A Report from the University of Vermont Transportation Research Center

Vermont 2016 Annual Seat Belt Use Survey

Final Report

TRC Report 17-001

January 2017

Samantha Tilton, James Sullivan, Jonathan Dowds, and Karen Sentoff

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Prepared by:

Samantha Tilton
Jim Sullivan
Jonathan Dowds
Karen Sentoff

Transportation Research Center
Farrell Hall
210 Colchester Avenue
Burlington, VT 05405

Website: www.uvm.edu/trc

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Disclaimer

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1 Introduction

The UMV TRC is contracted to conduct seat belt observational surveys to evaluate use rates in Vermont after the annual “Click-It-or-Ticket” enforcement mobilizations in May of 2015 and 2016. This report was prepared pursuant to the “GHSP Annual Seat Belt Survey” scope of work for the contract with the Vermont Agency of Transportation (VTrans). The objective of the project is to continue the annual survey of seat belt use in accordance with 23 CFR Part 1340 – *Uniform Criteria for State Observational Surveys of Seat Belt Use*. The purpose of this report is to document the activities which were completed under this contract for the 2016 survey.

In 2015, there were an estimated 57 fatalities in Vermont due to vehicle crashes, and at the writing of this document, there have been 64 for 2016 (AOT, 2017a). Forty-five percent of the fatalities involving vehicles with seatbelts available were unbelted occupants (AOT, 2017b). The use of safety belts reduces both fatalities and injuries to drivers and passengers. Vermont’s seat belt use rate has been increasing steadily in the last few decades, from approximately 54% in 1992 to approximately 86% in 2015 (Tilton et. al., 2016; VCJR, 2008). Fatalities have also dropped in that time from approximately 90 deaths in 1992 to 57 in 2015 (Tilton et. al., 2016; AOT, 2017a).

The Vermont Governor’s Highway Safety Program (GHSP) exists to support safe driving on Vermont highways. By promoting awareness through education, along with enforcement, the GHSP strives for zero deaths on the road. The GHSP has been conducting seat-belt use observation surveys to gauge usage on Vermont roads and compare the results over time. 2008 marked the tenth year that the GHSP used the current NHTSA-approved methodology which includes the survey matched with the high-visibility enforcement program (“Click-It-or-Ticket”) (VCJR, 2008). Each survey presents an opportunity to reflect on the effectiveness of the high-visibility enforcement efforts. Over the past twelve years, the seat belt usage rate statewide in Vermont has been above 80% with lower use in the more rural areas of the state (GHSP, 2016).

The purpose of this study was to conduct the annual seat belt survey for 2016 at 82 roadside locations to determine the percentage of drivers and front-seat passengers who were using seat belts. The field work for this survey was conducted primarily during the months of June, July, and August in 2016, following the annual “Click-It-or-Ticket” campaign in May. Following the field observations, NHTSA-approved procedures were followed to develop a statewide weighted average of seat-belt use, along with an estimate of the standard error and the non-response rate for the 2016 survey.

2 Study Area and Survey Design

The study area and design for this survey follows the NHTSA-approved design as established by VTrans in accordance with 23 CFR Part 1340. Sites were selected to reflect areas that account for 85 percent of fatalities in Vermont based on road-segment type from an NHTSA-approved road inventory. From these selected locations, geographic probabilities of selection were then determined for use in the statistical weighting process. Assignment of observation times and procedures followed the requirements of 23 CFR Part 1340 by working between 7:00am and 6:00pm during all days of the week selected at random. Drivers and passengers were recorded as wearing a seat belt if the shoulder belt was visible in front of the person's shoulder (23 CFR 1340, 2012). Computation of the weighted average, including sampling weights and standard error also followed the CFR 1340 guidelines and the NHTSA-approved survey design.

The survey sites were stratified across two dimensions during the site selection process: geographically by county groups (CG) and roadway functional classification (FC). All of Vermont's counties were included in the site-selection process and were grouped in the survey design as follows:

Table 1 County Group Description

County Group	Counties
BAD	Bennington, Addison (southwest)
CC	Chittenden
FGI	Franklin, Grand Isle (northwest)
NEK	Essex, Orleans, Caledonia (the "Northeast Kingdom")
Rut	Rutland (central-west)
WL	Washington, Lamoille (central)
WOW	Windsor, Windham, Orange (southeast)

Roadway functional classes were stratified in two categories – arterials and collectors. Therefore, in all, 14 stratified classifications were used to select road segments for observation - one for each CG in each FC. A total of 82 primary sites were selected, along with 22 back-up sites intended to provide substitute locations in case one of the primary sites would not be observed. In 2016, one of the primary sites could not be used so a back-up site was substituted. The primary site featured less than 10 vehicles in the 45-minute period of observation, so conducting the observation was not feasible. A map of the final set of observation sites is provided in Figure 1.

