Evaluation of Special Event Traffic Management: The Brickyard 400 Case Study

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August 1, 2008

TRB Paper 09-1730

Word Count: 2250 words + 15 x 250 words/Figure-Table = 6000 words

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ABSTRACT

This paper reports on the anonymous tracking of Bluetooth enabled consumer electronic devices to measure the travel time, or space mean speed, of travelers. This sampling technique was deployed at six interstate locations and two signalized arterials in the Indianapolis, IN metropolitan area the week of the NASCAR Brickyard 400. The week prior to the race before data was also collected from a subset of those sites. The day of the race, almost 19,000 unique MAC address were captured at the eight locations. From that information real-time travel time estimates were provided to Indiana Department of Transportation (INDOT) mobile data terminals. After the race, the data was processed to obtain travel time plots and origin destination matrixes to provide a quantitative evaluation of race day traffic management operations. Selected reports and charts from that analysis are discussed in the paper.

INTRODUCTION

The Indianapolis Motor Speedway (IMS) was built as an automobile testing facility in 1909 with the first 500 mile race held in 1911. Since that time, the 2.5 mile oval track facility has evolved into a facility that seats 257,000 spectators and has over a 1 billion dollar economic impact on Indiana. The Indianapolis 500 and Brickyard 400 are attended by over 400,000 spectators, making them the two largest single day sporting events in the world.

The first efforts at managing traffic attending this facility begin in 1947 and evolved into an extensive effort involving over 700 law enforcement and transportation officials today. This paper reports on a novel travel time monitoring technique implemented for assessing and improving the race traffic management operations.

TRAVEL TIME MONITORING CONCEPTS

Travel time is one of the oldest performance measures used to characterize an arterial or freeway system. The first direct measurement of travel times were based upon license plate matching techniques (1) in vehicle notes, mechanical devices attached to odometers (2), and then Global Positioning System (GPS) recording devices (3). More recently, cell phone and toll tag tracking has been proposed as a mechanism for collecting probe vehicle link travel times (4, 6). A variety of statistical techniques have been published that document techniques for estimating sample size or sample proportion necessary for reliably estimating travel time (2, 6, 7). In the past few months the tracking of consumer electronic devices has been proposed for measuring travel time across a variety of modes

(8) by matching MAC addresses acquired from Bluetooth radios. This paper reports on the use of this technology for monitoring travel time along selected routes for spectators travelling to and from the Brickyard 400 events at the Indianapolis Motor Speedway.

TRAFFIC MANAGEMENT CHALLENGES AND DATA COLLECTION

The IMS facility is located approximately 2 miles East of the west leg of I-465 (Figure 1). Virtually the entire I-465 corridor between I-1 and I-5 (Figure 1) was an active construction zone during this study, with the segment between I-1 and I-3 having 11' travel lanes. With 400,000 fans expected, there was significant planning devoted to ensuring smooth ingress and egress as well as real-time management of INDOT facilities on race day.

Prior to the race, several permanent and temporary traffic monitoring sites were identified for collecting a variety of traffic data (Figure 1). Sites I-1, I-2, I-3, I-4 and I-5 are located along the I-465 and site I-6 is along the I-65 corridor. Both of these facilities are managed by INDOT. Sites A-1 and A-2 are located adjacent to signalized arterials in the town of Speedway adjacent to the Indianapolis Motor Speedway (IMS). These sites were selected based upon their proximity to the IMS, I-465, and expected travel patterns of motorists arriving from the North and West.

The week prior to the race (July 18-20, 2008) baseline speed and volume were collected at sites I-3 and I-6 as well as Bluetooth MAC addresses at Sites I-1, I-2, I-3, A-1 and A-2. During race day, additional data collection sites I-4; I-5, and I-6 were deployed to acquire MAC addresses. Photographs of the monitoring equipment used to acquire MAC addresses at selected sites are shown in Figure 2. Figure 2a and Figure 2b show the battery powered University of Maryland data collection device installed at station A-1 adjacent to the travel lane. Figure 2c shows an INDOT data collection station (I-2) mounted on a wood pole. The Bluetooth antenna can be seen attached to the second ladder rung above the pole mounted cabinet in an active construction site approximately 100 feet from the nearest I-465 travel lane.

VOLUME AND SPEED CHARACTERISTICS OF STUDY AREA

Figure 3a and Figure 4a document the traffic flow rate and speed at site I-6 during the before period – July 18-20. Similarly, Figure 3b and Figure 4b document the traffic flow rate and speed at site I-6 during the weekend with race activity – July 18-20. The volumes figures (Figure 3a) illustrate fairly typical Friday, Saturday, Sunday characteristics the weekend prior the race. The weekend of the race (Figure 3b) one can clearly see the Southbound volume

peaking just before noon and the strong peaking of the Northbound volume just after 1800. The speeds indicate uncongested conditions, except for a brief incident on July 25, 2008 (Figure 4b).

Figure 5 and Figure 6 follow a similar structure for characterizing site I-3. The I-3 site is in the middle of an active construction zone and as a result the volumes and speeds only reflect measurement from two of the three lanes. However, even with reduced lane sampling, Figure 5a and Figure 5b, illustrate influence the advance signing used by INDOT to direct Chicago bound traffic on I-74 and I-65 to take the East leg of I-465, instead of the West leg during the Brickyard 400 event. In addition, the peaks associated with inbound and outbound to/from the IMS are clearly evident in Figure 5b. Figure 6a indicates the week prior the race had some minor variations in the speed. Figure 6b show similar characteristics, but also an incident in the Southbound direction on July 25, 2008 just before 1800.

TRAVEL TIME CHARACTERISTICS

As indicated in the introduction, MAC address matching (8) was used to estimate travel time between stations identified in Figure 1. Table 1 summarizes the MAC address hits for those stations on the Sunday before the race and the Sunday of the race. Table 2 shows examples of real-time travel times computed by taking the difference between time stamps on matching MAC addresses identified at different sites. This data was available on mobile data terminals of INDOT officials managing traffic operations. This data was not filtered and allowed the display of up to three hours. This required human operators to mentally filter the data. In examining the data it is clear there are two outliers at time 19:45, 19:25, 19:10 and 18:50. The remainder of the data points are clearly in the feasible range.

In regards to post-processing of the data to analyze operations, Figure 7 illustrates the match rate by time of day between sites I-1 and I-2. Figure 8 and Figure 9 illustrate the before and after travel time for two alternative paths to the IMS. Specifically,

- Figure 8 shows the travel time for vehicles traversing the path defined by I-1; I-2; and A-1 shown on Figure 1. Positive numbers are indicative of Northbound vehicles traversing the path A-1 to I-2 to I-1. The negative numbers are indicative of Southbound vehicles traversing the path I-1 to I-2 to A-1.
- Figure 9 shows the travel time for vehicles traversing the path defined by I-1; I-2; I-3 and A-2 shown on Figure 1, following the same convention for positive and negative values for Northbound and Southbound directions, respectively.

Both of these paths span interstate and signalized arterial segments Both Figure 8b and Figure 9b clearly quantify the increased travel time associated with the

incident on Friday evening as well as the increased travel times to/from stations A-1 and A-2.

