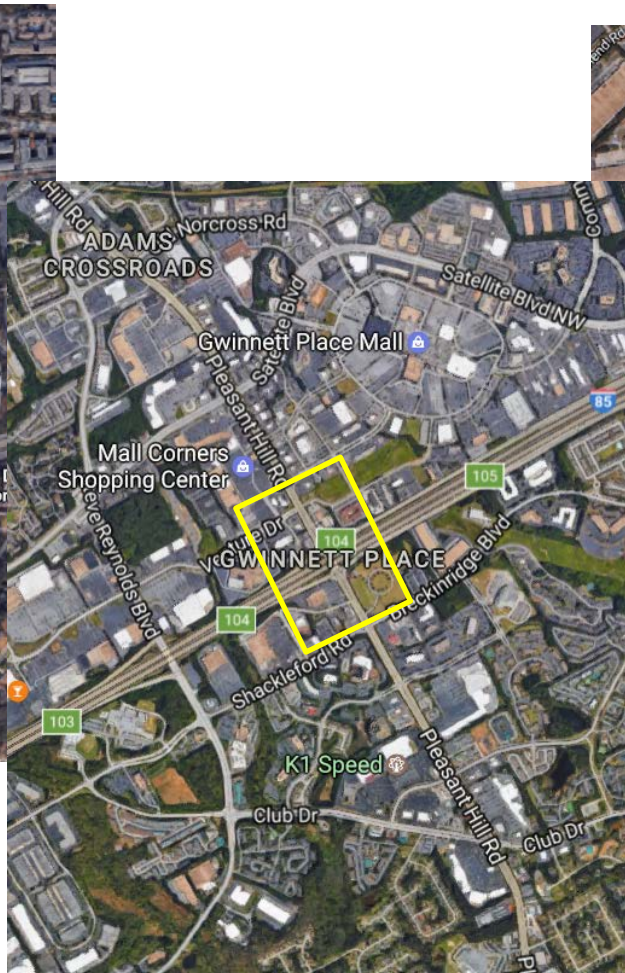
Source:
<http://www.divergingdiamond.com/>

DDIs in Georgia

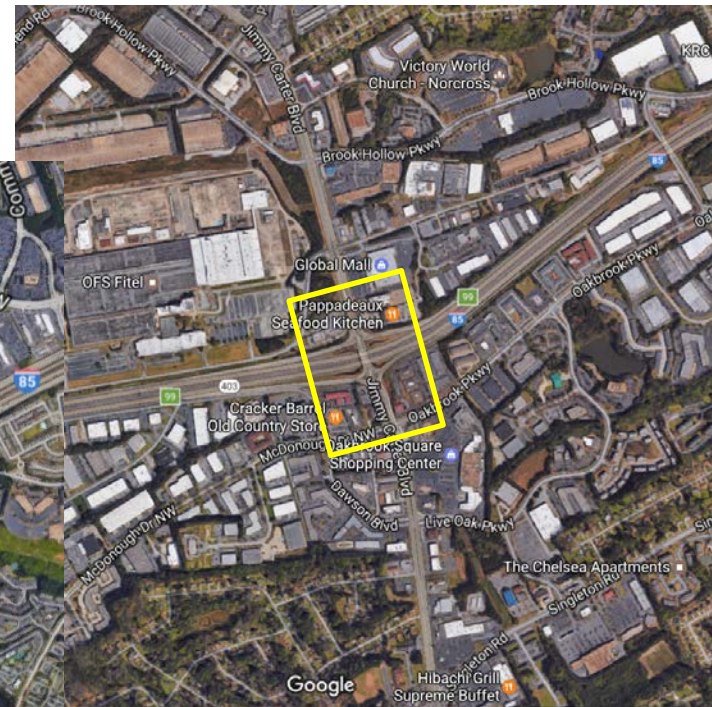
- 06/03/2012: #1, I-285 @ Ashford-Dunwoody Rd, Dunwoody, GA
- 06/09/2013: #2, I-85 @ Pleasant Hill Road, Duluth, GA
- 03/29/2015: #3, I-85 @ Jimmy Carter Blvd, Norcross, GA



