Selected Bluetooth Probe Data Applications

Jay Wasson & Jim Sturdevant,
Indiana Department of Transportation

Chris Day, Ross Haseman, Tom Brennan, Alex Hainen & Darcy Bullock
Purdue University School of Civil Engineering

References

Multimodal with vehicle, shuttle, and ped. modes

- Day, C.M., R.J. Haseman, H. Premachandra, T.M. Brennan, J.S. Wasson, J.R. Sturdevant, and D.M. Bullock, "Visualization and Assessment of **Arterial Progression** Quality Using High Resolution Signal Event Data and Measured Travel Time," Transportation Research Board Paper ID:10-0039, January 2010.
- Bullock, D.M., R.J. Haseman, J.S. Wasson, and R. Spitler, "Anonymous Bluetooth Probes for **Airport Security Line Service** Time Measurement: The Indianapolis Pilot Deployment," Transportation Research Board Paper ID:10-1438, January 2010.
- Haseman, R.J., J.S. Wasson, and D.M.Bullock, "Real Time Measurement of **Work Zone Travel Time Delay** and Evaluation Metrics," Transportation Research Board Paper ID:10-1442, January 2010.
- Wasson, J.S., J.R. Sturdevant, D.M. Bullock, "**Real-Time Travel Time Estimates Using MAC Address Matching**," *Institute of Transportation Engineers Journal*, ITE, Vol. 78, No. 6, pp. 20-23, June 2008.
- **Airport device follows fliers' phones, USA Today, Page 1, March 23, 2010** http://www.usatoday.com/tech/wireless/2010-03-23-cellphones_N.htm

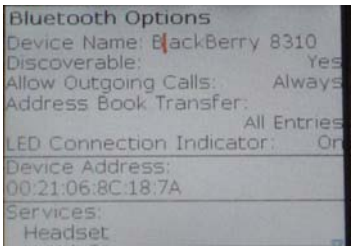
1. Freeway Construction Work zones
2. Traffic Signal Timing
3. Origin Destination
4. Airport Security Wait Times (Pedestrian)

Performance Measure Concepts

- Travel Time is a important performance measure for both arterials and freeways
- Travel Time data can identify transportation links with performance challenges
- Travel Time data needs to be complimented by high quality operations oriented data for identifying corrective actions.
  - i.e. High resolution traffic signal controller data is needed to identify corrective actions

Concept

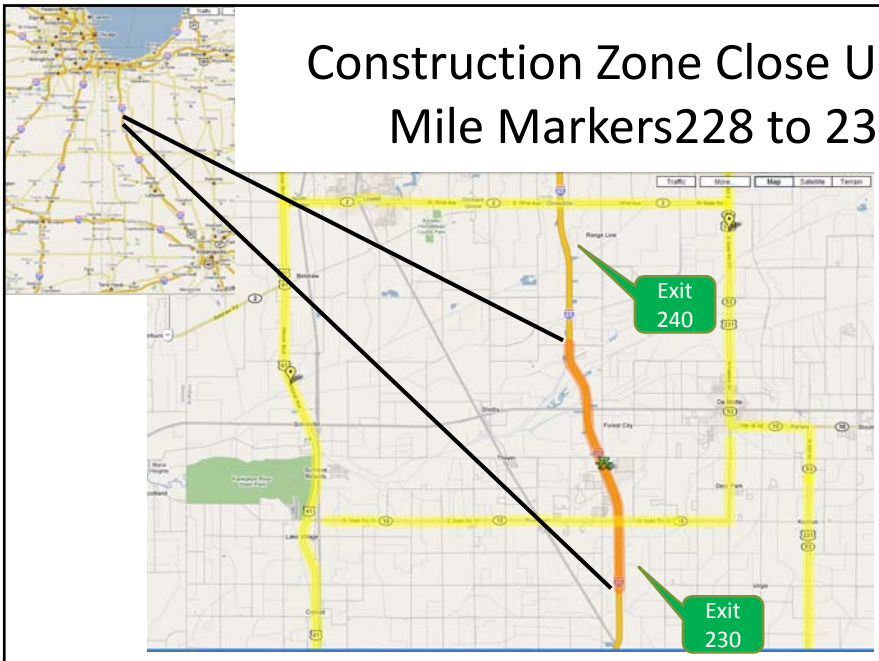
- **Bluetooth**: a wireless protocol utilizing short-range communications technology facilitating data transmission over short distances from fixed and/or mobile devices
- **MAC Address**: a 48 bit (>28 trillion) unique **address** assigned to a device by its manufacturer.



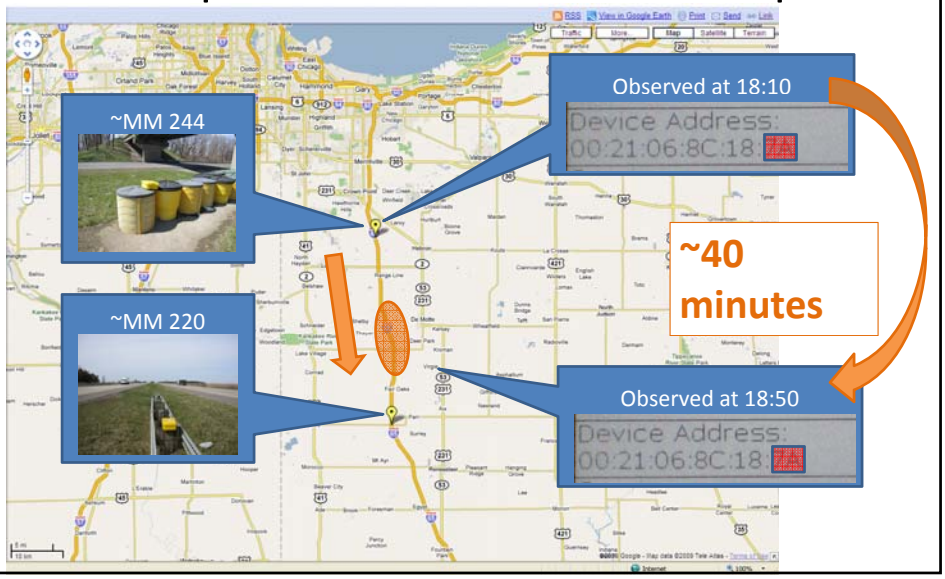
I-65 Construction Zone Travel Times

Mile Markers 228 to 235 (Lake, Newton, Jasper)

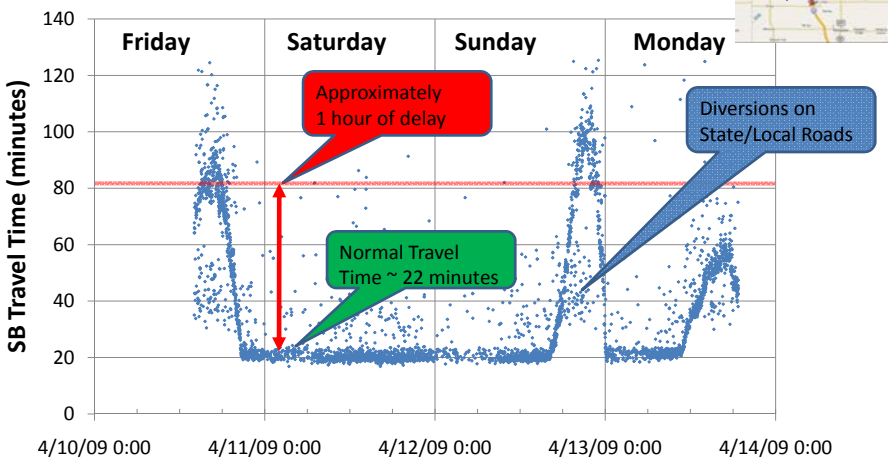
Construction Zone Close Up
Mile Markers228 to 235



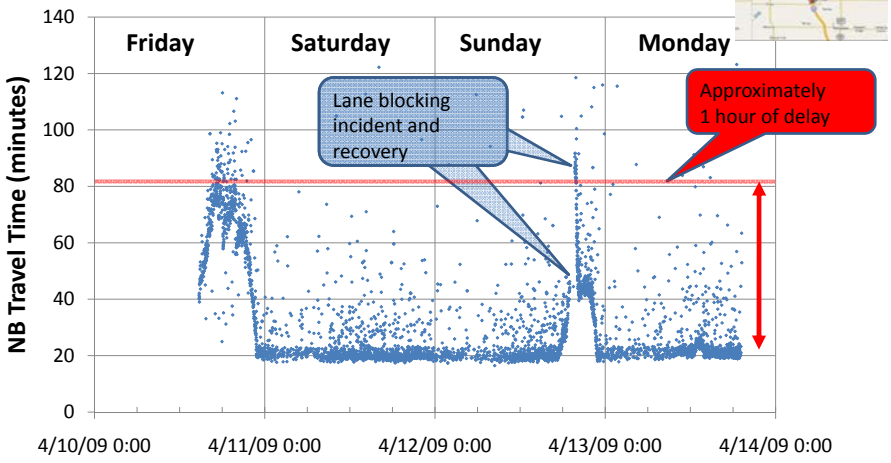
Easter Weekend: Southbound
Example 40 min travel time sample



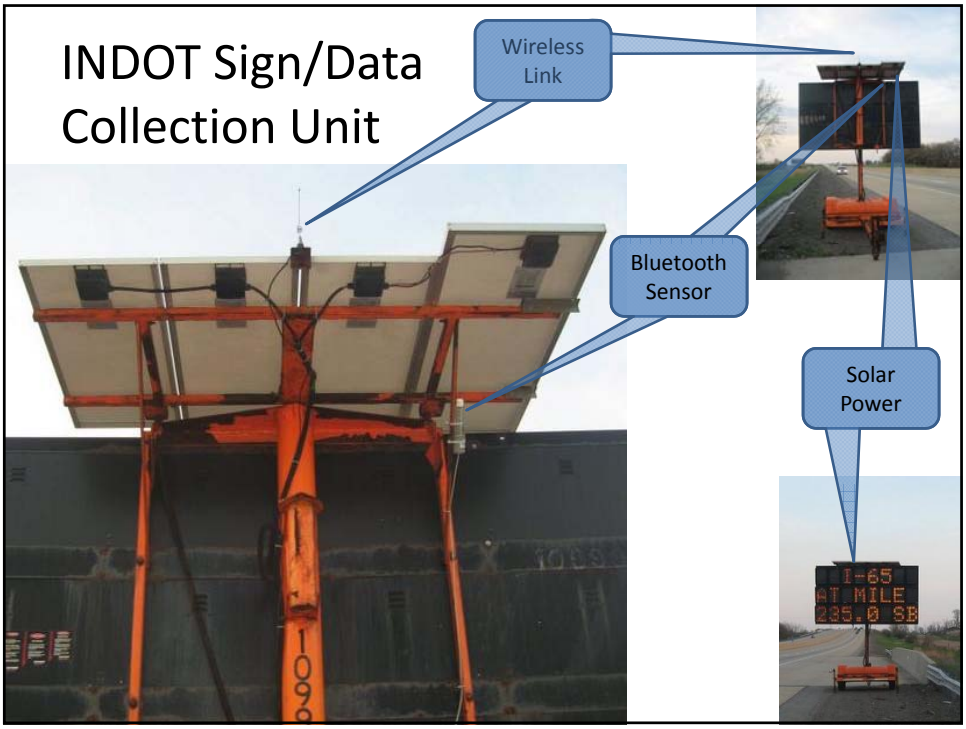
Easter Weekend
Southbound Travel Time (~24 miles)



