Applus Technologies, Inc.
28 Belamose Avenue, Suite D
Rocky Hill CT 06067
T (860) 372-4038
F (860) 218-1849
www.applustech.com

Connecticut Emissions Program

February 20, 2019

Chris Smith
Division Manager
Department of Motor Vehicles
Emissions Division
60 State Street
Wethersfield, CT 06161

Re: **2018 On-Road Vehicle Survey**

Dear Mr. Smith:

In accordance with Section 2.6.6 of Contract DMV-EM-11-001, Applus Technologies Inc. ("Applus") is pleased to provide the enclosed biennial On-Road Vehicle Survey for the 2018 calendar year.

The EPA outlines guidance for an out-of-cycle emissions test for program evaluation purposes in Title 40 of the Code of Federal Regulations, Sections §51.351, and §51.371. The sampling requirement indicated in the EPA guidance is "at least 0.5% of the vehicle fleet tested or 20,000 vehicles, whichever is less".

Since the Connecticut Vehicle Inspection Program ("CT VIP") performs approximately 2.1 million emissions tests every two years, the targeted number for collection, as in past evaluations was roughly 11,000 valid reads. As with the previous 2016 survey, Applus increased the targeted number to 15,000 valid reads for a larger sample.

Applus has completed this contractual obligation since 2005 by using remote sensing devices instead of the more intrusive roadside pullovers. Remote sensing technology remains the preferred, most cost-effective, safest and expedient method for completing the survey for the State of Connecticut.

For the 2018 study, Applus once again enlisted Hager Environmental & Atmospheric Technologies ("H.E.A.T."), to perform the data and emissions collection. H.E.A.T. also completed the surveys in 2014 and 2016. As in previous surveys, Applus worked closely with H.E.A.T. to analyze the data and complete the attached report and summary.

In total, H.E.A.T. captured 55,118 qualified measurements during the month of August 2018. After filtering out vehicles with unreadable plates, commercial vehicles, motorcycles, and vehicles from other jurisdictions, the number of valid samples dropped to 44,713. After matching the license plate numbers to the vehicle data from the Emissions Data Base Management System ("EDBMS") the sample dropped to 22,114.

Applus Technologies, Inc.

Connecticut Emissions Program

Finally, another 1,339 samples had to be excluded because of interfering plumes from another lane or vehicle. This brought the final sample to 20,775.

As the report explains, a small percentage of vehicles are identified as high emitters. High emitting vehicles are classified as those exceeding cut points used in past remote sensing studies (500 ppm HC, 3% CO, 2000 ppm NO). In total, 403 vehicles exceeded at least one of the cut points or 1.9% of the final sample. Please find the list of the 403 license plate numbers enclosed with this letter (Attachment A).

To complete our summary, Applus matched the 403 license plate numbers to the EDBMS/CIVLS registration data. For further evaluation, Applus targeted vehicles that were overdue or late at the time of the remote sensing survey (August 2018). In all, 100 of the 403 vehicles were identified as non-compliant with the emissions testing requirement.

Using the EDBMS/CIVLS registration and emissions data, the images provided by H.E.A.T. for the targeted vehicles were matched to the vehicle and plate descriptions.

Since the study, 20 of these vehicles were tested, passed and are in full compliance. One vehicle became exempt on January 1, 2019, and the registration status indicates 11 vehicles are inactive. Please note that at the time of the study (August 2018), the EDBMS/CIVLS data indicated expired registration dates for two of these vehicles.

As of February 1, 2019, our final analysis identified 68 vehicles with valid registrations which remain non-complaint with the emissions testing requirement.

Enclosed with this letter, you'll find the list of the 100 unique license plate numbers used in the evaluation (Attachment B), along with the images of these vehicles (Attachment C).

Should you have any questions related to the report completed by H.E.A.T., or the summary completed by Applus, or require additional information, please feel free to contact me.

Sincerely,

Mario DaPonte

Mario Daponte
Program Manager
Connecticut Vehicle Inspection Program

CC: Mr. John Getsie, CT DMV
Mr. Richard Pirolli, CT DEEP
Mr. Darrin Green, Chief Executive Officer, and Country Manager US, Applus Technologies, Inc.
Ms. Brenda Ackarman-Sioson, Director of Operations, Applus Technologies, Inc.

Hager Environmental & Atmospheric Technologies
HEAT

Connecticut Emissions and Safety Program

2018 On-Road Vehicle Survey

PREPARED FOR:

Applus

AND

THE STATE OF CONNECTICUT DEPARTMENT OF MOTOR VEHICLES

January 7, 2019

Connecticut Emissions and Safety Program

2018 On-Road Vehicle Survey

Prepared for:

Darrin Greene
Applus Technologies
444 North Michigan Avenue, Suite 1110
Chicago, IL 60611

January 7, 2019

Prepared By:

Hager Environmental & Atmospheric Technologies (H.E.A.T.)

Dr. Stewart Hager

539 Milwaukee Way

Knoxville TN, 37932

865-288-7890

www.HEATremotesensing.com

Table of Contents
Connecticut Emissions and Safety Program
2018 On-Road Vehicle Survey

TABLE OF EXHIBITS

TABLE OF ABBREVIATIONS

2D	Two Dimensional
ASM	Acceleration Simulation Mode
BAR	California Bureau of Automotive Repair
C	Degrees Celsius
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOT	US Department of Transportation
EDAR	Emission Detection And Reporting
EPA	US Environmental Protection Agency
F	Degrees Fahrenheit
FTP	US Federal Test Procedure for certifying vehicles
g/mi	Grams per mile
GVWR	Gross Vehicle Weight Rating
HEAT	Hager Environmental & Atmospheric Technologies
HC	Hydrocarbon(s)
I/M	Inspection and Maintenance
IM240	Vehicle emissions test driven on a dynamometer, 240 seconds in length
kg	Kilograms
kw	Kilowatts
lbs	Pounds
LDGV	Light Duty Gasoline Vehicle
LDGT	Light Duty Gasoline Truck
m	Meter
n	Number of samples
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
OBDII	On Board Diagnostics, Second Generation
OREMS	On-Road Emissions Measurement Standards
PEMS	Portable Emissions Monitoring System
ppm	Parts Per Million
QA	Quality Assurance
QC	Quality Control
SNR	Signal to Noise Ratio
t	Ton
TPD	Tons per Day (of pollutant emissions)
TSI	Two Speed Idle emissions test
VIN	Vehicle Identification Number
VIP	Vehicle Inspection Program
VMT	Vehicle Miles Traveled
VSP	Vehicle Specific Power

1 EXECUTIVE SUMMARY

As part of the biennial reporting to the EPA, the State of Connecticut Department of Motor Vehicles (DMV) requires the Connecticut Vehicle Inspection Program (CT VIP) to perform on-road emissions testing for program evaluations, as specified in 40CFR §51.351 and §51.371.

According to 40CFR §51.351 and §51.371, on-road emissions testing is not required on every vehicle or in every season. However, the requirement includes the testing of at least 0.5% of the subject vehicle population, or 20,000 vehicles; whichever is less. In the case of Connecticut, 20,000 is less. The on-road emission testing study is required to test vehicles out of its normal periodic testing cycle, for Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NO_x) and Carbon Dioxide (CO_2). The on-road emissions testing data is then compared to the most recent periodic test data for program evaluation. This can be accomplished by measuring on-road emissions through roadside pullovers or with the use of remote sensing devices. Roadside pullovers can include tailpipe and/or evaporative emission testing or a check of the onboard diagnostic (OBD) system. Since roadside pullovers can be considered intrusive, Connecticut has opted to use the non-intrusive remote sensing method. In addition, 40CFR §51.371 provides guidance to notify owners and require an out of cycle emissions inspection for vehicles identified as a high emitter through the on-road emissions testing survey.

For the 2018 biennial reporting, Applus Technologies, the contractor for the CT VIP, has subcontracted with Hager Environmental & Atmospheric Technologies (HEAT) to perform the study using their proprietary Emissions Detection and Reporting (EDAR) on-road remote sensing system. HEAT designed and performed the study in accordance with the requirements set in 40CFR Section §51.

HEAT's proprietary EDAR on-road remote sensing system was used to measure the required pollutants and collect associated data such as speed, acceleration, license plate, and the measurement of exhaust temperature (to determine if the vehicle was warmed up) in addition to the ability to determine vehicle shape.

The Connecticut on-road remote emissions survey was performed in the month of August of 2018. The survey was completed over a period of six testing days, at eight different locations, resulting in 55,118 measurements.

Due to vehicles outside of the allowed Vehicle Specific Power (VSP) limits (3 to 32 kW/t) 3,856 measurements were excluded, resulting in a total of 51,262 qualified measurements. Of those measured vehicles, 1,548 had unreadable plates, which further reduced the valid samples to 49,714. Commercial vehicles and motorcycles from Connecticut and other states represented another 2,100 samples. However, since the CT VIP does not currently test commercial vehicles or motorcycles, these samples were also excluded from the overall analysis.

In addition, 2,901vehicles were from states other than Connecticut. This reduced the valid samples of Connecticut vehicles to 44,713 with valid and complete sample information (speed, acceleration, emission measurements).

The 44,713 samples were compared to registration data provided by the DMV and Applus. In total, 22,114 vehicles were successfully matched. Analysis of the emissions data for the 22,114 vehicles, found that 1,339 had to be excluded due to interfering plumes (emissions from vehicles in adjoining lanes also being measured, etc.) resulting in a final sample of 20,775 vehicles. The survey identified a small percentage of the vehicles as high emitters (1.9% of the final sample). High emitting vehicles were identified as those exceeding cut points of 500 ppm HC, 3% CO, 2000 ppm NO. In total, 403 vehicles exceeded at least one of these cut points. Vehicle data will be provided to DMV and Applus to allow for motorist notification or further evaluation. Please reference Section 4 on page 29 of this report for a detailed breakdown of high emitters.

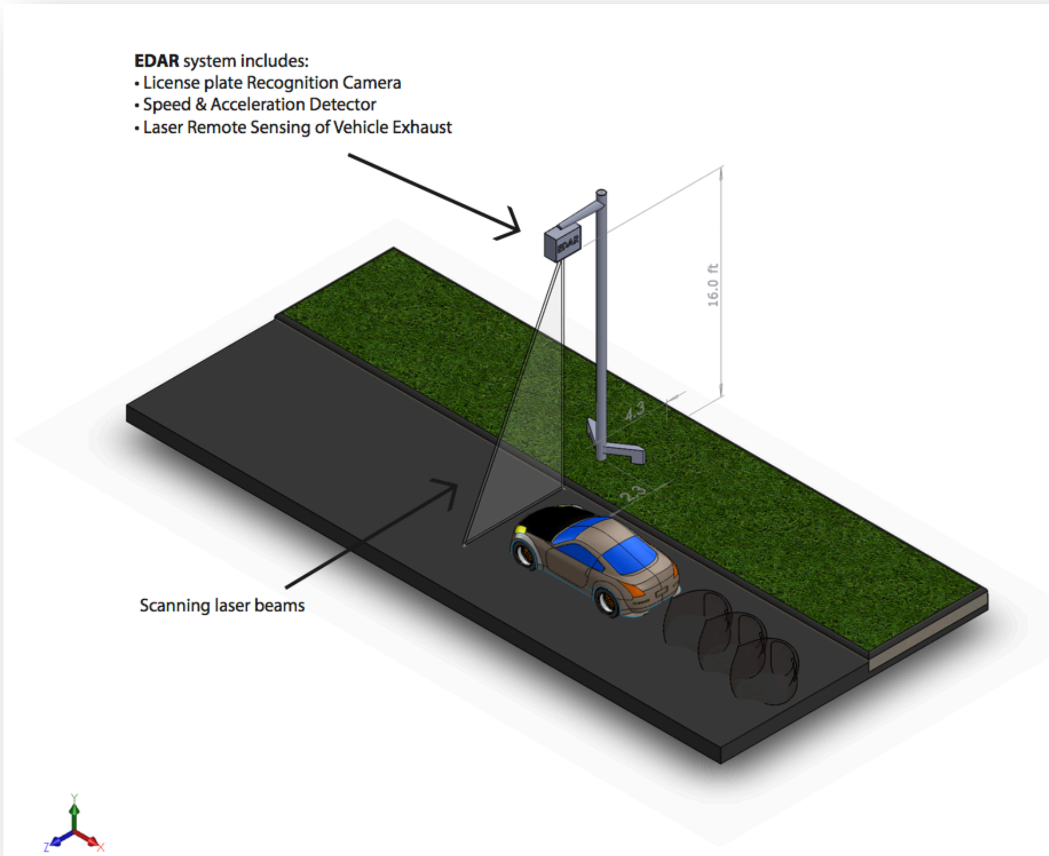
2 **STUDY DESIGN**

2.1 **Equipment Description**

The Connecticut survey was performed using HEAT's proprietary EDAR (Emission Detection And Reporting) on-road remote sensing system. EDAR is an eye-safe laser-based technology capable of remotely detecting and measuring the infrared absorption of environmentally critical gases coming out of virtually any moving vehicle: specifically, pollutants emitted by in-use vehicles. EDAR measures the entire exhaust plume as the vehicle passes underneath the unit allowing for the determination of the mass emission rates of the vehicle. Infrared lasers are scattered off the road surface and the back-scattered light is then collected by EDAR and focused onto the detector. The system is comprised of an eye-safe, laser-based infrared gas sensor, a vehicular speed/acceleration sensor, and a license plate reader.

The EDAR system is an unmanned, automated vehicle emissions measurement system, which collects data on pollutants such as CO, CO_2, NO_x and HC for the Connecticut survey. Speed and acceleration measurement sensors and the license plate camera are housed inside or near the EDAR unit. The entire system is designed so that it can be locked down to deter vandalism and theft. The all-in-one EDAR system is fully weatherproofed to protect it from environmental elements (heat, rain, snow, wind, etc). In addition, EDAR occupies a relatively small footprint, sitting on a single pole that is deployable roadside in either a temporary or permanent application. See Exhibit 1.

Exhibit 1 - Example of EDAR Roadside Implementation



EDAR emits a sheet of invisible laser light from above that explicitly measures specified molecules being emitted from any vehicle that breaks the beam. The lasers are tuned for the pollutants CO_2, CO, NO, and HC. EDAR measures each pollutant directly to give an absolute amount of what the vehicle has left behind. EDAR is the only remote sensing technology on the market that can measure absolute amounts of CO_2 directly. Due to the fact that EDAR looks down from above the roadway and can "see" a whole lane of traffic, the sensor can detect an entire exhaust plume as it exits the vehicle regardless of the tailpipe location or vehicle type all in one single footprint. Seeing the whole plume is advantageous since it allows for consistently high SNR (signal to noise ratio) and measurements that other systems were previously incapable of measuring such as absolute amounts which allows for determination of instantaneous emissions rates in mass per unit travelled (grams/mile). This unique measurement can be used to calculate the absolute amount of emissions produced by each vehicle instead of a measurement in terms of the ratio of the pollutant to CO_2. In addition, EDAR is able to take passive infrared images of the vehicles passing below the sensor, allowing the vehicle's shape to be determined (whether it is a heavy-duty truck, light-duty vehicle, motorcycle, bus, or a vehicle pulling a trailer), as well as any pollution hot spots such as evaporative HC emissions leaks on the vehicle. This method also demonstrates the location of the tailpipe by the CO_2 plume's position.

