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Enhanced Seat Belt Reminder Systems: An Observational Study Examining the Relationship With Seat Belt Use

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16. Abstract

Seat belt use dramatically reduces the likelihood of severe injury or death in the event of a motor vehicle crash. As reported by the 2016 National Occupant Protection Use Survey, over 90 percent of drivers and front passengers now use seat belts. Fatality Analysis Reporting System data from 2015 indicated that the nationwide seat belt use rate reached 89.7 percent but 48 percent of all fatally injured occupants are still unbelted. Vehicle technologies have the potential to increase belt use and have significant effects on injury and fatality rates. One approach to improving seat belt use is to expand the seat belt reminder system beyond the minimum required by the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Such systems are referred to as enhanced seat belt reminder (ESBR) systems. This project undertook a field observational study to determine the effectiveness of various ESBRs in increasing observed seat belt use. The study took place in 8 States with trained data collectors observing seat belt use of drivers and right-front seat passengers in passenger vehicles. Subsequently, using license plate numbers, vehicle make, model, and year were determined. Using this vehicle information, seat belt use observations were merged with ESBR features. Statistical models were fitted and tested, and estimates were interpreted to assess and compare how different ESBR designs affect seat belt use while controlling for the potential effects of belt use confounders (e.g., vehicle, occupant and site characteristics).

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Executive Summary

Reducing motor vehicle crashes and their related injuries remains a priority for the highway safety community. Over 90 percent of drivers and front passengers now use seat belts as reported by the 2016 National Occupant Protection Use Survey; however, the Fatality Analysis Reporting System data for 2015 indicates that about half of crash-related fatally injured occupants were unbelted. Motor vehicle manufacturers install seat belt reminder systems in compliance with the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The systems vary in their features including audible sounds, instrument panel icons, text messages, intensity, and duration. Some systems exceed FMVSS No. 208 requirements and are recognized as enhanced seat belt reminder (ESBR) systems. Through a multi-pronged approach, this project examined the effectiveness of various ESBR systems in promoting seat belt use among drivers and right-front seat passengers.

A research plan was developed based upon a literature review of current domestic and international practices. Trained data collectors observed drivers and right-front seat passengers and recorded their age, gender, and belt use; and the vehicle type and license plate number. Data collection sites were identified in 8 States, and included shopping malls, parking garages, office parks and tourist attractions with slow moving vehicles, in large metropolitan areas. States with and without primary seat belt use laws were included. A total of 69,984 vehicles were observed. Valid, in-scope, license plate numbers were available for 67,561 vehicles.

Concurrently, motor vehicle manufacturers were contacted to request specific information on the characteristics of their seat belt reminder systems by model and year. The requests called for descriptions of the: (a) makes, models, model years, (b) trim levels for each of their systems, (c) which occupants are monitored by the systems, (d) operator control of the systems, and (e) the number of stages that comprise the system. In addition, manufacturers were asked to report: (a) what initiates and terminates each stage, (b) the types and features of visual, auditory, and haptic displays, (c) whether any of the features are passenger specific, and (d) any other descriptive information. Fifteen manufacturers responded to the request, and provided information on a total of 46 ESBR systems.

Observed vehicle license plate information was given to cooperating State Motor Vehicle Administrations who provided the Vehicle Identification Numbers (VINs) associated with each license plate. The States were able to provide data on 61,074 vehicles. A VIN decoding program subsequently provided the specific make, model, and model year of each vehicle.

Analyses began with merging the seat belt observation data with the seat belt reminder system characteristics information provided by the manufacturers. Statistical models were fitted and tested to help assess the effectiveness of various ESBR designs while controlling for confounding factors such as vehicle, occupant, and site characteristics.

Results showed a beneficial effect of combinations of sound, icon, and text elements; of extended periods of warning systems; and of systems that are compliant with European New Car Assessment Program (EURO New Car Assessment Programme) standards. The effectiveness of the presence and magnitude of specific ESBR systems are dependent upon whether the State has a primary seat belt use law.

Introduction

1.1 Background and Objective

The Human Factors Research on Enhanced Seat Belt Reminder Systems project evaluated the effectiveness of these systems in promoting greater use of seat belts among drivers and right-front seat passengers, through direct observation of drivers in passenger vehicles in 8 States, compared with the specific characteristics of enhanced seat belt reminder systems (ESBRs).

Seat belt use dramatically reduces the likelihood of severe injury or death in the event of a crash. Nationwide passenger vehicle front seat belt use in the United States has now reached its highest level of 90.1 percent in 2015 (Pickrell & Li, 2016). Forty-eight percent of all fatally injured occupants, however, are still unbelted according to 2015 data from the Fatality Analysis Reporting System (NHTSA, 2016). Vehicle technologies have the potential to increase seat belt use and have significant effects on injury and fatality rates. One approach to improving seat belt use is to expand the ESBR systems beyond the minimum required by Federal Motor Vehicle Safety Standard (FMVSS) No. 208.

FMVSS No. 208 requires that if the driver's seat belt is not buckled, a continuous or intermittent audible signal must occur for not less than 4 and not more than 8 seconds. Depending on which option the manufacturer chooses to comply with, a warning light is turned on for not less than 60 seconds and not less than 4 and not more than 8 seconds after the ignition switch has been turned on. Past work (e.g., Transportation Research Board, 2003) has long suggested that the FMVSS No. 208 requirements, by themselves, are not particularly effective but did not offer any input on effective systems. Increasingly, automobile manufacturers have voluntarily installed ESBRs in their vehicles, and today most new vehicles have some form of enhancement over the minimum requirements. An observational study conducted by Westat for NHTSA approximately 10 years earlier than the present project observed significant benefits associated with ESBRs (Freedman, Levi, Zador, Lopdell, & Bergeron, 2007; Freedman, Lerner, Zador, Singer, & Levi, 2009). ESBRs were found to increase driver and right-front passenger belt use by 3- to 4 percentage points compared to vehicles without ESBRs. Other studies have since yielded similar conclusions (Ferguson, Wells, & Kirley, 2007; Williams, Wells, & Farmer, 2002; Lie, Krafft, Kullgren, & Tingvall, 2008). The earlier NHTSA study suggested some ESBR features that may contribute to more belt use, but conclusions were not definitive.

The Moving Ahead for Progress in the 21st Century Act (MAP-21) allows NHTSA to require or allow reminder systems that operate beyond the requirements of FMVSS No. 208. In support of the agency's decision making in this area, a new field observational study, conceptually similar to that conducted in 2005, was conducted and is described in this report. In the decade between the past and current observational studies, there has been substantial change in industry practice and vehicle occupant behavior. Most vehicles now have some form of enhancement beyond FMVSS No. 208. Systems are more sophisticated in their characteristics, and passenger seat belt status is more frequently incorporated into the reminder. The national front seat belt use increased from 81.7 percent to 88.5 percent in the 10-year period (2005-2015),[1] which represents

[1] The timeframe from 2005 to 2015 represents the time between previous research (Eby, Molnar, Kostyniuk, & Shope, 2005) and data collection for the current study. It does not represent 10 calendar years.

about a 36 percent decrease in non-use (Pickrell & Li, 2016). In primary law States where drivers can be pulled over solely for non-use of seat belts, occupant seat belt use exceeded 91 percent in 2015 (Pickrell & Li, 2016). The present study provides both an update to earlier research and the opportunity to examine more definitively the features associated with greater ESBR effectiveness.

1.2 Overview of Project Activity

The project consisted of four broad activities (**Figure 1**):

1. Development of the study plan, materials, and procedures;
2. Collection of data on vehicles, occupants, and belt use;
3. Collection of information on the details of ESBR systems for specific vehicles; and
4. Analysis of the data and conclusions regarding ESBR systems.