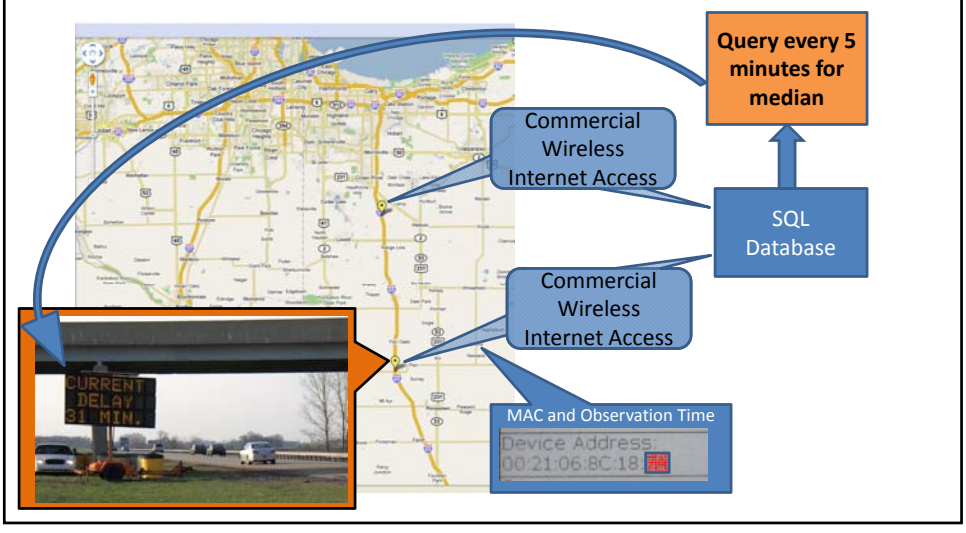
Easter Weekend
Northbound Travel Time (~24 miles)



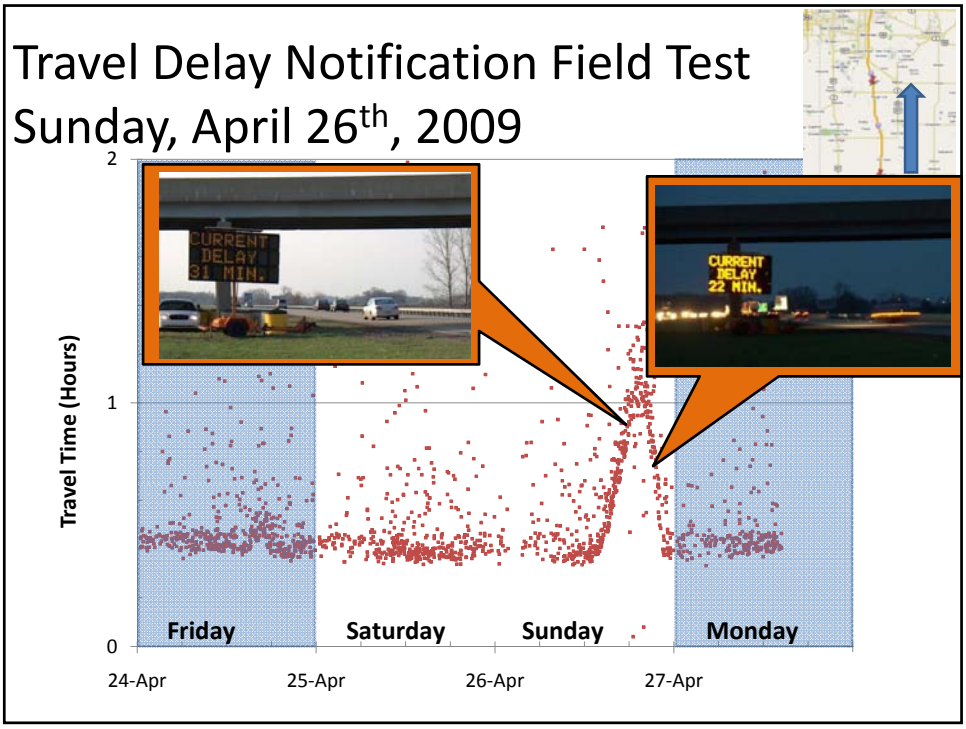
INDOT Sign/Data Collection Unit



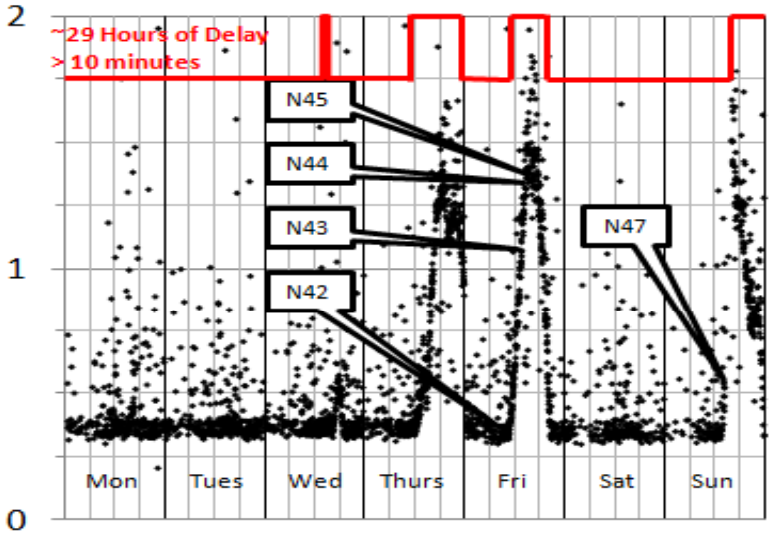
Real Time Implementation



Travel Delay Notification Field Test
Sunday, April 26th, 2009



June 29-July 5, 2009
Highway crashes and Travel Time



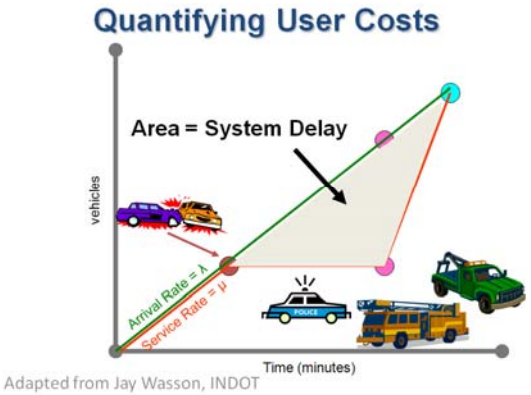
Hours of Operation Delay > 10 min

Table 2. Hours with delay > 10 minutes present and configuration of construction zone

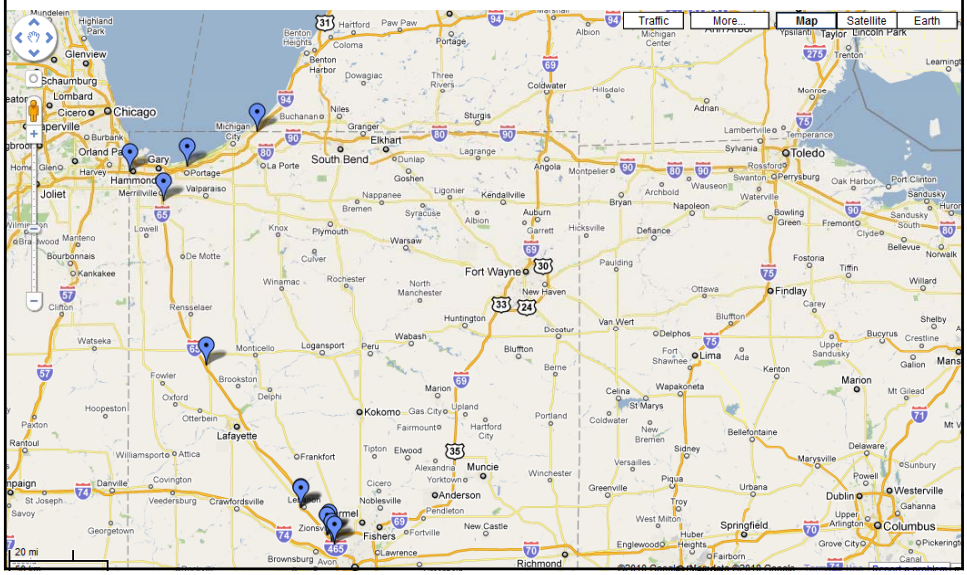
Week Number	Time Period (2009)	Northbound			Hours of travel time data	Southbound		
		Operation where delay >10 minutes		Lanes Open		Operation where delay >10 minutes		Lanes Open
		hours	%			hours	%	
Week 1	May 4-10	24	16.2	1	148	20	13.5	1
Week 2	May 11-17	11	11.3	1	97	9	9.3	1
Week 3	May 18-24	3	3.8	1-2	78	20	25.6	1
Week 4	May 25-31	22	16.5	2-1	133	12	9.0	1
Week 5	June 1-7	14	8.3	1	168	15	8.9	1
Week 6	June 8-14	18	10.7	1	168	15	8.9	1
Week 7	June 15-21	25	16.8	1	149	14	9.4	1
Week 8	June 22-28	18	12.6	1	143	8	5.6	1
Week 9	June 29-July 5	29	17.2	1	168	10	6.0	1-2
Week 10	July 6-July 12	35	20.8	1	168	0	0	2
Week 11	July 13-July 19	33	19.6	1	168	0	0	2
Week 12	July 20-July 26	40	29.4	1	136	27	19.9	2-1

Outcome

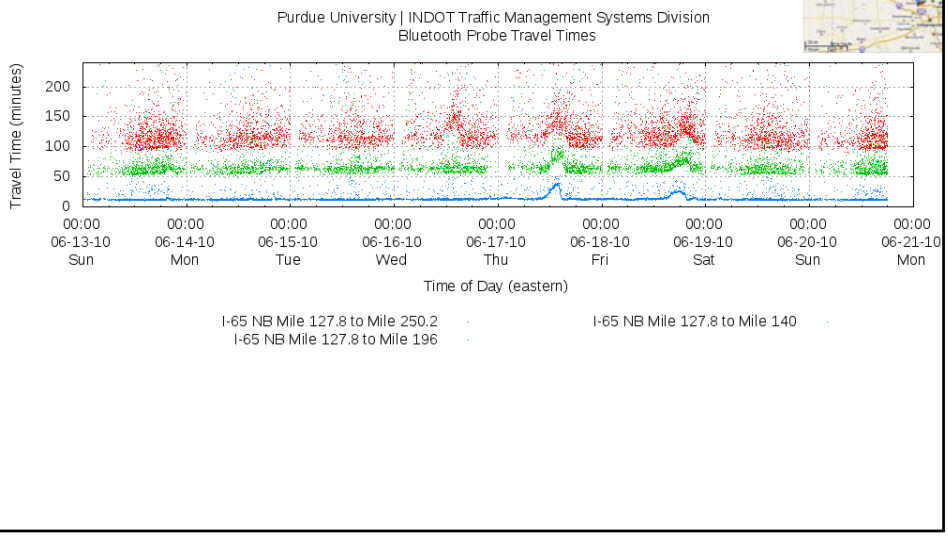
- Lane closure policy was changed for 2010 to maintain two travel lanes from ~0600 to ~2000