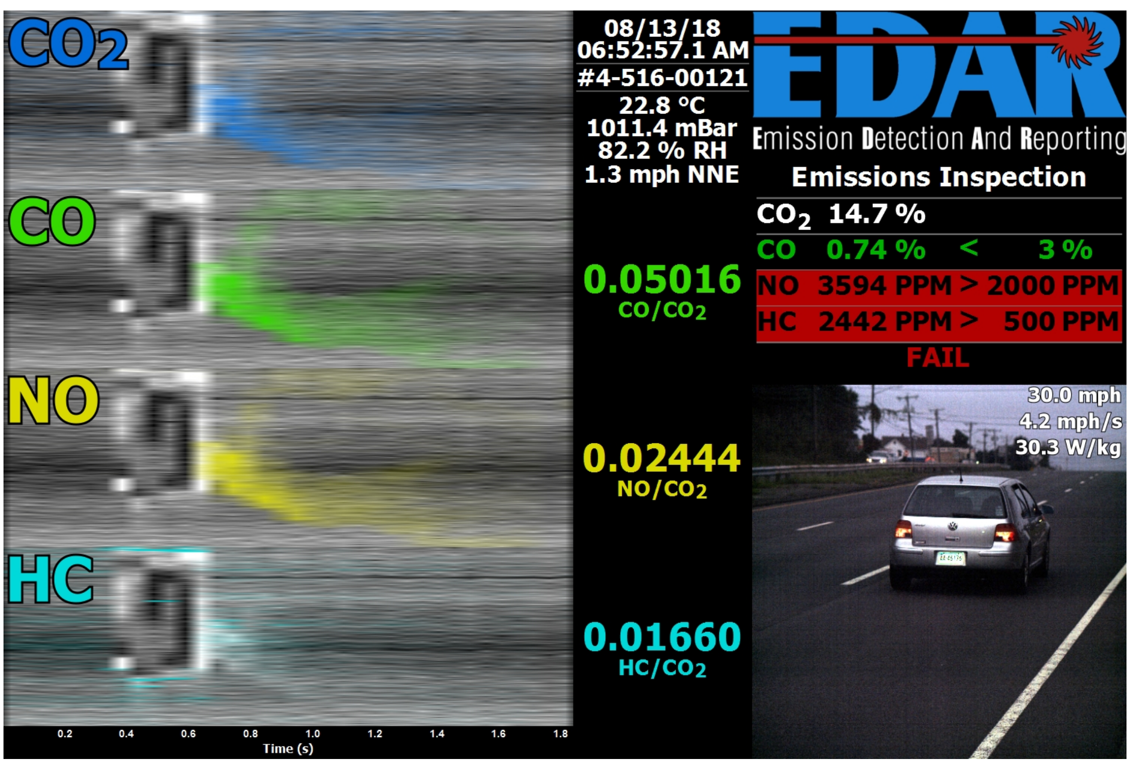
The EDAR system also gathers vehicle characteristic data necessary for analysis of the emissions results. These include:

- A laser-based rangefinder system for vehicle speed and acceleration measurements. The rangefinder detects the vehicles from above in the same manner as the gas sensor.
- A system to measure current weather conditions, including ambient temperature, barometric pressure, relative humidity and, wind speed and direction.
- A license plate recognition (LPR) camera that identifies and transcribes the license plate of each vehicle automatically when its emissions are measured.

Furthermore, the EDAR system has the additional unique capability of using infrared spectroscopic methods in order to measure the temperature of the exhaust as it exits the tailpipe. For each vehicle, EDAR finds the exhaust plume at the location where it exits the tailpipe of the vehicle at the moment when the plume becomes visible. This gives a measure of the temperature of the exiting exhaust gases. The temperature of the exhaust gases relative to the ambient temperature are an indication of if the vehicle is in a warmed-up condition, that is, not in cold start. If the vehicle were in cold start, it may have high emissions appearing to indicate the vehicle has an emissions problem. However, the EDAR unit can be used to identify these vehicles so they are not identified as false positive high emitters as opposed to the true high emitters.

Additionally, EDAR produces a report for every vehicle detected and evaluated. As displayed in Exhibit 2, EDAR captures a 2D image of the vehicle and plume for the four gases as well as the license plate, date, time, speed, acceleration, temperature, barometric pressure, humidity, wind speed, a pass or fail indication, and an actual image of the vehicle itself.

Exhibit 2 - Example EDAR Report



2.2 **Equipment QA/QC Audits**

2.2.1 **Factory Testing and Certification**

The Connecticut on-road emissions study was performed using EDAR systems, which were assembled by a highly specialized electro-optical manufacturer in the U.S. under the direction of HEAT's strict quality assurance requirements. After the units are built and aligned, they undergo several tests and verifications before they are deployed in the field. Each EDAR unit arrives assembled from the factory with known spectroscopic settings.

The quality assurance process includes HEAT further confirming the pollutant measurement settings by performing validation testing with known gas quantities under various conditions and speeds. HEAT then configures each EDAR system with unique field settings catered to the unit's deployment requirements.

HEAT also performs outdoor validation of EDAR using test gas tanks mounted to an electric vehicle and vehicles with extended tailpipes that deposit its exhaust outside the field of view with a simulated exhaust pipe and gas flow controllers. The test vehicle provides a known ground truth to verify that each EDAR is operating properly at various speeds. HEAT obtains tanks where each test gas is mixed with specified target pollutants and varies between low and high concentrations for each pollutant. The test vehicle is driven past the EDAR a number of times for each test gas flowing at a constant volumetric rate. The test takes place in a controlled area to eliminate unknown emission sources. The results are then checked to confirm that each EDAR unit is calibrated properly and measuring within normal specifications. After outdoor calibration is complete, each EDAR unit is tested under various environmental extremes (temperature and humidity) in a specially designed environmental test chamber.

Due to the absolute nature of EDAR's spectroscopic measurements, it can measure the targeted pollutants without explicit field calibration and still remain within normal specifications. In other words, EDAR doesn't need to be calibrated in the field for correct operating and highly accurate measurements.

2.2.2 **Detector Accuracy**

The EDAR system's measurements have higher accuracies than the range of the certified gas sample accuracy and the detector accuracy standards of the California Bureau of Automotive Repair (BAR) On-Road Emissions Measurement Standards (OREMS).

Minimum accuracies according to California BAR are:

- The carbon monoxide (CO%) reading will be within ± 10% of the Certified Gas Sample, or an absolute value of ± 0.25% CO (whichever is greater), for a gas range less than or equal to 3.00% CO. The CO% reading will be within ± 15% of the Certified Gas Sample for a gas range greater than 3.00% CO.

- The hydrocarbon reading (recorded in ppm propane) will be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250 ppm propane, (whichever is greater).

- The nitric oxide reading (ppm) will be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250 ppm NO, (whichever is greater).

HEAT has participated in validation and correlation studies for on-road emissions in both the United States and Europe. The integrity of HEAT's data has been validated by various blind studies comparing the EDAR system to a Portable Emissions Measurement System (PEMS), chaser vans, calibrated gases, as well as other in-situ measurement devices. All studies have shown that the accuracy and sensitivity of EDAR is far above that of conventional remote sensing technologies.

In the United States, an independent blind validation study was performed by the Colorado Department of Public Health and Environment (CDPHE), the United States EPA and Eastern Research Group (ERG) using an RSD audit truck equipped with calibrated gases. The results show a remarkably high correlation (R^2 of 0.99) could be attested for all gases with speeds ranging from 15mph to 60mph during the CDPHE and EPA blind validation study.

EDAR system accuracies as performed by Colorado, ERG and EPA study:

Gas	Accuracy
Carbon Monoxide (CO)	± 0.0075%
Nitric Oxide (NO)	± 20 ppm
Total Hydrocarbons (HC)	± 125 ppm

- The carbon monoxide (CO%) readings are within an absolute value of ± 0.0075% of the Certified Gas Sample.
- The nitric oxide reading (ppm) are within an absolute value of ± 20 ppm NO.
- The hydrocarbon readings are within an absolute value of ± 125 ppm hexane.
- The EDAR system has been found to have no drift allowing for the unit to be set up to run continuously collecting accurate data without any need for calibration.
- The r-squares of the linear regression between the EDAR unit's measurements and known concentrations of each gas at the various speeds were calculated. A "r squared" of one means perfect fit and an "r squared" of zero means no fit. The EDAR system's r-squares show excellent correlation and high linearity for all gases:
    - Methane – 0.983
    - Propane – ranged 0.996 to 0.934
    - NO – 0.998
    - CO – 0.996

2.2.3 Speed and Acceleration

The vehicle speed measurement is recorded to within ± 1.0 miles per hour. The vehicle acceleration measurement is recorded to within ± 0.5 miles per hour per 1.0 second.

2.2.4 Daily Audits

EDAR's temporary deployment system was used in Connecticut with two EDAR units that were deployed using specially designed transportable mounts. For this study, HEAT deployed EDAR systems using the temporary deployments that were set up and taken down daily.

Once the EDAR unit is deployed on the transportable mount, the operator aligns the unit to the reflective tape that is used on road to enhance surface albedo. After this alignment is complete, operators check to ensure that all equipment is running properly. As shown in Exhibit 1, the EDAR unit is attached to the gantry along with the license plate camera and the speed and acceleration recording unit.

Each session during the study was monitored remotely from Knoxville via the Internet for correct operation and data collection. Any unforeseen events were either handled with remote or on-site adjustments.

As noted earlier, the nature of EDAR's technology eliminates the need for field calibration. EDAR's patented technology uses similar principals as active satellite remote sensing platforms that constantly subtracts the background. It can remotely measure quantities and relative amounts of targeted pollutants in an exhaust plume due to the absolute nature of the measurement – long term – without the need for calibration. This gives HEAT's data unprecedented accuracy, precision and consistency, and allows for minimal human operational intervention.

2.2.5 **NO to NO_x Conversion Assumptions**

The units used for this study were EDAR units that were programed to measure pollutants from light duty vehicles. Therefore, the vast majority of nitric oxides emitted from the vehicle tailpipe are in the form of NO. The NO is later oxidized to NO_2, and other oxides of nitrogen, which are collectively referred to as NOx. The particular EDAR units used in this study were factory calibrated to measure NO. Since only NO is measured, in order to determine the total amount of NOx in the exhaust a conversion factor of 1.03 can be applied (as suggested by US EPA IM240 guidance). However, there is evidence in other countries to suggest that the NO to NOx conversion factor should be slightly higher. For simplicity, we report only NO measurements for this study. All exhibits in this report display NO values.

2.2.6 **Humidity Impact**

It has been known as early as 1970 that the intake air temperature and humidity are the ambient conditions having the dominant effect on the formation of NOx in internal combustion engines. The impact of ambient temperature and humidity on emissions is of interest because it is difficult to compare NO_x emissions from engines tested at different locations due to the variations in emission rates caused by the varying ambient conditions.

In order to convert all of the NO_x measurements to the same basis (adjust measurements for ambient conditions), a "NO_x correction factor" can be applied to account for ambient conditions. The NO_x correction factor is defined as KNO_x. It is applied in the following manner:

$$NO_x - \text{actual} = KNO_x * NO_x - \text{reference}$$

For light-duty, spark-ignition engines, the recommended practice is whatever procedure is used in MOVES. The equation for the correction factor is:

$$K_{NOX}=1 + 0.00446(T-25) – 0.018708(H – 10.71) \text{ for SI units}$$

Adjusted for consistent units of °C and grams per kg of dry air

$$K_{NOX}=1 + 0.0076(T-85) – 0.00216(H – 75) \text{ for English units}$$

Adjusted for consistent units of °F and grains per lb. of dry air

2.3 Measurement Sites

HEAT selected nine sites in the Connecticut I/M area based on the following criteria:

- Demonstrate a sampling of the I/M area fleet
- Have high enough traffic volume to obtain sufficient measurements
- Have a slight grade to ensure the vehicles were operating under load
- Be free from hazardous conditions

Exhibit 3 below provides the details about each site. Exhibit 4 shows the locations on a map.

Exhibit 3 - Description of Sites where Sampling was Performed

Site	Location Description	City	County
HEAT08	SR 372 (Berlin Rd) to I-91N	Cromwell	Middlesex
HEAT12	SR 30 South to I-84 West	Manchester	Hartford
HEAT19	On Ramp from Hwy 5 to I-9S	Berlin	Hartford
HEAT22	Exit 62 entrance ramp onto I-84 East from Buckland Rd	Manchester	Hartford
HEAT24	On ramp to I-84E from Queen St	Southington	Hartford
HEAT25	On ramp to I-84W from Queen St	Southington	Hartford
HEAT29	US 5 South near exit for Cedar St	Newington	Hartford
HEAT30	US 5 North near Prospect St	Newington	Hartford

Exhibit 4 - Locations of Sampling Sites

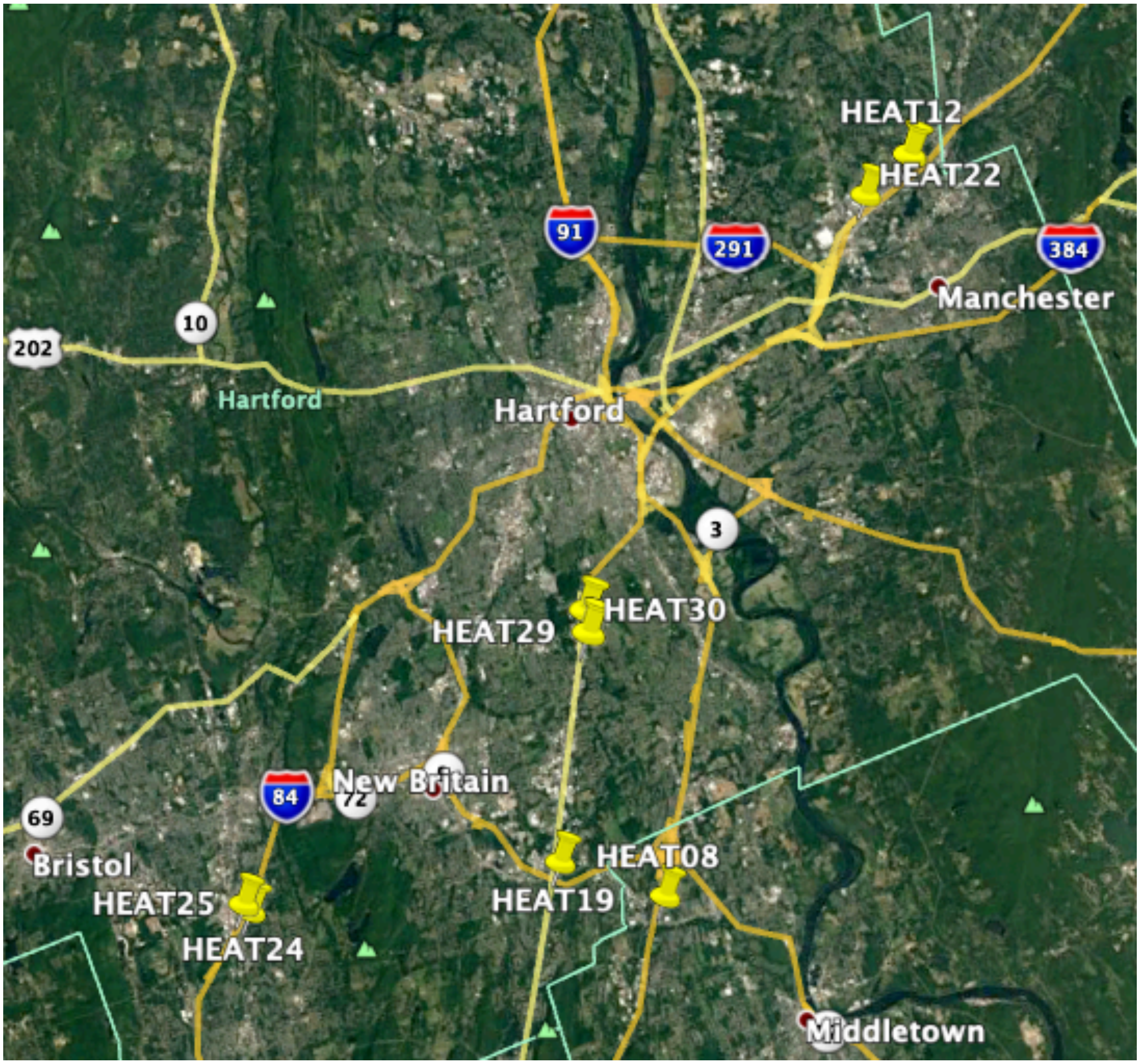


Exhibit 5 shows the measurements of each day from each EDAR unit of the two EDAR units deployed, valid emissions measurements, and the percentage of valid measurements that were successful.

