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YEAR2
Submitted to CATSS

EVALUATION OF "AUTOSENSE-III" LASER DETECTION TECHNOLOGY FOR TRAFFIC APPLICATIONS ON I-4

Project Period

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By

Haitham Al-Deek, Ph.D., P.E.
Associate Professor and Associate Director of CATSS for ITS Programs, and
Director of the Transportation System Institute (TSI)
Department of Civil & Environmental Engineering
University of Central Florida
Orlando, FL 32816
Phone: (407) 823-2988
Fax: (407) 823-3315
E-mail: haldeek@pegasus.cc.ucf.edu
http://www.catss.ucf.edu/tsi

And

Sherif Ishak, Ph.D.
Assistant Professor
Department of Civil and Environmental Engineering
Louisiana State University
Baton Rouge, LA 70803
Phone: (225)-578-4846
Email: sishak@lsu.edu

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EXECUTIVE SUMMARY

The major tasks of this project include procuring the two AUTOSENSE III units; selecting a site on I-4 for installation of the units, installing the units successfully on I-4, establishing a remote communication link through cellular data line to download data form the units, and evaluating the data received from the two units. All these tasks were accomplished successfully during this project.

This study was conducted to evaluate the laser detection technology AUTOSENSE III on I-4 in Orlando, Florida. Two units were tested in site in the westbound direction. The two units were mounted overhead nearby Lake Ivanhoe. In order to validate the AUTOSENSE III counts, the same site was videotaped using the Florida Department of Transportation (FDOT) Closed Circuit TV (CCTV) cameras for three days from 6 to 10 AM and the video counts were used as ground truth. Since the AUTOSENSE III devices can provide vehicle classification of up to 11 types of vehicles, it was important to test the vehicle classification capabilities as well. For the purpose of the study, only trucks were identified as a major type of vehicle.

The analysis was conducted using graphical representations of the data and appropriate statistical procedures. Counts were based on one minute and five minutes to reduce the errors caused by lack of time synchronization between the AUTOSENSE III clock and the camcorder clock. Although the visual inspection of the graphical plots shows that the two sources were relatively close, the statistical tests on the difference in counts concluded that the data from the two sources significantly different. This conclusion was consistent when considering all types of vehicles and when considering trucks only. The only exception was for the right lane, which showed no significant difference in the truck counts.

EVALUATION OF "AUTOSENSE-III" LASER DETECTION TECHNOLOGY FOR TRAFFIC APPLICATIONS ON I-4

INTRODUCTION

The UCF-CATSS funds were used to purchase two AUTOSENSE III units from SEO in April 1999. The UCF-TSI research team, FDOT, and SEO agreed on the appropriate location for installation of the two units on I-4, this was next to the Lake Ivanhoe interchange. Selection of this location was based on incident history, availability of sign structure for mounting the units, and presence of loop detector data as well as CCTV video cameras operated by the FDOT Regional Traffic Management Center (RTMC) located in Orlando. The FDOT cameras and adjacent loop detector stations would be used for comparison with traffic data collected from the AUTOSENSE III units.

SEO had to secure an installation permit from FDOT permit's office in Deland to install the two AUTOSENSE III units on I-4 sign structure at Lake Ivanhoe. In addition, an AT&T wireless agreement had to be signed between UCF legal council and AT&T so that data from the two units can be accessed through a website and cellular data line. This legal process took about 5 months. SEO hired a subcontractor to close I-4 lanes during two consecutive nights while the AUTOSENSE III units are being installed on the sign structure. Finally, the two units were installed in September 1999 and are currently operational.

Figure 1 shows the traffic data system block diagram used at the I-4 site. The mounting configuration is shown in Figure 2, where two units were installed to an overhead structure, each covering two of the three lanes. Each unit provides lane coverage as illustrated in Figure 3. A snapshot of the I-4 site showing the two units in operation, along with the computer, is given in Figure 4.

Each AUTOSENSE III unit is capable of measuring three traffic parameters: speed, lane occupancy, and traffic volume in 30-second increments. All counts are classified into a total of 12 vehicle types as shown in Figure 5. The figure shows the description of each type and its category. For illustration, Figure 6 shows a sample of the raw data collected by the AUTOSENSE III device.

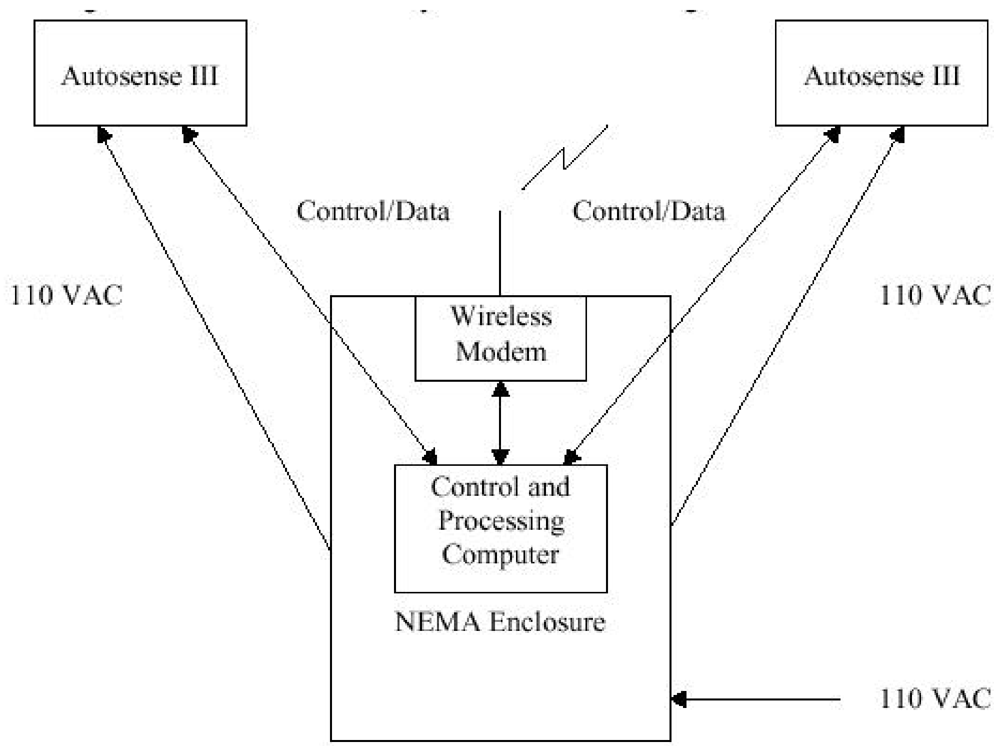


Figure 1: Traffic Data System Block Diagram

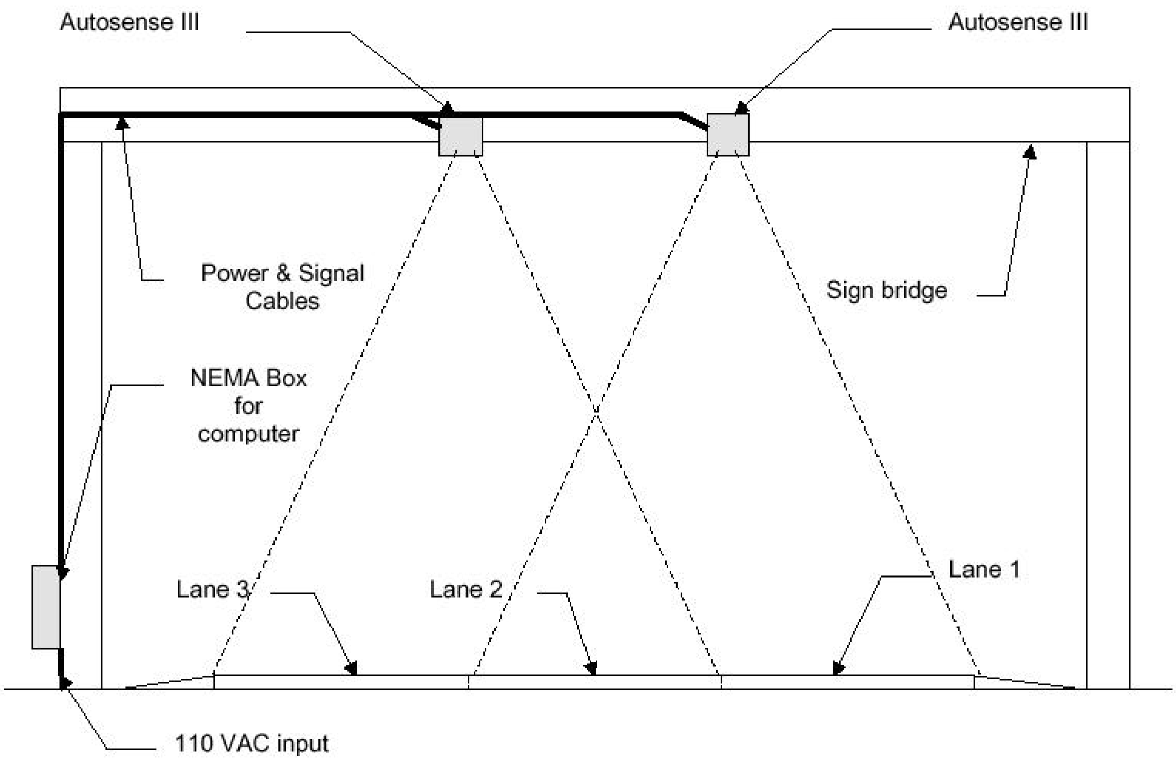


Figure 2: Roadside System Mounting Configuration

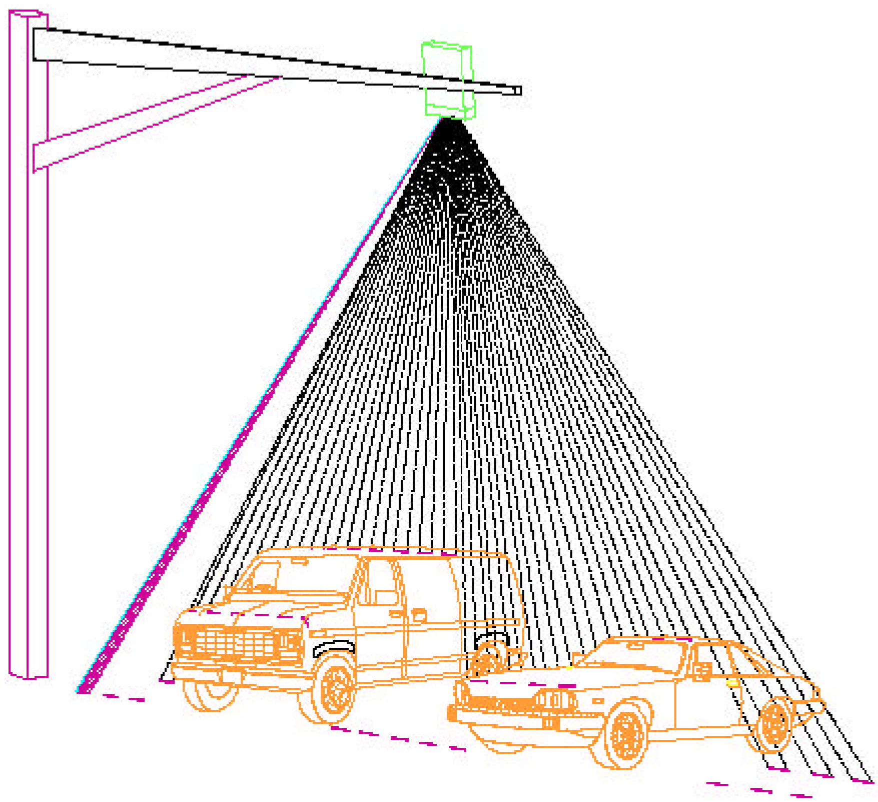


Figure 3: AUTOSENSE III Lane Coverage

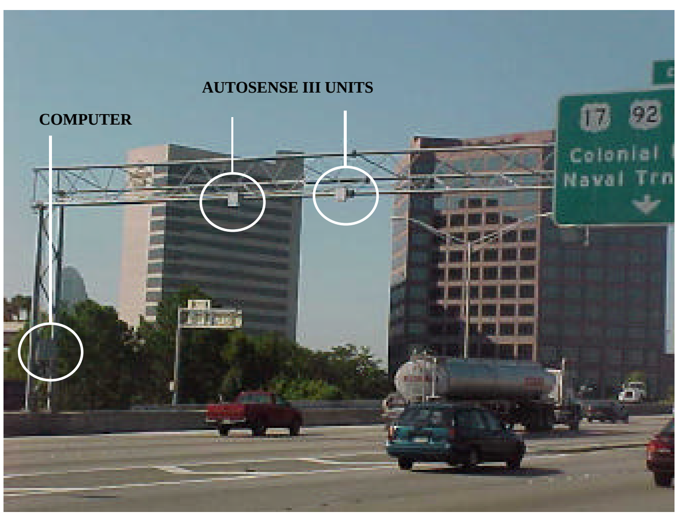


Figure 4: AUTOSENSE III Installation on I-4. Two AUTOSENSE III Units Installed on the Interstate 4 Sign Structure at the Lake Ivanhoe Interchange on Westbound I-4