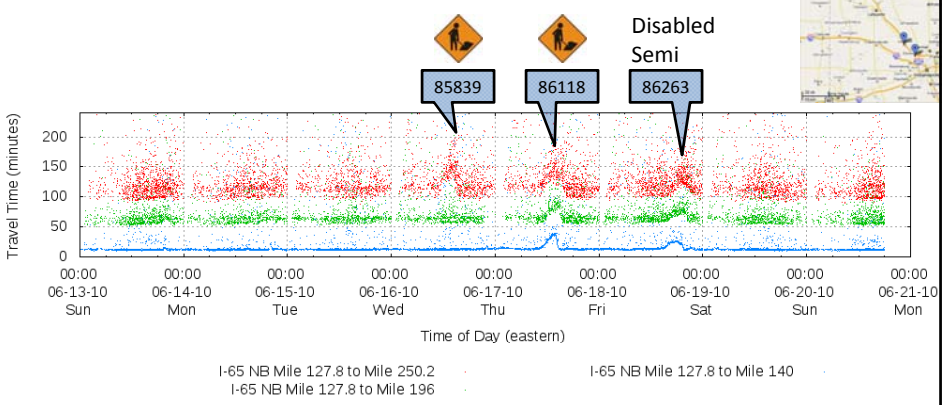
Overview of Permanent 2010 BT Sites



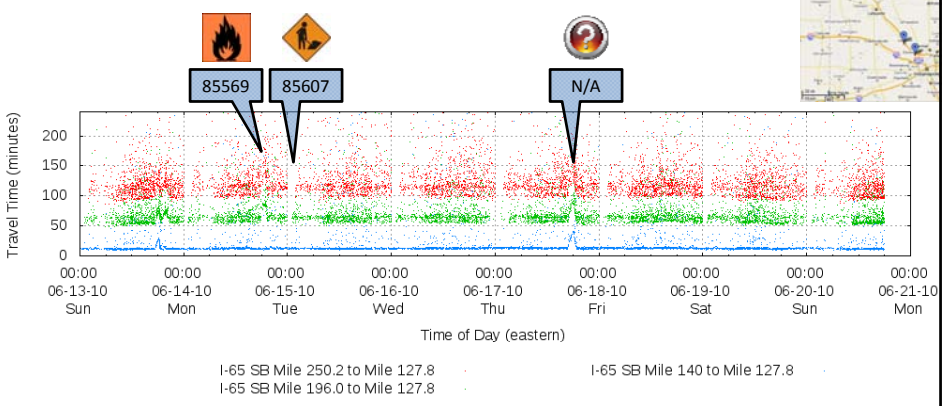
I-65 NB



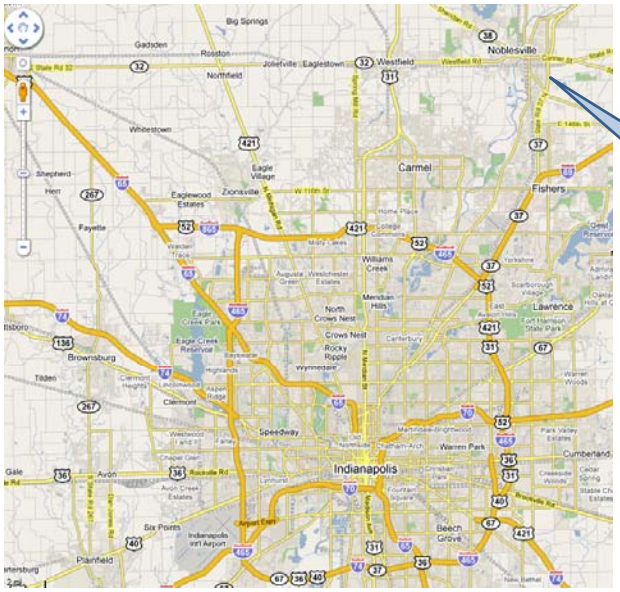
I-65 NB Travel Time



I-65 SB



Sample SR 32 Arterial Data



SR 32 Instrumented Arterial from SR 238 to SR 37

Traffic Signal Timing Process

Today's Talk

I. Define Objectives, Assess and Prioritize activities by Time of Day and location

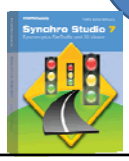
II. Assembly relevant data to support timing and docu-mentation objectives

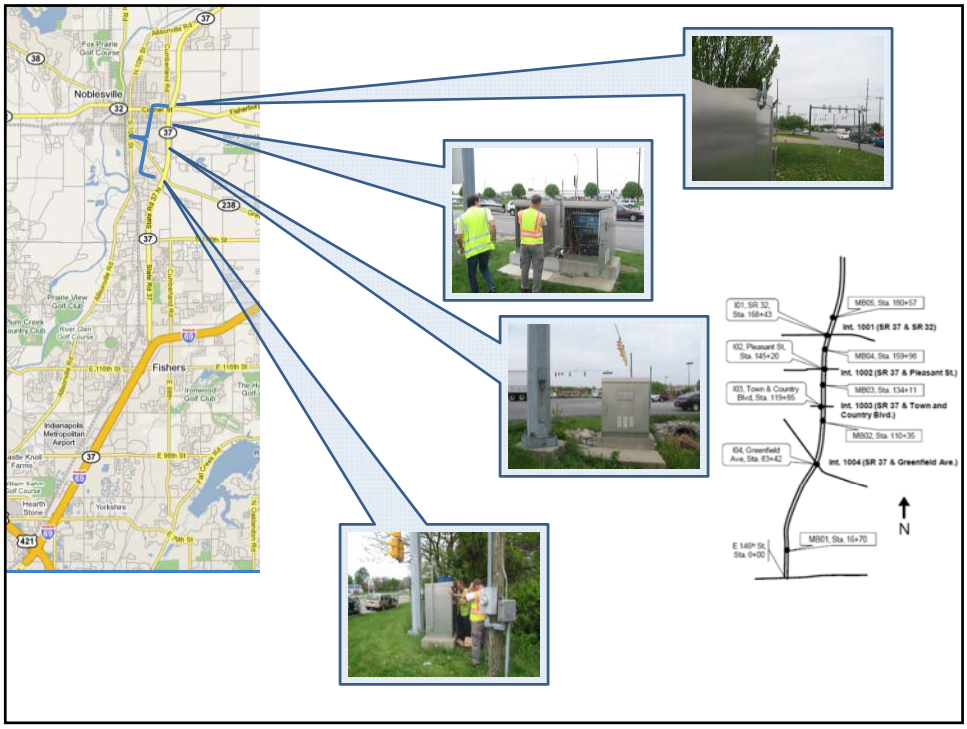
III. Software Modeling

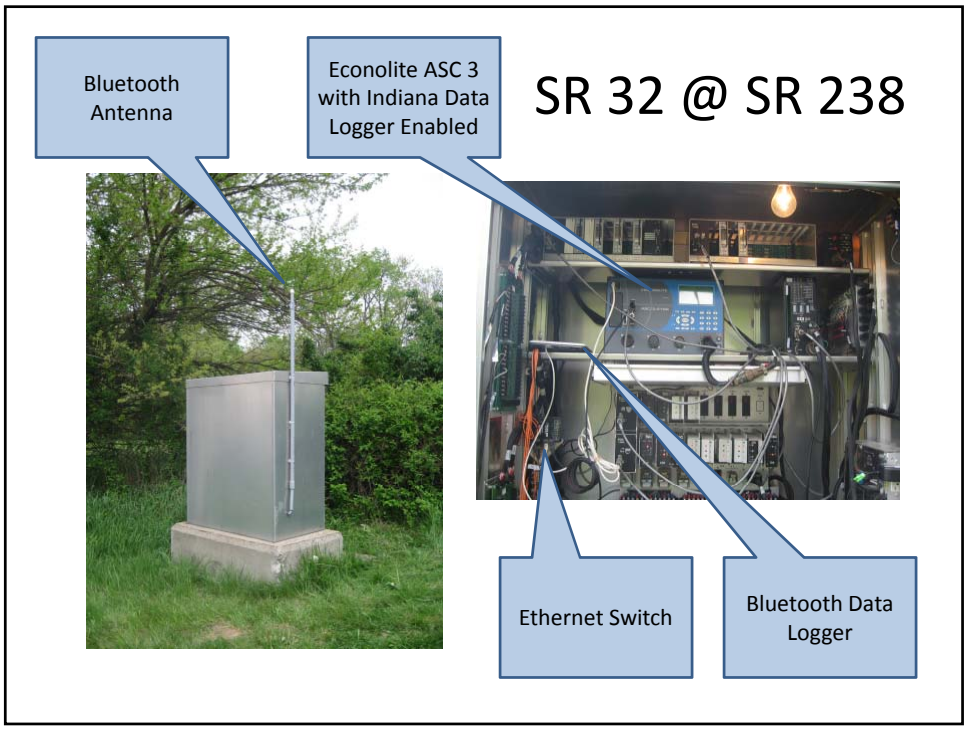
IV. Timing Design and Docu-mentation

V. Deployment

VI. Assess




Noblesville
Fishers
Indianapolis Metropolitan Airport
Yorkshire
Int. 1001 (SR 37 & SR 32)
Int. 1002 (SR 37 & Pleasant St.)
Int. 1003 (SR 37 & Town and Country Blvd.)
Int. 1004 (SR 37 & Greenfield Ave.)
N


Bluetooth Antenna
Econolite ASC 3 with Indiana Data Logger Enabled
SR 32 @ SR 238
Ethernet Switch
Bluetooth Data Logger

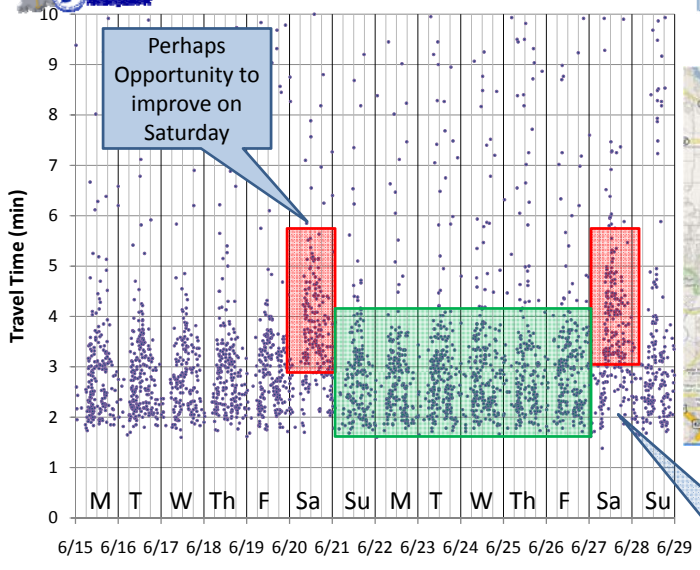
Probe Monitoring Stations

Long Term Installation with Real-Time SQL Based Travel Time Calc

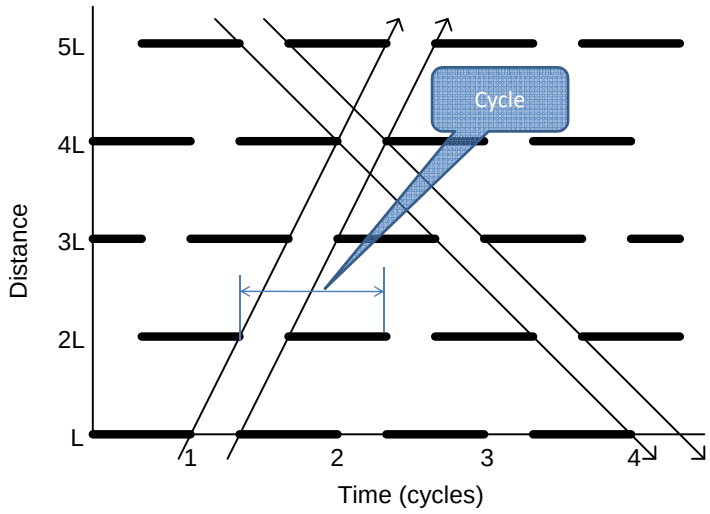
Short Term Battery Powered Device (Traffax)..Data post processed

