BURGESS & NIPLE

Memorandum

5085 Reed Road | Columbus, Ohio 43220 | 614.459.2050

To: Mr. Doug Crabill
City of Urbana

February 24, 2016

From: Brian Moore, PE
Kendra Schenk, PE, PTOE
Burgess & Niple, Inc.

Subject: US 36 & US 68 Intersection Study

Burgess & Niple, Inc. (B&N) has completed a study of the US 36 and US 68 roundabout intersection. This memorandum summarizes the study process and findings.

Traffic Counts

B&N collected peak hour traffic counts on Thursday, January 7, 2016 at the intersection of US 36 (Scioto Street/Miami Street) and US 68 (Main Street). Miovision video technology was used to collect counts from 6 AM to 9 AM and 3 PM to 6 PM. The existing AM and PM peak hour counts are illustrated in **Figure 1** with the raw counts included in the appendix.

Figure 1 – Existing Peak Hour Counts

Existing and Future Design Hour Volumes

From the existing counts, design hour volumes were developed for both existing conditions and future year 2036. Using methodologies outlined in the ODOT *Ohio Certified Traffic Manual*, a design hour factor (DHF) of 1.12 was developed from 2014 ADT counts from the ODOT website and the 2016 turning movement counts. Calculations are included in the appendix. The DHF was applied to the existing peak hour count to obtain the 30th highest hour which is used for design. This adjustment to existing counts will help to accurately compare the existing conditions to the future year conditions. The existing AM and PM peak hour design volumes are illustrated in **Figure 2**.

Using historical short term hourly count data obtained from the ODOT website in this location for 2008, 2011, and 2014, an annual linear growth rate of 0.5% per year was determined. It appeared as though there was an unusually high period of growth and decline in 2011 and 2014. Therefore, the growth rate was determined using the average annual growth rate between 2008 and the 2016 counts.

After the existing volumes were grown, the DHF was applied to determine the future year 2036 design peak hour volumes which are illustrated in **Figure 3**.

These volumes will be used in the capacity analysis detailed below.

Crash Analysis

Using ODOT's GIS Crash Analysis Tool (GCAT), crash information for this intersection was obtained. In discussions with ODOT, the crash database is updated with July 2015 data. The crashes for August 2012 through July 2015 (the most recent three years of data) were analyzed and are summarized in the collision diagram in **Figure 7**.

A total of 65 crashes were reported over this three year time period. Of the 65 crashes, only nine were injury crashes. **Figure 4** illustrates the distribution of crashes per year. The number of crashes more than doubled between 2013 and 2014 (13 to 28). There were 21 crashes in the first seven months of 2015. If this pattern continued in 2015, the total number of crashes is projected to be 36 which is significantly higher than the number of crashes reported in 2014. The roundabout configuration has been in place since

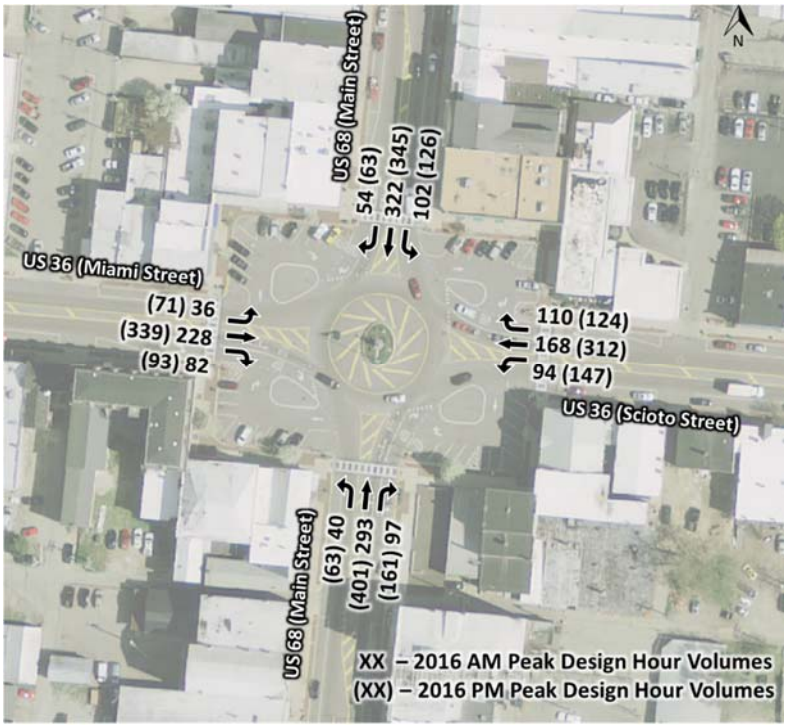


Figure 2 – 2016 Design Hour Volumes

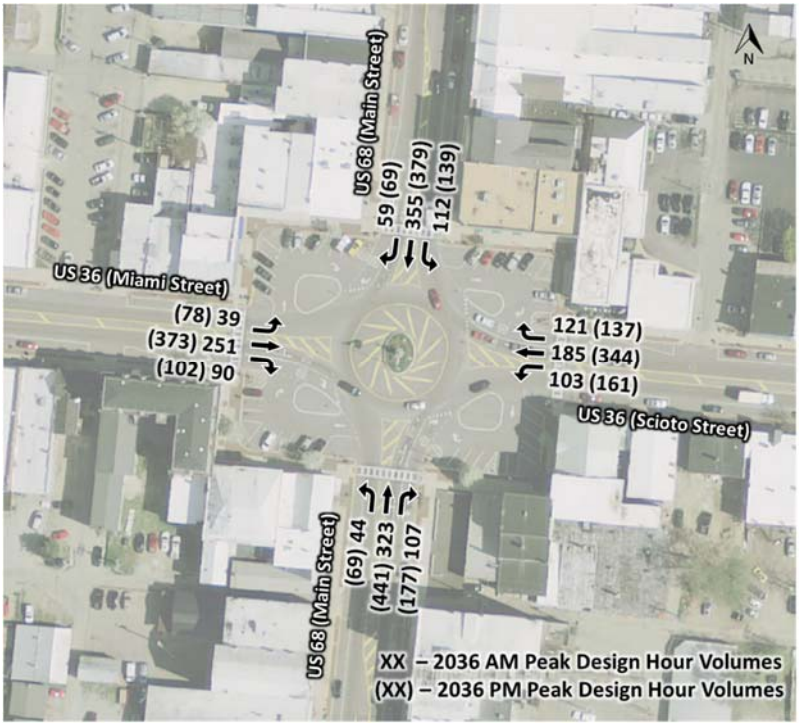


Figure 3 – 2036 Design Hour Volumes

approximately 2009. Therefore, driver unfamiliarity with the roundabout is likely not a contributing factor to these crashes.

The frequency of crashes by type of crash is illustrated in **Figure 5**. The vast majority of crashes were rear end or angle collisions.

A high number of collisions were sideswipe in the same direction. Due to the path overlap created by the striping on the approaches, vehicles, specifically trucks, have difficulty navigating the roundabout entry which results in the sideswiping of another vehicle. Often times this vehicle was also attempting to enter the roundabout from the same approach but from the right lane.

Additionally, a larger than expected number of crashes were fixed object collisions. In reviewing the crash reports, many of the yield signs were struck at least once because of the lack of curb in the area. Drivers claimed they didn't see the post and collided with the sign. Without a physical constraint, such as a curb, the vehicle path is not clearly defined making it difficult for drivers to maintain the intended travel path.

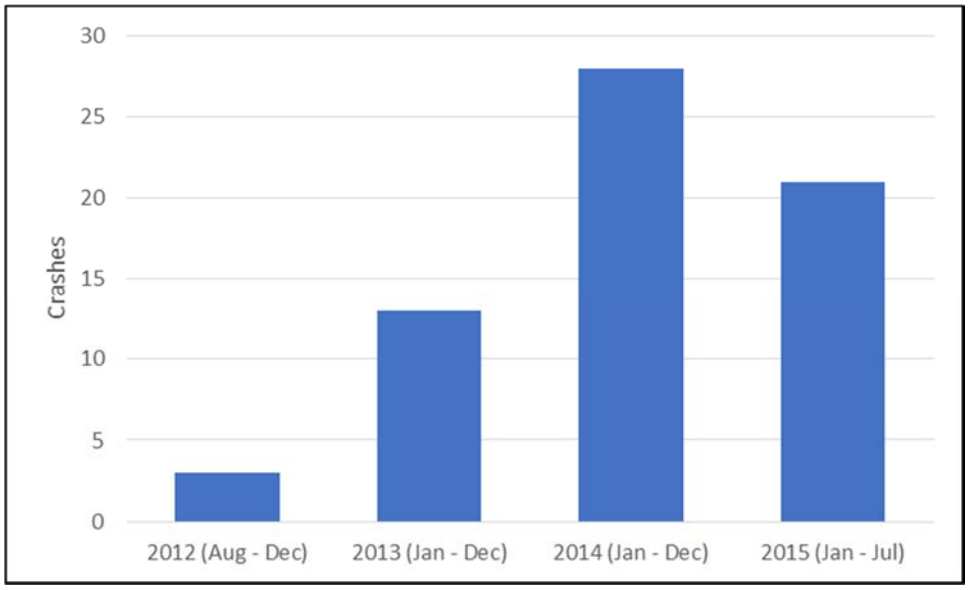


Figure 4 – Crashes per Year

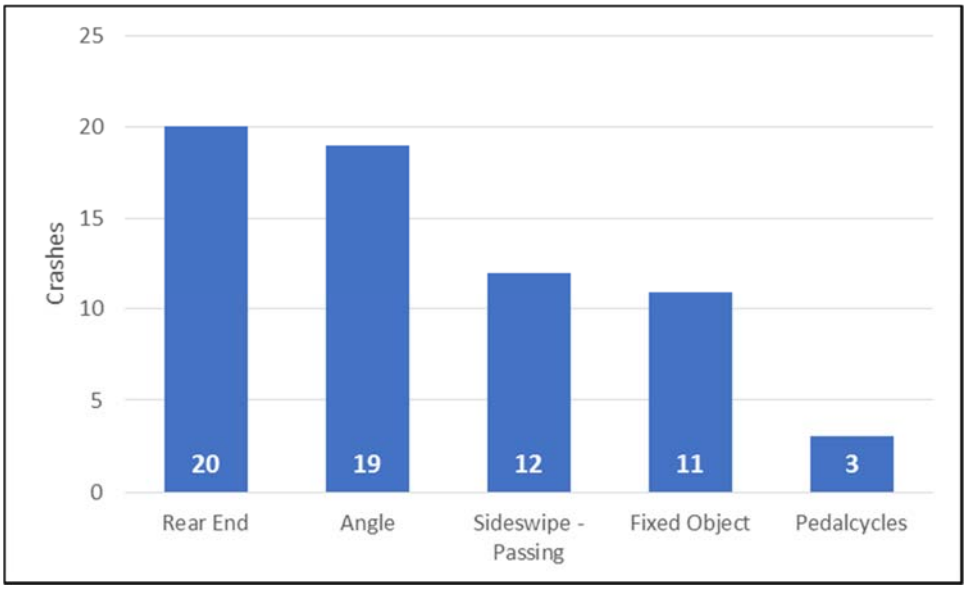


Figure 5 – Frequency of Crashes by Crash Type

While rear end collisions are not uncommon at roundabouts, several of the crash reports indicated that these collisions occurred at the crosswalks. Specifically on the exit approaches, when a vehicle was stopped because of a pedestrian in the crosswalk, a second vehicle exiting the roundabout rear ended the stopped vehicle. The placement of the crosswalks make it difficult for drivers within the roundabout to notice and react to pedestrians and resulting stopped vehicles.

Angle collisions on the entry approaches are also not uncommon at roundabouts. However, because of the alignment of the approaches at this location, the sight lines of the vehicles in the right-turn lanes are impaired by vehicles in the shared through and left-turn lane. The current striping design does not provide appropriate lane and yield line placement and contributes to this problem. When sight lines are impaired, vehicles cannot see oncoming traffic when entering the roundabout which results in angle collisions. In review of the crash reports, a specific cause of the angle collision was not specified. However, review of the field conditions indicate that the substandard lane and yield line placements may result in limited sight distance and increased potential for angle collisions.

The vast majority (53 – 83%) of crashes occurred on dry pavement which indicates that pavement conditions are not likely contributing to crashes. 44 (68%) of the crashes occurred in daylight conditions and 18 (28%) occurred during night time conditions but reports indicated the intersection lighting was operational at the time of the crash.

For comparison purposes, research from the *NCHRP Report 572 – Roundabouts in the United States* indicates that an urban single lane roundabout has an average of 3 crashes per year while an urban multilane roundabout has an average of 13 crashes per year. The roundabout at US 36 and US 68 experienced an average of over 21 crashes per year over the past three years. This research indicates that the crash frequency at this location is significantly higher than other roundabout sites.

Capacity Analysis

Recent research has been conducted on the capacity of roundabouts. The research results provided updates to the capacity equations included in the *Highway Capacity Manual 2010* (*HCM*). Lee Rodegerdts made a presentation entitled *Reassessment of Roundabout Capacity Models for the Highway Capacity Manual* (*HCM*) at the 2014 TRB Roundabout conference. This presentation contains the recently updated capacity models which will be part of the next version of the *HCM*. A copy of this presentation is included in the appendix.

Using *SIDRA* software, which allows the user to modify the capacity equations in the *HCM* module, the operations of the existing roundabout lane configuration were modeled. These results were also verified through the use of a B&N developed spreadsheet that includes the updated *HCM* equations.

Table 1 summarizes the operational results for both the 2016 and 2036 AM and PM peak hour operations for the existing roundabout lane configuration. The calculations are included in the appendix.

Table 1: US 36 & US 68 Peak Hour Operational Results												
	Northbound (US 68 – Main Street)			Westbound (US 36 – Scioto Street)			Southbound (US 68 – Main Street)			Eastbound (US 36 – Miami Street)		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
2016 AM Peak Hour												
LOS	A		A	A		A	B		A	A		A
Delay	9.3		5.4	7.7		5.4	10.2		4.5	9.9		6.1
v/c	0.421		0.123	0.325		0.136	0.498		0.063	0.388		0.120
	A – 8.4			A – 7.0			A – 9.5			A – 9.0		
2016 PM Peak Hour												
LOS	C		A	C		A	C		A	C		A
Delay	16.5		7.2	15.5		6.4	16.1		5.5	17.1		6.8
v/c	0.657		0.228	0.638		0.172	0.654		0.088	0.640		0.145
	B – 14.1			B – 13.6			B – 14.9			C – 15.2		
	Northbound (US 68 – Main Street)			Westbound (US 36 – Scioto Street)			Southbound (US 68 – Main Street)			Eastbound (US 36 – Miami Street)		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
2036 AM Peak Hour												
LOS	B		A	A		A	B		A	B		A
Delay	10.7		5.8	8.6		5.8	12.0		4.7	11.6		6.7
v/c	0.482		0.141	0.372		0.156	0.566		0.072	0.451		0.140
	A – 9.6			A – 7.8			B – 11.1			B – 10.4		
2036 PM Peak Hour												
LOS	C		A	C		A	C		A	C		A
Delay	23.0		8.1	21.2		7.1	22.2		5.9	23.9		7.5
v/c	0.764		0.265	0.742		0.201	0.759		0.101	0.750		0.170
	C – 19.1			C – 18.2			C – 20.3			C – 20.9		

The analysis indicates that the roundabout will operate acceptably with the existing lane configuration.

In order to determine if the roundabout footprint and lane configuration could be reduced, an analysis was conducted to evaluate the effects of removing the exclusive right-turn lane on each approach. The updated equations were used for this analysis and each approach was evaluated one-by-one. The results are summarized in **Table 2**. Calculations are provided in the appendix. Only operations for the approach in which the exclusive right-turn lane is eliminated is presented as the other approaches were not affected.

Table 2: Effects of Eliminating Exclusive Right-Turn Lanes by Approach				
Northbound (US 68 – Main Street)				
	2016 AM	**2016 PM**	**2036 AM**	**2036 PM**
LOS	B	F	C	F
Delay	13.6	52.3	17.3	104.6
v/c	0.586	0.975	0.675	1.142
Westbound (US 36 – Scioto Street)				
	2016 AM	**2016 PM**	**2036 AM**	**2036 PM**
LOS	B	E	B	F
Delay	11.2	36.4	13.5	71.7
v/c	0.498	0.892	0.573	1.045
Southbound (US 68 – Main Street)				
	2016 AM	**2016 PM**	**2036 AM**	**2036 PM**
LOS	B	D	C	E
Delay	13.2	27.3	16.6	48.2
v/c	0.601	0.814	0.685	0.951
Eastbound (US 36 – Miami Street)				
	2016 AM	**2016 PM**	**2036 AM**	**2036 PM**
LOS	B	E	C	F
Delay	14.8	37.1	19.2	72.3
v/c	0.560	0.874	0.656	1.031

Under the 2016 volume analysis, each approach still operates under capacity with a single entry lane. However, during the 2016 PM peak hour several volume-to-capacity ratios (v/c) are very close to 1 with a single entry lane. With even a small amount of growth, the lack of right-turn lane could mean longer delays and v/c over 1 as evident through the 2036 analysis. In the 2036 PM peak hour, all but the southbound approach operate with v/c greater than 1 with a single entry lane. Even though this analysis shows the southbound approach operating with v/c slightly less than 1, even a minor increase in volume may result in the approach operating over capacity.

Given that the roundabout under its current configuration is operating acceptably under existing conditions and is projected to continue to operate acceptably without excess capacity, it is recommended that the current roundabout configuration remain. Any modifications to the intersection to reduce the crash frequency should not change the current lane configuration, but emphasize lane use and channelization and sight line improvements. Increased delay that results from the reconfiguration of approaches from multilane entries to single entries will cause more congestion which increases the potential for more rear end collisions.

Geometric Deficiencies

The existing intersection consists of a large area of asphalt pavement and is striped as a roundabout. There are no curbed splitter islands to guide vehicles or forcing vehicles to slow. The right turn bypasses are currently in line with the circulatory lane of the roundabout. As a result, path overlap exists between the vehicle entering the roundabout and the vehicle turning right. This creates a potential conflict point between the two adjacent lanes. Also, on each approach, the yield line for the right turn lane is not ahead of the entering roundabout lane a distance that will allow the driver to see oncoming vehicles should a vehicle be in the adjacent left/ thru lane.

Another problem with the roundabout is there is existing parking on all four quadrants. The wide entrances to the parking lot allow for vehicles to enter/ exit at any of the drives. Also, the first parking stall requires a driver to back out of the space into the exit lane of the roundabout. In addition, delivery trucks use the quadrants for loading/ unloading. This restricts sight distances for right turn traffic while a delivery vehicle is parked at these locations.

The existing pedestrian crossings are marked and are approximately 50’ in length and are approximately 70’ from the intersection on the east/ west approaches and 40’ from the intersection on the north/ south approaches.

Recommendations

To improve the safety of the intersection and provide better access for pedestrians, a recommended improvement was developed (see **Figure 6**). This solution provides the following safety benefits.

- Splitter Islands: These are proposed for each of the approaches to better guide vehicles to their proper lane. Doing so should also slow vehicles prior to the roundabout.
- Right Turn Bypass: These newly aligned right turn bypasses will allow for motorists to see around vehicles in the adjacent lane entering the roundabout. A raised median will be added between the right turn bypass lane and the adjacent left/ thru lane. This will help reduce speeds, better align the vehicles entering the roundabout and discourage cut-through movements.
- Pedestrian Crossings: For all the crossings, a pedestrian refuge area is being provided. This will allow pedestrians to focus on crossing either the entry or exit approach. Also, rectangular rapid flashing beacons will be provided on each of the crossings. Pedestrians can activate these when they want to cross the road.
- Drive Entrances: Well defined entrances/ exits will be provided for each of the parking areas at the quadrants of the roundabout. These will remain one-way entrances as indicated on **Figure 6**. These should reduce driver confusion.
- Curb and Sidewalk Extensions: These will be provided at the pedestrian crossings to shorten the distance pedestrians must travel for crossing each roadway.
- Loading Zones: The existing unmarked loading/ unloading zones at the quadrants of the roundabout will be eliminated and replaced with raised islands. To provide loading/ unloading zones for the nearby businesses, on street parking stalls will be limited to loading zones during an 8 am to 5 pm duration throughout the day.

The estimated project costs for the improvements (2019 dollars) are $960,000. A breakdown of these costs are shown below.

*Most current estimate is towards the end of the document.