A literature review was conducted to identify current domestic and international practices and research as a basis for the research plan. Next a detailed research plan was developed that included: (a) data to be collected, (b) test locations, (c) sample size, (d) data collection methods, and (e) analysis methods. Based on this plan, detailed data collection protocols and instruments were developed.

Data collection on observed seat belt use had four primary aspects. First, data collectors were recruited and trained. Next, the data collectors were deployed to the data collection sites where they recorded observational data on the vehicle and its license plate number, the vehicle occupants, and seat belt usage. Data collectors observed: (a) slow-moving passenger vehicles, (b) at selected sites in large metropolitan areas, and (c) in States with and without a primary belt use law. Data collection sites included: (a) shopping malls and centers, (b) parking lots and garages, (c) office parks, and (d) tourist attractions with high volumes of traffic. Given that the presence or absence of belt reminder systems and vehicle model year cannot be ascertained by data collectors in advance, all passenger vehicles (e.g., passenger cars, sport utility vehicles, light trucks, and mini-vans) passing in front of the trained data collectors, were recorded using Google 7 Nexus tablets, which were loaded with a customized data collection program as well as navigation software. License plate information was then forwarded to the cooperating State Motor Vehicle Administration, which then provided back the Vehicle Identification Number (VIN) associated with the license plate. Then, a VIN decoding program was used to determine the vehicle make, model, and year associated with each VIN. Once field data collection was underway, a parallel effort began to determine the specific details of the seat belt reminder system associated with each make/model/year vehicle.

Data analysis began with the merging of the observational data and the ESBR descriptive data sets. Then, statistical models were fitted and tested, and estimates were interpreted to assess and compare how different ESBR designs affect seat belt use while controlling for the potential effects of belt use confounders (e.g., vehicle, occupant, and site characteristics).

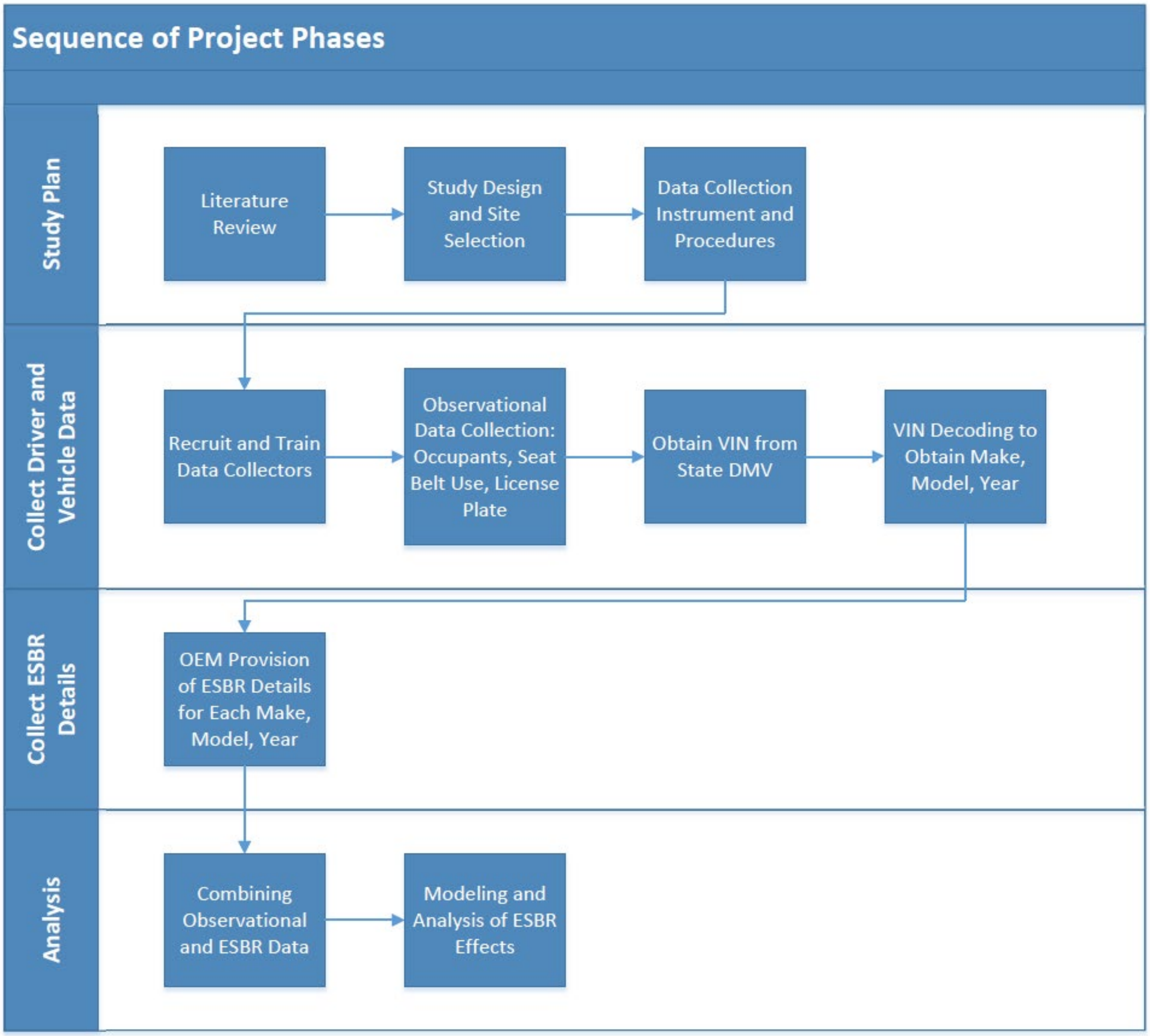

Figure 1. Sequence of project phases.

Study Plan

In order to complete this study, careful planning of each phase was required. First, a comprehensive literature review was conducted which informed the detailed research plan. Based on the research plan, the study sample was drawn and the data collection instruments and procedures were created.

2.1 Literature Review

The literature review addressed information regarding research and industry practice since 2004 and focused on ESBR considerations relevant to drivers and right-front seat passengers of passenger vehicles. It did not explicitly address other seating positions, other types of vehicles, or other types of strategies for encouraging the use of seat belts (e.g., interlocks, enforcement programs, safety campaigns) (Singer, Polson, Burkhardt, Lerner, & Barragan, 2014). This section summarizes some of the key findings.

2.1.1 ESBR Effectiveness and User Attitudes

Multiple studies from various countries have confirmed the general effectiveness of ESBRs in promoting increased seat belt use. Because of differences in the ESBR systems studied and baseline comparisons of seat belt use rates, it is difficult to indicate a specific degree of benefit. Across the studies reviewed, ESBR system related seat belt use increased up to 16 percent (Ferguson et al., 2007; Freedman et al., 2007; Young, Regan, Triggs, Stephan, Mitsopoulous-Rubens, & Tomasevic, 2008; UN/ECE, 2006; Krafft et al., 2007; Lie et al., 2018.) Another study (Farmer & Wells, 2010) compared fatal crash rates among vehicles with and without ESBRs over the 2000–2007 period. When controlling for the effects of vehicle age, a net decrease in fatalities of about 2 percent was attributable to the presence of an ESBR.