Figure 10 illustrates the only large increases in travel time associated with the race. In this case, virtually all of the Northbound motorists elected to Exit at the 10th street ramp adjacent to Station I-4, despite message signs advising them to proceed to Crawfordsville Road (Station I-3). As a result, the 10th street arterial begin backing up on the interstate (Figure 11a) and severely restricting all Northbound traffic on I-465 (Figure 11b). INDOT dispatched a crew to temporarily close the ramp (Figure 11c) and the queuing quickly dissipated (Figure 11d).

When comparing Figure 8a with Figure 8b (as well as Figure 9a with Figure 9b) it is apparent there are many more samples in the second week of data collection. This is due to the improved data collection equipment deployed at sites I-2 and I-3 capable of faster MAC address acquisition and perhaps the increase in Bluetooth devices during race weekend. Also, when comparing the number of Northbound and Southbound samples in Figure 8b and Figure 9b the Southbound direction clearly has a larger sample size. This is most likely an artifact of the Bluetooth antennas as sites I-2 and I-3 being mounted on the West side of the interstate, thus the Southbound traffic was closest to the antenna at those sites.

ORIGIN-DESTINATION CHARACTERISTICS

In addition to collecting link data, MAC address matching can be used to estimate origin destination matrixes. Table 3a shows the O-D matrix during pre-race period. Table 3b shows the minimum observed travel time during the pre-race period and Table 3c shows the average travel time during the pre-race period. Table 4a,b and c show the same information for the post-race period. By inspection, one can see the shift from sites adjacent to the track (sites A-1 and A-2) being destinations before the race, to being origin points after the race.

CONCLUSION

This paper illustrated how MAC address tracking can be used to assess traffic management strategies used for large special events. In this case, the traffic assignment strategies developed over several years were found to work exceptionally well, with the exception of one ramp problem that was quickly addressed through established diversion practices. The larger four lane arterial servicing parking lots adjacent to station A-2 was found to work almost as well, with some brief periods of delays extending up to 10 minutes. The smaller roads and denser signal network servicing parking lots adjacent to station A-1 were observed to experience larger delays, on the order of 20 minutes for longer periods of time.

These results indicate that there is significant promise for real-time management of special event traffic entering multiple parking lots from multiple routes, particularly for venues that do not have as mature of traffic management strategies as the Brickyard 400.

Finally, the dynamic message signs used to route I-74 and I-65 traffic around the East side of I-465 were found to be effective at reducing the Northbound through traffic on I-465 (Figure 5) on race day. A future study is planned with MAC address tracking to estimate the proportion of motorists that conform to those advisory signs.

ACKNOWLEDGEMENTS

This work was supported in part by the Indiana Department of Transportation, the University of Maryland and Purdue University. The contents of this paper reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policies of their respective organizations. These contents do not constitute a standard, specification, or regulation.

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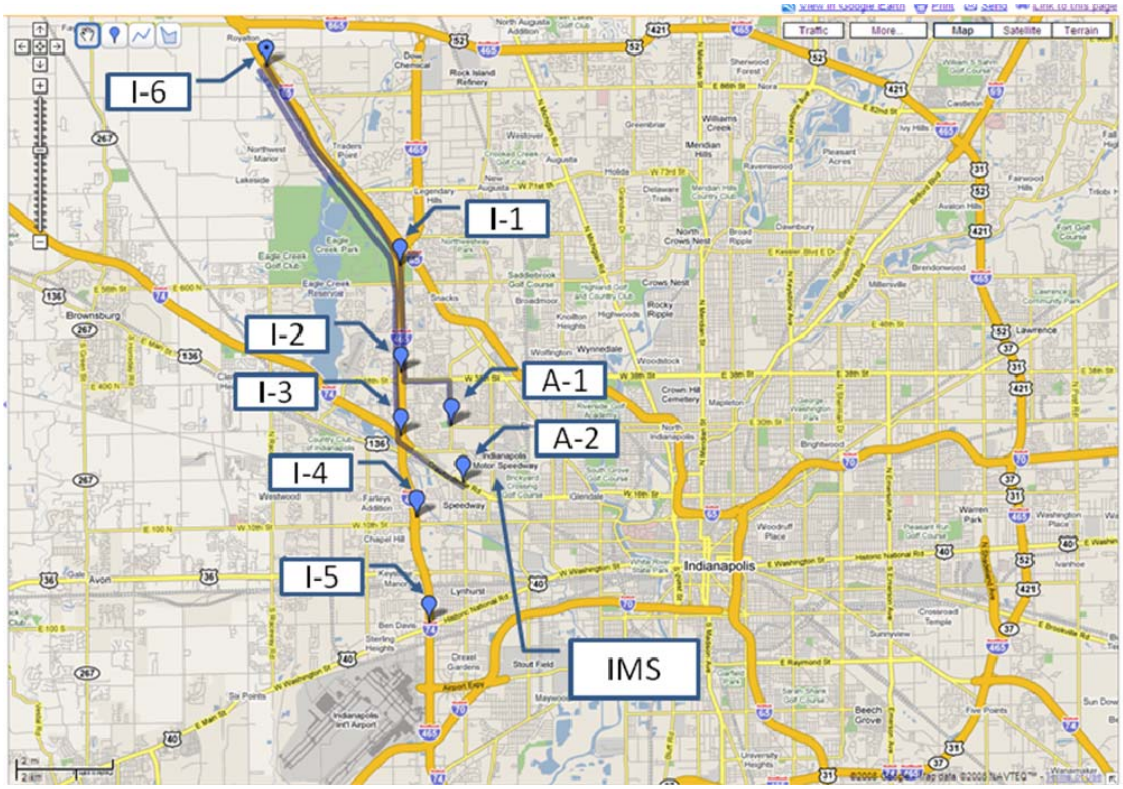
FIGURES



Site Code	Data Collected July 18-20, 2008	Data Collected July 25-27, 2008	Location
I-1	MAC Address	MAC Address	I-465 (Exit 20) at I65, Median between I-465 lanes
I-2	MAC Address	MAC Address	I-465 (Exit 17) at 38th Street, Northwest Quadrant
I-3	MAC Address, Speed, and Volume	MAC Address, Speed, and Volume	I-465 (Exit 16) at I74, Northwest Quadrant
I-4		MAC Address	I-465 (Exit 14) at 10th Street Northeast Quadrant
I-5		MAC Address	I-465 (Exit 12) at Washington Street, Northwest Quadrant
I-6		MAC Address, Speed and Volume	I-65 (MM 127.8)
A-1	MAC Address	MAC Address	Moller Road at W. 30th Street, West side of T-Intersection
A-2	MAC Address	MAC Address	North Lyndhurst Drive at Crawfordsville Road, West approach