Exhibit 5 - Daily Measurements

EDAR	Date	Site	Location Description	City	County	Attempted Measures	Valid Emissions Read	Valid %
6	8/6/18	HEAT25	On ramp to I-84W from Queen St	Southington	Hartford	5047	5006	99.2%
4	8/6/18	HEAT24	On ramp to I-84E from Queen St	Southington	Hartford	4273	4197	98.2%
4	8/7/18	HEAT22	Exit 62 entrance ramp onto I-84 East from Buckland Rd	Manchester	Hartford	8596	7430	86.4%
6	8/7/18	HEAT12	SR 30 South to I-84 West	Manchester	Hartford	3218	2988	92.9%
4	8/10/18	HEAT12	SR 30 South to I-84 West	Manchester	Hartford	9851	7927	80.5%
6	8/10/18	HEAT25	On ramp to I-84W from Queen St	Southington	Hartford	5290	5208	98.4%
6	8/13/18	HEAT29	US 5 South near exit for Cedar St	Newington	Hartford	1875	1733	92.4%
4	8/13/18	HEAT30	US 5 North near Prospect St	Newington	Hartford	1030	998	96.9%
6	8/14/18	HEAT08	SR 372 (Berlin Rd) to I-91N	Cromwell	Middlesex	3755	3716	99.0%
4	8/14/18	HEAT19	On Ramp from Hwy 5 to I-9S	Berlin	Hartford	806	799	99.1%
6	8/15/18	HEAT25	On ramp to I-84W from Queen St	Southington	Hartford	5633	5583	99.1%
4	8/15/18	HEAT24	On ramp to I-84E from Queen St	Southington	Hartford	5744	5677	98.8%
					EDAR 4	**30300**	**27028**	**89.2%**
					EDAR 6	**24818**	**24234**	**97.6%**

2.3.1 **Weather Considerations**

Inclement weather such as rain or heavy snow resulting in wet pavement prevents remote sensing devices from taking accurate reads due to the fact that water is a large absorber of infrared light. Additionally, fog, dust or humidity does **not** affect the measurement of the EDAR reads of gasses. The recording of the temperature and humidity during hours when sampling was performed is shown in Exhibit 6 and Exhibit 7.

Exhibit 6 - Hourly Temperature by Site

Date	Unit	Site	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM
8/6/18	4	HEAT24	20	22	22	23	26	28	30	32	34	35	36	36	37
8/6/18	6	HEAT25	20	22	22	23	26	28	30	31	33	35	34	34	34
8/7/18	4	HEAT22	26	26	25	26	27	29	30	32	34	34	35	34	34
8/7/18	6	HEAT12	24	25	25	26	28	29	32	31	32	34	34	35	35
8/10/18	4	HEAT12	20	20	19	20	21	24	27	28	30	32	32	33	31
8/10/18	6	HEAT25	17	20	19	21	22	24	28	29	31	32	32	33	28
8/13/18	4	HEAT30	22	22	23	23	23	24	24	25	25	25	23	22	22
8/13/18	6	HEAT29	22	22	22	22	22	23	23	24	24	24	23	22	22
8/14/18	4	HEAT19	22	22	24	26	27	27	28	28	28	28	27	32	32
8/14/18	6	HEAT08	22	22	23	25	25	25	30	30	29	30	30	30	31
8/15/18	4	HEAT24	20	22	22	23	26	27	27	28	29	31	32	32	33
8/15/18	6	HEAT25	22	22	21	23	26	25	28	27	28	30	32	32	33

Exhibit 7 - Hourly Humidity by Site

Date	Unit	Site	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM
8/6/18	4	HEAT24	96	90	84	79	69	65	59	56	53	45	44	43	41
8/6/18	6	HEAT25	96	83	85	80	73	66	60	58	53	45	46	46	44
8/7/18	4	HEAT22	79	79	82	80	74	71	65	62	54	51	50	51	51
8/7/18	6	HEAT12	91	81	82	80	70	68	57	62	56	51	51	50	50
8/10/18	4	HEAT12	81	81	83	81	77	68	58	55	52	47	46	43	50
8/10/18	6	HEAT25	93	84	81	77	73	65	55	52	49	46	44	42	58
8/13/18	4	HEAT30	90	87	82	82	81	79	78	75	74	74	93	90	90
8/13/18	6	HEAT29	86	86	86	85	84	83	81	80	78	77	93	90	90
8/14/18	4	HEAT19	97	93	91	79	74	67	63	60	54	58	60	56	53
8/14/18	6	HEAT08	100	96	93	84	71	79	61	61	66	59	59	56	49
8/15/18	4	HEAT24	93	84	86	82	69	65	66	62	57	53	51	48	48
8/15/18	6	HEAT25	90	88	90	83	68	71	55	64	59	55	50	48	48

2.4 Sources of Data and Data Collected

The EDAR unit pollutant measurements (HC, CO, CO2 and NO) and license plate were the two main sources of data used for this report. The information below demonstrates the format of the data collected in this report.

2.4.1 Information Collected

- HEAT units operated – EDAR 4 and EDAR 6
- Date
- Time
- License plate image
- HC, CO, CO_2, and NO measurements
- Speed
- Acceleration
- Temperature of the vehicle

2.4.2 Data Collection Statistics

- Unit
- Site
- Hourly temperature
- Hourly humidity

2.4.3 Vehicle Registration Data

The license plate data collected by the HEAT license plate recognition camera system was submitted to Applus and the Department of Motor Vehicles so that vehicle VIN and other vehicle data could be provided for analysis. The information provided includes:[1]

- License plate
- Vehicle Identification Number (VIN)
- Model year
- Make
- Body style
- EPA vehicle type

2.5 Analysis of Collected Data

HEAT applied the following screening checks to the measurements to ensure the data used for fleet evaluation and fleet comparisons were reasonable and consistent:

- Screening of exhaust plumes
- Screening of day-to-day variations in emissions values
- Screening for Vehicle Specific Power (VSP) range

The first two of these screening procedures are described in the following paragraphs. The VSP screening is described in section 3.2.

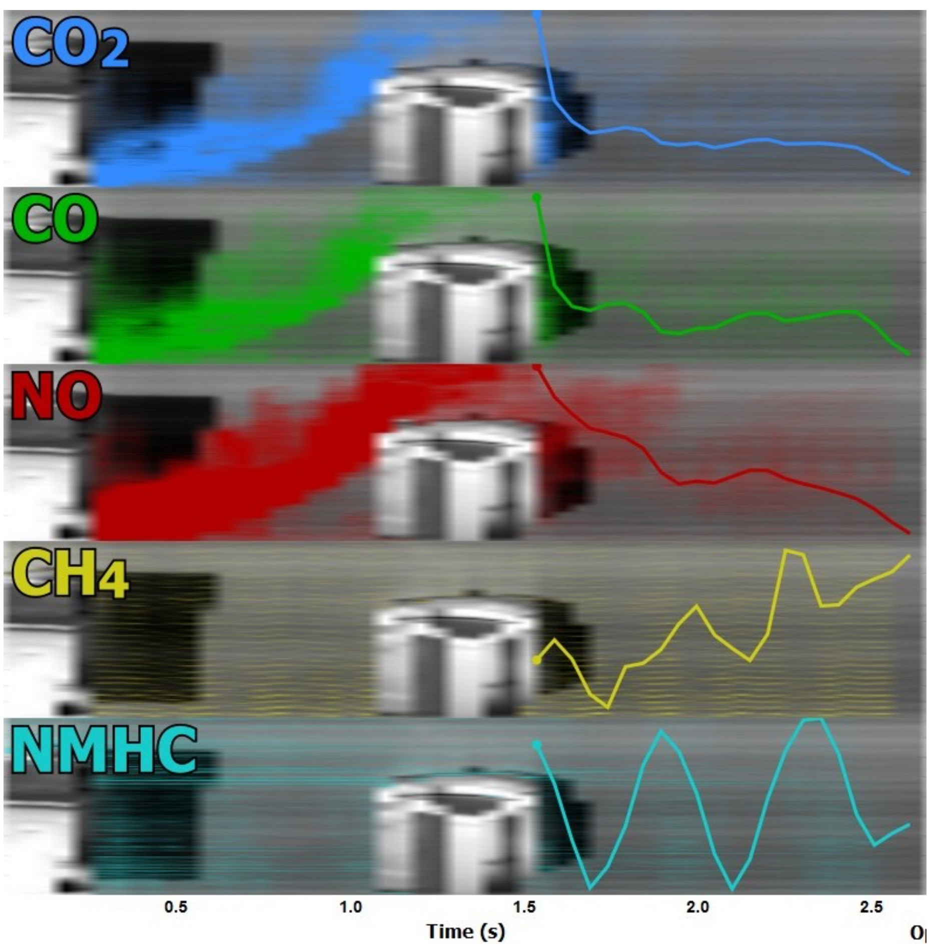
[1] Only vehicle data was provided. No personal motorist information was released to HEAT or Applus Technologies

2.5.1 **Screening of Exhaust Plumes**

Since EDAR measures the exhaust plume with a sheet of laser light scanning across the roadway, EDAR is able to construct two-dimensional images of passing vehicles and their respective emission plumes. One axis of the image depicts the length across the road, while the other axis depicts the passage of time. EDAR can form a 2D passive infrared image of a vehicle as the vehicle moves underneath the unit. The vehicle image can show the shape of the vehicle, its lane position and the position of its tailpipe. In addition, EDAR forms an active image of a vehicle's emission plume showing the quantity of pollutant detected per unit area or optical mass. The units for optical mass are moles/m^2. The plume image shows the position of the plume for each pollutant as well as the dispersion rate of the plume.

The gas record is considered valid if there is one scan where the average measurement of CO_2 in the scan exceeds 0.004 moles/m^2. Furthermore, the linear correlation coefficient or Pearson's correlation criteria (r) is applied between the CO2 measurements and the CO, NO and HC measurements. If the correlation factor is relatively high, the measurement is considered valid. This signifies that there are no interfering plumes. Interfering plumes usually have different ratios of pollutant to CO2; therefore, the linear correlation coefficient drops in value. The highest linear correlation coefficient is 1.0, whereas values near zero indicate no correlation and negative 1.0 indicates complete negative correlation. When gas readings are near zero for CO, NO and HC, then correlation values are ignored, because of the lack of presence of those gases.

Exhibit 8 - Vehicle Driving Through the Plume of a Preceding High Emitter



2.5.2 **Screening of Hourly Data**

HEAT's EDAR units were monitored remotely from Knoxville on an hourly basis. Parameters were set up so that HEAT's engineers would be alerted to anomalies or changes that did not meet the parameters.

2.5.3 **Screening of Day-to-Day Variations In Emissions Values**

Daily decile values were compared for the different emissions gases. The middle cluster of the decile values were averaged and plotted. The average values remained stable across the board as shown in Exhibits 9 to 11. August 13th had the lowest average model year. This could explain why it has the highest average for all the pollutants. This justifies the attempt to choose sites in a variety of social and economic areas.

Due to the absolute nature of the measurement, daily variations come from different locations and scenarios. Higher NO normally derives from engines that have elevated temperature or cylinder pressures (such as when operating under high loads). Sites with steeper slopes will have slightly higher NO.

Exhibit 9 - NO Deciles

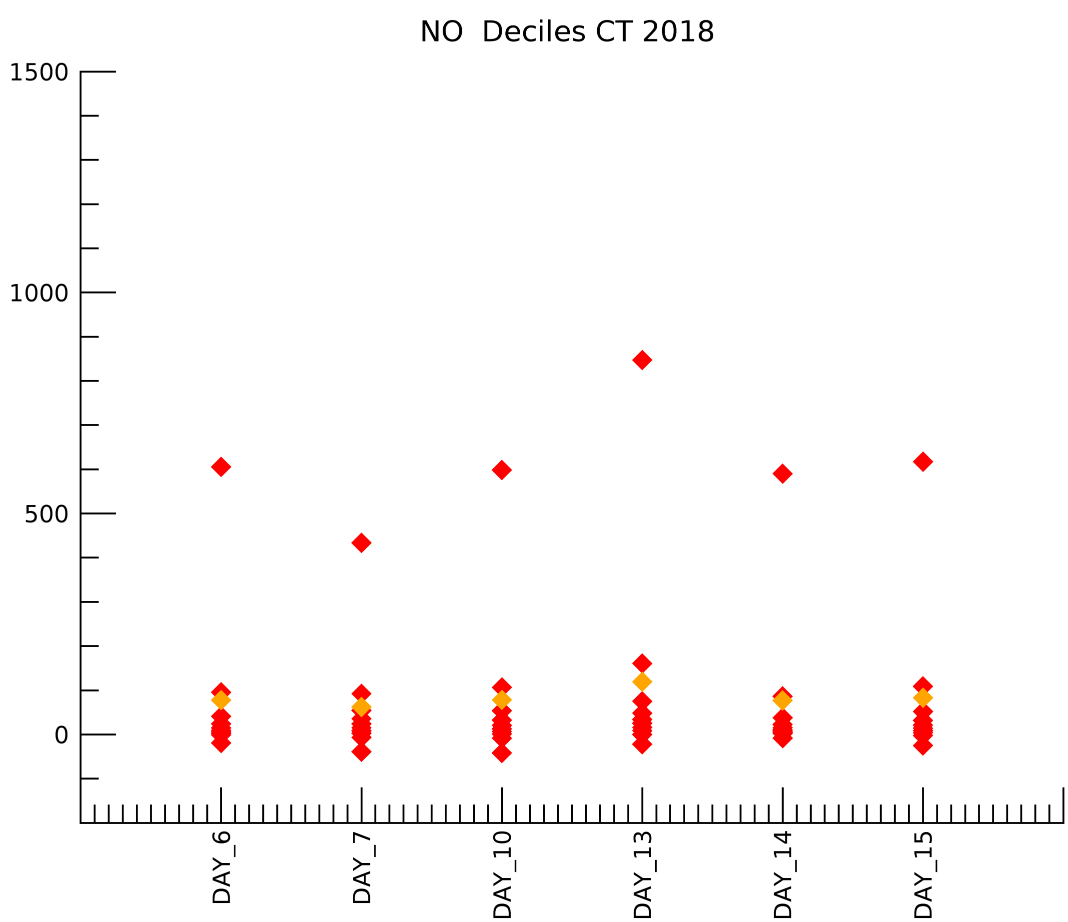


Exhibit 10 - HC Deciles

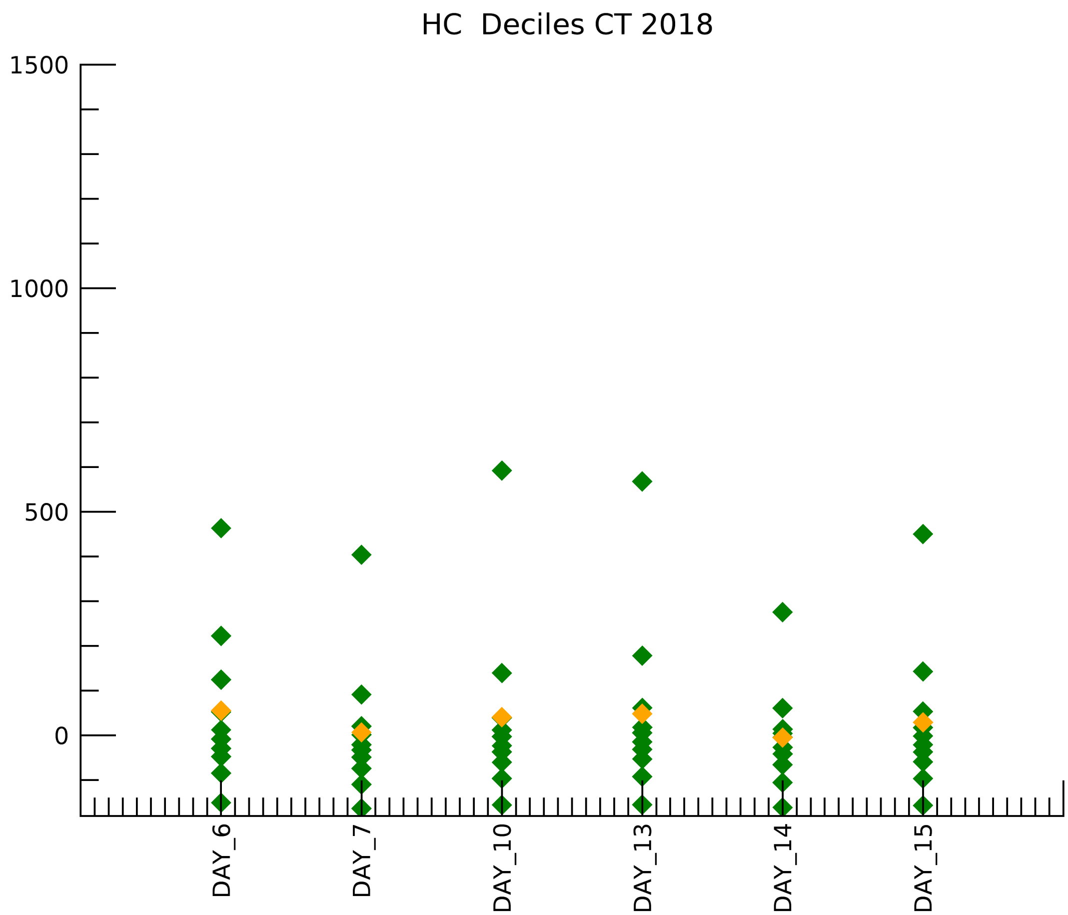
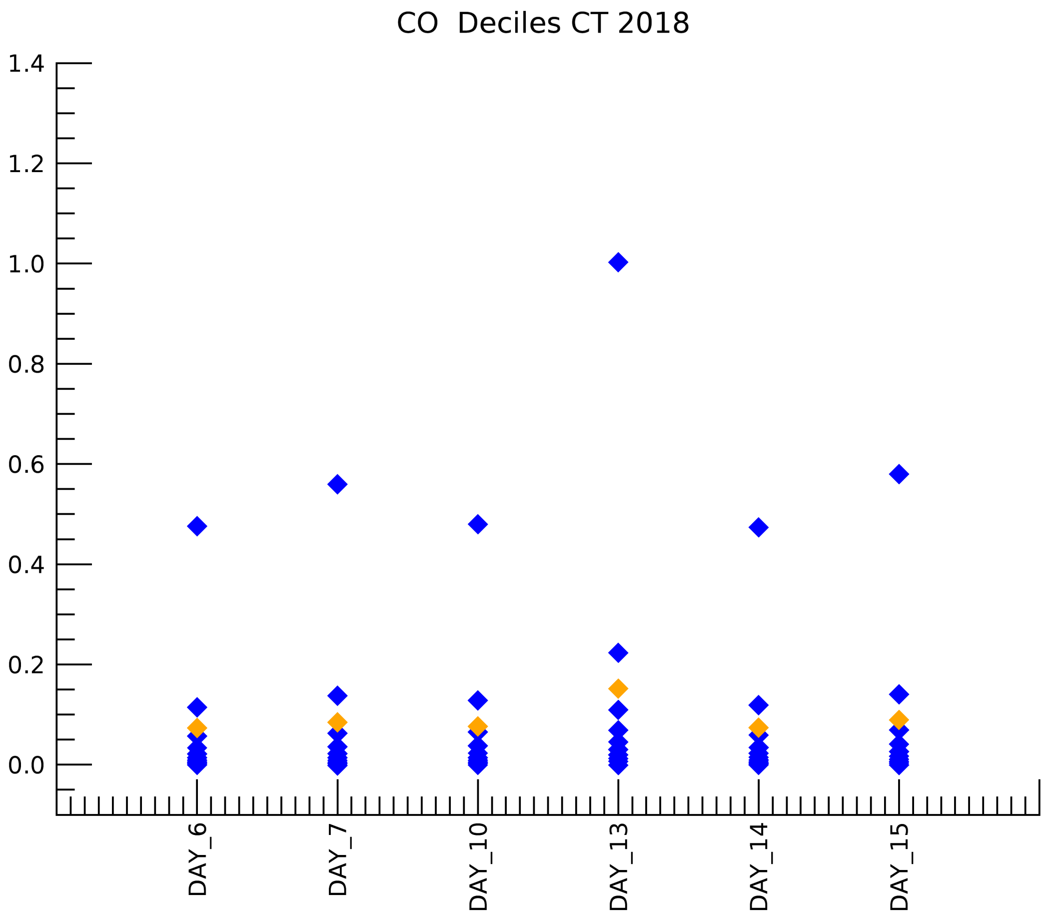