Benefits

Based on ODOT's Economic Crash Analysis Tool (ECAT), by converting the intersection of US 36 and US 68 into a modern roundabout with curbs, splitter islands, and appropriate signing and striping, the expected average crash frequency (estimated average number of crashes that occur at the study site) is reduced from 3.6 crashes per year to 2.2 crashes per year. For this location, the predicted average crash frequency (estimated average number of crashes that occur at similar sites) is 2.2 crashes per year. With the proposed improvements, the maximum potential for safety improvement is recognized. This results in a total value of safety benefits of nearly $653,070. The net present cost associated with improving safety at this intersection is roughly $637,410 which results in a benefit-to-cost ratio of 1.02.

BURGESS & NIPLE

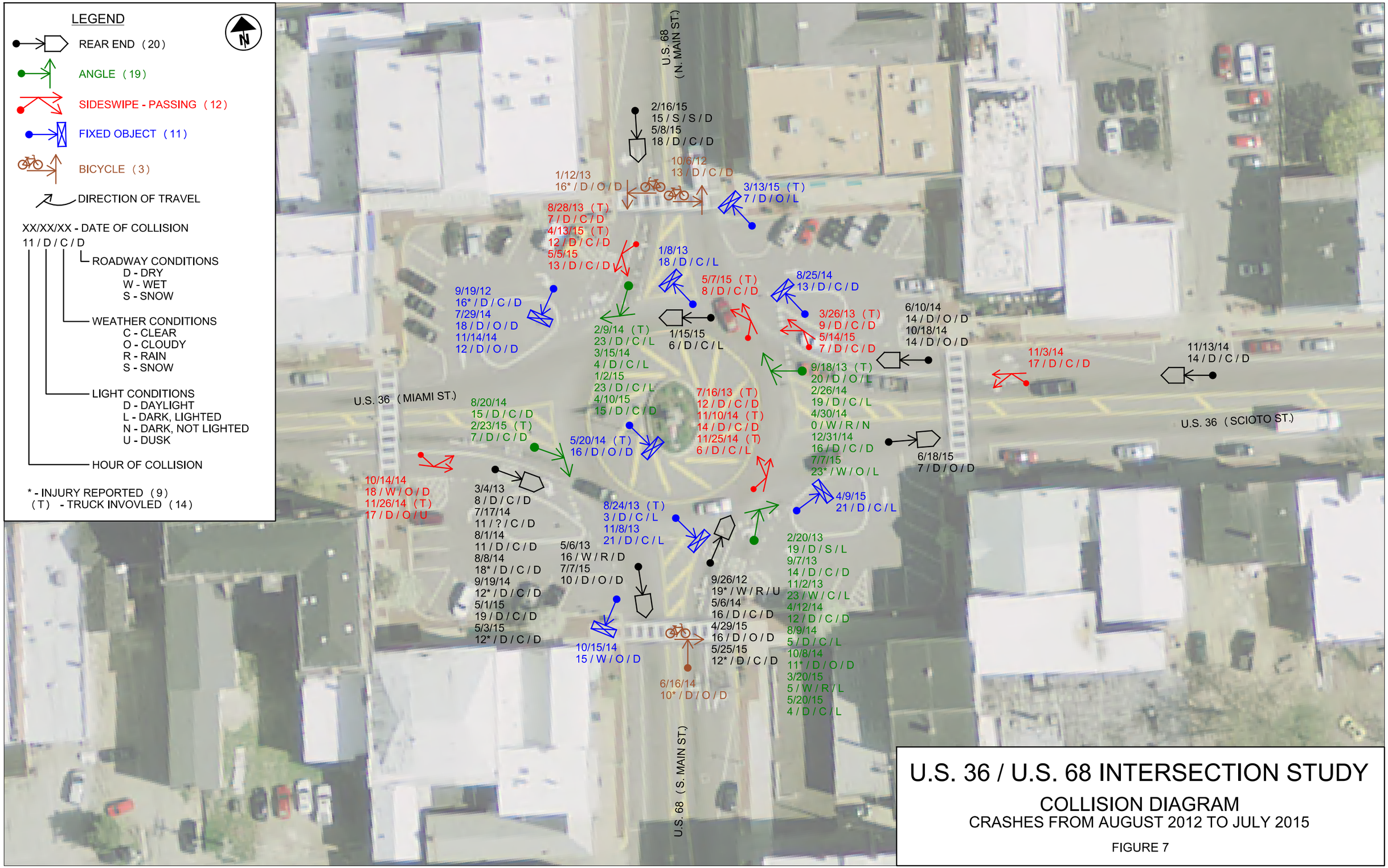
Urbana
The heart of Champaign County

US 36/US 68 INTERSECTION IMPROVEMENTS
FIGURE 6

2/22/2016

0 30 60

N



U.S. 36 / U.S. 68 INTERSECTION STUDY

COLLISION DIAGRAM

CRASHES FROM AUGUST 2012 TO JULY 2015

FIGURE 7

Burgess & Niple
5085 Reed Rd

Columbus, Ohio, United States 43220
614-459-2050 x 356 cpopovich@burnip.com

Count Name: Urbana Intersection
Site Code:
Start Date: 01/07/2016

Turning Movement Data

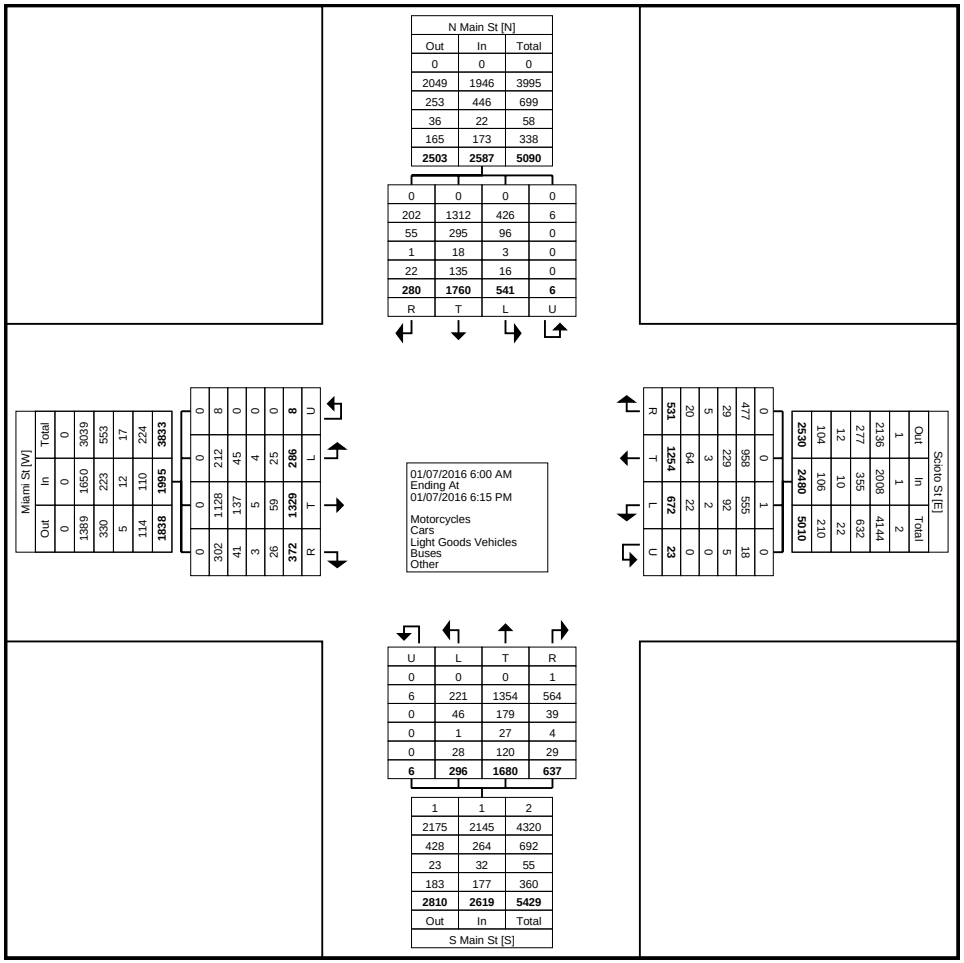
Start Time	N Main St Southbound					Scioto St Westbound					S Main St Northbound					Miami St Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
6:00 AM	3	54	11	0	68	4	18	21	0	43	18	23	3	0	44	16	25	7	0	48	203
6:15 AM	5	55	16	0	76	6	20	19	0	45	12	33	8	0	53	16	27	6	0	49	223
6:30 AM	7	59	9	0	75	11	25	33	0	69	11	50	11	0	72	10	32	5	0	47	263
6:45 AM	9	66	16	0	91	17	41	29	0	87	25	66	10	0	101	4	41	13	0	58	337
Hourly Total	24	234	52	0	310	38	104	102	0	244	66	172	32	0	270	46	125	31	0	202	1026
7:00 AM	11	73	13	0	97	10	33	38	2	83	15	45	7	0	67	6	43	11	0	60	307
7:15 AM	17	75	21	0	113	11	43	31	1	86	23	90	10	0	123	8	49	6	1	64	386
7:30 AM	8	89	14	0	111	11	42	26	1	80	16	34	12	0	62	17	57	9	1	84	337
7:45 AM	14	64	27	0	105	32	40	20	0	92	27	68	11	0	106	15	69	9	0	93	396
Hourly Total	50	301	75	0	426	64	158	115	4	341	81	237	40	0	358	46	218	35	2	301	1426
8:00 AM	12	76	18	0	106	26	35	24	0	85	11	53	6	0	70	16	41	6	0	63	324
8:15 AM	10	69	27	0	106	19	38	21	0	78	30	61	11	0	102	17	45	7	0	69	355
8:30 AM	12	79	18	1	110	21	37	19	0	77	19	80	8	0	107	25	49	10	0	84	378
8:45 AM	10	66	24	1	101	20	31	15	0	66	22	53	12	0	87	13	55	12	0	80	334
Hourly Total	44	290	87	2	423	86	141	79	0	306	82	247	37	0	366	71	190	35	0	296	1391
9:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hourly Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3:00 PM	9	81	35	0	125	40	73	26	3	142	35	91	9	1	136	17	49	21	0	87	490
3:15 PM	20	75	30	0	125	34	53	26	1	114	26	66	22	0	114	11	57	12	0	80	433
3:30 PM	11	100	35	0	146	13	59	34	2	108	26	91	18	0	135	11	80	10	0	101	490
3:45 PM	18	69	21	0	108	20	64	38	2	124	37	99	13	1	150	22	74	17	0	113	495
Hourly Total	58	325	121	0	504	107	249	124	8	488	124	347	62	2	535	61	260	60	0	381	1908
4:00 PM	15	74	27	0	116	24	72	27	0	123	36	85	11	0	132	16	77	14	0	107	478
4:15 PM	10	89	24	2	125	38	69	33	0	140	40	90	10	0	140	19	69	13	0	101	506
4:30 PM	13	76	39	0	128	29	74	29	2	134	31	84	11	0	126	26	83	18	1	128	516
4:45 PM	10	78	19	0	107	26	72	27	2	127	30	94	18	0	142	16	60	12	1	89	465
Hourly Total	48	317	109	2	476	117	287	116	4	524	137	353	50	0	540	77	289	57	2	425	1965
5:00 PM	17	75	22	1	115	26	71	35	1	133	38	75	16	2	131	26	61	21	1	109	488
5:15 PM	15	69	30	1	115	25	92	38	3	158	28	77	13	1	119	18	79	20	1	118	510
5:30 PM	11	78	23	0	112	36	81	32	2	151	50	91	24	0	165	13	60	17	1	91	519
5:45 PM	13	71	22	0	106	32	71	31	1	135	31	81	22	1	135	14	47	10	1	72	448
Hourly Total	56	293	97	2	448	119	315	136	7	577	147	324	75	4	550	71	247	68	4	390	1965
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	280	1760	541	6	2587	531	1254	672	23	2480	637	1680	296	6	2619	372	1329	286	8	1995	9681
Approach %	10.8	68.0	20.9	0.2	-	21.4	50.6	27.1	0.9	-	24.3	64.1	11.3	0.2	-	18.6	66.6	14.3	0.4	-	-
Total %	2.9	18.2	5.6	0.1	26.7	5.5	13.0	6.9	0.2	25.6	6.6	17.4	3.1	0.1	27.1	3.8	13.7	3.0	0.1	20.6	-
Motorcycles	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	2

% Motorcycles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cars	202	1312	426	6	1946	477	958	555	18	2008	564	1354	221	6	2145	302	1128	212	8	1650	7749
% Cars	72.1	74.5	78.7	100.0	75.2	89.8	76.4	82.6	78.3	81.0	88.5	80.6	74.7	100.0	81.9	81.2	84.9	74.1	100.0	82.7	80.0
Light Goods Vehicles	55	295	96	0	446	29	229	92	5	355	39	179	46	0	264	41	137	45	0	223	1288
% Light Goods Vehicles	19.6	16.8	17.7	0.0	17.2	5.5	18.3	13.7	21.7	14.3	6.1	10.7	15.5	0.0	10.1	11.0	10.3	15.7	0.0	11.2	13.3
Buses	1	18	3	0	22	5	3	2	0	10	4	27	1	0	32	3	5	4	0	12	76
% Buses	0.4	1.0	0.6	0.0	0.9	0.9	0.2	0.3	0.0	0.4	0.6	1.6	0.3	0.0	1.2	0.8	0.4	1.4	0.0	0.6	0.8
Single-Unit Trucks	13	64	10	0	87	17	27	11	0	55	18	38	12	0	68	9	21	20	0	50	260
% Single-Unit Trucks	4.6	3.6	1.8	0.0	3.4	3.2	2.2	1.6	0.0	2.2	2.8	2.3	4.1	0.0	2.6	2.4	1.6	7.0	0.0	2.5	2.7
Articulated Trucks	9	71	6	0	86	3	37	11	0	51	11	82	16	0	109	17	38	5	0	60	306
% Articulated Trucks	3.2	4.0	1.1	0.0	3.3	0.6	3.0	1.6	0.0	2.1	1.7	4.9	5.4	0.0	4.2	4.6	2.9	1.7	0.0	3.0	3.2

Burgess & Niple
5085 Reed Rd

Columbus, Ohio, United States 43220
614-459-2050 x 356 cpopovich@burnip.com

Count Name: Urbana Intersection
Site Code:
Start Date: 01/07/2016



Turning Movement Data Plot

Burgess & Niple
5085 Reed Rd

Columbus, Ohio, United States 43220
614-459-2050 x 356 cpopovich@burnip.com

Count Name: Urbana Intersection
Site Code:
Start Date: 01/07/2016

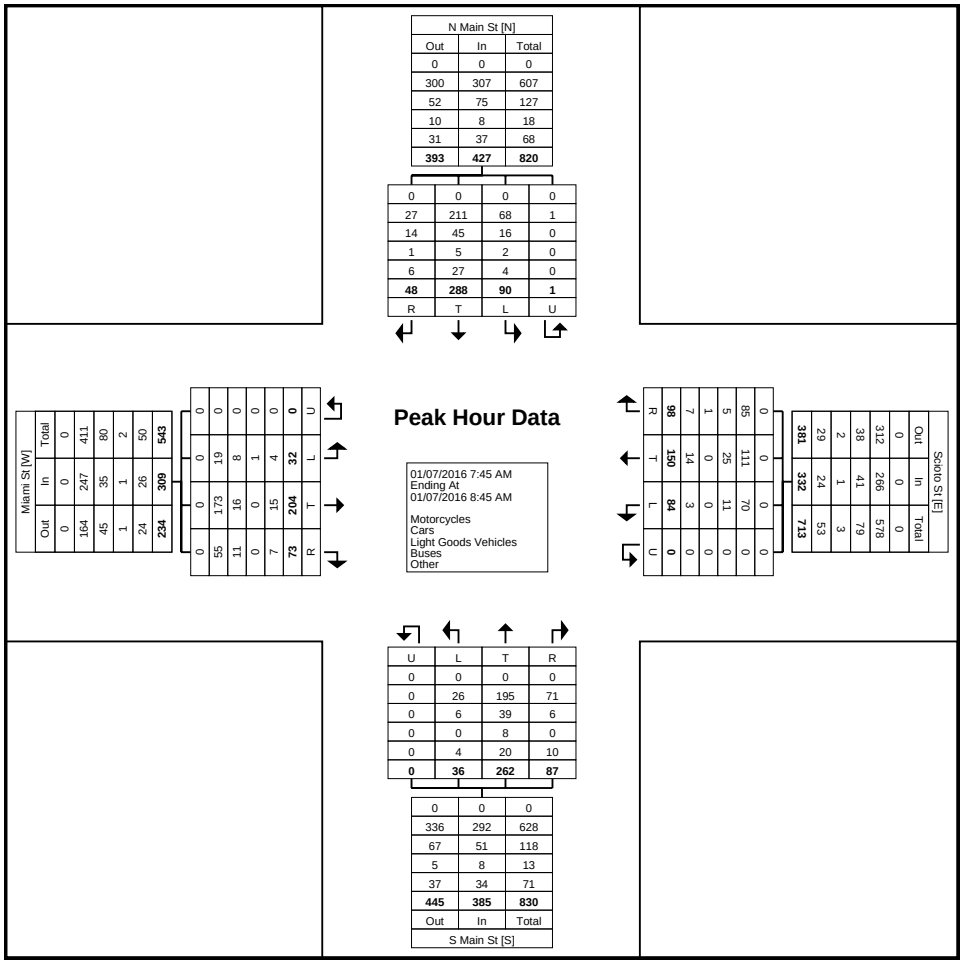
Turning Movement Peak Hour Data (7:45 AM)

Start Time	N Main St Southbound					Scioto St Westbound					S Main St Northbound					Miami St Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
7:45 AM	14	64	27	0	105	32	40	20	0	92	27	68	11	0	106	15	69	9	0	93	396
8:00 AM	12	76	18	0	106	26	35	24	0	85	11	53	6	0	70	16	41	6	0	63	324
8:15 AM	10	69	27	0	106	19	38	21	0	78	30	61	11	0	102	17	45	7	0	69	355
8:30 AM	12	79	18	1	110	21	37	19	0	77	19	80	8	0	107	25	49	10	0	84	378
Total	48	288	90	1	427	98	150	84	0	332	87	262	36	0	385	73	204	32	0	309	1453
Approach %	11.2	67.4	21.1	0.2	-	29.5	45.2	25.3	0.0	-	22.6	68.1	9.4	0.0	-	23.6	66.0	10.4	0.0	-	-
Total %	3.3	19.8	6.2	0.1	29.4	6.7	10.3	5.8	0.0	22.8	6.0	18.0	2.5	0.0	26.5	5.0	14.0	2.2	0.0	21.3	-
PHF	0.857	0.911	0.833	0.250	0.970	0.766	0.938	0.875	0.000	0.902	0.725	0.819	0.818	0.000	0.900	0.730	0.739	0.800	0.000	0.831	0.917
Motorcycles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% Motorcycles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0
Cars	27	211	68	1	307	85	111	70	0	266	71	195	26	0	292	55	173	19	0	247	1112
% Cars	56.3	73.3	75.6	100.0	71.9	86.7	74.0	83.3	-	80.1	81.6	74.4	72.2	-	75.8	75.3	84.8	59.4	-	79.9	76.5
Light Goods Vehicles	14	45	16	0	75	5	25	11	0	41	6	39	6	0	51	11	16	8	0	35	202
% Light Goods Vehicles	29.2	15.6	17.8	0.0	17.6	5.1	16.7	13.1	-	12.3	6.9	14.9	16.7	-	13.2	15.1	7.8	25.0	-	11.3	13.9
Buses	1	5	2	0	8	1	0	0	0	1	0	8	0	0	8	0	0	1	0	1	18
% Buses	2.1	1.7	2.2	0.0	1.9	1.0	0.0	0.0	-	0.3	0.0	3.1	0.0	-	2.1	0.0	0.0	3.1	-	0.3	1.2
Single-Unit Trucks	3	8	2	0	13	7	10	2	0	19	7	10	1	0	18	2	7	3	0	12	62
% Single-Unit Trucks	6.3	2.8	2.2	0.0	3.0	7.1	6.7	2.4	-	5.7	8.0	3.8	2.8	-	4.7	2.7	3.4	9.4	-	3.9	4.3
Articulated Trucks	3	19	2	0	24	0	4	1	0	5	3	10	3	0	16	5	8	1	0	14	59
% Articulated Trucks	6.3	6.6	2.2	0.0	5.6	0.0	2.7	1.2	-	1.5	3.4	3.8	8.3	-	4.2	6.8	3.9	3.1	-	4.5	4.1

Burgess & Niple
5085 Reed Rd

Columbus, Ohio, United States 43220
614-459-2050 x 356 cpopovich@burnip.com

Count Name: Urbana Intersection
Site Code:
Start Date: 01/07/2016



Turning Movement Peak Hour Data Plot (7:45 AM)

