NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
ADVANCED TRAFFIC ANALYSIS CENTER

Traffic Data Collection Technology Assessment

Final Report

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BACKGROUND

The availability of reliable traffic data is key to traffic operations, transportation planning, and traffic design projects. The process of traffic data collection has evolved over time and has numerous methods associated with it. Common methods include manual counts (by field data collection personnel), deployment of Automatic Data Recorders etc. The choice of data collection method depends on factors such as data needs (volume, speed, and classification), duration of data collection (short counts, permanent stations etc.), data collection location, weather conditions etc. The available data collection technologies can be broadly classified into intrusive type and non-intrusive type. In the past, short counts were generally done using intrusive technologies, whereas only permanent station locations were reserved for non-intrusive technologies. With advancements in non-intrusive data collection devices, there has been an increase in their use for short counts/temporary data collections as well. This has drastically improved personnel safety by reducing their interaction with traffic.

STUDY OBJECTIVES

The main objective of this study was to test both intrusive and non-intrusive data collection devices and to provide North Dakota Department of Transportation (NDDOT) with insight into the accuracy of the various data collection technologies and the applicability of the tested devices. All devices were temporarily deployed along with ATAC's Traffic Data Collection System (TDCS). The TDCS has been upgraded to be able to accommodate not only Autoscope based systems but also the radar-based Wavetronix systems including the SS105 and SS125 sensors.

The devices were evaluated based on their accuracy in collecting traffic volumes and classification.

DATA COLLECTION EQUIPMENT

The data collection equipment evaluated in this study included both intrusive and non-intrusive type devices. A mix of equipment currently being used as well as equipment that could be considered for future data collections were evaluated in this study. The following data collection equipment was included in this study:

- *Video-based system – Miovision*
  Video-based systems use on-board microprocessor and algorithms to analyze the video feed. These systems can be used to collect volume, speed, occupancy, turning movements, etc. Certain factors such as environmental conditions and lighting affect the video quality resulting in poor system performance (which may be recurring and temporary in nature). The factors include snow, rain, glare, dirt on camera lens etc. Miovision is a non-intrusive video-based data collection unit with capabilities to collect various types of traffic data. It may be programmed to schedule data recording. After completion of data collection, the recorded video is uploaded to Miovision Platform for processing.
- *ATR*
  These are existing permanent traffic recording stations installed and maintained by NDDOT. These feature in-pavement inductive loops, the data from which is saved on the roadside devices. These sites are directly connected to NDDOT's Bismarck office.

- *Radar-based system – Wavetronix*
  Radar systems use the digital clocks to determine the time-delay of signal returned after being reflected from a vehicle in their range. These systems are generally ranging in nature due to which they can detect multiple lanes and directions within their range. Due to these capabilities the radar sensors can collect very accurate and reliable data such as volume, speed, classification, headway etc. However, at times, radar sensors may falsely detect a vehicle. Wavetronix SmartSensor is a frequency modulation-based radar system for traffic data collection. It can record up to 22 lanes with a detection range between 6' – 250'. For the purpose of this study, Wavetronix SS125 unit was connected to an EarthCam unit. The SS125 is equipped with dual-radar and two reception antennae.

- *EarthCam*
  The EarthCam unit mainly served as a portable cell site for connecting the Wavetronix Radar unit to the EarthCam servers. The data was continuously processed off-site and was available through the Traffic Management interface. Also, the calibration process for the radar setup was completed as per instructions received during the device deployment at each of the sites. It should be noted that while EarthCam is generally associated with video surveillance equipment the traffic sensors do not use video but rather radar.

- *ADR Portable Counter/Classifier*
  PEEK's ADR Portable Counter/Classifier is a pneumatic road tube-based data collection system. The unit collects and processes data on site and the collected data can be then transferred to a computer after the completion of data collection. Custom vehicle classifications can be setup. The classifications are based on axle spacing.

- *Tally*
  Tally is also a pneumatic road tube-based system. It only collects axle hits and data has to be read off of the display at the completion of data collection interval/duration.

- *MetroCount*
  MetroCount's MC5600 is also a pneumatic road tube-based vehicle count/classifier system. The axle hits are stored on the on-board memory and the data is transferred to a computer system after the completion of data collection. This transferred data is then processed using software which can utilize custom built classification system. The classifications are based on axle spacing.

- *Laser-based – Peek AxleLight*
  Laser-based systems use low energy laser beams to a target area (usually above the crown of the pavement) and measure the time it takes for the reflected beam to return to the sensor. These can collect data such as volume, speed, length, number of axles etc. Laser-based sensors are known to be limited due to issues such as occlusion and dirt on the lens. Peek AxleLight is one such data collection device. It deploys a ranging system and hence does not require a reflector on the far-side. It is compatible with Peek's ADR Plus units. To collect classification data, a pair of these units can be setup in tandem. Unfortunately, the AxleLight units could not be tested along with the other devices. However, a sample setup was done on a separate occasion.

Table 1 lists the data collection devices, their application for short counts and long-term/permanent counts (as tested) and their relative ease of installation and calibration (if needed).

Table 1: Data collection equipment types, applications and ease of installation/calibration

Device	Intrusive/Non-Intrusive	Short Counts	Long-term/ Permanent counts	Ease of Installation & Calibration
Miovision	Non-Intrusive	Yes	No	++++
ATR	Non-Intrusive	No	Yes	+
Wavetronix + EarthCam	Non-Intrusive	No	Yes	+++
ADR	Intrusive	Yes	No	++
Tally	Intrusive	Yes	No	++
MetroCount	Intrusive	Yes	No	++
AxleLight	Non-Intrusive	Yes	No	+

FIELD TESTS

Field tests were conducted by deploying all of the devices during the same time intervals. In addition to the aforementioned data collection devices, video was recorded with camera aimed perpendicular to the lanes of travel. Manual counts from this recorded video were used as baseline volumes. The data was collected during the first week of September. The dates and approx. time durations of data collection are listed in table 2. The clocks on all the devices (except for ATR) were synchronized before the start of each data collection. Although not synchronized, the clock on the ATR was never found to be more than a couple minutes off when compared to the other devices.

Table 2: Dates and time durations of data collection

DOT Station	Date	Approx. Duration
235 (ATR)	Sept 3, 2013	2 pm – 4 pm
501 (ATR)	Sept 4, 2013	9 am – 12 pm
285 (ATR)	Sept 4, 2013	2 pm – 5 pm
CMC 0918 (ATR)	Sept 5, 2013	9 am – 11 am

Due to poor cellphone signal strength, Wavetronix (in conjunction with the EarthCam equipment) could not be installed at the CMC 0918 ATR location.

SITE LOCATIONS

Out of the various potential NDDOT ATR and WIM locations, four stations were selected for the purpose of this study. The stations were selected such that they include a variety of functional classes. Also, factors such as feasibility of safe deployment of data collections devices and availability of source of power were also considered. After performing site visits the following locations were finalized for testing:

1. NDDOT Station 235
   This ATR site is located on Interstate 29 between the 12th Ave N and 19th Ave N interchanges in Fargo. Its location is part of the urban interstate system in the Fargo – Moorhead area. This site has three northbound and two southbound lanes. Each of the lanes is equipped with detectors. For the purpose of this study, data collection equipment was deployed in only the northbound lanes. The speed limit at this section of interstate is 55mph.
2. NDDOT Station 501
   This ATR site is located on S University Drive between 15th Ave S and 15 ½ Ave S in Fargo. This particular ATR is located on an urban principal arterial. The site has two northbound and two southbound lanes. In addition, there is a two way turn lane. For the purpose of this study, data collection equipment was deployed in all of the lanes. However, the data from the two way turn lane was not used in the analysis. The speed limit on this section is 35mph.
3. NDDOT Station 285
   This ATR site is located on a rural interstate section of I-29 north of the Davenport interchange. It is a typical rural interstate section and has two northbound and two southbound lanes. The data collection equipment was setup on the southbound lanes. The speed limit on this section of rural interstate is 75mph.
4. CMC 0918
   This ATR location is located on Cass County 4 which is an east-west rural major collector in Ayr. It a typical 2-lane highway and thus has one eastbound and one westbound lane. The data collection equipment was setup on both lanes. The speed limit on this location is 55mph.

Table 3: Site locations

DOT Station	Site	Location Type	Direction(s)
235 (ATR)	NB I-29 (north of 12th Ave N)	Urban Interstate	NB
501 (ATR)	S University Drive (south of 15th Ave S)	Urban Principal Arterial	NB & SB
285 (ATR)	I-29 (north of Davenport interchange)	Rural Interstate	SB
CMC 0918 (ATR)	Cass Co 4 (Ayr)	Rural Major Collector	EB & WB

As these sites are NDDOT ATR locations, only mainline through movements were tested and the collected data did not include turning movement counts.

BASELINE DATA

Baseline data was obtained by performing manual counts on the video recorded using the TDCS. The TDCS consists of Autoscope Image Sensor AIS camera and Autoscope 2004 MVP. The components can be readily upgraded to the SoloPro II and ACIP4 processor panel. The recording system has been upgraded to a 4-channel DVR.

DATA ANALYSIS

Baseline data was compared to each of the different data sources.

Scatter Plots

Scatter plots were used to visually show relationship between two sets of numbers - one set representing the baseline data and the other set representing the compared data source. Scatter plots can show if the vehicles were under- or over-counted.

Percent Differences

Percent differences were used to indicate by how much the data collection device under- or over-counts the data. The percent difference in this case is the ratio of accumulated errors to the total baseline volumes.

$$V_{pd} = \frac{V_c - V_b}{V_b} \times 100$$

Where,

$V_{pd} = Percent\ Difference\ in\ Volume$

$V_c = Volume\ collected\ using\ data\ collection\ device$

$V_b = Baseline\ Volume$

A positive percent difference would indicate over-counting of vehicles and a negative percent difference would indicate under-counting.

RESULTS

The results of data analysis are presented in this section. The tables 12 thru 15 present overall percent differences in volumes. The output of individual sources is compared to the baseline data.

DOT Station 235 - NB I-29 (north of 12th Ave N)

Table 12: DOT Station 235 overall percent differences

Source	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision	Tally
Northbound	-13.1%	-13.1%	0.03%	-7.1%	1.5%	0.4%	-13.2%

DOT Station 501 - S University Drive (south of 15th Ave S)

Table 13: DOT Station 501 overall percent differences

Source	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision	Tally
Northbound	-34.6%	-36.2%	-3.1%	-10.9%	0.6%	-2.5%	1.9%
Southbound	-32.9%	-29.3%	0.4%	-7.7%	-0.2%	0.5%	

DOT Station 285 - I-29 (north of Davenport interchange)

Table 14: DOT Station 285 overall percent differences

Source	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision	Tally
Southbound	-6.1%	-8.3%	-0.1%	-0.7%	-0.8%	-0.3%	10.2%

DOT Station CMC 0918 - Cass Co 4 (Ayr)

Table 15: DOT Station CMC 0918 overall percent differences

<table>
<tr><th>Source</th><th>ADR</th><th>Sabre</th><th>EarthCam</th><th>MetroCount</th><th>ATR</th><th>Miovision</th><th>Tally</th></tr>
<tr><td>Eastbound</td><td>0%</td><td>3.8%</td><td>No Data</td><td>3.8%</td><td>19.2%</td><td>-3.8%</td><td rowspan="2">30.6%</td></tr>
<tr><td>Westbound</td><td>0%</td><td>0%</td><td>No Data</td><td>-4.3%</td><td>-26.1%</td><td>-4.3%</td></tr>
</table>

The tables 16 thru 19 show comparison of 2-hour traffic volumes. The output of individual sources as well as the baseline volume data divided into Passenger Car, Single Unit, and Combination Units of vehicle classes is included in the tables.

