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HOV LANE PERFORMANCE MONITORING SYSTEM

Final Report

by

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DISCLAIMER

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EXCUTIVE SUMMARY

High occupancy vehicle (HOV) lanes promote carpooling, van and bus usage. The lanes maximize person throughput instead of just vehicle throughput. HOV lanes offer a travel time savings for multiple occupant vehicles over single occupant vehicles by restricting access to vehicles that have two or more occupants. Making more efficient use of existing road system through HOV lanes is a cost-effective solution to improve mobility. Continuous monitoring of the system performance is a key to a successful implementation. Proliferation of internet enabled and location aware electronic and navigation systems has made network wide travel time data available in recent years. However measuring HOV performance requires separate travel time data for HOV and general purpose lanes. Motivated by advancements in travel time measurement technologies, a pattern recognition algorithm for separating travel time on HOV and regular lanes collected by Bluetooth sensors is designed and implemented in this project. The algorithm is part of a framework for fusing traffic data from several sources to estimate key HOV indicators.

The HOV lanes on both I-270 northbound and southbound were used for a case study based on 2013 data. Data from various sources including Bluetooth and stationary detectors were imported and investigated. A novel and innovative data clustering approach was developed to separate travel time data on HOV and general purpose lanes. Two separate algorithms based on both hard and soft clustering were examined. A fuel efficiency procedure was applied for estimating fuel savings on HOV lanes. Value of time, cost of fuel and vehicle occupancy data were collected from trustable sources. By blending travel time, volume and occupancy data several performance measures including travel time savings, person throughput, and fuel savings were calculated for HOV lanes. By applying financial factors including value of time and fuel cost, economical performance of the HOV lanes were estimated and reported.

This approach was the first attempt of its kind to evaluate performance of HOV facilities by taking advantage of year-round traffic data from various sources. By installing Bluetooth sensors on US-50 in Maryland, the system can be expanded to cover more HOV corridors. The approach can also be used to produce performance measures on HOT lanes.

Using HOV may result in reduction of Green House Gas (GHG) emissions. Finding appropriate models to measure such savings and incorporating the model into the evaluation framework is also subject of future research. Findings of this project are incorporated into the Annual Maryland Mobility Report,

1.0 INTRODUCTION

Effective identification and examination of issues related to urban congestion is critical for mobility improvement. In 2012, the Maryland State Highway Administration's (SHA) released the first state highway mobility report to "Support Maryland Economy and Communities with Reliable Movement of People and Goods" (Mahapatra, et al., 2012). The 2013 Maryland State Highway Mobility Report has included HOV travel time benefits as one of the five new areas in this report. Making more efficient use of the existing system through HOV lanes is one of the cost effective solutions to improve highway mobility: HOV lanes can increase person throughput, provide a viable alternative transportation mode for commuters and provide a significant time savings (Mahapatra, et al., 2013).

University of Maryland has developed a methodology for measuring HOV travel time by applying pattern recognition algorithms on Bluetooth data. Study results on I-270 indicate that travel time patterns on HOV lane and general purpose lane are very different during HOV operational hours. Thus, separate performance measures (i.e. Travel Time Index) for HOV lanes and general purpose lanes can be generated. Existing studies on collecting and identifying HOV lane traffic information are very limited. A study by Turner (1995) discussed the technique of separating HOV and Non-HOV lane travel time through license plate matching data. However, license plate matching requires high initial cost for equipment purchase. Jang et al. (2012) utilized loop detector data obtained from California Department of Transportation Performance Measurement System (PeMS) to identify HOV lane traffic data. The loop detector data only provides point traffic information, which compromised its accuracy in travel time estimation. By taking advantage of data collected from different sources (e.g. RITIS and Bluetooth), this project developed a monitoring system that takes advantage of Bluetooth as well as traffic volume data to produce performance measures for an HOV facility. The target corridor is I-270 since it has permanently installed Bluetooth sensors. The system is also expandable to other corridors. The aim of this system is to assist transportation managers in monitoring HOV performance, and to measure the time and monetary savings of existing HOV lane facility.

2.0 DATA SOURCES USED FOR MARYLAND MOBILITY REPORT SUMMARY

Data from all available traffic detectors on both northbound and southbound of the study area was retrieved from Regional Integrated Traffic Information System (RITIS) for the entire year 2013 and data availability results are summarized in appendix D. SHA's Office of Planning provided high quality lane by lane volume and speed data on two additional locations that were not included in RITIS. Unfortunately most of the CHART detectors in the study area suffer from data quality issues including significant time periods in which no data is reported. After a thorough investigation, the following stationary detectors were used as lane by lane volume and speed data sources:

Table 1. Traffic volume detectors on I-270

Detector ID	Location	Latitude	Longitude
P00004 (SHA)	I-270 South of MD 121 (ATR#04)	39.20502926	-77.27118566
P00060 (SHA)	I-270 South of Middlebrook Rd (ATR#60)	39.168932	-77.24277098
NAVTEQ_3503	I-270 North of Democracy Blvd	39.026097	-77.133628

A comprehensive quality control procedure was conducted and data smoothing and repair procedures were used to ensure volume data is appropriate for performance measurement.

Eight Bluetooth sensors are installed along the I-270 HOV corridor that continuously report MAC address of the active detectable electronic devices. The following figure shows the location of sensors marked by purple pins drops.