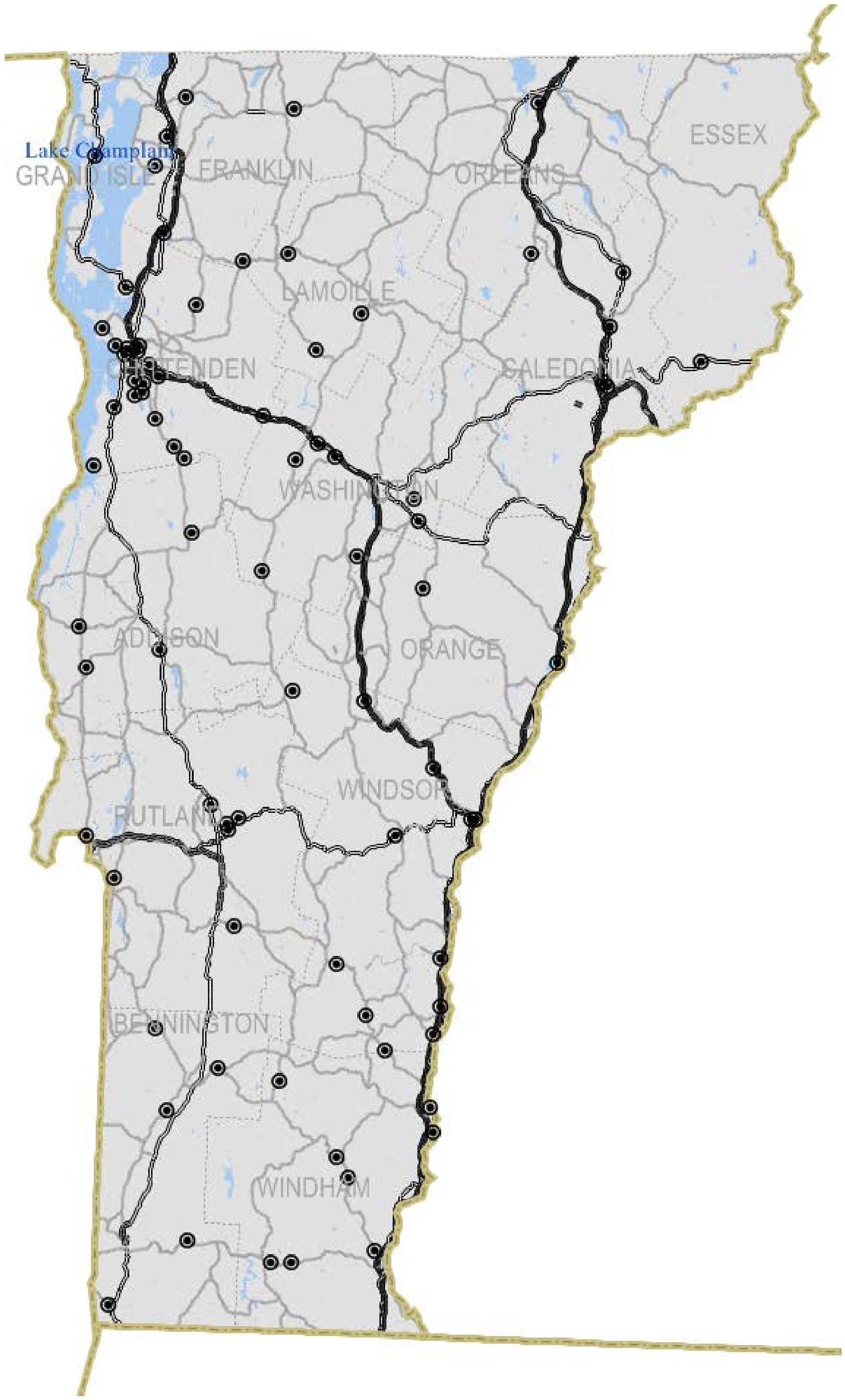

Figure 1 Observation Sites Used in the 2016 Seat Belt Use Survey

The 82 sites were designed to collect an adequate set of observations for the effective estimation of a statewide seat-belt use rate with a standard error that is under 2.5% and a "non-response" rate, or "couldn't tell" rate that is under 10%, as dictated by the 23 CFR 1340. This design was expected to generate between 12,000 and 15,000 observations of drivers on Vermont roads and to meet the CFR requirement for standard error. During the 2016 survey, 15,057 successful observations of drivers were made. Along with 4,639 successful observations of front-seat passengers, a total of 19,696 seat belt observations were made.

3 Methodology

3.1 Data Collection Method

A method for collecting the observation data was first developed while staff were being trained to make effective observations. Sites closest to the UVM TRC in Burlington were used for testing the roadside observation procedures in 2015 before implementing the survey on a full scale. The goals of the method development were (1) to keep roadside observers safe, and (2) to collect effective counts of seat-belt use rates with non-response rates of less than 10%.

Staff considered several different options for how to create the optimal counting procedure which would allow for maximum effectiveness and ease for the user. An iPad was chosen as the ideal tool as it would allow for easy data collection that could be saved for future reference. Staff decided to use the "Tally Counters" app for iPad as it allowed for multiple variables to be counted and stored at the same time. The most effective method for saving the data for each site was to take a screenshot of the iPad screen with the Tally Counter app showing at the end of the count. This allowed the precise coordinates of the observation location to be recorded as well. The screen shot was then tagged with the site location and time. Screenshots (see Figure 2.) were then sent back to the office where another staff person entered the data into an Excel worksheet and archived the screenshot.

For each site, the following data was recorded:

- Name of observer
- Site ID
- Direction of travel being observed
- Date and start and end times of observation

For each observation, the seat belt use status of driver and front-seat passenger (if applicable) were recorded:

- Belted (if the shoulder belt is visible in front of the person's shoulder)
- Unbelted (if the shoulder belt is not in front of the person's shoulder)
- Couldn't Tell (if it cannot be determined if the driver or passenger is belted)

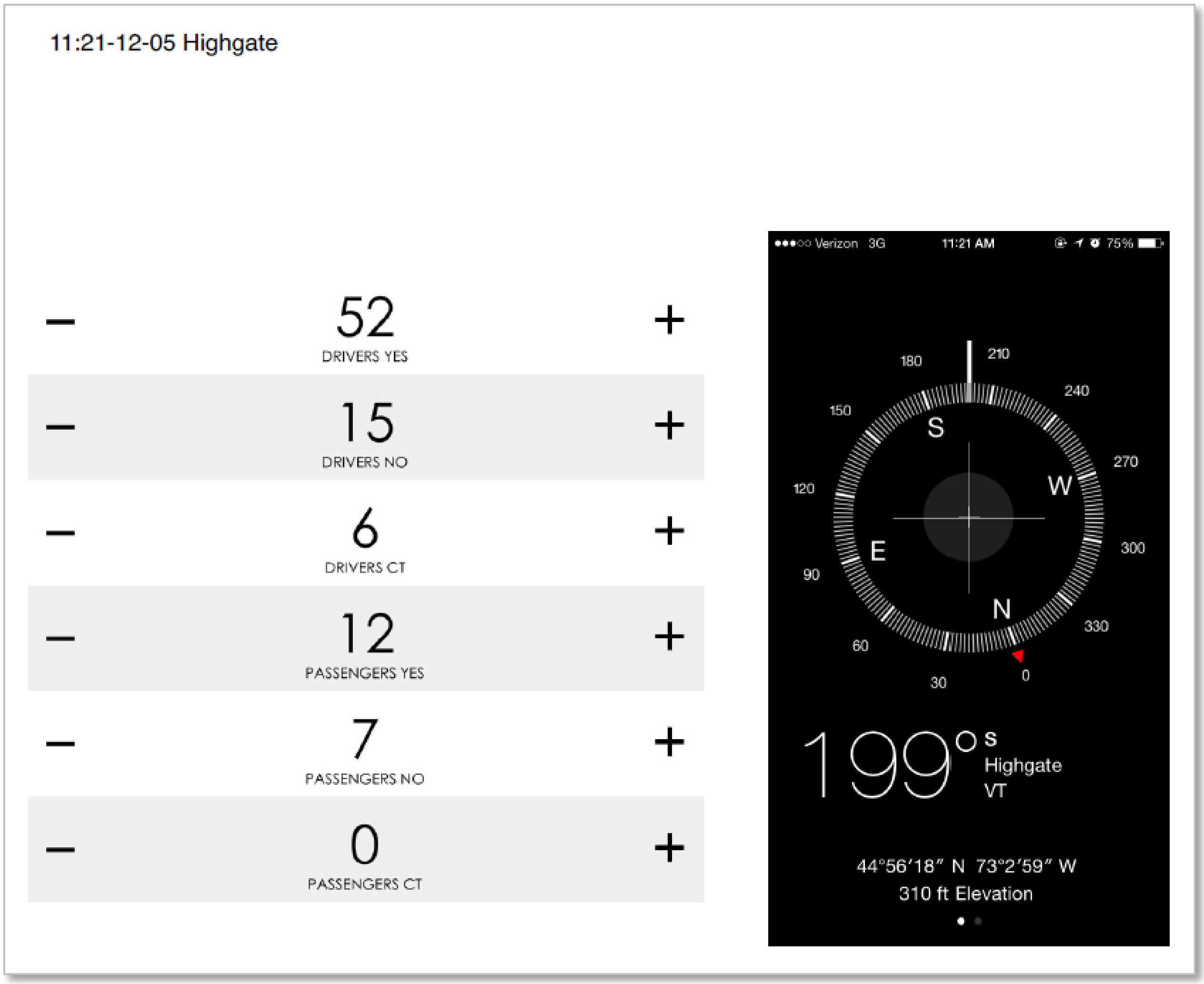

Figure 2 Example Screenshot

Observations were conducted during randomly selected daylight hours on weekdays between 7 a.m. and 6 p.m. Data collection was conducted for 45 minutes at each site.

Several challenges to data collection presented themselves over the course of the field work. While weather, especially rain, had the potential to impact staff's ability to collect data, it proved to be the sun that was the biggest obstacle to making observations. Overall the most common challenges were:

- Glare on windshields created a challenge as seat belt observers could sometimes move positions or observe in the opposite direction to avoid glare, but often this did not solve the problem.
- Seats with a built-in seat belt which was anchored into the seat rather than on the frame of the vehicle also created a difficult situation to see if the seat belt was being used or not.

- Cabins of large vehicles were often too high for staff to see inside. Large vehicles included construction vehicles and large trucks.
- Clothing color that matched the color of the seat belt was another challenging situation to make a clear observation.

Each of these challenges contributed to the non-response rate, or the recording of a "Couldn't Tell" during observation.

3.2 Collection of Data

Staff observed vehicles from the side of the road to record seat belt use by drivers and front seat passengers. Staff were instructed to observe all lanes of traffic, if possible, in one direction of travel, or to note which lane they were observing for sites with 2 lanes in each direction. Observations were made of all front seat occupants (driver and passenger) within a 45-minute time.