Short Term Installation with Real-Time SQL Based Travel Time Calc

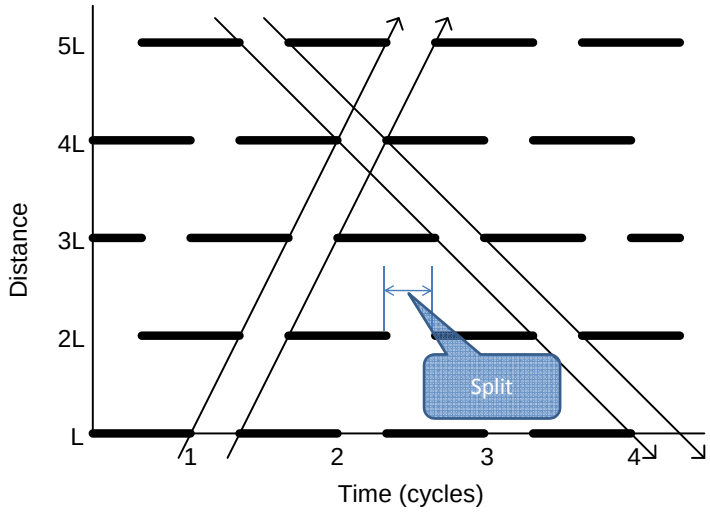
SR-37 Travel Times



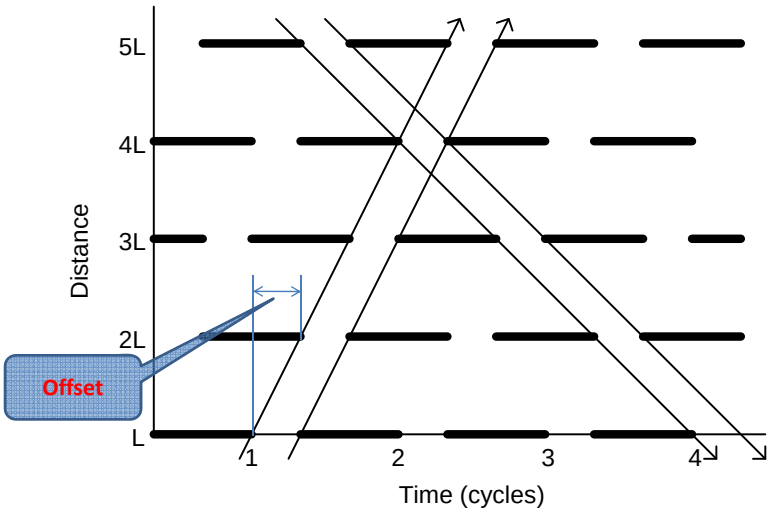
Coordination: Split, **Cycle**, Offset



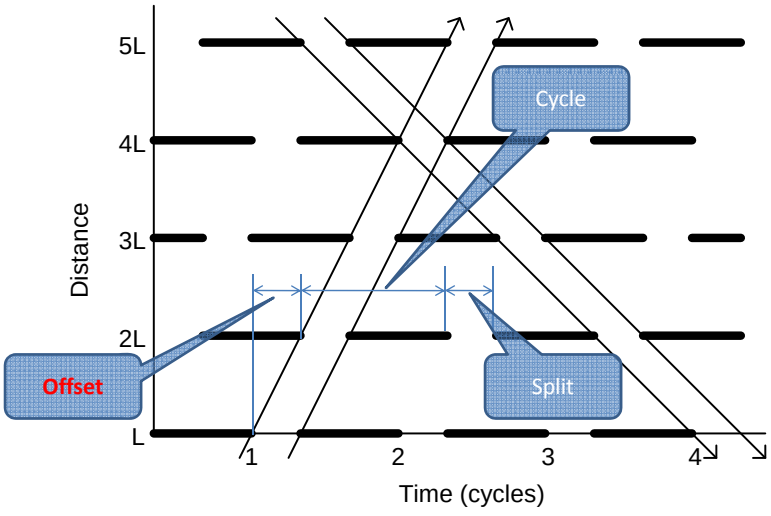
Coordination: **Split**, Cycle, Offset

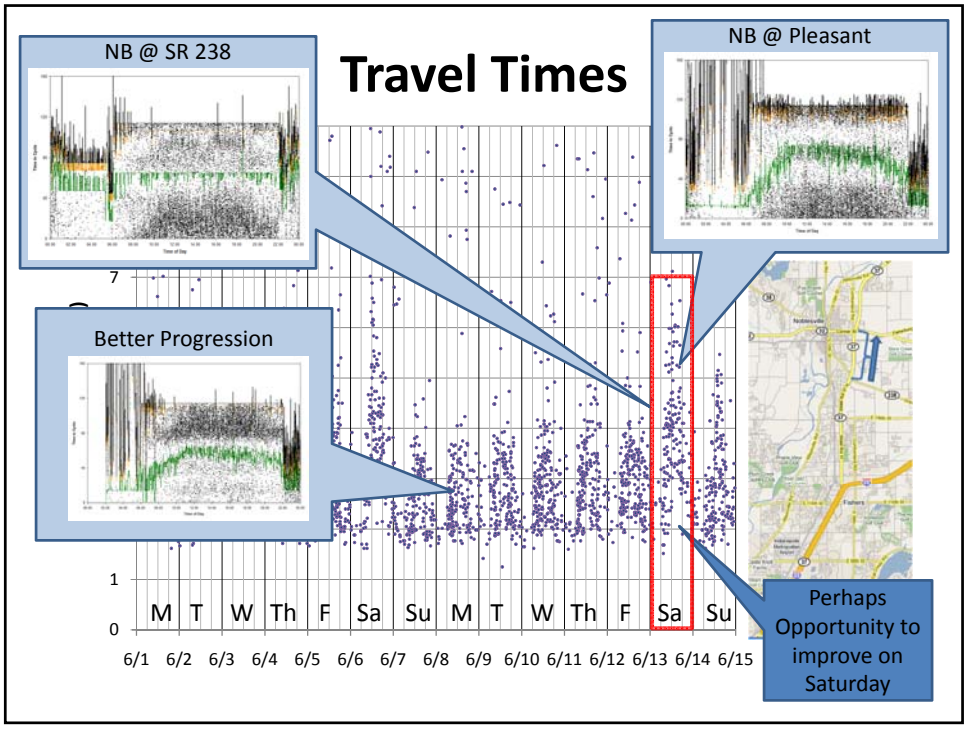


Coordination: Split, Cycle, **Offset**



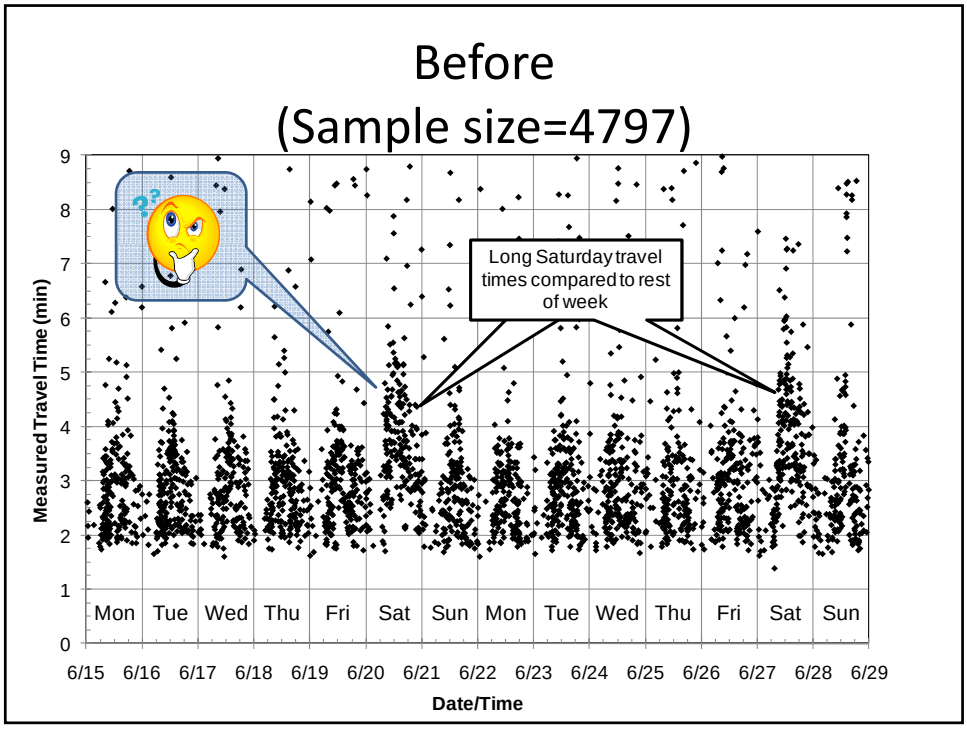
Coordination: Split, Cycle, Offset

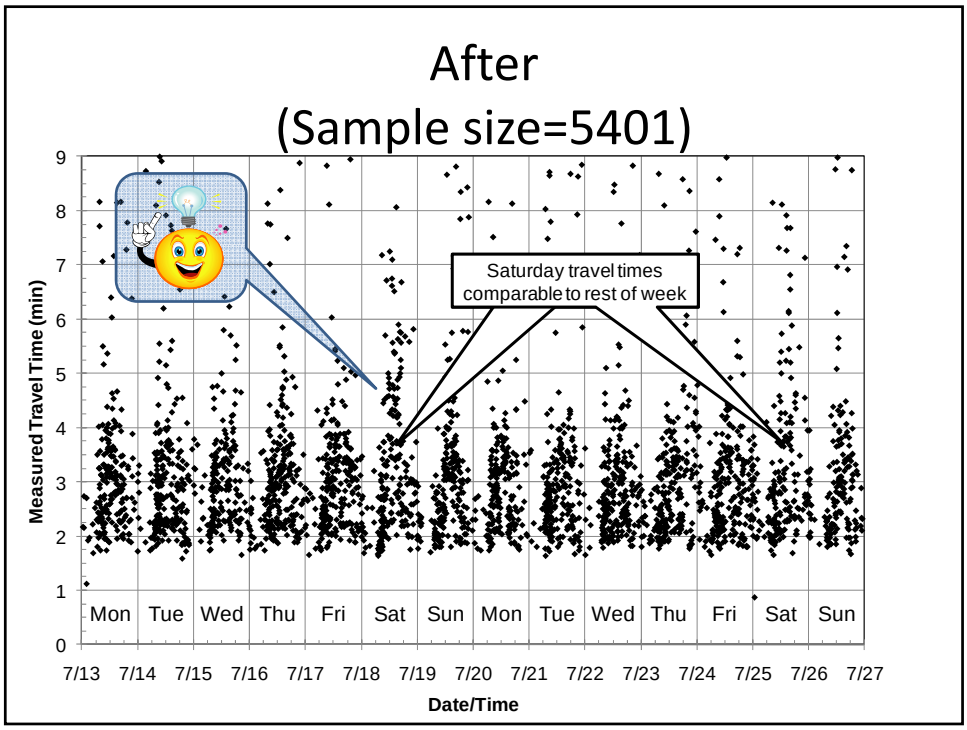




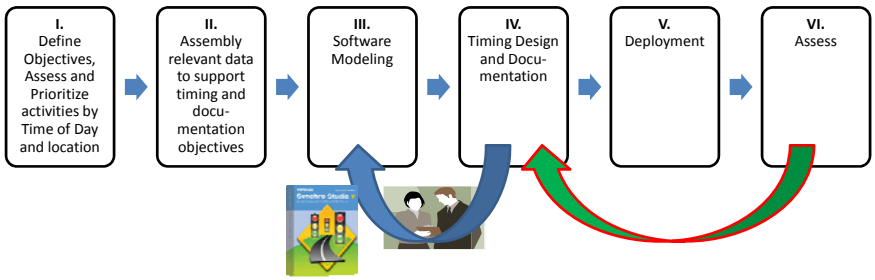
Change in Arrivals on Green

Intersection	Movement	MOE	June 06, Actual	June 06, Predicted After Offset Adjustment	July 25, Actual	July 18, Actual*
SR 37 & SR 32	Northbound	N_g	1755	1425	1472	1810
		POG	59.6%	48.4%	54.9%	56.8%
	Southbound	N_g	1702	1702	1544	1659
		POG	41.2%	41.2%	42.4%	39.0%
SR 37 & Pleasant St.	Northbound	N_g	1628	2655	2741	2995*
		POG	40.1%	65.5%	76.0%	76.6%*
	Southbound	N_g	3180	3674	3371	3471*
		POG	52.9%	61.2%	62.7%	63.0%*
SR 37 & Town and Country Blvd.	Northbound	N_g	3114	2961	2974	3507
		POG	79.5%	75.9%	81.0%	78.7%
	Southbound	N_g	3441	3056	2875	3007
		POG	80.2%	71.1%	72.6%	73.0%
SR 37 & Greenfield Ave.	Northbound	N_g	1678	2917	2827	3438
		POG	37.9%	65.6%	68.6%	69.8%
	Southbound	N_g	2979	3215	3045	3221
		POG	58.9%	63.3%	67.5%	68.2%
Arterial Network		? N_g	19477	21605	20849	23108
		N	34856	34856	31569	35072
		Overall POG	55.9%	62.0%	66.0%	65.9%