- Number of class 0 vehicles (unknown type)
- Number of class 1 vehicles (motorcycle)
- Number of class 2 vehicles (motorcycle with trailer)
- Number of class 3 vehicles (automobile or pickup)
- Number of class 4 vehicles (auto/pickup with trailer)
- Number of class 5 vehicles (van or sport utility vehicle)
- Number of class 6 vehicles (van/SUV with trailer)
- Number of class 7 vehicles (single unit truck or bus)
- Number of class 8 vehicles (single unit truck/bus with trailer)
- Number of class 9 vehicles (tractor with 1 trailer)
- Number of class 10 vehicles (tractor with 2 trailers)
- Number of class 11 vehicles (tractor with 3 trailers)
- Total number of vehicles
- Average vehicle speed (in miles per hour)
- Occupancy
- Headway (in seconds)

Figure 5: AUTOSENSE III Vehicle Classification

		Cls 0	Cls 1	Cls 2	Cls 3	Cls 4	Cls 5	Cls 6	Cls 7	Cls 8	Cls 9	Cls 10	Cls 11	Ln 1	Ln 1	Ln 1	Ln 1
Date	Time	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Ln 1	Total	Spd	Occ	Hdw
6/2/99	6:37:08	0	0	0	2	0	1	0	0	0	0	0	0	3	43	4%	6.2
6/2/99	6:37:38	0	0	0	0	0	1	0	0	0	0	0	0	1	49	1%	30.0
6/2/99	6:38:08	0	0	0	5	0	0	0	2	0	0	0	0	7	51	9%	3.8
6/2/99	6:38:38	0	0	0	2	0	2	0	0	0	1	0	0	5	53	9%	6.2
6/2/99	6:39:08	0	0	0	7	0	4	0	0	0	0	0	0	11	46	13%	2.0
6/2/99	6:39:38	0	0	0	1	0	1	0	0	0	0	0	0	2	47	2%	8.9
6/2/99	6:40:08	0	0	0	5	0	1	0	0	0	0	0	0	6	44	7%	2.3
6/2/99	6:40:38	0	0	0	0	0	1	1	0	0	0	0	0	2	46	4%	4.8
6/2/99	6:41:08	0	0	0	3	0	1	0	0	0	0	0	0	4	49	4%	5.0
6/2/99	6:41:38	0	0	0	4	0	3	2	0	0	0	0	0	9	44	14%	2.6
6/2/99	6:42:08	0	0	0	3	0	4	0	2	0	0	0	0	9	44	15%	2.6
6/2/99	6:42:38	0	0	0	2	0	3	0	0	0	0	0	0	5	33	9%	2.8
6/2/99	6:43:08	0	0	0	0	0	1	0	1	0	0	0	0	2	48	3%	8.2
6/2/99	6:43:38	0	0	0	1	0	0	0	1	0	1	0	0	3	43	4%	30.0
6/2/99	6:44:08	0	0	0	6	0	4	0	0	0	0	0	0	10	52	10%	2.7
6/2/99	6:44:38	0	0	0	6	0	2	0	1	0	0	0	0	9	44	11%	2.3
6/2/99	6:45:08	0	0	0	2	0	5	0	0	0	0	0	0	7	39	10%	2.7
6/2/99	6:45:38	0	0	0	1	0	4	0	0	0	0	0	0	5	46	6%	4.0
6/2/99	6:46:08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%	30.0
6/2/99	6:46:39	0	0	0	2	0	1	0	0	0	0	0	0	3	62	2%	1.6
6/2/99	6:47:08	0	0	0	7	0	4	0	0	0	0	0	0	11	55	11%	1.8
6/2/99	6:47:39	0	0	0	10	0	8	0	0	0	0	0	0	18	46	22%	1.3
6/2/99	6:48:08	0	0	0	3	0	1	0	1	0	0	0	0	5	44	7%	5.6

Figure 6: Example of Traffic Data File

DATA COLLECTION

In order to evaluate the laser detection technology (AUTOSENSE III), two units were installed on I-4, Orlando, Florida in the westbound direction. The two units were mounted on an overhead structure according to the specification set by the manufacturer. The two units were connected to a notebook that has wireless internet connection to upload the data to a designated website for storage. The files were compiled every 24 hours.

Three days were selected to evaluate the performance of AUTOSENSE in traffic measurements and vehicle classification. In each of the three days, the time period from 6:00 AM to 10:00 AM was used to accommodate the morning peak period. Videotaping was used as a ground truth in the analysis. All videotape counts were conducted by lane in one minute increments. Trucks were counted separately from vehicles to compare with the vehicle classification feature of AUTOSENSE. The following days were selected for the analysis:

May 31, 2000
June 7, 2000
June 8, 2000

GRAPHICAL REPRESENTATION

The comparison between AUTOSENSE III counts and the videotape counts was visually inspected using graphical plots of the data over the four-hour period for each of the three days. The visual inspection was necessary to ensure the data sets from both sources were time synchronized. This was identified by inspecting the major changes in the one-minute traffic counts from each source. The observations from all three days showed that the time stamp was off by 4 minutes. Therefore, the time stamps of all counts were adjusted accordingly. Figure 7 shows the one-minute counts observed on May 31st, 2000 from both sources for the right lane after synchronization was applied. Similarly, using the same time shift, counts for the center and left lanes were adjusted as shown in Figure 8 and Figure 9. Due to the lack of time precision, the resolution of the data was reduced to 5 minutes to eliminate some of the random fluctuations. In the next section, the graphical representations of the data from both sources will be displayed as 5 minute counts. Each day will be presented separately for each lane and once for all Vehicle Types and then for trucks only.

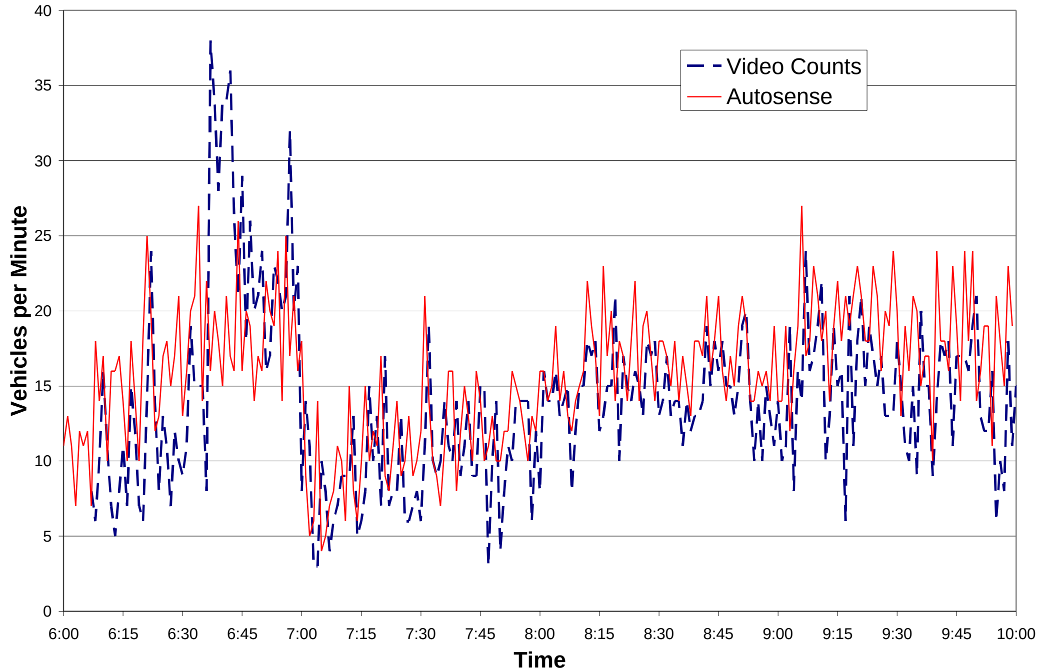


Figure 7: AUTOSENSE III Counts vs. Video Counts (One minute resolution) – Right Lane

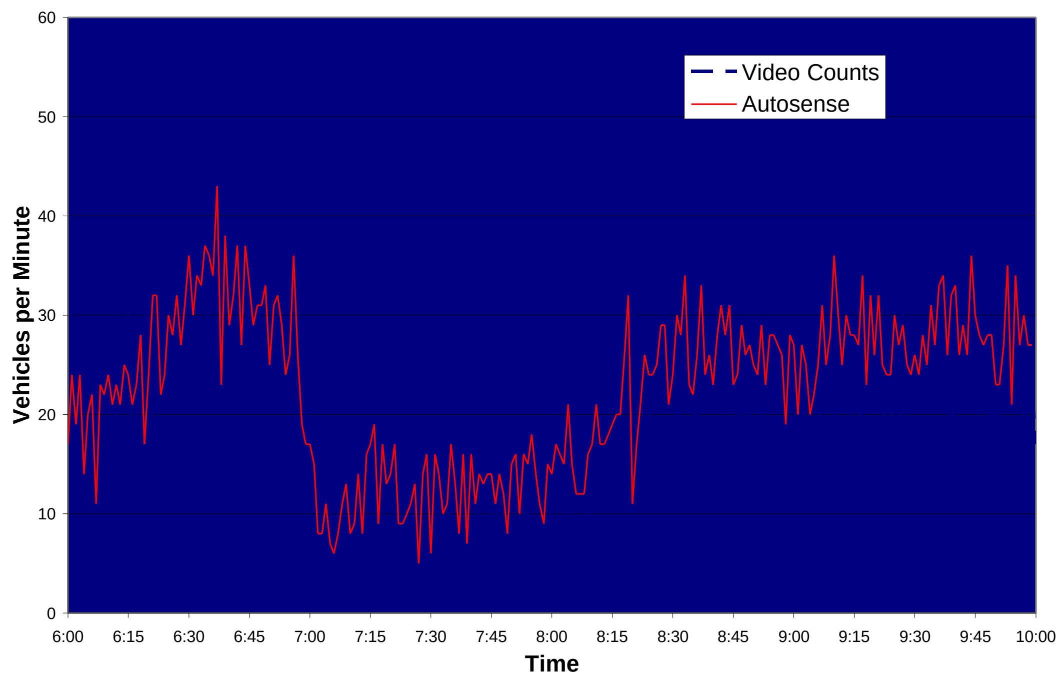


Figure 8: AUTOSENSE III Counts vs. Video Counts (One minute resolution) – Center Lane