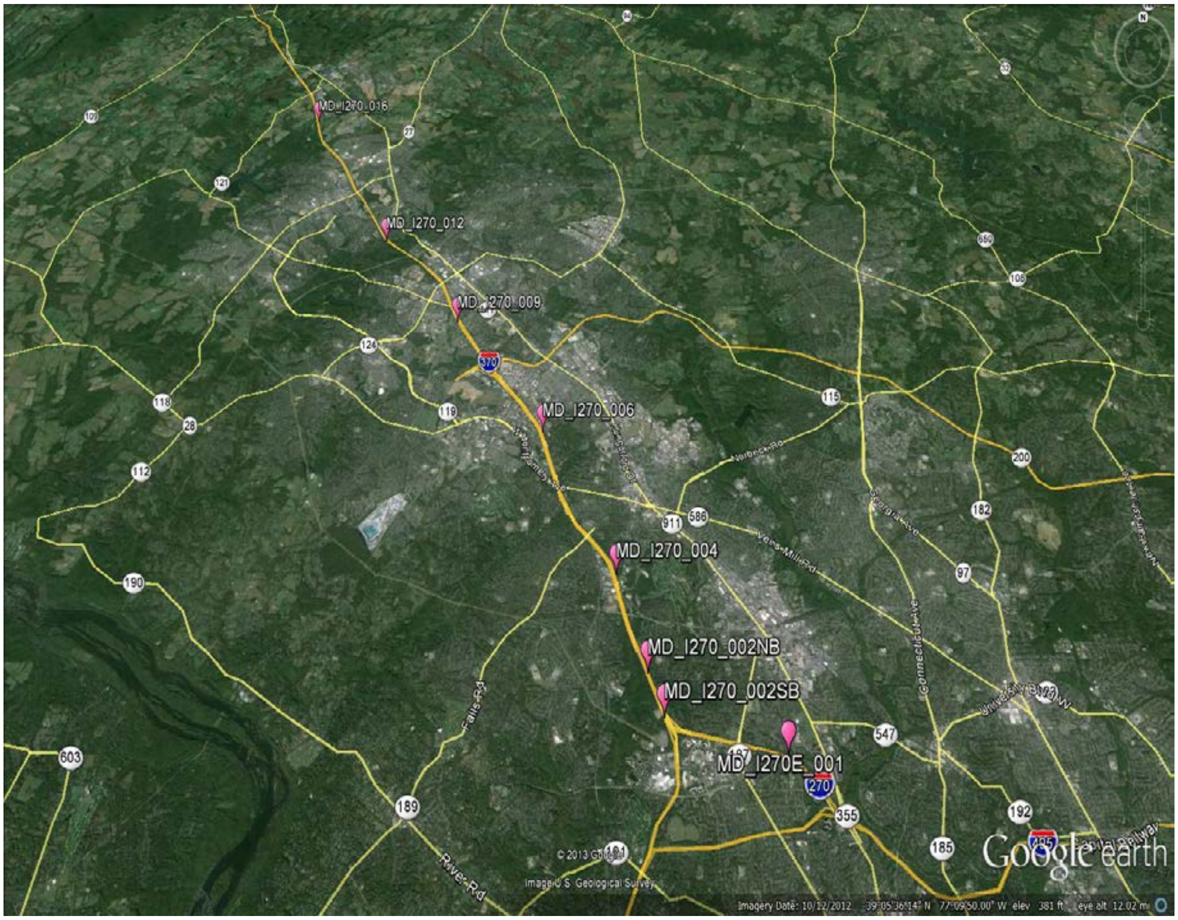

Figure 1. Location of Bluetooth sensors on I-270

For the year of 2013, more than 80 million Bluetooth raw records were retrieved from the data repository at CATT. The following stepwise processes were applied on the Bluetooth data to generate travel time:

Data clean up and redundancy elimination: Bluetooth sensors sweep the surrounding environment to record and report active MAC addresses in short intervals. There is a chance that a MAC address is reported multiple times by the same sensor especially when the traffic moves slowly. The first such detection for each MAC address is identified and the redundant records are flagged as the first step in data processing.

Matching: travel time samples are created by matching MAC addresses between two consecutive Bluetooth detectors. Travel time records were matched for the sensors at both ends of the HOV corridor in each direction. For verification purposes data was matched for shorter portions between other pairs of sensors as well.

Filtering: since vehicles travel at different speeds, they experience different travel times. In order to estimate average travel time on a segment, travel time observations must be aggregated in desired intervals. However, there are vehicles that travel wither too fast or too slow with respect to the average traffic speed. These outlier samples must be eliminated. A four step filtering approach is applied to the matched data.

Pattern recognition: the novel part of the approach used in this project lays in the pattern recognition component. When HOV regulations are in effect (afternoon on the northbound and morning on the southbound during week days), two distinct travel time patterns emerge. Since HOV users enjoy faster speeds, their travel time start to deviate from what is experienced in general purpose lanes. At the end of HOV hour travel times becomes equal between the two sets. Two algorithms including k-mean clustering based on shortest distance, and EM-clustering based on distribution were implemented and applied on the data. After marking observations belonging to each cluster, separate average travel time was produced for HOV as well as general purpose lanes.

Figure 2 shows an example for a typical day on the northbound I-270. Average travel time by INRIX and Bluetooth as well as individual travel time observations are shown. As illustrated, probe data does not have enough resolution to provide separate travel time for the mixed lane facilities. Although Bluetooth travel time samples exhibit difference between travel time of HOV and other lanes, the traditional matching and aggregation methodology applied to the Bluetooth data produces average travel time for all lanes. So it is necessary to use pattern recognition solutions to generate two set of aggregate travel times during HOV operational hours.

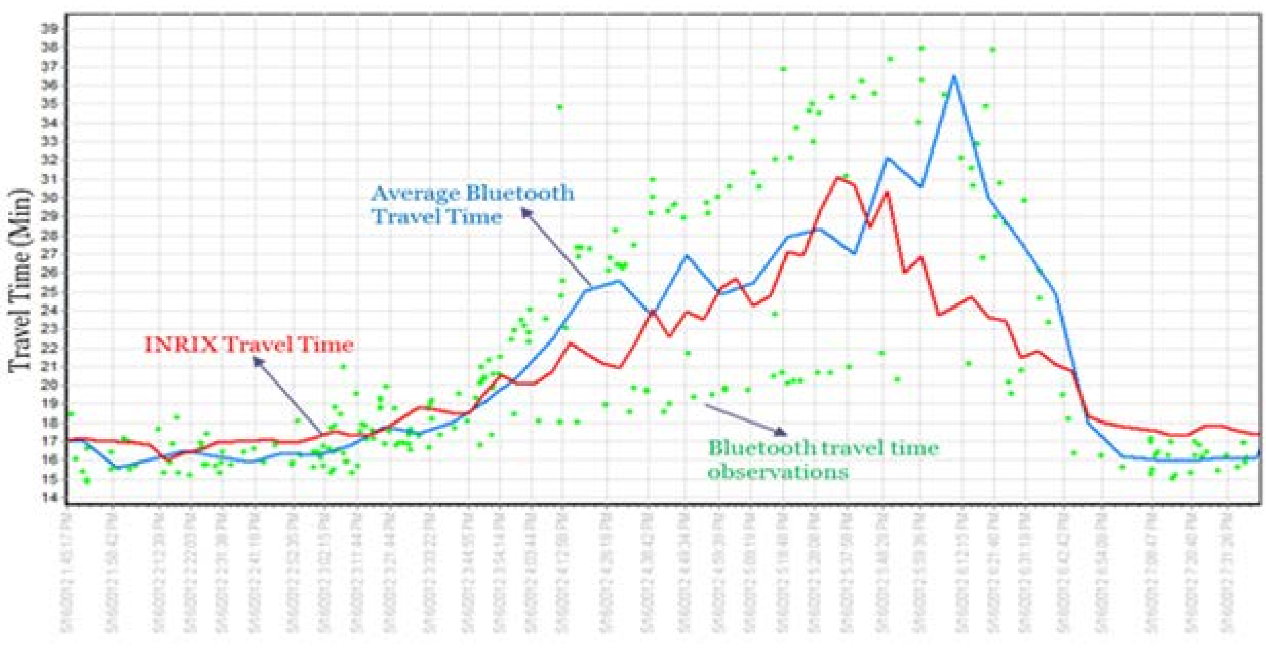

Figure 2. Travel time patterns on HOV and general purpose lanes on I-270 northbound

2.1 DATE CLUSTERING AND PATTERN RECOGNITION

There have been few previous efforts to measure travel time of the HOV lanes. A study by Shawn M. Turner (1995) separates HOV and Non-HOV lane through license plate matching data. However, license plate matching requires high initial cost for equipment purchase and is not easily scalable. Jang et al. (2012) utilized loop detector data obtained from California Department of Transportation Performance Measurement System (PeMS) to identify HOV lane traffic data however this approach results in indirect travel time estimation rather than travel time measurement. Figure 3 shows one week travel time pattern on I-270 northbound using Bluetooth data. Afternoon travel time peak can be observed for the work days, and the graph for Tuesday traffic is expanded to exhibit distinct travel time patterns.

In order to separate travel patterns of the HOV lanes, a data clustering approach was developed. K-means is one of the simplest unsupervised learning algorithms that solve the well-known clustering problem. The procedure follows a simple way to classify a given data set through a certain number of clusters (assume k clusters) fixed a priori. The main idea is to define k centroids, one for each cluster. These centroids should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest centroid. When no point is pending, the first step is completed and an early grouping is done. At this point we need to re-calculate k new centroids as barycenters of the clusters resulting from the previous step.