Burgess & Niple
5085 Reed Rd

Columbus, Ohio, United States 43220
614-459-2050 x 356 cpopovich@burnip.com

Count Name: Urbana Intersection
Site Code:
Start Date: 01/07/2016

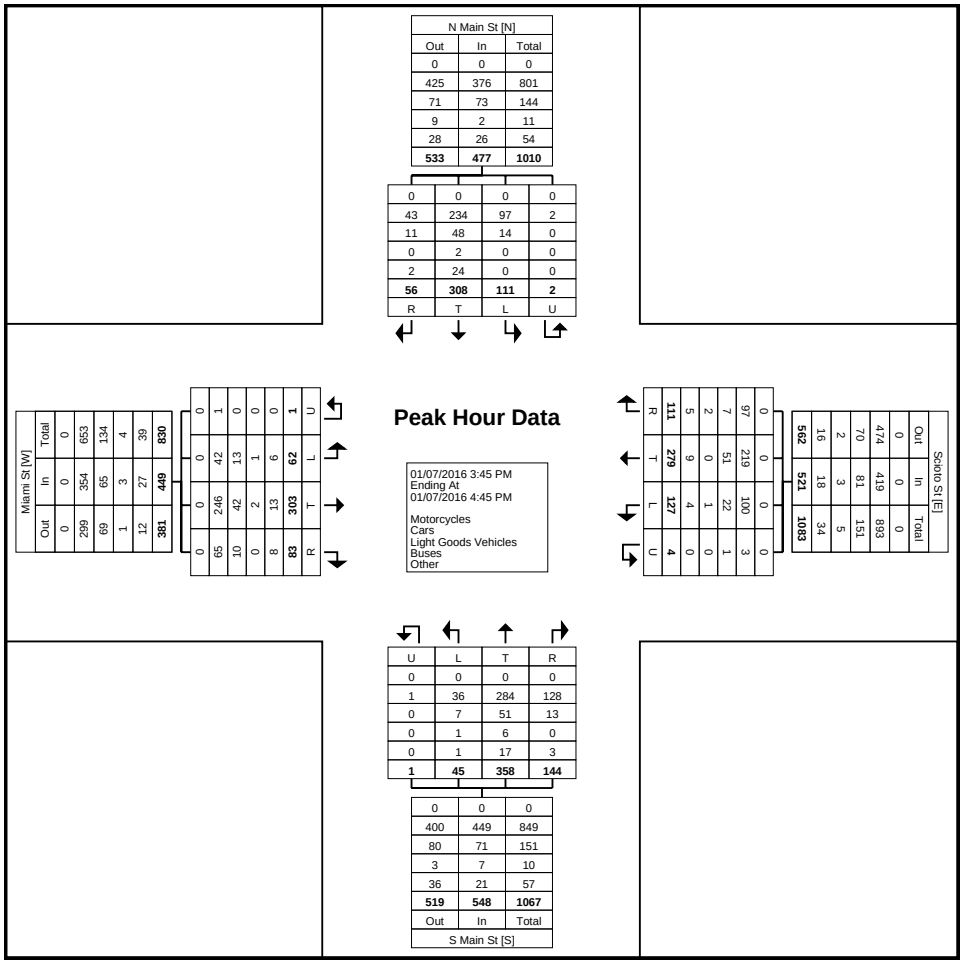
Turning Movement Peak Hour Data (3:45 PM)

Start Time	N Main St Southbound					Scioto St Westbound					S Main St Northbound					Miami St Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
3:45 PM	18	69	21	0	108	20	64	38	2	124	37	99	13	1	150	22	74	17	0	113	495
4:00 PM	15	74	27	0	116	24	72	27	0	123	36	85	11	0	132	16	77	14	0	107	478
4:15 PM	10	89	24	2	125	38	69	33	0	140	40	90	10	0	140	19	69	13	0	101	506
4:30 PM	13	76	39	0	128	29	74	29	2	134	31	84	11	0	126	26	83	18	1	128	516
Total	56	308	111	2	477	111	279	127	4	521	144	358	45	1	548	83	303	62	1	449	1995
Approach %	11.7	64.6	23.3	0.4	-	21.3	53.6	24.4	0.8	-	26.3	65.3	8.2	0.2	-	18.5	67.5	13.8	0.2	-	-
Total %	2.8	15.4	5.6	0.1	23.9	5.6	14.0	6.4	0.2	26.1	7.2	17.9	2.3	0.1	27.5	4.2	15.2	3.1	0.1	22.5	-
PHF	0.778	0.865	0.712	0.250	0.932	0.730	0.943	0.836	0.500	0.930	0.900	0.904	0.865	0.250	0.913	0.798	0.913	0.861	0.250	0.877	0.967
Motorcycles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% Motorcycles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cars	43	234	97	2	376	97	219	100	3	419	128	284	36	1	449	65	246	42	1	354	1598
% Cars	76.8	76.0	87.4	100.0	78.8	87.4	78.5	78.7	75.0	80.4	88.9	79.3	80.0	100.0	81.9	78.3	81.2	67.7	100.0	78.8	80.1
Light Goods Vehicles	11	48	14	0	73	7	51	22	1	81	13	51	7	0	71	10	42	13	0	65	290
% Light Goods Vehicles	19.6	15.6	12.6	0.0	15.3	6.3	18.3	17.3	25.0	15.5	9.0	14.2	15.6	0.0	13.0	12.0	13.9	21.0	0.0	14.5	14.5
Buses	0	2	0	0	2	2	0	1	0	3	0	6	1	0	7	0	2	1	0	3	15
% Buses	0.0	0.6	0.0	0.0	0.4	1.8	0.0	0.8	0.0	0.6	0.0	1.7	2.2	0.0	1.3	0.0	0.7	1.6	0.0	0.7	0.8
Single-Unit Trucks	1	15	0	0	16	3	3	1	0	7	1	6	1	0	8	2	4	4	0	10	41
% Single-Unit Trucks	1.8	4.9	0.0	0.0	3.4	2.7	1.1	0.8	0.0	1.3	0.7	1.7	2.2	0.0	1.5	2.4	1.3	6.5	0.0	2.2	2.1
Articulated Trucks	1	9	0	0	10	2	6	3	0	11	2	11	0	0	13	6	9	2	0	17	51
% Articulated Trucks	1.8	2.9	0.0	0.0	2.1	1.8	2.2	2.4	0.0	2.1	1.4	3.1	0.0	0.0	2.4	7.2	3.0	3.2	0.0	3.8	2.6

Burgess & Niple
5085 Reed Rd

Columbus, Ohio, United States 43220
614-459-2050 x 356 cpopovich@burnip.com

Count Name: Urbana Intersection
Site Code:
Start Date: 01/07/2016



Turning Movement Peak Hour Data Plot (3:45 PM)

Burgess & Niple
5085 Reed Rd

Columbus, Ohio, United States 43220
614-459-2050 x 356 cpopovich@burnip.com

Count Name: Urbana Intersection
Site Code:
Start Date: 01/07/2016

DESIGN HOUR FACTOR CALCULATION

	2014 ADT	2016 ADT	2016 PM	Kcalc	K	ratio
North Leg	12167	12289	1009	8.21%	9.05%	1.10
South Leg	14869	15018	1080	7.19%	9.05%	1.26
East Leg	14913	15062	1081	7.18%	8.36%	1.16
West Leg	9474	9569	840	8.78%	8.36%	0.95
						1.12 DHF

Reassessment of Roundabout Capacity Models for the Highway Capacity Manual

Lee A. Rodegerdts

TRB 4th International Roundabout Conference

Seattle, WA

April 17, 2014

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives
http://safety.fhwa.dot.gov

Motivation for Research

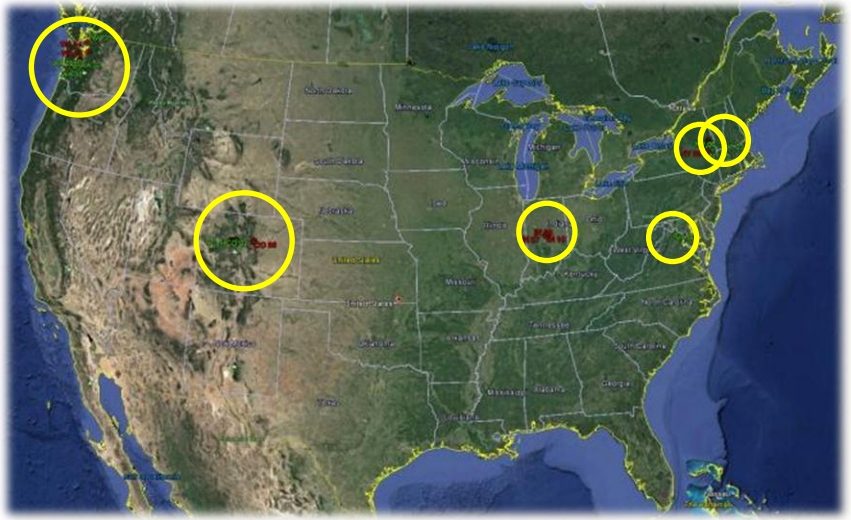
- New capacity models for roundabouts added to HCM 2010 based on NCHRP Report 572 (2007)
- Concern throughout user community that capacities are lower than currently being observed
- Results of perceived capacity underestimation is either oversizing roundabouts or avoiding them altogether
- NOTE: All findings subject to refinement during the adoption process by the TRB Committee on Highway Capacity and Quality of Service

Purpose of Research Effort

- Collect new set of national field data (2012-2013)
  - NCHRP Report 572 data: 2003
- Determine fit of HCM 2010 model to new data
- Determine best course of action to improve fit as needed within constraints of time and budget:
  - Calibrate using critical headway and follow-up time
  - Develop new exponential or linear regression model
  - Identify flow-based or geometric-based factors if beneficial in improving model fit

Site Selection

- 23 intersections across the United States:
  - Colorado (5)
  - Indiana (7, all in Carmel)
  - New York (2)
  - Virginia (1)
  - Vermont (1)
  - Washington (7)



- Each approach studied at a given intersection is considered a “site” for this analysis

Data Collection

- Video recording of 48 hours at each site (2012-2013)
- Cameras focused on entering-circulating-exiting area
- Back of queue not always observed
  - Camera angles
  - Saturated but slowly rolling queues

Conditions for Data to be Usable

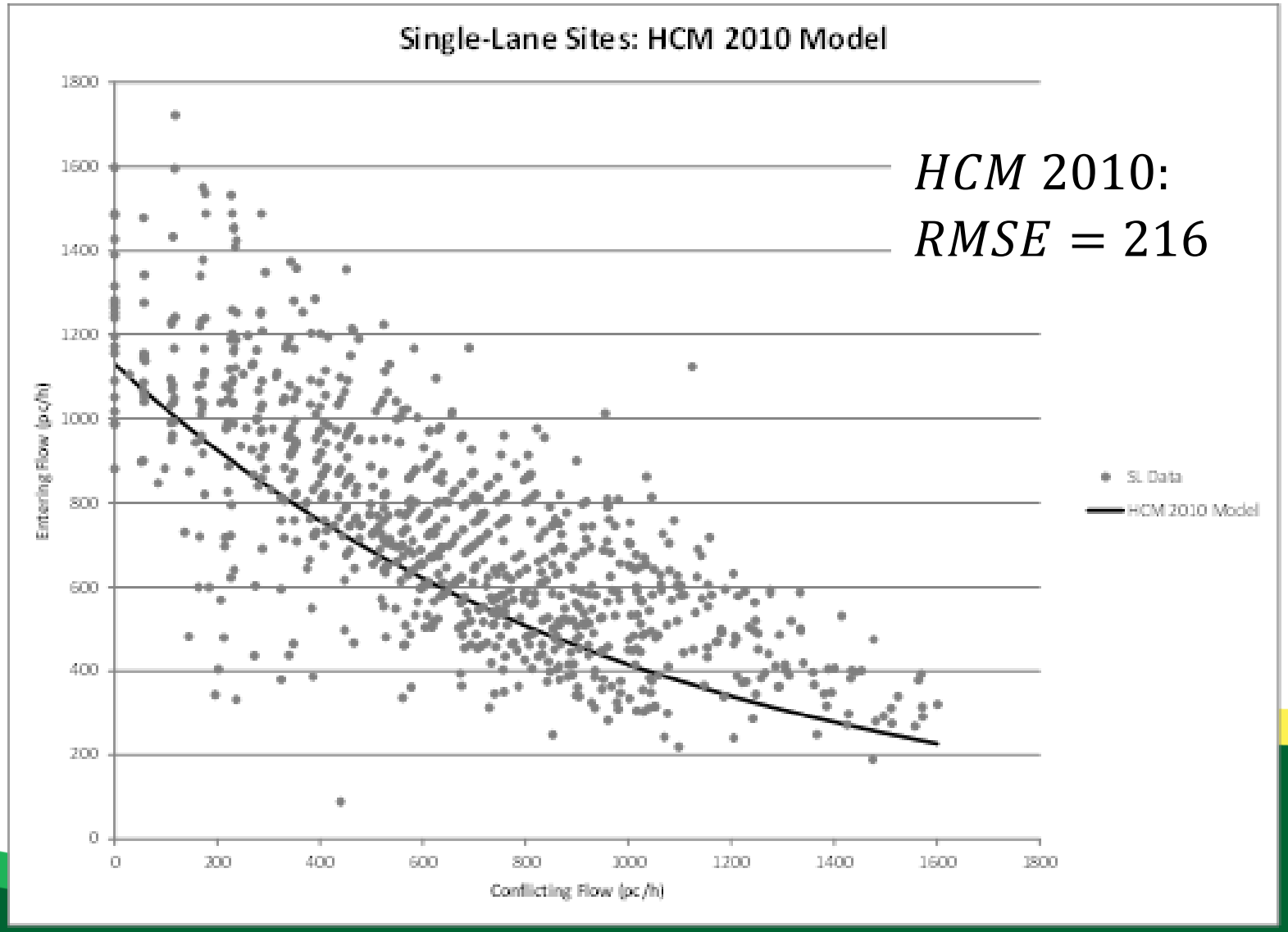
- Looking only for data periods that represent capacity conditions: continuous queuing over the entire study interval (1 min)
- Two criteria examined:
  - Minimum queue recorded (where possible)
  - Maximum move-up time <= 6 s
    - Camera angle prevented visibility of queue, or
    - Conditions saturated but rolling queue
- Generally consistent with NCHRP Report 572 methods

Usable Data for Capacity Analysis

- Single-lane sites: 876 minutes
- Multilane sites: 1,285 minutes (all types)
  - Multilane 1x2: 56
  - Multilane 2x1: 231 right lane, 288 left lane
  - Multilane 2x2: 365 right lane, 345 left lane

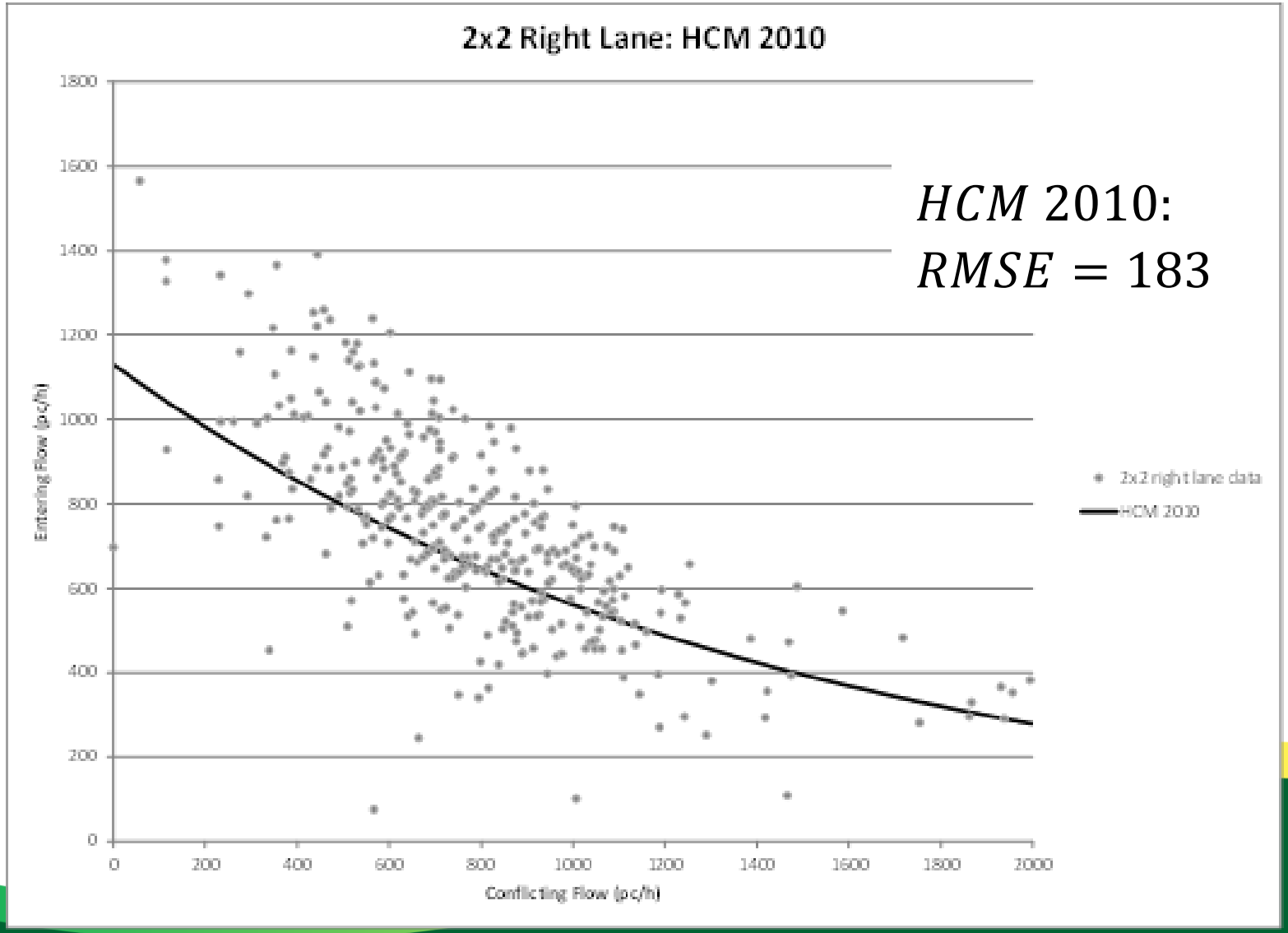
- NCHRP Report 572: single-lane 318 minutes, multilane 383 minutes (all types)
- Significantly larger dataset than for NCHRP Report 572