DOT Station 235 - NB I-29 (north of 12th Ave N)

Table 16: DOT Station 235 PC/SU/CU traffic volumes and percent difference results

<table>
<tr><th>Source</th><th>Baseline</th><th>ADR</th><th>Sabre</th><th>EarthCam</th><th>MetroCount</th><th>ATR</th><th>Miovision</th></tr>
<tr><td>NB – Passenger Cars</td><td>1,862</td><td>1,433
(-23.0%)</td><td>1,420
(-23.7%)</td><td>1,924
(3.3%)</td><td>1,607
(-13.7%)</td><td>1,837
(-1.3%)</td><td>1,854
(-0.4%)</td></tr>
<tr><td>NB – Single Units</td><td>100</td><td>64
(-36.0%)</td><td>66
(-34.0%)</td><td rowspan="2">235
(-9.3%)</td><td>139
(39.0%)</td><td>112
(12.0%)</td><td>106
(6.0%)</td></tr>
<tr><td>NB – Combination Units</td><td>159</td><td>347
(118.2%)</td><td>357
(124.5%)</td><td>191
(20.1%)</td><td>203
(27.7%)</td><td>169
(6.3%)</td></tr>
</table>

DOT Station 501 - S University Drive (south of 15th Ave S)

Table 17: DOT Station 501 PC/SU/CU traffic volumes and percent difference results

<table>
<tr><th>Source</th><th>Baseline</th><th>ADR</th><th>Sabre</th><th>EarthCam</th><th>MetroCount</th><th>ATR</th><th>Miovision</th></tr>
<tr><td>NB – Passenger Cars</td><td>1,414</td><td>580
(-59.0%)</td><td>609
(-56.9%)</td><td>1,337
(-5.4%)</td><td>1,198
(-15.3%)</td><td>-</td><td>1,377
(-2.6%)</td></tr>
<tr><td>NB – Single Units</td><td>16</td><td>33
(106.3%)</td><td>43
(168.8%)</td><td rowspan="2">58
(190%)</td><td>41
(156.3%)</td><td>-</td><td>17
(6.3%)</td></tr>
<tr><td>NB – Combination Units</td><td>4</td><td>252
(6200.0%)</td><td>250
(6150.0%)</td><td>16
(300.0%)</td><td>-</td><td>4
(0%)</td></tr>
<tr><td>SB – Passenger Cars</td><td>1,533</td><td>740
(-51.7%)</td><td>810
(-47.2%)</td><td>1,520
(-0.8%)</td><td>1,372
(-10.5%)</td><td>-</td><td>1,534
(0.1%)</td></tr>
<tr><td>SB – Single Units</td><td>30</td><td>54
(80%)</td><td>51
(70%)</td><td rowspan="2">78
(122.9%)</td><td>52
(73.3%)</td><td>-</td><td>38
(26.7%)</td></tr>
<tr><td>SB – Combination Units</td><td>5</td><td>263
(5160.0%)</td><td>258
(5060.0%)</td><td>16
(220.0%)</td><td>-</td><td>4
(-20.0%)</td></tr>
</table>

DOT Station 285 - I-29 (north of Davenport interchange)

Table 18: DOT Station 285 PC/SU/CU traffic volumes and percent difference results

Source	Baseline	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision
SB – Passenger Cars	762	671 (-11.9%)	654 (-14.2%)	762 (0%)	664 (-12.9%)	757 (-0.7%)	764 (0.3%)
SB – Single Units	16	18 (12.5%)	26 (62.5%)	117 (6.4%)	90 (462.5%)	18 (12.5%)	19 (18.8%)
SB – Combination Units	94	134 (42.6%)	124 (31.9%)		60 (36.2%)	98 (4.3%)	94 (0%)

DOT Station CMC 0918 - Cass Co 4 (Ayr)

Table 19: DOT Station CMC 0918 PC/SU/CU traffic volumes and percent difference results

Source	Baseline	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision
EB – Passenger Cars	18	18 (0%)	15 (-16.7%)	No Data	19 (5.6%)	-	17 (-5.6%)
EB – Single Units	0	0 (-%)	0 (-%)	No Data	0 (-%)	-	0 (-%)
EB – Combination Units	8	8 (0%)	8 (0%)	No Data	8 (0%)	-	8 (0%)
WB – Passenger Cars	16	15 (-6.3%)	19 (18.8%)	No Data	12 (-25%)	-	15 (-6.3%)
WB – Single Units	0	0 (-%)	0 (-%)	No Data	1 (-%)	-	0 (-%)
WB – Combination Units	7	8 (14.3%)	8 (14.3%)	No Data	9 (28.6%)	-	7 (0%)

The tables 20 thru 23 present comparisons of volumes by vehicle class. The output of individual sources as well as the baseline volume data is included in the tables.

DOT Station 235 - NB I-29 (north of 12th Ave N)

Table 20: DOT Station 235 Class 1 through 13 volume results

Source	Baseline	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision
Class 1	15	15	12	N/A	14	14	N/A
Class 2	732	1,052	1,031	N/A	1,105	1,432	N/A
Class 3	1,104	344	356	N/A	460	388	N/A
Class 4	11	22	21	N/A	28	3	N/A
Class 5	25	18	20	N/A	91	69	N/A
Class 6	70	40	39	N/A	38	41	N/A
Class 7	5	6	7	N/A	10	2	N/A
Class 8	0	137	135	N/A	38	50	N/A
Class 9	155	123	123	N/A	95	138	N/A
Class 10	3	48	53	N/A	26	15	N/A

Class 11	0	2	1	N/A	1	0	N/A
Class 12	1	0	0	N/A	0	0	N/A
Class 13	0	37	45	N/A	31	0	N/A

DOT Station 501 - S University Drive (south of 15th Ave S)

Table 21: DOT Station 501 Class 1 through 13 volume results

Source	Baseline	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision
NB Class 1	16	7	14	N/A	11	N/A	N/A
NB Class 2	622	461	475	N/A	923	N/A	N/A
NB Class 3	766	110	120	N/A	262	N/A	N/A
NB Class 4	10	2	0	N/A	2	N/A	N/A
NB Class 5	14	5	7	N/A	28	N/A	N/A
NB Class 6	2	23	23	N/A	7	N/A	N/A
NB Class 7	0	5	13	N/A	6	N/A	N/A
NB Class 8	2	132	150	N/A	12	N/A	N/A
NB Class 9	2	23	18	N/A	1	N/A	N/A
NB Class 10	0	49	44	N/A	0	N/A	N/A
NB Class 11	0	3	2	N/A	0	N/A	N/A
NB Class 12	0	0	0	N/A	0	N/A	N/A
NB Class 13	0	45	36	N/A	3	N/A	N/A
SB Class 1	9	4	14	N/A	10	N/A	N/A
SB Class 2	675	557	626	N/A	1,066	N/A	N/A
SB Class 3	840	176	164	N/A	291	N/A	N/A
SB Class 4	9	3	6	N/A	5	N/A	N/A
SB Class 5	28	12	8	N/A	36	N/A	N/A
SB Class 6	6	22	25	N/A	5	N/A	N/A
SB Class 7	0	20	18	N/A	11	N/A	N/A
SB Class 8	2	169	159	N/A	9	N/A	N/A
SB Class 9	3	18	19	N/A	2	N/A	N/A
SB Class 10	0	45	44	N/A	0	N/A	N/A
SB Class 11	0	1	1	N/A	1	N/A	N/A
SB Class 12	0	0	0	N/A	0	N/A	N/A
SB Class 13	0	30	35	N/A	4	N/A	N/A

DOT Station 285 - I-29 (north of Davenport interchange)

Table 22: DOT Station 285 Class 1 through 13 volume results

Source	Baseline	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision
Class 1	7	6	4	N/A	5	1	N/A
Class 2	313	478	476	N/A	537	493	N/A
Class 3	441	183	169	N/A	119	259	N/A
Class 4	1	4	5	N/A	3	4	N/A
Class 5	4	4	9	N/A	11	7	N/A
Class 6	12	13	16	N/A	78	11	N/A

Class 7	0	1	1	N/A	1	0	N/A
Class 8	2	38	32	N/A	7	6	N/A
Class 9	81	71	68	N/A	27	81	N/A
Class 10	10	17	14	N/A	10	9	N/A
Class 11	0	2	0	N/A	1	0	N/A
Class 12	1	2	1	N/A	0	1	N/A
Class 13	0	4	9	N/A	15	1	N/A

DOT Station CMC 0918 - Cass Co 4 (Ayr)

Table 23: DOT Station CMC 0918 Class 1 through 13 volume results

Source	Baseline	ADR	Sabre	EarthCam	MetroCount	ATR	Miovision
EB Class 1	0	0	0	No Data	0	N/A	N/A
EB Class 2	4	10	10	No Data	10	N/A	N/A
EB Class 3	14	8	9	No Data	9	N/A	N/A
EB Class 4	0	0	0	No Data	0	N/A	N/A
EB Class 5	0	0	0	No Data	0	N/A	N/A
EB Class 6	0	0	0	No Data	0	N/A	N/A
EB Class 7	0	0	0	No Data	0	N/A	N/A
EB Class 8	0	0	0	No Data	0	N/A	N/A
EB Class 9	6	5	5	No Data	5	N/A	N/A
EB Class 10	2	2	2	No Data	2	N/A	N/A
EB Class 11	0	0	0	No Data	0	N/A	N/A
EB Class 12	0	0	0	No Data	0	N/A	N/A
EB Class 13	0	1	1	No Data	1	N/A	N/A
WB Class 1	1	1	1	No Data	1	N/A	N/A
WB Class 2	3	4	4	No Data	3	N/A	N/A
WB Class 3	12	10	10	No Data	8	N/A	N/A
WB Class 4	0	0	0	No Data	0	N/A	N/A
WB Class 5	0	0	0	No Data	0	N/A	N/A
WB Class 6	0	0	0	No Data	1	N/A	N/A
WB Class 7	0	0	0	No Data	0	N/A	N/A
WB Class 8	0	2	2	No Data	3	N/A	N/A
WB Class 9	6	4	5	No Data	2	N/A	N/A
WB Class 10	1	2	1	No Data	1	N/A	N/A
WB Class 11	0	0	0	No Data	0	N/A	N/A
WB Class 12	0	0	0	No Data	0	N/A	N/A
WB Class 13	0	0	0	No Data	3	N/A	N/A

DISCUSSION

The results are discussed by data collection equipment type.

ADR Results (Pneumatic Tube Based System)

Rural 2-lane Highway Application

The ADR performed very well in the rural 2-lane highway application. The total volumes had negligible errors when compared to baseline.

Multi-lane Applications

The overall percent differences as compared to Baseline volumes show that the ADR performed poorly in its urban interstate (multi-lane) application. The percent difference was 13.1% in this case. Similar to interstate in urban setting, the ADR performed poorly in its rural interstate (multi-lane) application with 6.1% in this setting. The overall percent differences show that the ADR performed worse in its urban principal arterial (multi-lane and bidirectional) application.

Classification Results

The ADR also appears to have poor results for classification in the multi-lane situations. The percent difference is very high in these situations. For example, it can be seen that at DOT station 501, the percent difference for combination units is over 1000%.

Setup/Installation

The installation of ADR requires personnel to cross travel lanes due to its intrusive nature. Other than that, the setup of the device was simple and straightforward.

Notes

The pneumatic road tube type counters tend to underperform where there are multiple lanes in one direction. This happens primarily due to multiple vehicles' axles hitting the tubes at the same time or very close to each other. There are infinite ways in which such axle hits may occur, making it difficult to weed out the data and provide accurate results. The post processing of collected data takes care of some of the issues but may not be very effective in some cases (for example DOT Station 501).

The data at DOT Station 501 – S University Drive was collected very close to the AM peak hour. Also, the location is close to two signalized intersections. At times, the traffic was stopping, decelerating, or accelerating while going through the test location. This appears to have adversely affected most of the devices.

As noted in this section, pneumatic tube-based counters failed to meet expected data quality standards due to known limitations. However, an alternate sensor layout while collecting classification data on locations with similar multi-lane characteristics is expected to improve the data quality. At such locations, unidirectional paired axle sensor layout should be used. NDDOT has indicated that these alternative sensor layouts are used in multi-lane situations.

Sabre Results (Pneumatic Tube Based System)

Rural 2-lane Highway Application

Very similar to ADR, Sabre performed very well in the rural 2-lane highway application. It over-counted vehicles in the eastbound direction by 3.8%.