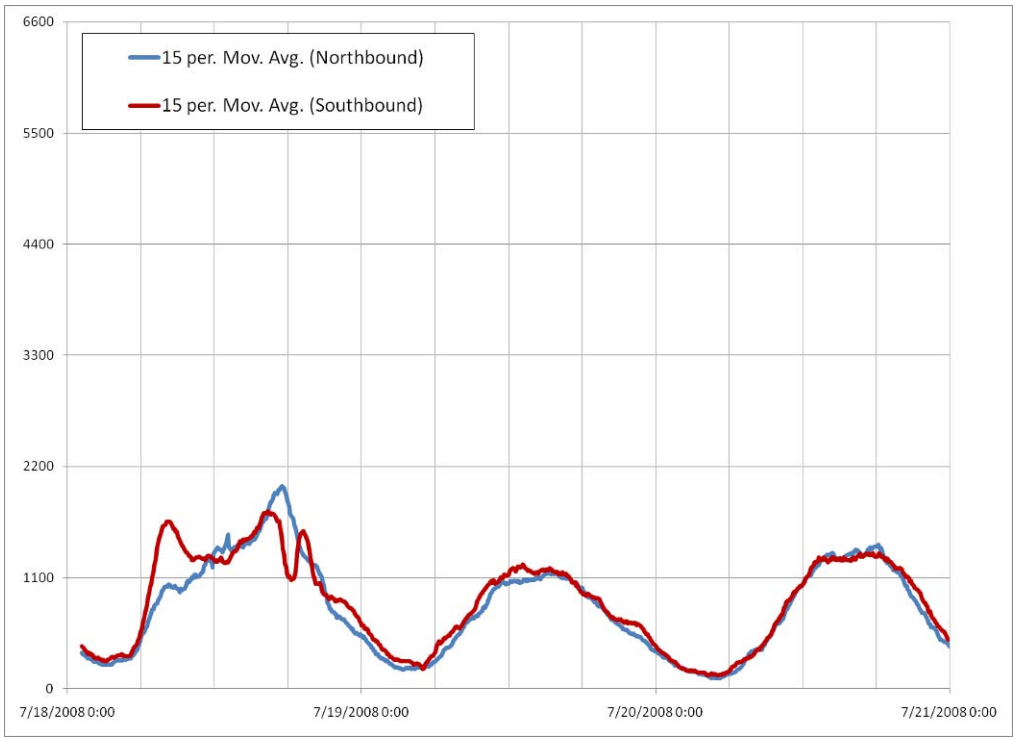
Figure 1: Travel time monitoring stations along principal routes on West side of Indianapolis.

a) University of Maryland mobile data collection equipment at site A-2.

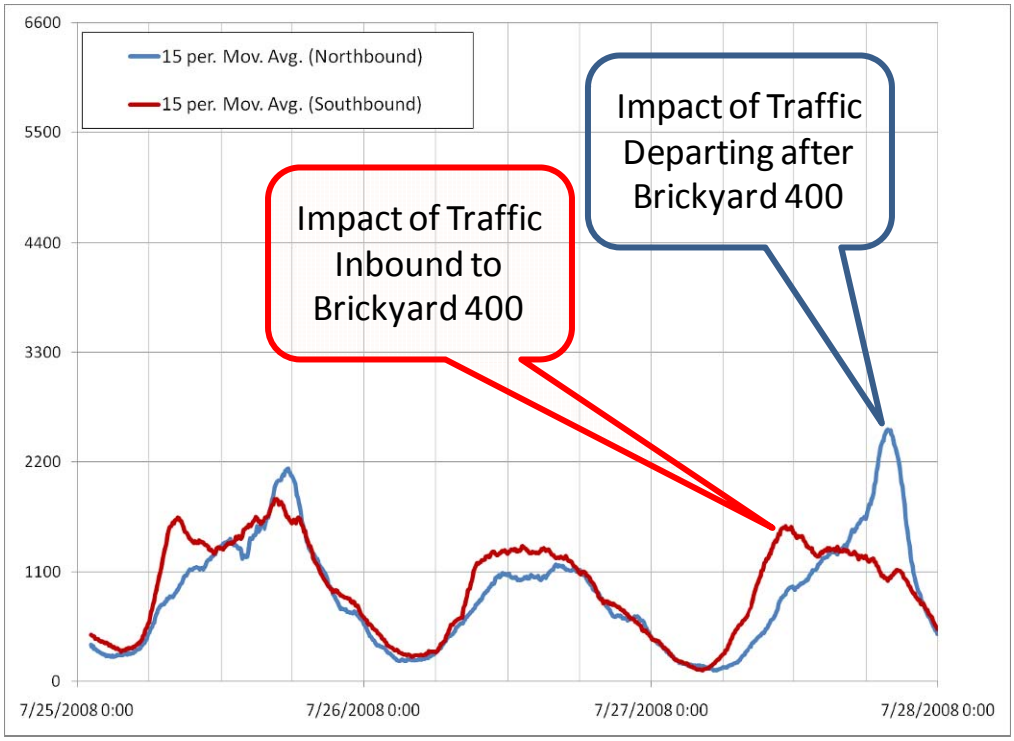
b) Site A-2 mobile equipment installed adjacent to sign.

c) INDOT Monitoring Site I-2, adjacent to I-465.

Figure 2: Photographs of data collection equipment at selected sites.