#1



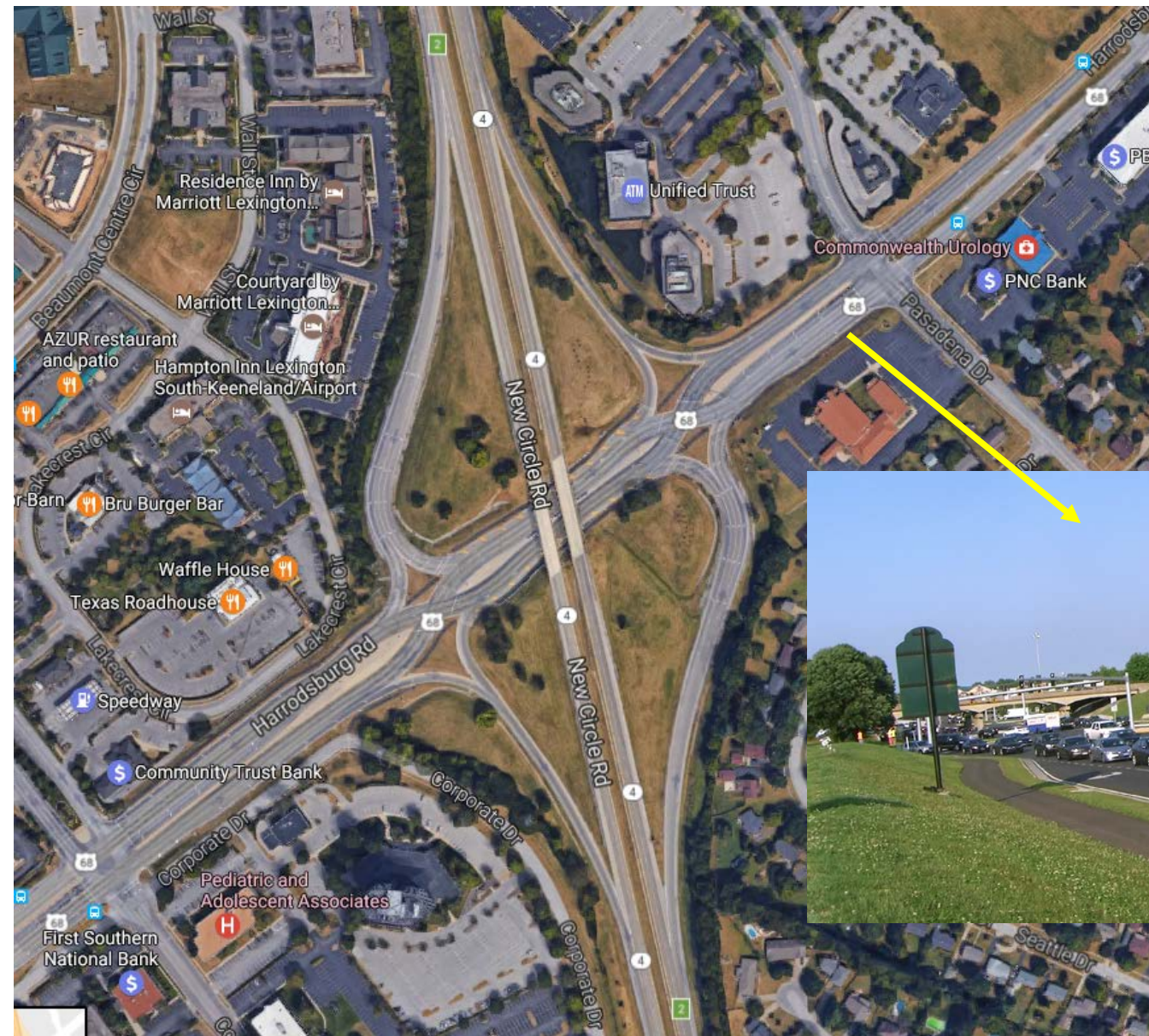
#2



#3

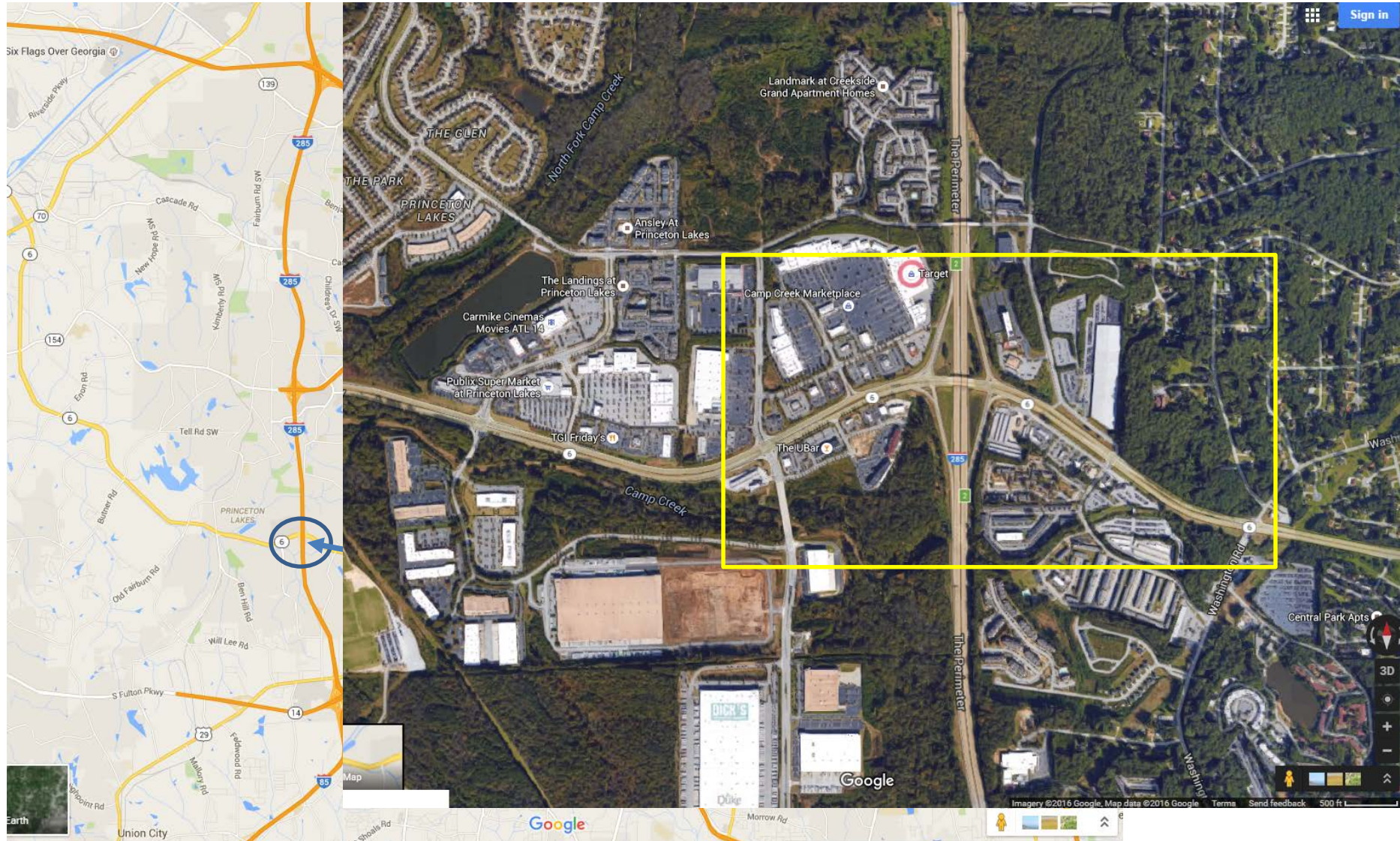
All in Greater Atlanta area; all in heavy traffic commercial area.