Multi-lane Applications

The overall percent differences as compared to Baseline volumes show that Sabre consistently undercounted in multi-lane applications. In urban interstate and rural interstate settings it undercounted by 13.1% and 8.3% respectively. Sabre performed poorly in its rural interstate (multi-lane) application where it undercounted by 36.2% in northbound and 29.3% in southbound direction.

Classification Results

The Sabre also appears to have poor results for classification. Similar to ADR, it appears to have under-counted the passenger cars and over-counted the trucks as a result of sensor layout.

Setup/Installation

The installation of pneumatic tubes for Sabre also requires personnel to cross travel lanes due to its intrusive nature. However, the setup of the device itself was simple and straightforward.

Notes

The Sabre had the same issues at the multi-lane locations as the ADR due to tube layout.

EarthCam Results (Radar Based System)

Rural 2-lane Highway Application

As mentioned earlier, EarthCam could not be tested at this test site.

Multi-lane Applications

The comparison of overall percent differences as compared to Baseline volumes show that the EarthCam performed very well in its urban interstate (multi-lane) application. The difference at this location was only 0.03%. EarthCam also performed very well in its rural interstate (multi-lane) application with a percent difference of 0.1%. The data also shows that EarthCam performed well in its urban principal arterial (multi-lane) application. At this test site, the difference was 3.1% in northbound direction and 0.4% in the southbound direction.

Classification Results
In addition to comparison of total volumes, the data was further analyzed as Passenger Car and Trucks classifications. The classifications are based on length and are as below:

- Class 1 = 0.00' to 22.00'
- Class 2 = 22.01' to 40.00'
- Class 3 = 40.01' to 68.00'
- Class 4 = 68.01' to 80.00'
- Class 5 is 80.01' to 255.00'

Passenger Cars

Trucks

Out of the three locations where EarthCam could be setup, it appears to have done well on classification in two of them – DOT Stations 235 (urban interstate) and 285 (rural interstate). At these stations the truck versus passenger cars classification was within 10% of the baseline data. The DOT station 501 (urban principal arterial) was affected by stop-and-go traffic as mentioned earlier. Similar to the other devices, EarthCam under-counted the passenger cars and over-counted the trucks.

Setup/Installation
Once the Wavetronix radar device has been installed at an appropriate height and offset from the edge of the roadway, the setup of the EarthCam device is easy and straightforward. The dedicated personnel at EarthCam can handle the calibration at their end which can be verified in the field itself, before finalizing setup. The Wavetronix has a handy option of self-calibration which was found to be capable of providing robust results.

Notes
In addition to being affected by stop-and-go traffic during peak hour at the urban principal arterial location, the EarthCam unit was also subject to acceptable cellular signal reception. Again, it should be noted that EarthCam is not using video sensors but rather 3rd party radar-based sensors. The total cost for this type of set-up can be fairly high at approximately $15,000 to $20,000 for equipment and 1 year service.

MetroCount Results (Pneumatic Tube Based System)
Rural 2-lane Highway Application
MetroCount performed well in the rural 2-lane highway application. It over-counted the vehicles by 3.8% in eastbound and under-counted by 4.3% in westbound direction.

Multi-lane Applications
The overall percent differences for MetroCount show that it performed acceptably in its urban interstate (multi-lane) application with 7.1%. It also performed well in the rural interstate (multi-lane) application with 0.7%. Further comparison show that MetroCount performed poorly in its urban principal arterial (multi-lane) application with 10.9% in the northbound direction and 7.7% in the southbound direction.

Classification Results
The classification results show that MetroCount Performed poorly in the multi-lane situations again due to sensor layout issues.

Setup/Installation
Similar to other pneumatic tube-based data collection devices, the installation MetroCount also requires personnel to cross travel lanes due to its intrusive nature. The setup of the device itself requires a computer on-site. The device itself is significantly lighter in weight as compared to other similar devices with classification capabilities.

Notes
At times, there was not enough number of vehicles of certain class to decisively compare across the board. Additionally, the data collected had noise, which affected the truck classification. A solution to reducing the noise and collecting more reliable data has been found in the form of vented end plugs.

ATR Results (In-pavement Inductive Loop Based System)
Rural 2-lane Highway Application
At the rural 2-lane location, the ATR results appear to be non-acceptable with a percent difference 19.2% in the eastbound direction and 26.1% in the westbound direction. It is possible there were some time difference issues at this location as results are typically very accurate for these types of counters.

Multi-lane Applications
As the comparison of overall traffic volumes shows, the ATR performed very well in multi-lane setting. The percent difference was only 1.5% at the urban interstate site. At the rural interstate location, the total volumes collected by ATR the difference is only 0.8%. And at the urban principal arterial location the percent difference 0.6% in the northbound direction and 0.2% in the southbound direction.

Classification Results
Traffic volumes by class were available for two test locations – urban interstate and rural interstate. The classification results at both locations show very good performance in counting passenger cars with 1.3% at urban and 0.7% in the rural setting).

Setup/Installation
The installation of such permanent stations requires planning ahead (laying of loops while construction/reconstruction) or lane closures (during retro-fitting of the inductive loops). Once setup, ATRs are known to be robust in collecting traffic data.

Notes
CMC 0918 (rural 2-lane location) had low volume of traffic go through during the data collection. As a result, the percent differences in volumes appear so high even when the actual difference in vehicles registered is low. Also, there may have been some time clock differences at this location.

Miovision Results (Video Based System)

Rural 2-lane Highway Application

Miovision performed acceptably in the rural 2-lane setting. It undercounted in both eastbound and westbound direction by 3.8% and 4.3% respectively.

Multi-lane Applications

The overall percent differences in volumes show that Miovision performed very well at multi-lane locations. At the urban interstate location, the difference was only 0.4% and only 0.3% at the rural interstate location. The overall percent differences show that the Miovision performed very well in the urban principal arterial (multi-lane) setting also with 2.5% in the northbound direction and only 0.5% in the southbound direction.

Classification Results

The classification results show that Miovision performed very well in counting passenger cars at urban interstate, rural interstate and urban principal arterial locations. Although the percent differences in counting single units and combination units appear high, Miovision has performed acceptably at all but one location – DOT Station 501 - S University Dr. As is the case with other devices, it appears that reliable counts may not be recorded as the traffic stream going through the test site was affected by queues and shockwaves from traffic signal and congestion downstream of the field test site.

Setup/Installation

The setup of Miovision is very simple and straightforward. The flexibility in programming the start time and lightweight fish-eye camera make the installation much uncomplicated. However, the post-processing on collected data is not done in-house and has cost(s) associated with it with which NDDOT is already familiar.

Notes

At times, the percent differences (especially single unit and combination unit percent differences) appear to be high due to low traffic volumes.

Tally Results (Pneumatic Tube Based System)

Tally's output was compared to the baseline data after applying axle factors as provided by the NDDOT. It is important to note that the axle factors can have a significant impact on the final count number.

Rural 2-lane Highway Application

The overall percent differences as compared to Baseline volumes show that Tally performed very poorly at the rural 2-lane highway location with a difference 30.6%.

Multi-lane Applications

Further, comparisons show that Tally performed poorly in its urban and rural interstate (multi-lane) applications with a difference of 13.2% and 10.2% respectively. Tally appears to have performed well under urban principal arterial setting. It over-counted by 1.9% (combination of both directions).

Classification Results

Tally does not have classification capabilities and thus its results could not be compared to baseline classification results.

Setup/Installation

The installation of pneumatic tube for Tally also requires personnel to cross travel lanes due to its intrusive nature. However, the setup of the device is very easy.

Notes

It was noted that as tested, Tally device had limited applications. There are limited options of data collection as it only records axle hits and the observations have to be manually read at the end of each interval.

AxleLight (Laser Based System)

Setup/Installation

During the test setup of Peek's AxleLight devices, it was noted that installation of laser devices may require special circumstances. The best-case scenario is when the devices are setup at guardrail posts as they have to be mounted very low (the laser beam has to clear the crown in the pavement while remaining under the ground clearance of majority of the vehicles). This may be attained in the rural and urban interstate locations. In addition, it was seen that slight movement in the device angles could result in the devices getting out of calibration. Setup on a temporary post would require the post to be quite sturdy as to not allow movement.

The laser devices could not be setup for a test at the urban principal arterial location. As is the case with most urban locations, the furniture zones are generally higher than the optimal mount height of the laser devices due to the presence of curb/gutter at the edge of furniture zone.

Autoscope (Video Based System)

Notes

A recent project completed at ATAC involved setup of an Autoscope equipped intersection approaches (primarily used for detection) could be easily set for recording turning movement counts. An acceptable trade-off between traffic detection and counting showed that the output from cameras was within 10% when comparing approach totals and within 15% when comparing individual turning movement totals at an intersection with exclusive right- and left- turn lanes.

CONCLUSIONS

All of the technologies as tested in this report have been shown to have the potential to collect accurate traffic information. However, each technology has certain limitations and potential for error depending on the deployment circumstances and sensor installation layouts. It is important with all technologies that processes and instructions are put into place that detail these situations and proper uses. The layout of pneumatic tubes on multi-lane roads is an example of the importance of these procedures.

This study also shows that some of the newer non-intrusive technologies such as Video and Radar are certainly viable alternatives to traditional tube counter technologies. And in the case of multi-lane high volume situations, they are preferred alternatives due to accurate results and safety considerations.

The technologies as tested continue to be advanced and improved especially in the area of video detection. Because of this it is recommended that new technology should be continuously monitored and tested to provide NDDOT with valuable information on the state of the art in traffic data collection.