Many studies examined driver attitudes toward seat belt use and ESBRs. An important factor in developing effective ESBR systems is understanding occupants' motivations and attitudes towards belt use and reminders. A survey of more than 1,200 drivers and passengers indicated that part-time seat belt users most often cite driving a short distance (67%), forgetting (60%), and comfort (47%) as reasons for not using a seat belt (Kidd, McCartt, & Oesch, 2014). Self-reported non-users most often cite comfort (77%), not needing a seat belt (54%), and disliking being told what to do (50%) as reasons for never using seat belts. Other studies have found similar reasons for non-use (Eby, Molnar, Kostyniuk, & Shope, 2005; TRB, 2003). An ESBR was acceptable to about twice as many of the part-time users and a larger proportion of the non-users than other technologies (e.g., entertainment interlocks, speed interlocks, and resistance in the accelerator pedal) (Kidd et al., 2014). These other technologies were also judged to be less effective at increasing belt use than ESBRs. Ferguson et al. (2007) found a similar result in a survey of drivers of Honda vehicles with ESBRs. Of the 68 drivers who reported that they "usually" wear seat belts, 81 percent reported using them more since having the reminder in their vehicle. The 11 participants who reported that they "occasionally" wore seat belts were approximately evenly split on whether the ESBR made them buckle up more frequently, and whether they liked the system. The same survey also found that among all surveyed drivers, 90 percent liked the ESBR system and would want one in their next vehicle. Similarly, Young et al. (2008) found that most drivers considered the ESBR visual and auditory warnings acceptable and many reported that they would like to keep the ESBR system after the study.

2.1.2 Recommendations for ESBR Features

Although many studies have compared the effects of ESBRs against a basic seat belt reminder, relatively few have investigated specific features of enhanced systems. Table 1 summarizes the recommendations for specific features from a variety of sources (Singer et al., 2014). Although the importance of an extended duty cycle (e.g., a flashing icon or text warning) has been clear for promoting belt use, authors have also pointed out the need for consideration of user annoyance. One aspect of this is the timing of the initiation of more aggressive portions of the reminder algorithm. Through a national telephone survey, Kidd et al. (2014) found that: (a) 50 percent of respondents reported buckling up before the vehicle starts, (b) one-third buckle up after the vehicle starts but before it is placed in gear, (c) 5 percent buckle up after the vehicle is in gear but before it is moving, and (d) 4 percent buckle up as the vehicle is moving. Van Houten, Malenfant, Austin, & Lebbon (2005) also investigated the discrete points during trip initiation when drivers buckled. After observing buckling sequences for about 1,600 drivers in two urban areas in the United States and Canada, they found that 31 percent of drivers fastened their seat belts before ignition, 42 percent after ignition, and 23 percent after placing the vehicle in gear. Van Houten, Malenfant, Reagan, Sifrit, & Compton (2009) and other researchers (Freedman et al., 2009; Kidd et al., 2014) note that it might be more effective to isolate the buckling reminder from the other stimuli by activating the reminder after the driver has the opportunity to buckle up without the prompt, thereby limiting the reminder to only those drivers least likely to buckle up.

Table 1. Recommendations in literature for ESBR system features

Recommendations	Sources
1. Use both visual and auditory warnings.	Krafft, Kullgren, Lie, & Tingvall (2007) reporting on 2002 recommendations from the European Enhanced Vehicle Safety Committee (EEVC) Young et al. (2008) Freedman et al. (2009)
2. Consider allowing users to select customized ESBR sounds. Users should not be allowed to eliminate auditory reminders entirely, only select a more favorable sound that is within limits to ensure that the signals still serve as effective reminders.	Eby et al. (2005) Freedman et. al (2009)
3. Follow Euro New Car Assessment Programme recommendations.	Kidd (2012) Insurance Institute for Highway Safety (IIHS) (2013)
4. Make system adaptive, becoming more intense with continued non-use.	Eby et al. (2005) Krafft et al. (2007) reporting on 2002 recommendations from the EEVC Freedman et al. (2009) Kidd et al. (2014)
5. Initiate reminder after vehicle is moving.	Van Houten et al. (2005) Freedman et al. (2009) Van Houten et al. (2009) Kidd et al. (2014)
6. Make deactivation of the ESBR system possible but difficult.	Eby et al. (2005) Krafft et al. (2007) reporting on 2002 recommendations from the EEVC Freedman et al. (2009)

2.1.3 New Car Assessment Programs

The New Car Assessment Program (NCAP) is a government car safety program tasked with providing comparative information on the safety of new vehicles to assist consumers with vehicle purchasing decisions. NCAP crash-tests new vehicles and rates them on how well they protect occupants in frontal, side, and rollover crashes and may provide incentive for industry to incorporate additional safety features. Unlike the United States, Europe and other parts of the world have consumer information program protocols for seat belt systems. The Euro New Car Assessment Programme has promoted more extensive ESBRs, with a protocol in place since 2002. Aspects include the timing and duration of an initial signal, provisions for an optional Intermediate signal, and the duration and characteristics of a final signal. Additional points are awarded for front seat and rear seat passenger ESBRs. Specifically, key requirements and recommendations of the Seat Belt Reminder Assessment Protocol for driver and right-front seat passengers include the following (Euro New Car Assessment Programme, 2015):

- Seat occupancy must be detected for front seat passengers (driver seat occupancy is assumed).
- Seat belt use must be actively monitored throughout the drive.
- The reminder system should start at the commencement of a trip. Short breaks of up to 30 seconds in the trip do not require the system to restart.
- An initial audio and/or visual signal is recommended shortly after vehicle startup or motion, if a seat belt is not in use.
- An optional Intermediate signal may be given. If the signal is more sophisticated than a simple audiovisual signal, the final reminder signal may be delayed.
- The final signal, which is the only signal required by Euro New Car Assessment Programme, must occur before at least one of the following.
    - Engine running for 60 seconds
    - Vehicle in forward motion for 60 seconds
    - Vehicle in forward motion for 500 meters
    - Vehicle in forward motion has reached 25 km/h
- If an initial signal is used, the final signal may be delayed, but must start within 30 seconds of reaching 25 km/h, as long as the initial signal meets at least one of the following requirements.
    - Constant, flashing, or intermittent visual signal for at least 30 seconds
    - Text message for at least 5 seconds
    - Clear voice message
- The final signal must have a duration of at least 90 seconds.
    - If the final signal is not continuous, it must then meet the following criteria:
        - Signal must start with a positive audiovisual signal for at least 5 seconds
        - Gaps of more than 1 second in the signal must not occur more than every 5 seconds
        - Gaps of less than 1 second which allow for visual signals to be displayed and audio signals which beep are ignored
        - Gaps exceeding 3 seconds are not counted towards the 90 second duration
        - No gap can last for more than 25 seconds
- Once the final signal has started, it must only stop when it has reached its set maximum duration, when the seat belts are fastened, when the engine has stopped, or when the vehicle has been put in reverse gear.
- Users should be allowed to deactivate the ESBR to prevent destructive tampering with the system.

Complete details are available in Version 7.0 of the Assessment Protocol – Safety Assist at https://cdn.euroncap.com/media/20876/euro-ncap-assessment-protocol-sa-v70.pdf.

The Euro New Car Assessment Programme protocol is broadly supported in Europe, with various other countries and regions adopting similar consumer information protocols, although with some differences. These include Australia, China, Japan, Southeast Asia, Korea, and Latin America/Caribbean. In addition to Euro New Car Assessment Programme-like provisions, various countries have mandatory requirements for reminder systems that are enhanced relative to FMVSS No. 208. In contrast to these other regions, the United States does not have an NCAP protocol addressing seat belt reminder systems. Although about 90 percent of recent vehicle models sold in the United States have some enhancement exceeding FMVSS No. 208 requirements, the Insurance Institute for Highway Safety (IIHS, 2013) found only 16 percent of these vehicle models meet Euro New Car Assessment Programme criteria.

2.2 Study Design and Site Selection

The design of the current study updated the methods used in the 2005 data collection (Freedman et al., 2007). Pairs of data collectors were stationed at multiple sites in 8 States (i.e., 4 with primary belt use laws; 4 without primary belt use laws). For each observed passenger vehicle (i.e., passenger cars, light trucks, SUVs, and mini-vans), the data collectors recorded: (a) the presence and characteristics of the driver and right-front seat passenger(s), (b) seat belt usage by the driver and right-front seat passenger, (c) vehicle descriptive data, (d) vehicle license plate number, and (e) vehicle license plate State. The license plate information was subsequently used to obtain the VIN, which in turn was decoded to identify the vehicle's make, model, and year.