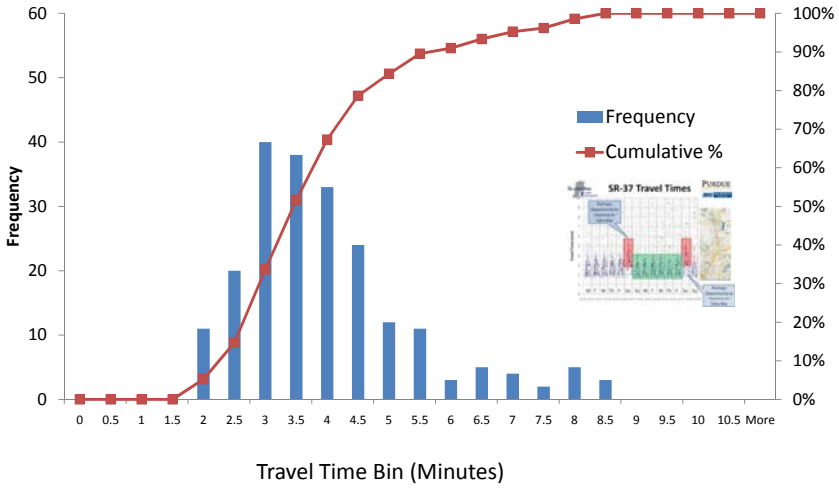

Before
(Sample size=4797)
Measured Travel Time (min)
Long Saturday travel times compared to rest of week
Mon Tue Wed Thu Fri Sat Sun Mon Tue Wed Thu Fri Sat Sun
6/15 6/16 6/17 6/18 6/19 6/20 6/21 6/22 6/23 6/24 6/25 6/26 6/27 6/28 6/29
Date/Time


After
(Sample size=5401)
Measured Travel Time (min)
Saturday travel times comparable to rest of week
Mon Tue Wed Thu Fri Sat Sun Mon Tue Wed Thu Fri Sat Sun
7/13 7/14 7/15 7/16 7/17 7/18 7/19 7/20 7/21 7/22 7/23 7/24 7/25 7/26 7/27
Date/Time

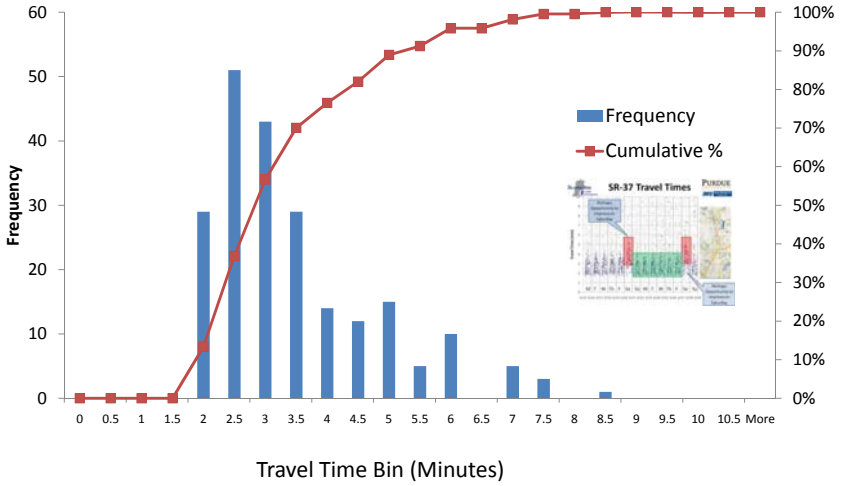
Lets Statistically Evaluate the Impact



NB: June 6, 2009 0900-1200 Travel Time Histograms

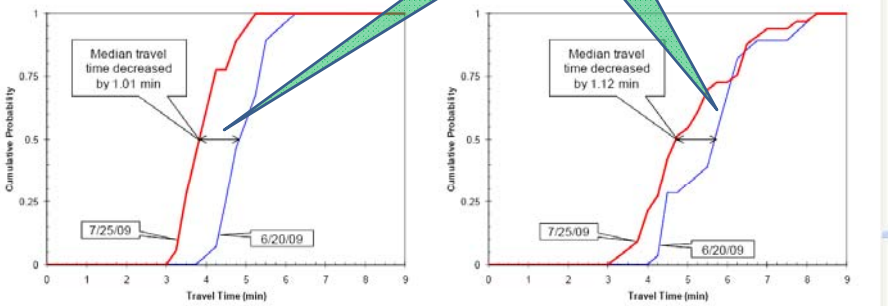


NB: July 18, 2009
0900-1200 Travel Time Histograms



Before (6/20/09)
After (7/25/09)

~1 min Travel Time Reduction

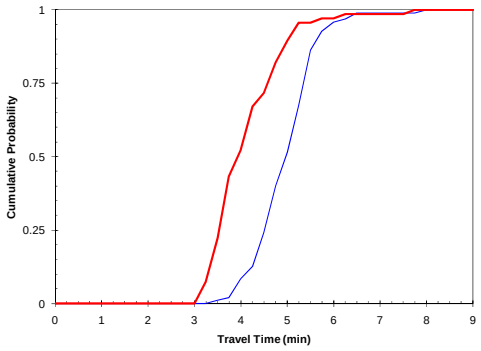


(a) Northbound on SR 37 (Midblock)

(b) Southbound on SR 37 (Midblock)

Business Case: SR 37 Timing Improvements

(Largest Cost Benefit/Reduction/Avoidance)



0600 -2200 (8,500 veh)

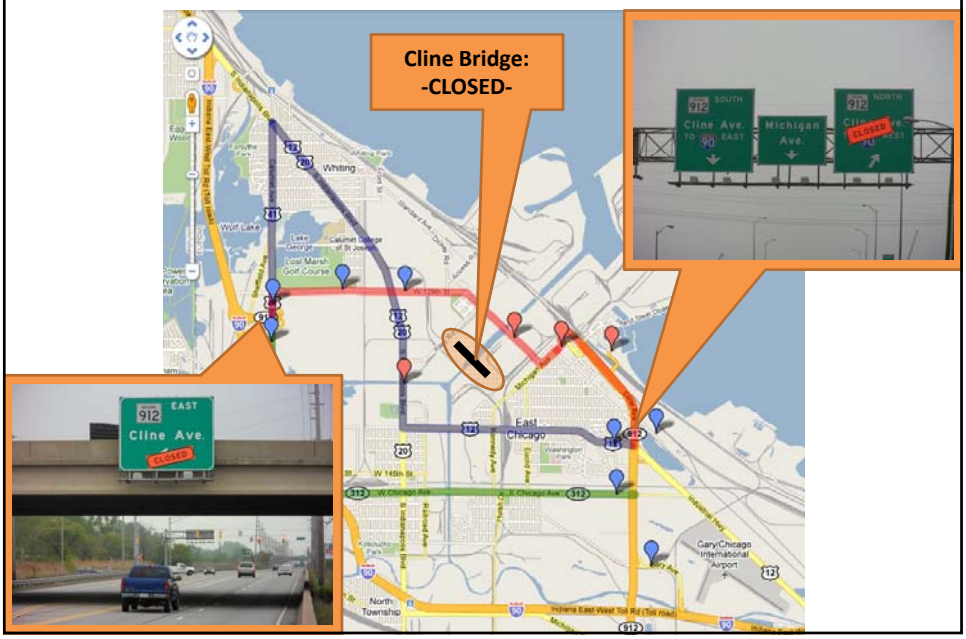
USER SAVINGS

- Travel time tests for SR37 Corridor have improved Northbound Travel Time by ~ 1 Minute.
- **~8,500** Cars per Day Are Effected by this benefit (NB).
- **~0.17 Cents** per minute ($10/hour) saved for each driver in fuel costs and time value.
- **~1.0 Minutes** are assumed saved on average for the intersection over 1-Year with improvements.
- User benefit =

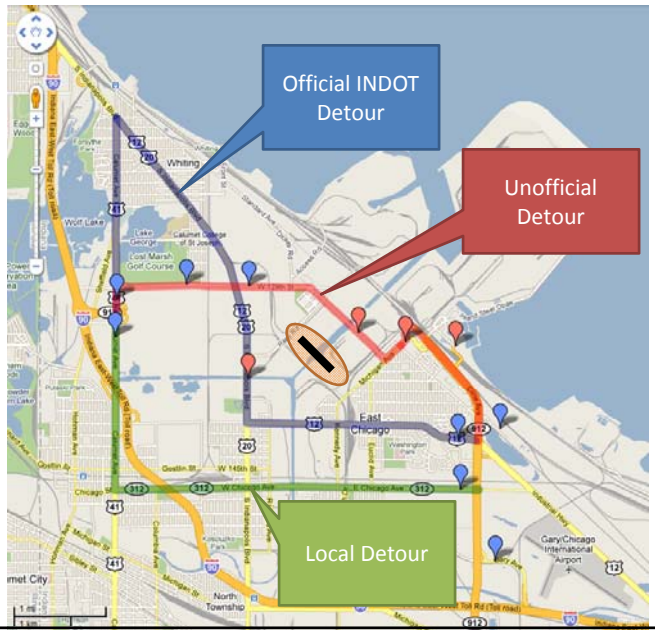
  (8,500 Veh/Day * $0.17/min * 1-min/Veh * 2*52 Days/Year)= **$150,000/year** for a 1.6 mile stretch of roadway is realized.