Appendix A: Scatter Plots

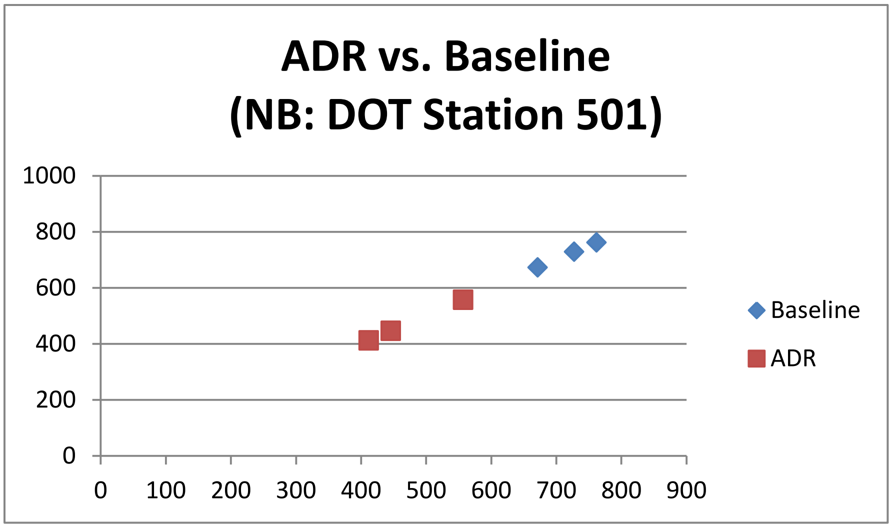

Figure 1. ADR vs. Baseline NB DOT Station 501 Scatter Plot

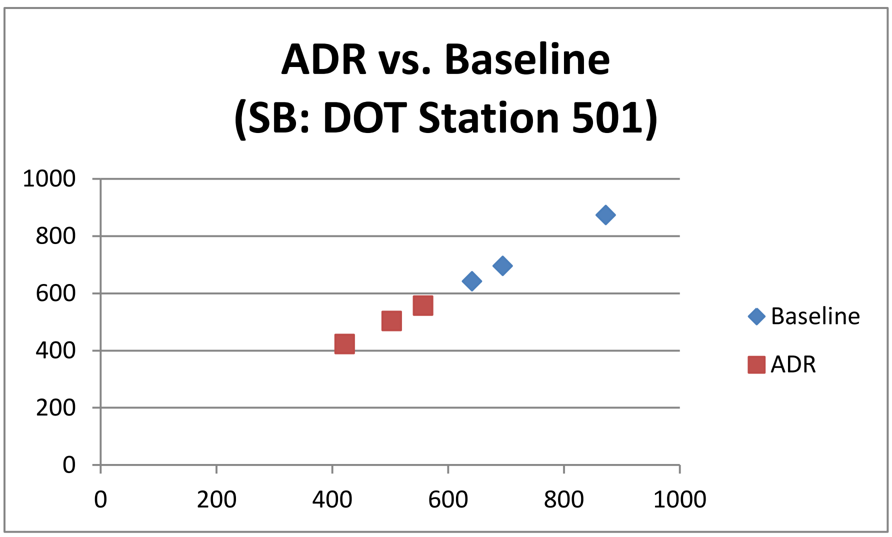

Figure 2. ADR vs. Baseline SB: DOT Station 501 Scatter Plot

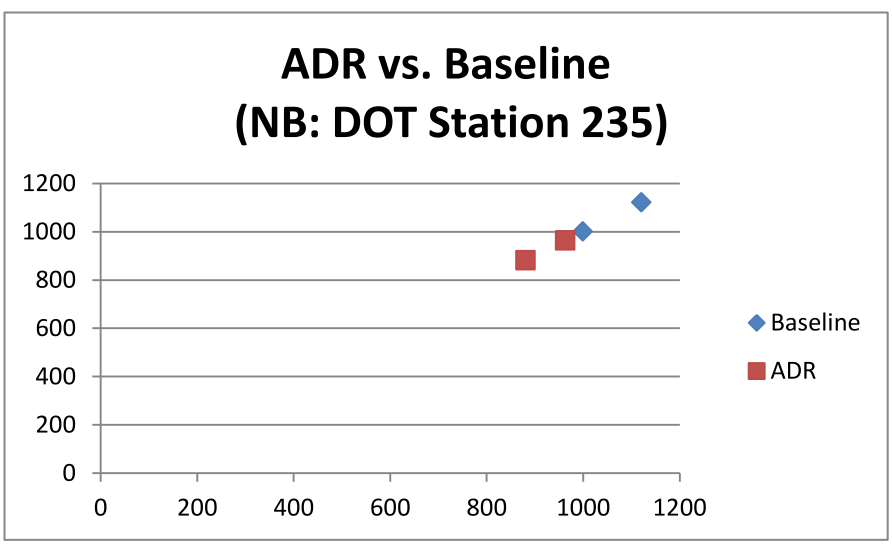

Figure 3. ADR vs. Baseline NB DOT Station 235 Scatter Plot

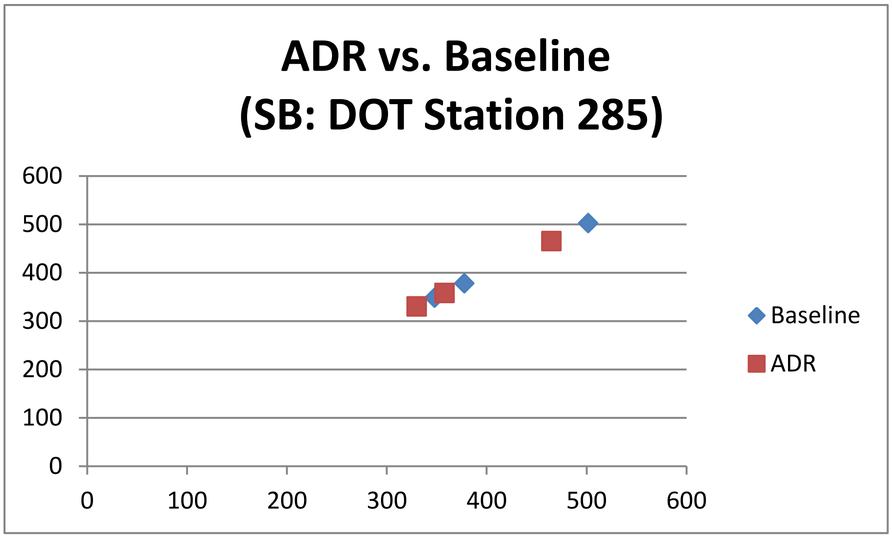

Figure 4. ADR vs. Baseline SB DOT Station 285 Scatter Plot

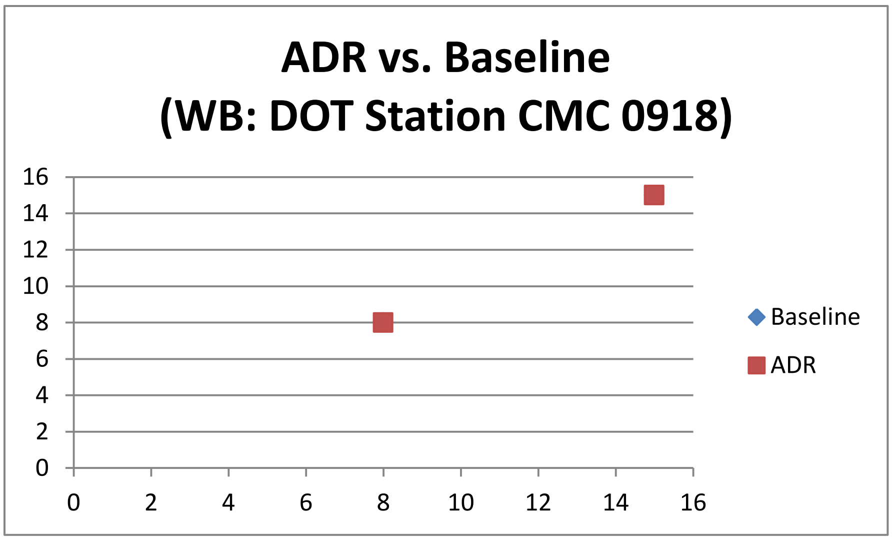

Figure 5. ADR vs. Baseline WB DOT Station CMC 0918 Scatter Plot

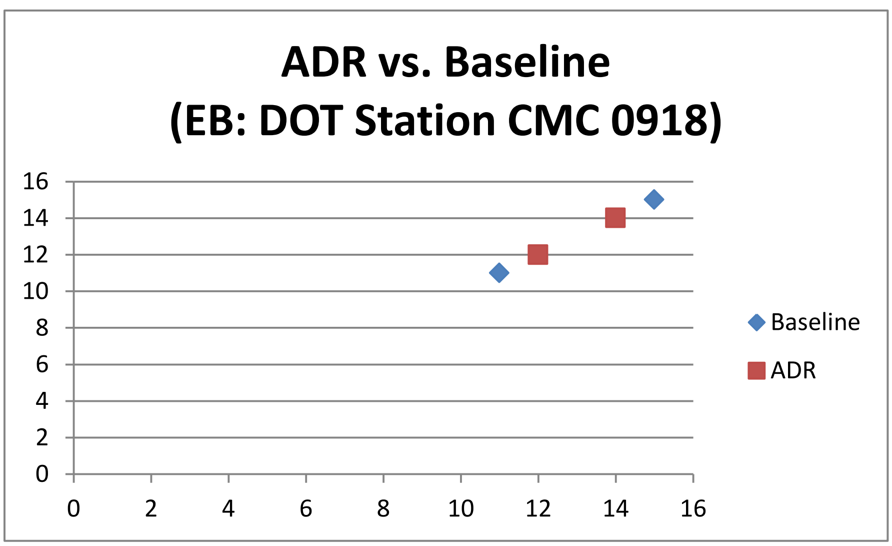

Figure 6. ADR vs. Baseline EB DOT Station CMC 0918 Scatter Plot

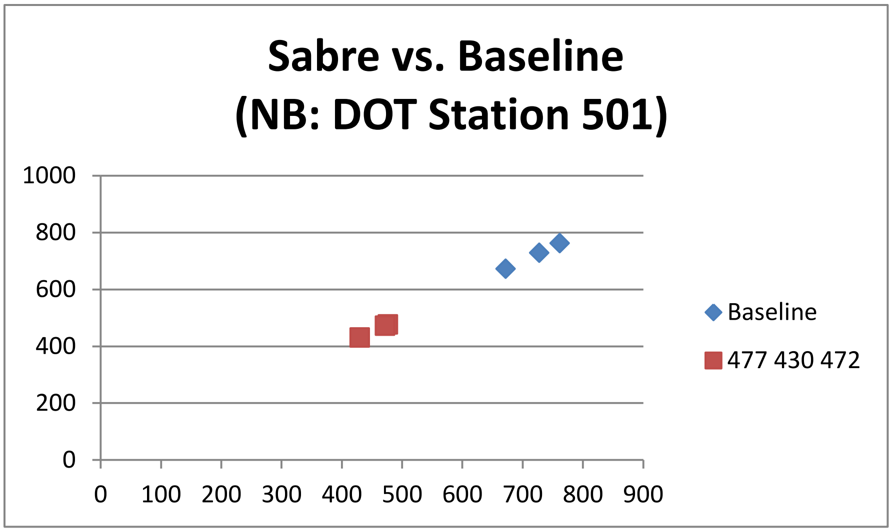

Figure 7. Sabre vs. Baseline NB DOT Station 501 Scatter Plot

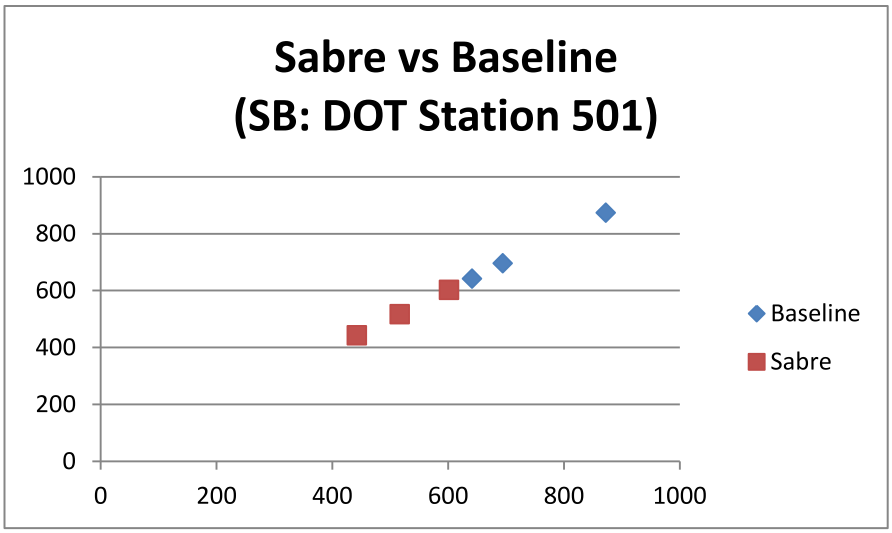