A subset of backup sites were also observed to serve as substitutes, if necessary. One primary site proved to need a backup site substitution due to a lack of vehicles to observe in the 45-minute time period selected. This site also lacked enough vehicles to make a 45-minute observation in 2015, something to consider when updating the locations of the test sites in 2018. Locations with a relatively low AADT may not have more than 10 or 11 vehicles pass during a 45-minute period in the off-peak periods.

A typical day of field observation included a driver and one or more additional staff members on an observation team. When multiple staff observers were available, the driver would drop off one observer at the first site, drop the next observer at a second site, wait for the second site to be observed, then backtrack to pick up the first observer before returning back to UVM. For sites that were far from the UVM TRC, normally no more than 2 sites were feasible to be observed in a day. One overnight stay was included in the observation period to eliminate the longest travel times to/from a group of sites in the far southeast corner of the state.

Interstate sites were observed from the emergency turnaround nearest the proposed site, by senior staff, following the protocols required by an Interstate U-Turn Authorization permit (Appendix A). A separate staff person was responsible for the interstate sites as well as obtaining the permit to allow for the TRC vehicle to use the turnaround. A complete summary of the observations for each site is provided in Appendix B.

3.3 Data Analysis

Under the stratified multistage sample design that was used to determine the 82 intended sites, the inclusion probability for each observation in the statewide sample is the product of the inclusion probabilities at each stage (NHTSA, 2011). A total of 8 stages were used in the sample design:

For the location of each observation site:

a. County Group

b. Functional Classification of the Roadway

c. Road Segment

For the specific observations at each site:

d. Time Segment Observed – weekend, weekday non-peak, weekday peak

e. Travel Direction Observed

f. Lanes Each Way Observed

g. Observation Rate

h. Front Seat Occupants Observed

Therefore, in order to calculate a weighted average of the observation rates at each site, inclusion probabilities corresponding to each of the stratification stages were needed.

The inclusion probabilities for the first 3 stages (a., b., and c.) are directly related to the selection of sites. Since the site locations were maintained from the original NHTSA-approved survey design for Vermont, the combined inclusion probabilities to account for these three location-based stages was already known. These inclusion probabilities are included in the site-description table in Appendix B. These inclusion probabilities are based on the vehicle-miles of travel (VMT) represented by the specific site location, which are then divided by the total VMT in the stage-category being considered. The 14 geographic stage-categories are described in Section 2. The VMT represented by each specific site is also provided in Appendix B.

The inclusion probabilities for the Time Segment Observed stage corresponds to the probability of an observation being on a weekend, a non-peak hour of a weekday, or a peak-hour of a weekday. This inclusion probability is also based on the VMT represented by the specific site location divided by the total VMT in the stage-category being considered (weekend, weekday peak, or weekday non-peak).

The inclusion probabilities of the Travel Direction Observed stage corresponds to the probability of an observation being made in both travel directions at its site. Since all of the sites observed in this study were on roads with two-way traffic and only one of those directions was observed in each case (to reduce glare and maximize safety), the inclusion probabilities for all of the sites for Travel Direction Observed were 0.5. This value indicates that, for every site, only one of the two possible travel directions was observed.

The inclusion probabilities of the Lanes Each Way Observed stage corresponds to the probability of an observation being made for all of the travel lanes in each direction at a site. The goal for all of the sites observed in this study was to observe all lanes of travel in the direction chosen for observation. When this was successful, the inclusion probabilities for Lanes Each Way Observed were 1.0. However, at 3 of the sites, 2 lanes of travel were present for the direction chosen, but only one could be observed. At these sites, safety concerns typically prevented the observation staff from getting close enough to the roadside to observe the inner lane. For these 3 sites, the Lanes Each Way Observed inclusion probabilities were 0.5.

The inclusion probabilities of the Observation Rate stage corresponds to the probability of an observation being made for each vehicle that passes. Therefore, these inclusion probabilities correspond to the success rate of observations for the site, or the inverse of the non-response rate. This value was calculated by dividing the number of vehicles where a successful observation was made (Belted or Unbelted) divided by the total number of vehicles that passed during the observation period (Belted or Unbelted + Couldn't Tell).

The inclusion probabilities of the Front Seat Occupants Observed stage correspond to the probability of an observation being made for all of the front-row occupants of a vehicle (driver and passenger) at a site. Since all of the sites observed in this study included observation of all front seat occupants for the site being observed, the inclusion probabilities for all of the sites for Front Seat Occupants Observed were 1.0.

From these inclusion probabilities, a sample weight was calculated for each site y, by taking the inverse of the product of all its inclusion probabilities:

$$w_y = \frac{1}{\pi_{ifry}\pi_{jy}\pi_{ky}\pi_{ly}\pi_{my}\pi_{ny}}$$

Where π corresponds to the probability of selection, and the subscripts refer to:

- r –region (CG)
- f –functional classification (FC)
- i –road segment
- j –time segment
- k - road direction
- l –lane
- m –vehicle
- n –front-seat occupant

Once the weights had been calculated for each site, the statewide weighted usage rate (R) was calculated as:

$$R = \frac{\sum(bd_y + bp_y)w_y}{\sum(bd_y + bp_y + ud_y + up_y)w_y}$$

Where:

- bd_y is the count of belted drivers at site y
- bp_y is the count of belted passengers at site y
- ud_y is the count of unbelted drivers at site y
- up_y is the count of unbelted passengers at site y

The unweighted statewide usage rate (r) was also calculated as:

$$r = \frac{\sum(bd_y + bp_y)}{\sum(bd_y + bp_y + ud_y + up_y)}$$

But individual raw usage rates can also be calculated at each site y as:

$$r_y = \frac{bd_y + bp_y}{bd_y + bp_y + ud_y + up_y}$$

The standard error (SE) of the entire survey was then calculated as:

$$SE = \sqrt{\frac{(\frac{r}{n})(1 - \frac{r}{n})}{\sum_y(bd_y + bp_y + ud_y + up_y)}}$$

Where *n* is the number of sites (82). In the event that the SE exceeds 2.5%, additional observations are taken at existing sites to increase observations until the desired precision is achieved. During the 2016 observation survey it was not necessary to make additional observations since the original SE was below 2.5%.

4 Results

During our field work, a total of 18,982successful observations of seat belt use were made at the 82 sites used to calculate the statewide weighted average. Observations from 1 of the back-up sites was used in place of a primary site which did not have any observations during the 45-minute period when observation was attempted. The final non-response rate was 0.7%. **The overall weighted statewide seat belt use rate for Vermont was calculated to be 80.4% and the standard error rate was calculated to 0.2%.**

Table 2 provides the raw (unweighted) rates (r) for all observations used to calculate the statewide rate.

Table 2: Raw (Unweighted) Seat Belt Usage Rates

Front-Seat Occupant	RawObservation Rate (r)
Driver Only	85.7%
Passenger Only	87.0%
Both	86.0%

Summary statistics for raw seat belt usage rates at all 82 sites used to calculate the statewide rate are provided in Table 3.

Table 3: Raw Usage Rates

	Min	Max	Mean
Observation Rates	84.4%	100.0%	99.2%
Raw Usage Rates (r_y) (Driver Only)	66.4%	94.8%	84.5%
Raw Usage Rates (r_y) (Passenger Only)	50.0%	100.0%	84.2%

Seat belt use rates observed at each of the 82 sites statewide which contributed to the final weighted rate of 80.4% are shown in Figure 3.