Problems of DDI with Congested Signal Intersection Nearby



Hwy 4 @ Harrodsburg Rd
Lexington, KY

Project Location and Study Area



Current Layout of Camp Creek Pkwy & N Commerce Dr.



	LT	TH	TH&RT	RT
SB	<u>3</u>	1		1
WB	2	2	1	
NB	1	1		1
EB	2	2	<u>1</u>	



Site Condition

- Bridge Length: 236.33 ft; Deck Width: 94.667 ft
- EB LT onto I-285 NB currently backs up to upstream signal intersection
- GDOT Predicts long queue backing up to I-285 mainline during PM Peak



2020 PM Peak Traffic (Open Year)



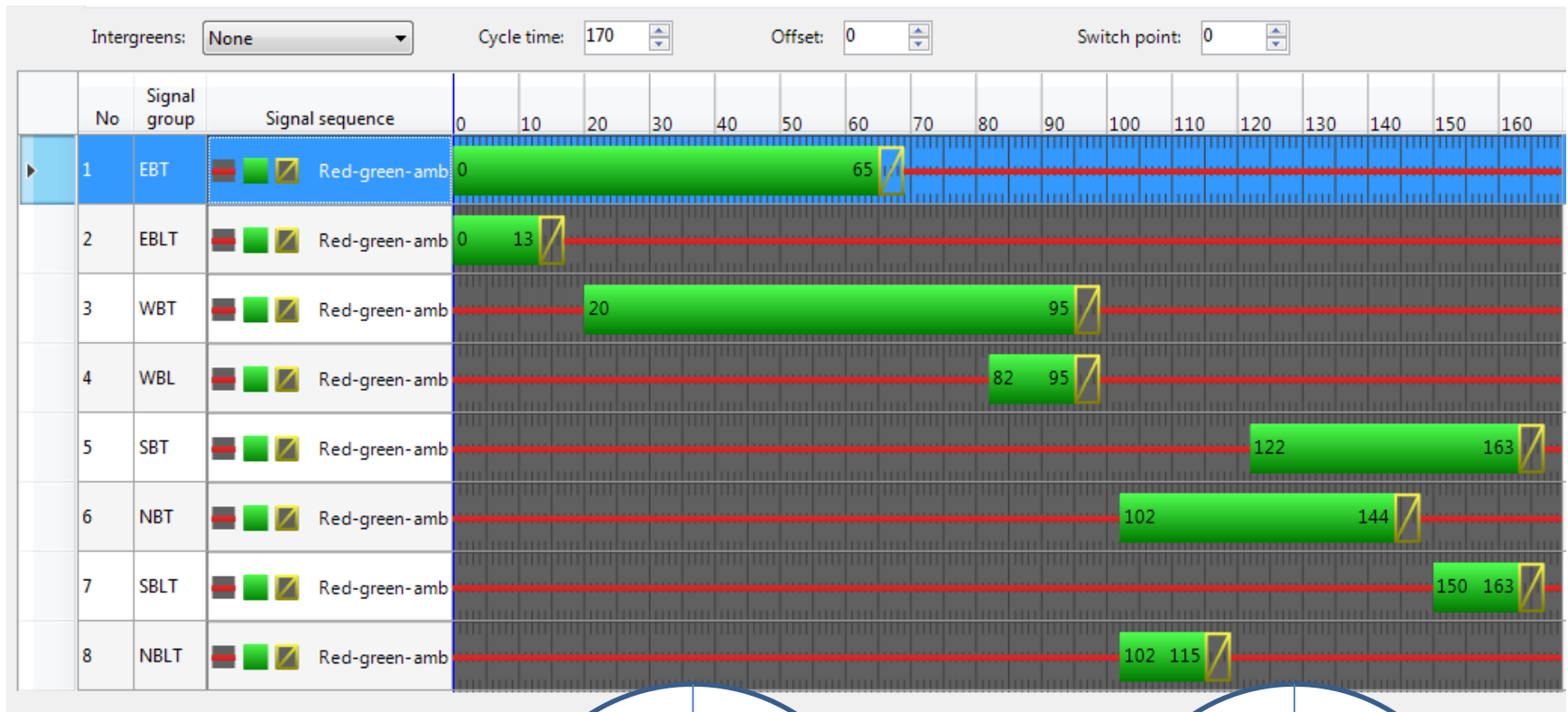
Also analyzed traffic flows under 2014 (current) and 2040 (design year)
 GDOT plans to use the DDI as temporary congestion relieve solution.