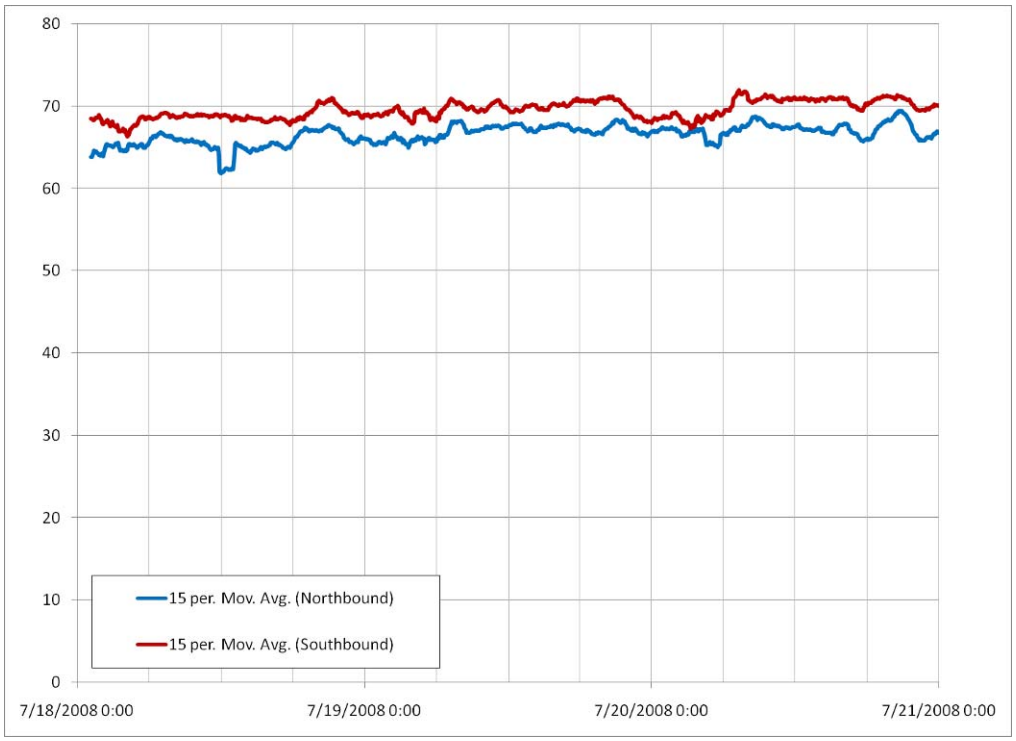


a) July 18-20, 2008

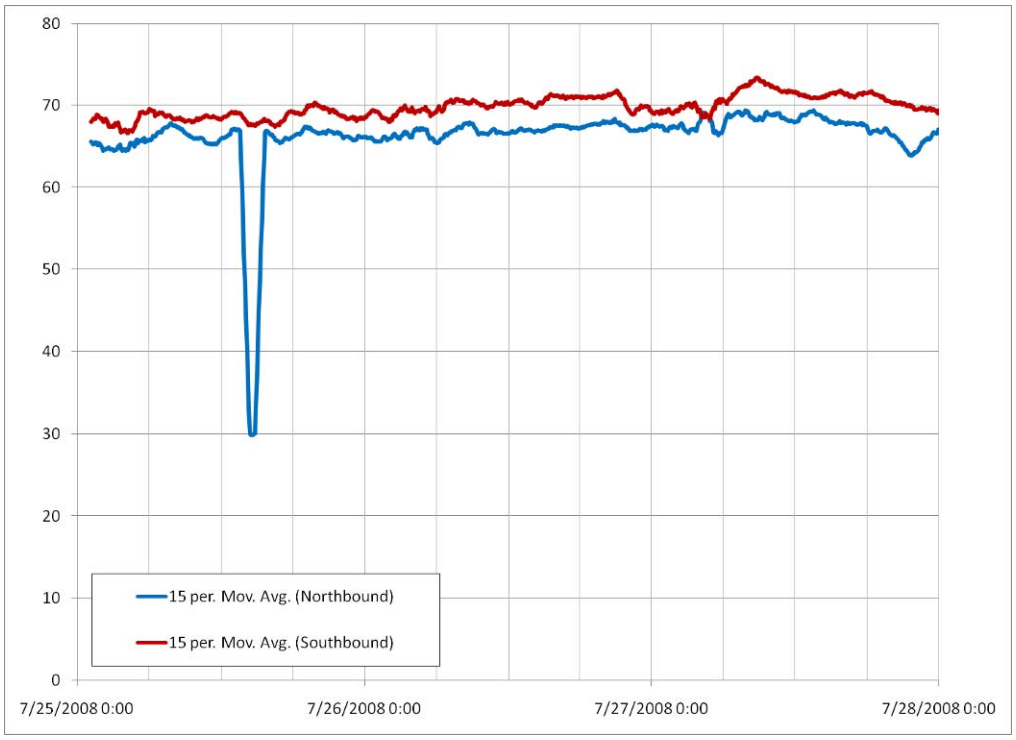


b) July 25-27, 2008

Figure 3: Traffic flow rate (vph) at MM 127.8 on I-65 (Site I-6) where Southbound flow is influenced by Inbound IMS Traffic and Northbound flow is influenced by Outbound IMS Traffic.