Figure 8. Sabre vs. Baseline SB DOT Station 501 Scatter Plot

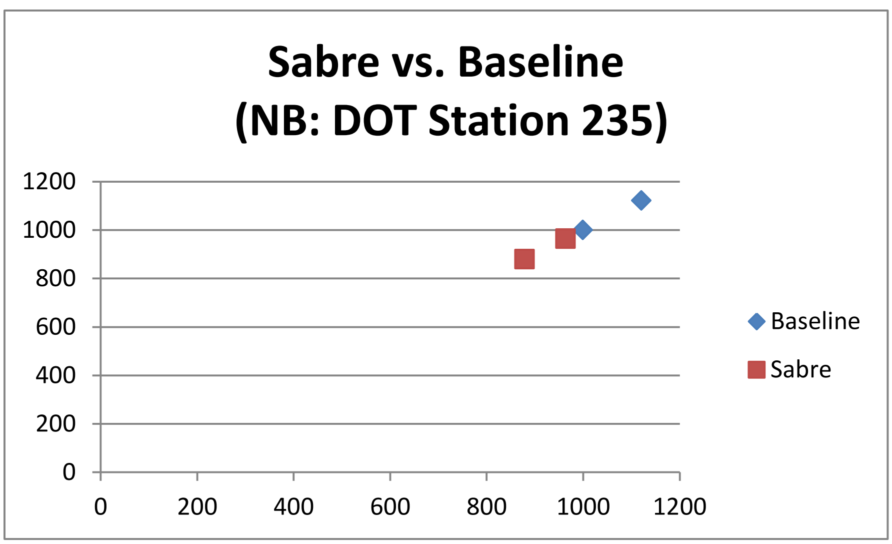

Figure 9. Sabre vs. Baseline NB DOT Station 235 Scatter Plot

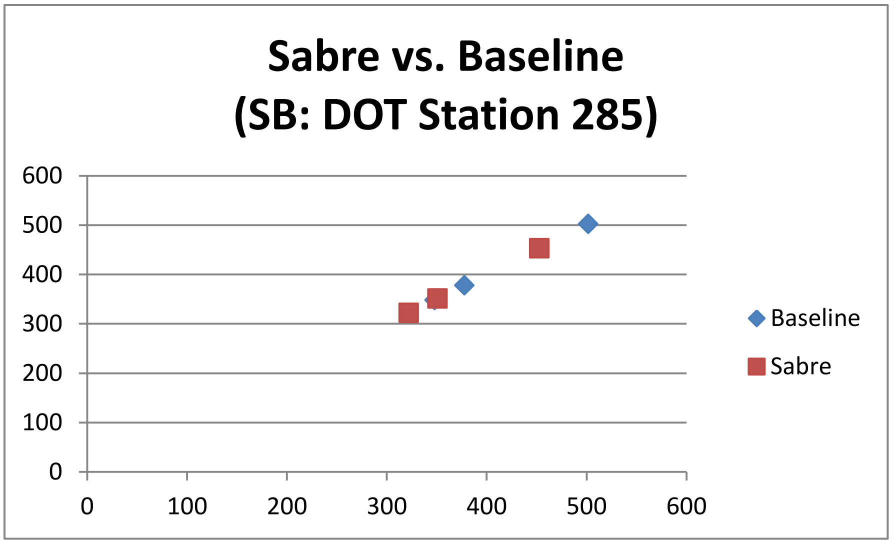

Figure 10. Sabre vs. Baseline SB DOT Station 285 Scatter Plot

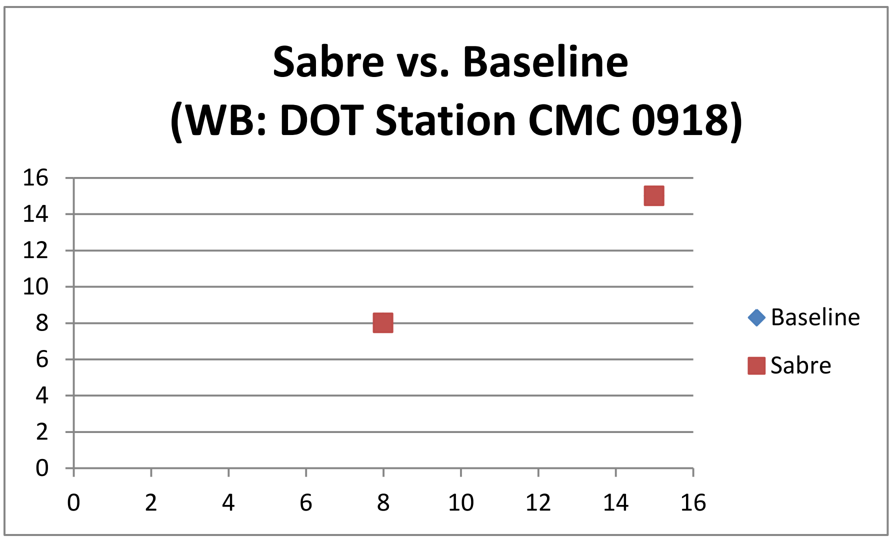

Figure 11. Sabre vs. Baseline WB DOT Station CMC 0918 Scatter

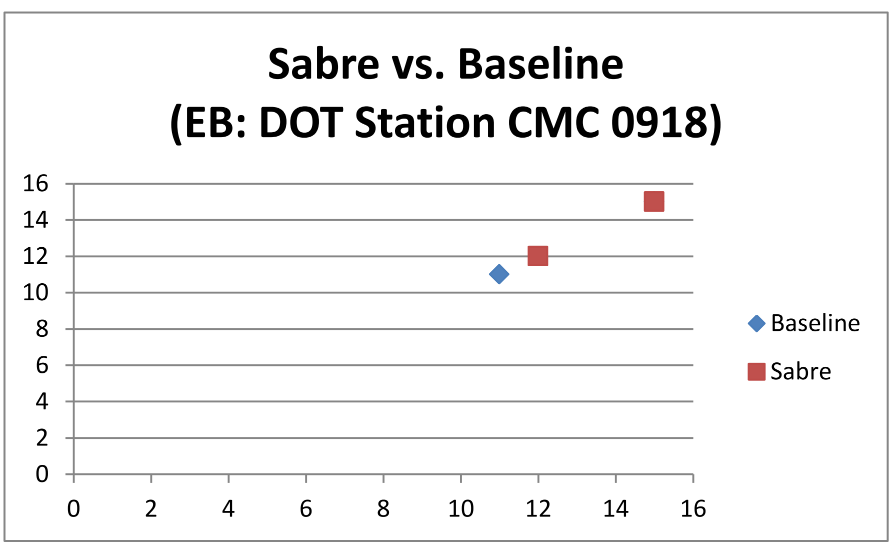

Figure 12. Sabre vs. Baseline WB DOT Station CMC 0918 Scatter

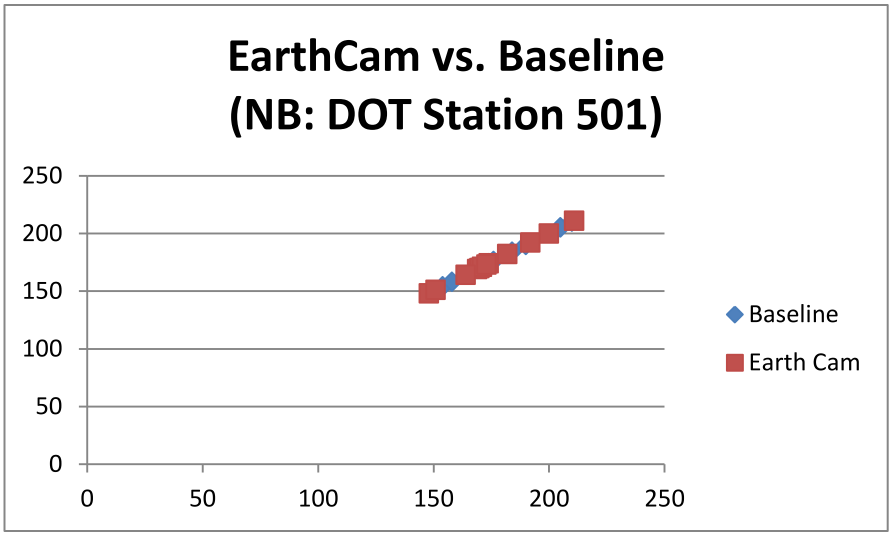

Figure 13. EarthCam vs. Baseline NB DOT Station 501 Scatter

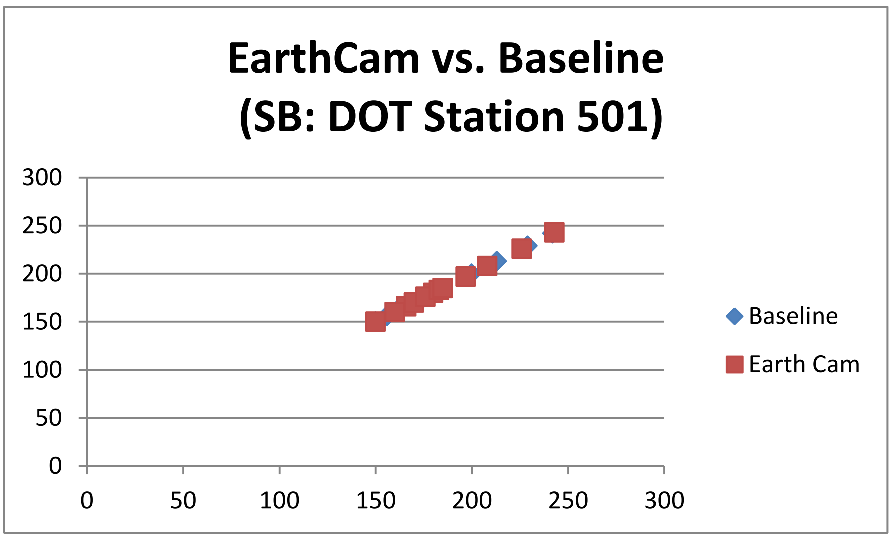

Figure 14. EarthCam vs. Baseline SB DOT Station 501 Scatter

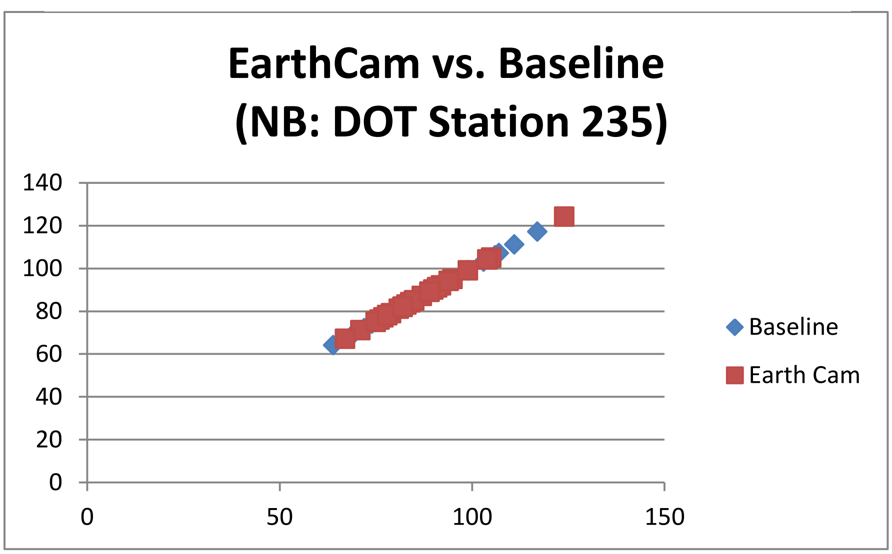

Figure 15. Sabre vs. Baseline NB DOT Station 235 Scatter

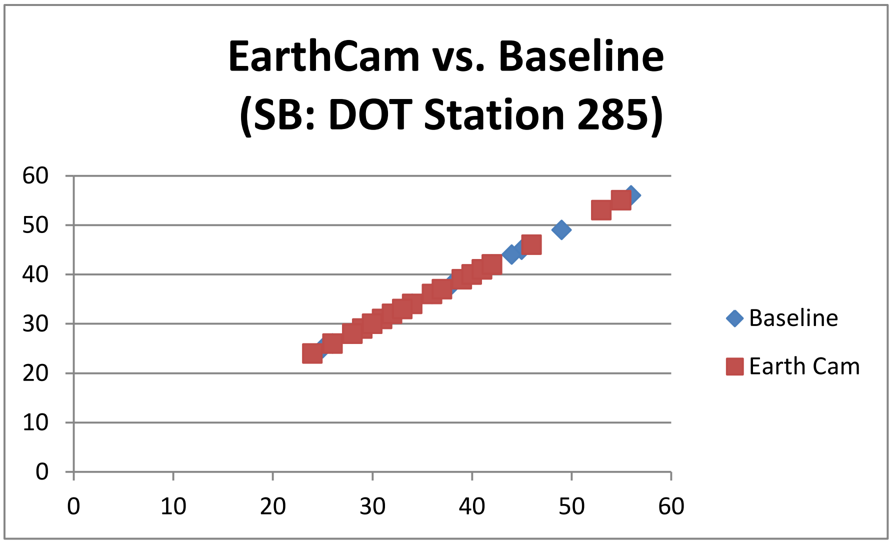