Research Approach

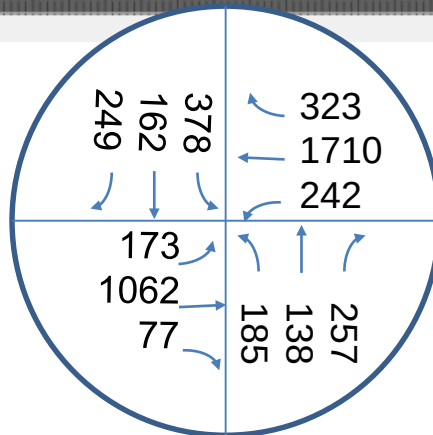
- Identify improvement options in signal timing and coordination
- Explore alternative designs at N Commerce to better handle increased traffic demand from future DDI.
- Apply incremental enhancements to the corridor.

Objective: Enable the DDI to work efficiently for 5-7 years after opening

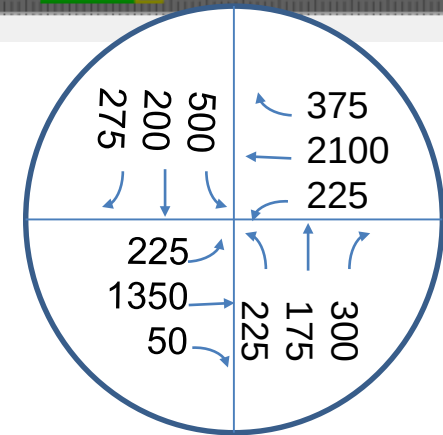
Current Signal Timing Plan (N Commerce Dr.)



**13 seconds Lead & Lag
protected left turn
phases**



Current Volume(2014 PM)



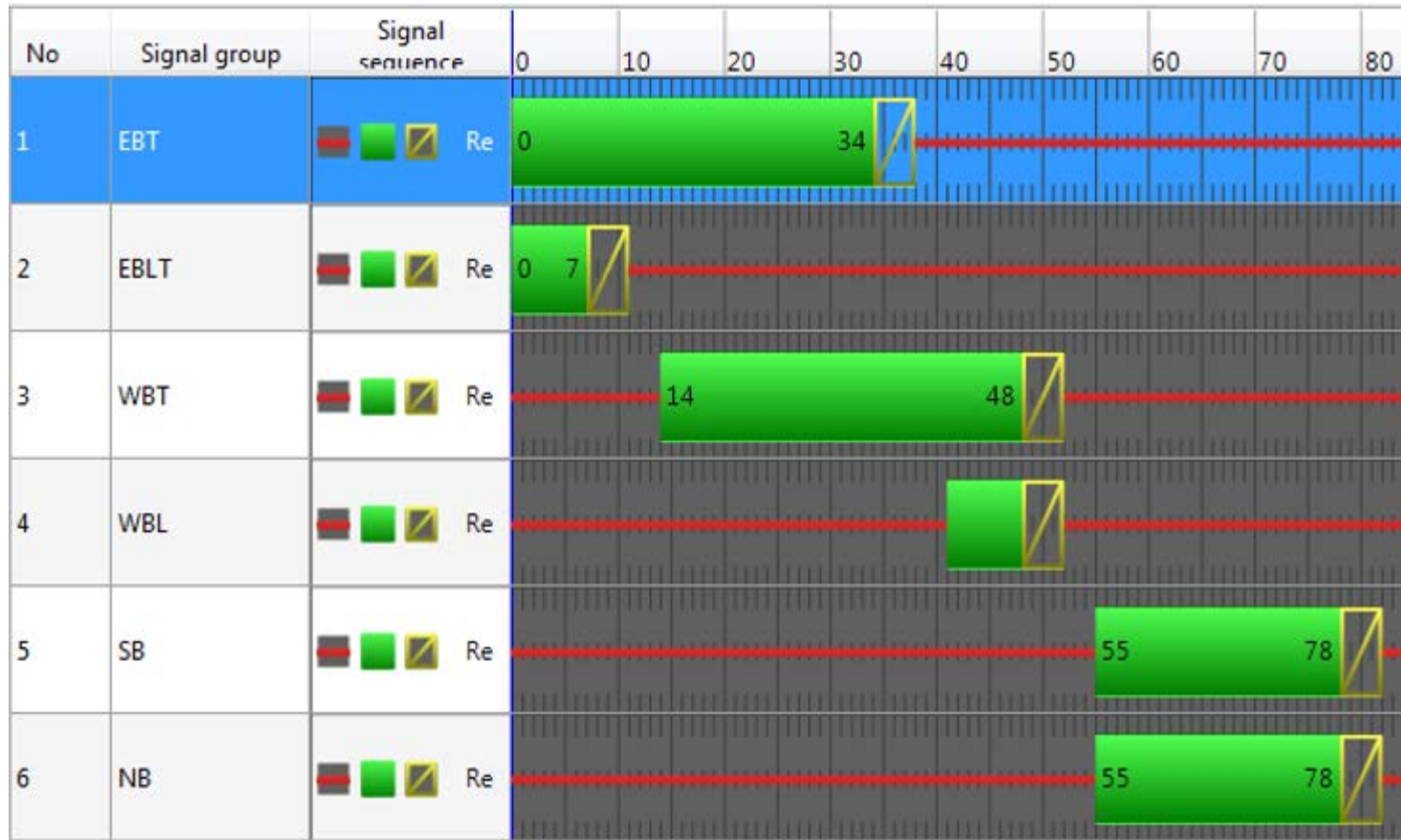
Current Volume(2020 PM)