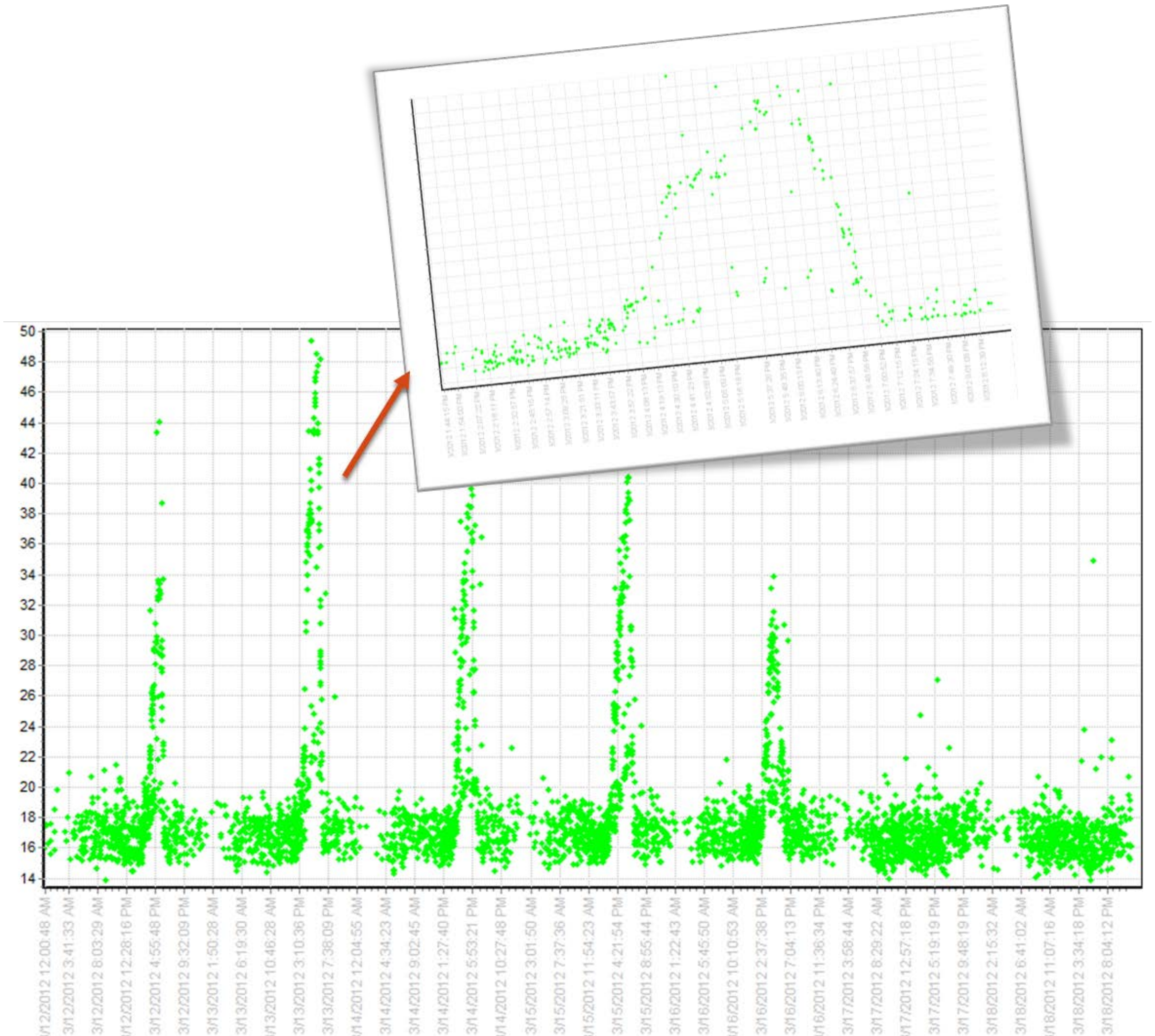

Figure 3. Bluetooth travel time data on I-270 northbound for one week

After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new centroid. A loop has been generated. As a result of this loop we may notice that the k centroids change their location step by step until no more changes are done. In other words centroids do not move any more. The following shows the steps for K-Means algorithm:

Step 0:

Select K objects as initial centroids.

Step 1: (Assignment)

For each object compute distances to k centroids.

Assign each object to the cluster to which it is the closest.

Step 2: (New Centroids)

Compute a new centroid for each cluster.

Step 3: (Convergence)

Stop if the change in the centroids is less than the selected convergence criterion.

Otherwise repeat Step 1.

K-Means falls into the category of hard clustering methods that allow each sample belong to only one cluster and distances are Euclidean. K-Means clustering is a soft clustering method that takes advantage of a membership probability for assigning samples to clusters. A mixture model is required for EM algorithm, since probabilities are involved. In this project we have only two clusters and we assumed normal distribution for each cluster. The EM iteration alternates between performing an expectation (E) step, which creates a function for the expectation of the log-likelihood evaluated using the current estimate for the parameters, and a maximization (M) step, which computes parameters maximizing the expected log-likelihood found on the E step. These parameter-estimates are then used to determine the distribution of the latent variables in the next E step. Figure 4 shows a flowchart of the EM algorithm.

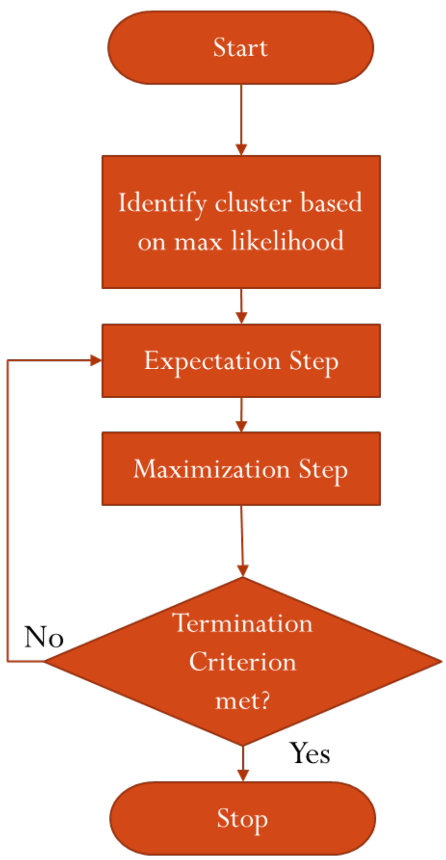

Figure 4. Sample results of the pattern recognition and data clustering

A large number of experiments were conducted on Bluetooth data from different days and the clustering results were visualized and evaluated. Figure 5 shows sample results. Both methods were proven to produce high quality clusters.

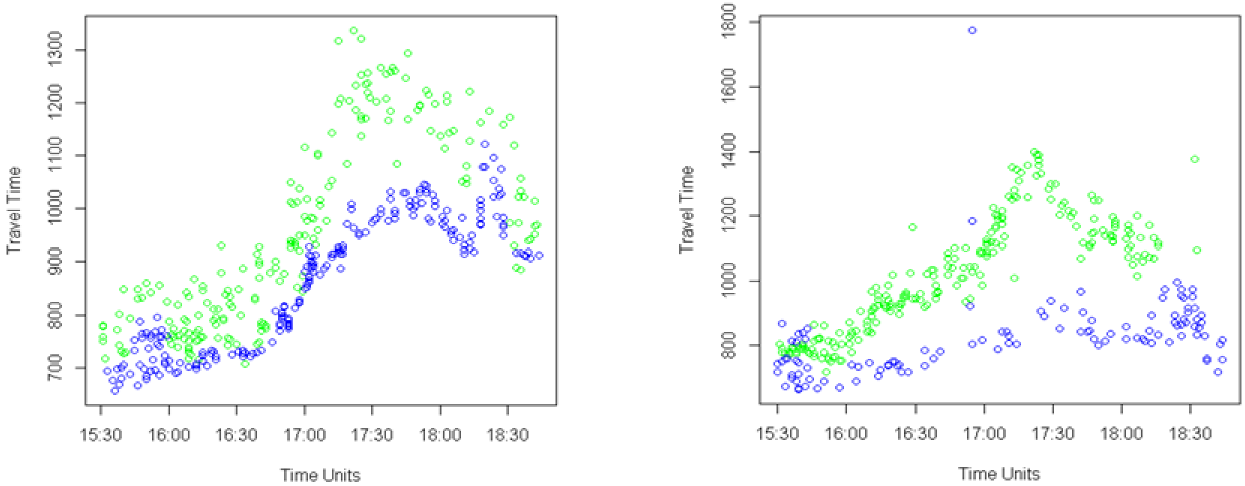

Figure 5. Sample results of the pattern recognition and data clustering

3.0 HOV PERFORMANCE MEASUREMENT

After data preparation, performance measures for the HOV lanes can be generated by fusing travel time, volume and vehicle occupancy data. In order to produce monetary benefits of HOV lanes value of time information is required which is shown in appendix A. Vehicle occupancy rates were provided by the SHA as shown in appendix B.