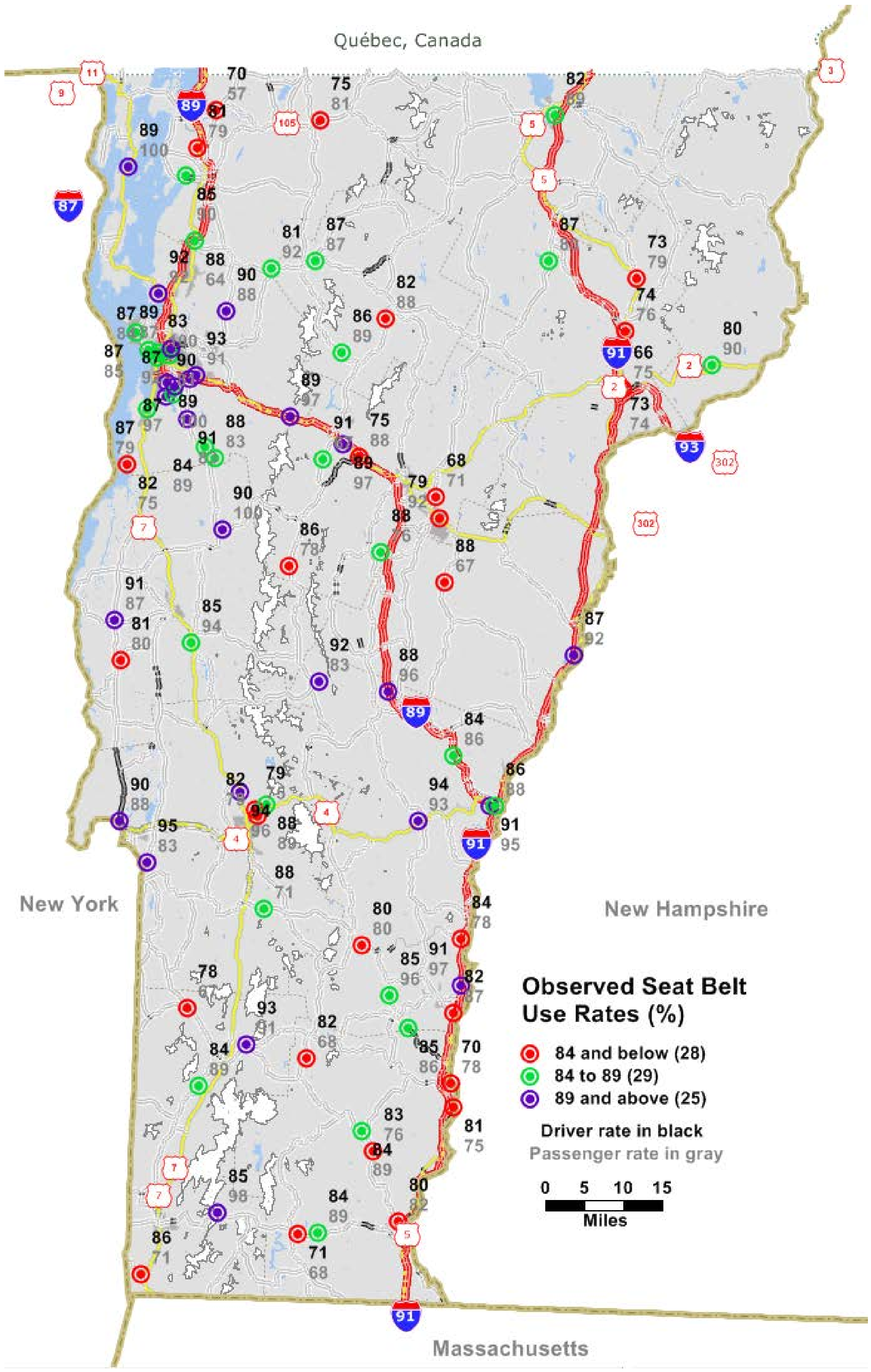

Figure 3 Statewide Seat Belt Use Rates

Site-by-site raw seat belt use rates are provided in Appendix C.

5 Conclusions and Discussion of Methodology

In 2016, the weighted average statewide seat belt use rate of 80.4% was found to have decreased significantly from its value of 85.8% in 2015. This apparent decrease was significant enough to warrant attention from an enforcement and policy perspective. However, upon further inspection of the observations, it became apparent that the raw results had not changed appreciably, as seen in Table 4.

Table 4: Seat Belt Rate Comparison 2015 - 2016

Year	Total Occupants Observed	Total Occupants Belted	Belted %
2015	25,277	21,918	86.7%
2016	19,696	16,938	86.0%

In addition, the raw results in 2015 were very similar to the weighted average, but in 2016 the two diverged significantly. Based on this discrepancy, the weighting process dictated by Vermont's NHTSA-approved plan was reviewed carefully and found to misrepresent the use of seat-belts statewide. The primary shortcoming of the NHTSA-approved method is that, for Vermont, the weighting process makes our overall weighted statewide rate significantly affected by the raw rates at just 4 of our 82 observation sites - TRC13, TRC32, TRC50, and TRC56. These four sites alone account for 72% of the total weighting the estimation of a statewide average (see Appendix C for actual site-specific use rates and weights), but comprise only 1% (206) of the 19,696 observations.

Each of these sites is on a low-volume roadway with a relatively low DVMT. The weighting process responds to this by weighting these samples very highly in the geographic probability of selection step, so they have an enormous influence on the overall weighted average, whereas they do not have a significant influence on the raw average. In fact, taking the raw average of these 4 sites alone for 2015 and 2016 gives us a good approximation the statewide weighted average (Table 5).

Table 5: Raw Rate for Selected Sites

Year	Raw Average Statewide	Raw Average of TRC13, TRC32, TRC50, and TRC56	Weighted Average Statewide
2015	86.4%	85.6%	85.8%
2016	84.6%	78.5%	80.4%

In particular, TRC13, which is in Barre, Vermont, had a very low rate of seat-belt usage this year (69%), which affected our weighted average significantly. The fact that these 4 sites would be observed alone and provide a fairly accurate idea of the overall statewide weighted average is very troubling. None of the individual observation sites should have such a large influence on the final weighted average. For enforcement and policy purposes, the UVM TRC recommends considering the raw average statewide rate as a more accurate indicator of seat-belt use amongst Vermonters. **As such, our conclusion is that the rate has not changed appreciably between 2015 and 2016.**

Before the 2018 observations are made, Vermont will have the opportunity to revise its site selections and its statistical process for calculating a weighted average statewide use rate. It will be critical at that time to consider a variety of geographic and statistical methodologies for weighting the sites, along with an increase in the number of sites to be observed. Each of these considerations has the potential to reduce the reliance of the final statewide weighted average on a small subset of the sites, as is the case currently.

Some examples of alternate procedures for developing geographic probabilities of selection based on county groups (CG) and functional classifications (FC) include:

- Re-grouping roadways with a new selection of CGs and FCs so that groups with a low number of sites and low DVMT do not exist – these result in unusually high weights

- Adding sites in groups with a low number of sites and low DVMT to reduce the reliance on individual low-volume sites
- Enforcing a constraint on the variance of the resulting weights and running the process stochastically until the resulting weights meet the constraint
- Developing a new observation process that dramatically increases the DVMT representation of individual observations

In the interest of advancing the last alternate procedure listed, the UVM TRC has been exploring the use of video-based data collection for the purpose of conducting future seat belt observation surveys. The UVM TRC has extensive experience with collecting standard color and thermal video data for traffic counting and snow & ice control performance measurement. These efforts have involved extensive logging of video recordings in roadside and vehicle-mounted environments for visual and automated review back in a secure office environment. The benefit of using video-based data collection is that the visual or automated review of the recorded video can be repeated using different personnel or different computing procedures to improve the quality of methodology.

For these reasons, the use of video-based data collection offers a variety of advantages over the current in-person roadside observation procedure used for Vermont's annual seat belt survey. The ability to mount or drive a camera at a site or along a driven trajectory will eliminate the need to leave an observer at the roadside, improving the safety for observers and diversifying the variety of people who are capable of conducting the observations. In addition, with video recordings representing the seat belt sites or trajectories, observations can be repeated by different observers so an estimate of the margin of error for a site-specific observation rate can be made. Objective assessments of observers can be made over time and training can be rapidly improved for more accurate observation rates over time.

Figure 4 Camera Mounted to Roadside Power Pole

Roadside video data collection was pilot tested using equipment that UVM TRC already owned from a previous project aimed at counting non-motorized traffic on a roadway. Permission was obtained to install the camera system on roadside power poles for this test (see Figure 4).