Suggested Changes at N Commerce



Same cycle length, but NB and SB Split Phasing
Longer protected LT phase for WBL, and longer split phase for SB

Suggested Changes at Desert Dr.



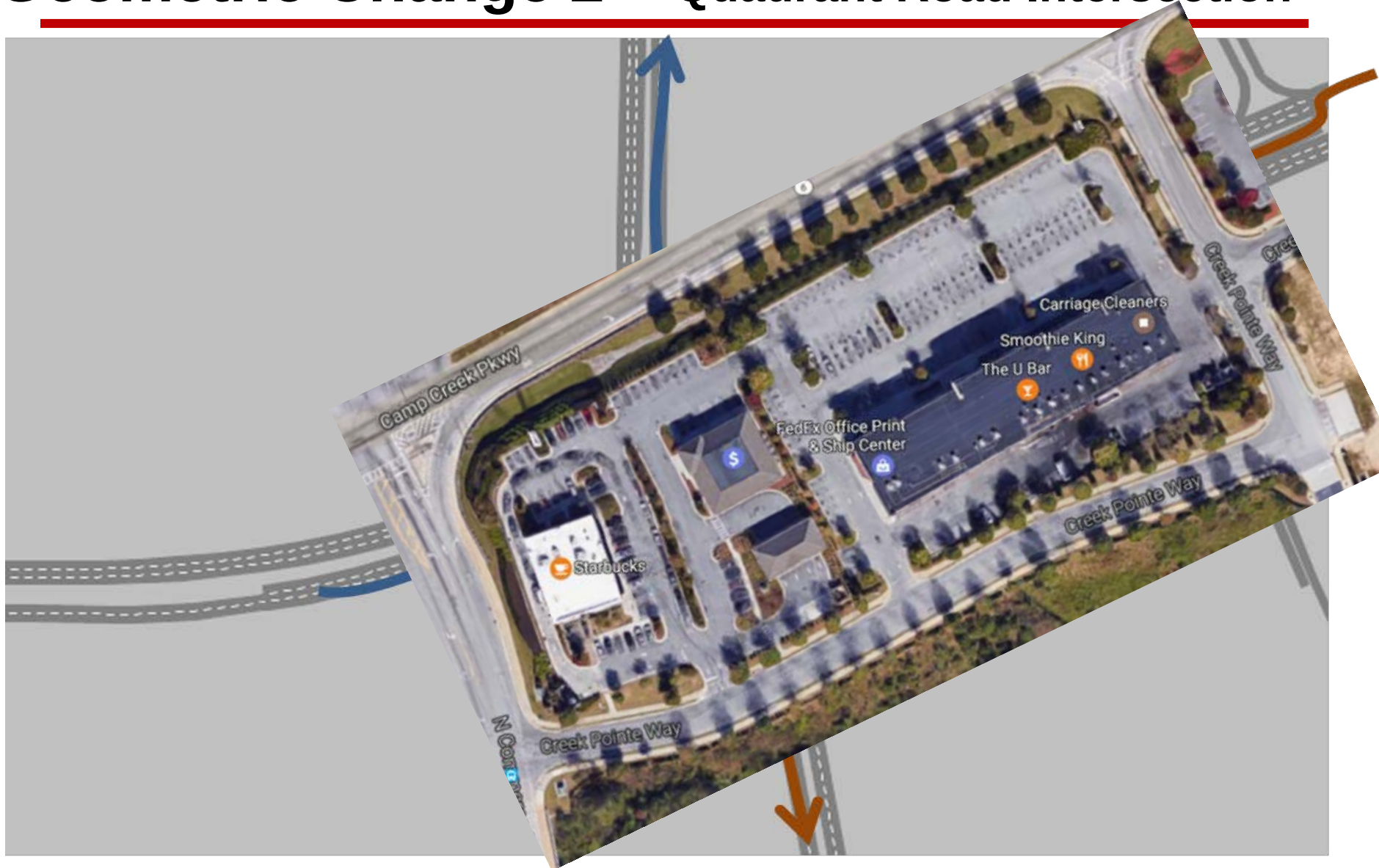
Half cycle length

Geometric Change 1 – Partial CFI on major road



Double displaced left turn lanes, median opening 270 ft before intersection, right turn bypass lane each direction, saved 20 Sec protected LT assigned to Major TH

Geometric Change 2 – Quadrant Road Intersection



Convert back road into a 2-lane one-way street, double WB LT lanes, single EB RT lane YIELD Control, saved 20-sec protect LT assigned to major TH

Cases Considered (Cycle length=170 Sec)

0. Base case (No build)
1. Case 0 + Signal Timing Adjustment
(Split phase in NB/SB at N Commerce & half cycle at Desert)
2. Case 1 + replacing diamond with DDI
3. Case 2 + Partial CFI in EB/WB at N Commerce
4. Case 2 + QRI at N Commerce

	2014 PM Peak	2020 PM Peak	2040 PM Peak
Case 0	X	X	X
Case 1	X	X	X
Case 2	X	X	X
Case 3	X	X	X
Case 4	X	X	X

Distance between N Commerce and West Ramp: about 1,600 ft

Simulation (VISSIM 6.0)

- 4% truck on all roads
- Ten runs each scenario
 - 900 sec worm up, 3,600 sec simulation
- MOEs measured (by approach & by movement)
 - Queue, Throughput, Average Stop, Delay
 - LOS determined by weighted average delay

Table 1. Level of Service Criteria for Signalized Intersections

Level of Service	Average Control Delay (seconds/vehicle)	General Description
A	≤10	Free Flow
B	>10 – 20	Stable Flow (slight delays)
C	>20 – 35	Stable flow (acceptable delays)