Figure 16. EarthCam vs. Baseline SB DOT Station 285 Scatter

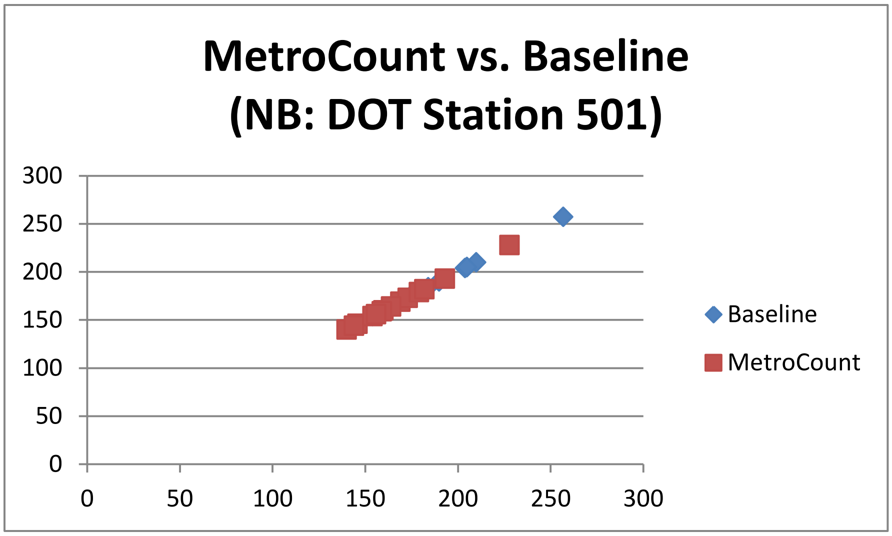

Figure 17. MetroCount vs. Baseline NB DOT Station 501 Scatter Plot

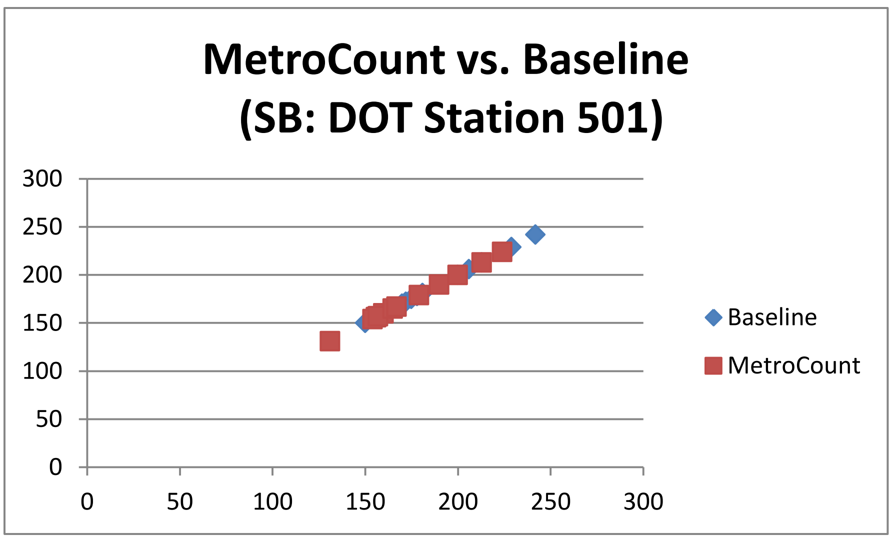

Figure 18. MetroCount vs. Baseline SB DOT Station 501 Scatter Plot

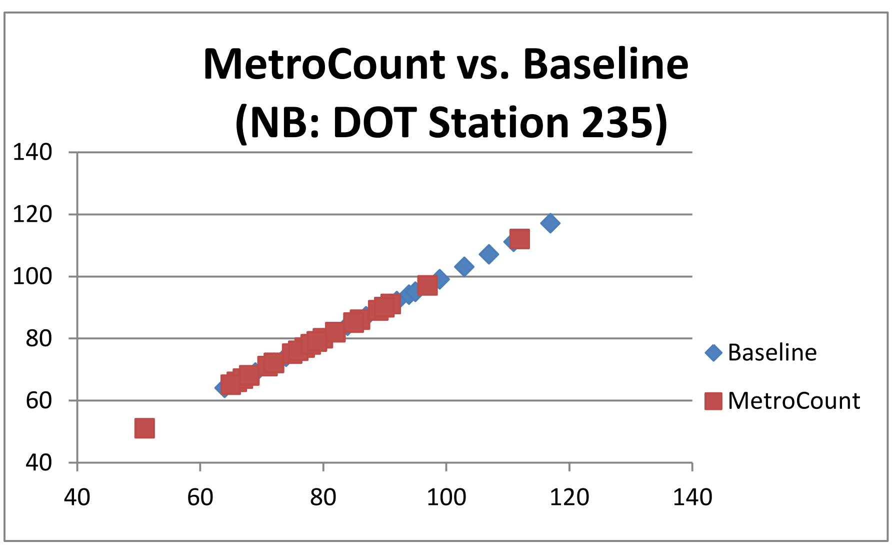

Figure 19. MetroCount vs. Baseline NB DOT Station 235 Scatter Plot

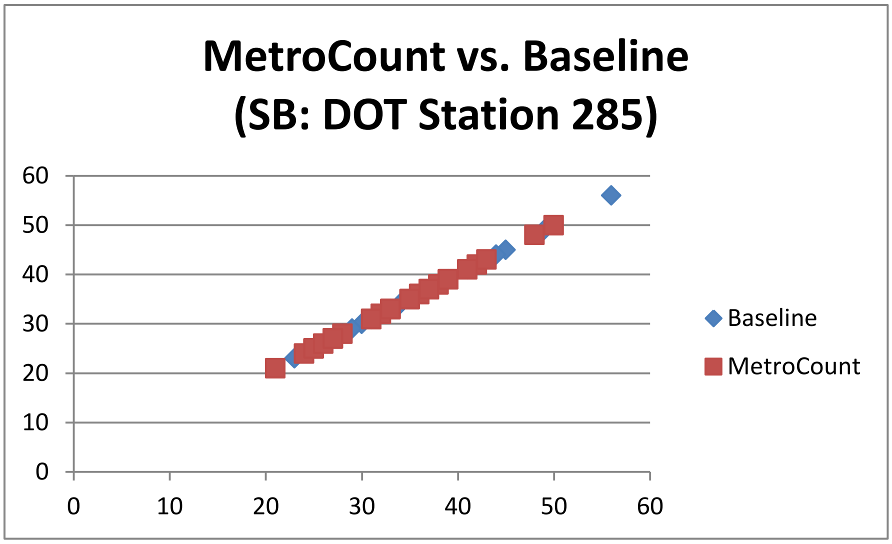

Figure 20. MetroCount vs. Baseline SB DOT Station 285 Scatter Plot

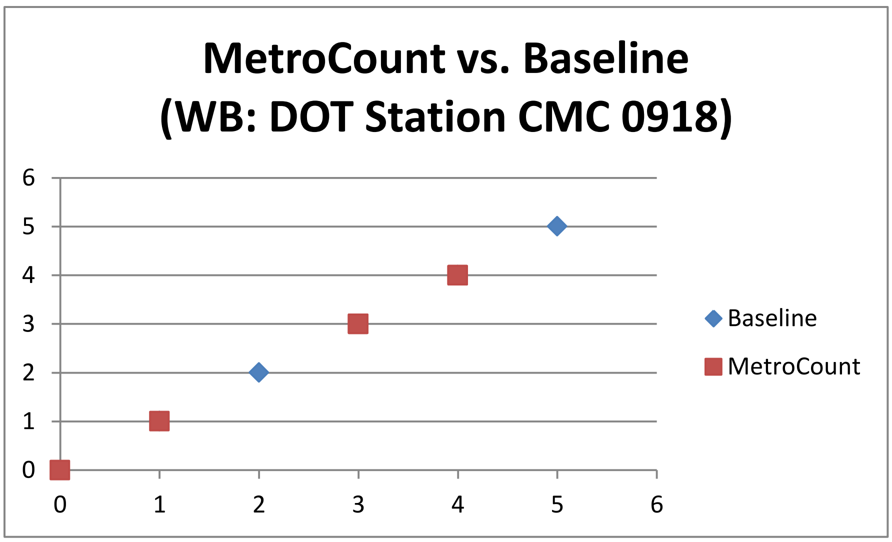

Figure 21. MetroCount vs. Baseline WB DOT Station CMC 0918 Scatter

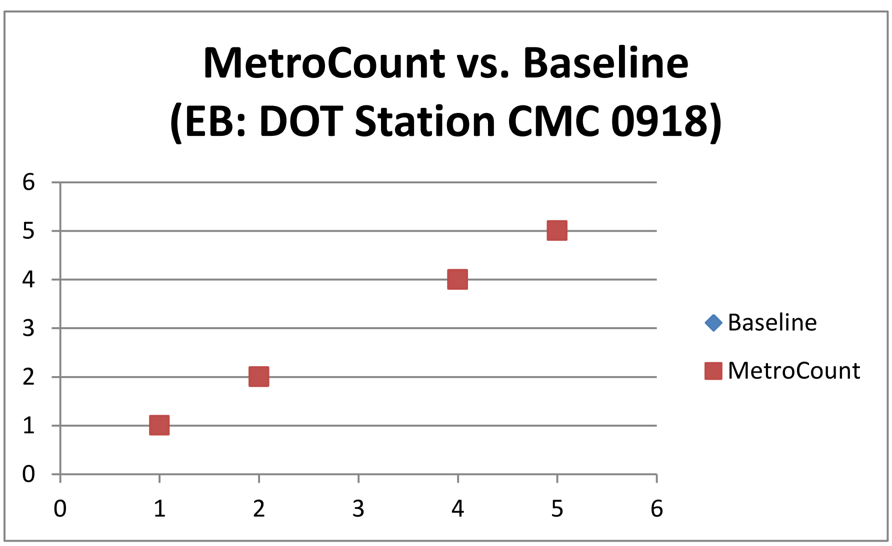

Figure 22. MetroCount vs. Baseline EB DOT Station CMC 0918 Scatter Plot

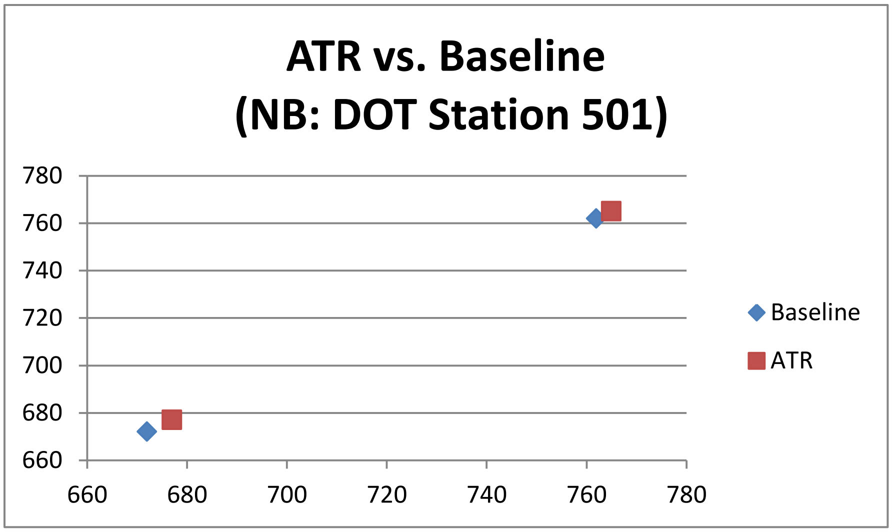