Fit of HCM 2010 Model: Single-Lane



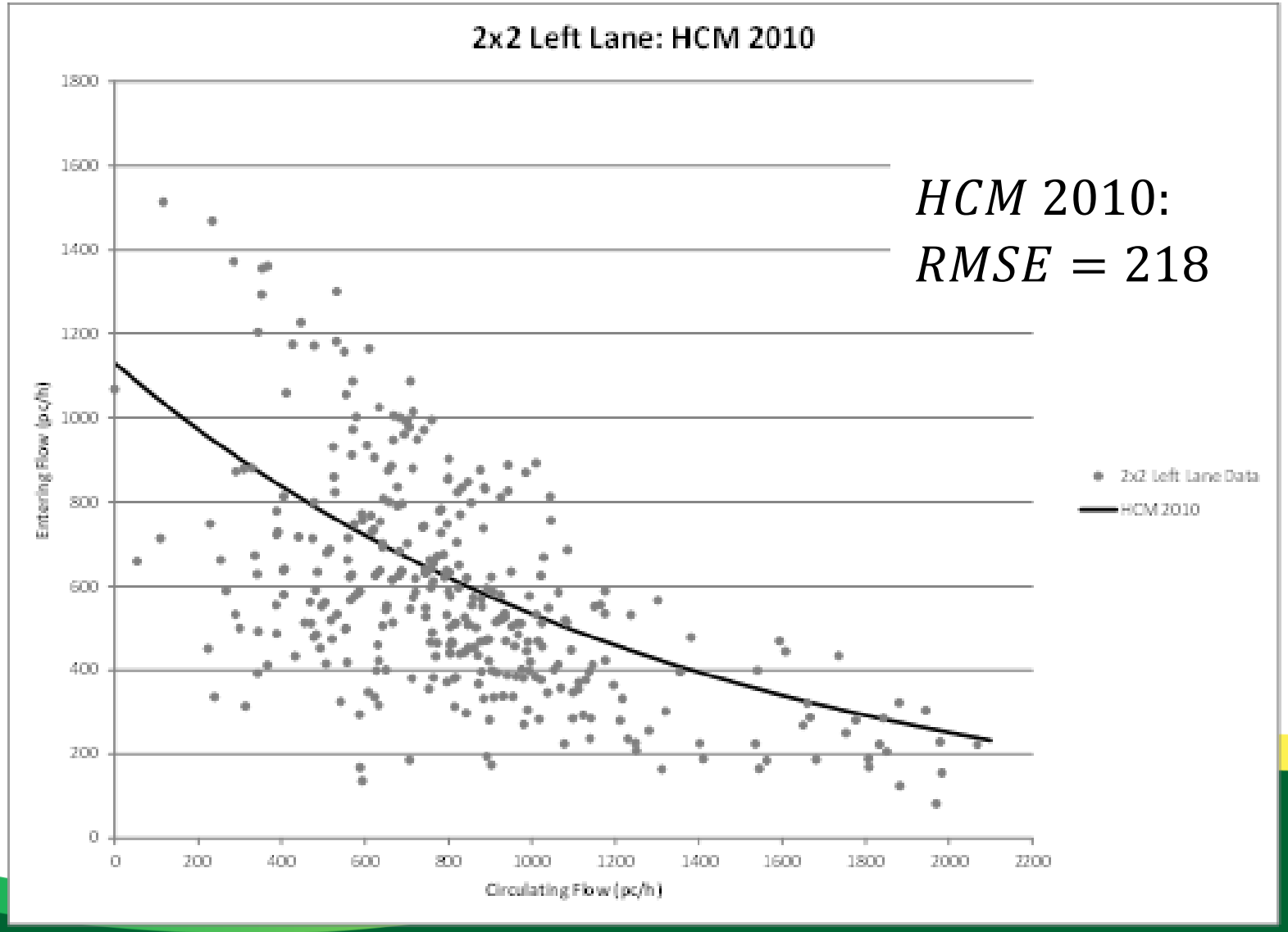
$HCM\ 2010$:
$RMSE = 216$

Fit of HCM 2010 Model: 2x2 Right Lane

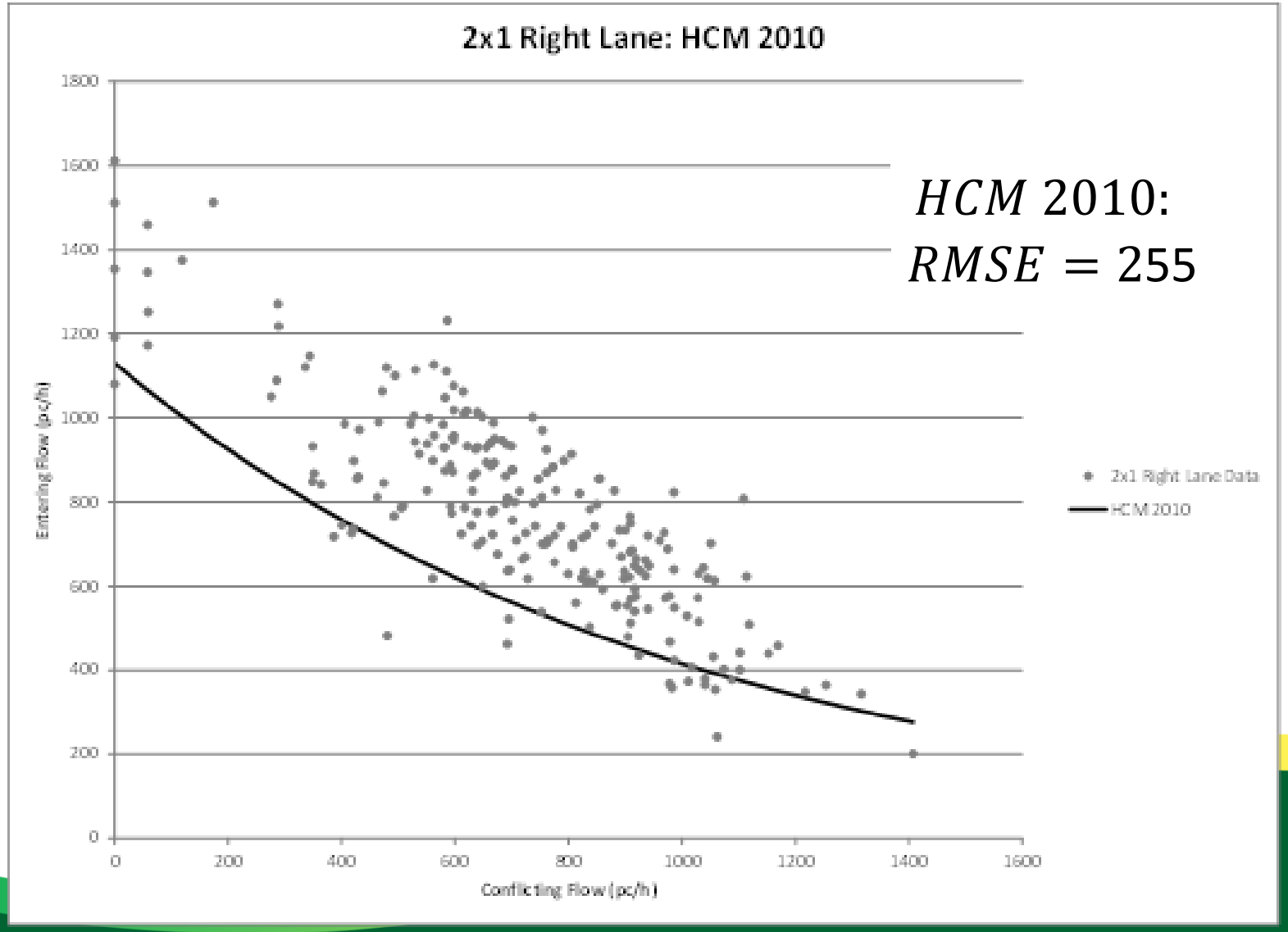


$HCM\ 2010$:
$RMSE = 183$

Fit of HCM 2010 Model: 2x2 Left Lane

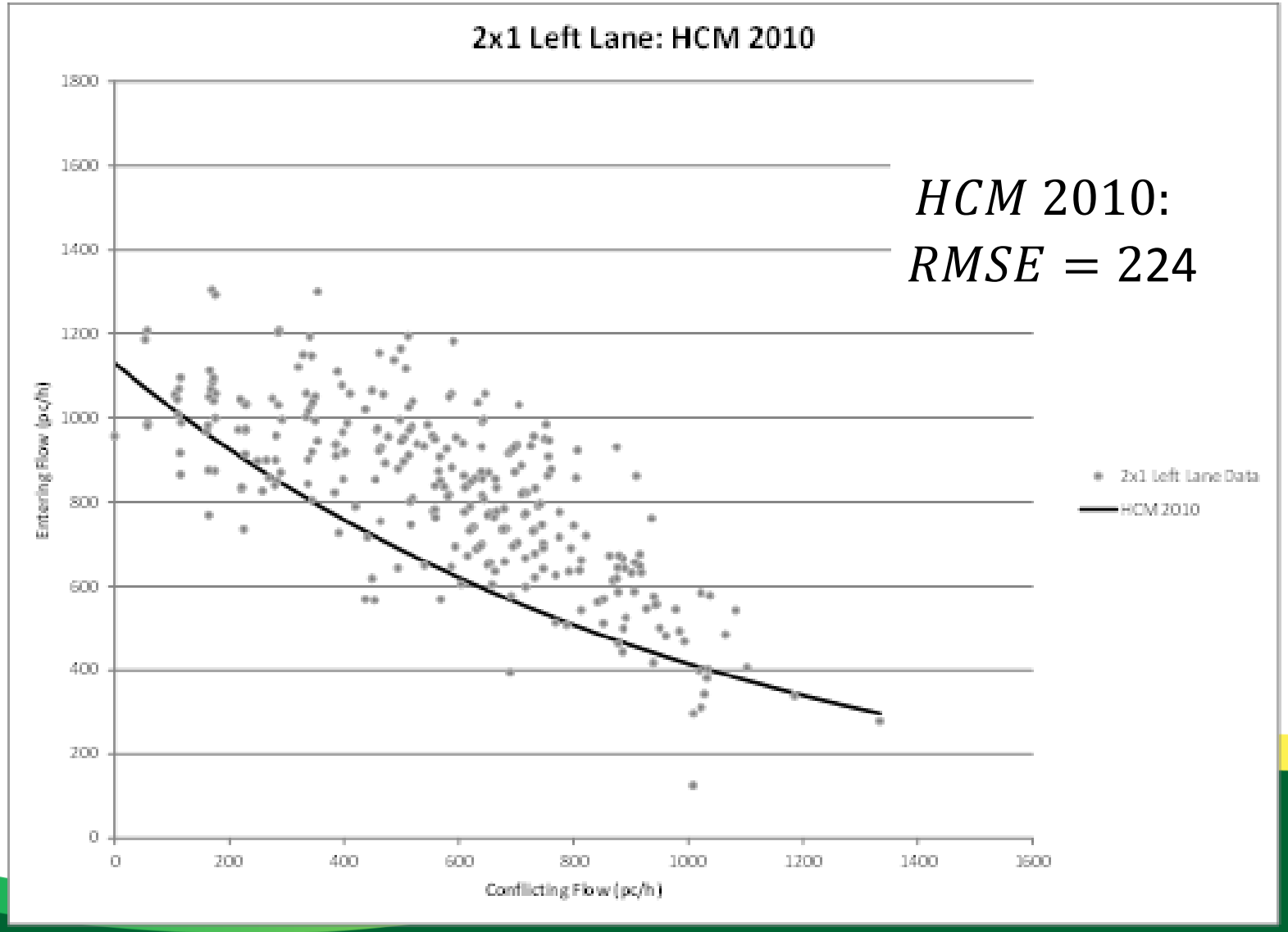


Fit of HCM 2010 Model: 2x1 Right Lane



$HCM\ 2010$:
$RMSE = 255$

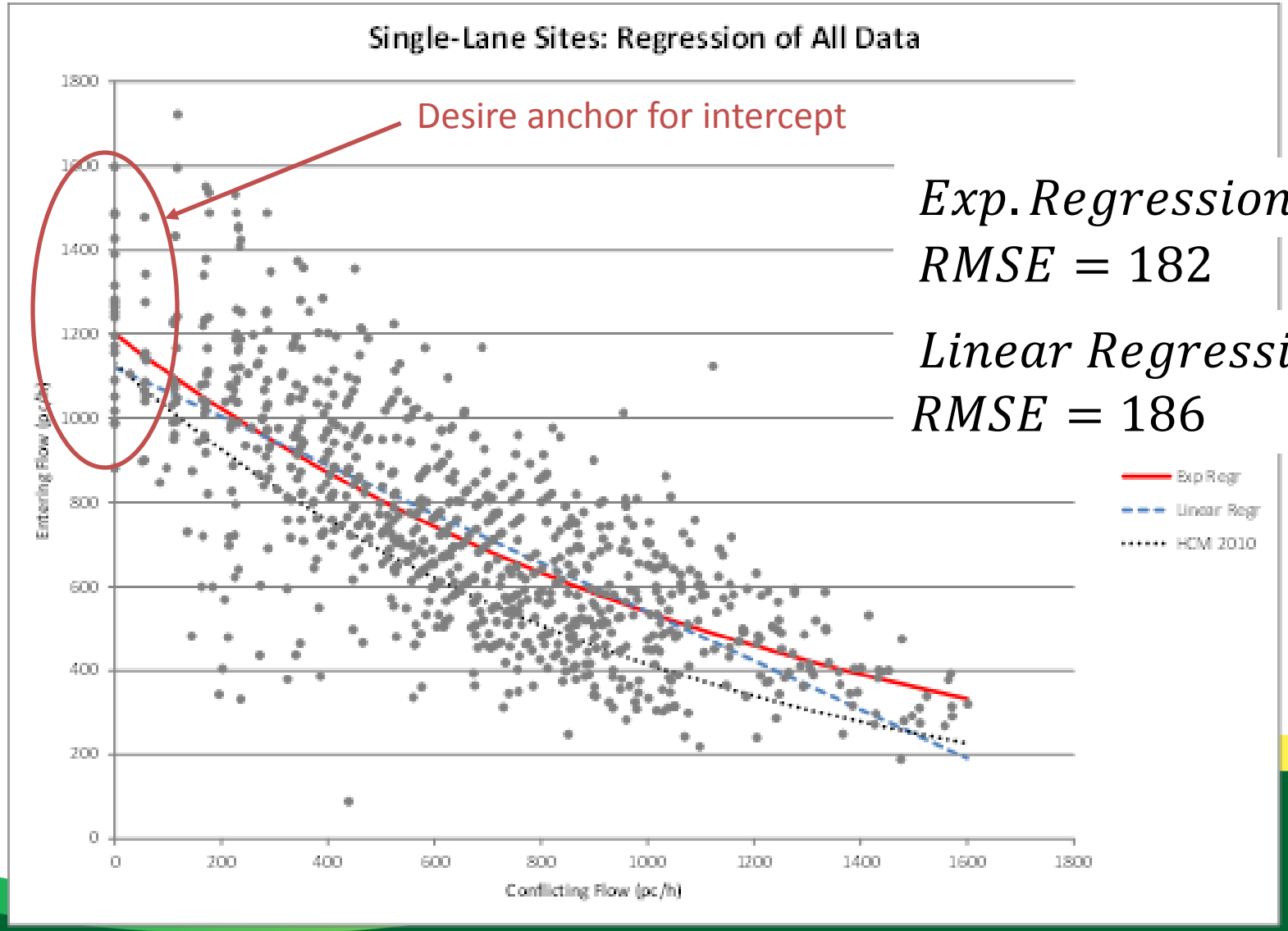
Fit of HCM 2010 Model: 2x1 Left Lane



Modeling Techniques

- Basic model forms analyzed:
  - *Exponential:* $v_e = Ae^{-Bv_c}$
  - *Linear:* $v_e = A - Bv_c$
- Gap acceptance parameters for HCM 2010 calibration (measured under queued conditions)
  - *Critical Headway (t_c)*
  - *Follow-Up Time (t_f)*
- Model parameters set to minimize Root Mean Square Error (RMSE) when allowed to vary

Example of Regression: Single-Lane Sites



$Exp.Regression$:
$RMSE = 182$

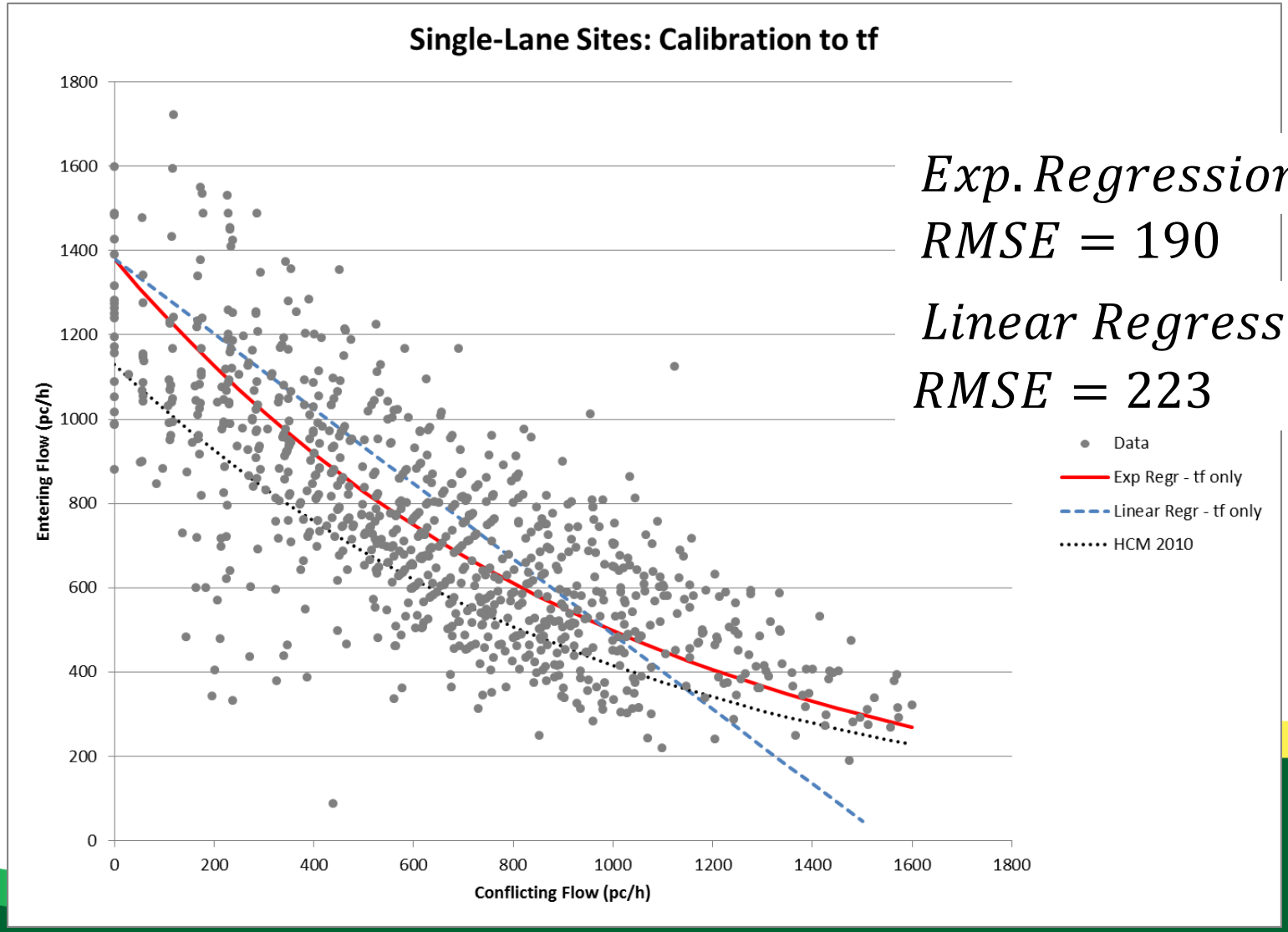
$Linear\ Regression$:
$RMSE = 186$

Follow-Up Time Field Measurements

- Measured under queued conditions
- Outliers greater than mean+ 3 s.d. removed
- Intercept A = $3600/t_f$

State	Number Observations	Mean	Standard Deviation	Intercept
Single-Lane	2,647	2.6	1.0	1,380
2x2 Right Lane	1,964	2.5	1.0	1,420
2x2 Left Lane	1,563	2.7	1.2	1,350
2x1 Right Lane	886	2.3	0.9	1,560
2x1 Left Lane	948	2.1	0.6	1,710
1x2	318	2.5	0.9	1,440