D	>35 – 55	Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding)
E	>55 – 80	Unstable flow (intolerable delay)
F ¹	>80	Forced flow (congested and queues fail to clear)

Source: *Highway Capacity Manual 2010*, Transportation Research Board, 2010.

RESULTS

Case 0 (No Build)

Approach		Movement	Queue Length (ft, veh)		Throughput (veh/hr)	Average Stop per vehicle	Approach Delay (sec) & LOS			Intersection Delay (sec) & LOS	
			Average	Max							
Commence Dr.	EB	LT / TH / RT	67/284/0	202/1070/50	217/1324/50	1.2/0.8/0.6	96/56/21	60.3	E	99.3	F
	WB	LT / TH / RT	66/1273/1098	213/1697/1690	203/1898/331	0.8/0.7/0.7	78.3/52.9/44.6	53.8	D		
	NB	LT / TH / RT	1195/1194/0	1697/1697/34	159/141/258	2.7/1/0.3	347.2/76/17.3	125.8	F		
	SB	LT / TH / RT	1258/1259/439	1468/1470/716	307/144/184	4.2/1.7/1.1	596.9/152.1/84.7	347.2	F		
	EB	TH / RT	41/0	252/0	798/1359	0.4/0	20/4.2	10.1	B	28.1	C
	WB	LT / TH	69/70	422/422	96/1606	0.7/0.6	26.7/29.5	29.3	C		
	NB										
	SB	LT/RT1/RT2	239/303/93	1144/1516/1149	594/401/784	1.1/1.6/0.3	76.1/66.3/19.3	48.8	D		
	EB	LT / TH	145/23	533/203	509/888	1.3/0.2	45.4/10.6	23.3	C	37.3	D
	WB	TH / RT	744/526	1241/1087	672/867	1/0.3	79.1/21.7	46.8	D		
	NB	LT/RT	187/3	667/141	1040/225	0.8/0.1	48.6/6.6	41.1	D		
	SB										
Desert Dr.	EB	LT / TH / RT	17/50/47	151/536/536	46/880/49	0.9/0.4/0.6	57.2/15.4/22.2	17.8	B	41.2	D
	WB	LT / TH / RT	32/107/123	181/685/718	80/1127/325	1/0.5/0.4	75.3/25.4/19.6	26.8	C		
	NB	LT / TH / RT	201/201/201	428/428/428	98/45/85	2.4/2.1/2.3	133.4/143.4/146.3	140.7	F		
	SB	LT / TH	220/220	596/596	224/76	1.4/1.2	113.1/111.1	114.7	F		

Case 1 (Case 0 + Signal Adjustment)