Figure 23. ATR vs. Baseline NB DOT Station 501 Scatter Plot

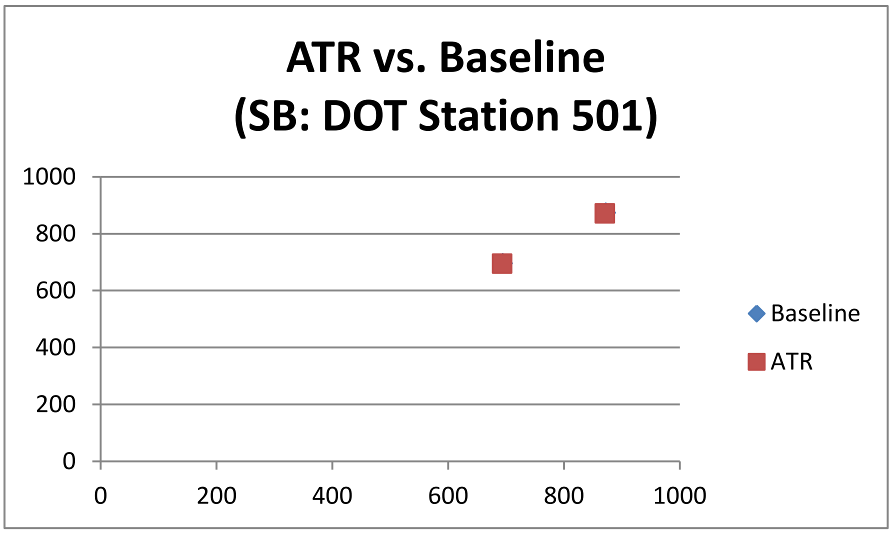

Figure 24. ATR vs. Baseline SB DOT Station 501 Scatter Plot

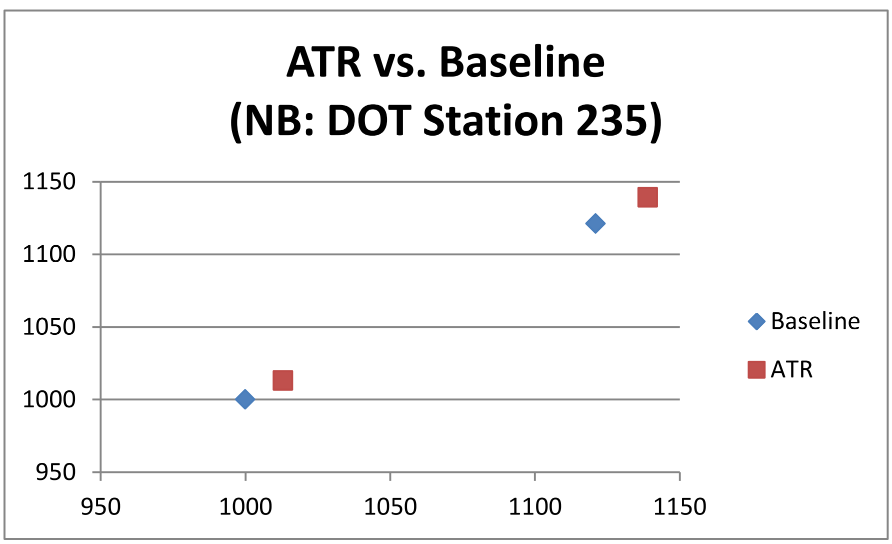

Figure 25. ATR vs. Baseline NB DOT Station 235 Scatter Plot

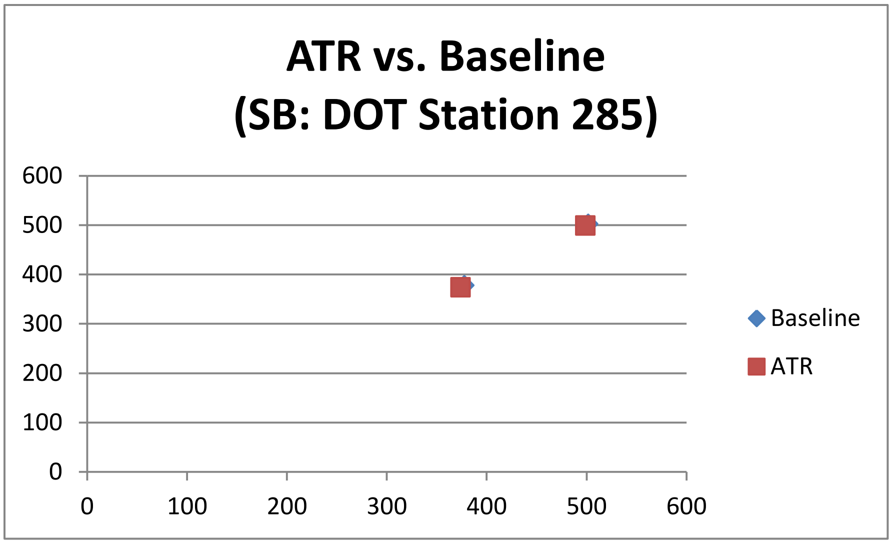

Figure 26. ATR vs. Baseline SB DOT Station 285 Scatter Plot

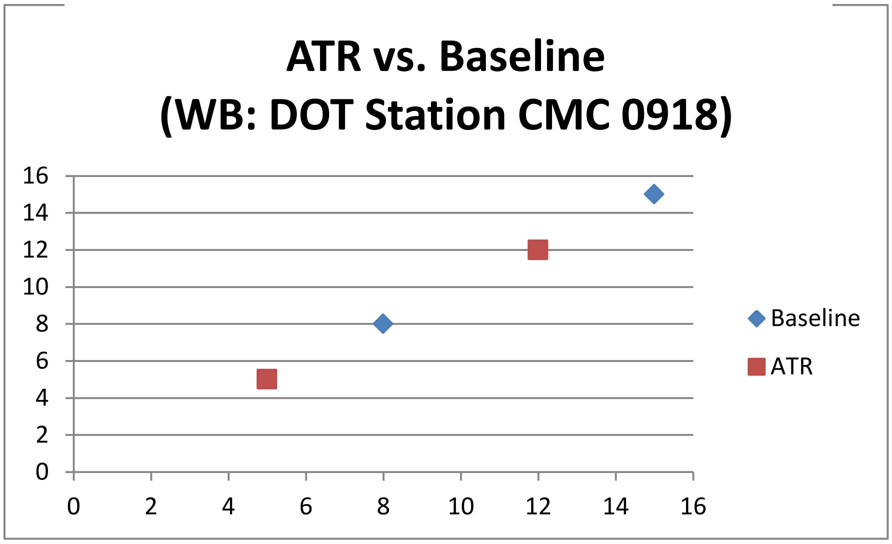

Figure 27. ATR vs. Baseline WB DOT Station CMC 0918 Scatter Plot

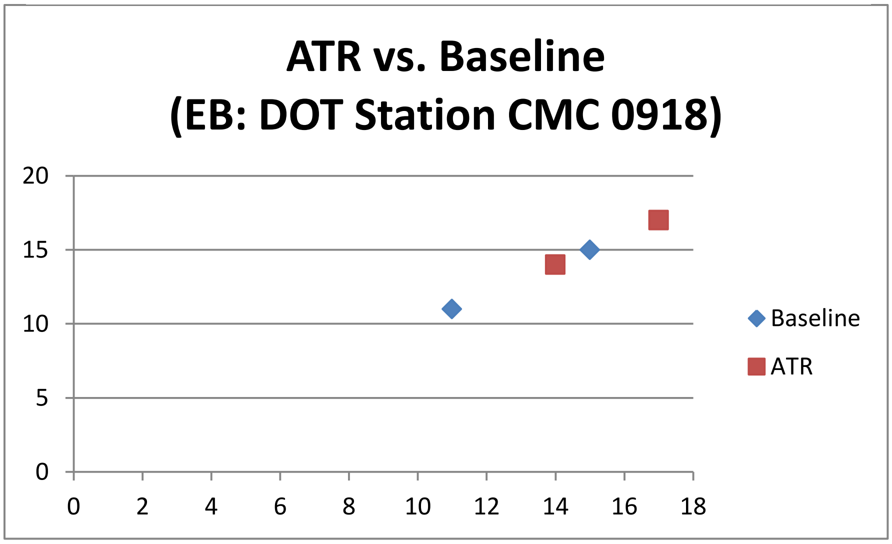

Figure 28. ATR vs. Baseline EB DOT Station CMC 0918 Scatter Plot

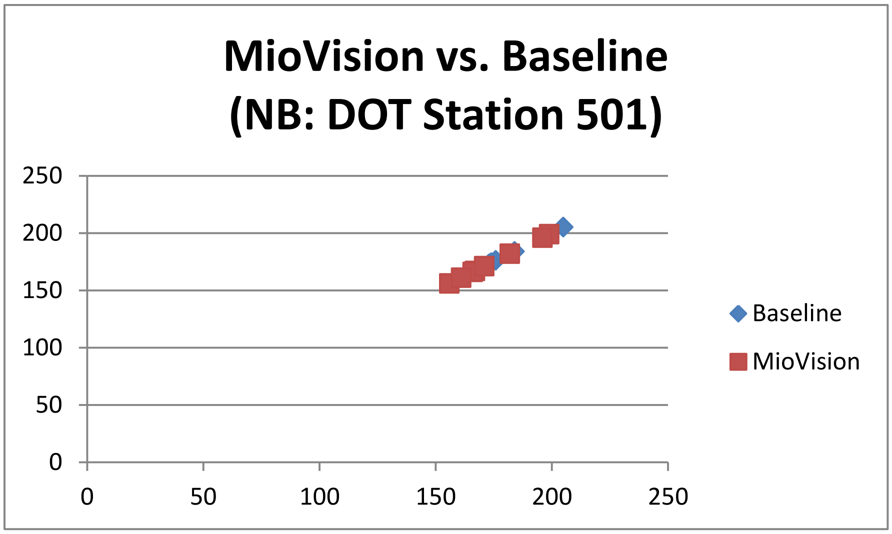

Figure 29. MioVision vs. Baseline NB DOT Station 501 Scatter

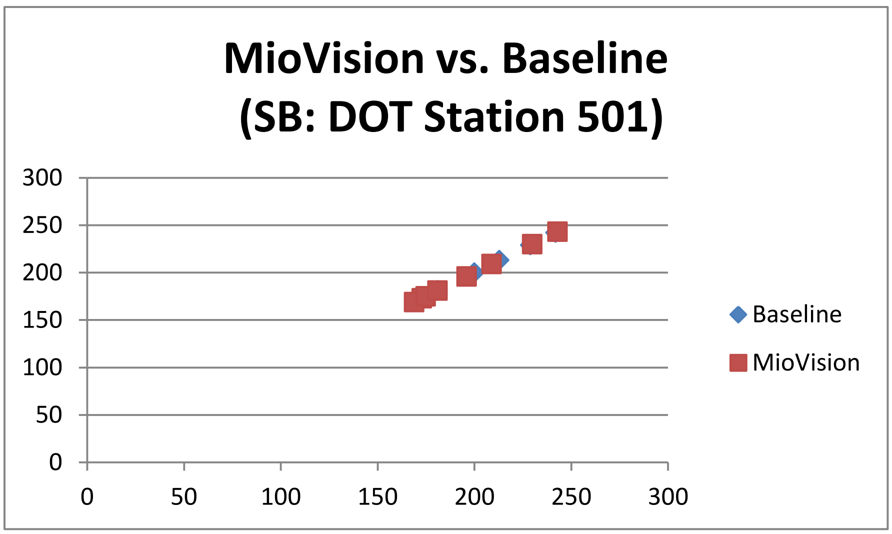

Figure 30. MioVision vs. Baseline SB DOT Station 501 Scatter

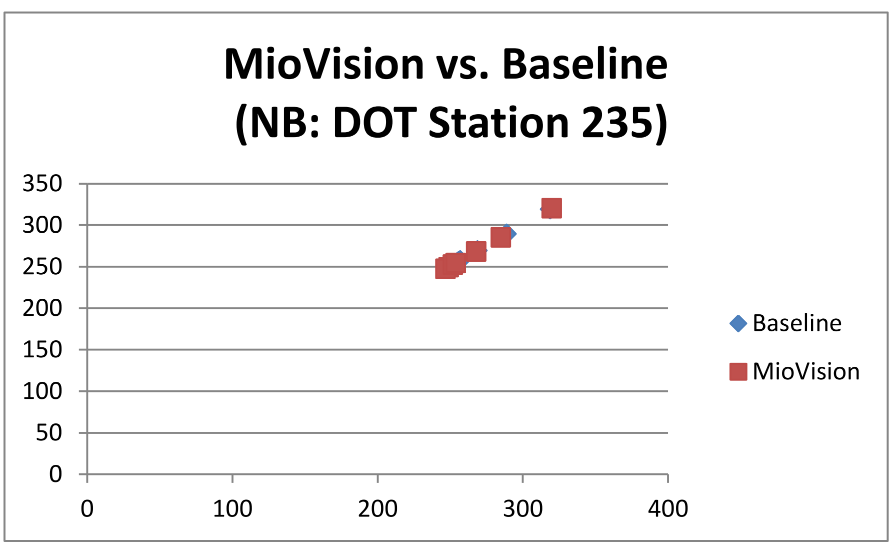