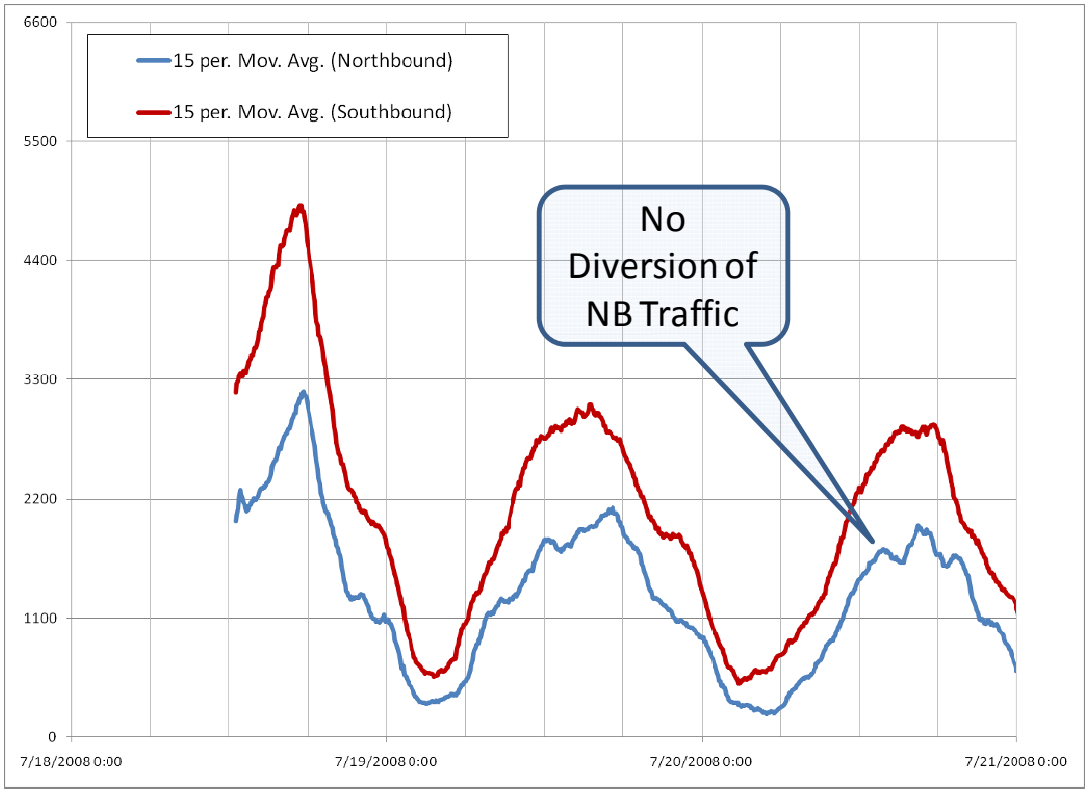


a) July 18-20, 2008

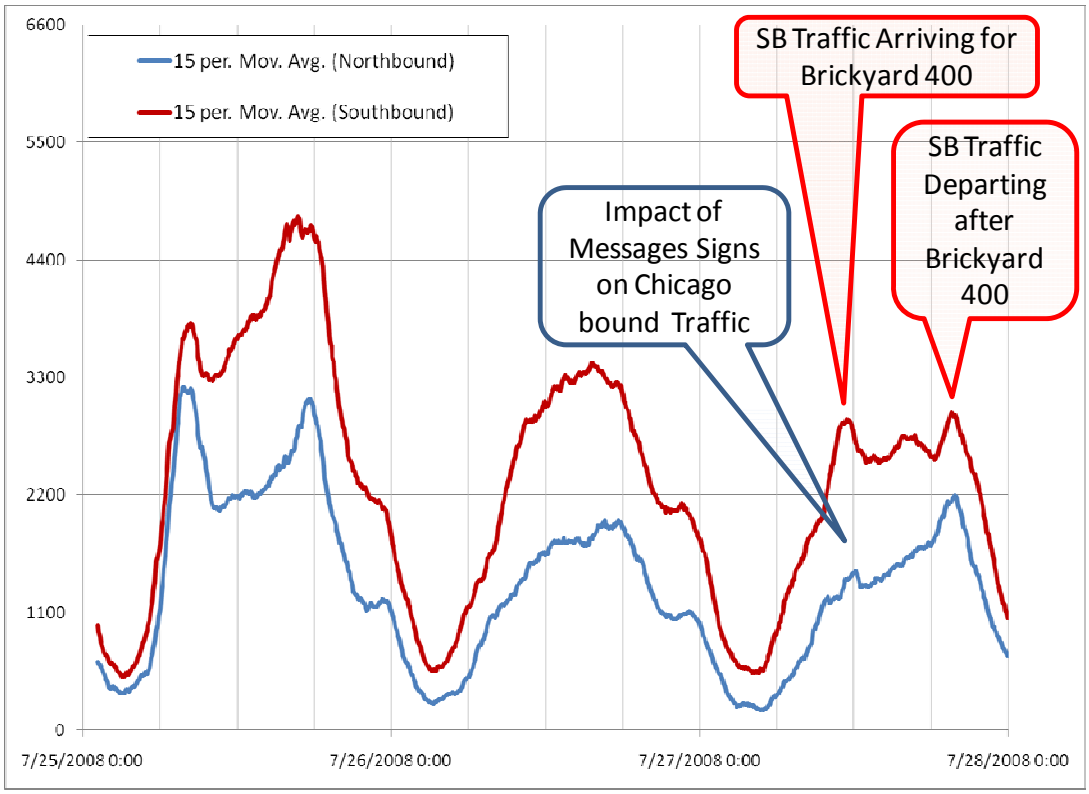


b) July 25-27, 2008

Figure 4: Average speed (mph) at I-65 MM 127.8

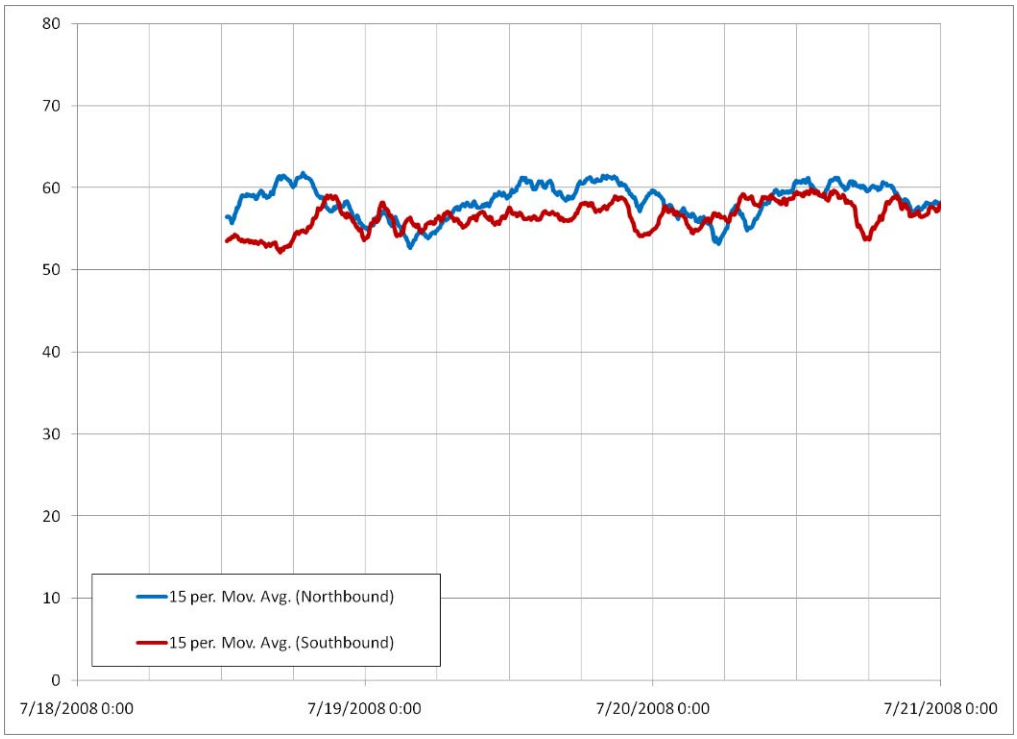


a) July 18-20, 2008

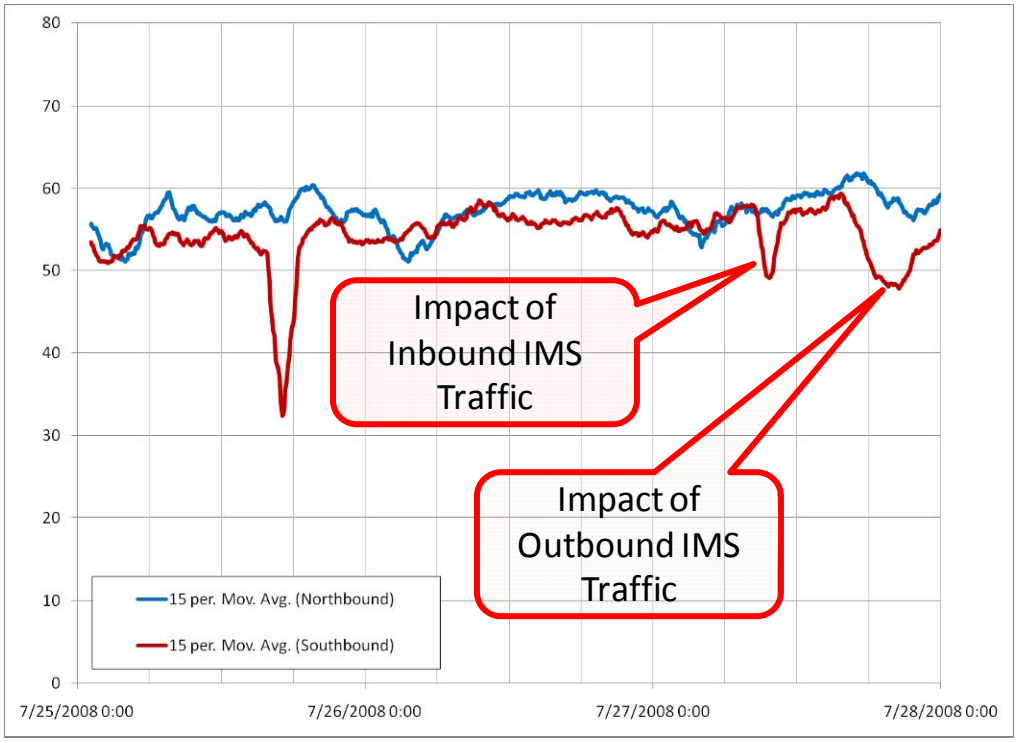


b) July 25-27, 2008

Figure 5: Traffic flow rate (vph) at Exit 16 on I-465 (Site I-3)



a) July 18-20, 2008



b) July 25-27, 2008

Figure 6: Average speed (mph) at Exit 16 on I-465 (Site I-3)