Approach		Movement	Queue Length (ft, veh)		Throughput (veh/hr)	Average Stop per vehicle	Approach Delay (sec) & LOS			Intersection Delay (sec) & LOS	
			Average	Max							
Commence Dr.	EB	LT / TH / RT	67/150/5	210/745/244	221/1325/50	1/0.7/0.6	88.1/45.4/22.7	50.6	D	50.0	D
	WB	LT / TH / RT	63/928/496	230/1657/1659	208/1945/344	0.8/0.6/0.6	75.8/44.6/37.2	46.2	D		
	NB	LT / TH / RT	155/153/36	613/611/524	232/174/312	1/1/0.8	79.9/78.3/19.9	53.4	D		
	SB	LT / TH / RT	97/136/13	544/616/304	493/196/271	0.9/1/0.5	67.2/82.6/17.8	56.5	E		
	EB	TH / RT	61/0	298/48	892/1502	0.7/0	27.7/3.9	12.8	B	24.1	C
	WB	LT / TH	51/52	354/353	94/1606	0.8/0.4	28.8/19.6	20.1	C		
	NB										
	SB	LT/RT1/RT2	357/143/22	1460/946/409	597/414/798	1.3/0.9/0.1	88.1/38.1/11.5	42.7	D		
	EB	LT / TH	219/34	555/288	568/929	1.4/0.3	51.9/13.8	28.2	C	39.1	D
	WB	TH / RT	737/541	1245/1087	669/863	1/0.3	79.7/23	47.7	D		
	NB	LT/RT	189/3	678/153	1040/223	0.8/0.1	49/6.8	41.6	D		
	SB										
Dessert Dr.	EB	LT / TH / RT	14/45/39	112/503/503	50/922/48	0.9/0.3/0.6	46.5/13.7/23.2	15.7	B	30.6	C
	WB	LT / TH / RT	21/211/235	143/825/858	75/1124/327	1/0.8/0.7	55.6/38.4/32.5	38.1	D		
	NB	LT / TH / RT	49/49/49	300/300/300	97/50/100	1.2/1/1.2	39.8/43.3/45	42.7	D		
	SB	LT / TH	53/53	337/337	233/75	0.9/0.7	33/32	32.9	C		

Case 2 (Case 1 + DDI)

Approach		Movement	Queue Length (ft, veh)		Throughput (veh/hr)	Average Stop per vehicle	Approach Delay (sec) & LOS			Intersection Delay (sec) & LOS	
			Average	Max							
Commence Dr.	EB	LT / TH / RT	70/163/52	225/773/566	229/1367/49	1.1/0.7/1.2	90.6/42.8/69.5	50.5	D	57.4	E
	WB	LT / TH / RT	191/1185/882	709/1674/1685	169/1882/328	1.4/0.7/0.7	141.1/52.3/44.6	56.8	E		
	NB	LT / TH / RT	211/210/76	712/711/619	229/170/308	1/1/0.7	83.2/80.3/22.6	57.0	E		
	SB	LT / TH / RT	440/440/15	1002/1003/338	469/167/242	0.9/1.6/0.7	70/145.7/50.6	72.7	E		
	EB	TH / RT	66/1	335/93	879/1483	0.7/0	29.9/4	13.6	B	22.3	C
	WB	LT / TH	129/129	557/557	93/1596	0/0.7	3.2/30.3	29.6	C		
	NB										
	SB	LT/RT1/RT2	43/312/150	247/1512/896	540/377/747	0.6/1.4/0.1	25.5/63.4/9.9	27.3	C		
	EB	LT / TH	6/6	167/167	872/546	0/0	4.5/3.7	4.2	A	15.3	B
	WB	TH / RT	128/58	844/721	684/868	1/0.1	42.5/7.8	23.7	C		
	NB	LT/RT	109/2	819/134	1021/229	0.7/0.1	19.5/5.6	17.5	B		
	SB										
Dessert Dr.	EB	LT / TH / RT	14/84/100	138/458/494	50/905/48	0.9/0.6/0.6	48.3/28.5/22.8	29.4	C	31.9	C
	WB	LT / TH / RT	19/183/208	141/786/819	74/1117/324	1/0.8/0.7	52.3/36.5/31.5	35.3	D		
	NB	LT / TH / RT	23/23/30	206/206/219	101/50/98	1.2/0.7/0.4	30.9/26/9.6	21.5	C		
	SB	LT / TH	51/51	331/331	228/72	0.8/0.7	32.4/31.8	31.9	C		

Case 3 (Case 2 + Partial CFI at N Commerce)