Table 2 lists the States and cities selected for data collection. The study plan is based on using one major urban area within each State, with two States selected from each geographic quadrant of the United States, one with a primary belt use law and one with a secondary belt use law. Although the intent was to use the same regions for data collection as in the earlier study, some substitutions were required due to subsequent changes in local seat belt use laws. One prior study site, Florida, adopted a primary belt use law in 2009 and was replaced with Colorado. Missouri was also replaced. Although Missouri is a secondary belt use law State, Kansas City now has a primary seat belt ordinance. Consequently, Kansas City, Missouri was replaced with Lincoln, Nebraska. Additionally, the plan shifted the assignment of NHTSA regions within the quadrants to accommodate the need for a secondary belt use law State in each one. To put it in perspective, there are currently 16 secondary belt use law States in the United States. Eight of these States fall into NHTSA Regions 8 and 10, so some reconfiguring of the Southern and Western regions was required. There are no secondary States in the southeastern United States.

Table 2. City/State data collection locations by type of belt use law

Quadrant/NHTSA Regions	Primary	Secondary
Northeastern **NHTSA Regions 1, 2, 3**	Greater Washington, DC	Virginia Beach/Norfolk, VA
Southern **NHTSA Regions 4, 6, 8**	San Antonio, TX	Denver, CO
Central **NHTSA Regions 5, 7**	Des Moines, IA	Lincoln, NE
Western **NHTSA Regions 9, 10**	San Diego, CA	Phoenix, AZ

The study included a total of 448 specific data collection sites. These included shopping centers and malls, office parks, parking lots and garages, and general public attractions such as zoos, and amusement parks. The site visits took place at various times during the day, including morning and early evening hours. The estimates derived from this focused sample does not generate unbiased results applicable to the population of driver and right-front seat occupants, in all vehicles in the United States, because the set of observations was non-random and geographically limited. Effect estimates, however, are valid for the studied population. We also believe that ESBR effectiveness estimates for the whole population would not differ greatly from those to be estimated in this study. Note that belt use tends to be lower in rural areas than in urban areas, and ESBR systems tend to have a larger effect among occasional belt users than among regular belt users. This suggests that ESBR effects could be larger nationally than those estimated using data limited to the selected urban cities.

The data collection plan was estimated to yield approximately 50,000 vehicle observations. This estimate was based in part on the experience from similar sites in the prior study. The plan called for 128 hours of data collection in each city, with about 50 observations per hour, resulting in an estimated 6,400 observations for each of the eight cities. Ultimately, a larger sample was observed, further described in Section 3.2.

Collection of Observational Driver and Vehicle Data

Data collection began with the recruitment and training of data collectors, followed by the implementation of the field observation procedures. In order to obtain the information on the specific make, model, and year of each observed vehicle, the license plate information was first used to determine the vehicle's VIN. The VIN was then decoded to identify the vehicle make, model, and year.

3.1 Field Staff Recruiting and Training

Eighteen data collectors were recruited for the study: two for each of the eight study sites plus two additional back-up data collectors. Two of the data collectors also served as quality control monitors (QC monitors) or supervisors. Westat's field director recruited and hired the data collectors. Individuals with previous transportation research experience were recruited. The field director then conducted in-depth interviews with candidates who passed an initial screening of the collected resumes. During the interviews, all potential data collectors were screened to: (a) ensure that they would be available during the training and data collection periods, (b) had a valid driver's license, (c) had access to reliable, (d) insured transportation, (e) possessed the required employment qualifications, and (f) passed the background screening. In addition, the field director sought to hire people who were comfortable using a tablet, and who lived in or near a study area. If local staff were not available, data collectors traveled to the selected area.

All recruited staff attended a 2-day training session in the week prior to data collection. The training sessions and manual covered the following topics:

- Background and overview of the ESBR study;
- Detailed instructions on caring for the tablet and transmitting data to Westat;
- Administrative procedures;
- Description of field techniques and an overview of how to collect data;
- Detailed instructions on utilizing the maps and Google Navigation with the site assignment sheets to locate sites; and
- Detailed instructions on data collection with the tablet, and a quiz on recording license plates.

Equipment was dispersed on the first day of training. Data collectors received a messenger bag that included: (a) the training manual, (b) site assignment sheets, (c) maps, (d) mailing materials, (e) a clipboard, (f) a tablet and accessories, (g) a safety vest, (h) an official letter explaining the study to any inquirers, and (i) an identification badge. Westat staff went over every piece of equipment with the data collector to ensure that they received a complete package and to introduce them to the different accessories for the tablet.

3.2 Observational Data Collection

Data collection took place over a 14-day period in October 2015. Observations were made on weekdays and weekends beginning around 7:30 a.m. and lasting until approximately 6 p.m. The data collection protocol involved both data collectors standing at the entrance to a site and making observations as vehicles entered. The observation period was two hours.

Each team followed a schedule called the Site assignment sheet for their State. This document listed their sites along with location information and the date and time for each visit. If the assigned site was unworkable, a corresponding alternate site was provided and data collectors reported the site issue in the tablet. Reasons for not conducting data collection at the assigned site included: (a) assigned site not found, (b) asked to leave, (c) no good observation location, (d) dangerous, (e) construction, or (f) accident. Data collectors positioned themselves at the best location for making vehicle, occupant, and belt use observations unobtrusively (usually at the entrance to the site parking lot).

Data was captured using Google 7 Nexus tablets with specially developed software, adapted from software used for the National Occupant Protection Use Survey (NOPUS). Tablets were customized for each observer based on their assigned city. The program identified each tablet by its unique serial number and sent the appropriate site and team information to the data collectors.

All data were recorded on the tablet. One person was the recorder and one was the spotter. The spotter called out information for the Recorder to log in the tablet. The spotter had a spotter card that listed the order of the variables and the options for each variable. This allowed the spotter to call out the variables sequentially, with the correct vocabulary, thereby facilitating the recording process. The spotter also had a clipboard and pen so that they could transcribe the license plate and then read it to the recorder. This allowed the data collectors to check their work by reading and confirming the license plate number back to each other.

The tablet program stepped the team through the observation process via a series of screens. The tablet recorded the same data elements as in the previous study. Site-level information was recorded first. Data collectors selected:

1. Site ID – A unique ID provided on the Site assignment sheet to identify each site.
2. Weather – The options were Light Precipitation, Light Fog, or Clear.
3. Data collector names – Their name and the name of their partner.

The tablet program required completion of all the data elements before advancing to another screen. The tablet program automatically recorded time, date, and GPS location for each site. It also calculated the observation duration. Data collectors needed to start at the assigned time, but the tablet notified them when the observation period expired. Once data collectors entered the site-level information, the program advanced to the vehicle-level entry screens. Data collectors selected:

1. Driver Belt Use – The options were:
    a. Yes (Belt was visible across the front of the driver);
    b. No (No belt was visible across the front of the driver or belt was being used improperly, behind the arm or back); or
    c. Don't Know (Observer was unable to determine belt use).
2. Driver Gender – The options were:
    a. Male;
    b. Female; or
    c. Don't Know.