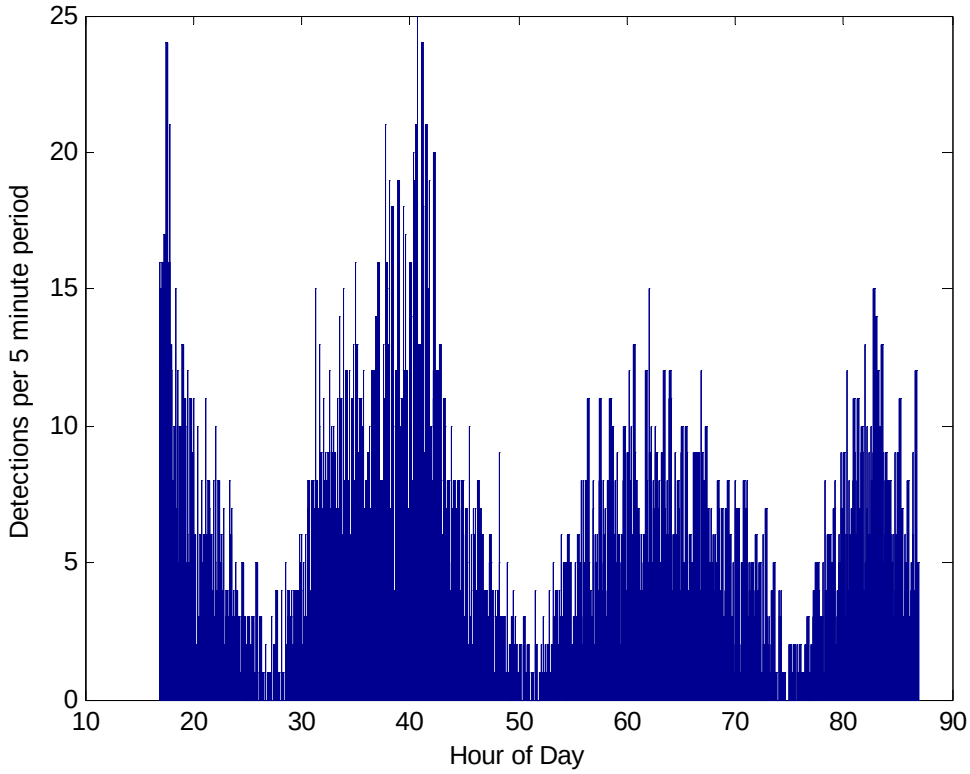
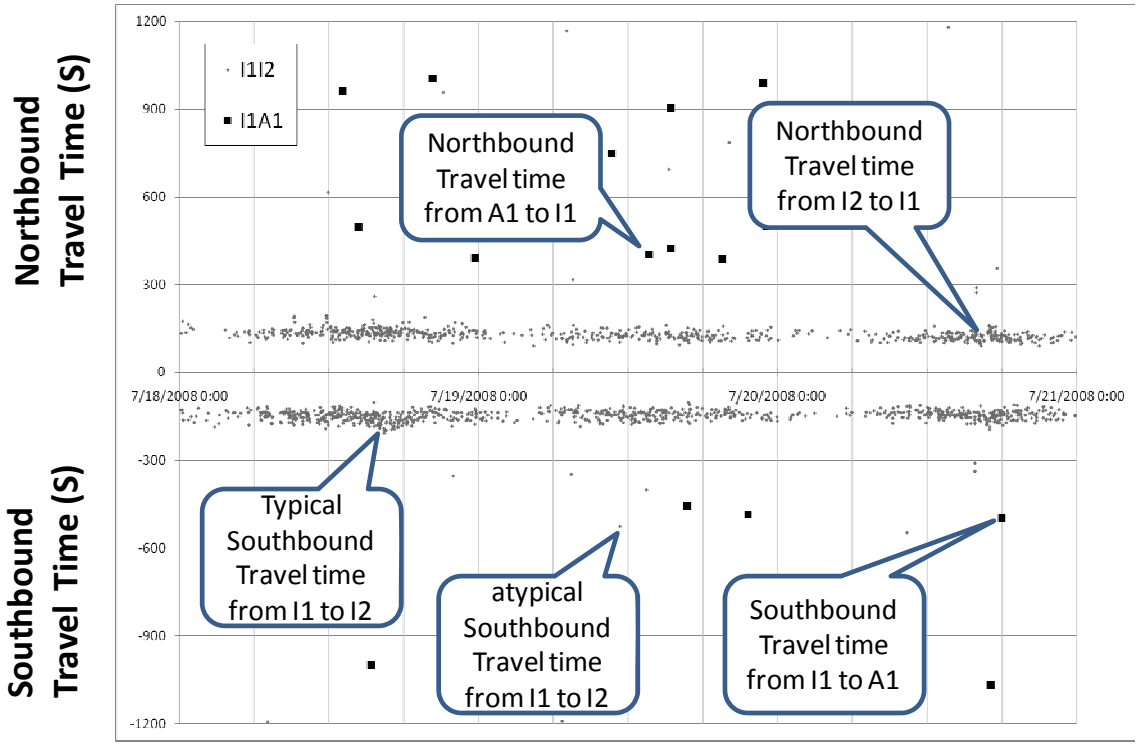
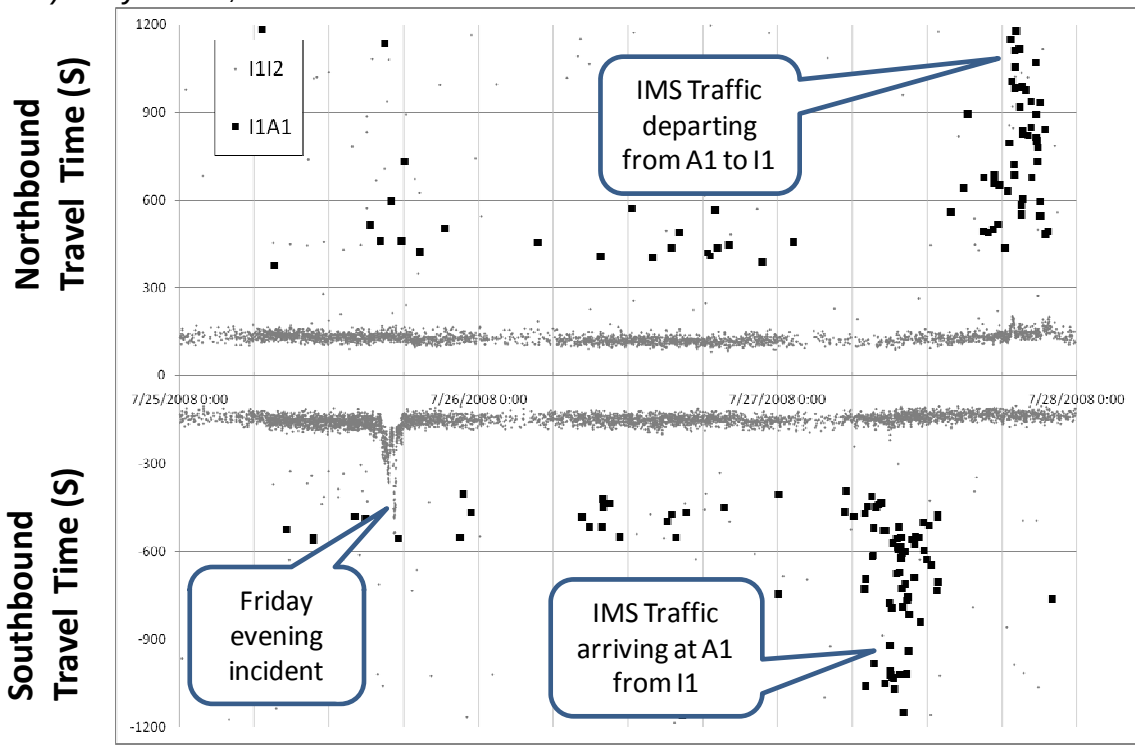