Exhibit 11 - CO Deciles



3 ANALYSIS OF DATA COLLECTED

3.1 General Statistics

The data was collected over 6 days in the month of August using two EDAR units (EDAR 4 and EDAR 6). A total of 55,118 attempted measures were made, of those 3,856 vehicles were excluded due to Vehicle Specific Power (VSP) resulting in a total of 51,262 vehicles with valid VSP within 3 to 32 kW/t. Of those vehicles, 1,548 had unreadable plates, which resulted in valid vehicles of 49,714. There were 2,901 vehicles from states other than Connecticut as well as 2,100 commercial vehicles and motorcycles from Connecticut and other states: resulting in approximately 44,713 (81.1% of the survey) measurements made of vehicles with complete emissions information (speed, acceleration, emission measurements). The Connecticut registration data matched 22,114, out of which 1,339 were excluded due to interfering plumes resulting in a total of 20,775.

Exhibit 12 below shows the EDAR measurements during the 2018 period of testing in Connecticut. Vehicles registered in other states comprised 11.2% of the survey, while commercial vehicles and motorcycles totaled 8.1%. The CT VIP currently does not test commercial vehicles or motorcycles, therefore these samples were excluded from the study analysis and removed from the sample as shown in Exhibit 13. A small sample of heavy-duty commercial vehicles were evaluated separately in Section 5 of this report.

Exhibit 12 - Number of Vehicles Measured by State of Registration or Vehicle Type

Vehicle Type or State	n	Fraction
Connecticut	20,775	80.6%
Massachusetts	1119	4.3%
New York	728	2.8%
New Jersey	279	1.1%
Other	775	3.0%
Commercial and Motorcycles	2,100	8.1%
Total	25,776	100%

Exhibit 13 - Data Collection and Analysis Statistics

Connecticut On-Road Remote Sensing Measurements Description	
EDAR Units	2
Sites	8
Data Collection Days	6
Vehicles Measured	55,118
Vehicles Excluded for Weather and VSP	3,856
Valid Measured within 3-32 kW/t VSP	51,262
Vehicles with Visible License Plate	49,714
Out of State Plates	2,901
Commercial Vehicles and Motorcycles	2,100
Vehicles with Connecticut Plates	44,713
Vehicles Matched to CT Registrations (excludes 2015 and newer MY)	22,114
Valid Measurements after Removing Measurements with Interfering Plumes	20,775
Unique Connecticut Vehicles Identified	17,838
Unique Connecticut Vehicles Identified Once	15,338
Unique Connecticut Vehicles Identified Twice	2,076
Unique Connecticut Vehicles Identified Three Times	350
Unique Connecticut Vehicles Identified Four or More Times	74

3.2 Vehicle Specific Power

In order to make meaningful comparisons between various vehicle emissions testing methodologies, it is important to know the instantaneous loading conditions of the vehicle under test. This is particularly true for the case of remote sensing measurements, where a "snapshot" of the emissions of the vehicle under test is captured at a specific loading condition.

In 1999[2], Jimenez advanced a new metric called Vehicle Specific Power (VSP) as a development over prior load classification parameters. VSP is an estimate of the ratio of instantaneous vehicle power to vehicle mass. The main advantage of VSP is that it avoids the necessity of knowing intrinsic vehicle and engine parameters in favor of parameters that can mostly be acquired remotely, like vehicle speed/acceleration and road grade. It is also advantageous in its simplicity as being a one-dimensional parameter. Jimenez showed the effectiveness of VSP through comparative analysis and was later adopted by the EPA for use in its modeling efforts[3].

The equation for VSP incorporates various loading components acting on the vehicle under test. It includes the internal effect of "acceleration resistance," due to the engine's rotating components, as well as the external effects of road grade, rolling resistance, and aerodynamic

[2] Cires.colorado.edu/jimenez/Papers/Jimenez_PhD_Thesis.pdf

[3] www.epa.gov/ttnchie1/conference/ei12/mobile/koupal.pdf

drag. Jimenez developed typical values for each effect which are embedded in the following equation:

$$SP = v \cdot (1.1 \cdot a + 9.81 \cdot \sin(\alpha) + 0.132 + 0.000302 \cdot (v + v_w)^2)$$

Where:

SP is specific power in $\frac{kW}{t}$, $\frac{W}{kg}$, or $\frac{m^2}{s^3}$

v is vehicle speed in $\frac{m}{s}$

a is vehicle acceleration in $\frac{m}{s^2}$

is roadway angle of inclination to the horizontal

v_w is headwind speed in $\frac{m}{s}$

In summary, the main use of VSP in remote sensing is for screening out vehicles which could be under high load and operating open loop (not near stoichiometry and therefore are expected to have high emissions) or at very low load where the vehicle would not produce NO because the vehicle is not under load.

3.3 **Vehicle Fleet Emission Concentrations and VSPs**

3.3.1 **Emissions Concentrations by Jurisdiction**

During the course of the study, license plates from over 26 states as well as Canada and the US Government were observed. Exhibit 14 lists the average CO, HC, NO, and VSP measurements for Connecticut vehicles as well as the top three states observed which were Massachusetts, New York, and New Jersey.

The averages by jurisdiction, along with the 95% confidence intervals, shown in the black vertical bars, are plotted in Exhibits 15 through 17. The numbers of samples of measurements of out-of-state vehicles were relatively small. This explains the large confidence intervals. This means the difference in the average emissions were not statistically significant.

Exhibit 14 also lists the average emissions of 2,089 commercial vehicles that were observed, as well as 11 motorcycles from Connecticut and other states. The average NO emissions of the trucks and motorcycles were considerably higher than the passenger vehicles, plus the average CO measurements for the motorcycles surpassed all of the other CO averages.

In summary, the main use of VSP in remote sensing is for screening out vehicles which could be under high load and operating open loop (not near stoichiometry and therefore are expected to have high emissions) or at very low load where the vehicle would not produce NO because the vehicle is not under load.

Exhibit 14 - Average Pollutant Concentrations and VSP by Jurisdictions

	n	CO%	HC ppm	NO ppm	VSP kW/t
Emissions by State or Type					
Connecticut	20,775	0.09	35	82	9.3
Massachusetts	1119	0.1	28	62	6.5
New York	728	0.04	28	37	7.7
New Jersey	279	0.08	27	46	7.6
Other	775	0.07	28	73	6.4
Weighted Average	23,676	0.09	34	80	9.1
Vehicles Excluded at the Request of the State					
Commercial	2089	0.01	69	179	11.8
Motorcycles	11	0.15	208	163	13.5
Plates Not Readable	1548	0.11	60	118	11.1
Weighted Average	3,648	0.05	66	153	11.5
Total On-Road	**27,324**				

Exhibit 15 - Mean HC Concentration by Jurisdiction

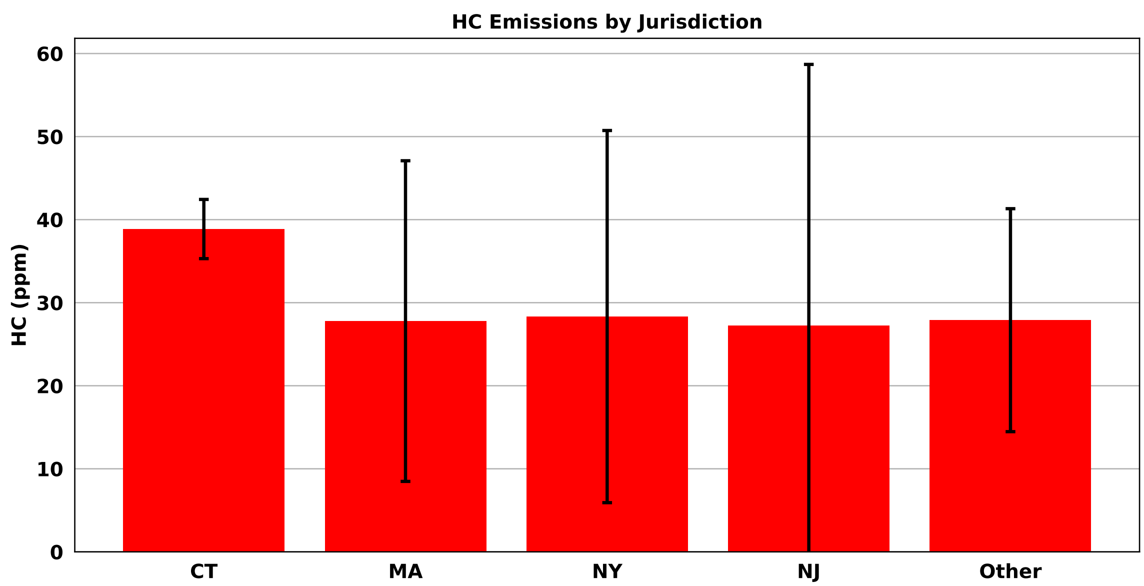


Exhibit 16 - Mean CO Concentration by Jurisdiction

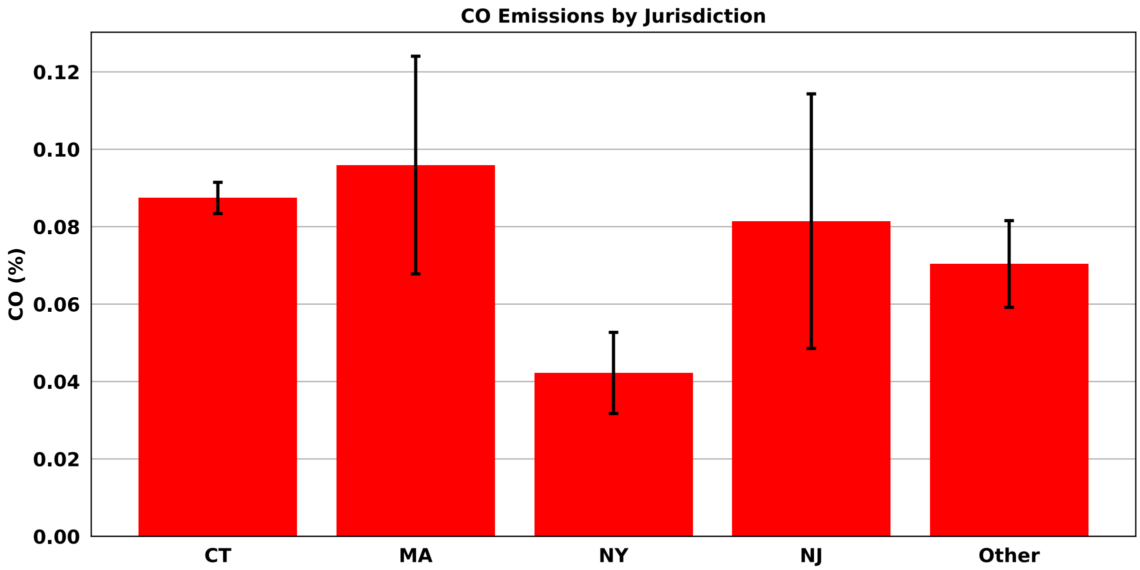


Exhibit 17 - Mean NO Concentration by Jurisdiction

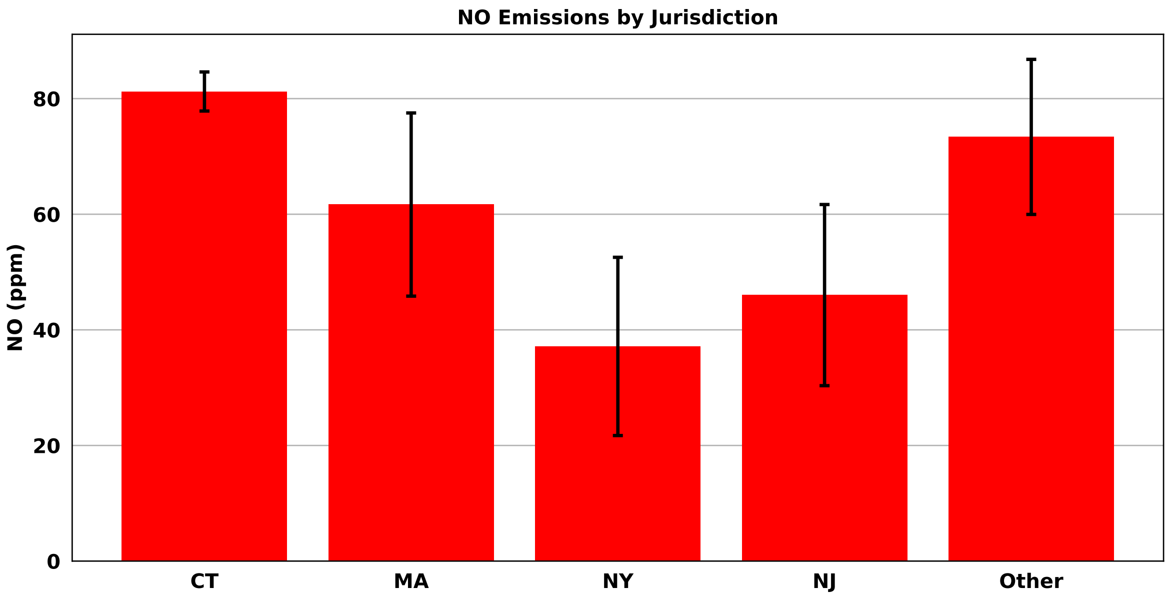
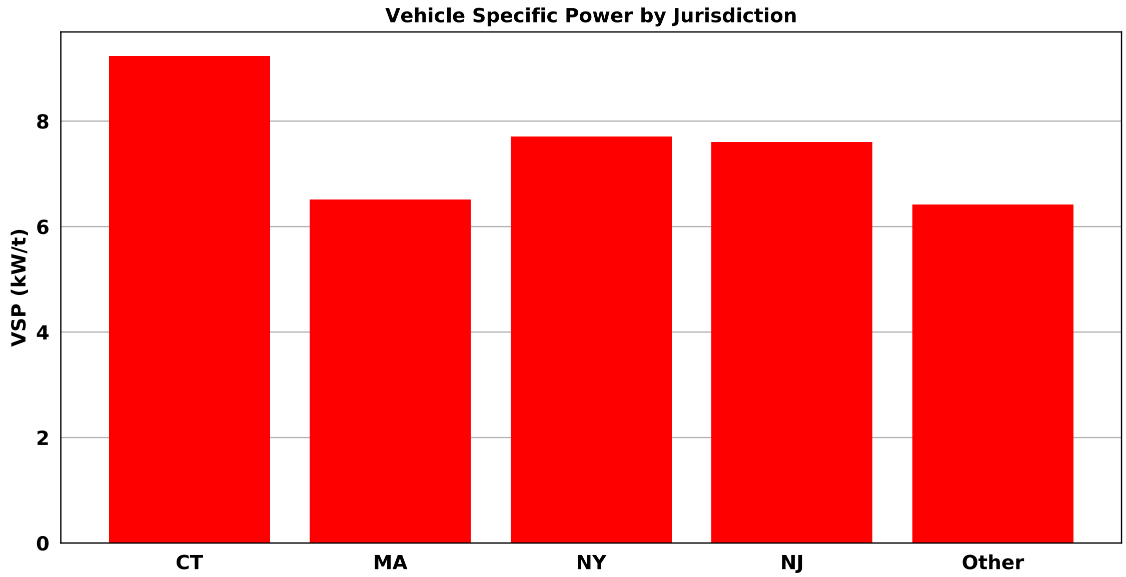


Exhibit 18 - VSP by Jurisdiction



3.3.2 Connecticut Average Emissions by Model Year

The sampled fleet population distribution and average emissions concentrations by model year are shown in Exhibits 19 to 22.