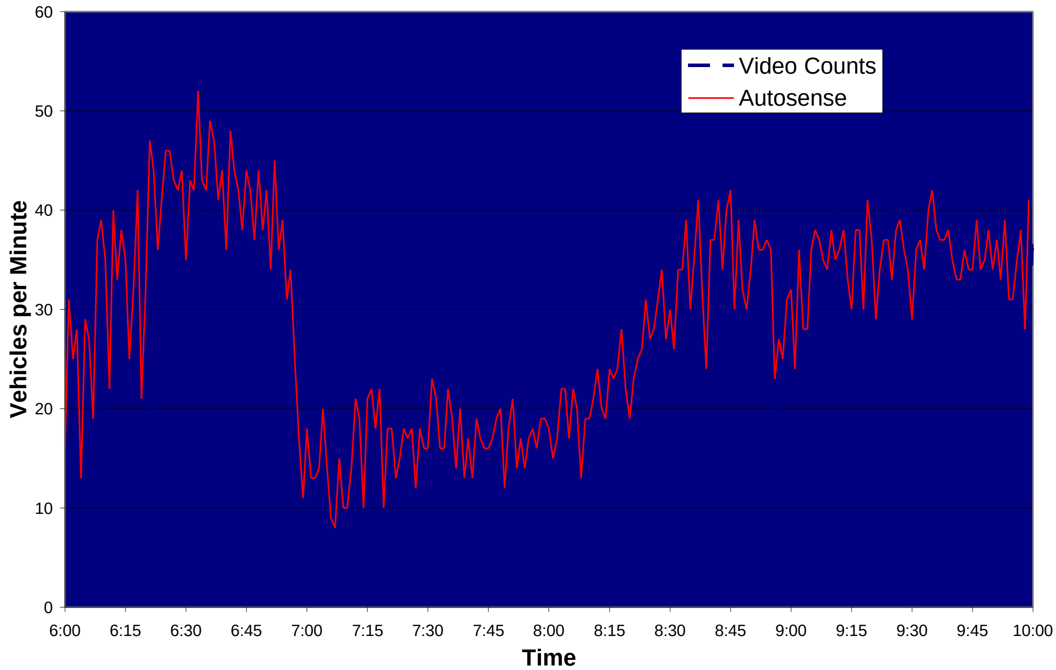


Figure 9: AUTOSENSE III Counts vs. Video Counts (One minute resolution) – Left Lane

RESULTS FOR MAY 31, 2000

All Vehicle Types

This section presents the 5 minute comparisons between video and AUTOSENSE counts for each lane. Figures 10 through 12 appear to show similarities between the two data sets over time with the exception of some short time periods when the difference appears significant. Generally, the two sets were comparable for that day.

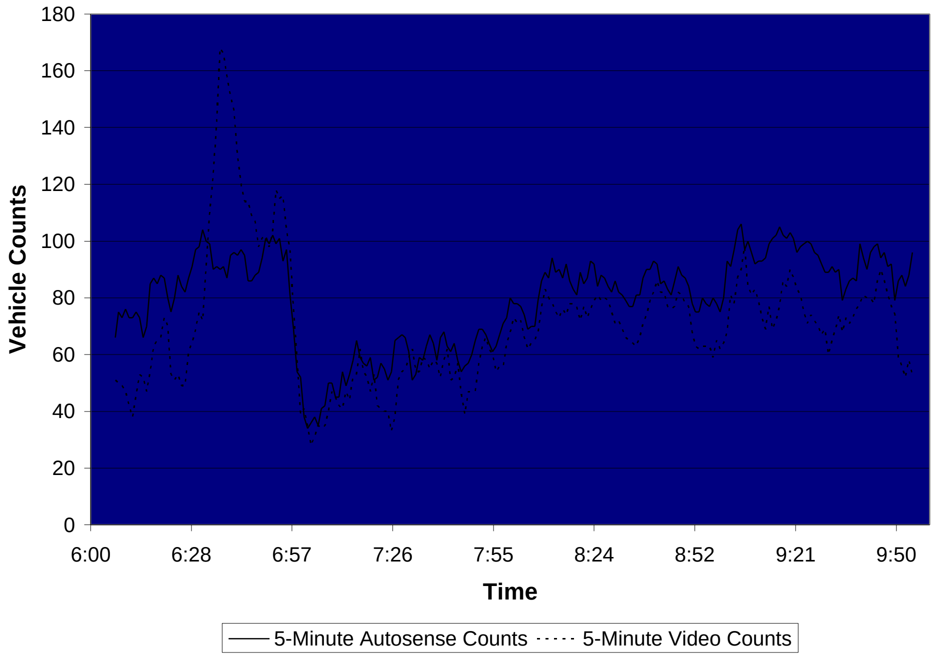


Figure 10: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Right Lane

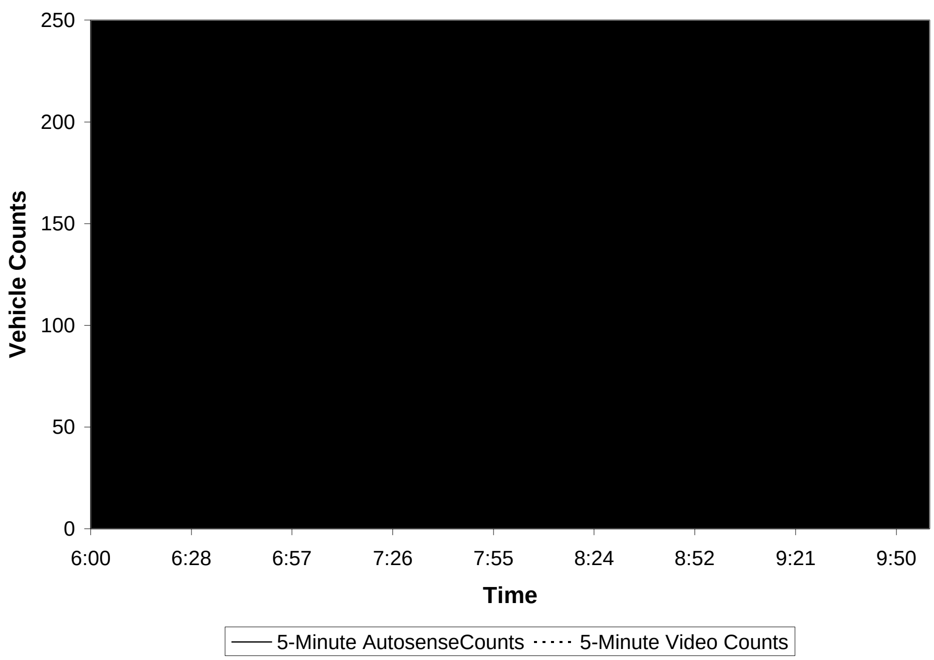


Figure 11: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Center Lane

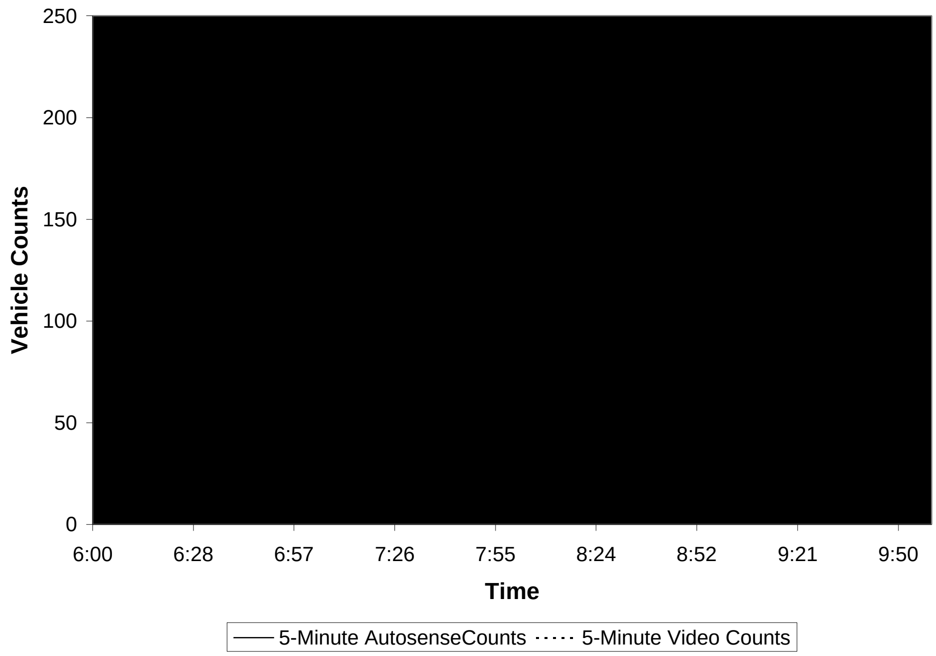


Figure 12: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Left Lane

Trucks Only

This section presents the comparison between truck counts from AUTOSENSE and the videotapes. Trucks classified as type 6 through 11 by AUTOSENSE were considered in as typical trucks in the video counts. So, the truck video counts were compared to the total counts of vehicle classified as type 6 through 11 by AUTOSENSE. Figures 13 through 15 show the 5 minute counts of trucks for each lane. The figures show that the two sources are still comparable although larger deviations are observed more often.