39

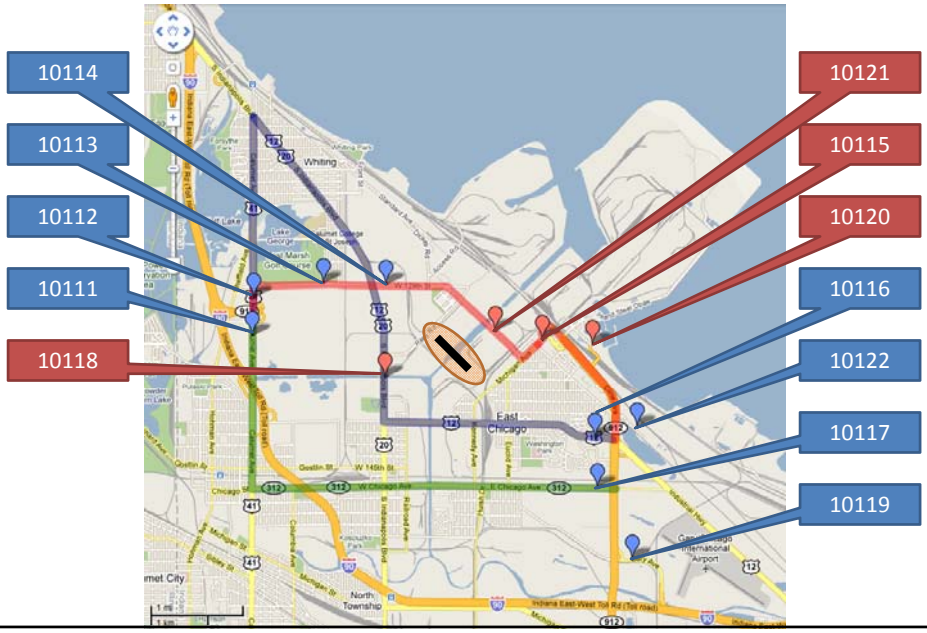
Cline Avenue Bridge Closure



Detour Options



Station Numbering



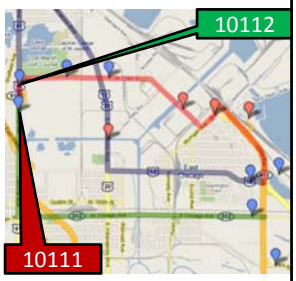
10122

Three Objectives

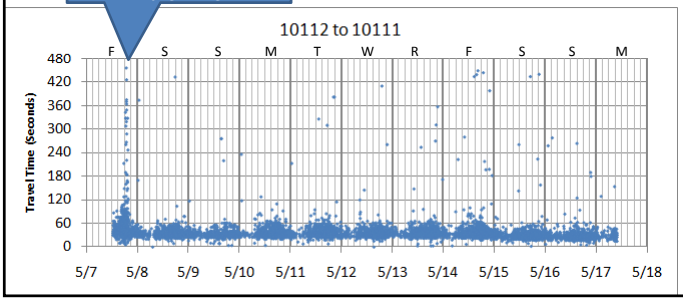
1. Determine the extent to which each of the three detour routes are utilized.
2. Observe the impact to major industries and establishments in the area.
   - 10115/10121 (Plant Entrance congestion)
3. Look at local origin-destination paths as a result of the closure.
   - 10114/10115 (No congestion on unofficial)

10112 to 10111

	10111	10112	10113	10114	10115	10116	10117	10118	10119	10120	10121	10122
10111	--	6707	1068	560	120	137	250	187	174	117	143	107
10112	6885	--	1324	747	197	169	175	277	112	120	259	121
10113	872	1067	--	1228	357	176	53	388	29	130	510	98
10114	401	531	1138	--	1154	467	190	1387	99	403	1714	291
10115	112	185	420	1626	--	490	587	255	602	721	3449	266
10116	72	95	154	596	397	--	1599	1849	925	840	316	1375
10117	86	71	22	147	262	638	--	165	1140	264	203	329
10118	176	220	381	1553	95	1812	296	--	102	357	127	495
10119	93	60	28	212	606	1029	794	142	--	807	443	742
10120	38	54	111	456	623	1086	551	381	685	--	470	455
10121	115	201	524	2109	2764	333	377	159	340	443	--	230
10122	43	51	79	275	329	1526	480	477	706	686	237	--



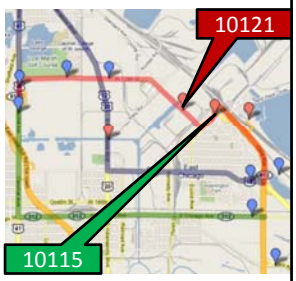
Non-recurrent spike in Travel Time

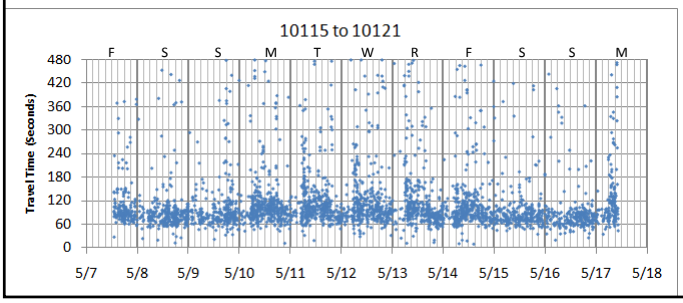


Values		
Row Labels	Sum of 11N12	Sum of 12N11
May		
7-May	534	663
8-May	659	677
9-May	543	590
10-May	708	666
11-May	659	692
12-May	686	666
13-May	697	673
14-May	795	765
15-May	685	714
16-May	533	651
17-May	208	128
Grand Total	6707	6885

10115 to 10121

	10111	10112	10113	10114	10115	10116	10117	10118	10119	10120	10121	10122
10111	--	6707	1068	560	120	137	250	187	174	117	143	107
10112	6885	--	1324	747	197	169	175	277	112	120	259	121
10113	872	1067	--	1228	357	176	53	388	29	130	510	98
10114	401	531	1138	--	1154	467	190	1387	99	403	1714	291
10115	112	185	420	1626	--	490	587	255	602	721	3449	266
10116	72	95	154	596	397	--	1599	1849	925	840	316	1375
10117	86	71	22	147	262	638	--	165	1140	264	203	329
10118	176	220	381	1553	95	1812	296	--	102	357	127	495
10119	93	60	28	212	606	1029	794	142	--	807	443	742
10120	38	54	111	456	623	1086	551	381	685	--	470	455
10121	115	201	524	2109	2764	333	377	159	340	443	--	230
10122	43	51	79	275	329	1526	480	477	706	686	237	--





Values		
Row Labels	Sum of 15N21	Sum of 21N15
May		
7-May	180	224
8-May	292	215
9-May	289	164
10-May	418	314
11-May	399	357
12-May	400	350
13-May	395	348
14-May	383	338
15-May	273	193
16-May	254	179
17-May	166	82
Grand Total	3449	2764

10121 to 10115

	10111	10112	10113	10114	10115	10116	10117	10118	10119	10120	10121	10122
10111	--	6707	1068	560	120	137	250	187	174	117	143	107
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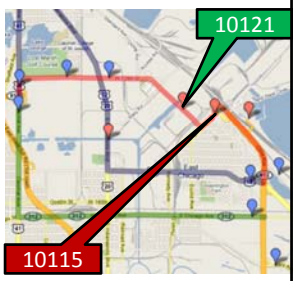

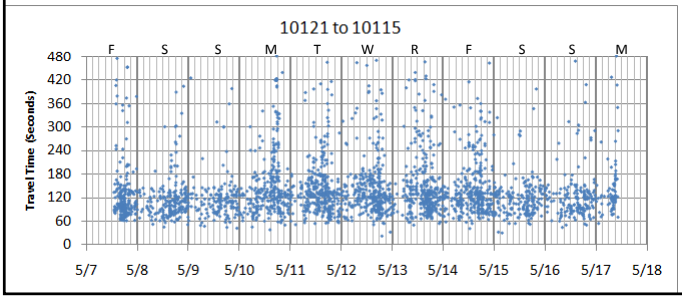

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Grand Total	3449	2764

Darcy Bullock
Ross Haseman
Purdue University

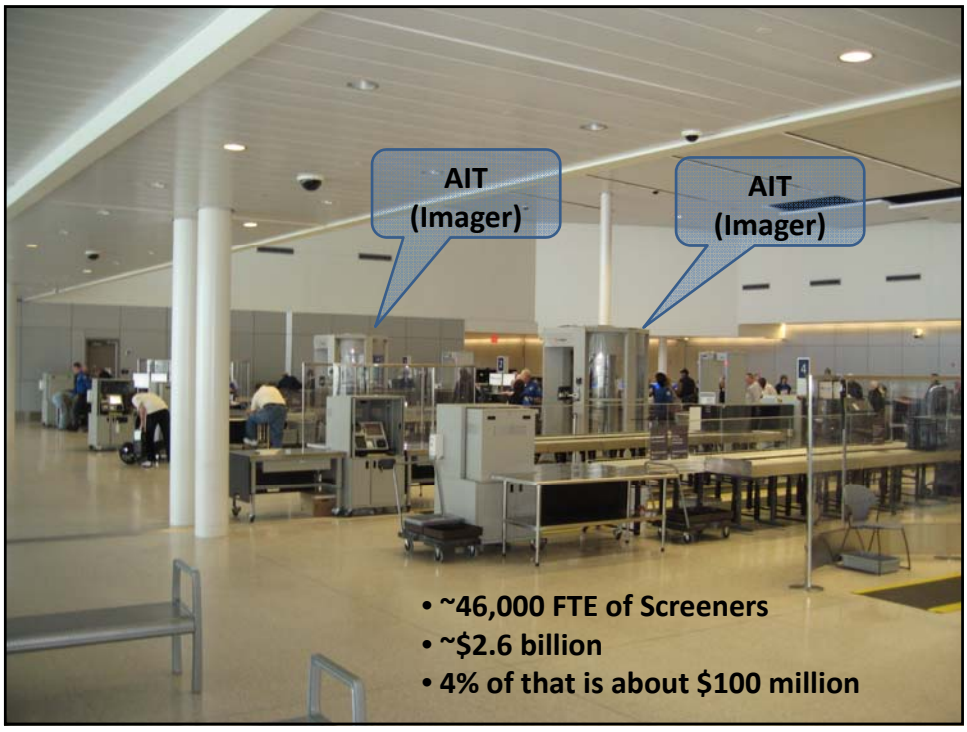
Jay Wasson
Indiana Department of Transportation

Robert Spitler
Indianapolis Airport Authority

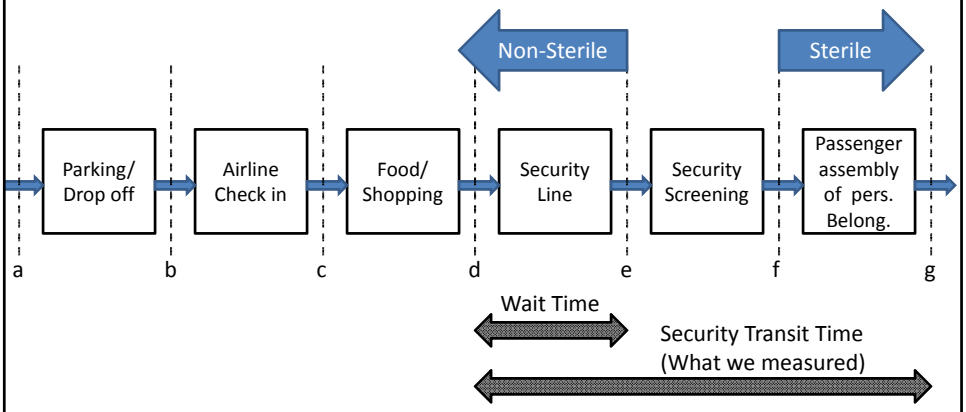
Systems are Always Changing

- At least initially, AIT's will likely be reducing capacity at some airports.
- Last year, **769.6** million travelers boarded planes in the U.S. or planes bound for the U.S., according to new data from the Bureau of Transportation Statistics. That's down 5.3% from 812.3 million passengers in 2008 and down 8.2% from the record **838.2** million air travelers in the U.S. market in 2007.