Figure 7: Match Rate from I1 to I2 vs. Time (total matches 5094) for units deployed at 1700 on July 24, 2008 (Hour 17 in plot) and retrieved at 0800 on July 28, 2008 (Hour 87 in plot)

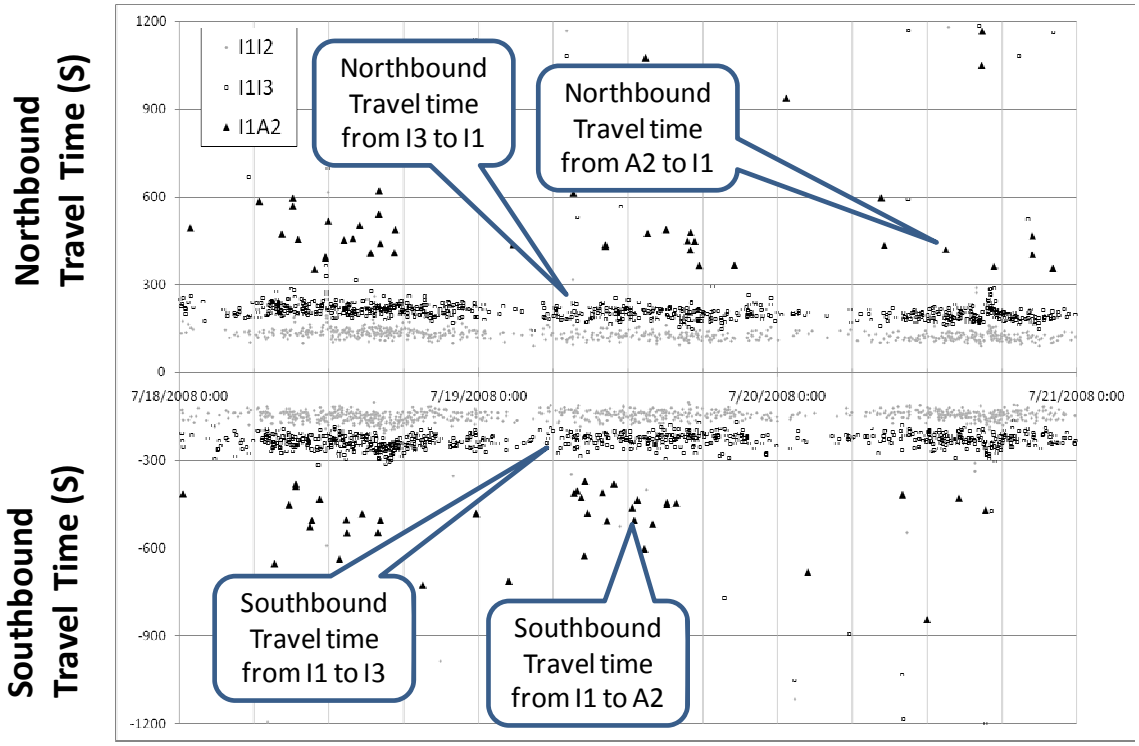


a) July 18-20, 2008

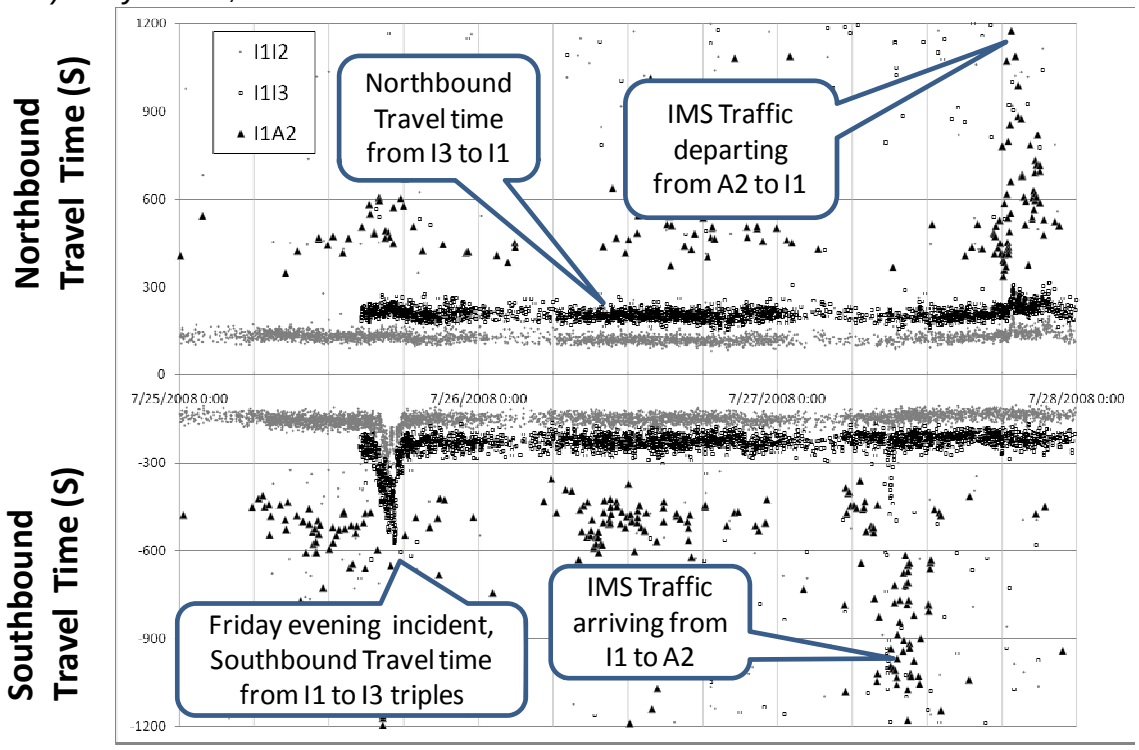


b) July 25-27, 2008

Figure 8: Travel Time Plot: Stations I-1, I-2, A-1



a) July 18-20, 2008



b) July 25-27, 2008

Figure 9: Travel Time Plot: Stations I-1, I-2, I3, A2

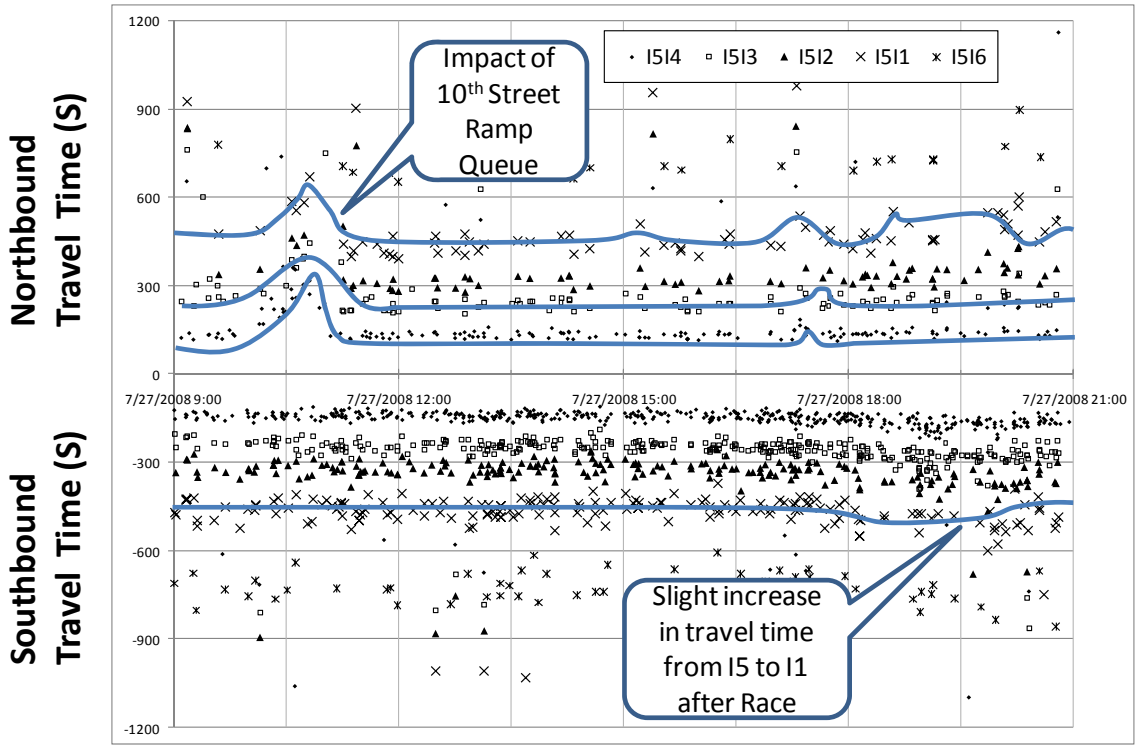


Figure 10: Travel Time Plot: Stations I-5, I-4, I-3, I-2, I-1, I-6 on July 27, 2008 from 0900 to 2100.

a) 10: 25: Ramp queue causing 2 mile backup on I-465 across all three lanes

b) 10: 35: NB I-465 flow highly restricted by exit ramp queue

c) 10: 44: NB I-465 Ramp Closed

d) 11:05: NB I-465 queue cleared, I-465 freeflowing and ramp reopening

Figure 11: Images of 10th Street Exit Queue and Impact on I-465

TABLES

Table 1: Summary of MAC Addresses acquired at study sites.

	Sunday July 20th 2008		Sunday July 27th 2008	
Site Code	Hits	Unique Hits	Hits	Unique Hits
I-1	3476	2499	4270	3094
I-2	4162	1826	14729	2806
I-3	4388	1951	15400	3666
I-4	--	--	16989	3367
I-5	--	--	2918	1183
I-6	--	--	10750	2557
A-1	2446	583	4470	1179
A-2	608	399	13430	1111

Table 2: Example Real-Time Travel Time Data Screen available on mobile data terminals on race day (Station I-3 to I-6)

Date	Last Data		Computed Travel Time for Size	Matching MAC Adddresses		
2008-07-27	19:55:00	2	08:19	08:25		
2008-07-27	19:50:00	2	08:07	08:09		
2008-07-27	19:45:00	3	08:36	08:44	**52:30**	
2008-07-27	19:40:00	1	08:32			
2008-07-27	19:35:00	1	08:49			
2008-07-27	19:30:00	3	08:54	09:35	09:44	
2008-07-27	19:25:00	2	08:05	**86:48**		
2008-07-27	19:20:00	0				
2008-07-27	19:15:00	0				
2008-07-27	19:10:00	2	08:31	**142:22**		
2008-07-27	19:05:00	1	138:25			
2008-07-27	19:00:00	0				
2008-07-27	18:55:00	0				
2008-07-27	18:50:00	4	08:10	08:18	08:55	**41:21**
2008-07-27	18:45:00	1	08:34			
2008-07-27	18:40:00	3	07:52	08:23	08:25	
2008-07-27	18:35:00	1	08:21			
2008-07-27	18:30:00	0				
2008-07-27	18:25:00	4	07:54	07:59	08:00	09:16
2008-07-27	18:20:00	1	08:53			
2008-07-27	18:15:00	1	08:53			

Table 3: MAC address Origin Destination Table for July 27, 2008 10:00– 14:00