The older the model year, the more likely there will be higher emissions (the vehicles were certified to high emission rates) and greater variation in those emissions due to the aging and failure of the emission control system components. HEAT's data confirms this by showing considerable variation in the older model year averages.

The sensitivity of the EDAR system is especially demonstrated in the gradual increase of gases in model years 2007 and later. Furthermore, large variation of model years older than 22 years could be due to lack of samples. The number of samples for each year is shown in Exhibit 19.

Exhibit 19 - Sampled Connecticut Light Duty Vehicle Distribution in the Study

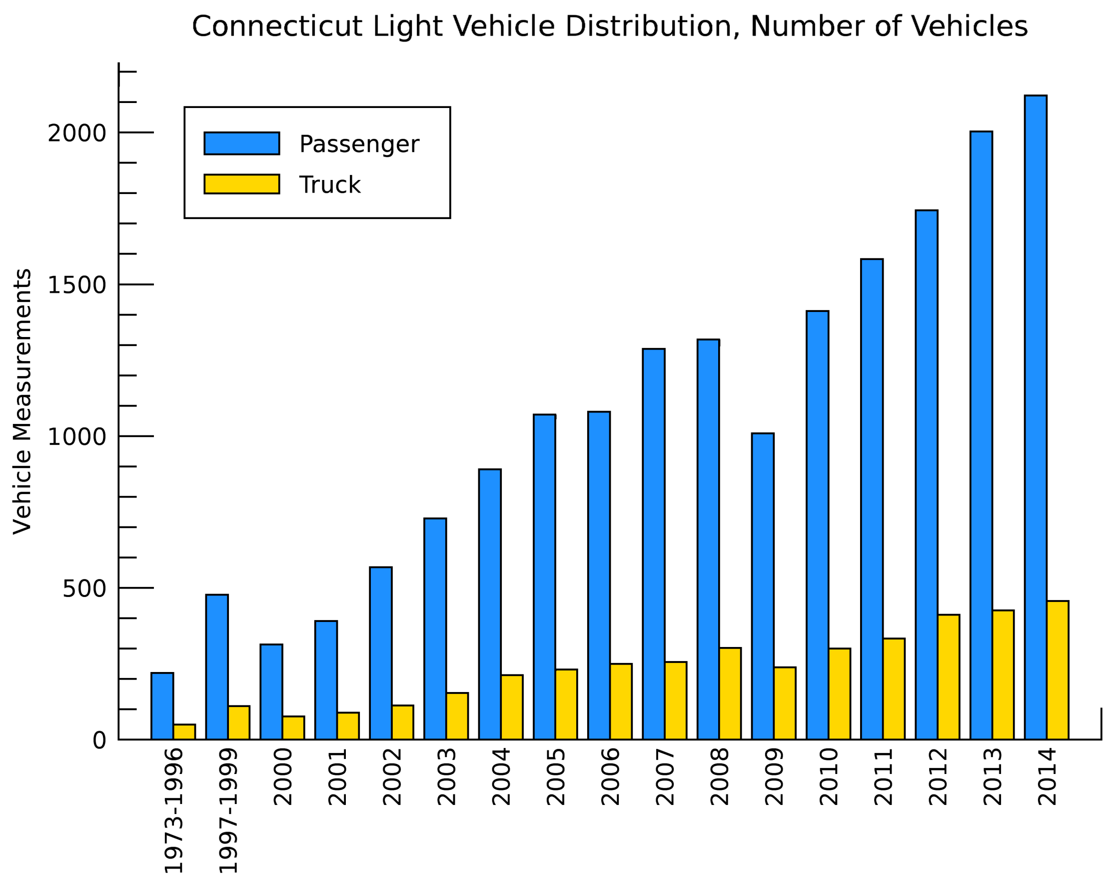


Exhibit 20 - Average CO Emissions

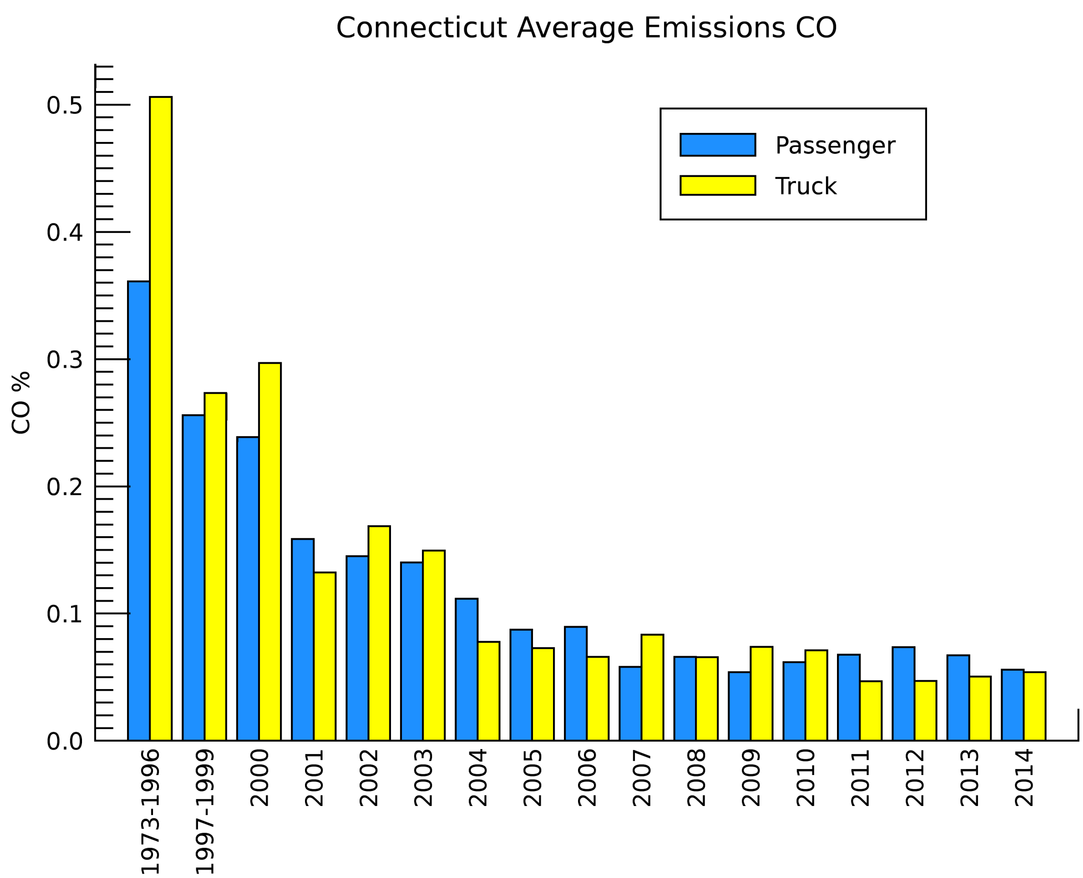


Exhibit 21 - Average NO Emissions

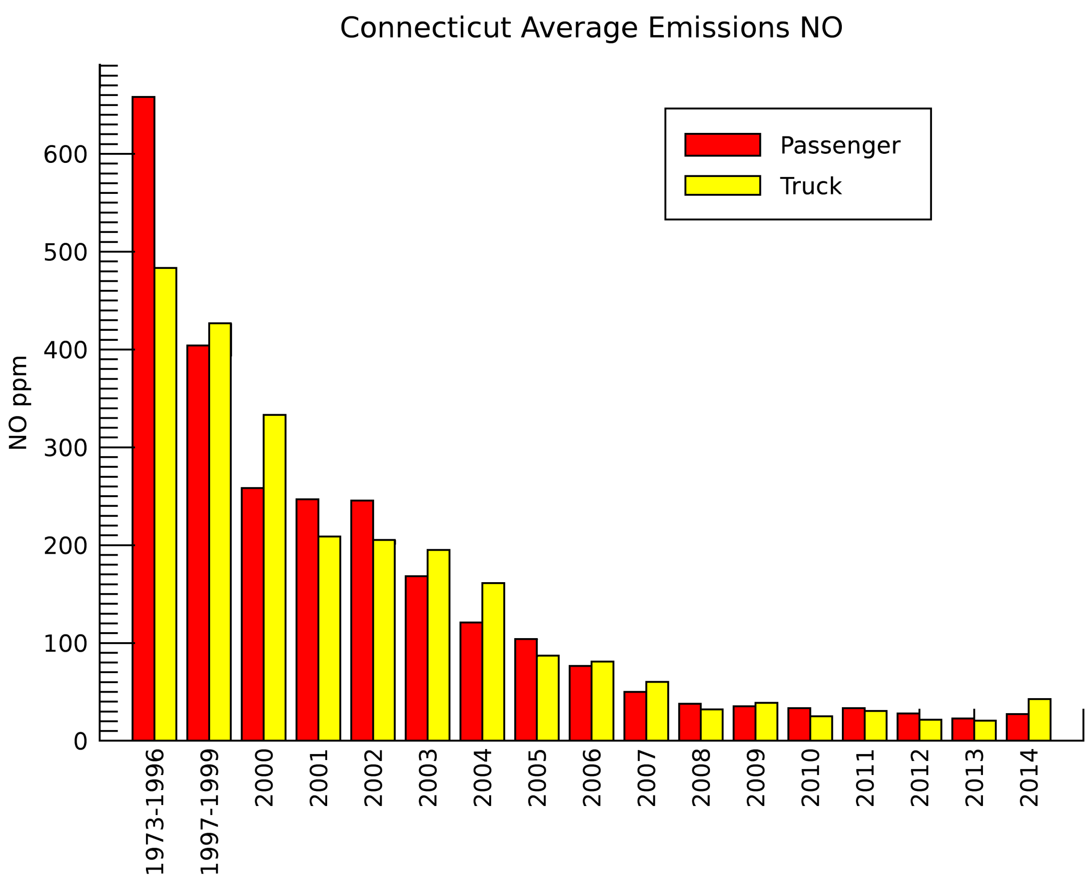
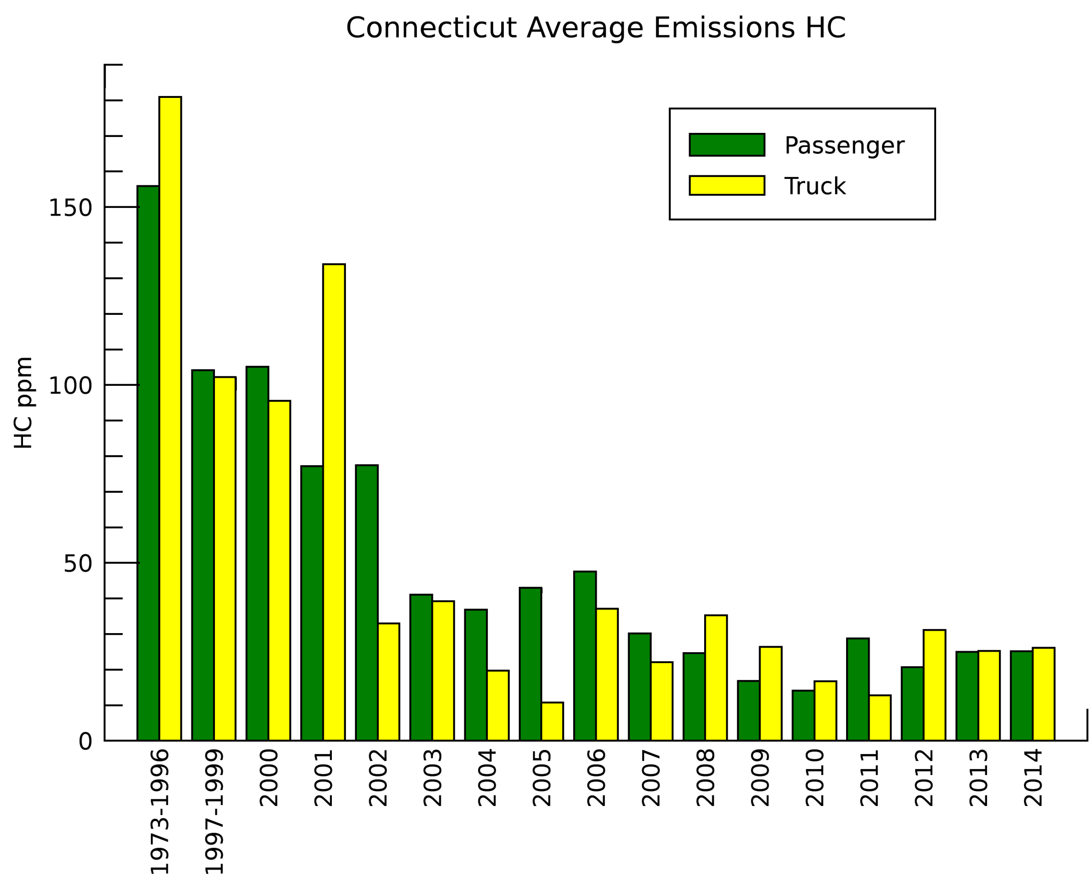


Exhibit 22 - Average HC Emissions



3.3.3 **Approximate Emission Contributions by Model Year**

The contributions of emissions of HC, CO, and NO for the light duty vehicles (passenger vehicles and trucks, by model year) that were observed in this study were calculated from the concentration measurements to provide a comparison to the results from previous studies. The results from this analysis are shown in Exhibits 23 through 26. The contributions are binned by model year with recent years omitted since they were not tested by the Connecticut smog stations. As an approximation, the VMT for the vehicles at all sites are considered the same. Similar to the manner in which the previous vendor performed the estimations, the VMT was assumed to be proportional to the number of vehicle measurements, which is shown in Exhibit 23 by model year and classification. To estimate the emission contributions, each measurement was converted to grams-per-fuel-gallon and divided by approximate fuel efficiency to obtain grams-per-mile. The fuel efficiency is estimated from U.S. DOT estimates by model year[4]. This will weigh the emissions from the light duty trucks as well as older vehicles toward higher emissions since they typically have lower fuel efficiency.

[4] www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

The contributions appear to be proportional to model years for CO and HC measurements with the highest contribution from 2013 and 2014 respectfully. NO also shows proportionality to the model years but has a more distinct drop after 2002. The highest contribution of NO comes from the 1997-1999 model years. The 2009 model year dip is due to the effects of the recession on the purchase of new vehicle. New car sales dropped ~30% from 2007 to 2009.