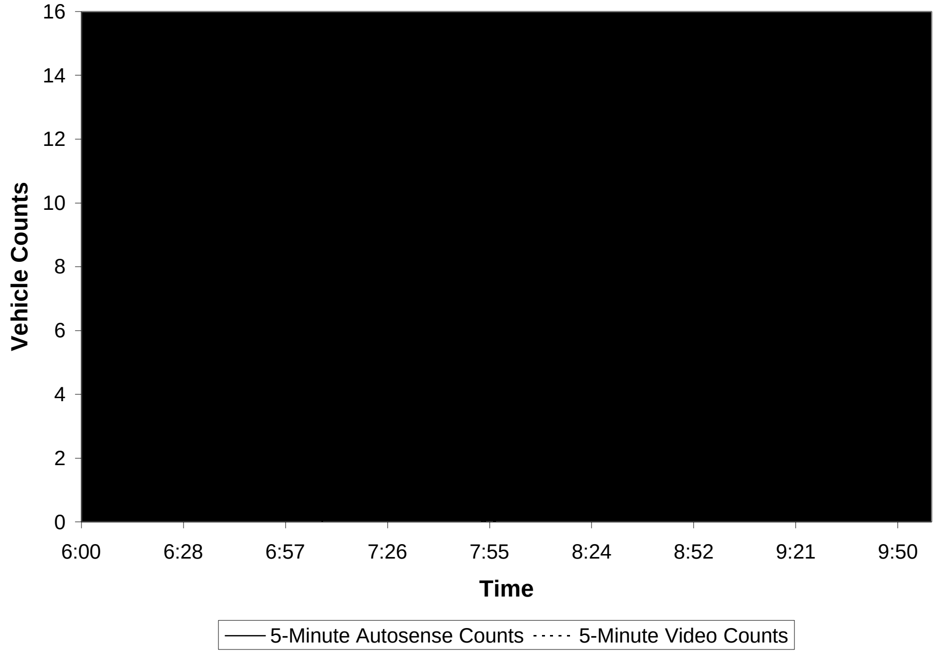


Figure 13: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Right Lane

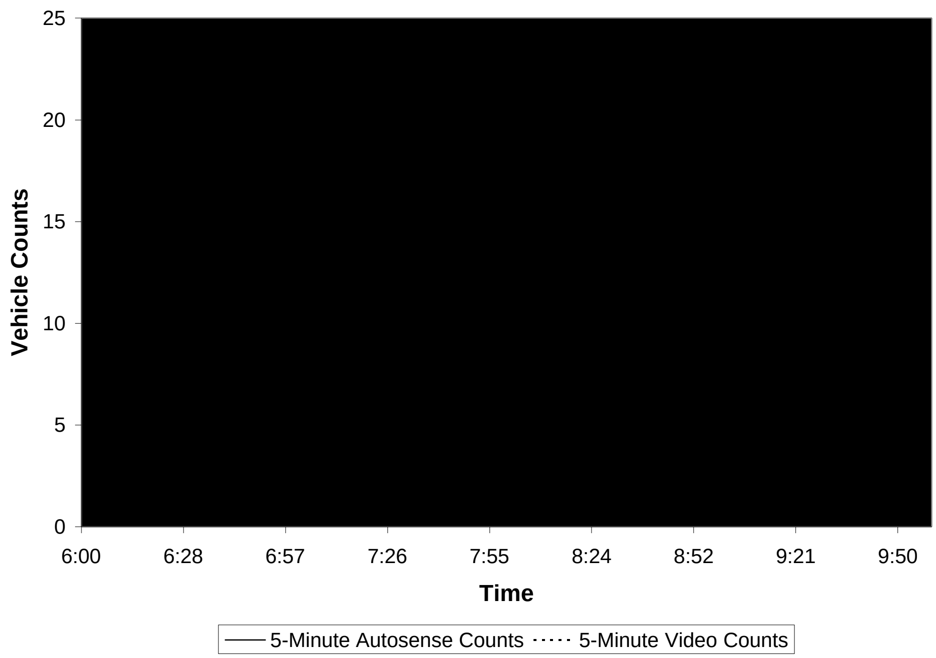


Figure 14: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Center Lane

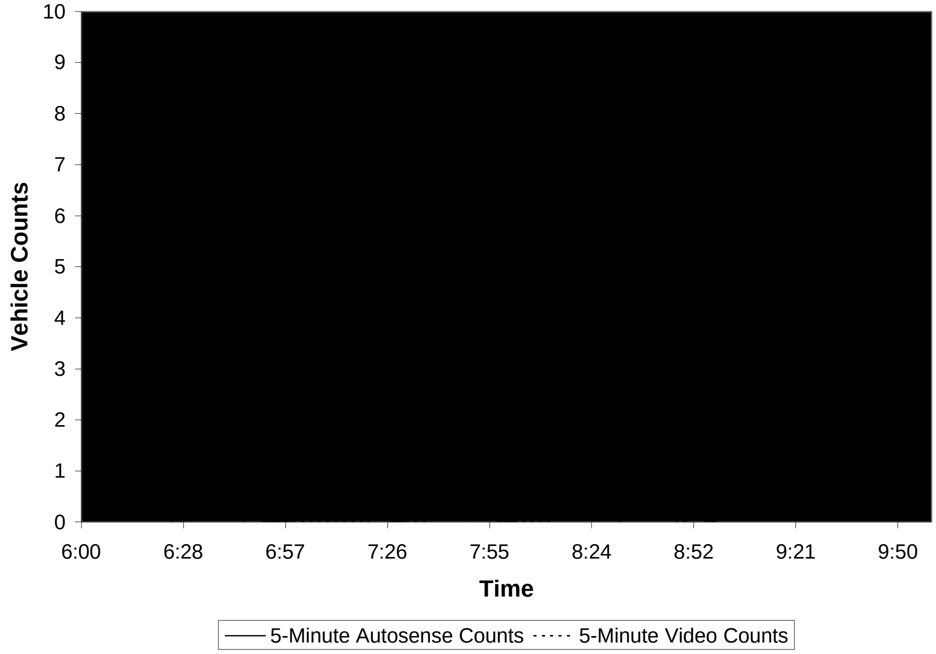


Figure 15: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Left Lane

RESULTS FOR JUNE 7, 2000 AND JUNE 8, 2000

Similarly, the five-minute counts were used to compare AUTOSENSE with the ground truth (video counts) for two other days, June 7th and 8th, 2000. Each lane is presented separately in the next subsections. Truck counts are also plotted separately to verify the accuracy of classification. Appendix A shows the graphical representations of the AUTOSENSE III counts vs. Video counts for both days.

STATISTICAL ANALYSIS

In order to compare the counts collected by the AUTOSENSE III units with those by video tapes, statistical analysis was conducted to measure the correlation between the two data sets and to test if the difference in counts was significant. The first approach was based on calculation of the correlation coefficients between the two data sets for each lane, each day, and for all Vehicle Types and for trucks only. Table 1 shows the correlation coefficients by day and by lane using synchronized one minute counts of all types of vehicles. For a perfect match, the correlation coefficient between two data sets should be equal to 1.0, or as close to 1.0 as possible. The table shows the left and center lanes on May 31st, 2000 to have relatively higher correlation coefficients compared to the rest of the data sets. Table 2 also shows very low correlation coefficients for truck counts in all lanes and all days.

Due to the lack of accurate time synchronization between the video counts and the AUTOSENSE III counts, the data was further aggregated into 5 minute counts to overcome this problem. Table 3 and Table 4 show the correlation coefficients using 5 minute counts. Both tables show major improvements in the correlation coefficients. The left lane showed correlation coefficients of 83% and higher in all three days for all types of vehicles. However, the center and right lanes showed relatively less correlation between the two data sources. This trend is consistent with the truck counts except that all correlation coefficients are comparatively lower.

Table 1: All Vehicle Types, one minute counts

	Left	Center	Right
May 31, 2000	0.881	0.705	0.384
June 7, 2000	0.586	0.290	0.237
June 8, 2000	0.501	0.173	0.135

Table 2: Trucks only, one minute counts

	Left	Center	Right
May 31, 2000	0.115	0.139	0.125
June 7, 2000	0.12	0.157	0.213
June 8, 2000	0.205	0.179	0.099

Table 3: All Vehicle Types, 5-minute counts

	Left	Center	Right
May 31, 2000	0.974	0.946	0.676
June 7, 2000	0.833	0.759	0.749
June 8, 2000	0.896	0.642	0.529

Table 4: Trucks only, 5-minute counts

	Left	Center	Right
May 31, 2000	0.620	0.780	0.648
June 7, 2000	0.360	0.426	0.275
June 8, 2000	0.491	0.527	0.222

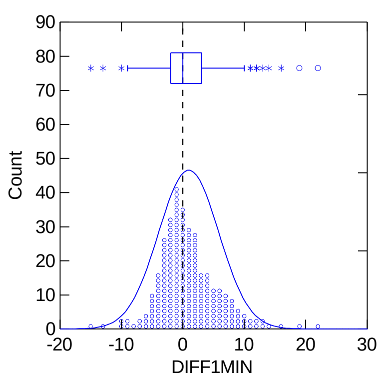
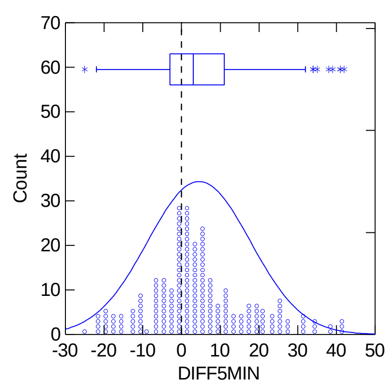
Test of Hypothesis

The T-test was used on the paired differences between the two sources of data: AUTOSENSE III and Video Tapes. The test was conducted to show if the difference is statistically significant or not at level of significance (0.05). The test results were grouped into 6 tables, showing each of the three lanes. The testing was also conducted for all types of vehicles and for trucks only. The test is verifying the claim that there is no difference between the two sources. The P value is compared against the level of significance (0.05) to reach either of the two possible conclusions:

1. If P <= 0.05, we reject the null hypothesis; i.e. we reject that there is no difference. In other words, the two sources show statistically significant differences.
2. If P > 0.05, we fail to reject the null hypothesis, i.e. we fail to reject that there is no difference. In other words, the two sources show statistically insignificant differences.

Tables 5 through 7 show that the P value is consistently smaller than 0.05 for all scenarios considered. This implies that the AUTOSENSE III data is significantly different from the Video data (ground truth). The same conclusions were also supported by the T-tests for the truck counts for the left and center lanes shown in Tables 8 and 9. However, the right lane did not exhibit such differences since the P value was consistently higher than 0.05 (see Table 10), leading to the conclusion that there was no significant difference between the truck counts on the right lane.

Table 5: One T-Test for All Vehicle Types (Left Lane)

	One-Minute Counts				Five-Minute Counts			
Day	Mean	T	DF	P	Mean	T	DF	P
May 31st, 2000	0.956	2.953	228	0.003	4.507	5.127	228	0.000
								
June 7th, 2000	1.346	3.740	227	0.000	6.518	10.084	227	0.000

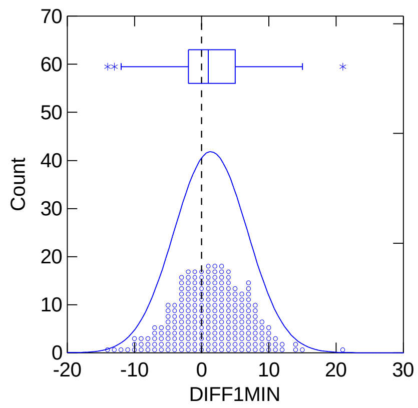
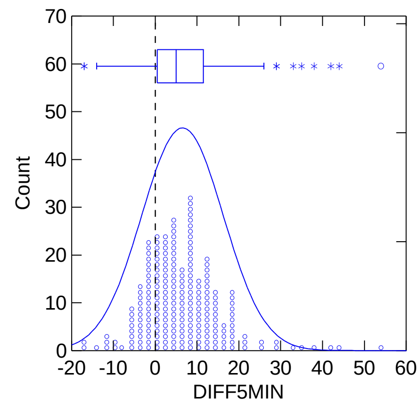
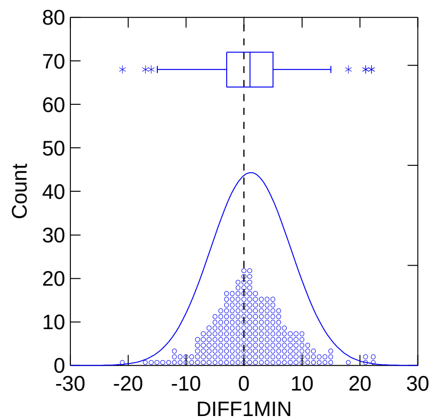
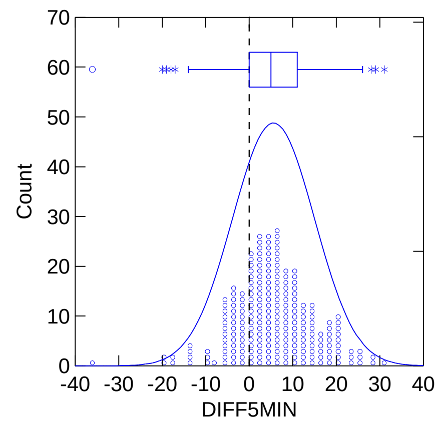
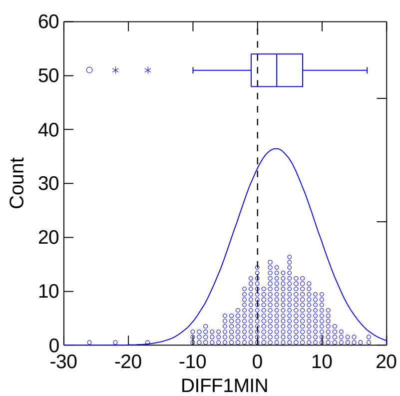
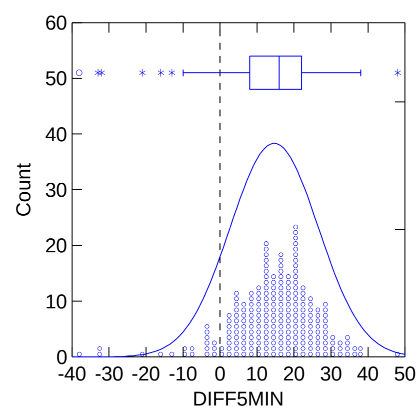
								