3. Driver Age – The options were:
    a. Young (16-24);
    b. Adult (25-69);
    c. Senior (70+); or
    d. Don't Know.
4. License Plate Number – Data collectors recorded this information by entering the numbers and letters using the tablet's virtual keyboard.
5. License Plate State – The program defaulted to the State where the observations were taking place so that the observer simply needed to confirm the State. The tablets were also programmed to show the surrounding States as options. If the vehicle's license plate State was from a surrounding State, the data collectors were asked to select the State from the options given. If the State did not appear as one of the options in the tablet, data collectors were instructed not to record the vehicle.
6. Number of Front Seat Passengers:
    a. 0;
    b. 1; or
    c. 2.
7. Right-Front Passenger Belt Use – The options were:
    a. Yes (Belt was visible across the front of the occupant);
    b. No (No belt was visible across the front of the occupant or belt was being used improperly, behind the arm or back); or
    c. Don't Know (Observer was unable to determine belt use).
8. Right-Front Passenger Gender – The options were:
    a. Male;
    b. Female; or
    c. Don't Know.
9. Right-Front Passenger Age – The options were:
    a. Youth (8-15)
    b. Young (16-24);
    c. Adult (25-69);
    d. Senior (70+); or
    e. Don't Know.

Please see **Appendix A** for the Field Guide which provides a concise summary of data collection procedures.

After completing data collection at each site, data collectors transmitted their data to Westat. Another custom program enabled the tablets to securely connect to the Westat servers. The tablets were equipped with SIM cards and WiFi radios to allow data collectors to send their data via the cell network or WiFi, as needed. Data were exported from the tablet in CSV files and input into an SQL database.

Project staff examined and cleaned the data within 24 hours of collection. Several quality control checks were executed immediately to verify various aspects of the data and to address problems while staff were still in the field. These quality control checks included checking:

- The sites scheduled versus sites received;
- That tablet files were saved and received correctly, without technical problems;
- That data collection lasted for the required two hours;
- That data collection occurred at the assigned location;
- That data collectors followed protocol by standing in one spot at the entrance of the site; and,
- The number of observations at each location to make sure the sites had enough traffic volume.

If any irregularities or inconsistencies were found, the team was contacted and asked for an explanation of the problem at the site. If necessary, data collection at the site was rescheduled and completed again.

Ultimately, data collectors captured information on 69,984 vehicles. However, only 67,561 or 96.5 percent of the observations had valid license plate numbers (2,423 vehicles had licenses plates from States which were out of scope or incomplete). Table 3 provides a breakout of the vehicle observations with complete license plate information, for each study area.

Table 3. Number of recorded vehicle observations

Metro Area	Belt Use Law	Number of Valid License Plates
Greater Washington, DC	Primary	7,742
San Antonio, TX	Primary	7,882
Des Moines, IA	Primary	9,905
San Diego, CA	Primary	8,393
Virginia Beach/Norfolk, VA	Secondary	7,581
Denver, CO	Secondary	9,296
Lincoln, NE	Secondary	8,436
Phoenix, AZ	Secondary	8,326
All		**67,561**

Once the field period ended, all data were examined and prepared for the DMVs. Most States have complicated rules regarding license plates, including: (a) the number of characters in a plate, (b) how to use hyphens or spaces, (c) using the letter O or the number 0, and (d) using the letter I or the number 1. Based on these rules, license plate entries made by data collectors were edited according to each State's regulation. In addition, several States had specific codes, which were required to indicate whether the plate was a specialty or standard plate. If data collectors didn't know the code but had made a note indicating the type of specialty plate, Westat staff added the code for DMV use.

3.3 Obtaining Vehicle Identification Numbers (VINs)

Initial contact with State DMVs began in the spring of 2015, before the field period occurred. The first step of the process involved NHTSA sending an introductory letter to representatives at each DMV to establish knowledge of the study before Westat project staff began communication. Once a relationship was established between Westat and a State DMV contact, input file specifications were established, as well as a protocol for file transfer (FTP, e-mail, or disk). After data collection and as soon as all paperwork was completed, a file of license plates for a given State was extracted from the observational database, converted into the State's desired file format, and transmitted to the State via their desired method. States processed the files quickly and returned the output to Westat. All license plates that had a matching VIN were updated in the Westat SQL database. Of the 67,561 valid license plates, 61,074 were returned with accurate, 17-character VINs (6,487 were decoded but returned with error codes and therefore could not be used). This is an overall match rate of 90 percent (see Table 4).

Table 4. Number of observations, license plates, and VINs

Metro Area	Number of Valid License Plates	Number of Accurate VINs Returned
Greater Washington, DC	7,742	6,665
San Antonio, TX	7,882	6,798
Des Moines, IA	9,905	8,732
San Diego, CA	8,393	8,001
Virginia Beach/Norfolk, VA	7,581	6,519
Denver, CO	9,296	8,476
Lincoln, NE	8,436	8,016
Phoenix, AZ	8,326	7,867
All	**67,561**	**61,074**

3.4 VIN Decoding to Obtain Make, Model, Model Year

The VIN provided by the State DMVs needed decoding to ascertain a vehicle's make, model, and model year. Westat used NHTSA's online VIN decoder for the process. Two batch files of approximately 30,000 records were fed into the program. The decoder returned 58,208 records with cleanly decoded VINs that contained a model and model year. This is a match rate of 95.3 percent. The model and model year information on each record was subsequently appended onto the observation record in the Westat SQL database.

Table 5 below presents a summary of the breakdown of the number of observations after each stage of data processing.

Table 5. Breakdown of number of usable vehicle observations after each data processing step

Processing Step	Number of Problem Vehicle Observations	Number of Usable Vehicle Observations
Raw Observations	0	69,984
License Plate Cleaning	2,423	67,561
DMVs Provided VINS	6,487	61,074
VIN Decoding	2,862	58,208

Next, a series of quality control measures was instituted to facilitate the process of matching observed vehicles to ESBR systems. First, a list of all makes and models was compiled. If the ESBR information for a given make was not submitted by the manufacturer (see Section 4), those vehicle observations were not included in the ESBR analyses. Second, if the make and model indicated by the VIN reflected a non-passenger vehicle, those records were dropped from analysis. Any other records with incomplete make, model, and model year information were also dropped because they could not be matched to an ESBR system.

ESBR System Details for Make/Model/Model Year

A comprehensive and detailed set of ESBR descriptions for the vehicles that comprise the observed vehicle fleet was used to associate observed seat belt use with ESBR features.

The ESBR system details form was structured in two parts. Part I recorded general information on the ESBR system, such as: (a) makes, models, model years, and trim levels to which it applies; (b) what occupants are monitored by the system; (c) operator control of the system; and (d) the number of stages (i.e., beyond the required FMVSS No. 208 display) that comprise the system. Part II then recorded information on each stage of the system. This included: (a) what initiates the stage; (b) what terminates the stage; (c) visual display types and features; (d) auditory display types and features; (e) haptic display types and features; (f) passenger-specific displays; and (g) any additional descriptive information. A complete copy of the form is attached as **Appendix B**.

A total of 46 distinct OEM ESBR systems were identified among these (note that some systems were used by multiple vehicle brands). Ultimately the completeness of the data on each system varied to some degree, but major aspects of the ESBR were evident.

Table 6. OEMs providing information on ESBR systems

Manufacturer	Brands Included	Number of ESBR Systems
BMW Group	BMW, Mini	1
FCA	Chrysler, Dodge, Fiat, Jeep, Ram Truck	6
Ford Motor Company	Ford, Lincoln, Mercury	2
General Motors	Chevrolet, Buick, GMC, Cadillac, Hummer, Pontiac, Saab, Saturn	4
Honda	Honda, Acura	2
Hyundai	Hyundai, Kia	3
Jaguar Land Rover	Land Rover, Jaguar	2
Mazda	Mazda	2
Mercedes-Benz	Mercedes	1
Mitsubishi	Mitsubishi	9
Nissan	Nissan, Infinity	2
Subaru	Subaru	4
Toyota	Toyota, Lexus, Scion	4
Volkswagen Group of America	Volkswagen, Audi	2

Manufacturer	Brands Included	Number of ESBR Systems
Volvo	Volvo	2
All		**46**

Analysis

5.1 Combining Observational and ESBR Data

Observational data were collected as described in Sections 2.2 and 3.2 for a total of 69,984 vehicles. Additional data cleaning during the analysis further reduced the number of vehicle observations. Table 7 describes additional exclusions, and the associated vehicle counts.[2] Further explanation is provided below.