Exhibit 23 - VMT Contribution by Model Year

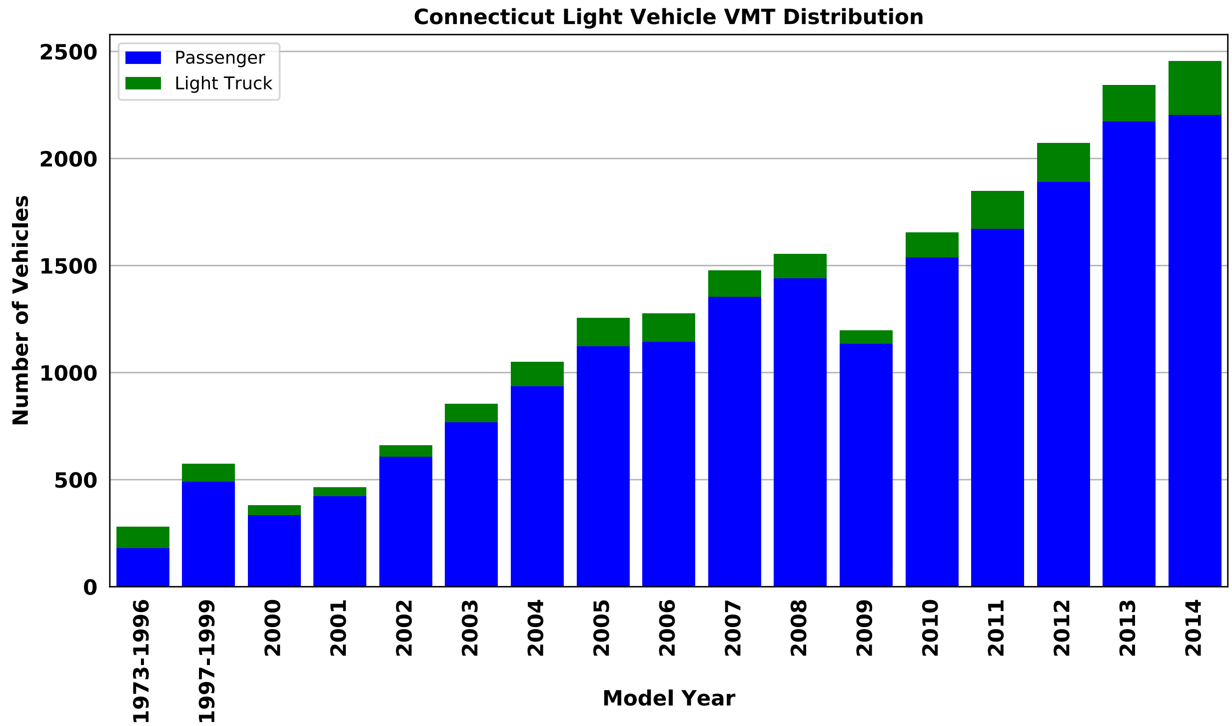


Exhibit 24 - HC Contribution by Model Year

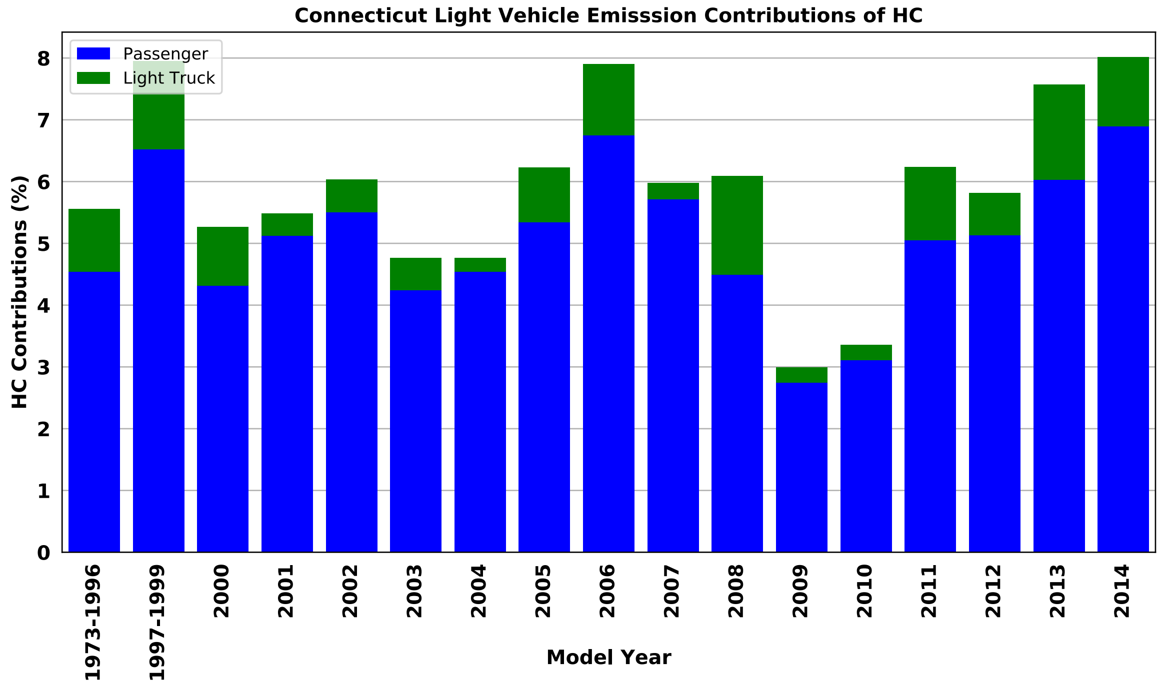


Exhibit 25 - CO Contribution by Model Year

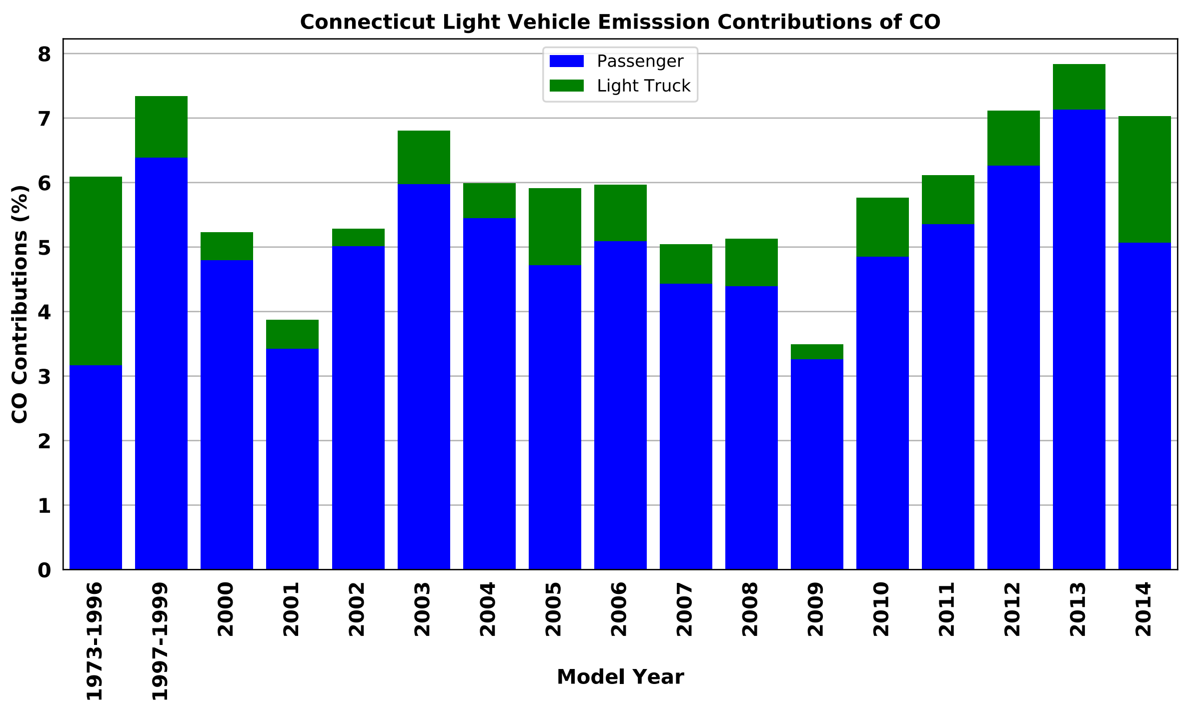
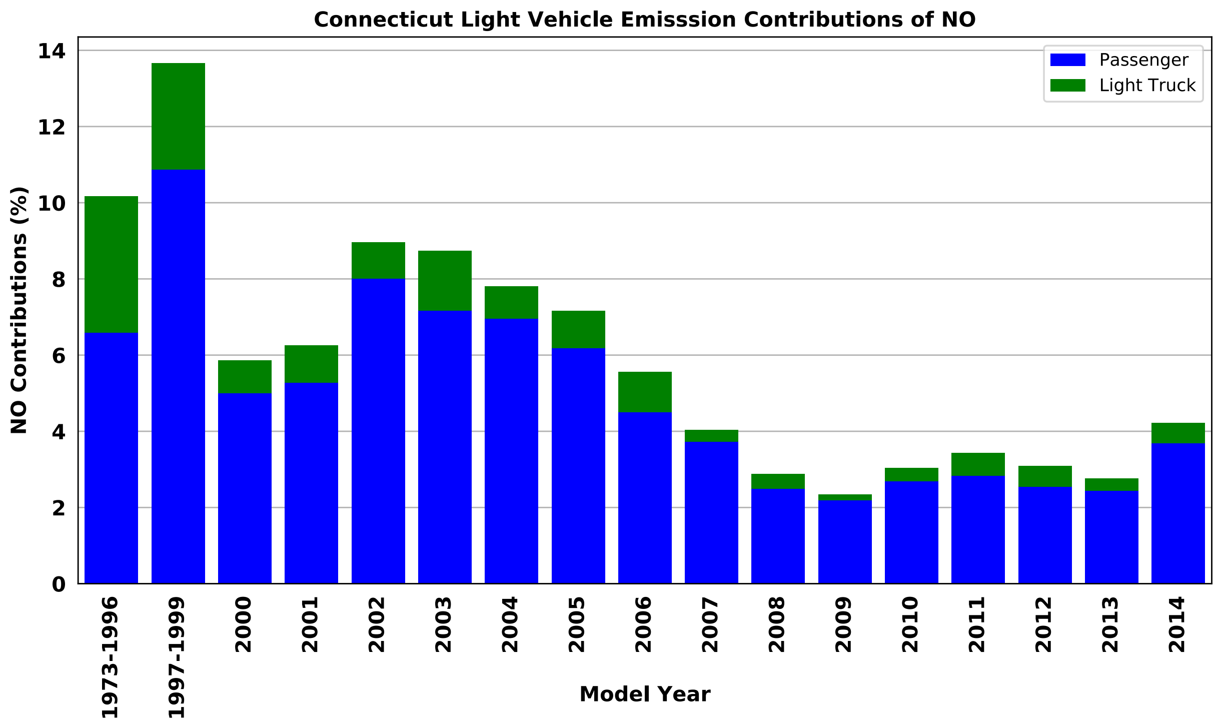


Exhibit 26 - NO Contribution by Model Year



4 HIGH EMITTERS

High Emitters were identified from 22,114 vehicle measurements that were matched to Connecticut registrations. Cut points similar to those used in previous studies of 500 ppm HC, 3% CO, 2000 ppm NO were used to identify the high emitters and allow for comparison to the previous studies.

4.1 High Emitters Summary

Using similar cut points as were used in previous studies, the number of high emitters for HC, CO or NO that exceeded at least one cut-point amounted to 403 vehicles or 1.9% of the identified population. The average emissions for all these vehicles were 1495ppm HC, 4.8% CO, and 2528ppm of NO. The majority of high emitters failed for HC emissions. Exhibit 27 lists the breakdown of high emitters by cut-point. In addition, exhibit 28 lists the combination of cut-points exceeded which demonstrates that only a handful of vehicles exceeded more than one cut-point. After an analysis of the exhaust temperature data, the 403 high emitters indicate that none of these vehicles had high emissions due to operation in cold start mode.

Exhibit 27 - High Emitters

HE Cutpoint	Count
Emissions cutpoints exceeded:	
HC > 500 ppm	321
CO > 3%	43
NO > 2000 ppm	64
Vehicles exceeding one or more cutpoints	403
Total cutpoints exceeded	428

Exhibit 28 - High Emitters by Pollutant Combination

HE Cutpoint Combinations	Count
Single pollutant:	
HC Only	300
CO Only	28
NO Only	53
Two pollutants:	
HC & CO Only	11
HC & NO Only	11
CO & NO Only	0
Three pollutants:	
HC, CO, & NO	0
Total	403

4.2 **Analysis of Exhaust Temperature Data**

The temperature of the exhaust gases exiting the tailpipe were measured by the EDAR unit for each vehicle. The difference in temperature between the ambient and exhaust were used to evaluate the operation of the vehicle and to observe any trends found in the data.

The high-emitters in this study have exhaust temperatures of an average 33.2ºC above ambient. The exhaust temperatures ranged from ambient, to about 245ºC above ambient. These temperatures were found to be constant with vehicle flow studies. Vehicles with tailpipe temperatures within 2ºC of ambient were considered to be not in a cold start mode. In addition, none of the vehicles below 2ºC of ambient temperature were high emitters.

5 COMMERCIAL VEHICLE

In 2018, Commercial vehicle data was also analyzed to provide an overall picture of the heavy-duty vehicles in Connecticut. The findings demonstrate that 43% of the commercial vehicles are diesel which can be compared to gasoline vehicles using grams of pollutant per kilograms of fuel of g/kg instead of tailpipe concentrations.

Vehicles with Plate Type or Registration Usage 'Commercial' in the data provided, equaled 570, of which 564 had valid gas measurements. Out of the 564 records, a total of 452 had proper VSP parameters and did not have interfering plumes.

The main differences between the commercial vehicles and the total measured fleet are the amounts of CO and NO detected. This is mainly due to the amount of diesel vehicles in the commercial fleet. Diesel vehicles on average have larger amounts NO and lower amounts of CO than gasoline vehicles. This is evident in the averages shown in Exhibit 29.

Exhibit 29 – Grams pollutant per kilogram of fuel for commercial vehicles

Vehicle Recorded GVWR > 10000

Averages	Total Light Duty Fleet	Total Commercial	Commercial Gasoline	Commercial Diesel
CO g/kg	11.143	7.210	10.886	3.322
NO g/kg	1.120	2.595	1.385	4.740
HC g/kg	1.018	1.105	1.014	1.323

- The findings demonstrate that the total combined commercial vehicles have more than double the amount of NO than the entire measured light duty vehicle fleet; while the commercial diesel vehicles show an exceedance of four times the amount of NO emitted when compared to the light duty fleet.

In contrast, the commercial diesel vehicles exhibit over 70% less CO than the entire vehicle fleet.

Whereas, HC remained consistent throughout each category.

According to the emission data provided by Connecticut, out of the original 584 commercial vehicles given only 66 have been tested at a station.

6 **FINDINGS**

The on road remote sensing data were matched with the vehicle inspection data for the fleet from the prior two years. By comparing when the last passing inspection was completed for the high emitters, it can be seen that there is no indication of vehicles being falsely passed in the program. In addition, the rate of high emitters observed on road was 1.9% (as noted previously), indicating that the Connecticut Vehicle Inspection Program is effective at maintaining vehicle on road emissions.

Following are the results of the on-road emissions survey. Results are reported in concentrations to allow for comparison to the previous study, and the previous results are noted.

Average emissions

- Average emissions of Connecticut registered light vehicles were 54 ppm HC hexane, 0.087% CO and 80 ppm NO. The last study performed found average concentrations for light duty vehicles of 55 ppm HC hexane, 0.11% CO and 111ppm NO.
- Tier 2 models, 2004 and newer, continue to have well controlled emissions.
- A small fraction of vehicles had very high emissions and contributed a substantial portion of light vehicle emissions:
    - 403 (1.9%) of vehicles had HC greater than 500 ppm, CO emissions greater than 3%, or NO greater than 2000 ppm.
- The combined heavy-duty commercial vehicles proved to have more than double the amount of NO than the entire measured light duty vehicle fleet.
- The commercial diesel vehicles also showed an exceedance of four times the amount of NO emitted when compared to the light duty fleet.
- Comparison of Connecticut Vehicle Inspection Program results for each individual on-road high emitters measured by EDAR indicates that there is no indication of vehicles being falsely passed for emissions in the Inspection Program.
- Vehicle data will be provided to DMV and Applus to allow for motorist notification or further evaluation.

Applus Technologies, Inc.