Reviewing the video recorded at these types of locations, though, it became clear that a roadside camera mounted on a power pole could be as much as 25 feet from the position of the driver as the vehicle passed, making the observation of the driver's seat belt status very difficult. In addition, this positioning often resulted in an unacceptable level of glare reflection off the windshield of the approaching vehicle, making observation impossible. In fact, it was often easier to discern the belted status of the drivers of vehicles on the far side of the road, as opposed to the near side. The series of images in Figure 5 illustrate the variety of views of the far side of the roadway that are possible with a roadside installation.

Inspired by the types of imagery that are viewable in the still images on Google's Streetview tool, the UVM TRC decided to begin experimenting with a vehicle-mounted camera for collection of trajectory-based video for seat belt observation. Examples of images obtained from Google Streetview of Vermont drivers' and passengers' seat belt status are shown in the series of images in Figure 6.

Figure 5 Video Images Obtained from a Roadside Camera Installation

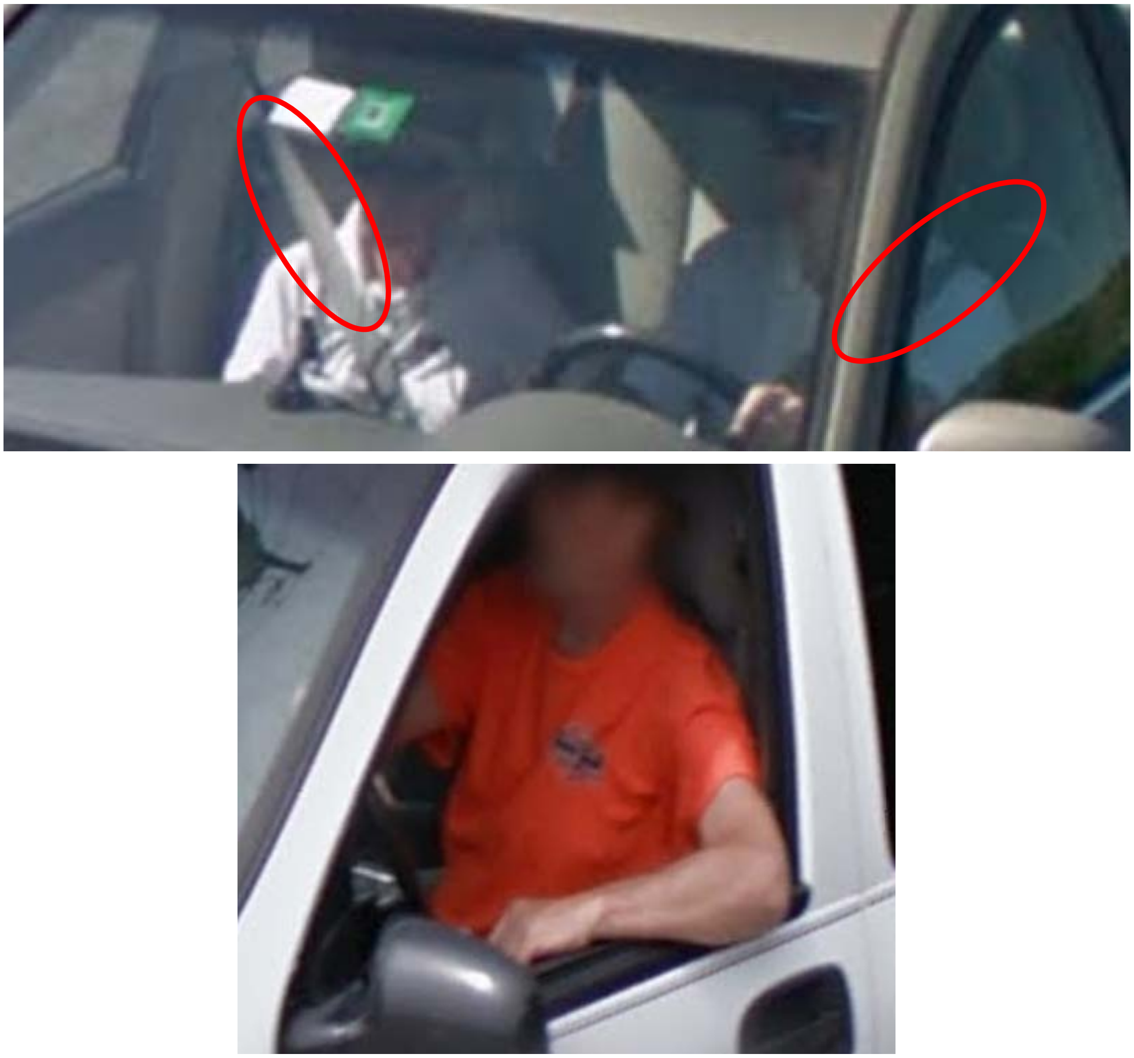

Figure 6 Drivers and Passengers' Seat Belt Use in Vermont (Google Streetview)

Other images obtained from Google Streetview also reveal drivers' use of portable computing devices while driving, as shown in Figure 7. Google uses a versatile image recording system mounted on top of a vehicle to obtain its imagery (see Figure 8).

Figure 7 Drivers Using Portable Computing Devices While Driving in Vermont (Google Streetview)

Figure 8 The Google Streetview Car

Attempts by the UVM TRC to replicate the image quality obtained from the Google Streetview Car have been unsuccessful but promising. Although the issue of glare has been largely resolved through the use of polarized filters on the camera and the issue of proximity to the driver has been resolved by using a drivers-side camera mounted to record the opposing traffic stream, the resolution obtained by the UVM TRC's effort has not been high enough to discern the belted status of the driver of an opposing vehicle (see Figure 9).

Figure 9 Insufficient Resolution of Imagery Obtained by the UVM TRC

The reason for this poor resolution is largely an issue with the frame rate of the recording. The UVM TRC camera is recording high-definition video at about 30 frames per second. However, since the opposing traffic stream is being recorded, the relative speed of the driver can be over 80 mph, making the resulting still images hazy. The high-definition multimedia interface (HDMI) standard, version 1.4 introduced the kind of bandwidth required to deliver 4K video, but it was limited to about 30 frames per second. Newer HDMI 2.0 cameras can capture 4K video at up to 60 frames per second, allowing a much higher resolution of still images captured from the playback. We expect that a camera with the capability of recording at 60 frames per second will allow the discernment of the belted status of the front-seat occupants of an opposing vehicle in traffic.

The use of a trajectory-based video capture system to assist with the Vermont seat belt observation surveys will significantly enhance the quality of the survey in a variety of ways. As mentioned previously, the availability of recorded video for repeated observations will enhance quality control of the observations. However, this process will also allow observations to be made in a wider variety of weather conditions, and in multiple seasons, improving the sample representation of year-long vehicle miles of travel in Vermont. Currently, our 82 static observation sites represent only 0.01% of the total annual VMT in Vermont. Trajectory-based observations are expected to dramatically improve that figure, reducing the impact of site-specific weights on the resulting weighted average.

6 References

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Appendix A: Interstate U-Turn Authorization Permit

CERTIFICATE

Samantha Tilton
University of Vermont

Vermont Agency of Transportation

INTERSTATE U-TURN AUTHORIZATION

The Bearer of this Certificate, as a representative of the University of Vermont, is hereby authorized to utilize the U-Turns on Interstate 89 from the New Hampshire/Vermont State Line to Exit 13 both westbound and eastbound, and on Interstate 91 from the U.S./Canadian Border to Exit 7 both northbound and southbound, during the execution of her duties while conducting a 2016 Seatbelt Survey through the University of Vermont's Transportation Research Center. Anticipated timeframe for this research work is August 3 through August 18, 2016. If the work is not completed by that date, this Certificate will remain in effect until the work is completed and accepted by all pertinent parties as long as employee is assigned to said assignment.

Persons using the U-Turns shall abide by the following and the Guidelines for the Proper use of U-Turns on Limited Access Highways on the reverse side of this Certificate:

1. Have this authorization in his/her possession.
2. Use the U-Turn with the utmost caution.
3. Use a flashing amber light located on the roof of the vehicle.
4. Yield to all Interstate-through traffic.
5. U-Turns will not be utilized during inclement weather or fog conditions.