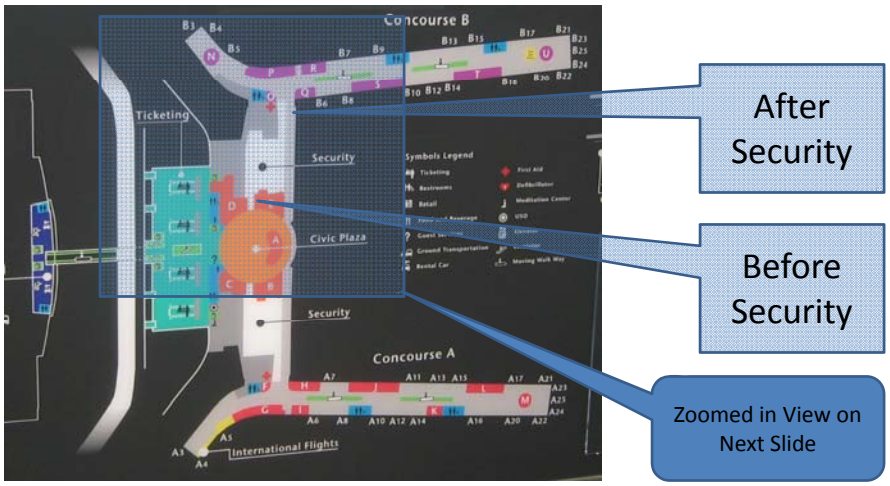
http://www.usatoday.com/travel/flights/2010-03-29-airline-passengers-revenue-decline_N.htm