The following steps were applied to the data in order to regenerate performance measures:

HOV and non-HOV throughput: since SHA provided volume data in an hourly basis, lane by lane volume data was aggregated for general purpose lanes for each detector location shown in table 1. For all working days during 2013 (weekdays minus public holidays) average hourly volume for each set of lanes for each hour of the day. In order to produce person throughput per lane, occupancy rates were retrieved from appendix B and applied to the average vehicle throughput.

Travel time savings: as discussed earlier, one advantage of the approach used in this project is continuous measurement of travel time on HOV as well as general purpose lanes. For all working days of the year, travel time was aggregated in 30 minute intervals on both northbound and southbound directions. Then travel time for each interval was produced by averaging travel time on all days.

Monetary savings: using the value of time assumption in appendix A, for each time interval the number of people that used HOV facility were multiplied by their travel time savings (travel time on general purpose lanes minus HOV travel time) and the results were added for the entire year in each direction.

Figure 6 shows general architecture of the performance monitoring system.

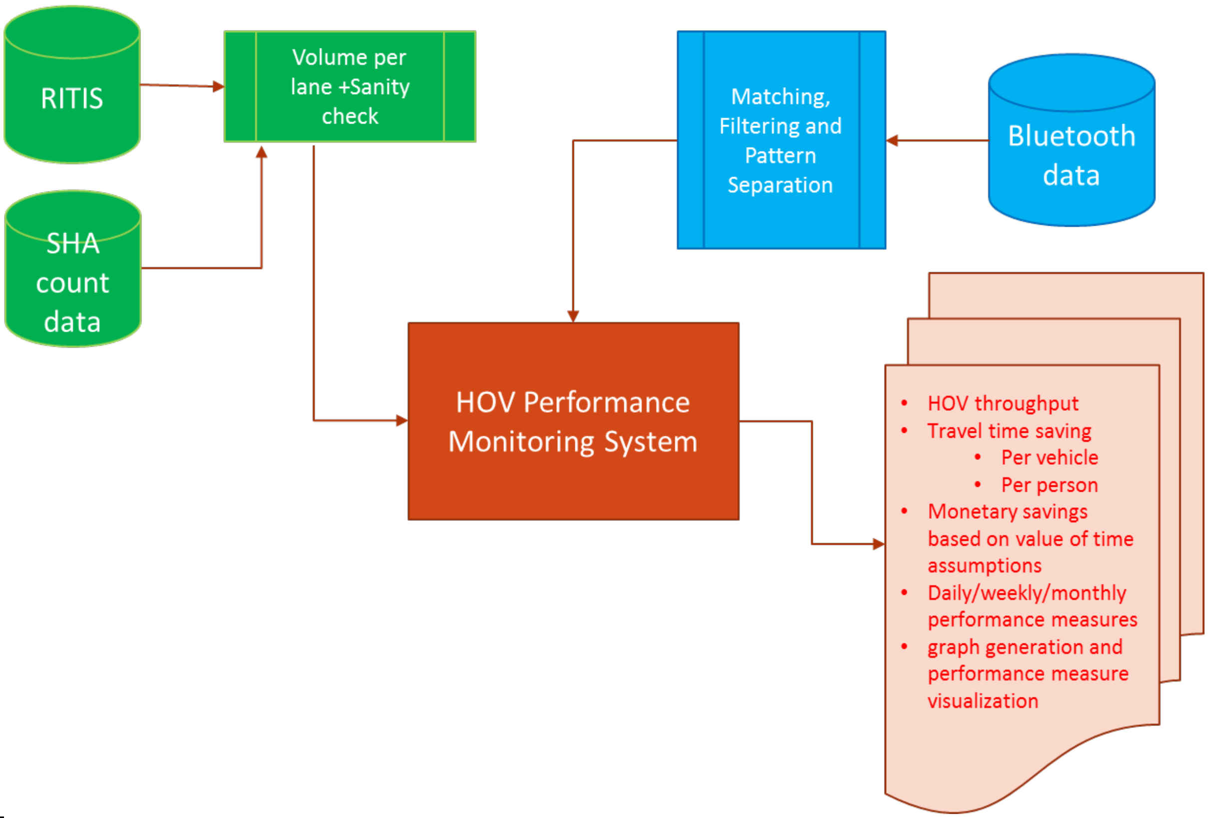

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Figure 6. Architecture of the HOV performance monitoring system

The following sections provide a brief history of the results formatted according to the Maryland Mobility Report to be included in the upcoming 2014 report.

4.0 SHORT SUMMARY FOR INCLUSION IN MARYLAND MOBILITY REPORT 2014

High occupancy vehicle (HOV) lanes promote carpooling, van and bus usage. The lanes maximize person throughput instead of just vehicle throughput. HOV lanes offer a travel time savings for multiple occupant vehicles over single occupant vehicles by restricting access to vehicles that have two or more occupants.

There are two roadways in Maryland where HOV lanes are in operation. They are:

• I-270 – I-495 to MD 121 (Northbound)

• I-270 – MD 117 to I-495 (Southbound)

• US 50 – US 301 to I-95

The I-270 HOV lanes operate southbound from 6:00 to 9:00 AM and northbound from 3:30 to 6:30 PM while the US 50 HOV lanes operate 24 hours a day. The HOV lanes are restricted to two or more occupants per vehicles, transit vehicles, motorcycles, or plug-in hybrid vehicles (permit required). HOV lanes in combination with park and ride lots increase person throughput and provide a viable alternative transportation mode for commuters.