Failure to comply with any of the above shall be grounds for revoking this authorization.

Kevin Marshia, P. E. — Date: 8/2/16
Chief Engineer
Highway Division
Vermont Agency of Transportation
1 National Life Drive
Montpelier, VT 05633-5001

VTrans Working to Get You There — Vermont Agency of Transportation

c: State Police, Lt. John Flannigan and Sgt. Owen Ballinger
Montpelier Project Files

C:\Users\DHolden\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\V6NQM3XG\UVM Research Program 2016 Seatbelt Survey Samantha Tilton.doc

Appendix B: Observation Results by 45-Minute Observation Period

Heading Legend:

SID = Observation Site ID Number (internal to study).

TRC ID = Observation site ID for sites observed in 2015

CG = County group.

FC = Functional classification of roadway.

S = Site status – Primary (P) or Back-up (B).

DVMT = Daily vehicle-miles of travel represented by the road segment

SEGID = Agency of Transportation Segment ID

Route = Agency of Transportation highway designation of roadway.

CntSta = Nearest continuous traffic count station.

AADT = Annualized Average Daily Traffic.

$\boldsymbol{\pi_{ifr}}$ **=** Probability that a segment is included in its County Group, Functional Classification group, and Segment group.

City or Town = Vermont city or town where the count site was located

Date Observed = Date which observations were conducted.

Driver Belted = Driver was observed wearing a seat belt.

Driver Not Belted = Driver was observed not wearing a seat belt.

Driver Couldn't Tell = Observer could not determine if driver was wearing a seat belt.

Passenger Belted = Passenger was observed wearing a seat belt.

Passenger Not Belted = Passenger was observed not wearing a seat belt.

Passenger Couldn't Tell = Observer could not determine if passenger was wearing a seat belt.

TRC ID	CG	FC	S	SID	DVMT	SEGID	Route	FC	CntSta	AADT	City or Town	Date Observed	π_{ilfr}	Driver Belted	Driver Not Belted	Driver Couldn't Tell	Passenger Belted	Passenger Not Belted	Passenger Couldn't Tell	Total Belted	Total Successfully Observed
TRC01	CC	Art	P	1106	3,779	8817	TH-4	14	D156	15300	Burlington	8/4/2016	0.0645	314	54	0	81	13	0	395	462
TRC02	CC	Art	P	1111	13,242	7984	TH-9	12	D001	14600	Burlington	8/4/2016	0.2261	369	57	0	92	18	0	461	536
TRC03	CC	Col	P	1207	1,156	8189	TH-13	17	D447	11800	Burlington	8/11/2016	0.0189	20	4	0	2	0	0	22	26
TRC04	CC	Art	P	1103	1,338	40542	TH-3	16	D331	6400	S. Burlington	8/4/2016	0.0229	160	21	1	43	8	0	203	232
TRC05	CC	Art	P	1110	5,242	40244	VT-116	14	D525	5500	S. Burlington	7/25/2016	0.0894	124	18	0	32	1	0	156	175
TRC06	CC	Col	P	1206	1,380	40505	TH-6	17	D524	5000	S. Burlington	9/19/2016	0.0225	91	11	0	14	0	0	105	116
TRC08	CC	Col	P	1201	2,056	40497	TH-10	17	SOBR40	4000	S. Burlington	7/25/2016	0.0336	83	12	0	11	1	0	94	107
TRC09	WL	Art	P	6104	22,599	V015-080207	V015-	6	NA	5700	Cambridge	7/26/2016	0.1055	113	17	1	40	6	0	153	176
TRC10	WL	Art	P	6107	6,885	V104-080201	V104-	6	NA	3500	Cambridge	7/26/2016	0.0321	69	16	0	23	2	0	92	110
TRC11	FGI	Col	P	3202	403	V207-060902	VT-207	7	F155	3100	Highgate	6/1/2016	0.0152	43	20	1	2	2	1	89	130
TRC12	WL	Art	P	6102	6,818	U302-120201	U302-	14	NA	6800	Barre Town	7/27/2016	0.0319	130	34	1	46	4	0	176	214
TRC13	WL	Col	P	6201	1,091	S6104120201	S6104	17	W239	2000	Barre Town	7/27/2016	0.0065	41	19	0	10	4	0	51	74
TRC14	CC	Art	P	1102	42,509	5177	I-89	1	W089	25500	Bolton	8/15/2016	0.7258	204	26	6	34	1	0	238	265
TRC15	WL	Art	P	6101	23,382	V100-120601	V100-	6	W364	3800	Duxbury	7/16/2016	0.1091	162	23	0	89	11	0	72	82
TRC18	WL	Art	P	6105	115,783	I089-000011	I-89-	1	W034	23100	Middlesex	8/16/2016	0.5405	204	26	6	34	1	0	238	265
TRC19	WL	Col	P	6203	1,799	U002-121002	U002-	7	W145	3800	Middlesex	7/16/2016	0.0107	70	23	0	30	4	0	100	127
TRC20	WL	Col	B	6221	8,465	V064-121301	V064-	7	W357	3400	Northfield	7/16/2016	0.1929	100	13	0	42	13	0	142	168
TRC21	WL	Col	P	6202	32,378	V108-080803	V108-	7	L130	8400	Stowe	6/28/2016	0.091	124	21	0	49	6	1	173	200
TRC22	CC	Art	P	1107	5,333	12336	US-2	16	D019	10100	Colchester	8/8/2016	0.0904	315	29	0	132	11	0	447	487
TRC23	CC	Art	P	1105	5,292	57918	TH-1	16	COLC19	14000	Colchester	8/4/2016	0.0585	299	44	0	52	9	0	351	404
TRC24	CC	Art	P	1112	3,428	11978	VT-15	14	COLC13	20900	Colchester	8/3/2016	0.0254	472	56	3	114	17	0	586	659
TRC25	CC	Art	P	1108	1,488	51145	I-89	11	D423	8500	Williston	9/16/2016	0.0368	630	78	6	108	9	2	738	825
TRC26	CC	Col	P	1203	2,254	39275	TH-5	19	SHEL01	3400	Shelburne	7/25/2016	0.1295	94	10	0	17	4	0	111	125
TRC27	CC	Art	P	1113	7,582	61599	VT-116	6	D296	10400	Hinesburg	7/21/2016	0.0372	168	17	0	34	7	0	202	226
TRC28	CC	Art	P	1109	2,179	22281	VT-116	6	D127	3700	Hinesburg	7/21/2016	0.1521	85	16	1	25	3	0	110	129
TRC29	CC	Art	P	1101	8,906	39109	US-7	14	D243	18400	Shelburne	7/21/2016	0.0606	435	63	0	68	18	0	503	584
TRC30	CC	Col	P	1205	3,706	22311	TH-5	7	D360	1600	Hinesburg	7/21/2016	0.0071	28	4	0	5	1	0	33	38
TRC32	CC	Col	P	1204	437	10583	TH-4	9	D370	770	Charlotte	7/21/2016	0.0146	18	4	0	3	1	0	21	26
TRC33	BAd	Col	P	2201	2,737	V017-010302	V017-	7	A015	1600	Bristol	6/30/2016	0.179	44	5	0	10	0	0	54	59
TRC34	WL	Art	P	6103	38,340	V100-080701	V100-	6	L179	8700	Morristown	6/28/2016	0.08	164	36	1	42	6	0	206	248
TRC35	CC	Col	P	1202	4,897	49157	VT-128	7	D309	2100	Westford	7/26/2016	0.0344	27	3	0	7	1	0	34	38
TRC36	FGI	Art	P	3101	8,207	V104A060801	VT-104A	6	F047	4700	Georgia	6/23/2016	0.0104	97	13	3	9	5	0	106	124
TRC37	BAd	Art	P	2101	2,048	V022A010203	V022A	6	A113	4500	Bridport	6/27/2016	0.0332	136	14	2	55	8	0	191	213
TRC38	BAd	Col	P	2203	6,245	V074-011807	V074-	7	A154	1900	Shoreham	6/27/2016	0.0761	26	6	0	4	1	0	30	37
TRC39	BAd	Art	P	2106	14,919	U007-011703	U007-	2	A107	7900	Salisbury	7/7/2016	0.0125	224	38	2	73	5	0	297	340
TRC40	WL	Art	P	6106	2,683	V100-121702	V100-	6	W008	1300	Warren	7/7/2016	0.2214	31	5	0	14	4	1	45	54
TRC42	WOW	Art	P	7109	47,229	I091-000016	I-91	1	N002	7700	Fairlee	8/16/2016	0.3659	220	32	3	108	10	3	328	370