June 8th, 2000	1.143	2.514	229	0.013	5.543	8.937	229	0.000
								

Table 6: One T-Test for All Vehicle Types (Center Lane)

	One-Minute Counts				Five-Minute Counts			
Day	Mean	T	DF	P	Mean	T	DF	P
May 31st, 2000	2.860	6.917	228	0.000	14.655	18.619	228	0.000
								
June 7th, 2000	3.39	9.694	227	0.000	16.789	29.803	227	0.000

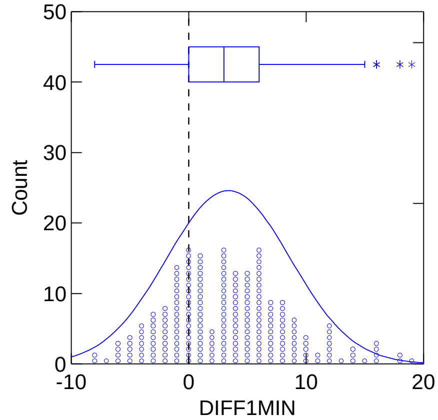
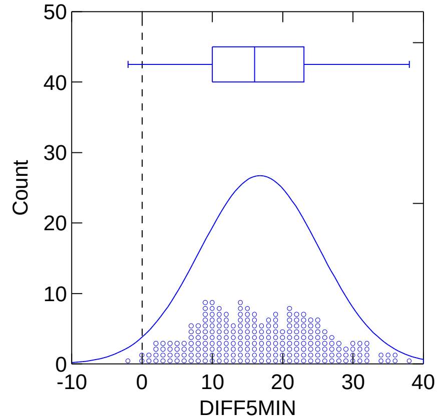
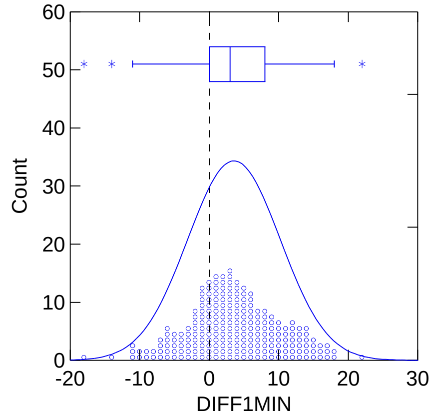
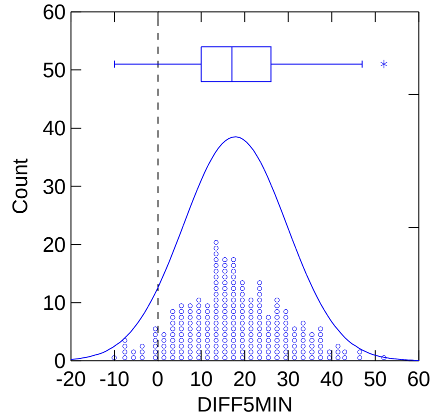
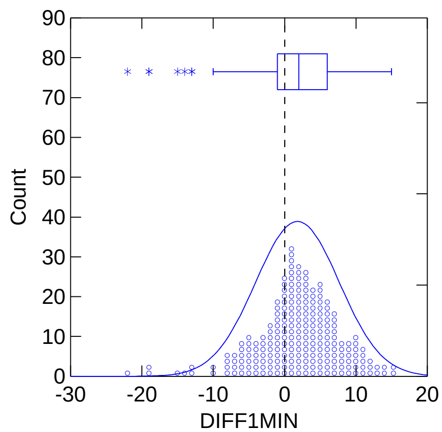
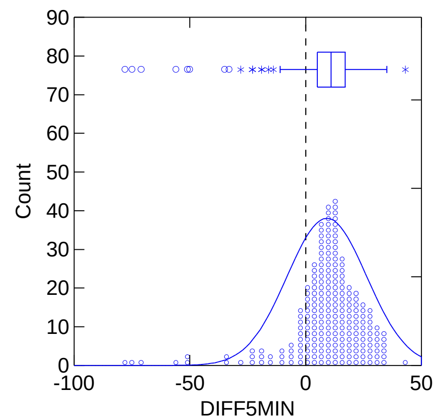
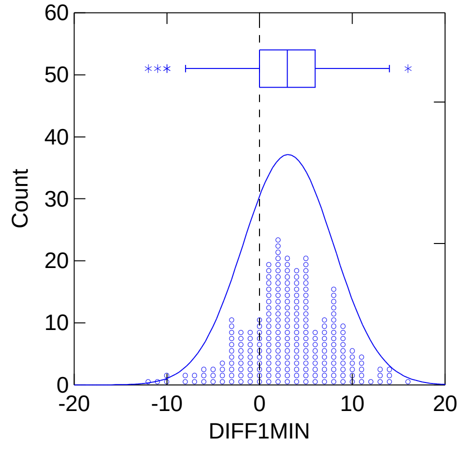
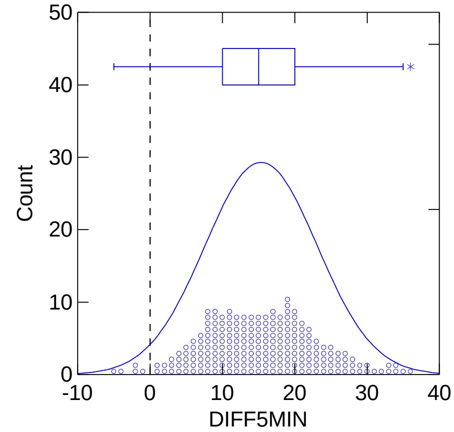
								
June 8th, 2000	3.563	8.106	228	0.000	17.764	22.673	228	0.000
								

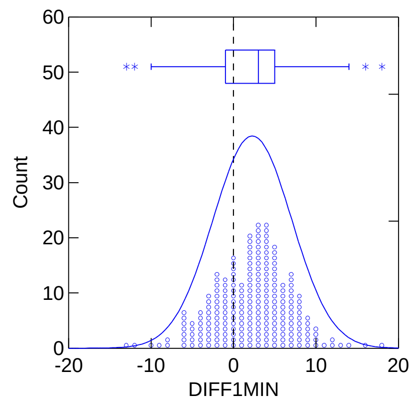
Table 7: One T-Test for All Vehicle Types (Right Lane)

	One-Minute Counts				Five-Minute Counts			
Day	Mean	T	DF	P	Mean	T	DF	P
May 31st, 2000	1.803	4.647	228	0.000	9.148	8.072	228	0.000
								
June 7th, 2000	3.083	9.506	227	0.000	15.346	29.868	227	0.000





June 8th, 2000	2.278	7.237	229	0.000	11.091	20.25	229	0.000



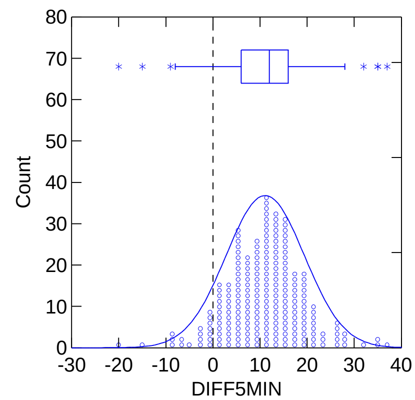
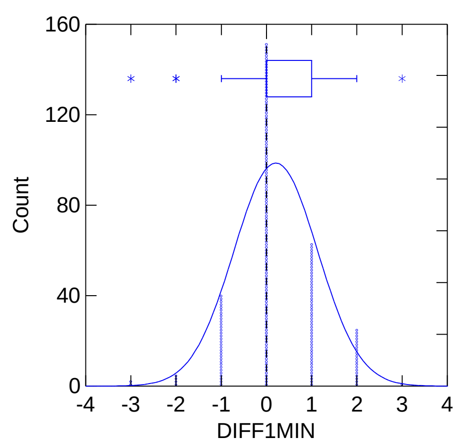
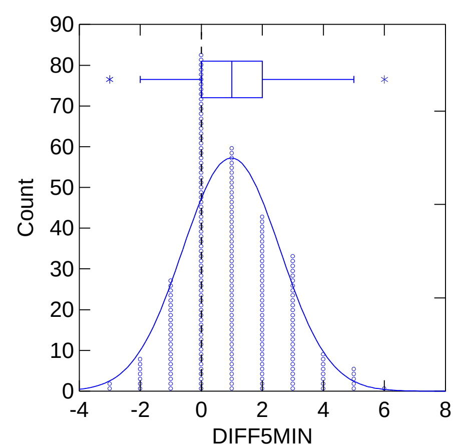


Table 8: One T-Test for Trucks Only (Left Lane)

	One-Minute Counts				Five-Minute Counts			
Day	Mean	T	DF	P	Mean	T	DF	P
May 31st, 2000	0.205	3.355	228	0.001	0.987	9.356	228	0.000





June 7th, 2000	0.307	4.725	227	0.000	1.5	10.997	227	0.000

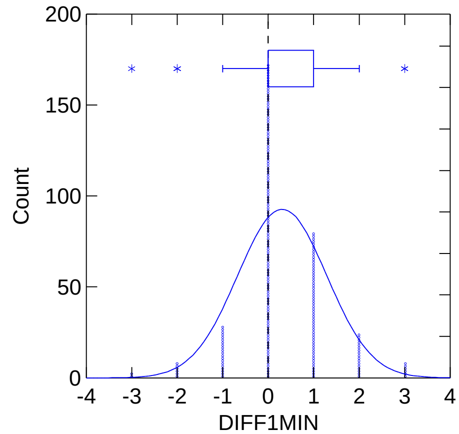
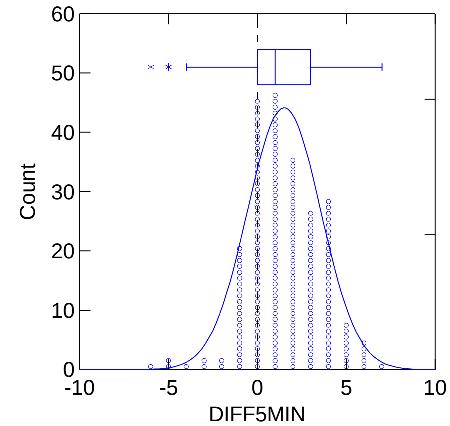
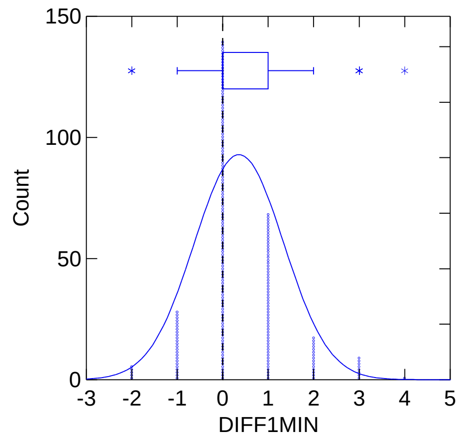
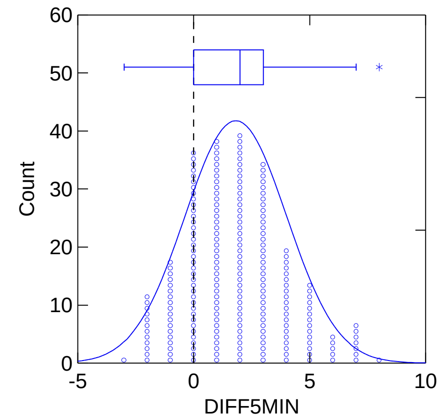
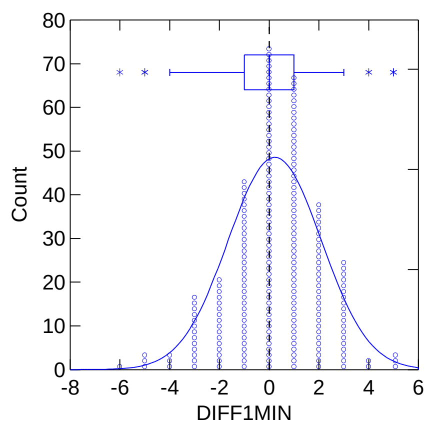
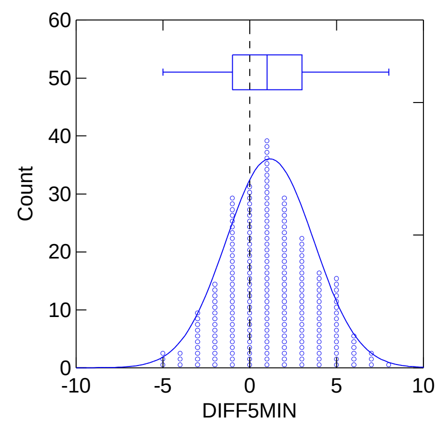
								