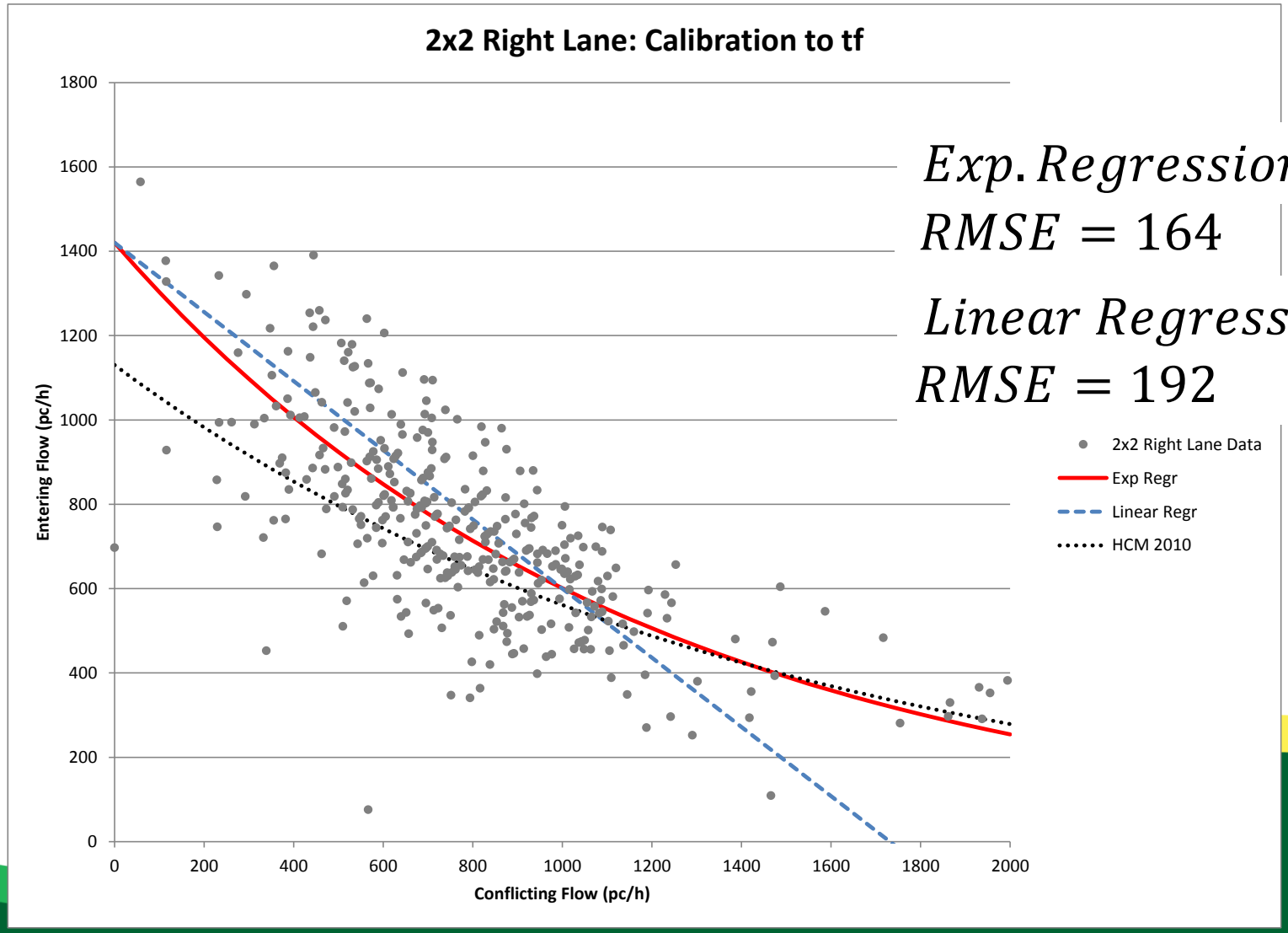
Single-Lane Sites: Calibrated to National Follow-Up Time



$Exp. Regression$:
$RMSE = 190$

$Linear\ Regression$:
$RMSE = 223$

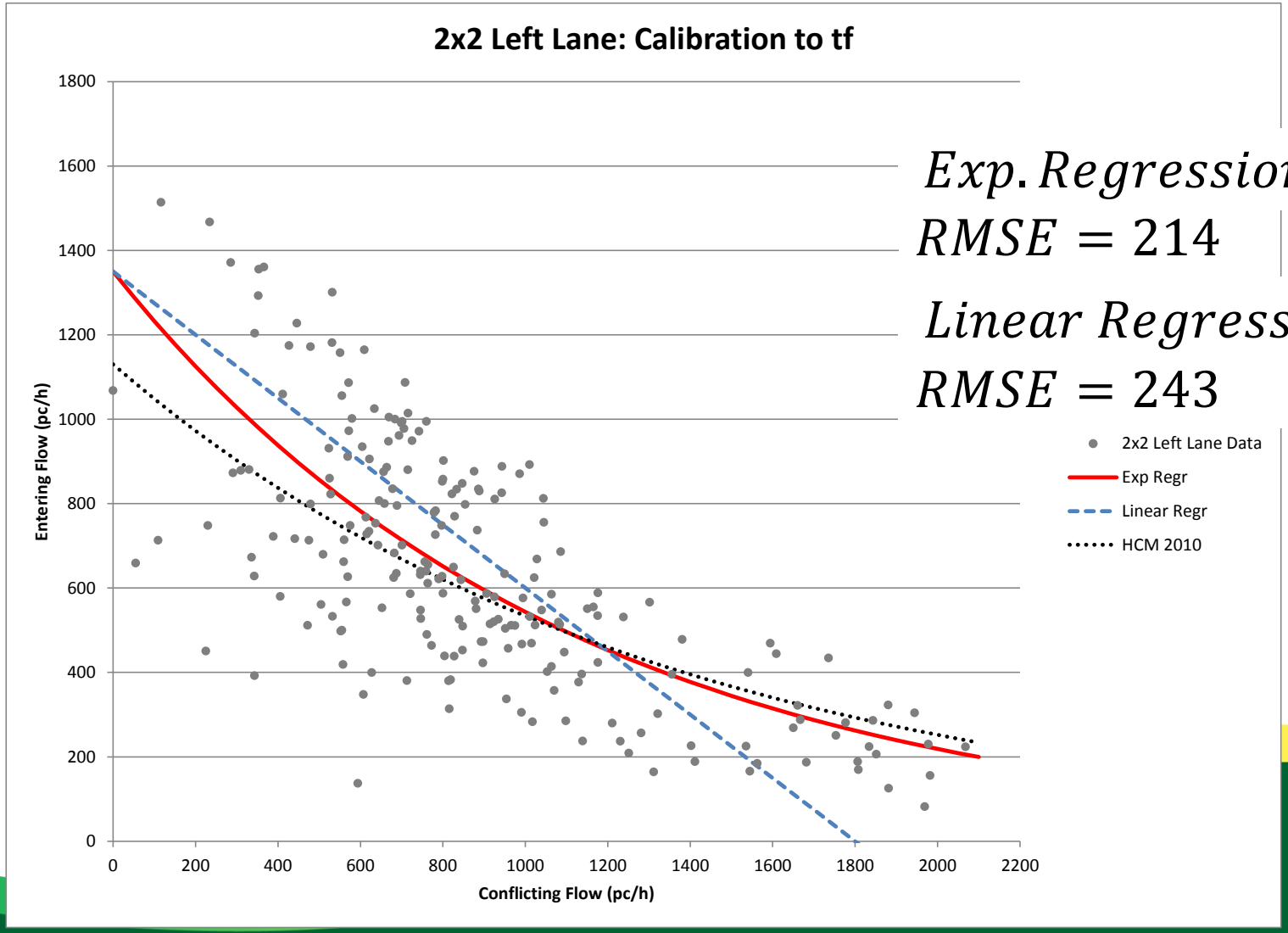
2x2 Right Lane: Calibrated to National Follow-Up Time



$Exp.Regression$:
$RMSE = 164$

$Linear\ Regression$:
$RMSE = 192$

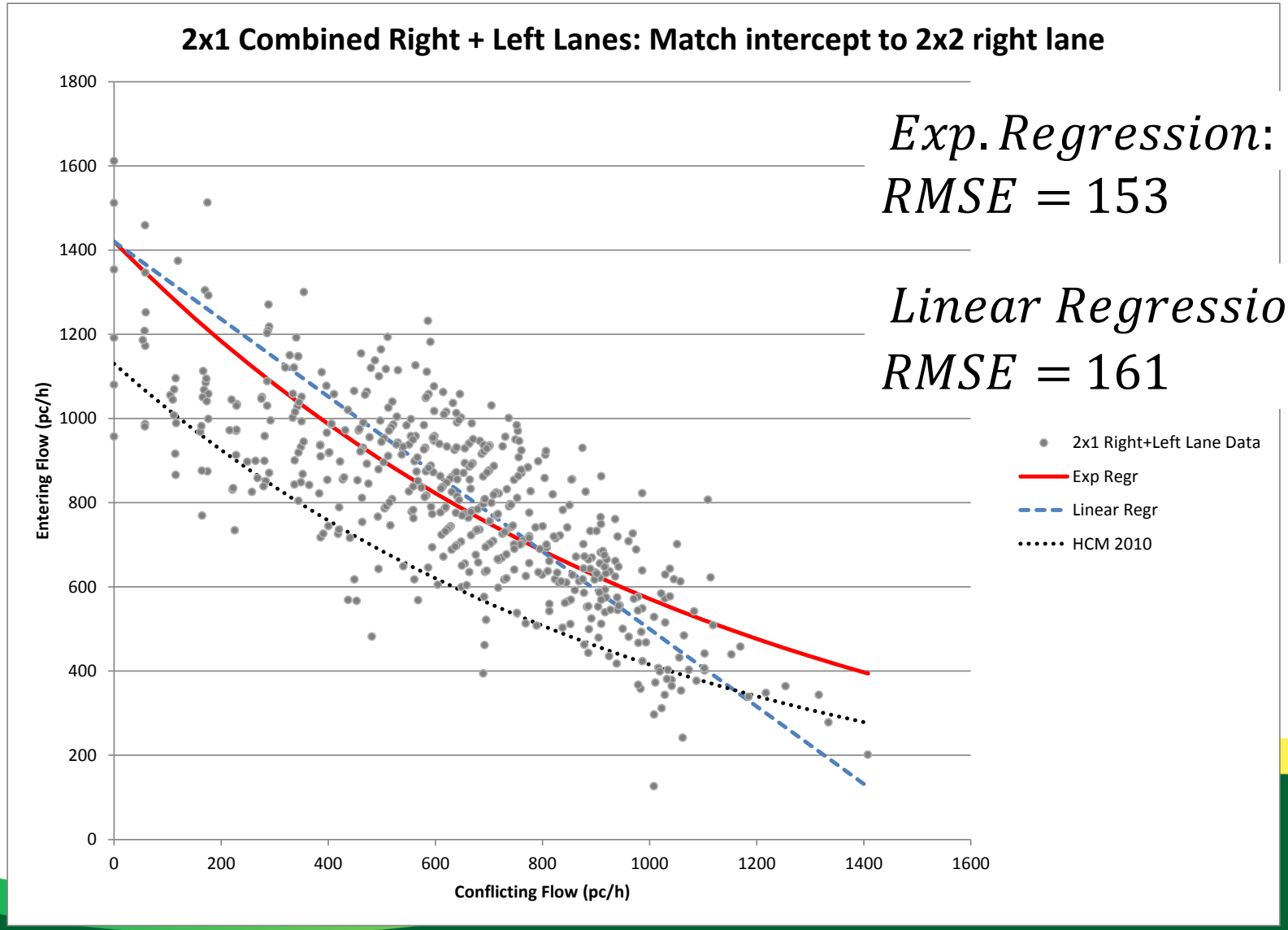
2x2 Left Lane: Calibrated to National Follow-Up Time



$Exp. Regression$:
$RMSE = 214$

$Linear\ Regression$:
$RMSE = 243$

2x1 Sites: Use 2x2 Right Lane Intercept



$$Exp.Regression: RMSE = 153$$

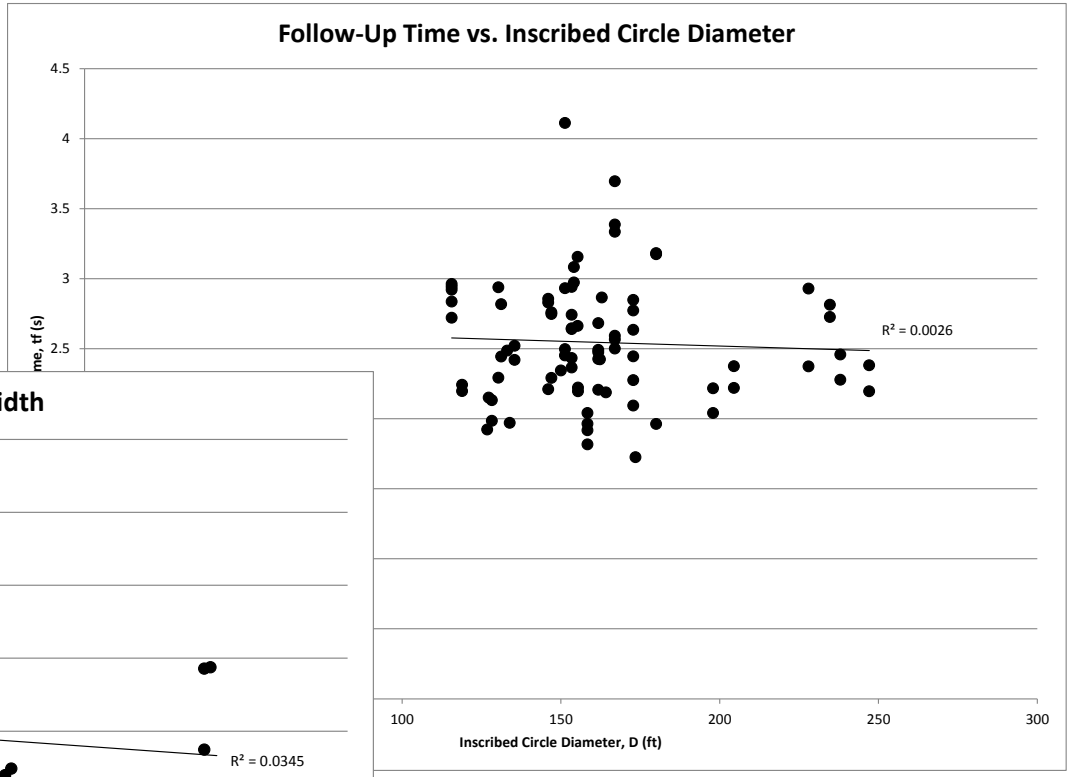
$$Linear\ Regression: RMSE = 161$$

Geometric Effects

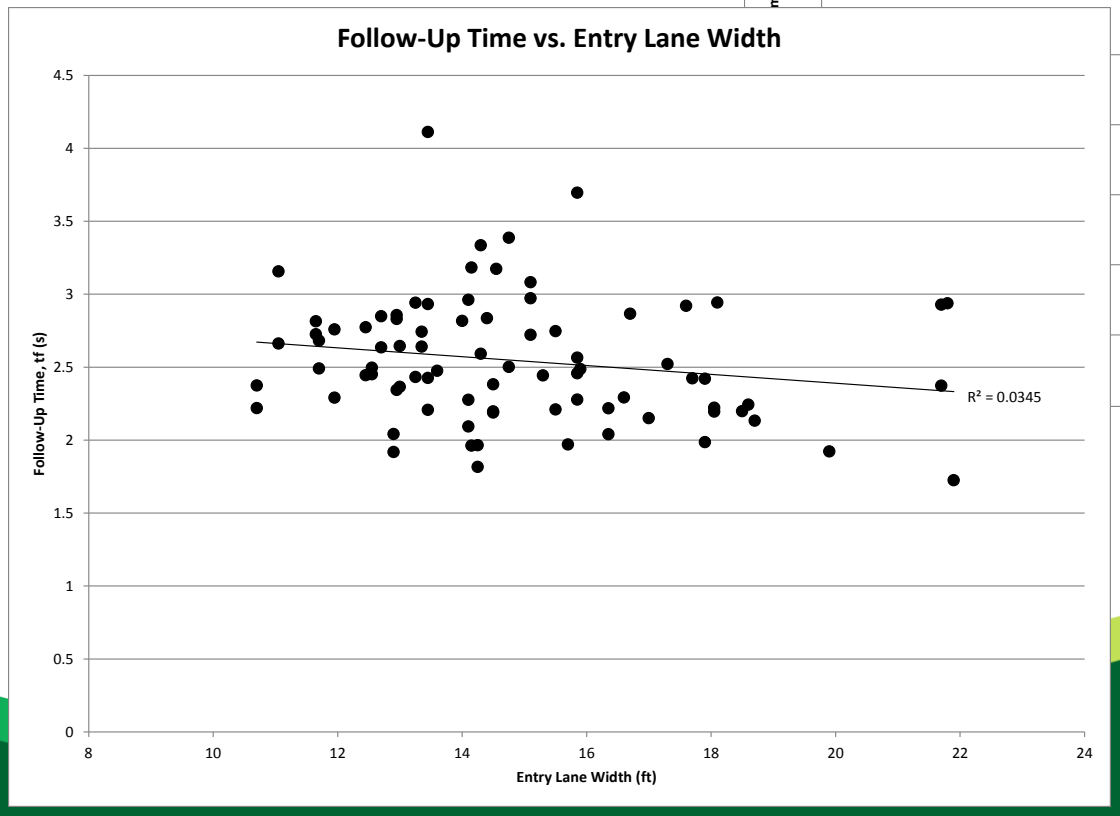
- Explored relationships between follow-up time and key geometric parameters:
  - Inscribed circle diameter
  - Entry lane width
  - Entry angle
  - Splitter island width (for exiting effect)
- Conclusion: Trends are apparent but not strong enough to include in the capacity model

Geometric Effects (cont.)

ICD



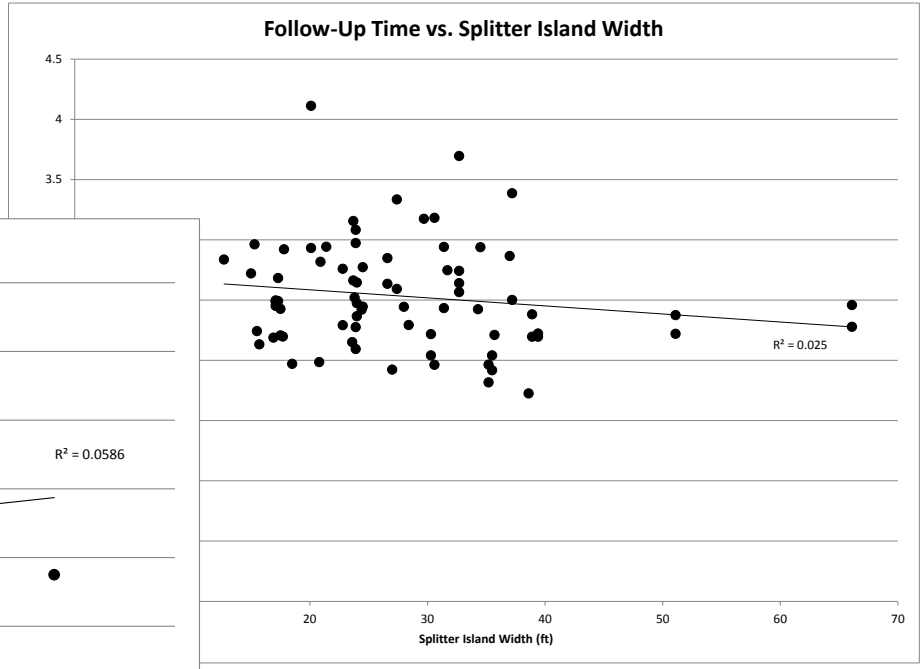
Entry Lane Width



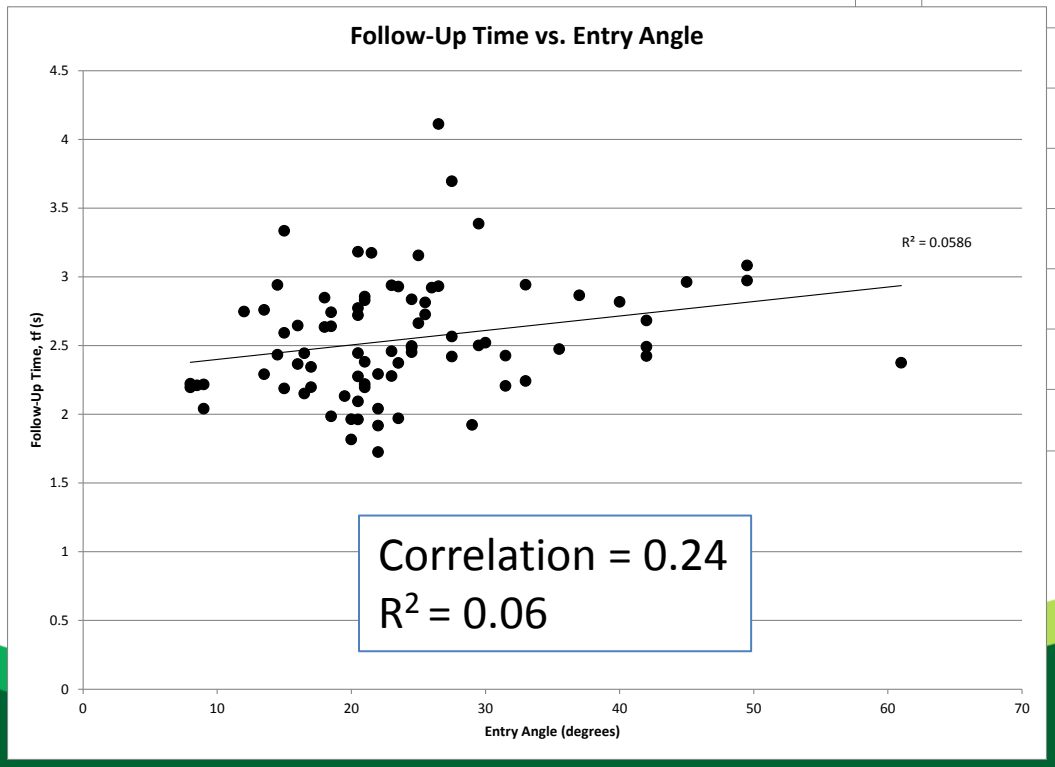
Geometric effects (cont.)