TRC ID	CG	FC	S	SID	DVMT	SEGID	Route	FC	CntSta	AADT	City or Town	Date Observed	π_{ilfr}	Driver Belted	Driver Not Belted	Driver Couldn't Tell	Passenger Belted	Passenger Not Belted	Passenger Couldn't Tell	Total Belted	Total Successfully Observed
TRC43	WOW	Art	P	7104	78,002	I089-000002	I-89	1	Y085	23300	Hartford	8/8/2016	0.5813	785	75	5	368	18	0	1153	1246
TRC44	WOW	Art	P	7114	123,938	I089-000005	I-89	1	Y001	14200	Randolph	8/11/2016	0.5422	425	60	6	197	9	2	622	691
TRC46	WOW	Art	P	7112	115,603	I091-000008	I-91	1	Y075	11900	Weathersfield	8/11/2016	0.0216	404	41	8	154	4	3	558	603
TRC47	WOW	Col	P	7206	3,952	U005-140810	U005-	7	Y223	10400	Hartford	8/8/2016	0.0437	256	42	0	65	9	0	321	372
TRC48	WOW	Col	P	7201	7,990	V014-141701	V014-	7	Y003	1600	Sharon	8/8/2016	0.0475	32	6	0	12	2	0	44	52
TRC49	FGI	Art	P	3103	11,314	U002-070402	US-2	6	G102	2900	N Hero	6/1/2016	0.0036	32	4	2	9	0	5	41	45
TRC50	FGI	Col	P	3201	774	S6F239	TH12	9	F165	1500	St Albans Town	6/23/2016	0.1157	35	6	0	9	1	0	44	51
TRC51	FGI	Col	P	3203	1,337	U007-061501	US-7	7	F149	4500	Swanton	6/23/2016	0.0569	101	23	0	30	8	0	131	162
TRC52	FGI	Art	P	3102	13,555	V105-060308	VT-105	6	NA	6400	Enosburg	6/23/2016	0.0285	100	33	5	38	9	1	138	180
TRC53	Rut	Art	P	5104	6,124	V022A110710	V022A	6	NA	4900	Fair Haven	6/27/2016	0.0633	123	13	2	43	6	0	166	185
TRC54	Rut	Art	P	5103	13,632	U004-112003	U004-	14	R081	12900	Rutland Town	7/14/2016	0.0406	280	63	1	88	23	0	368	454
TRC55	Rut	Art	P	5102	8,740	V030-111706	V030-	6	R126	2800	Poultney	7/11/2016	0.0023	73	4	0	15	3	1	88	95
TRC56	Rut	Col	P	5202	373	S3216112001	S3216	17	R472	1200	Rutland Town	7/14/2016	0.1126	34	9	0	9	3	0	43	55
TRC57	Rut	Art	P	5101	24,261	U004-111003	U004-	2	R112	11200	Mendon	7/14/2016	0.117	230	32	3	80	10	0	310	352
TRC58	Rut	Art	P	5105	25,189	U007-111601	U007-	2	R102	9000	Pittsford	7/14/2016	0.0328	185	12	2	55	2	0	240	254
TRC59	Rut	Col	P	5201	5,419	V140-112502	V140-	7	R316	910	Wallingford	7/11/2016	0.047	23	3	0	5	2	0	28	33
TRC60	BAd	Art	P	2105	9,207	V030-021002	V030-	6	B121	2500	Rupert	6/20/2016	0.0891	40	11	0	8	4	0	48	63
TRC61	BAd	Art	P	2102	17,478	V011-021602	V011-	6	B114	6900	Winhall	6/3/2016	0.0668	183	14	10	59	6	4	242	262
TRC62	BAd	Col	P	2202	12,555	V007A020601	V007A	7	B103	4900	Manchester	6/21/2016	0.0662	103	19	0	42	5	0	145	169
TRC63	BAd	Art	P	2104	12,972	V009-021703	V009-	2	B130	3500	Woodford	6/16/2016	0.0896	90	16	5	49	1	2	139	156
TRC64	BAd	Art	P	2103	17,562	U007-020802	U007-	2	B112	6100	Pownal	6/6/2016	0.0089	108	18	3	30	12	4	138	168
TRC65	WOW	Col	P	7204	1,620	S0176141502	S0176	7	Y300	1300	Rochester	7/7/2016	0.0347	24	2	0	10	2	0	34	38
TRC66	WOW	Art	P	7116	7,387	U004-142403	U004-	2	Y116	8600	Woodstock	7/19/2016	0.0582	227	15	0	92	7	0	319	341
TRC67	WOW	Art	P	7101	12,406	V103-141002	V103-	2	Y062	9000	Ludlow	7/12/2016	0.0728	165	42	1	53	13	1	218	273
TRC68	WOW	Art	P	7111	15,536	V103-140708	V103-	2	Y161	4600	Chester	7/12/2016	0.0138	78	14	1	27	1	0	105	120
TRC69	WOW	Art	P	7107	2,928	V103-140701	V103-	2	Y427	5200	Chester	8/2/2016	0.0179	121	22	0	48	8	0	169	199
TRC70	WOW	Art	P	7108	3,832	V100-131002	V100-	6	NA	2500	Londonderry	6/16/2016	0.043	80	18	0	15	7	0	95	120
TRC71	WOW	Art	P	7113	9,162	V011-141813	V011-	6	Y133	9000	Springfield	8/2/2016	0.0115	197	44	0	73	11	0	270	325
TRC72	WOW	Col	P	7203	2,111	S0117131404	S0117	7	X153	6700	Bellows Falls	7/29/2016	0.0133	136	58	0	46	13	0	182	253
TRC73	WOW	Art	P	7102	2,835	U005-132005	U005-	6	NA	4300	Westminster	7/29/2016	0.0795	165	38	0	60	20	0	225	283
TRC74	WOW	Art	P	7103	16,967	V030-131704	V030-	6	X124	3800	Townshend	7/28/2016	0.0413	97	18	0	34	4	0	131	153
TRC75	WOW	Art	P	7105	8,813	V030-131204	V030-	6	NA	5200	Newfane	7/28/2016	0.0488	106	22	0	35	11	0	141	174
TRC76	WOW	Art	P	7110	10,410	V009-132204	V009-	2	X133	5700	Wilmington	7/28/2016	0.0835	65	26	0	19	9	0	84	119
TRC77	WOW	Art	P	7115	17,794	V009-131101	V009-	2	X134	4800	Marlboro	7/28/2016	0.0813	101	19	1	50	6	0	151	176
TRC78	WOW	Art	P	7106	17,323	V030-130203	V030-	16	X130	6300	Brattleboro	7/28/2016	0.0574	123	31	0	46	10	0	169	210
TRC79	WOW	Col	P	7202	10,500	V131-142005	V131-	7	Y177	5400	Weathersfield	7/29/2016	0.0125	154	30	0	60	17	0	214	261
TRC80	NEK	Art	P	4104	2,505	V191-100703	V191-	6	NA	3300	Derby	7/5/2016	0.0212	81	18	1	32	4	0	113	135
TRC81	NEK	Art	P	4102	4,245	V016-100801	V016-	6	P022	1600	Glover	7/5/2016	0.0283	45	7	0	16	4	0	61	72
TRC82	NEK	Col	P	4202	5,151	U005-030202	U005-	7	C101	2700	Burke	7/18/2016	0.0035	45	17	0	15	4	0	60	81