June 8th, 2000	0.358	5.508	228	0.000	1.817	12.571	228	0.000
								

Table 9: One T-Test for Trucks Only (Center Lane)

	One-Minute Counts				Five-Minute Counts			
Day	Mean	T	DF	P	Mean	T	DF	P
May 31st, 2000	0.227	1.827	228	0.069	1.157	6.915	228	0.000
								
June 7th, 2000	0.471	3.977	226	0.000	2.189	8.595	226	0.000

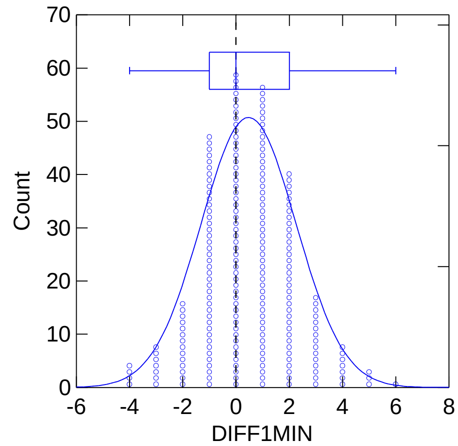
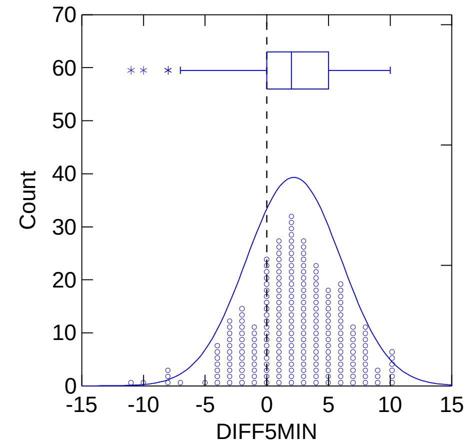
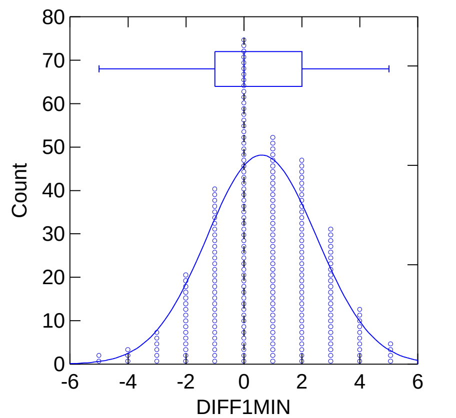
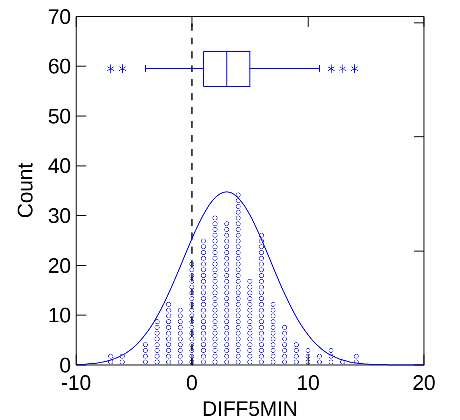
<table>
<tr><td></td><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td rowspan="2">June 8th, 2000</td><td>0.616</td><td>4.913</td><td>228</td><td>0.000</td><td>2.978</td><td>12.013</td><td>228</td><td>0.000</td></tr>
<tr><td colspan="4"></td><td colspan="4"></td></tr>
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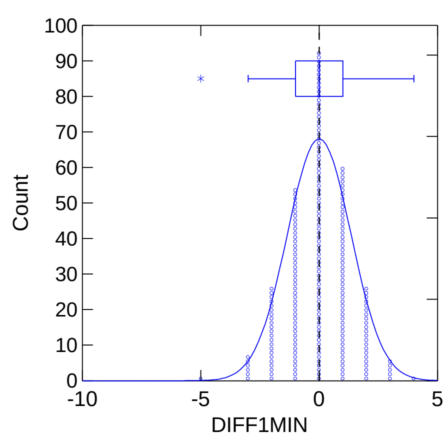
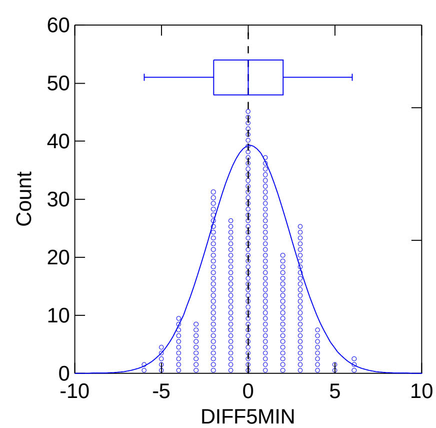
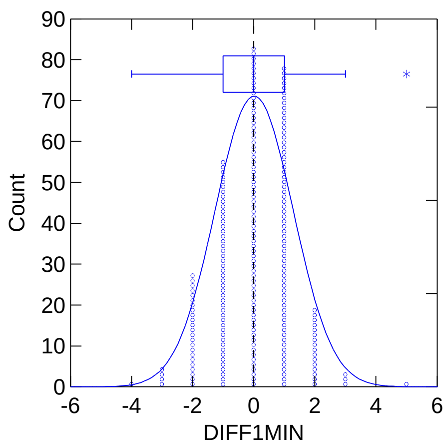
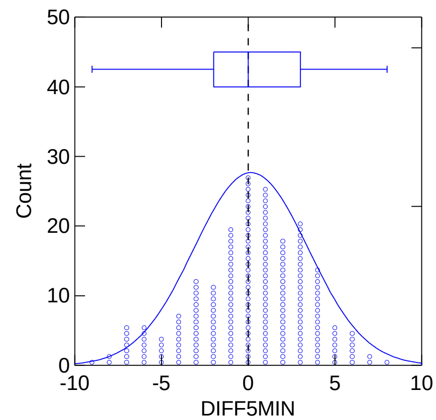
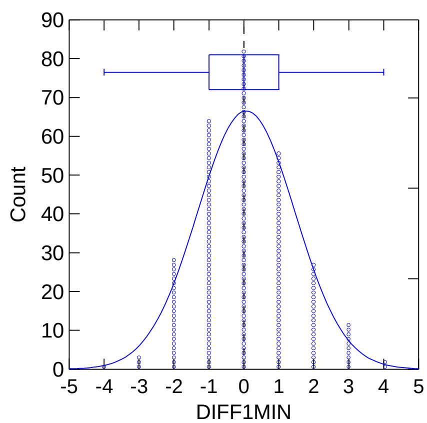
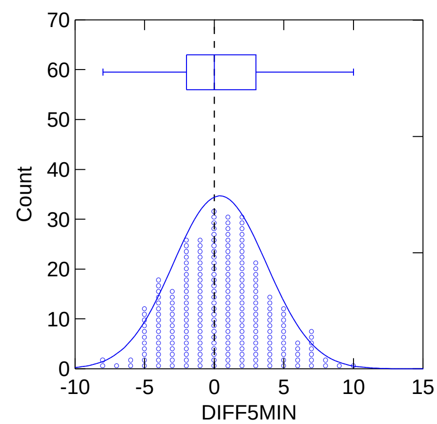
Table 10: One T-Test for Trucks Only (Right Lane)

<table>
<tr><td></td><td colspan="4">One-Minute Counts</td><td colspan="4">Five-Minute Counts</td></tr>
<tr><td>Day</td><td>Mean</td><td>T</td><td>DF</td><td>P</td><td>Mean</td><td>T</td><td>DF</td><td>P</td></tr>
<tr><td rowspan="2">May 31st, 2000</td><td>0.004</td><td>0.049</td><td>228</td><td>0.961</td><td>0.1</td><td>0.654</td><td>228</td><td>0.514</td></tr>
<tr><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td>June 7th, 2000</td><td>0.013</td><td>0.155</td><td>227</td><td>0.877</td><td>0.162</td><td>0.746</td><td>227</td><td>0.457</td></tr>
</table>

<table>
<tr><td></td><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td rowspan="2">June 8th, 2000</td><td>0.069</td><td>0.750</td><td>232</td><td>0.454</td><td>0.403</td><td>1.838</td><td>232</td><td>0.067</td></tr>
<tr><td colspan="4"></td><td colspan="4"></td></tr>
</table>

CONCLUSIONS

This study was conducted to evaluate the laser detection technology AUTOSENSE III on I-4 in Orlando, Florida. Two units were tested in site in the westbound direction. The two units were mounted overhead nearby Lake Ivanhoe. In order to validate the AUTOSENSE III counts, the same site was videotaped for three days from 6 to 10 AM and the video counts were used as ground truth. Since the AUTOSENSE III devices can provide vehicle classification of up to 11 types of vehicles, it was important to test the vehicle classification capabilities as well. For the purpose of the study, only trucks were identified as a major type of vehicle.

The analysis was conducted using graphical representations of the data and appropriate statistical procedures. Counts were based on one minute and five minutes to reduce the errors caused by lack of time synchronization between the AUTOSENSE III clock and the camcorder clock. Although the visual inspection of the graphical plots shows that the two sources were relatively close, the statistical tests on the difference in counts concluded that the data from the two sources significantly different. This conclusion was consistent when considering all types of vehicles and when considering trucks only. The only exception was for the right lane, which showed no significant difference in the truck counts. Based on the results of this study, the accuracy of this technology is questionable. This has been further supported by similar experience with the Orlando-Orange County Expressway Authority OOCEA (although the data they collected is much less than ours). The OOCEA met with the UCF research team and demonstrated through ground truth counts that Autosense failed to classify trucks on their toll plazas. The No further investigation of traffic engineering applications of Autosense III is warranted unless SEO finds out the reasons for this discrepancy in truck counts and improves its accuracy.