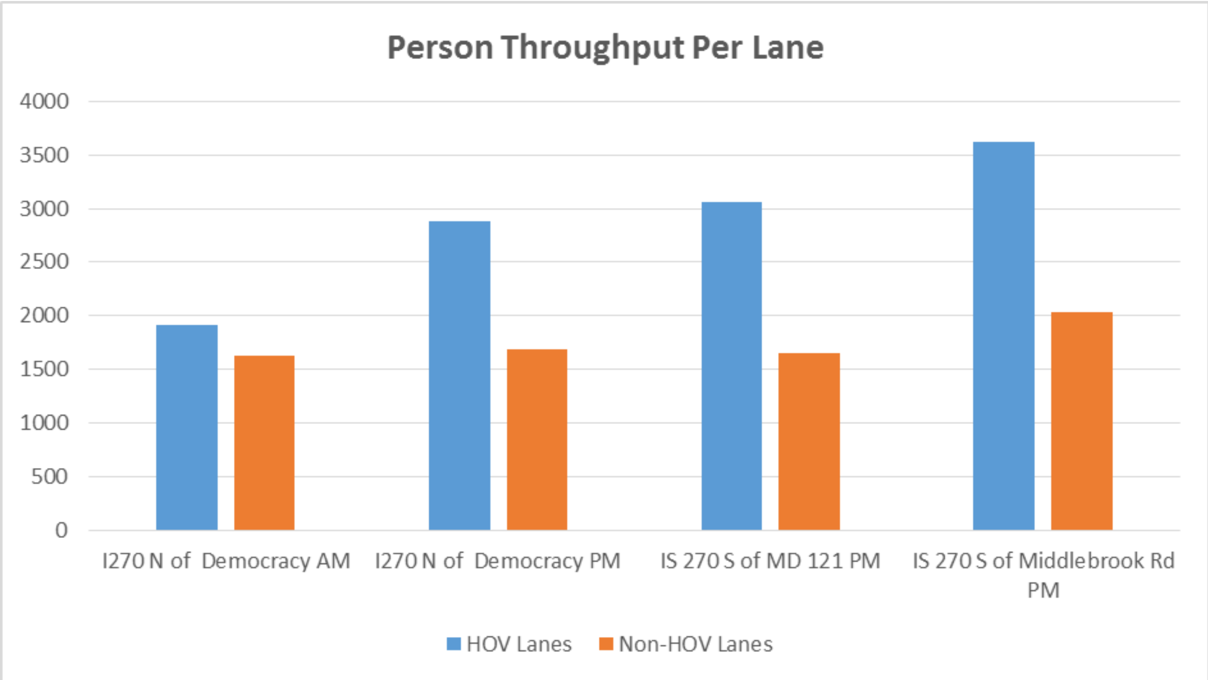
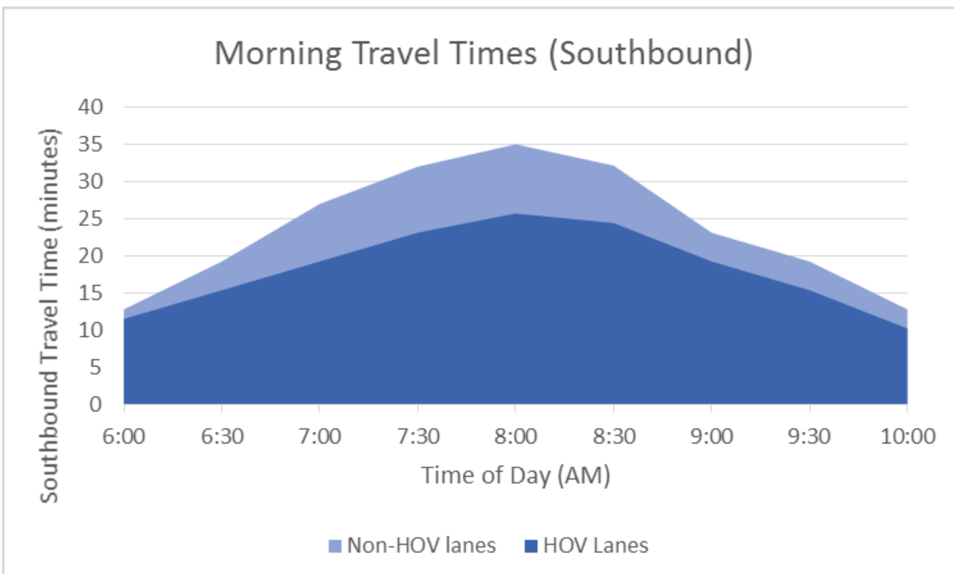


Figure 7. Person throughput per lane for I270 Northbound and Southbound

The person throughput is higher in the HOV lanes than the non-HOV or general purpose lanes even though the number of vehicles traversing the HOV lanes is lower.

The HOV lanes also provide for a significant time savings. In the afternoon, motorists on I-270 can save up to 16 minutes utilizing the high occupancy vehicle lanes versus the general purpose lanes for travelling the entire length of the facility. Average travel time saving during afternoon peak is 8 minutes, with 5.7 minute standard deviation, with maximum time saving of 16 minutes at the peak of peak. A travel time savings of up to 9 minutes occurs in the morning peak period using the I-270 HOV lanes. Average travel time saving during morning peak is 6 minutes, with 2.5 minute standard deviation.

HOV lanes on I-270 northbound resulted in 1,195,244 million person-hour time saving which has a value of $3.4 million (based on the value of time equal to $31.36 per hour). This number for I-270 southbound is $0.45 million. Data analysis shows that 90% of the time average speed on HOV lanes has been above 45 mph.



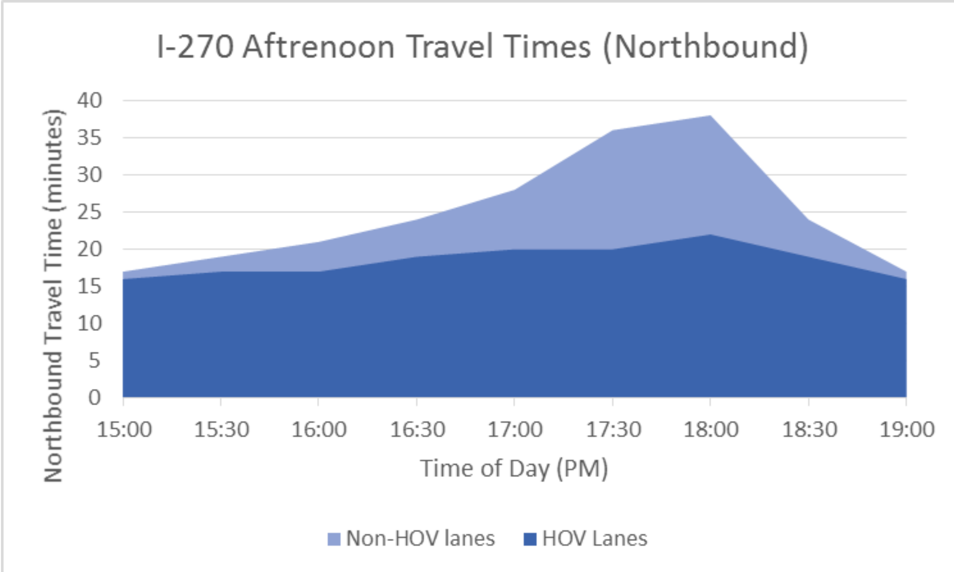


Figure 8. Morning and afternoon travel time patterns on I-270 HOV corridors

Table 2 shows a summary table for the performance measures.

Table 2. Summary of I-270 HOV performance measures

	Total Travel Time Savings		Fuel Savings		TOTAL SAVINGS
	('000 Hours)	($ Million)	('000 Gallons)	($ Million)	($ Million)
I-270 SB - AM Period (9 miles of HOV) ***6 min. avg. savings compared to general lanes***	14	$0.45	16	$0.06	$0.51
I-270 NB - PM Period (16 miles of HOV) ***8 min. avg. savings compared to general lanes***	108	$3.40	155	$0.57	$3.97
TOTAL	122	**$3.85**	171	**$0.63**	**$4.48**

As table 2 shows, fuel savings have been calculated as a performance measure. A methodology used by the Texas Transportation Institute (TTI) that is used for estimating wasted fuel in the Annual Mobility Report has been adopted to calculate fuel savings. In this method, average fuel saving economy calculation is used to estimate the difference in fuel consumption of the vehicles operating in HOV and general purpose lanes which exhibit different congestion levels. The following is a regression equation resulting from fuel efficiency data from EPA/FHWA's MOVES model (2011 Urban Mobility Report Methodology A-201)

[1] http://mobility.tamu.edu/ums/congestion-data

$$Passenger\ Car\ Fuel\ Economy = -0.0066 * Speed^2 + 0.823 * Speed + 6.1577 \quad (1)$$

The following steps were applied to calculate fuel savings:

Calculate average vehicle throughput for each hour of the day using the volume data.

Apply equation (1) above to calculate passenger car fuel economy for HOV and General Purpose lanes by plugging average hourly speed of each set of lanes in the equation.

Calculate difference in fuel consumption for traversing the length of corridor and multiply it by the hourly volume of HOV.