TRC ID	CG	FC	S	SID	DVMT	SEGID	Route	FC	CntSta	AADT	City or Town	Date Observed	π $_{ilfr}$	Driver Belted	Driver Not Belted	Driver Couldn't Tell	Passenger Belted	Passenger Not Belted	Passenger Couldn't Tell	Total Belted	Total Successfully Observed
TRC84	NEK	Col	P	4201	14,437	U005-030707	U005-	7	C146/CYA	14300	Lyndon	7/18/2016	0.0794	282	100	0	98	31	0	380	511
TRC85	NEK	Art	P	4101	1,746	U005-031108	U005-	16	C165	5600	St Johnsbury	7/18/2016	0.0087	106	39	0	32	11	0	138	188
TRC86	NEK	Art	P	4103	2,843	U002-031115	U002-	14	C160	8600	St Johnsbury	7/18/2016	0.0142	152	77	1	52	17	0	204	298
TRC87	WOW	Col	P	7205	4,614	V110-091502	V110-	7	N127	860	Washington	7/27/2016	0.0252	21	3	0	6	3	0	27	33
TRC88	NEK	Art	P	4105	3,603	U002-050706	U002-	2	E007	2600	Concord	7/19/2016	0.018	49	12	0	28	3	0	77	92
TRC89	CC	Art	P	1104	3,187	51487	US-2	14	WILL12	11590	Williston	10/30/2016	0.0545	299	24	1	96	9	0	395	428

Appendix C: Raw Seat Belt Use Rates by Site

Site ID	City or Town	Raw Use Rate (driver and passenger)	Raw Use Rate (driver)	Raw Use Rate (passenger)	Sample Weight
TRC01	Burlington	85.5%	85.3%	86.2%	6,990
TRC02	Burlington	86.0%	86.6%	83.6%	569
TRC03	Burlington	84.6%	83.3%	100.0%	26,064
TRC04	S. Burlington	87.5%	88.4%	84.3%	55,862
TRC05	S. Burlington	89.1%	87.3%	97.0%	3,636
TRC06	S. Burlington	90.5%	89.2%	100.0%	18,346
TRC08	S. Burlington	87.9%	87.4%	91.7%	24,663
TRC09	Cambridge	86.9%	86.9%	87.0%	240
TRC10	Cambridge	83.6%	81.2%	92.0%	2,578
TRC11	Highgate	68.5%	69.6%	60.0%	97,534
TRC12	Barre Town	82.2%	79.3%	92.0%	7,870
TRC13	Barre Town	68.9%	68.3%	71.4%	240,232
TRC14	Bolton	89.8%	88.7%	97.1%	38
TRC15	Duxbury	87.8%	91.4%	66.7%	223
TRC18	Middlesex	89.8%	88.7%	97.1%	19
TRC19	Middlesex	78.7%	75.3%	88.2%	1,066
TRC20	Northfield	84.5%	88.5%	76.4%	693
TRC21	Stowe	86.5%	85.5%	89.1%	274
TRC22	Colchester	91.8%	91.6%	92.3%	3,511
TRC23	Colchester	86.9%	87.2%	85.2%	1,191
TRC24	Colchester	88.9%	89.4%	87.0%	8,536
TRC25	Williston	89.5%	89.0%	92.3%	30,450
TRC26	Shelburne	88.8%	90.4%	81.0%	20,538
TRC27	Hinesburg	89.4%	90.8%	82.9%	1,735
TRC28	Hinesburg	85.3%	84.2%	89.3%	21,180
TRC29	Shelburne	86.1%	87.3%	79.1%	421
TRC30	Hinesburg	86.8%	87.5%	83.3%	7,587
TRC32	Charlotte	80.8%	81.8%	75.0%	183,449
TRC33	Bristol	91.5%	89.8%	100.0%	14,257
TRC34	Morristown	83.1%	82.0%	87.5%	249
TRC35	Westford	89.5%	90.0%	87.5%	4,349
TRC36	Georgia	85.5%	88.2%	64.3%	6,184
TRC37	Bridport	89.7%	90.7%	87.3%	27,003
TRC38	Shoreham	81.1%	81.3%	80.0%	8,218
TRC39	Salisbury	87.4%	85.5%	93.6%	505
TRC40	Warren	83.3%	86.1%	77.8%	51,750

Site ID	City or Town	Raw Use Rate (driver and passenger)	Raw Use Rate (driver)	Raw Use Rate (passenger)	Sample Weight
TRC42	Fairlee	88.6%	87.3%	91.5%	166
TRC43	Hartford	92.5%	91.3%	95.3%	60
TRC44	Randolph	90.0%	87.6%	95.6%	24
TRC46	Weathersfield	92.5%	90.8%	97.5%	28
TRC47	Hartford	86.3%	85.9%	87.8%	19,961
TRC48	Sharon	84.6%	84.2%	85.7%	4,880
TRC49	N Hero	91.1%	88.9%	100.0%	3,754
TRC50	St Albans Town	86.3%	85.4%	90.0%	204,523
TRC51	Swanton	80.9%	81.5%	78.9%	3,682
TRC52	Enosburg	76.7%	75.2%	80.9%	2,285
TRC53	Fair Haven	89.7%	90.4%	87.8%	9,869
TRC54	Rutland Town	81.1%	81.6%	79.3%	1,979
TRC55	Poultney	92.6%	94.8%	83.3%	4,852
TRC56	Rutland Town	78.2%	79.1%	75.0%	1,986,254
TRC57	Mendon	88.1%	87.8%	88.9%	629
TRC58	Pittsford	94.5%	93.9%	96.5%	583
TRC59	Wallingford	84.8%	88.5%	71.4%	9,586
TRC60	Rupert	76.2%	78.4%	66.7%	3,937
TRC61	Winhall	92.4%	92.9%	90.8%	1,156
TRC62	Manchester	85.8%	84.4%	89.4%	2,031
TRC63	Woodford	89.1%	84.9%	98.0%	2,077
TRC64	Pownal	82.1%	85.7%	71.4%	1,130
TRC65	Rochester	89.5%	92.3%	83.3%	118,177
TRC66	Woodstock	93.5%	93.8%	92.9%	6,646
TRC67	Ludlow	79.9%	79.7%	80.3%	2,377
TRC68	Chester	87.5%	84.8%	96.4%	1,519
TRC69	Chester	84.9%	84.6%	85.7%	42,167
TRC70	Londonderry	79.2%	81.6%	68.2%	24,838
TRC71	Springfield	83.1%	81.7%	86.9%	4,325
TRC72	Bellows Falls	71.9%	70.1%	78.0%	70,182
TRC73	Westminster	79.5%	81.3%	75.0%	45,192
TRC74	Townshend	85.6%	84.3%	89.5%	1,263
TRC75	Newfane	81.0%	82.8%	76.1%	4,681
TRC76	Wilmington	70.6%	71.4%	67.9%	1,121
TRC77	Marlboro	85.8%	84.2%	89.3%	386
TRC78	Brattleboro	80.5%	79.9%	82.1%	1,210
TRC79	Weathersfield	82.0%	83.7%	77.9%	2,827
TRC80	Derby	83.7%	81.8%	88.9%	54,807
TRC81	Glover	84.7%	86.5%	80.0%	18,933

Site ID	City or Town	Raw Use Rate (driver and passenger)	Raw Use Rate (driver)	Raw Use Rate (passenger)	Sample Weight
TRC82	Burke	74.1%	72.6%	78.9%	11,687
TRC84	Lyndon	74.4%	73.8%	76.0%	1,486
TRC85	St Johnsbury	73.4%	73.1%	74.4%	37,491
TRC86	St Johnsbury	68.5%	66.4%	75.4%	14,157
TRC87	Washington	81.8%	87.5%	66.7%	14,653
TRC88	Concord	83.7%	80.3%	90.3%	26,273
TRC89	Williston	92.3%	92.6%	91.4%	118