APPENDIX A
COMPARISONS OF TRAFFIC COUNTS FOR JUNE 7, AND JUNE 8, 2000

June 7th, 2000: All Vehicle Types

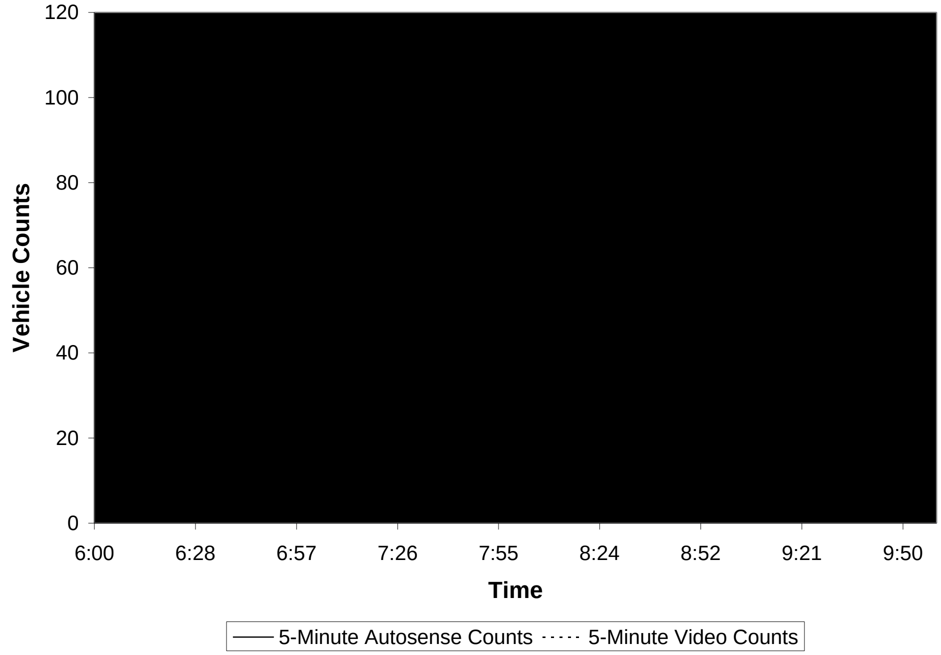


Figure 16: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Right Lane

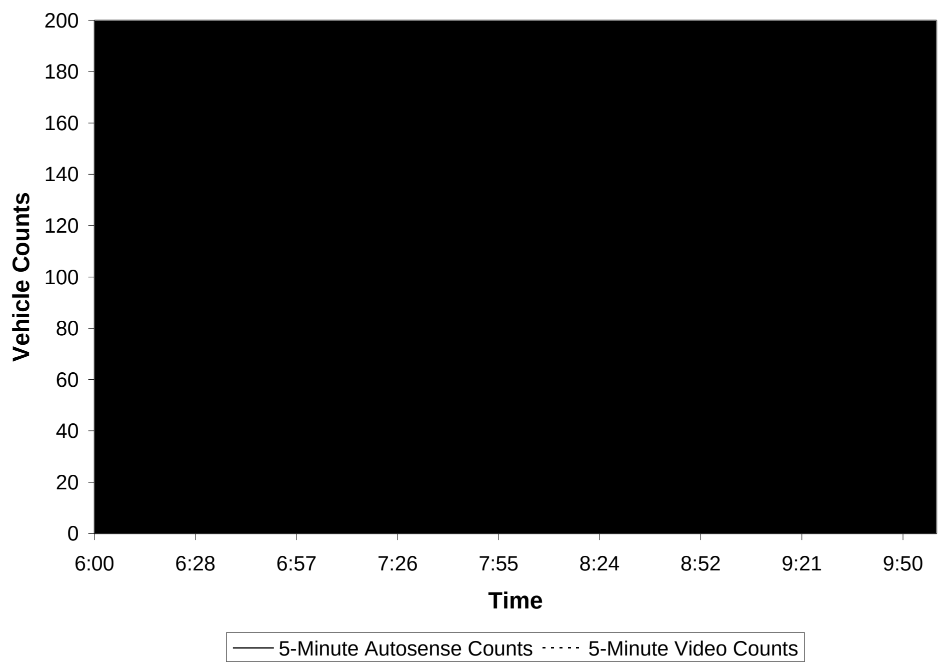


Figure 17: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Center Lane

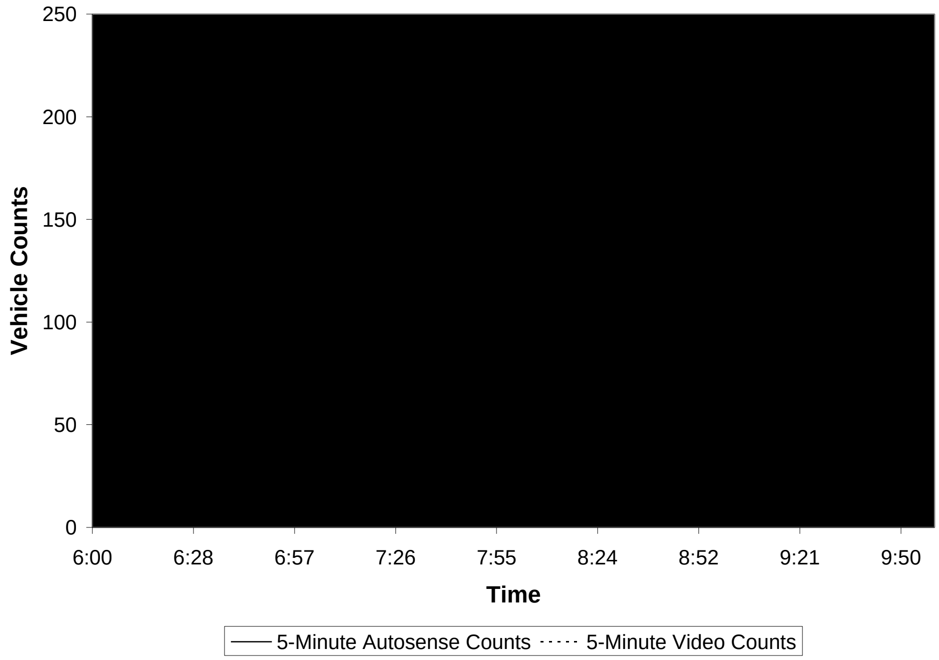


Figure 18: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Left Lane

June 7th, 2000: Trucks Only

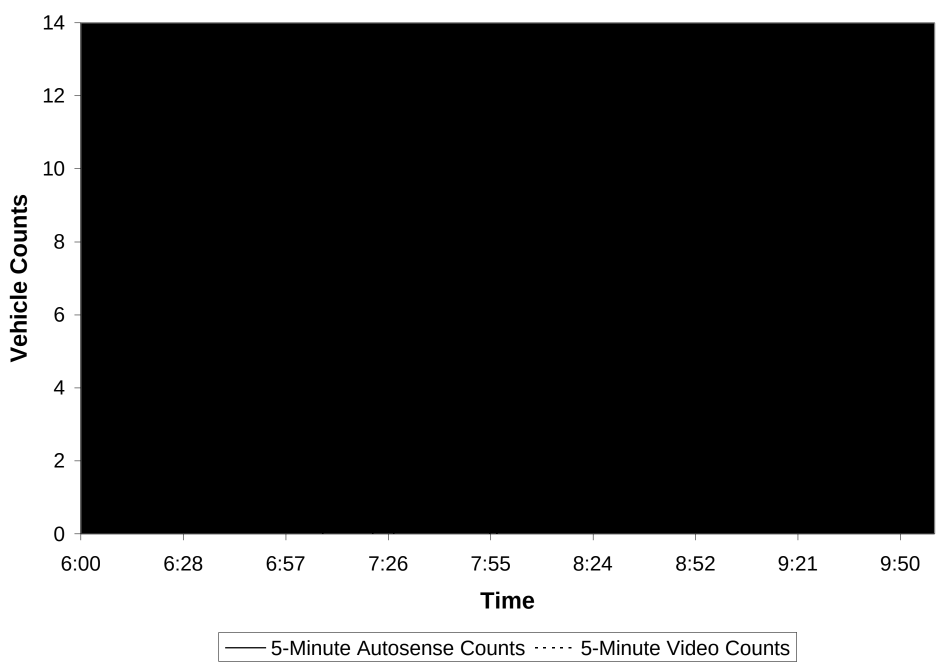


Figure 19: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Right Lane

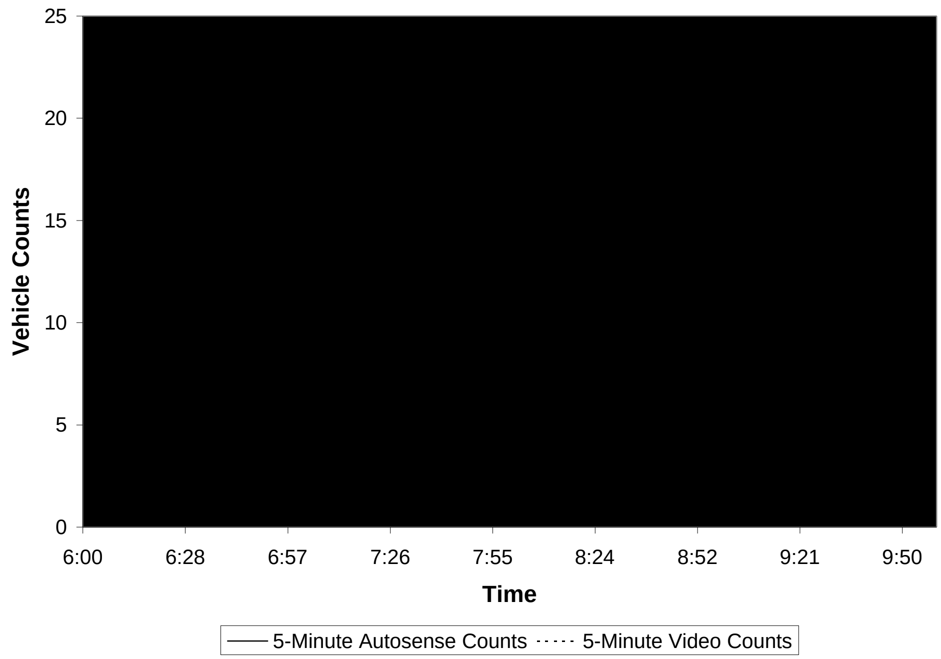


Figure 20: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Center Lane

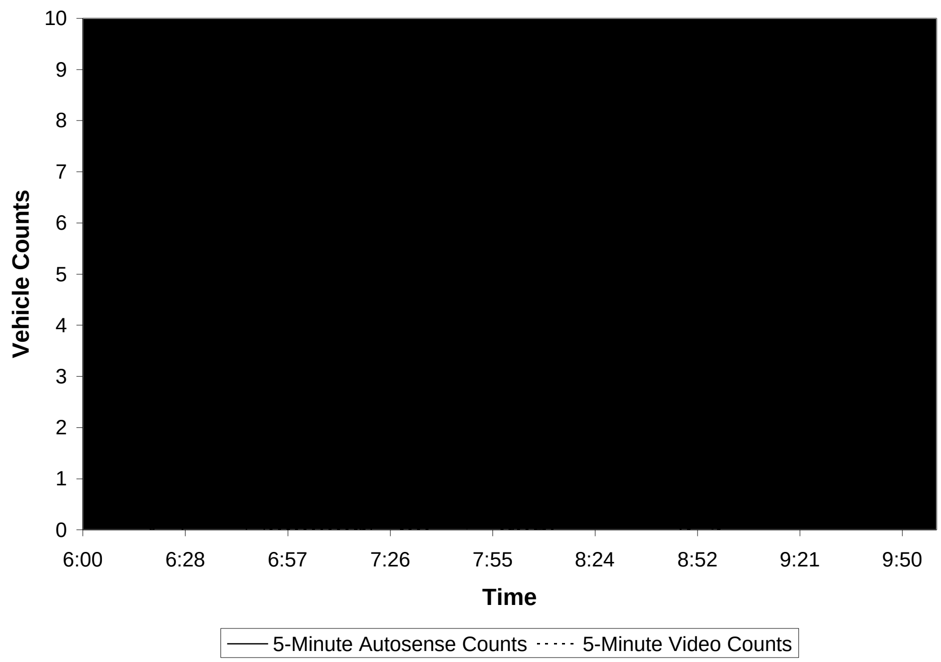


Figure 21: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Left Lane