Figure 31. MioVision vs. Baseline NB DOT Station 235 Scatter

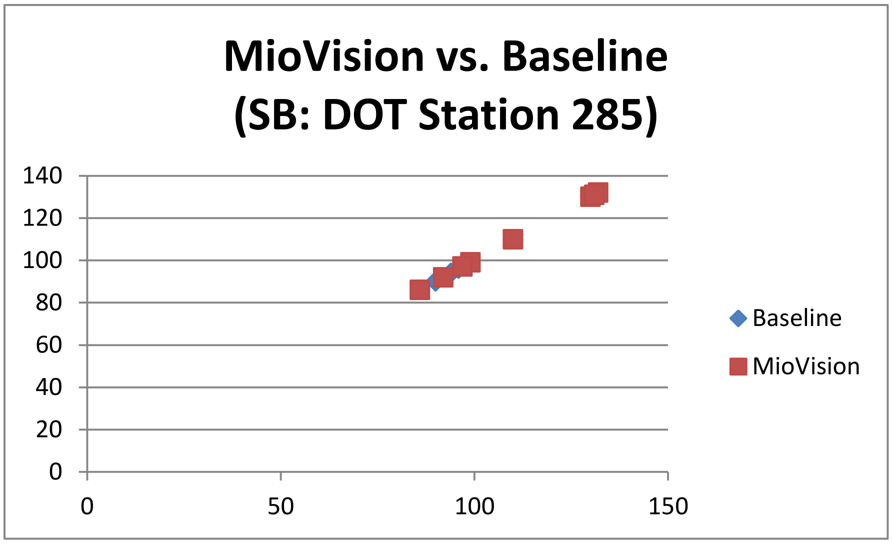

Figure 32. MioVision vs. Baseline SB DOT Station 285 Scatter

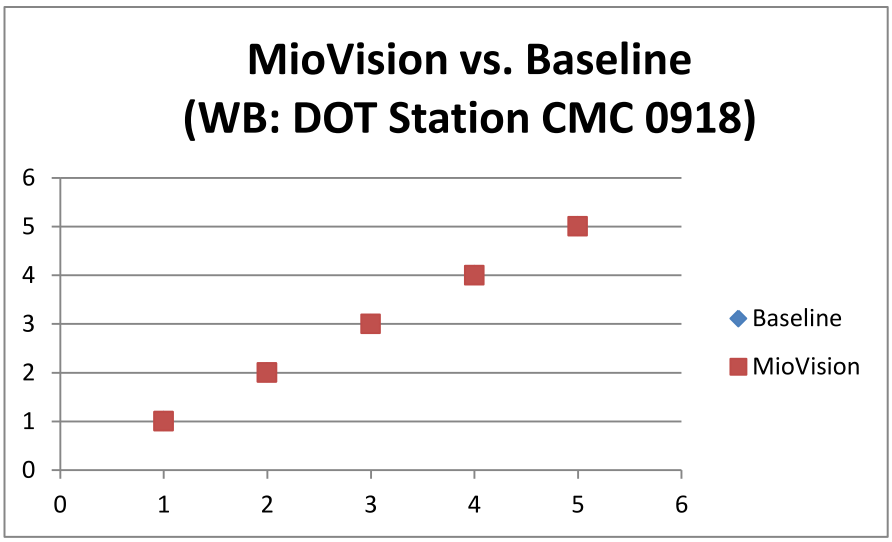

Figure 33. MioVision vs. Baseline WB DOT Station CMC 0918 Scatter Plot

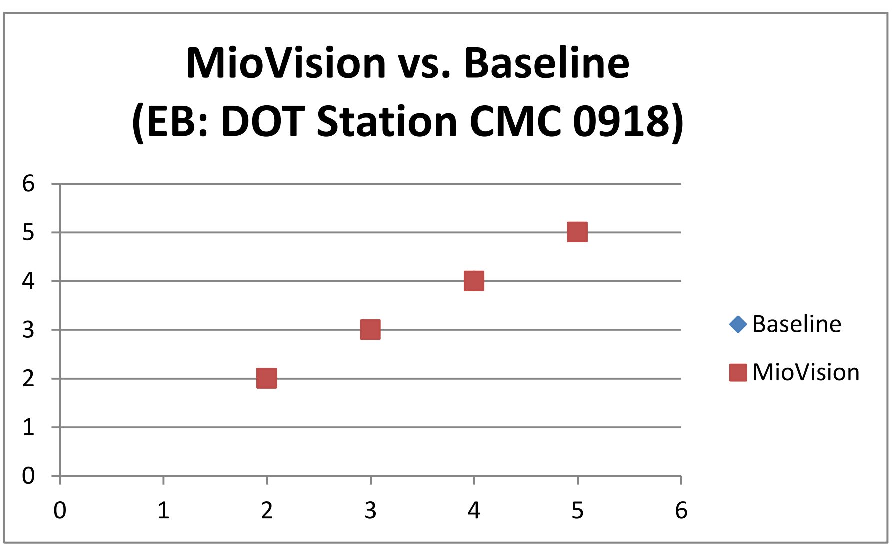

Figure 34. MioVision vs. Baseline EB DOT Station CMC 0918 Scatter

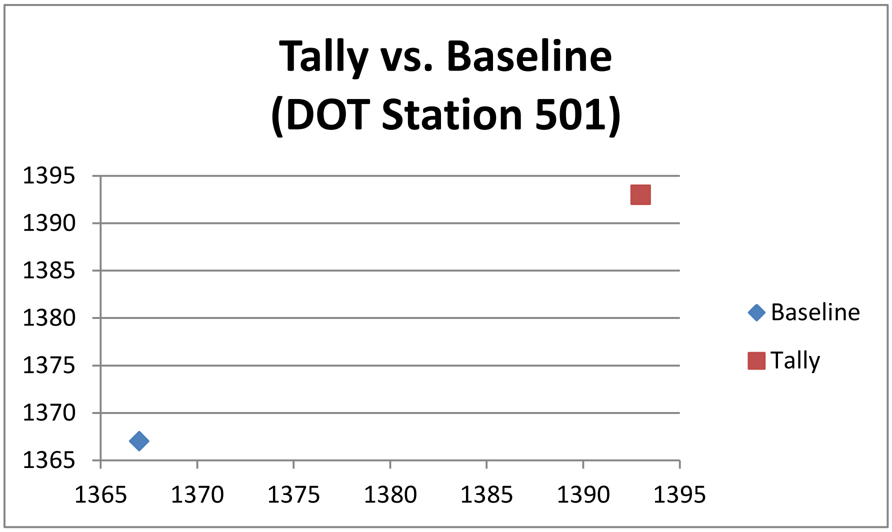

Figure 35. Tally vs. Baseline NB DOT Station 501 Scatter Plot

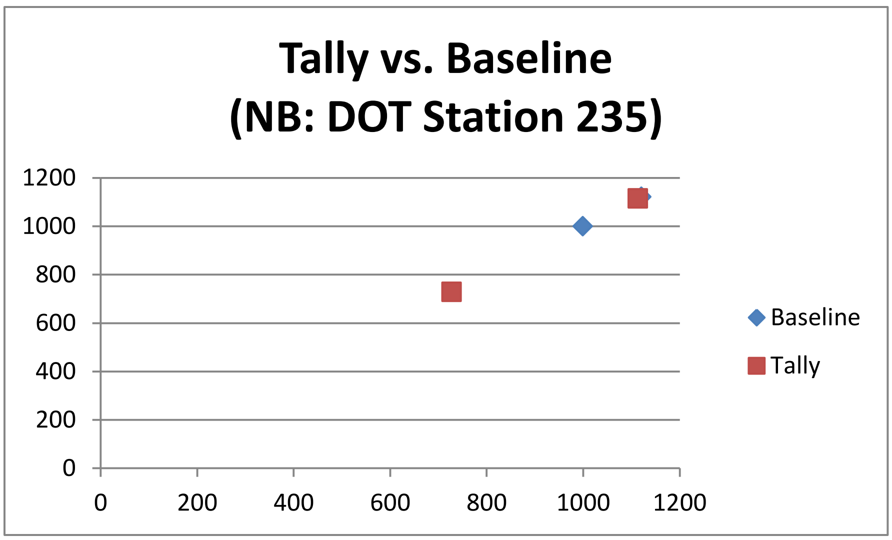

Figure 36. Tally vs. Baseline NB DOT Station 235 Scatter Plot

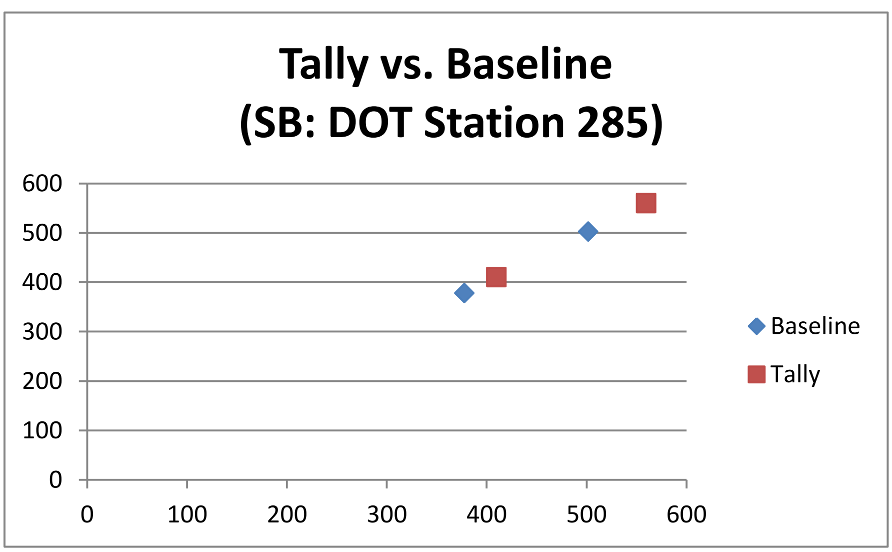

Figure 37. Tally vs. Baseline SB DOT Station 285 Scatter Plot

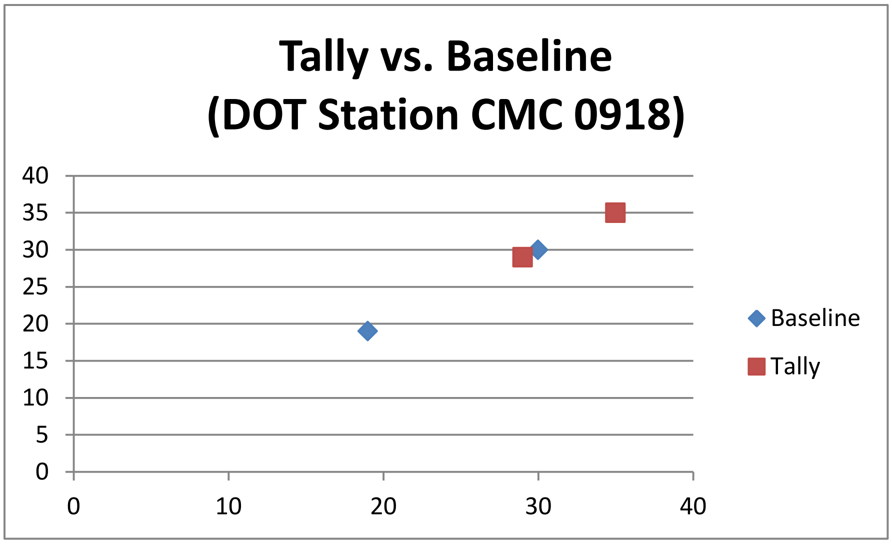

Figure 38. Tally vs. Baseline DOT Station CMC 0918 Scatter Plot