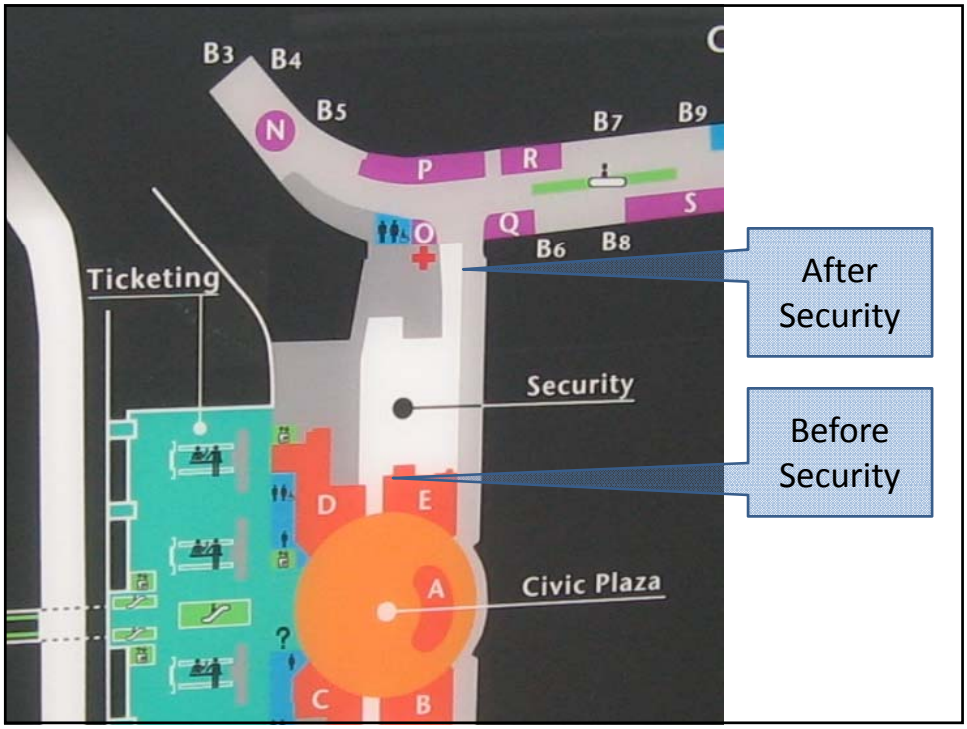


Terminology and Context for Airport Application

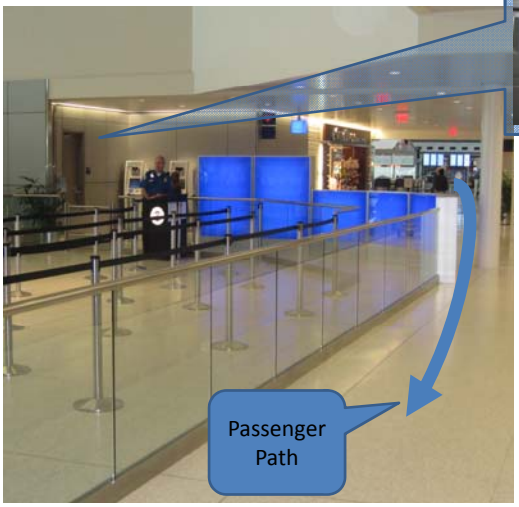


May 8, 2009 Deployment at IND for Concourse B

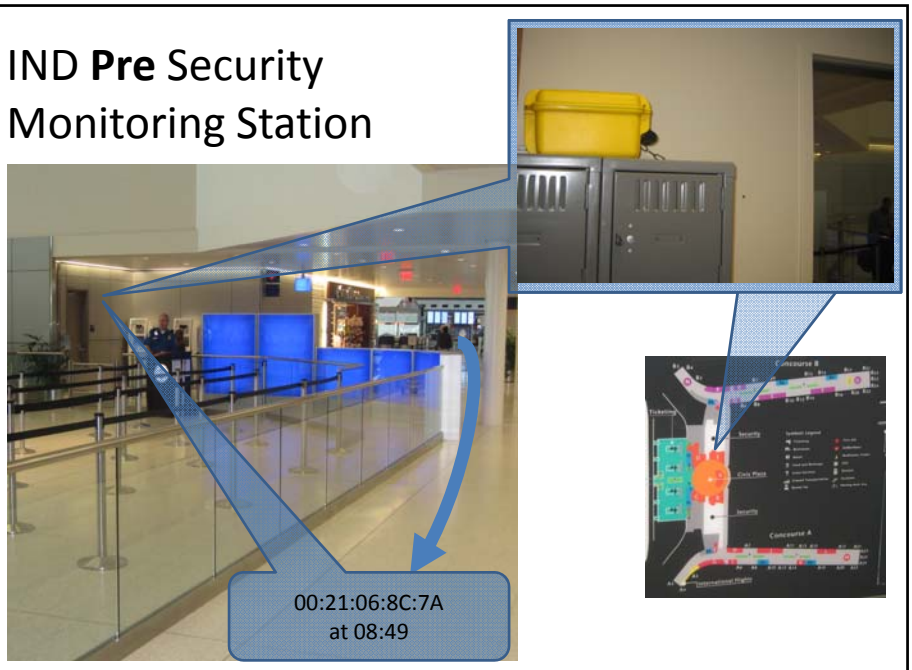




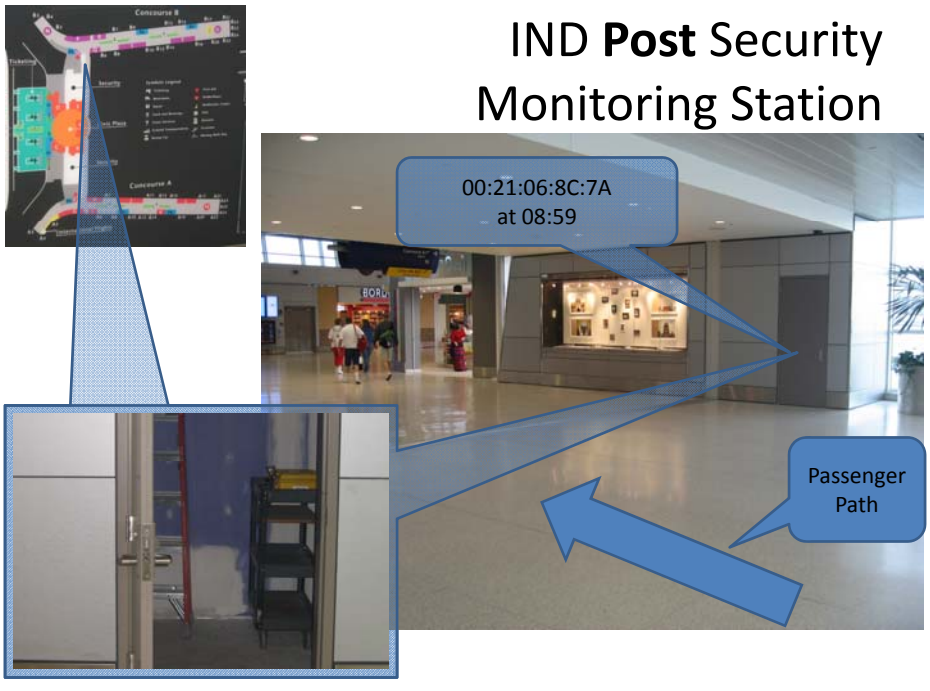
IND **Pre** Security Monitoring Station



IND **Pre** Security Monitoring Station



IND **Post** Security Monitoring Station



Components of Passenger Transit Time Between Observation Points

6. Walk past sensor on Sterile Concourse B

00:21:06:8C:7A at 08:59

5. Belongings repacked

4. Magnetometer

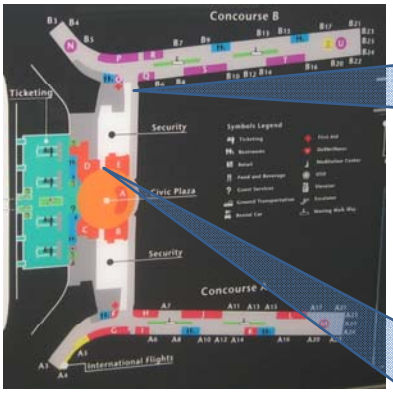
3. Belongings placed on belt

2. Queue & Document Check

1. Enter screening area.

00:21:06:8C:7A at 08:49

Example data for an Estimated Transit Time of 10 minutes

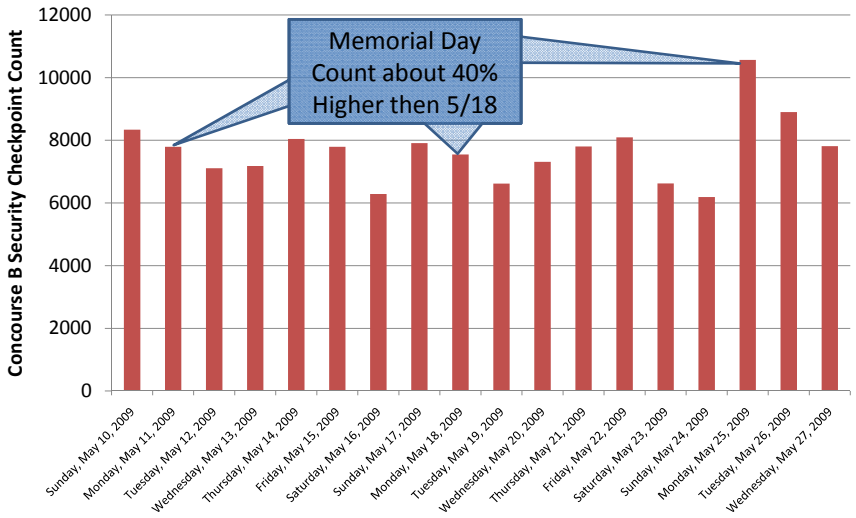


00:21:06:8C:7A at 08:59

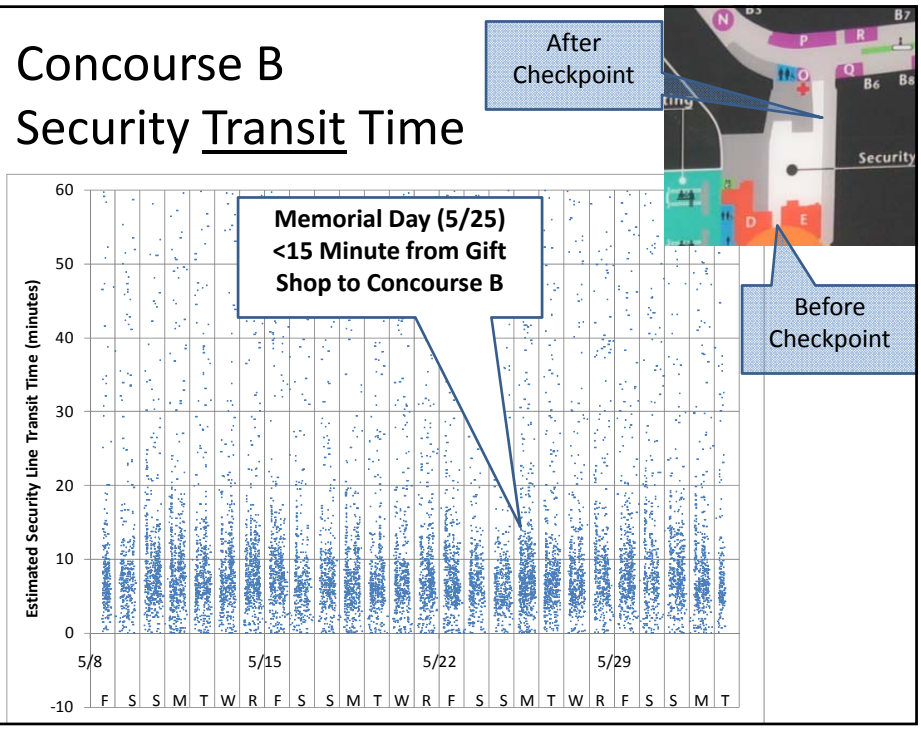
00:21:06:8C:7A at 08:49

8:59
-8:49
10 min

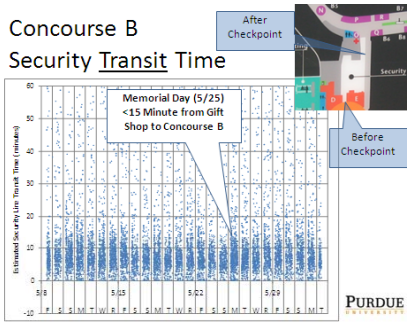
Concourse B Security Checkpoint Count



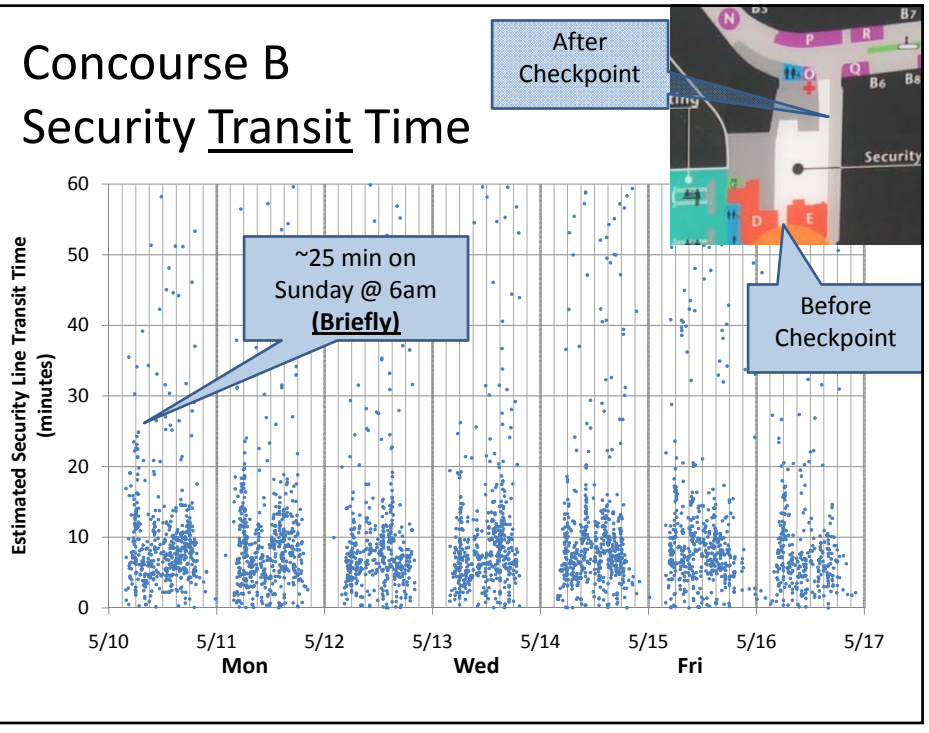
Concourse B Security Transit Time

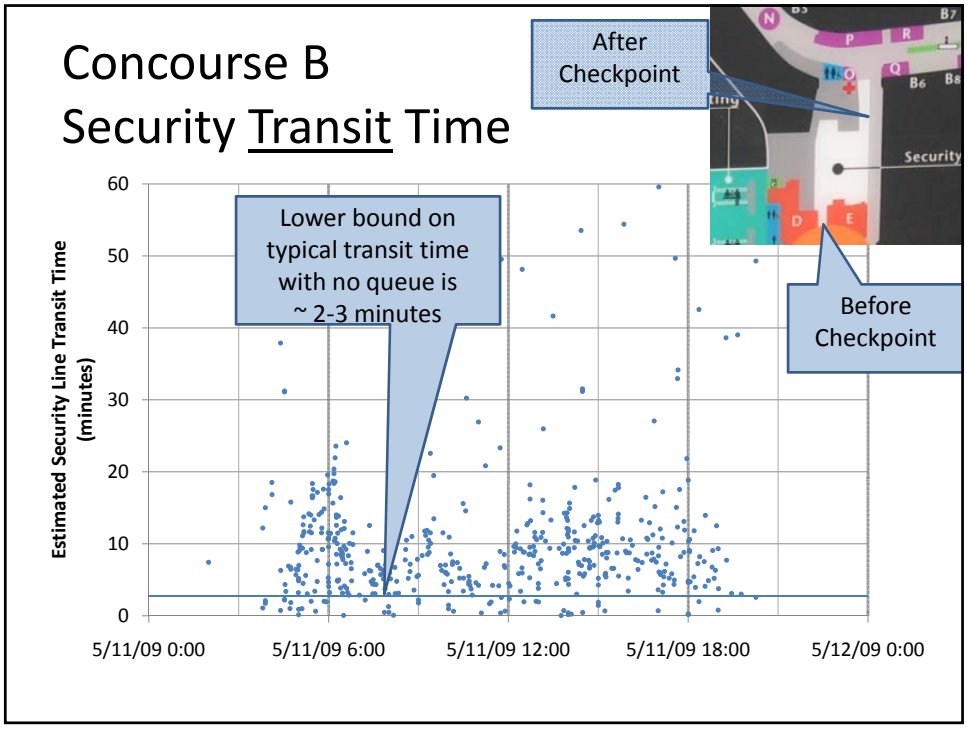


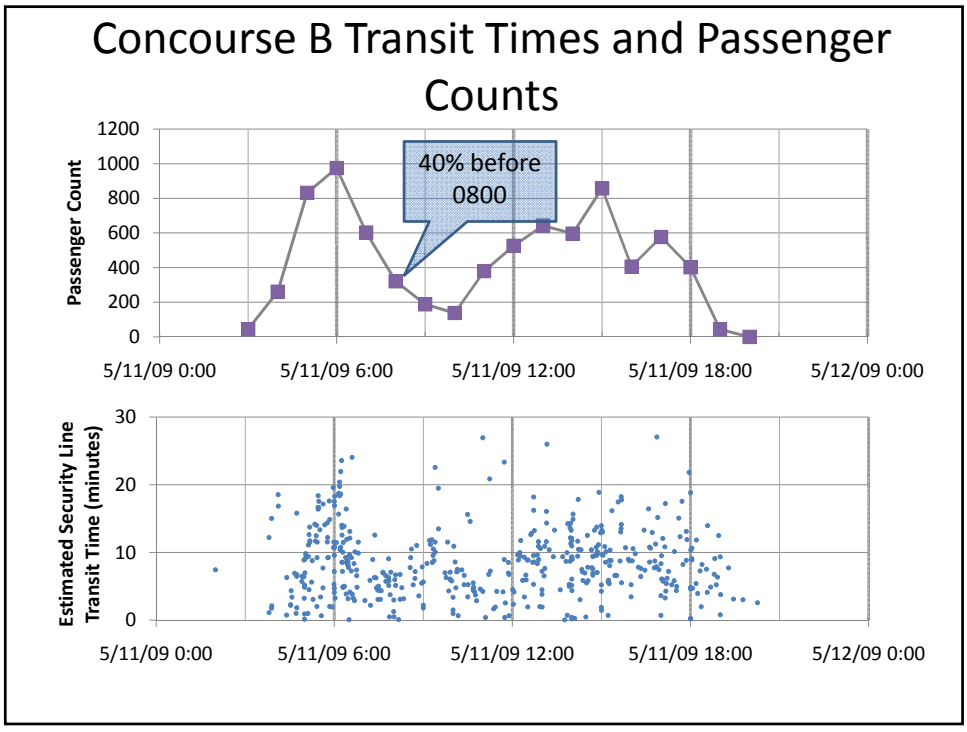
Estimated Cost to Collect 26 Days of Data at IND Using Manual Methods



- 40 hours labor/day
  - 20 hrs 4am to midnight
  - 1 to hand out cards
  - 1 to collect cards
  - No breaks
- Assume $25/hr
- $1000/day
- $26,000 in labor plus data reduction time




Concourse B
Security Transit Time
After Checkpoint
Before Checkpoint
Lower bound on typical transit time with no queue is ~ 2-3 minutes
Estimated Security Line Transit Time (minutes)
60
50
40
30
20
10
0
5/11/09 0:00
5/11/09 6:00
5/11/09 12:00
5/11/09 18:00
5/12/09 0:00
Security


Concourse B Transit Times and Passenger Counts
Passenger Count
1200
1000
800
600
400
200
0
40% before 0800
5/11/09 0:00
5/11/09 6:00
5/11/09 12:00
5/11/09 18:00
5/12/09 0:00
Estimated Security Line Transit Time (minutes)
30
20
10
0
5/11/09 0:00
5/11/09 6:00
5/11/09 12:00
5/11/09 18:00
5/12/09 0:00

References

Multimodal with vehicle, shuttle, and ped. modes

- Day, C.M., R.J. Haseman, H. Premachandra, T.M. Brennan, J.S. Wasson, J.R. Sturdevant, and D.M. Bullock, "Visualization and Assessment of **Arterial Progression** Quality Using High Resolution Signal Event Data and Measured Travel Time," Transportation Research Board Paper ID:10-0039, January 2010.
- Bullock, D.M., R.J. Haseman, J.S. Wasson, and R. Spitler, "Anonymous Bluetooth Probes for **Airport Security Line Service** Time Measurement: The Indianapolis Pilot Deployment," Transportation Research Board Paper ID:10-1438, January 2010.
- Haseman, R.J., J.S. Wasson, and D.M.Bullock, "Real Time Measurement of **Work Zone Travel Time Delay** and Evaluation Metrics," Transportation Research Board Paper ID:10-1442, January 2010.
- Wasson, J.S., J.R. Sturdevant, D.M. Bullock, "**Real-Time Travel Time Estimates Using MAC Address Matching**," *Institute of Transportation Engineers Journal*, ITE, Vol. 78, No. 6, pp. 20-23, June 2008.
- **Airport device follows fliers' phones, USA Today, Page 1, March 23, 2010** http://www.usatoday.com/tech/wireless/2010-03-23-cellphones_N.htm

Selected Bluetooth Probe Data Applications

Jay Wasson & Jim Sturdevant,
Indiana Department of Transportation

Chris Day, Ross Haseman, Tom Brennan, Alex Hainen & Darcy Bullock
Purdue University School of Civil Engineering