Table 7. Reasons for excluding observational data from ESBR analyses

Reason	Vehicle Count
Data collector indicated an error had been made	1,752
Vehicle observed was not a passenger vehicle	188
Valid VIN could not be obtained	7,041
Valid VIN but make/model/model year all missing	146
Repeat observation of same vehicle within site visit	653
All	**9,780**

Data collectors were able to record if they made an error in entering the data for a particular vehicle. Because there is no way to determine which data item was incorrectly recorded, these observations were not considered further. Using the license plate, some observations were linked to vehicle types that were excluded from the study (e.g., motorcycles, buses, and commercial trucks) so these also were removed from the analytic data set. A valid VIN could not be obtained for 7,041 observations, and for 146 vehicles with a valid VIN, the NHTSA VIN decoder returned missing information for make and model and model year. These observations were excluded because it was not possible to link them to an ESBR system. Finally, quality control checks on the data revealed that 653 vehicles had been observed multiple times. Although data collectors were trained to avoid duplicate observations, the demanding workload made it difficult to eliminate duplicates completely. Duplicates were considered acceptable if the observations were made during different site visits, but within a given site visit only the first, in chronological order, was retained for analysis. The concern with repeat observations within a site visit is essentially duplicated information (e.g., data collectors observed a vehicle more than once while the driver circled looking for a parking space).

Review of the observational data also revealed occasional inconsistencies in the vehicle type information reported by data collectors. Specifically, a vehicle of a given make, model, and model year may have been classified differently by different data collectors. With the existence of many “crossover” vehicles in the current market, such anomalies are not unexpected. However, these data were edited to ensure that data collector-introduced variability did not affect the ESBR analyses. Consideration was given to using the “body class” information provided by

[2] Note that a different hierarchy was used to partition the counts provided here than the counts provided in Section 3.

the DMV but these data were also found to be unreliable (sometimes missing and sometimes inconsistent). For this reason, a “majority rules” approach was applied to assign a common vehicle type classification to all observed vehicles of a given make, model, and model year. In the rare event that equal numbers of data collectors reported different vehicle types (i.e., there was no clear majority), one vehicle type was chosen randomly and assigned.

A considerable challenge in linking the observational data with the OEM provided ESBR data arises because the key vehicle information is not recorded in a consistent manner between the two data sets. For example, an entry in the ESBR data set for Audi may have the model reported as “A3/S3,” whereas the model information in the observational data set may be “A3” or, for a different vehicle, “S3.” As an example of the reverse situation, observational data for Honda may have the model reported as “Accord,” whereas the ESBR data set contains separate records for “Accord coupe” and “Accord sedan.” Additional complications occur when the information that distinguishes the ESBR system is represented by the “model” variable in one data set, yet split across two or more variables (such as “model” together with “trim,” “series,” or “doors”) in the other data set. To address these differences, careful editing was applied to key variables in both the observational and ESBR data sets prior to linking them together. The linking was based on model and model year.[3]

To describe the editing procedures in more detail, the examples in the preceding paragraph are used. Model year was considered in all editing; however, to keep the explanations concise this is not stated repeatedly. If the OEM indicated that the ESBR system information is the same for two models, such as the Audi A3 and Audi S3, then Audi records in the observational data set with model reported as “A3” or “S3” were edited to change the model information to “A3/S3..” When the model information in the observational data set was reported at a more aggregated level than in the ESBR data set, it was first necessary to check whether the models reported at a finer level by the OEM have the same ESBR system. For example, it was necessary to check if the coupe and sedan versions of the Honda Accord have the same ESBR system. If so, then Honda records in the ESBR data set with model reported as “Accord coupe” or “Accord sedan” were edited to change the model information to “Accord.” If the coupe and sedan versions of the Accord were reported as having different ESBR systems, then no editing was applied to the model information in either data set – thus precluding a link (because a link would be inappropriate given the inability to determine exactly which ESBR system was associated with the observed vehicle). For some records in the observational data set, information available from the VIN decoding process was used in conjunction with the data reported in the model variable to facilitate a link with the ESBR data set. For example, if the ESBR model for Dodge was reported as “Ram 1500,” but the VIN decoded data were reported as model = “Ram” and trim = “1500,” then the record in the observational data set was edited to change the model information to “Ram 1500.”

While the link between the observational and ESBR data was straightforward for many of the observed vehicles, the editing procedures outlined above required intensive manual review of the two data sets for the observations that did not link automatically. Given the limited resources available for the data cleaning and analysis phases of the study, and the large number of vehicles observed, the manual review process was not exhaustive and the editing procedure focused on

[3] It was first verified that vehicle make could be excluded from the linking process by making sure that no combination of model and model year was associated with multiple makes.

vehicles with model years from 2006 onwards. As a result, the absence of a link between an observed vehicle and an ESBR system occurred because:

- The observed vehicle does not have an ESBR system (because the OEM Inquiry on ESBRS details Form only requested information on vehicles with ESBRs);
- The observed vehicle has an ESBR system but the OEM did not provide data for that vehicle;
- The observed vehicle has an ESBR system for which the OEM provided information but the VIN decoding process did not produce information at a fine enough level to facilitate the link; or
- The observed vehicle has an ESBR system for which the OEM provided information and the link could have been established with the investment of additional resources for review and data editing.

As mentioned at the beginning of this section, observational data were recorded for a total of 69,984 vehicles. The sample size was reduced to 60,204 because of the exclusions summarized in Table 7. The study further focused on the 41,031 observed vehicles with model years from 2006 onwards because pre-2006 vehicles had already been analyzed in a prior study (Freedman et al., 2007). Table 8 summarizes the link status for this set of vehicles and shows that ESBR data were available for analysis for 35,353 vehicles.

Table 8. Link status for valid observations of vehicles with model years from 2006 onward

Link Status	Vehicle Count
Linked to an ESBR system	35,353
Linked to a system without an ESBR	11
Not linked	5,667
All	41,031

The ESBR analyses described in Section 5.2 are based on slightly fewer vehicles than 35,353 for two reasons. Observations were discarded if the driver's seat belt use, age, or gender were unknown, or if the presence of an extra front seat passenger was reported. The final sample size for driver analyses was 35,175 vehicles. After applying the additional constraint that the right-front passenger's seat belt use, age, and gender be known, the final sample size for passenger analyses was 8,896 vehicles.

5.2 Modeling and Analysis of ESBR Feature Effects

5.2.1 Methods

According to preliminary analyses, both drivers and passengers were substantially more often belted on average in States with a primary belt use law than in States with a secondary belt use law (see Table C1 in **Appendix C**). Also, ESBR designs for drivers are not always identical to ESBR designs for passengers. To avoid complications due to these differences, we investigated ESBR effects separately in four data sets defined in terms of occupant type and State belt use law. The analyses presented in this report are based on 35,175 observed vehicles with model years from 2006 onwards (see Section 5.1).

The key challenge in estimating the effect of an ESBR system on belt use, or for that matter of any vehicle feature's effect on any type of occupant behavior, is to separate the feature's effect from the combined effect of occupant characteristics (e.g., age and gender), all vehicle attributes (e.g., type and model year of vehicle), and situational determinants (e.g., location and time of observation, local laws, weather)—collectively referred to as covariates. Table C2 lists the covariates that we employed in this study.

We estimated the effect of ESBR systems on belt use based on the assumption that any difference between observed and estimated belt use rates can be attributed to the relevant ESBR system, provided that belt use rate estimates validly accounted for all other driver, vehicle, and environmental characteristics that could affect belt use. This assumption requires that:

1. All relevant potential factors that might affect belt use are known;
2. Data are available for all important factors; and
3. Statistical models validly accounted for the combined effects of all covariates that represented potential belt use confounders.