- Trends in intuitive direction but too weak to use

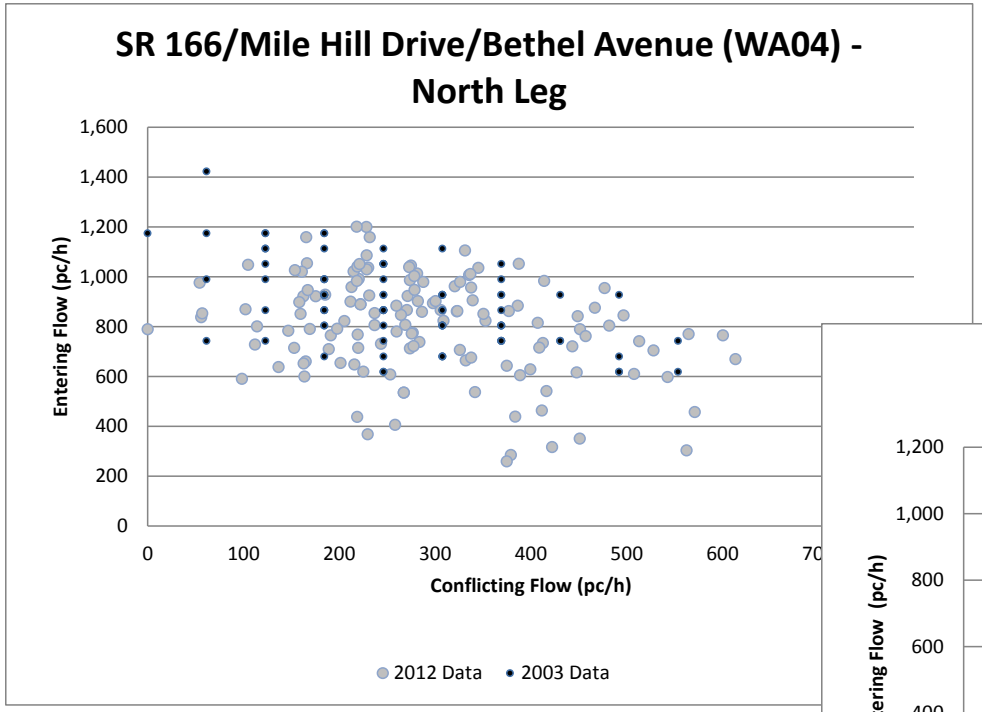
Splitter Island Width



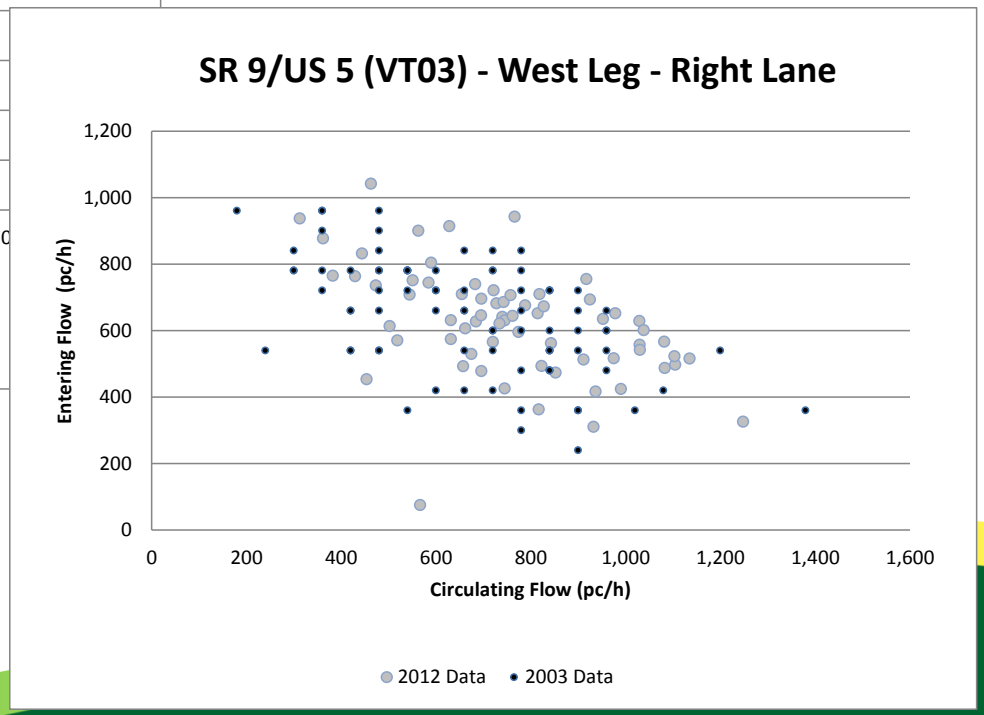
Entry Angle



Trends over Time: Sites in common with NCHRP Report 572 study



No apparent change in capacity between 2003 and 2012



Summary of Preliminary Findings

- Calibration to national follow-up time generally produces plausible results with means for calibration
- Adjustment made to 2x1 model for better fit
- Exponential form fits same or better than linear form in all cases
- Separate investigation found that calibration to local follow-up time produces best fit of all models to date

Recommended Candidate Models

- Single-lane model: $v_e = 1380 \exp(-0.00102\ v_c)$
- 2x2 right lane: $v_e = 1420 \exp(-0.00085\ v_c)$
- 2x2 left lane: $v_e = 1350 \exp(-0.00092\ v_c)$
- 2x1 both lanes: $v_e = 1420 \exp(-0.00091\ v_c)$
- 1x2: Use 2x2 right lane model
- Calibrate using local follow-up time where possible

- NOTE: All models subject to change through peer review and adoption by the TRB Committee on Highway Capacity and Quality of Service

Thank you!

- Lee Rodegerdts, lrodegerdts@kittelson.com

Photo: Lee Rodegerdts

MOVEMENT SUMMARY

Site: AM 2036 - New Equations - Current Geometry

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	48	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	1.00	25.2
8	T	351	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	0.80	27.3
18	R	116	11.0	0.141	5.8	LOS A	0.5	13.7	0.49	0.69	29.5
Approach		515	11.0	0.482	9.6	LOS A	2.4	66.4	0.60	0.79	27.5
East: US 36 (Scioto Street)											
1	L	112	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.93	26.0
6	T	201	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.73	28.3
16	R	132	8.0	0.156	5.8	LOS A	0.6	15.4	0.50	0.70	29.4
Approach		445	8.0	0.372	7.8	LOS A	1.6	42.8	0.56	0.77	27.9
North: US 68 (Main Street)											
7	L	122	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.96	24.6
4	T	386	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.78	26.5
14	R	64	11.0	0.072	4.7	LOS A	0.2	6.8	0.43	0.62	30.2
Approach		572	11.0	0.566	11.1	LOS B	3.4	92.7	0.62	0.80	26.4
West: US 36 (Miami Street)											
5	L	42	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	1.03	24.9
2	T	273	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	0.86	26.8
12	R	98	9.0	0.140	6.7	LOS A	0.5	13.2	0.57	0.78	28.9
Approach		413	9.0	0.451	10.4	LOS B	2.1	56.9	0.65	0.86	27.0
All Vehicles		1945	9.9	0.566	9.8	LOS A	3.4	92.7	0.61	0.80	27.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM 2036 - New Equations - No East Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	48	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	1.00	25.2
8	T	351	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	0.80	27.3
18	R	116	11.0	0.141	5.8	LOS A	0.5	13.7	0.49	0.69	29.5
Approach		515	11.0	0.482	9.6	LOS A	2.4	66.4	0.60	0.79	27.5
East: US 36 (Scioto Street)											
1	L	112	8.0	0.573	13.5	LOS B	3.7	98.8	0.73	1.04	24.0
6	T	201	8.0	0.573	13.5	LOS B	3.7	98.8	0.73	0.91	25.6
16	R	132	8.0	0.573	13.5	LOS B	3.7	98.8	0.73	0.94	25.4
Approach		445	8.0	0.573	13.5	LOS B	3.7	98.8	0.73	0.95	25.1
North: US 68 (Main Street)											
7	L	122	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.96	24.6
4	T	386	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.78	26.5
14	R	64	11.0	0.072	4.7	LOS A	0.2	6.8	0.43	0.62	30.2
Approach		572	11.0	0.566	11.1	LOS B	3.4	92.7	0.62	0.80	26.4
West: US 36 (Miami Street)											
5	L	42	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	1.03	24.9
2	T	273	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	0.86	26.8
12	R	98	9.0	0.140	6.7	LOS A	0.5	13.2	0.57	0.78	28.9
Approach		413	9.0	0.451	10.4	LOS B	2.1	56.9	0.65	0.86	27.0
All Vehicles		1945	9.9	0.573	11.1	LOS B	3.7	98.8	0.65	0.84	26.5

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM 2036 - New Equations - No North Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	48	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	1.00	25.2
8	T	351	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	0.80	27.3
18	R	116	11.0	0.141	5.8	LOS A	0.5	13.7	0.49	0.69	29.5
Approach		515	11.0	0.482	9.6	LOS A	2.4	66.4	0.60	0.79	27.5
East: US 36 (Scioto Street)											
1	L	112	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.93	26.0
6	T	201	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.73	28.3
16	R	132	8.0	0.156	5.8	LOS A	0.6	15.4	0.50	0.70	29.4
Approach		445	8.0	0.372	7.8	LOS A	1.6	42.8	0.56	0.77	27.9
North: US 68 (Main Street)											
7	L	122	11.0	0.685	16.6	LOS C	5.6	152.0	0.76	1.04	22.9
4	T	386	11.0	0.685	16.6	LOS C	5.6	152.0	0.76	0.92	24.3
14	R	64	11.0	0.685	16.6	LOS C	5.6	152.0	0.76	0.95	24.1
Approach		572	11.0	0.685	16.6	LOS C	5.6	152.0	0.76	0.95	24.0
West: US 36 (Miami Street)											
5	L	42	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	1.03	24.9
2	T	273	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	0.86	26.8
12	R	98	9.0	0.140	6.7	LOS A	0.5	13.2	0.57	0.78	28.9
Approach		413	9.0	0.451	10.4	LOS B	2.1	56.9	0.65	0.86	27.0
All Vehicles		1945	9.9	0.685	11.4	LOS B	5.6	152.0	0.65	0.85	26.3

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM 2036 - New Equations - No South Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	48	11.0	0.675	17.3	LOS C	5.1	139.5	0.78	1.10	22.7
8	T	351	11.0	0.675	17.3	LOS C	5.1	139.5	0.78	0.99	24.0
18	R	116	11.0	0.675	17.3	LOS C	5.1	139.5	0.78	1.01	23.9
Approach		515	11.0	0.675	17.3	LOS C	5.1	139.5	0.78	1.00	23.9
East: US 36 (Scioto Street)											
1	L	112	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.93	26.0
6	T	201	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.73	28.3
16	R	132	8.0	0.156	5.8	LOS A	0.6	15.4	0.50	0.70	29.4
Approach		445	8.0	0.372	7.8	LOS A	1.6	42.8	0.56	0.77	27.9
North: US 68 (Main Street)											
7	L	122	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.96	24.6
4	T	386	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.78	26.5
14	R	64	11.0	0.072	4.7	LOS A	0.2	6.8	0.43	0.62	30.2
Approach		572	11.0	0.566	11.1	LOS B	3.4	92.7	0.62	0.80	26.4
West: US 36 (Miami Street)											
5	L	42	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	1.03	24.9
2	T	273	9.0	0.451	11.6	LOS B	2.1	56.9	0.68	0.86	26.8
12	R	98	9.0	0.140	6.7	LOS A	0.5	13.2	0.57	0.78	28.9
Approach		413	9.0	0.451	10.4	LOS B	2.1	56.9	0.65	0.86	27.0
All Vehicles		1945	9.9	0.675	11.9	LOS B	5.1	139.5	0.66	0.86	26.1

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM 2036 - New Equations - No West Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	48	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	1.00	25.2
8	T	351	11.0	0.482	10.7	LOS B	2.4	66.4	0.63	0.80	27.3
18	R	116	11.0	0.141	5.8	LOS A	0.5	13.7	0.49	0.69	29.5
Approach		515	11.0	0.482	9.6	LOS A	2.4	66.4	0.60	0.79	27.5
East: US 36 (Scioto Street)											
1	L	112	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.93	26.0
6	T	201	8.0	0.372	8.6	LOS A	1.6	42.8	0.59	0.73	28.3
16	R	132	8.0	0.156	5.8	LOS A	0.6	15.4	0.50	0.70	29.4
Approach		445	8.0	0.372	7.8	LOS A	1.6	42.8	0.56	0.77	27.9
North: US 68 (Main Street)											
7	L	122	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.96	24.6
4	T	386	11.0	0.566	12.0	LOS B	3.4	92.7	0.64	0.78	26.5
14	R	64	11.0	0.072	4.7	LOS A	0.2	6.8	0.43	0.62	30.2
Approach		572	11.0	0.566	11.1	LOS B	3.4	92.7	0.62	0.80	26.4
West: US 36 (Miami Street)											
5	L	42	9.0	0.656	19.2	LOS C	4.4	117.1	0.81	1.12	22.1
2	T	273	9.0	0.656	19.2	LOS C	4.4	117.1	0.81	1.02	23.3
12	R	98	9.0	0.656	19.2	LOS C	4.4	117.1	0.81	1.04	23.1
Approach		413	9.0	0.656	19.2	LOS C	4.4	117.1	0.81	1.04	23.1
All Vehicles		1945	9.9	0.656	11.7	LOS B	4.4	117.1	0.64	0.84	26.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM Existing - New Equations - Current Geometry

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	43	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.95	25.8
8	T	318	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.72	28.1
18	R	105	11.0	0.123	5.4	LOS A	0.4	11.9	0.47	0.66	29.7
Approach		467	11.0	0.421	8.4	LOS A	1.9	52.0	0.56	0.73	28.2
East: US 36 (Scioto Street)											
1	L	102	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.90	26.4
6	T	183	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.68	28.8
16	R	120	8.0	0.136	5.4	LOS A	0.5	13.4	0.48	0.67	29.7
Approach		404	8.0	0.325	7.0	LOS A	1.4	36.7	0.53	0.73	28.4
North: US 68 (Main Street)											
7	L	111	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.91	25.3
4	T	350	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.70	27.5
14	R	59	11.0	0.063	4.5	LOS A	0.2	6.0	0.41	0.60	30.3
Approach		520	11.0	0.498	9.5	LOS A	2.6	71.2	0.56	0.73	27.2
West: US 36 (Miami Street)											
5	L	39	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	1.00	25.6
2	T	248	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	0.81	27.7
12	R	89	9.0	0.120	6.1	LOS A	0.4	11.3	0.54	0.74	29.3
Approach		376	9.0	0.388	9.0	LOS A	1.7	45.2	0.61	0.81	27.8
All Vehicles		1767	9.9	0.498	8.5	LOS A	2.6	71.2	0.56	0.75	27.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM Existing - New Equations - No East Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	43	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.95	25.8
8	T	318	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.72	28.1
18	R	105	11.0	0.123	5.4	LOS A	0.4	11.9	0.47	0.66	29.7
Approach		467	11.0	0.421	8.4	LOS A	1.9	52.0	0.56	0.73	28.2
East: US 36 (Scioto Street)											
1	L	102	8.0	0.498	11.2	LOS B	2.9	76.2	0.67	0.97	24.9
6	T	183	8.0	0.498	11.2	LOS B	2.9	76.2	0.67	0.81	26.8
16	R	120	8.0	0.498	11.2	LOS B	2.9	76.2	0.67	0.85	26.5
Approach		404	8.0	0.498	11.2	LOS B	2.9	76.2	0.67	0.86	26.2
North: US 68 (Main Street)											
7	L	111	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.91	25.3
4	T	350	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.70	27.5
14	R	59	11.0	0.063	4.5	LOS A	0.2	6.0	0.41	0.60	30.3
Approach		520	11.0	0.498	9.5	LOS A	2.6	71.2	0.56	0.73	27.2
West: US 36 (Miami Street)											
5	L	39	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	1.00	25.6
2	T	248	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	0.81	27.7
12	R	89	9.0	0.120	6.1	LOS A	0.4	11.3	0.54	0.74	29.3
Approach		376	9.0	0.388	9.0	LOS A	1.7	45.2	0.61	0.81	27.8
All Vehicles		1767	9.9	0.498	9.5	LOS A	2.9	76.2	0.60	0.78	27.3

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM Existing - New Equations - No North Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	43	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.95	25.8
8	T	318	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.72	28.1
18	R	105	11.0	0.123	5.4	LOS A	0.4	11.9	0.47	0.66	29.7
Approach		467	11.0	0.421	8.4	LOS A	1.9	52.0	0.56	0.73	28.2
East: US 36 (Scioto Street)											
1	L	102	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.90	26.4
6	T	183	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.68	28.8
16	R	120	8.0	0.136	5.4	LOS A	0.5	13.4	0.48	0.67	29.7
Approach		404	8.0	0.325	7.0	LOS A	1.4	36.7	0.53	0.73	28.4
North: US 68 (Main Street)											
7	L	111	11.0	0.601	13.2	LOS B	4.1	112.7	0.69	0.96	24.1
4	T	350	11.0	0.601	13.2	LOS B	4.1	112.7	0.69	0.80	25.9
14	R	59	11.0	0.601	13.2	LOS B	4.1	112.7	0.69	0.84	25.6
Approach		520	11.0	0.601	13.2	LOS B	4.1	112.7	0.69	0.84	25.4
West: US 36 (Miami Street)											
5	L	39	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	1.00	25.6
2	T	248	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	0.81	27.7
12	R	89	9.0	0.120	6.1	LOS A	0.4	11.3	0.54	0.74	29.3
Approach		376	9.0	0.388	9.0	LOS A	1.7	45.2	0.61	0.81	27.8
All Vehicles		1767	9.9	0.601	9.6	LOS A	4.1	112.7	0.60	0.78	27.3

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM Existing - New Equations - No South Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	43	11.0	0.586	13.6	LOS B	3.8	104.0	0.71	1.02	24.0
8	T	318	11.0	0.586	13.6	LOS B	3.8	104.0	0.71	0.88	25.7
18	R	105	11.0	0.586	13.6	LOS B	3.8	104.0	0.71	0.91	25.5
Approach		467	11.0	0.586	13.6	LOS B	3.8	104.0	0.71	0.90	25.5
East: US 36 (Scioto Street)											
1	L	102	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.90	26.4
6	T	183	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.68	28.8
16	R	120	8.0	0.136	5.4	LOS A	0.5	13.4	0.48	0.67	29.7
Approach		404	8.0	0.325	7.0	LOS A	1.4	36.7	0.53	0.73	28.4
North: US 68 (Main Street)											
7	L	111	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.91	25.3
4	T	350	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.70	27.5
14	R	59	11.0	0.063	4.5	LOS A	0.2	6.0	0.41	0.60	30.3
Approach		520	11.0	0.498	9.5	LOS A	2.6	71.2	0.56	0.73	27.2
West: US 36 (Miami Street)											
5	L	39	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	1.00	25.6
2	T	248	9.0	0.388	9.9	LOS A	1.7	45.2	0.64	0.81	27.7
12	R	89	9.0	0.120	6.1	LOS A	0.4	11.3	0.54	0.74	29.3
Approach		376	9.0	0.388	9.0	LOS A	1.7	45.2	0.61	0.81	27.8
All Vehicles		1767	9.9	0.586	9.9	LOS A	3.8	104.0	0.60	0.79	27.1

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: AM Existing - New Equations - No West Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	43	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.95	25.8
8	T	318	11.0	0.421	9.3	LOS A	1.9	52.0	0.58	0.72	28.1
18	R	105	11.0	0.123	5.4	LOS A	0.4	11.9	0.47	0.66	29.7
Approach		467	11.0	0.421	8.4	LOS A	1.9	52.0	0.56	0.73	28.2
East: US 36 (Scioto Street)											
1	L	102	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.90	26.4
6	T	183	8.0	0.325	7.7	LOS A	1.4	36.7	0.55	0.68	28.8
16	R	120	8.0	0.136	5.4	LOS A	0.5	13.4	0.48	0.67	29.7
Approach		404	8.0	0.325	7.0	LOS A	1.4	36.7	0.53	0.73	28.4
North: US 68 (Main Street)											
7	L	111	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.91	25.3
4	T	350	11.0	0.498	10.2	LOS B	2.6	71.2	0.58	0.70	27.5
14	R	59	11.0	0.063	4.5	LOS A	0.2	6.0	0.41	0.60	30.3
Approach		520	11.0	0.498	9.5	LOS A	2.6	71.2	0.56	0.73	27.2
West: US 36 (Miami Street)											
5	L	39	9.0	0.560	14.8	LOS B	3.3	88.5	0.75	1.07	23.6
2	T	248	9.0	0.560	14.8	LOS B	3.3	88.5	0.75	0.94	25.2
12	R	89	9.0	0.560	14.8	LOS B	3.3	88.5	0.75	0.96	25.0
Approach		376	9.0	0.560	14.8	LOS B	3.3	88.5	0.75	0.96	24.9
All Vehicles		1767	9.9	0.560	9.8	LOS A	3.3	88.5	0.59	0.78	27.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM 2036 - New Equations - Current Geometry