June 8th, 2000: All Vehicle Types

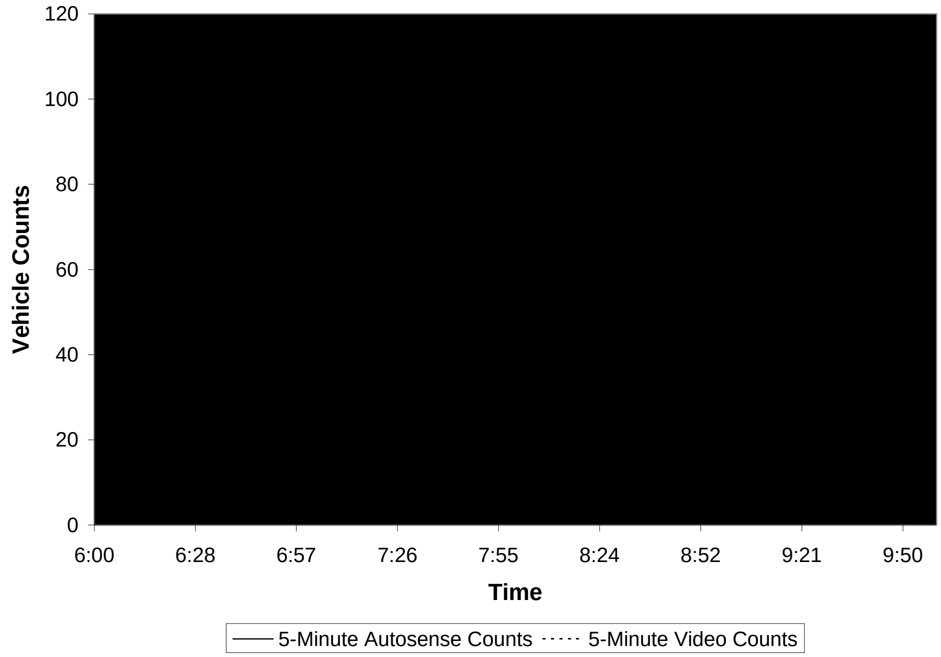


Figure 22: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Right Lane

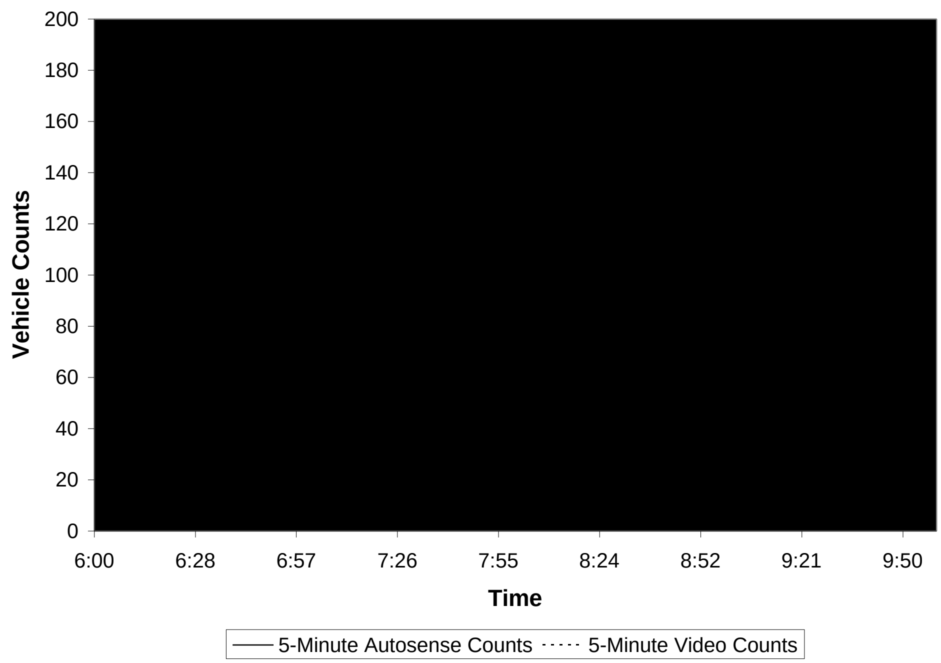


Figure 23: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Center Lane

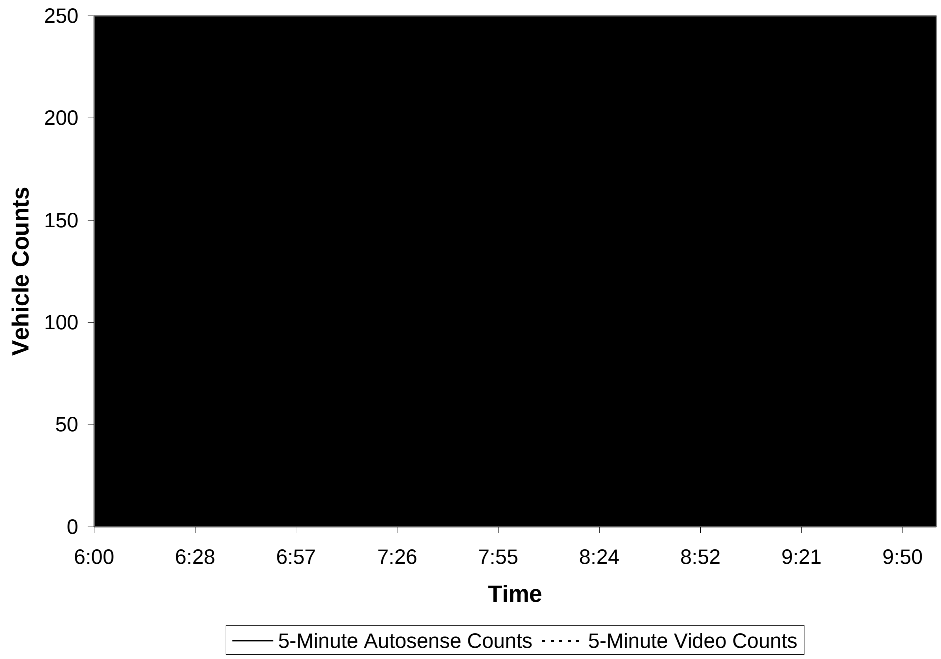


Figure 24: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Left Lane

June 8th, 2000: Trucks Only

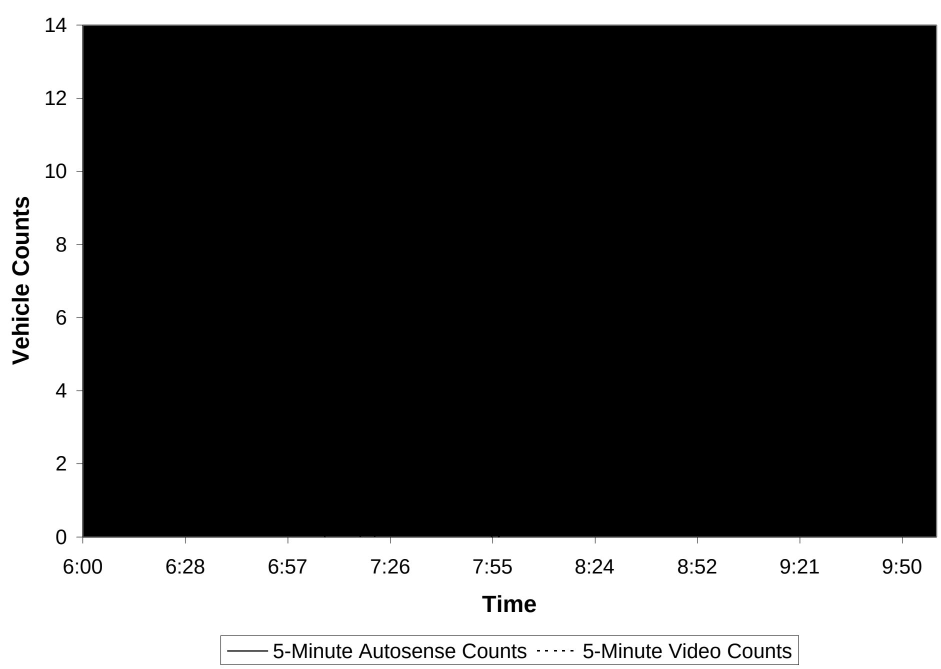


Figure 25: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Right Lane

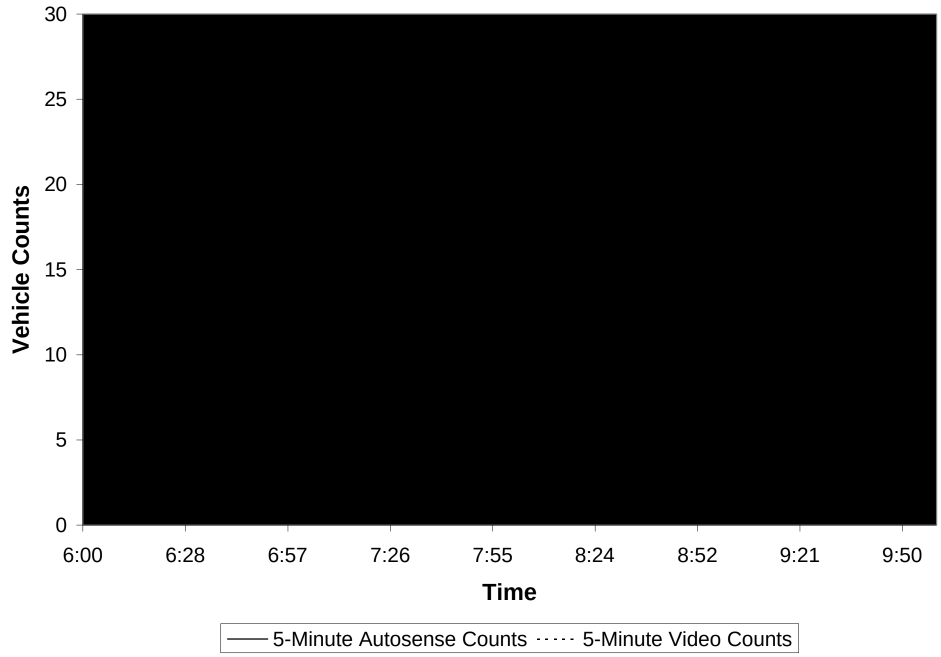


Figure 26: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Center Lane

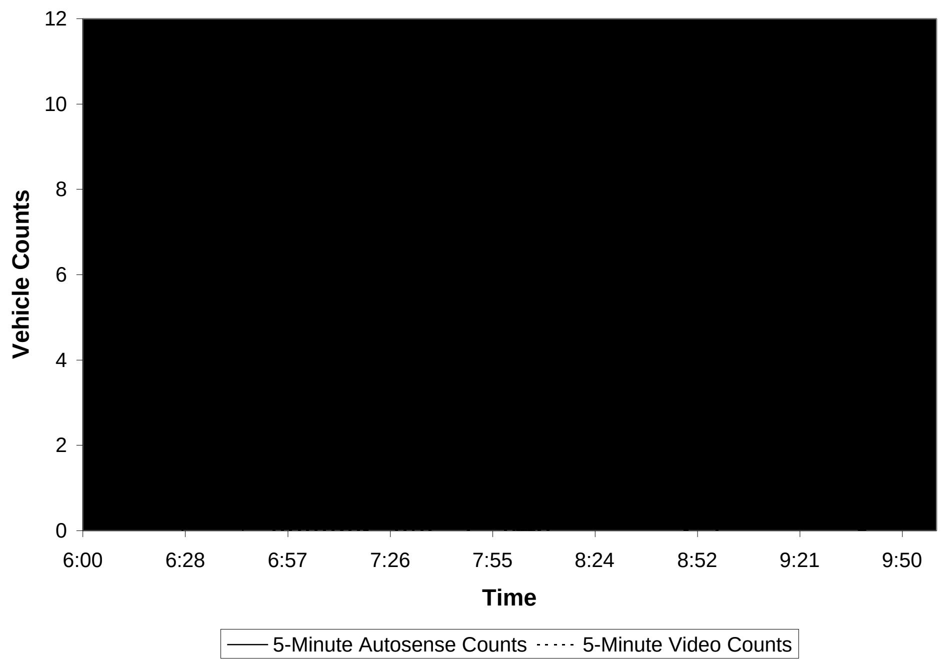


Figure 27: AUTOSENSE III Counts vs. Video Counts (five-minute resolution) – Left Lane