In Step 1, we estimated the probabilities of driver and passenger seat belt use (PredBelt), separately in States with a primary belt use law and with a secondary belt use law, as functions of the combined effects of all covariates. We used SAS software for logistic regression to estimate belt use probability as a function of the covariates.[4]

In Step 2, we first calculated the difference (Diff), between the binary variable (Belt = 0 or 1) that represented observed belt use for drivers or passengers and the corresponding belt use probability estimate (PredBelt), Diff = Belt – PredBelt, and then produced difference summary statistics for observations that shared the same ESBR system, as identified by the ESBR system ID variable linked to the occupant's vehicle. This was done separately for drivers and passengers in primary and in secondary belt use law States.

In Step 3, we identified ESBR systems with significantly positive or significantly negative sets of differences between observed and estimated belt use. An ESBR system was judged to have a *significantly positive belt use effect* if the lower 95 percent confidence limit of the mean difference between observed and estimated belt use was positive. Similarly, if that mean difference had a 95 percent upper confidence limit that was negative, the ESBR system was judged to have a *significantly negative belt use effect*. ESBR systems for which the 95 percent lower and upper confidence limits bracketed 0 were considered not to have a measurable effect on belt use. We classified ESBR systems this way four times: separately for drivers and passengers in States with a primary belt use law and in States with a secondary belt use law.

In Step 4, we compared selected ESBR system features among groups of ESBR systems that had a significantly positive, had a significantly negative, or had no significant belt use effect.

[4] Belt use is coded as 1 for belted, 0 for unbelted. p(x) = Prob(Belt = 1). p(x) = exp(g(x))/((1+exp(g(x)) is the inverse logistic transform of g(x). g(x) = log (p(x)/(1-p(x))). g(x) is a linear combination of components of the covariate vector x (SAS Institute Inc., Cary, NC, USA).

5.2.2 Results

Table 9 presents observation counts for drivers and right-front passengers in secondary belt use law States, primary belt use law States, and for all drivers and all right-front passengers. As Table 9 shows, several ESBR systems were rarely observed. Although NHTSA obtained information on 46 ESBR systems, 7 of the systems were not linked to any vehicle observations and were therefore not used for analysis. Of the 39 remaining systems, 14 were linked to fewer than 100 observed vehicles, and 25 were linked to more than 100 vehicles. The number of observed drivers in secondary and primary belt use law States were 16,659 and 18,516, respectively. The comparable numbers for right-front passengers were 4,084 and 4,812.

Table 9. Frequency counts by ESBR, type of occupant, and seat belt use law

ESBR System ID	Drivers: Secondary Law	Drivers: Primary Law	Right-Front Passengers: Secondary Law	Right-Front Passengers: Primary Law	Drivers	Right-Front Passengers	All
001	369	445	66	111	814	177	991
002	49	53	19	14	102	33	135
003	1,982	2,220	540	580	4,202	1,120	5,322
004	1,070	946	278	224	2,016	502	2,518
005	1,393	1,545	317	377	2,938	694	3,632
006	8	10	2	2	18	4	22
007	54	83	8	22	137	30	167
008	445	479	107	116	924	223	1,147
009	343	449	71	104	792	175	967
010	26	48	6	8	74	14	88
011	16	28	5	10	44	15	59
012	0	0	0	0	0	0	0
013	7	16	1	5	23	6	29
014	0	0	0	0	0	0	0
015	0	2	0	0	2	0	2
016	18	22	7	7	40	14	54
017	42	48	14	10	90	24	114
018	0	0	0	0	0	0	0
019	149	121	41	41	270	82	352
020	1,402	1,567	333	408	2,969	741	3,710
021	0	0	0	0	0	0	0
022	2,102	2,536	518	669	4,638	1,187	5,825
023	592	1,009	141	286	1,601	427	2,028
024	52	75	16	21	127	37	164
025	623	684	118	134	1,307	252	1,559
026	371	211	81	47	582	128	710
027	40	46	6	18	86	24	110
028	2	3	1	0	5	1	6
029	11	11	4	1	22	5	27

ESBR System ID	Drivers: Secondary Law	Drivers: Primary Law	Right-Front Passengers: Secondary Law	Right-Front Passengers: Primary Law	Drivers	Right-Front Passengers	All
030	6	5	1	0	11	1	12
031	16	9	2	0	25	2	27
032	263	149	66	41	412	107	519
033	1,228	1,500	323	431	2728	754	3,482
034	12	9	2	2	21	4	25

Table 10 presents the corresponding belt use proportions, for ESBR systems linked to at least one vehicle observation. In secondary belt use law States, overall driver and right-front passenger belt use rates were, respectively, 88.2 percent and 89.4 percent (see Table C1 for details). The corresponding percentages in primary belt use law States were 97.6 percent and 97.1 percent, respectively, showing that belt use rates were about 9 percentage points higher in primary belt use law States than in secondary belt use law States. Driver belt use varied for different ESBR systems between 63 percent and 100 percent in secondary belt use law States and between 88 percent and 100 percent in primary belt use law States. Right-front passenger belt use was more variable, in part because of smaller sample sizes.

Table 9. Frequency counts by ESBR, type of occupant, and seat belt use law (cont.)

ESBR System ID	Drivers: Secondary Law	Drivers: Primary Law	Right-Front Passengers: Secondary Law	Right-Front Passengers: Primary Law	Drivers	Right-Front Passengers	All
035	716	710	173	197	1,426	370	1,796
036	660	645	149	175	1305	324	1,629
037	0	0	0	0	0	0	0
038	277	289	65	75	566	140	706
039	732	658	220	155	1,390	375	1,765
040	418	473	108	139	891	247	1,138
041	180	204	53	67	384	120	504
042	0	0	0	0	0	0	0
043	3	9	0	3	12	3	15
044	841	1,060	192	290	1,901	482	2,383
045	141	139	30	22	280	52	332
046	0	0	0	0	0	0	0
All	**16,659**	**18,516**	**4,084**	**4,812**	**35,175**	**8,896**	**44,071**

Table 10. Average belt use proportions by ESBR, type of occupant, and seat belt use law

ESBR System ID	Drivers: Secondary Law	Drivers: Primary Law	Right-Front Passengers: Secondary Law	Right-Front Passengers: Primary Law	Drivers	Right-Front Passengers	All
001	0.93	0.98	0.89	0.98	0.95	0.95	0.95
002	0.94	1.00	1.00	0.93	0.97	0.97	0.97
003	0.89	0.98	0.93	0.99	0.94	0.96	0.95
004	0.82	0.99	0.83	0.96	0.90	0.89	0.90
005	0.90	0.97	0.92	0.96	0.94	0.95	0.94
006	0.63	0.90	0.50	1.00	0.78	0.75	0.77
007	0.80	0.95	1.00	1.00	0.89	1.00	0.91
008	0.89	0.97	0.84	0.96	0.93	0.90	0.93
009	0.86	0.96	0.92	0.97	0.92	0.95	0.92
010	0.85	0.96	1.00	0.88	0.92	0.93	0.92
011	0.94	1.00	0.60	1.00	0.98	0.87	0.95
013	0.86	0.88	1.00	1.00	0.87	1.00	0.90
015	N/A	1.00	N/A	N/A	1.00	N/A	1.00
016	0.94	1.00	1.00	1.00	0.98	1.00	0.98
017	0.88	0.92	0.86	1.00	0.90	0.92	0.90
019	0.79	0.98	0.73	0.98	0.88	0.85	0.87
020	0.84	0.97	0.86	0.97	0.91	0.92	0.91
022	0.89	0.98	0.90	0.97	0.94	0.94	0.94
023	0.93	0.98	0.91	0.96	0.96	0.95	0.96
024	0.94	1.00	1.00	1.00	0.98	1.00	0.98
025	0.86	0.97	0.90	0.96	0.92	0.93	0.92
026	0.91	0.99	0.96	1.00	0.94	0.98	0.94
027	0.88	0.98	0.67	0.89	0.93	0.83	0.91
028	1.00	1.00	1.00	N/A	1.00	1.00	1.00
029	1.00	1.00	1.00	1.00	1.00	1.00	1.00
030	1.00	1.00	1.00	N/A	1.00	1.00	1.00

Table 10. Average belt use proportions by ESBR, type of occupant, and seat belt use law (cont.)