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	75	5.0	0.764	23.0	LOS C	6.5	168.3	0.87	1.18	21.0
8	T	479	5.0	0.764	23.0	LOS C	6.5	168.3	0.87	1.11	21.9
18	R	192	5.0	0.265	8.1	LOS A	1.0	27.0	0.61	0.81	28.1
Approach		747	5.0	0.764	19.1	LOS C	6.5	168.3	0.80	1.04	23.1
East: US 36 (Scioto Street)											
1	L	175	4.0	0.742	21.2	LOS C	6.1	157.4	0.85	1.15	21.4
6	T	374	4.0	0.742	21.2	LOS C	6.1	157.4	0.85	1.08	22.4
16	R	149	4.0	0.201	7.1	LOS A	0.8	19.9	0.59	0.80	28.7
Approach		698	4.0	0.742	18.2	LOS C	6.1	157.4	0.80	1.04	23.2
North: US 68 (Main Street)											
7	L	151	6.0	0.759	22.2	LOS C	6.4	167.8	0.86	1.17	21.1
4	T	412	6.0	0.759	22.2	LOS C	6.4	167.8	0.86	1.09	22.1
14	R	75	6.0	0.101	5.9	LOS A	0.4	9.4	0.55	0.74	29.4
Approach		638	6.0	0.759	20.3	LOS C	6.4	167.8	0.82	1.07	22.4
West: US 36 (Miami Street)											
5	L	85	7.0	0.750	23.9	LOS C	5.6	149.0	0.85	1.18	20.7
2	T	405	7.0	0.750	23.9	LOS C	5.6	149.0	0.85	1.10	21.5
12	R	111	7.0	0.170	7.5	LOS A	0.6	16.0	0.60	0.81	28.4
Approach		601	7.0	0.750	20.9	LOS C	5.6	149.0	0.80	1.06	22.4
All Vehicles		2684	5.4	0.764	19.6	LOS C	6.5	168.3	0.80	1.05	22.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM 2036 - New Equations - No East Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	75	5.0	0.764	23.0	LOS C	6.5	168.3	0.87	1.18	21.0
8	T	479	5.0	0.764	23.0	LOS C	6.5	168.3	0.87	1.11	21.9
18	R	192	5.0	0.265	8.1	LOS A	1.0	27.0	0.61	0.81	28.1
Approach		747	5.0	0.764	19.1	LOS C	6.5	168.3	0.80	1.04	23.1
East: US 36 (Scioto Street)											
1	L	175	4.0	1.045	71.7	LOS F	28.1	723.8	1.00	2.10	12.4
6	T	374	4.0	1.045	71.7	LOS F	28.1	723.8	1.00	2.10	12.3
16	R	149	4.0	1.045	71.7	LOS F	28.1	723.8	1.00	2.10	12.2
Approach		698	4.0	1.045	71.7	LOS F	28.1	723.8	1.00	2.10	12.3
North: US 68 (Main Street)											
7	L	151	6.0	0.742	20.8	LOS C	6.1	160.5	0.84	1.15	21.5
4	T	412	6.0	0.742	20.8	LOS C	6.1	160.5	0.84	1.07	22.6
14	R	75	6.0	0.099	5.8	LOS A	0.4	9.3	0.54	0.73	29.5
Approach		638	6.0	0.742	19.1	LOS C	6.1	160.5	0.81	1.05	22.9
West: US 36 (Miami Street)											
5	L	85	7.0	0.745	23.4	LOS C	5.6	147.0	0.84	1.17	20.8
2	T	405	7.0	0.745	23.4	LOS C	5.6	147.0	0.84	1.09	21.7
12	R	111	7.0	0.169	7.4	LOS A	0.6	15.9	0.60	0.81	28.5
Approach		601	7.0	0.745	20.5	LOS C	5.6	147.0	0.80	1.05	22.5
All Vehicles		2684	5.4	1.045	33.1	LOS D	28.1	723.8	0.85	1.32	18.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM 2036 - New Equations - No North Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	75	5.0	0.764	23.0	LOS C	6.5	168.3	0.87	1.18	21.0
8	T	479	5.0	0.764	23.0	LOS C	6.5	168.3	0.87	1.11	21.9
18	R	192	5.0	0.265	8.1	LOS A	1.0	27.0	0.61	0.81	28.1
Approach		747	5.0	0.764	19.1	LOS C	6.5	168.3	0.80	1.04	23.1
East: US 36 (Scioto Street)											
1	L	175	4.0	0.742	21.2	LOS C	6.1	157.4	0.85	1.15	21.4
6	T	374	4.0	0.742	21.2	LOS C	6.1	157.4	0.85	1.08	22.4
16	R	149	4.0	0.201	7.1	LOS A	0.8	19.9	0.59	0.80	28.7
Approach		698	4.0	0.742	18.2	LOS C	6.1	157.4	0.80	1.04	23.2
North: US 68 (Main Street)											
7	L	151	6.0	0.951	48.2	LOS E	15.9	417.0	1.00	1.59	15.4
4	T	412	6.0	0.951	48.2	LOS E	15.9	417.0	1.00	1.59	15.5
14	R	75	6.0	0.951	48.2	LOS E	15.9	417.0	1.00	1.59	15.5
Approach		638	6.0	0.951	48.2	LOS E	15.9	417.0	1.00	1.59	15.5
West: US 36 (Miami Street)											
5	L	85	7.0	0.750	23.9	LOS C	5.6	149.0	0.85	1.18	20.7
2	T	405	7.0	0.750	23.9	LOS C	5.6	149.0	0.85	1.10	21.5
12	R	111	7.0	0.170	7.5	LOS A	0.6	16.0	0.60	0.81	28.4
Approach		601	7.0	0.750	20.9	LOS C	5.6	149.0	0.80	1.06	22.4
All Vehicles		2684	5.4	0.951	26.2	LOS D	15.9	417.0	0.85	1.18	20.6

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM 2036 - New Equations - No South Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	75	5.0	1.142	104.6	LOS F	44.2	1148.4	1.00	2.80	9.7
8	T	479	5.0	1.142	104.6	LOS F	44.2	1148.4	1.00	2.80	9.5
18	R	192	5.0	1.142	104.6	LOS F	44.2	1148.4	1.00	2.80	9.4
Approach		747	5.0	1.142	104.6	LOS F	44.2	1148.4	1.00	2.80	9.5
East: US 36 (Scioto Street)											
1	L	175	4.0	0.694	17.7	LOS C	5.4	139.4	0.82	1.11	22.5
6	T	374	4.0	0.694	17.7	LOS C	5.4	139.4	0.82	1.02	23.8
16	R	149	4.0	0.188	6.5	LOS A	0.7	18.8	0.56	0.76	29.0
Approach		698	4.0	0.694	15.3	LOS C	5.4	139.4	0.76	0.99	24.3
North: US 68 (Main Street)											
7	L	151	6.0	0.752	21.7	LOS C	6.3	164.8	0.85	1.16	21.3
4	T	412	6.0	0.752	21.7	LOS C	6.3	164.8	0.85	1.08	22.3
14	R	75	6.0	0.100	5.8	LOS A	0.4	9.4	0.54	0.74	29.4
Approach		638	6.0	0.752	19.8	LOS C	6.3	164.8	0.81	1.06	22.6
West: US 36 (Miami Street)											
5	L	85	7.0	0.750	23.9	LOS C	5.6	149.0	0.85	1.18	20.7
2	T	405	7.0	0.750	23.9	LOS C	5.6	149.0	0.85	1.10	21.5
12	R	111	7.0	0.170	7.5	LOS A	0.6	16.0	0.60	0.81	28.4
Approach		601	7.0	0.750	20.9	LOS C	5.6	149.0	0.80	1.06	22.4
All Vehicles		2684	5.4	1.142	42.5	LOS E	44.2	1148.4	0.85	1.52	16.6

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM 2036 - New Equations - No West Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	75	5.0	0.753	22.0	LOS C	6.3	163.4	0.86	1.17	21.3
8	T	479	5.0	0.753	22.0	LOS C	6.3	163.4	0.86	1.09	22.2
18	R	192	5.0	0.261	7.9	LOS A	1.0	26.7	0.60	0.81	28.2
Approach		747	5.0	0.753	18.4	LOS C	6.3	163.4	0.79	1.03	23.4
East: US 36 (Scioto Street)											
1	L	175	4.0	0.740	21.0	LOS C	6.1	156.6	0.85	1.15	21.5
6	T	374	4.0	0.740	21.0	LOS C	6.1	156.6	0.85	1.08	22.5
16	R	149	4.0	0.201	7.1	LOS A	0.8	19.8	0.58	0.80	28.7
Approach		698	4.0	0.740	18.0	LOS C	6.1	156.6	0.80	1.04	23.2
North: US 68 (Main Street)											
7	L	151	6.0	0.759	22.2	LOS C	6.4	167.8	0.86	1.17	21.1
4	T	412	6.0	0.759	22.2	LOS C	6.4	167.8	0.86	1.09	22.1
14	R	75	6.0	0.101	5.9	LOS A	0.4	9.4	0.55	0.74	29.4
Approach		638	6.0	0.759	20.3	LOS C	6.4	167.8	0.82	1.07	22.4
West: US 36 (Miami Street)											
5	L	85	7.0	1.031	72.3	LOS F	22.8	600.8	1.00	2.02	12.3
2	T	405	7.0	1.031	72.3	LOS F	22.8	600.8	1.00	2.02	12.2
12	R	111	7.0	1.031	72.3	LOS F	22.8	600.8	1.00	2.02	12.2
Approach		601	7.0	1.031	72.3	LOS F	22.8	600.8	1.00	2.02	12.2
All Vehicles		2684	5.4	1.031	30.8	LOS D	22.8	600.8	0.85	1.26	19.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM Existing - New Equations - Current Geometry

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	68	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	1.10	23.1
8	T	436	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	0.99	24.4
18	R	175	5.0	0.228	7.2	LOS A	0.9	23.1	0.58	0.79	28.6
Approach		679	5.0	0.657	14.1	LOS B	4.6	120.3	0.73	0.95	25.2
East: US 36 (Scioto Street)											
1	L	160	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	1.08	23.3
6	T	339	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	0.97	24.7
16	R	135	4.0	0.172	6.4	LOS A	0.7	17.0	0.56	0.76	29.1
Approach		634	4.0	0.638	13.6	LOS B	4.4	114.2	0.73	0.95	25.1
North: US 68 (Main Street)											
7	L	137	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	1.09	23.1
4	T	375	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	0.97	24.5
14	R	68	6.0	0.088	5.5	LOS A	0.3	8.2	0.52	0.71	29.7
Approach		580	6.0	0.654	14.9	LOS B	4.6	120.4	0.75	0.97	24.6
West: US 36 (Miami Street)											
5	L	77	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	1.10	22.8
2	T	368	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	0.98	24.1
12	R	101	7.0	0.145	6.8	LOS A	0.5	13.7	0.58	0.79	28.9
Approach		547	7.0	0.640	15.2	LOS C	4.1	107.4	0.74	0.96	24.7
All Vehicles		2440	5.4	0.657	14.4	LOS B	4.6	120.4	0.74	0.96	24.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM Existing - New Equations - No East Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	68	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	1.10	23.1
8	T	436	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	0.99	24.4
18	R	175	5.0	0.228	7.2	LOS A	0.9	23.1	0.58	0.79	28.6
Approach		679	5.0	0.657	14.1	LOS B	4.6	120.3	0.73	0.95	25.2
East: US 36 (Scioto Street)											
1	L	160	4.0	0.892	36.4	LOS E	12.3	317.0	1.00	1.39	17.6
6	T	339	4.0	0.892	36.4	LOS E	12.3	317.0	1.00	1.39	17.9
16	R	135	4.0	0.892	36.4	LOS E	12.3	317.0	1.00	1.39	17.8
Approach		634	4.0	0.892	36.4	LOS E	12.3	317.0	1.00	1.39	17.8
North: US 68 (Main Street)											
7	L	137	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	1.09	23.1
4	T	375	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	0.97	24.5
14	R	68	6.0	0.088	5.5	LOS A	0.3	8.2	0.52	0.71	29.7
Approach		580	6.0	0.654	14.9	LOS B	4.6	120.4	0.75	0.97	24.6
West: US 36 (Miami Street)											
5	L	77	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	1.10	22.8
2	T	368	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	0.98	24.1
12	R	101	7.0	0.145	6.8	LOS A	0.5	13.7	0.58	0.79	28.9
Approach		547	7.0	0.640	15.2	LOS C	4.1	107.4	0.74	0.96	24.7
All Vehicles		2440	5.4	0.892	20.3	LOS C	12.3	317.0	0.81	1.07	22.5

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM Existing - New Equations - No North Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	68	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	1.10	23.1
8	T	436	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	0.99	24.4
18	R	175	5.0	0.228	7.2	LOS A	0.9	23.1	0.58	0.79	28.6
Approach		679	5.0	0.657	14.1	LOS B	4.6	120.3	0.73	0.95	25.2
East: US 36 (Scioto Street)											
1	L	160	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	1.08	23.3
6	T	339	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	0.97	24.7
16	R	135	4.0	0.172	6.4	LOS A	0.7	17.0	0.56	0.76	29.1
Approach		634	4.0	0.638	13.6	LOS B	4.4	114.2	0.73	0.95	25.1
North: US 68 (Main Street)											
7	L	137	6.0	0.814	27.3	LOS D	8.6	224.1	0.92	1.24	19.7
4	T	375	6.0	0.814	27.3	LOS D	8.6	224.1	0.92	1.20	20.4
14	R	68	6.0	0.814	27.3	LOS D	8.6	224.1	0.92	1.21	20.3
Approach		580	6.0	0.814	27.3	LOS D	8.6	224.1	0.92	1.21	20.2
West: US 36 (Miami Street)											
5	L	77	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	1.10	22.8
2	T	368	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	0.98	24.1
12	R	101	7.0	0.145	6.8	LOS A	0.5	13.7	0.58	0.79	28.9
Approach		547	7.0	0.640	15.2	LOS C	4.1	107.4	0.74	0.96	24.7
All Vehicles		2440	5.4	0.814	17.4	LOS C	8.6	224.1	0.78	1.02	23.6

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM Existing - New Equations - No South Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	68	5.0	0.975	52.3	LOS F	19.2	498.1	1.00	1.69	14.8
8	T	436	5.0	0.975	52.3	LOS F	19.2	498.1	1.00	1.69	14.9
18	R	175	5.0	0.975	52.3	LOS F	19.2	498.1	1.00	1.69	14.8
Approach		679	5.0	0.975	52.3	LOS F	19.2	498.1	1.00	1.69	14.9
East: US 36 (Scioto Street)											
1	L	160	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	1.08	23.3
6	T	339	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	0.97	24.7
16	R	135	4.0	0.172	6.4	LOS A	0.7	17.0	0.56	0.76	29.1
Approach		634	4.0	0.638	13.6	LOS B	4.4	114.2	0.73	0.95	25.1
North: US 68 (Main Street)											
7	L	137	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	1.09	23.1
4	T	375	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	0.97	24.5
14	R	68	6.0	0.088	5.5	LOS A	0.3	8.2	0.52	0.71	29.7
Approach		580	6.0	0.654	14.9	LOS B	4.6	120.4	0.75	0.97	24.6
West: US 36 (Miami Street)											
5	L	77	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	1.10	22.8
2	T	368	7.0	0.640	17.1	LOS C	4.1	107.4	0.78	0.98	24.1
12	R	101	7.0	0.145	6.8	LOS A	0.5	13.7	0.58	0.79	28.9
Approach		547	7.0	0.640	15.2	LOS C	4.1	107.4	0.74	0.96	24.7
All Vehicles		2440	5.4	0.975	25.0	LOS D	19.2	498.1	0.81	1.17	20.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

MOVEMENT SUMMARY

Site: PM Existing - New Equations - No West Leg RT

US 36 & US 68
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: US 68 (Main Street)											
3	L	68	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	1.10	23.1
8	T	436	5.0	0.657	16.5	LOS C	4.6	120.3	0.79	0.99	24.4
18	R	175	5.0	0.228	7.2	LOS A	0.9	23.1	0.58	0.79	28.6
Approach		679	5.0	0.657	14.1	LOS B	4.6	120.3	0.73	0.95	25.2
East: US 36 (Scioto Street)											
1	L	160	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	1.08	23.3
6	T	339	4.0	0.638	15.5	LOS C	4.4	114.2	0.78	0.97	24.7
16	R	135	4.0	0.172	6.4	LOS A	0.7	17.0	0.56	0.76	29.1
Approach		634	4.0	0.638	13.6	LOS B	4.4	114.2	0.73	0.95	25.1
North: US 68 (Main Street)											
7	L	137	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	1.09	23.1
4	T	375	6.0	0.654	16.1	LOS C	4.6	120.4	0.78	0.97	24.5
14	R	68	6.0	0.088	5.5	LOS A	0.3	8.2	0.52	0.71	29.7
Approach		580	6.0	0.654	14.9	LOS B	4.6	120.4	0.75	0.97	24.6
West: US 36 (Miami Street)											
5	L	77	7.0	0.874	37.1	LOS E	9.9	261.8	0.95	1.37	17.5
2	T	368	7.0	0.874	37.1	LOS E	9.9	261.8	0.95	1.34	17.8
12	R	101	7.0	0.874	37.1	LOS E	9.9	261.8	0.95	1.35	17.7
Approach		547	7.0	0.874	37.1	LOS E	9.9	261.8	0.95	1.35	17.8
All Vehicles		2440	5.4	0.874	19.3	LOS C	9.9	261.8	0.78	1.04	22.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Model used. Geometric Delay not included.

*This is the most current estimate. However, Urban Resurfacing will be separate.