Multiply the number in step 3 by the number days that HOV was in effect (work days)

Use SHA's fuel price assumption provided by CHART ($3.69 /gallon) and multiply by the number in step 4.

5.0 SUMMARY AND FUTURE WORK

This project aimed at evaluating performance measures of HOV facilities. The HOV lanes on both I-270 northbound and southbound were used for a case study based on 2013 data. Data from various sources including Bluetooth and stationary detectors were imported and investigated. A novel and innovative data clustering approach was developed to separate travel time data on HOV and general purpose lanes. Two separate algorithms based on both hard and soft clustering were examined. A fuel efficiency procedure was applied for estimating fuel savings on HOV lanes. Value of time, cost of fuel and vehicle occupancy data were collected from trustable sources. By blending travel time, volume and occupancy data several performance measures including travel time savings, person throughput, and fuel savings were calculated for HOV lanes. By applying financial factors including value of time and fuel cost, economical performance of the HOV lanes were estimated and reported. Necessary graphs and tables for inclusion in 2014 Maryland Mobility Report were produced.

This approach was the first attempt of its kind to evaluate performance of HOV facilities by taking advantage of traffic data from various sources. In the future all components of the system exhibited in figure 6 will be developed and added to the integrated software framework. By installing Bluetooth sensors on US-50 in Maryland, the system can be expanded to cover more HOV corridors. The approach can also be used to produce performance measures on HOT lanes.

Using HOV may result in reduction of Green House Gas (GHG) emissions. Finding appropriate models to measure such savings and incorporating the model into the evaluation framework is also subject of future research.

6.0 APPENDICES

APPENDIX A

VALUE OF TIME ASSUMPTION

The assumptions for value of time are similar to the ones used for the rest of the Maryland Mobility report and are obtained from Center for Advanced Transportation Technology (CATT) at the University of Maryland as shown in the following memorandum.

Values of Time Used in the CHART Benefit Analysis in 2013

Time Values to Estimate the Total Direct Benefits to Highway Users in 2013

Reduction due to CHART		**Unit rate**
Delay	**Truck**	Driver *$19.29/hour (20.21)* [2]
		Cargo $45.40/hour [3]
	Car	*$31.36/hour (29.82)* [2]
Fuel Consumption		Gasoline *$3.58/gal (3.69)* [2]
		Diesel *$3.92/gal (3.97)* [2]
Emission	**HC**	$6,700/ton
	CO	$6,360/ton
	NO	$12,875/ton
	CO2	$23/metric ton [4]

Note: 1. Italic unit rates indicate changes in 2013, and the number in the parenthesis is the unit rate for the 2012 analysis
2. The car driver's cost and fuel price are updated based on the information from the U.S Census Bureau in Year 2013 and the Energy Information Administration in Year 2013, respectively.
3. The cargo time value is based on the study by the Texas Transportation Institute, Levinson (2003), and DeJong (2000).
4. CBO (Congressional Budget Office)'s cost estimate for S. 2191, America's Climate Security Act o

APPENDIX B
VEHICLE OCCUANCY ASSUMPTION

Vehicle occupancy rates for HOV and general purpose lanes are obtained from the Maryland State Highway Administration as shown in the following table.

Summer 2013										
Segments	**Vehicle Throughput** (per segment/Hour)					**Average Vehicle Occupancy** (persons per vehicle)			**Person Throughput** (per Lane)	
	Total	**GP**	**Legal HOV**	**Eligible HOV**	**% HOV 2+**	**GP***	**HOV**	**Overall**	**GP***	**HOV**
Southbound AM Peak Hour 6:00 am – 7:00 am										
I-270 East Spur West of MD 187	4,189	3,456	733	830	20%	1.18	2.40	1.39	1,355	1,756
I-270 West Spur North of Democracy Blvd	5,507	4,814	693	880	16%	1.06	2.58	1.25	1,697	1,786
I-270 South of Shady Grove Road	9,602	8,632	970	1,517	16%	1.14	2.42	1.27	1,974	2,347
*I-270 South of MD 118***	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Corridor Average	6,433	5,634	799	1,076	17%	1.13	2.47	1.30	1,675	1,963
Northbound PM Peak Hour (4:30 pm - 5:30 pm)										
I-270 East Spur West of MD 187	3,777	3,066	711	862	23%	1.13	2.63	1.41	1,158	1,867
I-270 West Spur North of Democracy Blvd	5,081	4,063	1,018	1,158	23%	1.04	2.46	1.32	1,402	2,509
I-270 South of Shady Grove Road	8,374	7,483	891	1,610	19%	1.17	2.21	1.28	1,456	1,967
I-270 South of MD 118	5,923	4,985	938	1,127	19%	1.08	2.58	1.28	1,718	2,419
Corridor Average	5,789	4,899	890	1,189	21%	1.11	2.47	1.32	1,434	2,191

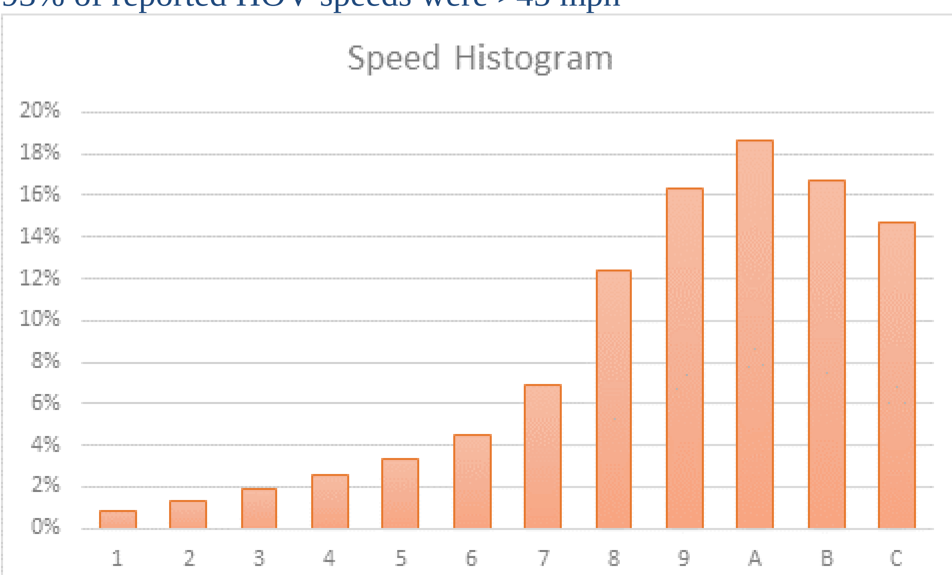
* *Value represents average per lane* ** *No HOV Lanes are present on I-270 SB south of MD 118*

APPENDIX C
SPEED HISTOGRAMS FOR HOV LANES BASED ON SHA DETECTORS

SPEED	Speed Bins in MPH
1	0-30
2	31-35
3	36-40
4	41-45
5	46-50
6	51-55
7	56-60
8	61-65
9	66-70
A	71-75
B	76-80
C	>80