Connecticut Emissions Program

Supplement to the 2018 On-Road Vehicle Survey

Attachment A – List of failed license plates by pollutant (August 2018)

Attachment B – Non-compliant evaluation (January 2019)

Attachment C – Images of non-compliant vehicles used in evaluation (January 2019)

2018 Remote Sensing Survey
Failed License Plates by Pollutant
Attachment A

CO	NO	HC
2U243	AK96550	AN47651
AK94661	AM45394	3ALGT6
3936CX	1ALXX9	3ASTN6
388YFH	7ARGP3	5AESW6
2N103	952UUZ	903SRU
346RSA	AA46176	AD47303
AN63748	AJ42477	AE99204
AE84560	AK53529	AG93977
AM55509	AK78953	AK69685
9907CU	AL43074	139MKB
C113629	AM62516	212WTW
437SFY	AN57014	275GOT
C081467	C100633	517YXK
C007777	8193	702YLF
AN88034	00CKXM	9ALJT2
7APML0	00EMYN	9ANEN6
C067281	0ANML9	AC24989
AM77663	0AWHS5	AC48463
2369DB	167ZMS	AC87750
644KFK	1796CL	AG73088
922XUN	2ALKH5	AH78150
274ZZJ	3ATVH8	AJ24327
AK94009	3AVEP4	AM32054
7AMKP1	4AHPV5	AM45394
8AKEW8	4ARNT5	AM94456
AP43645	510SFL	AP09506
313PFF	583PZD	AP36856
AL95586	5APAF3	BL5231
313XPE	5ATPE4	T5484T
262YPT	6276DC	125PYK
AD65197	6AMEA6	136UOB
6336CW	719XOZ	1ARVW7
AA33569	753MAB	245ZJB
AH27690	8343CL	265TFV
AN08891	848VBC	272UYH
AJ24504	863ZMS	289ZMS
AC47525	874NSN	2C9293
935YOP	8AKUP1	3337DD
9AGNU5	912EGM	346RSA
AP66651	954ZVR	371XHR

2018 Remote Sensing Survey
Failed License Plates by Pollutant
Attachment A

CO	NO	HC
AL66588	9AEHX9	475ZNX
6AVHH1	9AJGV1	558TSX
6APLS1	AB74697	5AKUU0
	AB96352	632YYW
	AC02712	644KFK
	AD48346	656KEU
	AF81551	6ATUS8
	AF97586	701ZBO
	AG48080	711EDH
	AG99481	794EXG
	AH21518	7ALKJ9
	AH31188	7ARGP3
	AH73159	7AVEN7
	AH93109	7CX943
	AJ12881	8AUEJ4
	AJ32319	934KYF
	AK61907	939XMF
	AL84087	962YZN
	AL93415	986RJE
	AM30660	9AMAH3
	AM30714	AA32697
	AM45351	AA46176
	AM93270	AA46176
	AN30933	AB97777
	AN32952	AC57633
	AN64695	AD64939
	AP43374	AG03513
	C016898	AG12363
	C058955	AH10266
	C076622	AH61272
	C12349	AH68306
	RDGD	AH97888
	VS6398	AJ52359
		AJ88692
		AJ96288
		AK79485
		AK88940
		AL43130
		AL48242
		AL76828

CO	NO	HC
		AL94235
		AM30948
		AM78505
		AN57014
		AP43645
		AP63021
		AP84009
		C046087
		C089585
		C100633
		C143323
		K38828
		T4793T
		ZT2129
		8193
		00BSDP
		07CD50
		0AAXB8
		0ALKA6
		0ANML9
		0ARMS2
		0ASEU6
		0AVSR9
		100APW
		111MDG
		111YYR
		117ZKK
		138ZEA
		146SKB
		182TTS
		1AHNV4
		1CS148
		207UYD
		212YFO
		212ZNE
		226SMV
		228ZYV
		232ZYZ
		238YMN
		242UEN

CO	NO	HC
		251HGL
		253MBE
		265HNT
		268TSE
		295FTL
		2ABGH7
		2ATWP9
		2C648
		2L476
		2U243
		313XPE
		322YDG
		3363DF
		339ZUJ
		345URT
		369ZTE
		387XPZ
		3ABSF7
		3AFAE5
		3AKJU5
		3AUDV9
		3AXHF0
		3CF135
		4086CS
		408WPG
		4198CU
		437SFY
		44CT55
		456XWB
		465YTW
		471XDF
		489ZOH
		494ZLD
		4ABHP2
		4ADWL6
		4AGXJ3
		4AHAE8
		4ARTF0
		505ZCW
		510SFL

CO	NO	HC
		511TMR
		529YRL
		541FXW
		549UDN
		559YZY
		569NZY
		5ALTH1
		604XSG
		6176CS
		620ULF
		653PFS
		664ZDB
		673ZRO
		68000C
		6AJHX2
		6AJMW5
		6AMEA6
		6AVHH1
		6AVKJ1
		6CC773
		707SVA
		727KVV
		750XZM
		751YPS
		760RXV
		761RGK
		777FLB
		784ZYV
		787WHX
		789WFU
		791ZVH
		7AAWW2
		7APLX3
		8052DE
		846YVZ
		850ZRR
		874NSN
		889YZN
		891WBK
		8AAER2

CO	NO	HC
		928THS
		954YCK
		954ZVR
		956BHZ
		959TYB
		9656CX
		976YZY
		980YCG
		999GKZ
		9AJJF3
		9APLF3
		9ASJP1
		9ATJR8
		9CH468
		AA72336
		AA77452
		AA84411
		AC14234
		AC25120
		AC43949
		AC56889
		AC68356
		AD11031
		AD25653
		AD37686
		AD60165
		AD61988
		AE84560
		AF13460
		AF26608
		AF36761
		AF47560
		AF97126
		AF98299
		AG33173
		AG36101
		AG36196
		AG42584
		AG49573
		AG49730

2018 Remote Sensing Survey
Failed License Plates by Pollutant
Attachment A

CO	NO	HC
		AG49956
		AG50248
		AG51046
		AG77846
		AG85579
		AH00912
		AH27390
		AH27690
		AH62274
		AH69442
		AH85568
		AH88554
		AH95896
		AH97856
		AJ04555
		AJ18691
		AJ25124
		AJ36538
		AJ36740
		AJ41621
		AJ43456
		AJ53429
		AK13976
		AK50150
		AK50856
		AK51111
		AK51553
		AK62648
		AK78930
		AK93196
		AK94661
		AK95056
		AL19439
		AL25496
		AL49855
		AL51770
		AL62697
		AL93415
		AL96656
		AM11559

CO	NO	HC
		AM11566
		AM28027
		AM30660
		AM41231
		AM43522
		AM47489
		AM54212
		AM55509
		AM60602
		AM77663
		AM89429
		AM94868
		AN30461
		AN62239
		AN77157
		AN88034
		AP22388
		AP24951
		AP40427
		AP43398
		AP45279
		AP62791
		AP63127
		AP70588
		AR00713
		AR29051
		BREZE1
		C037931
		C087980
		C089105
		C094065
		C100051
		C137934
		C143001
		C86945
		GU6992
		GY7128
		KILTD2
		WK4097

2018 Remote Sensing Survey
Non-Compliant Evaluation January 2019
Attachment B

Plate Number	Emissions Compliant as of 01/15/2019	Last Emissions Test Date	CIVLS Registration Status	CIVLS Registration Expiration Date	CIVLS Vehicle Description matches Image	Comments/Notes
ZT2129	**No**	4/28/2017	**Active**	5/21/2019	Yes	Vehicle was tested on 4/28/17 and Passed. Vehicle was due 8/20/18.
K38828	**No**	7/10/2017	**Active**	4/30/2019	Yes	Vehicle was tested on 7/10/17 and Passed. Vehicle was due 7/10/18.
C100633	**No**	9/13/2017	**Active**	7/13/2019	Yes	Vehicle was tested on 9/13/17 and Failed. Vehicle was due 8/14/17. Failed status sense 2017.
C094065	**No**	1/21/2016	**Inactive**	11/3/2019	Yes	Vehicle was tested on 1/21/16 and Passed. Plate transferred to new vehicle as of 1/17/19.
C087980	Yes	9/24/2018	**Active**	6/19/2019	Yes	Vehicle was tested on 9/24/18 and Passed.
C067281	**No**	8/5/2016	**Active**	7/6/2020	Yes	Vehicle was tested on 8/5/16 and Passed. Vehicle was due 8/7/18.
C037931	**No**	3/23/2018	**Active**	3/20/2020	Possible image is dark	Vehicle was tested on 3/23/18 and Failed. Vehicle was due 5/22/18.
C007777	Yes	9/24/2018	**Active**	8/9/2020	Yes	Vehicle was tested on 9/24/18 and Passed.
BREZE1	Yes	10/20/2018	**Active**	6/3/2019	Possible image is dark	Vehicle was tested on 10/20/18 and Passed.
AR29051	**No**	8/28/2015	**Active**	8/3/2020	Yes	Vehicle was tested on 8/28/15 and Passed. Vehicle was due 9/4/18.
AP84009	**No**	5/6/2015	**Active**	7/9/2020	Yes	Vehicle was tested on 5/6/15 and Passed. Vehicle was due 8/10/18.
AP63127	**No**	6/22/2018	**Active**	6/25/2020	Yes	Vehicle was tested on 6/22/18 and Failed. Vehicle was due 8/21/18.
AP45279	**No**	10/26/2018	**Active**	8/2/2020	Possible image is dark	Vehicle was tested on 10/26/18 and Failed. Vehicle was due 12/25/18.
AP43645	**No**	5/24/2017	**Active**	7/4/2020	Yes	Vehicle was tested on 5/24/17 and Failed. Vehicle was due 8/5/18. Failed status sense 2017.
AP43374	**No**	7/24/2018	**Active**	6/22/2020	Yes	Vehicle was tested on 7/24/18 and Failed. Vehicle was due 7/24/18. Failed status sense 2015.

Plate Number	Emissions Compliant as of 01/15/2019	Last Emissions Test Date	CIVLS Registration Status	CIVLS Registration Expiration Date	CIVLS Vehicle Description matches Image	Comments/Notes
AP22388	**No**	10/6/2018	**Active**	5/22/2020	Yes	Vehicle was tested on 10/6/17 and Failed. Vehicle was due 6/23/18.
AN88034	**No**	1/5/2018	**Active**	8/6/2020	Yes	Vehicle was tested on 1/5/18 and Failed. Vehicle was due 9/7/2018.
AN77157	**No**	3/23/2018	**Active**	4/16/2020	Yes	Vehicle was tested on 3/23/18 and Failed. Vehicle was due 5/22/18.
AM94456	**No**	6/17/2016	**Inactive**	3/13/2020	Yes	Vehicle was tested on 6/17/16 and Passed. Plate transferred to new vehicle as of 11/27/18.
AM77663	**No**	6/14/2017	**Inactive**	2/23/2020	Possible image is dark	Vehicle was tested on 6/14/17 and Failed. Vehicle was due 8/7/2018. Failed status sense 2017.
AM47489	**No**	2/28/2018	**Active**	2/13/2020	Yes	Vehicle was tested on 2/28/18 and Failed. Vehicle was due 4/29/18.
AM41231	**No**	N/A	**Active**	12/29/2019	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 12/11/18.
AM30714	**No**	4/2/2014	**Active**	7/12/2020	Yes	Vehicle was tested on 4/2/14 and Passed. Vehicle was due 8/13/18.
AM30660	**No**	8/25/2015	**Active**	12/25/2019	Possible image is dark	Vehicle was tested on 8/25/2015 and Passed. Vehicle was due 6/26/17.
AL95586	**No**	N/A	**Active**	11/5/2019	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 11/5/18.
AL93415	**No**	10/20/2017	**Active**	10/25/2019	Yes	Vehicle was tested on 10/20/17 and Failed. Vehicle was due 12/19/17. Failed status sense 2017.
AL66588	**No**	10/27/2015	**Active**	11/1/2019	Possible image is dark	Vehicle was tested on 10/27/2015 and Passed. Vehicle was due 12/17/17.
AK94009	**No**	11/27/2015	**Active**	8/9/2019	Yes	Vehicle was tested on 11/27/15 and Passed. Vehicle was due 11/27/16.
AK69685	**No**	N/A	**Active**	9/12/2019	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 2/4/18.

2018 Remote Sensing Survey
Non-Compliant Evaluation January 2019
Attachment B

Plate Number	Emissions Compliant as of 01/15/2019	Last Emissions Test Date	CIVLS Registration Status	CIVLS Registration Expiration Date	CIVLS Vehicle Description matches Image	Comments/Notes
AK51111	**No**	1/15/2016	**Active**	8/2/2019	Yes	Vehicle was tested on 1/15/16 and Passed. Vehicle was due 1/15/18.
AK13976	**No**	5/25/2017	**Inactive**	5/25/2019	Yes	Vehicle was tested on 5/25/17 and Failed. Vehicle was due 7/24/17. Failed status sense 2017
AJ53429	**No**	N/A	**Active**	3/28/2019	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 3/28/18.
AJ41621	**No**	9/6/2013	**Inactive**	4/6/2020	Yes	Vehicle was tested on 9/6/13 and Passed. Vehicle was due 9/6/14.
AJ36538	**No**	N/A	**Active**	6/4/2019	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 6/4/18.
AH93109	Yes	11/29/2018	**Active**	2/24/2019	Possible image is dark	Vehicle was tested on 11/29/18 and Passed.
AH78150	**No**	4/10/2018	**Inactive**	3/16/2019	Yes	Vehicle was tested on 4/10/18 and Failed. Vehicle was due 6/9/18.
AH73159	**No**	6/26/2014	**Active**	5/31/2019	Yes	Vehicle was tested on 6/26/14 and Passed. Vehicle was due 8/10/16.
AH68306	**No**	6/23/2015	**Active**	3/7/2019	Yes	Vehicle was tested on 6/23/15 and Passed. Vehicle was due 7/28/17.
AH61272	Yes	11/29/2018	**Active**	3/2/2019	Possible image is dark	Vehicle was tested on 11/29/18 and Passed.
AH31188	**No**	8/20/2015	**Active**	9/7/2019	Yes	Vehicle was tested on 8/20/15 and Failed. Vehicle was due 10/19/15. Failed status sense 2015.
AH27690	**No**	11/27/2017	**Inactive**	12/29/2018	Yes	Vehicle was tested on 11/27/17 and Failed. Vehicle was due 1/26/18.
AH21518	**No**	3/14/2013	**Active**	4/6/2019	Yes	Vehicle was tested on 3/14/13 and Passed. Vehicle was due 5/12/15.
AG99481	**No**	6/4/2016	**Active**	12/2/2018	Yes	Vehicle was tested on 6/4/2016 and failed. Vehicle was due 7/3/16, Failed status sense 2016.

2018 Remote Sensing Survey
Non-Compliant Evaluation January 2019
Attachment B

Plate Number	Emissions Compliant as of 01/15/2019	Last Emissions Test Date	CIVLS Registration Status	CIVLS Registration Expiration Date	CIVLS Vehicle Description matches Image	Comments/Notes
AG49730	**No**	10/18/2016	**Active**	10/19/2018	Yes	Vehicle was tested on 10/18/16 and Passed. Vehicle was due 10/18/17.
AG48080	**No**	7/25/2018	**Active**	9/25/2019	Yes	Vehicle was tested on 7/25/18 and failed. Vehicle was due 9/23/18.
AG42584	**No**	8/28/2015	**Active**	3/10/2019	Yes	Vehicle was tested on 8/28/15 and Passed. Vehicle is due 8/1/17.
AG36196	**No**	9/14/2015	**Inactive**	9/29/2018	Yes	Vehicle was tested on 9/14/15 and Passed. Vehicle is due 9/27/17.
AG33173	**No**	12/8/2018	**Active**	11/17/2020	Yes	Vehicle was tested on 12/8/18 and failed. Vehicle is due 2/6/19.
AG03513	**No**	10/29/2014	**Active**	9/1/2018	Yes	Vehicle was tested on 10/29/14 and Passed.
AF97586	**No**	N/A	**Active**	3/28/2020	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 11/13/18.
AF13460	**No**	6/11/2018	**Active**	6/30/2020	Yes	Vehicle was tested on 6/11/18 and failed. Vehicle was due 8/10/18.
AE99204	**No**	11/24/2014	**Active**	8/8/2018	Yes	Vehicle was tested on 11/24/14 and Passed.
AD64939	**No**	6/1/2018	**Active**	5/10/2018	Yes	Vehicle was tested on 6/1/2018 and failed. Vehicle was due 6/11/16, Failed status sense 2012.
AD61988	**No**	N/A	**Active**	6/6/2019	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 6/6/18.
AD37686	**No**	3/13/2012	**Active**	6/19/2020	Yes	License plate is associated with two active registrations; both Honda Civics, owned by the same party. Both vehicles are in failed status. The image matches the vehicle tested and failed on 3/13/12.
AC43949	**No**	6/7/2018	**Active**	11/22/2018	Yes	Vehicle was tested on 6/7/18 and failed. Vehicle was due 8/6/18.
AB97777	**No**	11/13/2015	**Active**	12/15/2019	Yes	Vehicle was tested on 11/13/2015 and Passed. Vehicle was due 1/2/2018.