US 68/US 36 Roundabout					
Preferred Alternative					
	Unit	Quantity	Unit Price (2015 Bid Tabs)	2015 Item Cost	2019 Item Cost (13.1% Inflation)
Urban Resurfacing Funding					
Pavement Planing	SQ YD	9037.05	$ 1.28	$ 11,540.00	$ 13,060.00
Surface Course	CU YD	439.30	$ 150.00	$ 65,900.00	$ 74,540.00
Tack Coat	Gallon	677.78	$ 2.09	$ 1,420.00	$ 1,610.00
Traffic Control (Striping)	Lump		$ 6,552.00	$ 6,560.00	$ 7,420.00
Contingency	%	10%		$ 7,886.00	$ 8,920.00
Subtotal Resurfacing Construction Cost				$ 93,306.00	$ 105,550.00
Engineering Cost				$ 18,662.00	$ 21,110.00
Construction Engineering Cost				$ 9,331.00	$ 10,555.00
Subtotal Resurfacing Funding				$ 121,299.00	$ 137,215.00
Resurfacing Local Match (20%)				$ 24,260.00	$ 27,450.00
Resurfacing Funding Request (95%)				$ 97,040.00	$ 109,780.00
ODOT Safety Funding					
Subgrade Compaction	SQ YD	652.19	$ 1.33	$ 870.00	$ 990.00
Curb, Type 6	FT	2141.73	$ 16.33	$ 34,990.00	$ 39,580.00
Curb and Gutter, Type 2	FT	1007.30	$ 19.07	$ 19,210.00	$ 21,730.00
Brick Repair	SQ FT	100.00	$ 18.15	$ 1,820.00	$ 2,060.00
4" Concrete Sidewalk	SQ FT	5869.68	$ 5.15	$ 30,260.00	$ 34,230.00
Pavement Removed and sawcutting	SQ YD	749.39	$ 8.75	$ 6,560.00	$ 7,420.00
Curb and Gutter Removed	FT	680.00	$ 5.86	$ 3,990.00	$ 4,520.00
Excavation	CU YD	27.98	$ 13.80	$ 390.00	$ 450.00
Curb Ramp	Each	8.00	$ 616.18	$ 4,930.00	$ 5,580.00
Erosion Control Miscellaneous	Lump		$ 8,736.00	$ 8,740.00	$ 9,890.00
MOT	Lump		$ 21,840.00	$ 21,840.00	$ 24,710.00
Roadway Miscellaneous	Lump		$ 16,016.00	$ 16,020.00	$ 18,120.00
Catch Basin Removed	Each	8.00	$ 439.44	$ 3,520.00	$ 3,990.00
Catch Basin	Each	8.00	$ 2,183.88	$ 17,480.00	$ 19,770.00
12" Type B Conduit	FT	80.00	$ 72.23	$ 5,780.00	$ 6,540.00
Colored Concrete	SQ FT	538.27	$ 10.50	$ 5,660.00	$ 6,410.00
Stamped Concrete (Splitter Islands & Truck Apron)	SQ FT	4973.88	$ 16.00	$ 79,590.00	$ 90,020.00
Miscellaneous (field office, mobilizations, etc.)	FT	650.00	$ 24.64	$ 16,020.00	$ 18,120.00
Layout Stakes	%	0.5%		$ 2,600.00	$ 2,950.00
Contingency	%	10%		$ 28,027.00	$ 31,700.00
Subtotal ODOT Safety Funding Construction Cost				$ 308,297.00	$ 348,780.00
Engineering Cost				$ 61,660.00	$ 69,760.00
Construction Engineering Cost				$ 30,830.00	$ 34,880.00
Subtotal ODOT Safety Funding				$ 400,787.00	$ 453,420.00
Safety Local Match (10%)				$ 40,080.00	$ 45,350.00
Safety Funding Request (90%)				$ 360,710.00	$ 408,080.00
Small City Project Funding					
Curb, Type 6	FT	627.55	$ 19.07	$ 11,970.00	$ 13,540.00
Subgrade Compaction	SQ YD	789.56	$ 1.33	$ 1,060.00	$ 1,200.00
8" Concrete Pavement	SQ YD	79.62	$ 59.63	$ 4,750.00	$ 5,380.00
4" Aggregate Base	CU YD	8.85	$ 45.91	$ 410.00	$ 470.00
4" Concrete Sidewalk	SQ FT	656.43	$ 5.15	$ 3,390.00	$ 3,840.00
Excavation	CU YD	17.43	$ 13.80	$ 250.00	$ 290.00
Pavement Removed	SQ YD	728.20	$ 8.75	$ 6,370.00	$ 7,210.00
Curb Removed	FT	449.31	$ 5.86	$ 2,640.00	$ 2,990.00
Catch Basin Removed	Each	4.00	$ 439.44	$ 1,760.00	$ 2,000.00
Catch Basin	Each	4.00	$ 2,183.88	$ 8,740.00	$ 9,890.00
12" Type B Conduit	FT	40.00	$ 72.23	$ 2,890.00	$ 3,270.00
Roadway Lighting	Lump		$ 45,000.00	$ 45,000.00	$ 50,900.00
Curb Ramp	Each	8.00	$ 616.18	$ 4,930.00	$ 5,580.00
Rectangular Rapid Flashing Beacon	Each	6.00	$ 11,000.00	$ 66,000.00	$ 74,650.00
Landscaping					
Trees	Lump		$ 3,200.00	$ 3,200.00	$ 3,620.00
Shrubs	Lump		$ 4,000.00	$ 4,000.00	$ 4,530.00
Ornamental Grass	Lump		$ 3,500.00	$ 3,500.00	$ 3,960.00
Mulch	Lump		$ 2,500.00	$ 2,500.00	$ 2,830.00
Fabric	Lump		$ 6,200.00	$ 6,200.00	$ 7,020.00
Subtotal Landscaping				$ 19,400.00	$ 21,960.00
Contingency	%	10%		$ 17,956.00	$ 20,310.00
Subtotal Small City Construction Cost				$ 197,516.00	$ 223,480.00
Engineering Cost				$ 39,510.00	$ 44,700.00
Construction Engineering Cost				$ 20,710.00	$ 23,440.00
Subtotal Small City Project Funding				$ 257,736.00	$ 291,620.00
Small City Local Match (5%)				$ 12,890.00	$ 14,590.00
Small City Funding Request (95%)				$ 244,850.00	$ 277,040.00
Total Local Match				$ 77,230.00	$ 87,390.00
Total Funding Request				$ 702,600.00	$ 794,900.00
Project Total Cost				$ 779,830.00	$ 882,290.00

OHIO DEPARTMENT OF TRANSPORTATION

Safety Funding Application

General Project Information	
Project Sponsoring Agency	City of Urbana
Project Name	Monument Square Roundabout Improvements
PID	
Project Manager	Tyler Bumbalough
Contact Phone	937-652-4324
Contact Email	tyler.bumbalough@ci.urbana.oh.us

Location Information			
ODOT District	7	County	CHP
Route Number	US 36/US 68	Road Name	Monument Square
Begin Logpoint	14.88/6.56	End Logpoint	15.05/6.68
Begin Latitude	40.108 / 40.107	Begin Longitude	(-)83.754 / (-)83.753
End Latitude	40.108 / 40.109	End Longitude	(-)83.751 / (-)83.752

Project Description

Summary of Crash Patterns

Crash data, between August 2012 and July 2015, was analyzed. A total of 65 crashes were reported over this three year time period. Of the 65 crashes, 9 were injury crashes. The types of crashes were as follows: 20 rear end, 19 angle, 12 sideswipe-passing, 11 fixed object and 3 pedalcylces. Rear end collisions are inherently part of roundabouts, but the large gap between the crosswalk and the roundabout on the Scioto and Miami Street legs compounds the problem. Angle collisions could be reduced by creating better line of sight for vehicles in the right lane bypass. Sideswipe-passing collisions are prevalent because of path overlap. The high number of fixed object crashes usually involved unprotected yield signs; the lack of splitter islands/curbing that separate traffic from these objects is one cause. Pedalcycle hits could be lessened if more warning devices were in place or less distance needed to be traveled by pedestrians. There were 3 crashes in partial year 2012, 13 in 2013, 28 in 2014 and 21 in partial year 2015. If the trend for 2015 continued, there would be a projected 36 crashes in 2015 over twelve months. The roundabout configuration has been in place since September of 2009, therefore driver unfamiliarity with the roundabout is likely not a contributing factor to these crashes. The vast majority (53 - 83%) of crashes occurred on dry pavement which indicates that pavement conditions are not likely contributing to crashes. Also, the majority of crashes (44 - 68%) occurred in daylight conditions. Nighttime crash reports (18 - 28%) indicated the intersection lighting was operational at the time of the crash. For comparison purposes, research from the NCHRP Report 572 - Roundabouts in the United States indicates that an urban single lane roundabout has an average of 3 crashes per year while an urban multilane roundabout has an average of 13 crashes per year. The roundabout at US 36 and US 68 experienced an average of over 21 crashes per year over the past three years. See the "Crash Analysis" section of the attached US 36 & US 68 Intersection Study Memorandum for a more detailed summary.

Summary of Recommended Countermeasures

To improve the safety of the intersection and provide better access for pedestrians, the following recommendations are proposed. 1) Splitter islands: proposed for each approach to better guide vehicles to their proper lane. Doing so should also slow vehicles prior to the roundabout. 2) Right turn bypass realignment: proposed new alignments will allow motorists to see around vehicles in the adjacent lane entering the roundabout. A raised median will be added between the right turn bypass lane and the adjacent left/thru lane. This will help reduce speeds, better align the vehicles entering the roundabout and discourage cut-through movements. 3) Pedestrian crossings: proposed crossings will now include a pedestrian refuge area. This will allow pedestrians to focus on crossing either the entry or exit approach. Also, rectangular rapid flashing beacons will be provided on each of the crossings. Pedestrians can activate these when they want to cross the road. 4) Drive entrances: proposed drive entrances/exits will be well defined in the parking quadrants. These will remain one-way and should reduce drive confusion. 5) Curb and sidewalk extensions: proposed bump-outs will be provided at the pedestrian crossings to shorten the distance pedestrians must travel for crossing each roadway. 6) Loading zones: existing unmarked loading/unloading zones at the quadrants of the roundabout will be eliminated and replaced with raised islands. To provide loading/unloading zones for the nearby businesses, on street parking stalls will be limited to loading zones during an 8 am to 5 pm duration throughout the day. 7) Parking stalls: corner parking spaces that require the user to back into the exit lane of the roundabout will be eliminated.

Project Priority Information

A pedestrian and roadway improvement project in Monument Square scored a "Medium" rating in the newly created Logan-Union-Champaign (LUC) RTPO (Regional Transportation Planning Organization) Transportation Plan according to the decision matrix on page 105. Within the same plan, this intersection ranked in the top ten for most crashes within Logan and Champaign Counties. It is listed as a Priority Road Safety Location according to page 93 of the document. The Transportation Plan Document is available at the following link: http://www.lucplanning.com/#!rtpo/cgbd . Within the City of Urbana, the U.S. 36/U.S. 68 intersection is probably the most important intersection, accommodating over 23,000 vpd and numerous pedestrians traversing the downtown.

Safety Funding Application

Crash Data

Crash Totals

	Fatal & Serious Injury (KA)	Visible Injury (B)	Non-Visible (C)	Property Damage Only (O)	Total
Existing Conditions: Predicted Crash Frequency	0.0599	0.2562	0.3680	1.4967	2.18
Existing Conditions: Expected Crash Frequency	0.0609	0.2683	0.4211	2.8232	3.57
Potential for Safety Improvement	0.0010	0.0121	0.0531	1.3265	1.39
Proposed Conditions: Expected Crash Frequency	0.0134	0.0590	0.0926	2.0045	2.17
Observed Crashes	0.2500	0.7500	1.2500	14.0000	16.25

Observed People Injury Totals

	Fatal Injury (K)	Serious Injury (A)	Visible Injury (B)	Non-Visible (C)	Total
Observed People Injury Totals	0.0000	0.2500	0.7500	2.7500	3.75

Application Scoring

Category	Scoring Value	Points Awarded	Points Possible
Expected Crash Frequency	3.57	2	10
Ratio of Observed Fatal and Serious Injuries to Observed Total Crashes	0.02	1	5
% of the Potential for Safety Improvement to Total Expected Crashes	38.94%	20	20
Relative Severity Index	$23,033	2	10
Equivalent Property Damage Only Index	2.45	2	5
Volume to Capacity Ratio	0.75	5	10
Benefit Cost Ratio	1.25	6	30
Safety Funding Request Percentage	44.78%	10	10
Total		48	100

Strategic Highway Safety Plan

Functional Class	Other Principal Arterial Roadway
Major Route AADT	14,770
Ohio Emphasis Area	Emphasis Area V - Incident and Congestion Related Crashes
Ohio Emphasis Area Subcategory	Rear End Crashes
FHWA Emphasis Area	Improving the design and operation of highway intersections
FHWA Improvement Category	Intersection geometry
FHWA Improvement Subcategory	Splitter island - install on one or more approaches

Work Locations

NLFID	Begin Logpoint	End Logpoint	Begin Latitude	Begin Longitude	Location Termini (i.e. from Street 1 to Street 2)
SCHPUS00068**C	6.560	6.680	40.107	-83.7530	Market Street to Court Street
SCHPUS00036**C	14.880	15.050	40.108	-83.7540	Walnut Street to Locust Street

OHIO DEPARTMENT OF TRANSPORTATION

Safety Funding Application

Project Funding

Project Phase	Safety Study	Interchange Mod. Study	PE - Environmental	PE - Detailed Design	Right of Way /Utilities	Construction	Total
Fiscal Year	2016		2017	2018	2018	2019	
Project Phase Completed	☑	☐	☐	☐	☐	N/A	
Previous Safety							$0.00
New Safety			$23,130.00	$39,654.00		$345,294.00	$408,078.00
Sponsor Funding	$29,000.00		$20,670.00	$35,228.00		$73,933.00	$158,831.00
ODOT Urban Resurfacing			$6,200.00	$10,688.00		$92,884.00	$109,772.00
ODOT Small City						$234,574.00	$234,574.00
Total	$29,000.00	$0.00	$50,000.00	$85,570.00	$0.00	$746,685.00	$911,255.00

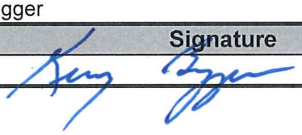
Additional Funding Detail

The City of Urbana also made application for an ODOT Small City grant on 2/24/16 to work in conjunction with funding from the ODOT Highway Safety grant. Urban Resurfacing has been requested for the extents of this project contingent on both grant applications being funded. Appropriate District 7 staff have been contacted to make this intention clear. If the Urban Resurfacing must be a separate PID and ODOT-let, the City recognizes that coordination will be imperative.

Project Development

Project Phase	Completed by	Completion Date
Safety Study	Kendra Schenk, PE, PTOE (Burgess and Niple)	2/24/2016

Applicant Information

Name	Title	Phone Number
Kerry Brugger	Director of Administration	937-652-4324
Signature		**Date**
		April 29, 2016

Version: 20150917

The following information should be included in submission of the safety project application:

1. An electronic copy of the Safety Engineering Study
2. All Excel Analysis Files
   May include Crash Analysis Module (CAM) Tool, Economic Crash Analysis Tool (ECAT), HSIP Application and Scoring Tool.
3. Benefit-Cost Results (Economic Analysis)
4. DSRT approval signatures

Tyler Bumbalough

From: Nichole Lawhorn <Nichole.Lawhorn@dot.state.oh.us>
Sent: Wednesday, February 24, 2016 4:57 PM
To: Tyler Bumbalough
Subject: 2016 Small City Project Application

Confirmation for form 2016 Small City Project Application

Submitted at 02/24/16 4:56 PM

Applicant/Project Sponsor:	City of Urbana
Name:	Tyler Bumbalough
Phone:	(937) 652-4324
Address:	205 S. Main Street Urbana, OH 43078
Fax, if applicable:	(937) 652-5145
Email:	tyler.bumbalough@ci.urbana.oh.us
Project PID:	
ODOT District:	7
County:	Champaign
Route:	US 36/US 68
Section:	14.88/6.56
Estimated Project Cost:	959641.00
Total Small City Funding Requested:	191662.50
Year Small City Funds Are Requested:	2019
Description:	The City of Urbana's purpose of this project is to make vehicular and pedestrian travel through Monument Square (US 36 and US 68 intersection) safer by decreasing entry/exit speeds, channelizing motorists and improving the visibility and overall safety of the pedestrian crosswalks (including the Miami/Walnut and Scioto/Locust intersections). Monument Square intersection was upgraded to a roundabout from a signalized intersection in September 2009. Though the injury and overall crashes have reduced since it operated as a signalized intersection, the crash frequency is still very high (21 per year) compared to an average urban roundabout (3 per year for single lane and 13 per year for multilane)

	Results of an intersection study, which included crash, capacity and alternatives analyses, indicate the following deficiencies with the present roundabout: no curbed islands for delineation including the inner circle (no truck apron), path overlap for the right-turn bypasses, sight distance obstruction for the right-turn bypasses based on the location of the yield lines, parking areas in the four corners which are not adequately separated from the travel lanes, obstructive loading/unloading zones for delivery trucks, and too great a distance for pedestrians to cross without a center refuge area and some type of pedestrian actuated warning to drivers. Major items of work will therefore include: curbing, traffic islands, truck apron, sidewalk and sidewalk bump-outs, ADA ramps, alley approach aprons, pedestrian actuated RRFBs, roadway lighting, landscaping, pavement planing, asphalt pavement and striping. In addition to ODOT Small Cities Funding, the City of Urbana will be applying for ODOT Safety Funding and has requested this project be added to the Urban Resurfacing docket if funded (for milling, asphalt and striping). Appropriate District 7 staff have been contacted to make this intention clear. If the Urban Resurfacing must be a separate PID and ODOT-let, the City recognizes that coordination will be imperative. Project termini: US 36 from Walnut Street to Locust Street to make the crosswalks there safer and US 68 from mid-100 block S. Main Street to mid-100 block N. Main Street to match the paving limits from a past Urban Resurfacing project. No right-of-way issues are anticipated and additional right-of-way should not be required. No environmental issues are anticipated, however this project is located in historic downtown Urbana, which is listed on the National Register of Historic Places. Excavation is limited to pavement, curb and sidewalk removal, catch basin realignment and lighting/landscaping installation.
Safety Engineering Study or Feasibility Study:	Safety Engineering Study or Feasibility Study
Date:	Feb 24, 2016
Comments:	Intersection study completed, including crash, capacity and alternatives analyses.
Environmental Process Phase:	
Date:	
Comments:	
Design Process Phase:	Design Process Phase
Date:	Feb 24, 2016
Comments:	Concept plan completed along with preliminary estimate.

Right-of-Way Process Phase:	
Date:	
Comments:	
Indicate the SINGLE category for which the application is being submitted:	Safety
ADT:	23904.00
Volume to Capacity:	0.75
Crash Rate:	2.48
Crash Frequency or Density (please indicate which is being provided):	65.00
Crash Frequency or Density:	Crash Frequency
Pavement Condition Rating (required for Roadway projects only):	0.00
Fiscal Year:	2017
Local Contribution:	16980.00
Other Sources*:	33020.00
Total Costs for Environmental:	50000.00
Fiscal Year:	2018
Local Contribution:	33222.80
Other Sources:	64531.20
Total Costs for Design:	97754.00
Fiscal Year:	2018
Local Contribution:	0.00
Other Sources:	0.00
Total Costs for Right-of-Way:	0.00
Fiscal Year:	2019
Small City Request (80% of the Federally eligible amount):	147264.00
Toll Revenue Credit (15% of the Federally eligible amount):	27612.00

Total Small City Funds Requested (Small City Request + Toll Revenue Credit):	174876.00
Local Contribution:	76118.00
Other Sources:	487756.00
Total Costs for Construction:	738750.00
Fiscal Year:	2019
Small City Request (80% of the Federally eligible amount):	14136.00
Toll Revenue Credit (15% of the Federally eligible amount):	2650.50
Total Small City Funds Requested (Small City Request + Toll Revenue Credit):	16786.50
Local Contribution:	7574.90
Other Sources:	48775.60
Total Costs for Construction Engineering:	73137.00
Total Local Contribution:	133895.70
Total Other Sources:	634082.80
Total Small City Request:	191662.50
Total Project Costs:	959641.00
Identify all sources of Local Contribution and Other Sources fields:	Local contribution will be from the City of Urbana Capital Improvements fund. Other funds include ODOT Urban Resurfacing (80/20) and ODOT Safety Funding (90/10) contingent on approval.
Explain the systematic evaluation undertaken to assess various initial project scopes and alternatives, cost estimates, and environmental and/or community impacts.:	Regarding the US 36/US 68 intersection, the City of Urbana has received mostly positive feedback since converting the intersection from signalized to a roundabout in 2009. The lingering issues are pedestrian safety and control of vehicle speeds and location. In January 2016, Burgess and Niple was selected to develop a preliminary concept and engineer's estimate for improvements to be made. In reaching these two outcomes, Burgess and Niple performed peak traffic counts, developed design hourly volumes for 2016 and 2036, performed a crash analysis spanning the past three years, performed a capacity analysis on alternatives and evaluated the geometric deficiencies of the current roundabout. A public meeting was held 2/1/16 to discuss the preferred alternative

	and receive feedback from community stakeholders about the current operation and future design of the downtown roundabout. Most public comments centered around traffic calming and pedestrian safety. Many of the public comments were taken into consideration and designed into the project concept. Burgess and Niple then created a technical memo, preferred alternative graphic and engineer's estimate by 2/24/16.
What other types of solutions have been considered for this project?:	During the previous intersection conversion in 2009, the "do nothing" alternative was evaluated to leave the intersection signalized. In any 75 second signal cycle, 16 seconds was all red time due to the large geometric footprint of the intersection. The better option from a safety and efficiency standpoint at that time was to convert to a roundabout. The alternative evaluation this time looked at whether to remove the right lane bypass in all directions or not.
Why was this alternative selected?:	LOS was greatly diminished if the right lane bypasses were eliminated, so the preferred alternative remained a single lane roundabout with two entrance lanes (left/through and right) in all four directions.
What are the forecasted impacts if this project is not awarded?:	The crash rates will continue to be very high. Three of the injury crashes reported at this intersection were vehicle/pedalcycles. If that rate continues, a serious injury or fatality could occur.
Signature:	 Direct Link to Image
Print Name of Submitter:	Kerry Brugger
Print Title of Submitter:	Director of Administration
Relative Severity Index:	View File
Photographs of Project Site:	View File
Proposed Preliminary Studies:	View File
Project Scope:	
Project Schedule:	
Project Cost Estimate:	View File
Project Plans:	View File
Other Attachments:	View File
Other Attachments:	View File