	Destination Site Code							
Origin Site Code	I-6	I-1	I-2	I-3	I-4	I-5	A-1	A-2
I-6		32	29	28	27	9	0	0
I-1	88		158	160	151	37	2	1
I-2	99	368		159	135	31	2	2
I-3	70	259	292		236	43	5	10
I-4	43	184	207	264		79	4	7
I-5	22	73	84	104	167		2	4
A-1	12	37	35	34	35	1		16
A-2	26	53	55	63	58	7	6	

a) Number of Matches

	Destination Site Code							
Origin Site Code	I-6	I-1	I-2	I-3	I-4	I-5	A-1	A-2
I-6		251	362	429	517	653	0	0
I-1	231		95	162	258	394	559	515
I-2	334	106		58	153	277	684	367
I-3	403	171	64		86	206	438	170
I-4	491	264	143	70		112	551	279
I-5	615	405	281	208	113		704	470
A-1	820	477	333	373	421	859		233
A-2	905	460	335	256	258	584	719	

b) Minimum travel time (in seconds)

	Destination Site Code							
Origin Site Code	I-6	I-1	I-2	I-3	I-4	I-5	A-1	A-2
I-6		430	666	689	757	995	0	0
I-1	342		359	449	484	872	1180	515
I-2	451	235		354	404	574	1168	448
I-3	556	385	253		306	569	750	279
I-4	672	569	397	265		451	616	370
I-5	833	601	470	349	208		707	538
A-1	1212	773	762	790	968	859		594
A-2	1431	1086	1027	872	1047	2065	1328	

c) Mean travel time (in seconds)

Table 4: MAC address Origin Destination Table for July 27, 2008 1800–2200

	Destination Site Code							
Origin Site Code	I-6	I-1	I-2	I-3	I-4	I-5	A-1	A-2
I-6		119	97	81	55	13	18	14
I-1	58		359	328	252	30	49	56
I-2	66	263		345	240	41	32	48
I-3	51	204	258		325	45	26	138
I-4	46	185	234	466		61	27	64
I-5	16	41	58	142	172		8	25
A-1	0	1	3	1	3	0		1
A-2	1	2	2	5	3	0	15	

a) Number of Matches

	Destination Site Code							
Origin Site Code	I-6	I-1	I-2	I-3	I-4	I-5	A-1	A-2
I-6		256	384	460	557	691	820	605
I-1	241		112	183	275	410	437	337
I-2	345	104		64	158	291	302	219
I-3	422	166	64		77	218	392	140
I-4	517	253	147	80		118	510	270
I-5	668	393	301	222	132		700	427
A-1	-	2063	1085	1335	1192	-		203
A-2	712	449	318	187	270	-	142	

b) Minimum Travel Time (in seconds)

	Destination Site Code							
Origin Site Code	I-6	I-1	I-2	I-3	I-4	I-5	A-1	A-2
I-6		287	442	593	662	1165	1369	1193
I-1	328		239	373	502	860	1002	809
I-2	420	238		229	340	778	979	635
I-3	544	449	269		291	637	895	582
I-4	652	524	376	239		437	1197	734
I-5	774	498	449	362	243		1037	1037
A-1	-	2063	1963	1335	1553	-		203
A-2	712	462	324	361	1016	-	1009	

c) Mean Travel Time (in seconds)