2018 Remote Sensing Survey
Non-Compliant Evaluation January 2019
Attachment B

Plate Number	Emissions Compliant as of 01/15/2019	Last Emissions Test Date	CIVLS Registration Status	CIVLS Registration Expiration Date	CIVLS Vehicle Description matches Image	Comments/Notes
AB96352	**No**	10/6/2017	**Active**	11/18/2019	Yes	Vehicle was tested on 10/6/17 and failed. Vehicle was due 12/5/17, Failed status sense 2017.
AA72336	Yes	10/6/2018	**Active**	7/14/2019	Yes	Vehicle was tested on 10/6/18 and Passed.
AA46176	Yes	10/19/2018	**Active**	11/29/2019	Yes	Vehicle was tested on 10/19/18 and Passed.
9ANEN6	**No**	6/7/2017	**Active**	5/1/2020	Yes	Vehicle was tested on 6/7/17 and Passed. Vehicle was due 6/7/18.
9AEHX9	**No**	12/31/2014	**Active**	1/7/2018	Yes	Vehicle was tested on 12/31/14 and Passed. Vehicle was due 12/17/16.
9907CU	Yes	11/27/2018	**Active**	12/26/2019	Possible image is dark	Vehicle was tested on 11/27/18 and Passed.
952UUZ	**No**	7/13/2015	**Active**	10/13/2018	Yes	Vehicle was tested on 7/13/15 and Passed. Vehicle was due 6/14/17.
939XMF	**No**	10/9/2015	**Active**	7/11/2019	Yes	Vehicle was tested on 10/9/15 and Passed. Vehicle was due 10/1/17.
889YZN	Yes	10/30/2018	**Active**	12/27/2019	Possible image is dark	Vehicle was tested on 10/30/18 and Passed.
850ZRR	**No**	12/28/2018	**Active**	11/16/2018	Yes	Vehicle was tested on 12/28/18 and failed. Vehicle was due 4/25/17, Failed status sense 2017.
848VBC	**No**	6/9/2015	**Active**	10/1/2017	Yes	Vehicle was tested on 6/9/15 and Passed. Vehicle was due 2/18/17.
7CX943	**No**	5/4/2016	**Active**	4/29/2018	Yes	Vehicle was tested on 5/4/16 and Passed. Vehicle was due 5/27/17.
7ARGP3	Yes	10/31/2018	**Active**	10/12/2020	Possible image is dark	Vehicle was tested on 10/31/18 and Passed.
7APML0	**No**	10/13/2016	**Active**	10/14/2018	Yes	Vehicle was tested on 10/13/16 and Passed. Vehicle was due 7/15/18.
7APLX3	Yes	12/5/2018	**Active**	1/6/2019	Yes	Vehicle was tested on 12/5/18 and Passed.
789WFU	**No**	4/13/2017	**Active**	6/6/2019	Yes	Vehicle was tested on 4/13/17 and Passed. Vehicle was due 6/6/18.

2018 Remote Sensing Survey
Non-Compliant Evaluation January 2019
Attachment B

Plate Number	Emissions Compliant as of 01/15/2019	Last Emissions Test Date	CIVLS Registration Status	CIVLS Registration Expiration Date	CIVLS Vehicle Description matches Image	Comments/Notes
751YPS	**No**	3/21/2017	**Active**	3/26/2019	Yes	Vehicle was tested on 3/21/17 and Passed. Vehicle was due 3/26/18.
719XOZ	**No**	5/21/2018	**Active**	5/21/2018	Yes	Vehicle was tested on 5/21/18 and failed. Vehicle was due 8/10/16, Failed status sense 2016
702YLF	Yes	12/28/2018	**Active**	12/20/2020	Yes	Vehicle was tested on 12/28/18 and Passed.
6AVKJ1	**No**	4/28/2017	**Active**	5/30/2019	Yes	Vehicle was tested on 4/28/17 and Passed. Vehicle was due 4/28/18.
6AVHH1	**No**	3/15/2016	**Active**	2/22/2019	Yes	Vehicle was tested on 3/15/16 and Passed. Vehicle was due 3/15/17.
6AMEA6	Yes	9/27/2018	**Active**	7/26/2020	Yes	Vehicle was tested on 7/19/18 and Failed, Retested on 9/27/18 and Passed.
5APAF3	**No**	10/1/2016	**Active**	9/27/2018	Yes	Vehicle was tested on 10/1/16 and Passed. Vehicle was due 8/13/18.
5AKUU0	**No**	8/2/2016	**Active**	6/10/2018	Yes	Vehicle was tested on 8/2/16 and Passed. Vehicle was due 7/29/18.
583PZD	**No**	6/13/2017	**Active**	6/6/2019	Yes	Vehicle was tested on 6/13/17 and failed. Vehicle was due 8/12/17.
4ARTF0	**No**	N/A	**Active**	1/16/2020	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 12/26/18. Vehicle will be non-compliant after 30 days from due date.
4ARNT5	Yes	1/3/2019	**Active**	12/23/2020	Yes	Vehicle was tested on 12/21/18 and FAILED, Retested on 12/22/18 and Failed. Vehicle was retested again on 1/03/19 and Passed.
4AHPV5	**No**	N/A	**Active**	3/29/2018	No	CIVLS data shows plate belongs to 2014 Nissan Rogue; RSD Image shows a Ford Focus
489ZOH	Yes	11/16/2018	**Active**	12/15/2020	Possible image is dark	Vehicle was tested on 11/16/18 and Passed.
3AXHF0	**No**	5/15/2018	**Active**	1/10/2020	Yes	Vehicle was tested on 3/16/18 and FAILED, Retested on 5/15/18 and Failed. Vehicle has not been back.

2018 Remote Sensing Survey
Non-Compliant Evaluation January 2019
Attachment B

Plate Number	Emissions Compliant as of 01/15/2019	Last Emissions Test Date	CIVLS Registration Status	CIVLS Registration Expiration Date	CIVLS Vehicle Description matches Image	Comments/Notes
3AUDV9	**No**	1/29/2016	**Inactive**	6/1/2019	Yes	Vehicle was tested on 1/29/16. Vehicle was due 1/10/18.
3ATVH8	**No**	N/A	**Active**	5/8/2019	N/A	Vehicle has not had a CT Emissions test. Vehicle was due 5/8/18.
3ALGT6	Yes	12/11/2018	**Active**	9/25/2020	Yes	Vehicle was tested on 9/24/18 and FAILED, Retested on 12/11/18 and Passed.
3363DF	Yes	9/20/2018	**Active**	8/5/2019	Yes	Vehicle was tested on 9/20/18 and Passed.
2ATWP9	**No**	6/6/2018	**Active**	4/23/2019	Yes	Vehicle was tested on 6/6/18 and FAILED.
268TSE	**No**	8/27/2016	**Active**	3/15/2019	Yes	Vehicle was tested on 8/27/16 and Passed. Vehicle was due 8/27/18.
265HNT	Yes	11/26/2018	**Active**	8/8/2020	Possible image is dark	Vehicle was tested on 8/10/18 and Failed, Retested on 11/26/18 and Passed.
2369DB	**No**	12/1/2016	**Active**	12/5/2018	No	Vehicle info states this should be a (2005 Ford F250 Super Duty) Sensing Image is showing a (Dodge Ram 4X4).
228ZYV	**No**	7/19/2017	**Inactive**	6/7/2019	Yes	Vehicle was tested on 7/19/17 and failed. Vehicle was due 9/17/17.
207UYD	Yes	11/3/2018	**Active**	11/30/2020	Possible image is dark	Vehicle was tested on 11/3/18 and Passed.
100APW	Yes	10/10/2018	**Active**	8/8/2020	Yes	Vehicle was tested on 10/10/18 and Passed.
0AWHS5	**No**	1/3/2012	**Inactive**	**8/6/2017**	Yes	Registration was expired at the time of the RSD. Vehicle was last tested on 1/3/12 with (Plate # 658YLY) and due date was 1/30/14.
00BSOP	Became Exempt in 2019	4/9/2015	**Inactive**	**3/11/2018**	Yes	Registration was expired at the time of the RSD. Vehicle was tested on 4/9/15 with (NO Plate) Vehicle was due 7/21/16.


SAAB
ZT·2129


189
AAA
REFRIGERATION SERVICE, INC.
COMMERCIAL
EMERGENCY
860-793-8825


C100633


C1094065
Jeep


C1087980


FORD
C067281


C1037931


4X4
C1007777


BREZE·1


AR·29051


AP-84009


AP-63127


ALTIMA
AP-45279


AP-43645

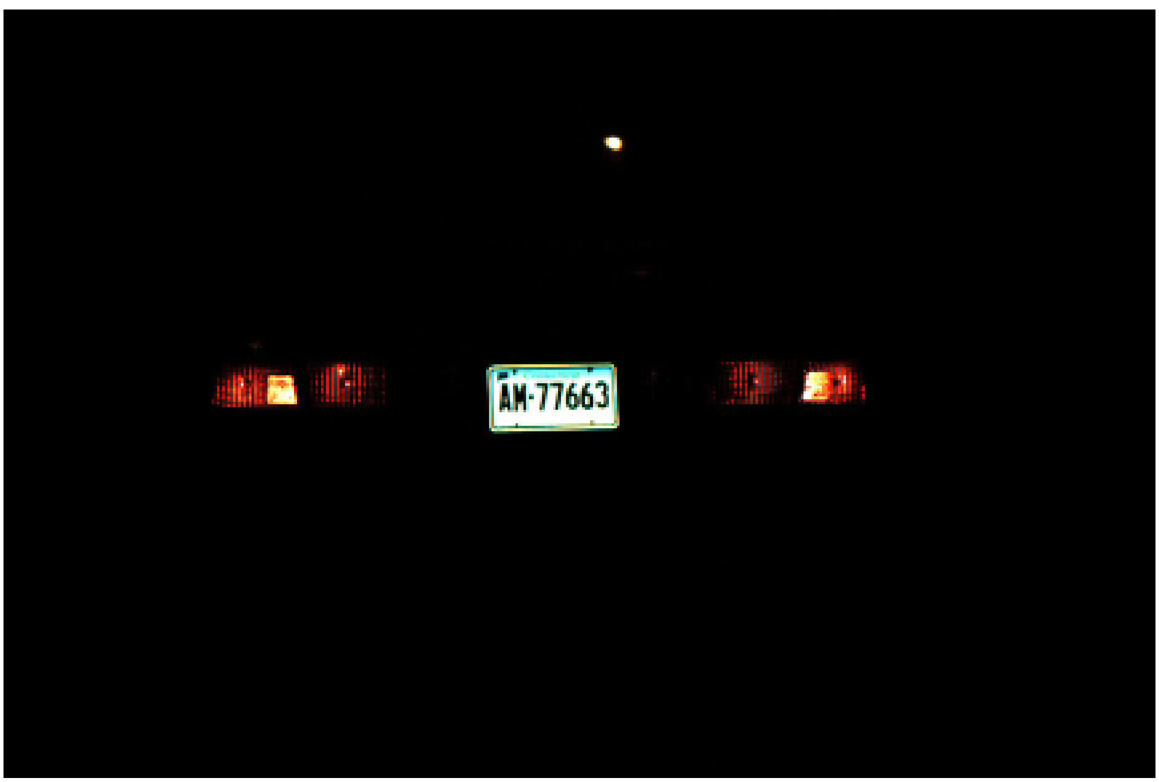

AP·43374


AP·22388


AN·88034


AN-77157


AM-94456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AM-47489
CHEVROLET


AM-41231


AM·30714


AM·30660


AL-95586


AL·93415


AL-66588


AK-94009


AK-69685
ST


AK-51111


AK·13976


AJ-53429


AJ-41621
ALTIMA
2.5 S


AJ-36538


DODGE


AH-78150
EXPLORER


AH-73159


AH-68306


AH-61272


AH-31188


AH-27690


AH-21518


AG-99481


AG-49730


AG-48080


AG-42584
xA


AG-36196


AG-33173


AG-03513


AF-97586


Team Blackmon
CHEVROLET
AF-13460


AE-99204
ALTIMA


AD-64939


AD-61988


AD-37686


AC-43949
CHEVROLET


AB·97777


HIGHLANDER
AB·96352


AA-72336


AA-46176


Charter Oak
Mechanical LLC
860-432-8915
RAM
9907-CU


REGAL CLEANING
Commercial Residential
860.331.8100
3363-DF
REGALCT.COM


DODGE
4X4
2369-DB


952·UUZ


COROLLA
939·XMF


889·YZN


850-ZRR


848-VBC


789-WFU


719·XOZ


702·YLF


583-PZD
HONDA
CR-V


489-ZOH


268·TSE
CHEVROLET


265·HNT


228-ZYV
MAXIMA


GMC
207-UYD


100-APV


ALTIMA
9AN-EN6


CHEVROLET
9AEHX9


SIERRA
GMC


7AP-MLO


7AP-LX3


6AV-KJ1


6AV-HH1


6AM-EA6


5AP-AF3
ODYSSEY


5AK-UUO

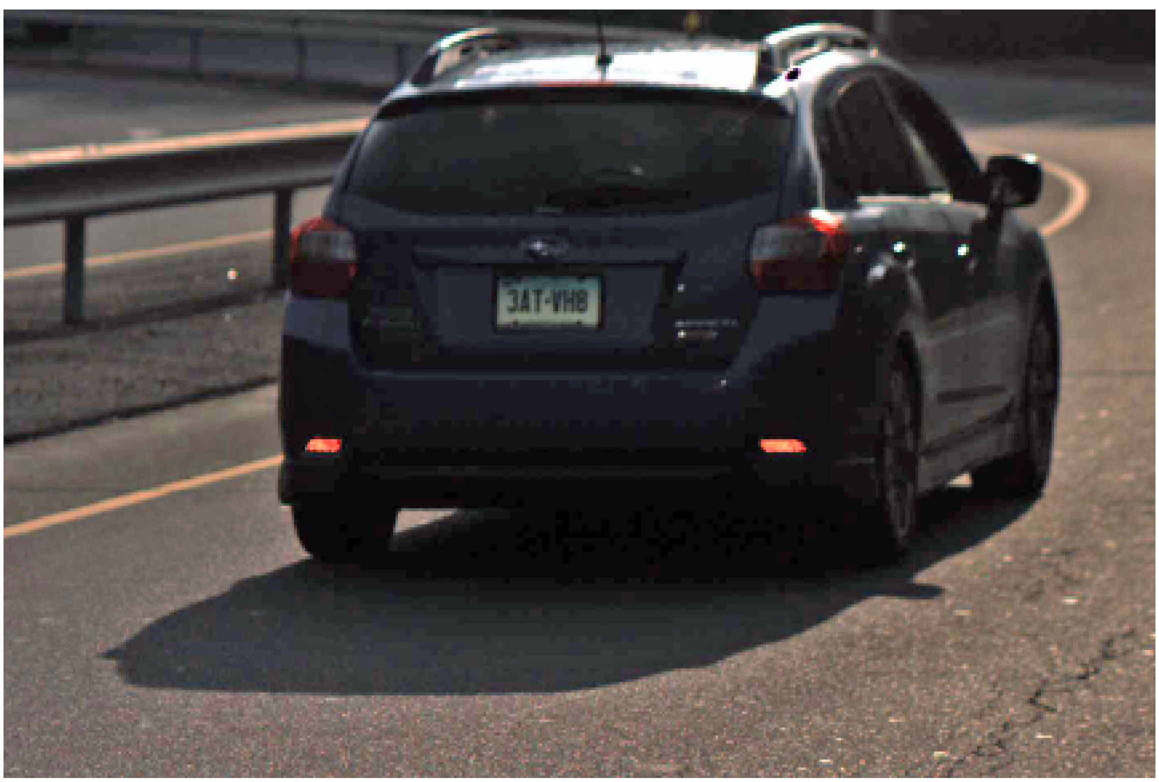

4AR·TFO


4AR·NT5


4AH·PV5


3AX·HF0


PATHFINDER
3AU-DV9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TOYOTA
2AT-WP9


OAW·HS5


00·BSOP