Approach		Movement	Queue Length (ft, veh)		Throughput (veh/hr)	Average Stop per vehicle	Approach Delay (sec) & LOS			Intersection Delay (sec) & LOS	
			Average	Max							
Commence Dr.	EB	LT / TH / RT	57/68/0	236/453/66	220/1325/50	0.9/0.5/0.4	76/29.6/9.4	35.3	D	42.5	D
	WB	LT / TH / RT	97/223/1	810/1087/128	214/1988/352	1.2/0.6/0.5	92.1/35.5/22	38.4	D		
	NB	LT / TH / RT	154/154/13	564/564/275	226/173/312	0.9/0.9/0.5	75.4/69.4/15.1	47.5	D		
	SB	LT / TH / RT	171/171/20	667/667/371	494/205/271	0.9/1/0.8	71.5/81.2/28.6	61.6	E		
	EB	TH / RT	79/0	292/0	1064/1384	0.7/0	31/3.1	15.2	B	15.3	B
	WB	LT / TH	79/79	422/422	99/1646	0/0.4	4.6/15.7	15.1	B		
	NB										
	SB	LT/RT1/RT2	48/83/0	256/424/0	564/403/782	0.7/0.8/0	23.2/31.9/1.6	15.6	B		
	EB	LT / TH	9/9	135/135	1096/503	0.1/0	4.6/2.7	4.0	A	10.5	B
	WB	TH / RT	64/4	491/280	695/877	0.8/0	33/5.2	17.5	B		
	NB	LT/RT	39/3	289/135	1037/224	0.4/0.2	11.4/4.6	10.2	B		
	SB										
Dessert Dr.	EB	LT / TH / RT	16/108/128	148/517/554	57/1075/56	0.9/0.6/0.6	49.3/29.3/25.4	30.1	C	33.6	C
	WB	LT / TH / RT	21/227/252	141/889/922	76/1122/326	1/0.8/0.7	55/37.9/33.2	37.8	D		
	NB	LT / TH / RT	30/30/36	269/269/281	96/49/101	1.2/0.8/0.6	33.4/35.9/18.1	27.6	C		
	SB	LT / TH	51/51	332/332	232/75	0.7/0.7	30.6/30.8	30.8	C		

Case 4 (Case 2 + QRI at N Commerce)

Approach		Movement	Queue Length (ft, veh)		Throughput (veh/hr)	Average Stop per vehicle	Approach Delay (sec) & LOS			Intersection Delay (sec) & LOS	
			Average	Max							
Commence Dr.	EB	LT / TH / RT	69/66/0	441/421/26	208/1583/54	2.1/0.4/0.1	115.5/20.6/3.8	23.6	C	38.2	D
	WB	LT / TH / RT	70/182/161	347/1015/972	120/2021/363	1.7/0.5/0.6	102.1/25.5/24	26.6	C		
	NB	LT / TH / RT	466/474/240	964/967/960	275/394/469	1.5/1.6/1.4	85.2/98.7/44.4	73.1	E		
	SB	LT / TH / RT	105/99/9	387/380/214	517/172/290	0.9/0.9/0.3	71.4/71.2/6	52.0	D		
	EB	TH / RT	55/1	311/104	856/1441	0.7/0	25.1/2.9	11.2	B	14.7	B
	WB	LT / TH	89/89	526/526	107/1647	0/0.5	1.7/17.5	16.5	B		
	NB										
	SB	LT/RT1/RT2	46/75/0	244/418/0	580/389/798	0.7/0.8/0	25.3/33.9/3.5	17.3	B		
	EB	LT / TH	6/6	133/133	890/541	0/0	4.7/3.2	4.1	A	12.4	B
	WB	TH / RT	74/12	631/449	703/896	0.8/0.1	35.3/5.8	18.8	B		
	NB	LT/RT	79/1	521/99	1036/229	0.6/0.1	15.6/5.6	13.8	B		
	SB										
Dessert Dr.	EB	LT / TH / RT	14/88/105	131/434/471	49/923/48	0.9/0.6/0.6	48.5/29.2/23.5	29.9	C	34.4	C
	WB	LT / TH / RT	20/236/261	129/940/974	78/1143/314	1/0.8/0.8	57/38.6/35.7	39.0	D		
	NB	LT / TH / RT	29/29/35	263/263/274	95/50/98	1.3/0.8/0.6	33.5/35.9/18.7	28.0	C		
	SB	LT / TH	50/50	318/318	219/76	0.8/0.7	31.3/31.3	31.4	C		

Summary of Intersection Delays

	Case 0	Case 1	Case 2 (DDI)	Case 3 (DDI+CFI)	Case 4 (DDI+QRI)
N Commerce Dr	99.3 (F)	50 (D)	57.4 (E)	42.5 (D)	38.2 (D)
West Ramp	28.1 (C)	24.1 (C)	22.3 (C)	15.3 (B)	14.7 (B)
East Ramp	37.3 (D)	39.1 (D)	15.3 (B)	10.5 (B)	12.4 (B)
Desert Dr	41.2 (D)	30.6 (C)	31.9 (C)	33.6 (C)	34.4 (C)

Conclusions

- **Adjust signal timing can yield significant reductions in intersection delay and network delay**
- **Convert the diamond into DDI reduces delays at ramp intersections (marginal reduction at west ramp) but increases delays at nearby intersections**
- **Apply alternative designs (partial CFI or QRI) at congested signal intersection(s) adjacent to DDI can lead to significant reductions in delays at the intersection of interest, and at the nearby DDI ramps -> better utilization of DDI's capacity.**

Questions?

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