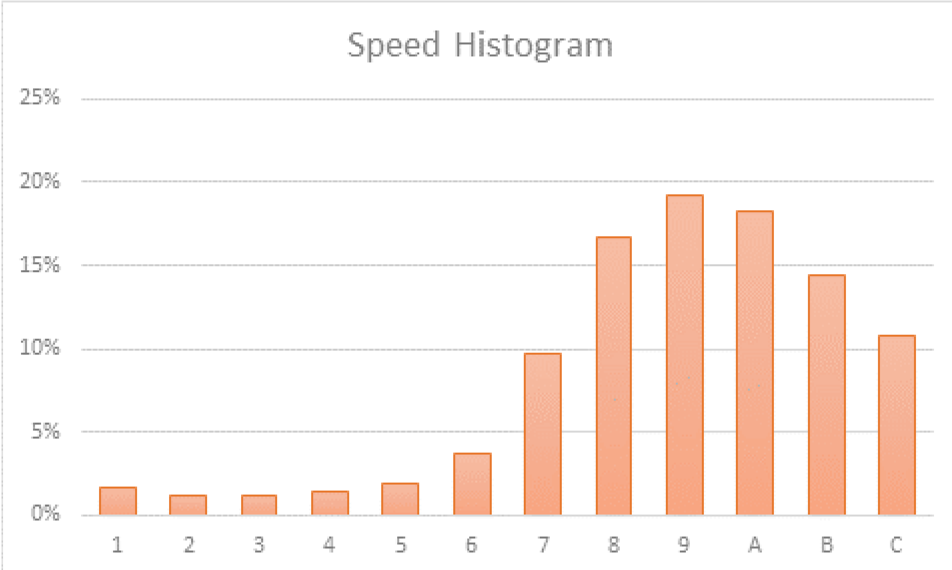
P0060 Northbound:

93% of reported HOV speeds were >45 mph

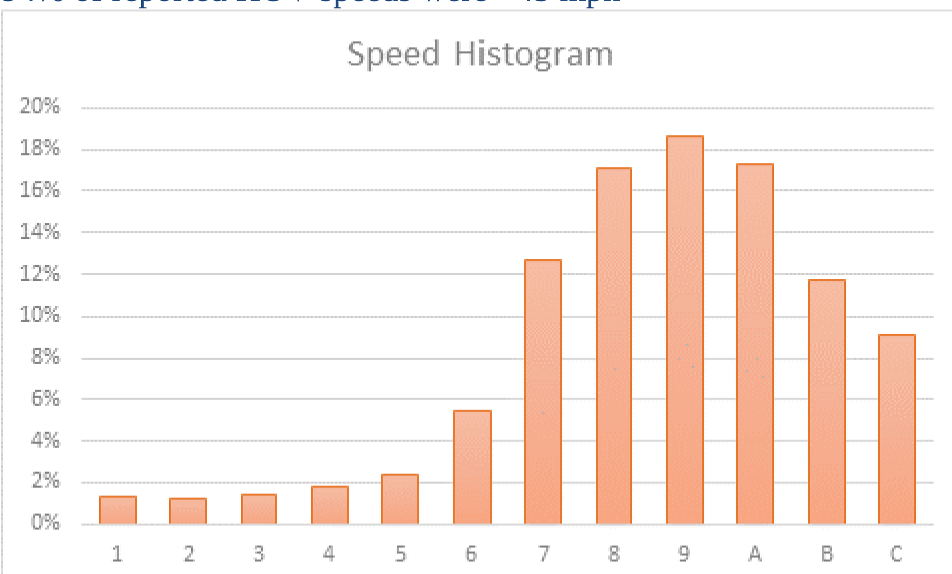


P0060 Southbound:

95% of reported HOV speeds were >45 mph



P0004 Northbound:
94% of reported HOV speeds were >45 mph

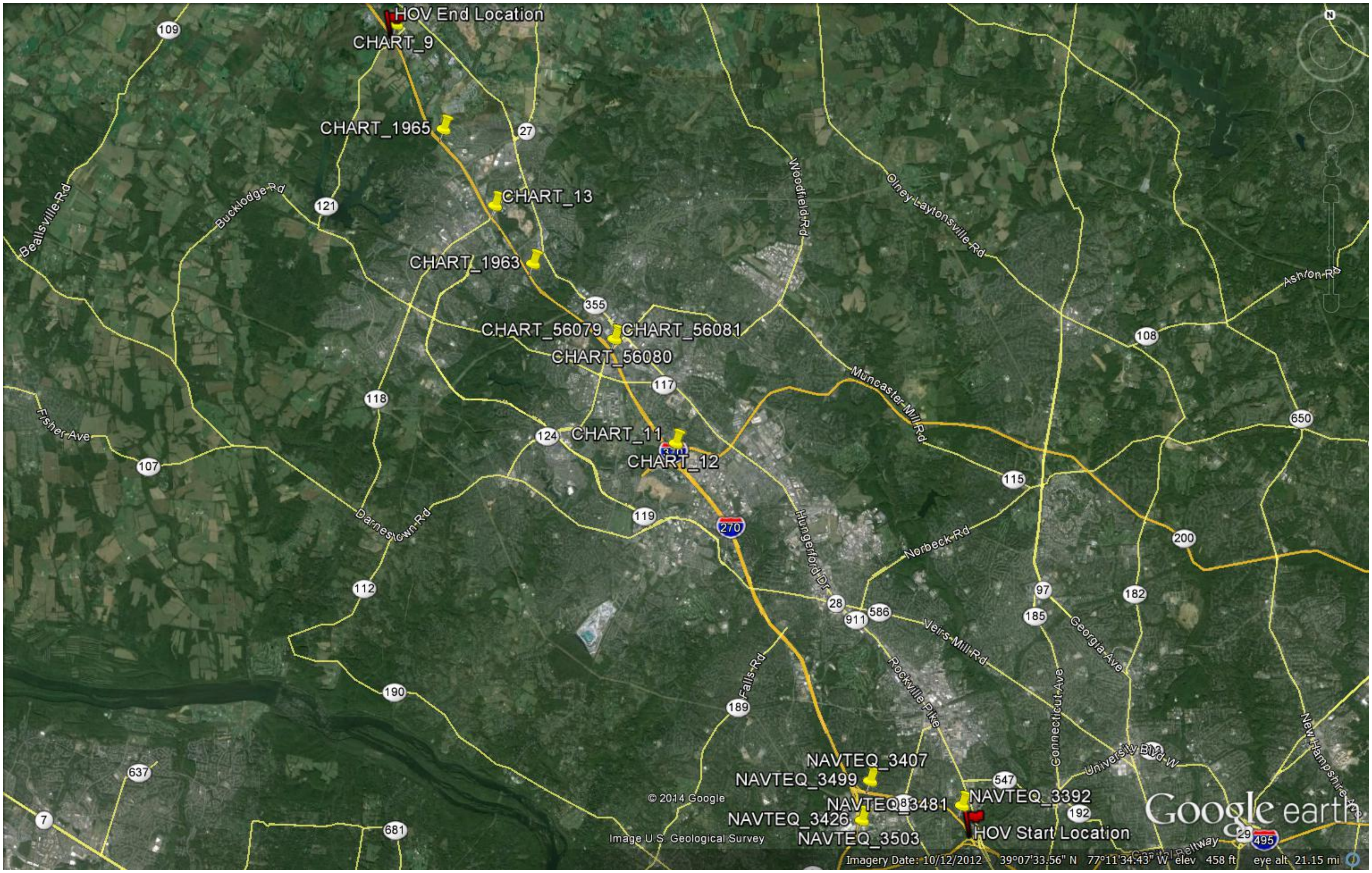


P0004 Southbound:
96% of reported HOV speeds were >45 mph

APPENDIX D
SUMMARY OF TRAFFIC DETECTOR INFORMATION ON I-270 HOV

Summary detector Information for northbound I-270 for year 2013

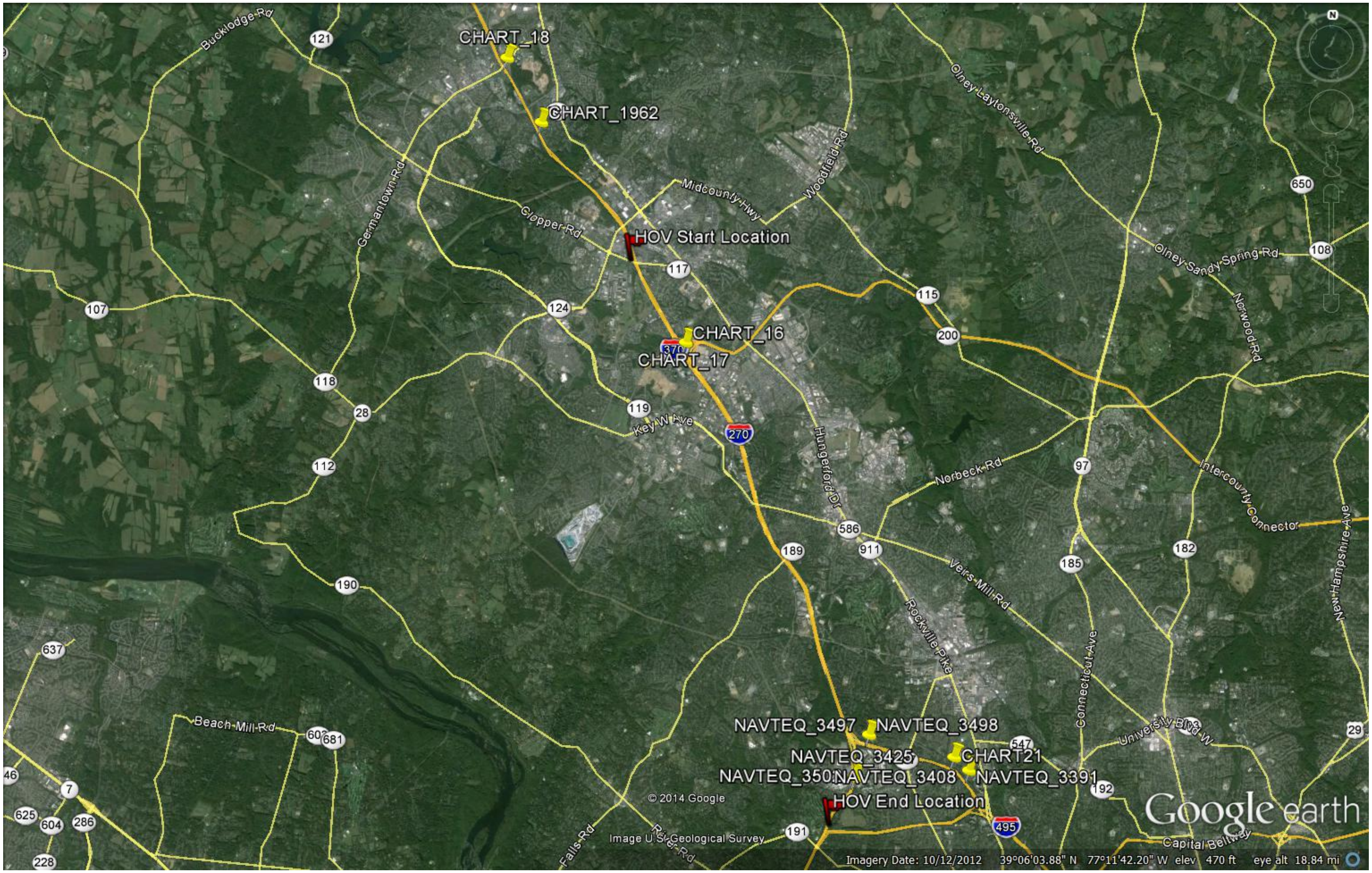
Detector ID	Zone ID	Organization	Location	# Lanes	Type	Lane Type	Temporal Coverage
NAVTEQ_3503	3503	NAVTEQ	I-270 @ 0.25 Mile South of Westlake Terrace	2 (2-3)	Microwave	General Purpose Lanes	good
NAVTEQ_3426	3426	NAVTEQ	I-270 HOV @ 0.25 Mile South of Westlake Terrace	1 (1)	Microwave	HOV	good
NAVTEQ_3392	3392	NAVTEQ	I-270 @ 0.23 Mile North of Grosvenor Ln	2 (2-3)	Microwave	General Purpose Lanes	good
NAVTEQ_3481	3481	NAVTEQ	I-270 HOV @ 0.23 Mile North of Grosvenor Ln	1 (1)	Microwave	HOV	good
NAVTEQ_3499	3499	NAVTEQ	I-270 @ 0.39 Mile North of Rockledge Blvd	3 (2-4)	Microwave	General Purpose Lanes	good
NAVTEQ_3407	3407	NAVTEQ	I-270 HOV @ 0.39 Mile North of Rockledge Blvd	1 (1)	Microwave	HOV	good
CHART_12	12	CHART	I-270 SB @ I-370	4 (1-4)	Unknown	General Purpose Lanes and HOV	more than half missing
CHART_11	11	CHART	I-270 SB @ I-370	2 (5-6)	Unknown	Local Lanes	more than half missing
CHART_56079	56079	CHART	I-270 NB @ MD 124	1 (1)	Unknown	HOV	more than half missing
CHART_56080	56080	CHART	I-270 NB @ MD 124	3 (2-4)	Unknown	General Purpose Lanes	more than half missing
CHART_56081	56081	CHART	I-270 NB @ MD 124	1 (5)	Unknown	Local Lane	more than half missing
CHART_1963	1963	CHART	IS 270 South of Middlebrook Rd	Unknown	ATR	Unknown	all missing
CHART_13	13	CHART	I-270 SB @ MD 118	4 (1-4)	RTMS	General Purpose Lanes and HOV	more than half missing
CHART_1965	1965	CHART	IS 270 South of MD 121	Unknown	ATR	Unknown	all missing
CHART_9	9	CHART	I-270 SB @ MD 121	3 (1-3)	Unknown	General Purpose Lanes and HOV	more than half missing



Detector locations on northbound I-270 for year 2013

Summary detector Information for southbound I-270 for year 2013

Detector ID	Zone ID	Organization	Location	# Lanes	Type	Lane Type	Temporal Coverage
CHART_18	18	CHART	I-270 SB @ MD 118	4 (1-4)	unknown	General Purpose Lanes and HOV	more than half missing
CHART_1962	1962	MDOT_CHART	IS 270 South of Middlebrook Rd	Unknown	ATR	Unknown	all missing
CHART_17	17	MDOT_CHART	I-270 SB @ I-370	4 (1-4)	unknown	General Purpose Lanes and HOV	more than half missing
CHART_16	16	MDOT_CHART	I-270 SB @ I-370	2 (5-6)	unknown	Local Lanes	more than half missing
NAVTEQ_3498	3498	NAVTEQ	I-270 @ 0.39 Mile North of Rockledge Blvd	2 (2-3)	Acoustic	General Purpose Lanes	good
NAVTEQ_3497	3497	NAVTEQ	I-270 @ 0.39 Mile North of Rockledge Blvd	1 (4)	Acoustic	Off Ramp	good
NAVTEQ_3406	3406	NAVTEQ	I-270 HOV @ 0.39 Mile North of Rockledge Blvd	1 (1)	Acoustic	HOV	good
CHART21	21	MDOT_CHART	I-270 between Grosvenor Lane and MD 187	3 (1-3)	RTMS	General Purpose Lanes and HOV	more than half missing
NAVTEQ_3391	3391	NAVTEQ	I-270 @ 0.23 Mile North of Grosvenor Ln	2 (2-3)	Microwave	General Purpose Lanes	good
NAVTEQ_3480	3480	NAVTEQ	I-270 HOV @ 0.23 Mile North of Grosvenor Ln	1 (1)	Microwave	HOV	good
NAVTEQ_3502	3502	NAVTEQ	I-270 @ 0.25 Mile South of Westlake Terrace	2 (2-3)	Microwave	General Purpose Lanes	good
NAVTEQ_3425	3425	NAVTEQ	I-270 HOV @ 0.25 Mile South of Westlake Terrace	1 (1)	Microwave	HOV	good



Detector locations on southbound I-270 for year 2013