ESBR System ID	Drivers: Secondary Law	Drivers: Primary Law	Right-Front Passengers: Secondary Law	Right-Front Passengers: Primary Law	Drivers	Right-Front Passengers	All
032	0.93	1.00	0.92	1.00	0.95	0.95	0.95
033	0.88	0.98	0.88	0.97	0.93	0.93	0.93
034	0.92	1.00	1.00	1.00	0.95	1.00	0.96
035	0.90	0.97	0.88	0.98	0.94	0.93	0.94
036	0.89	0.96	0.88	0.95	0.93	0.92	0.92
038	0.86	0.97	0.88	0.97	0.92	0.93	0.92
039	0.87	0.98	0.89	0.98	0.92	0.93	0.93
040	0.89	0.98	0.91	0.98	0.94	0.95	0.94
041	0.86	0.96	0.91	0.96	0.91	0.93	0.92
043	1.00	1.00	N/A	1.00	1.00	1.00	1.00
044	0.90	0.99	0.90	0.98	0.95	0.95	0.95
045	0.90	0.96	0.93	0.95	0.93	0.94	0.93
All	**0.88**	**0.98**	**0.89**	**0.97**	**0.93**	**0.94**	**0.93**

We used logistic regression to estimate belt use probability as a function of covariates (see Table C2 for the list of covariates and their definitions, and Table C3 for a summary of the statistically significant predictors). In Table 11, we present analysis of variance tables for secondary and for primary belt use law States for drivers and for right-front passengers. In secondary belt use law States, six covariates had highly significant effects ($p \leq 0.0001$) on driver belt use—driver age and gender, model year, site type, vehicle type, and the State in which the observation site was located—and four did not (the square of model year, area, day of week, and weather). For drivers, in primary belt use law States where average driver belt use was 97.6 percent, only four covariates—driver age and gender, vehicle type, and the State in which the observation site was located—were found to be significant (at the .05 level).

Because of the smaller sample sizes for right-front passengers, the corresponding logistic regression models could not be estimated using all covariates. Specifically, they produced quasi-complete separation of data points and, according to the SAS log, "the maximum likelihood estimate may not exist." Hence, the results in Table 11 for right-front passengers are based on models estimated with stepwise regression, with a p-value threshold of .05 used to determine which covariates should enter or be removed from the model. For secondary law States, stepwise regression retained seven covariates which were: right-front passenger age and gender, model year and its square, area, vehicle type, and the State in which the observation site was located. For primary law States, only two covariates were retained by stepwise regression: driver age and the State in which the observation site was located.

Table 11. Logistic regression model ANOVA for belt use by type of occupant and seat belt use law

Occupant	Seat Belt Law	Effect	Degrees of Freedom	Wald Chi-Square	P-value
Driver	Secondary	**D_Age**	**2**	**88.2310**	**<0.0001**
		D_Male(D_Age)	**3**	**20.9121**	**0.0001**
		MY	**1**	**26.6106**	**<0.0001**
		MY2	1	2.0974	0.1475
		Area	2	2.8196	0.2442
		Site_Type	**4**	**28.9188**	**<0.0001**
		Vehicle_Type	**2**	**18.0691**	**0.0001**
		DayofWeek	6	9.8786	0.1299
		Weather	2	0.5234	0.7698
		State_Abbr	**3**	**154.7832**	**<0.0001**
	Primary	**D_Age**	**2**	**17.2528**	**0.0002**
		D_Male(D_Age)	**3**	**9.1330**	**0.0276**
		MY	1	1.5656	0.2108
		MY2	1	0.2919	0.5890
		Area	2	1.3452	0.5104
		Site_Type	4	6.4309	0.1692
		Vehicle_Type	**2**	**9.1197**	**0.0105**
		DayofWeek	6	8.4607	0.2063
		Weather	1	0.2883	0.5913
		State_Abbr	**3**	**79.4503**	**<0.0001**
Right-Front Passenger	Secondary	**P_Age**	**3**	**21.8104**	**<0.0001**
		P_Male(P_Age)	**4**	**27.7890**	**<0.0001**
		MY	**1**	**6.6632**	**0.0098**
		MY2	**1**	**4.4529**	**0.0348**
		Area	**2**	**6.7375**	**0.0344**
		Vehicle_Type	**2**	**15.0965**	**0.0005**
		State_Abbr	**3**	**25.4316**	**<0.0001**
	Primary	**D_Age**	**2**	**7.8926**	**0.0193**
		State_Abbr	**3**	**49.4140**	**<0.0001**

Table 12 displays Hosmer-Lemeshow lackfit statistics for the four logistic regression models of belt use probability. This statistic is calculated in two steps. In step 1, observations are grouped into up to 10 cells based on their predicted belt use probability. In step 2, model-based estimates for the expected numbers of belted and unbelted occupants are compared to the corresponding observed counts of belted and unbelted occupants, and differences between expected and observed counts are tested for statistical significance. The chi-square statistic used for comparing observed and expected counts is adjusted for the number of parameters in the model. As Table 12 shows, none of the four models was rejected by the Hosmer-Lemeshow statistic as inadequate.

Table 12. Hosmer-Lemeshow lackfit tests by type of occupant and seat belt use law

Occupant	Seat Belt Law	Chi-Square	Degrees of Freedom	P-value
Driver	Secondary	12.8272	8	0.1179
	Primary	1.8967	8	0.9840
Right-Front Passenger	Secondary	11.8849	8	0.1564
	Primary	0.7006	5	0.9829

For vehicle occupants, the difference between average observed and covariate-predicted belt use is defined as Diff = Belt – PredBelt. In principle, the variable Diff can vary between -1 and 1. For a model that predicts belt use perfectly, Diff = 0 for every observation. Given that, PredBelt is constrained to the [0, 1] interval, the value of Diff can be positive only if Belt = 1 and PredBelt < 1; and it can be negative only if Belt = 0 and PredBelt > 0. It is a property of logistic regression (Agresti, 1990) that the average of Diff for all observations included in the model equals 0. However, the average of Diff can differ from 0 in subgroups of observations, such as subgroups with the same ESBR system. In fact, the observed belt use rate for a group of observations can be larger (smaller) than the corresponding average of model-based estimates for belt use probabilities in the group indicating that group members have a systematically better (worse) belt use rate than would be expected if group members had not shared some common factor(s) that modified their belt use probability. For occupant observations in vehicles with the same ESBR system, we have attributed the common factor to having the same ESBR system. More specifically, we computed the average Diff (AvgDiff) by ESBR system, and the corresponding lower and upper 95 percent confidence interval limits for AvgDiff. ESBR systems were then classified into three groups. Group "L" included ESBR systems with an upper confidence bound less than 0. Group "M" included ESBR systems with lower and upper confidence bounds that bracketed 0. Group "U" included ESBR systems with a lower confidence bound greater than 0.

Table 13 presents summary results for Diff statistics by type of occupant and belt use law, and levels of the ESBR performance indicator that classifies ESBRs as below expected (L), above expected (U), or no different than expected (M). The rows where the performance indicator is blank present summaries across all systems by type of occupant and seat belt use law. Note that the (frequency-weighted) mean of AvgDiff (MDiff) is 0 for all four data sets. As expected, LDiff < 0 whenever the performance indicator is blank, L, or M, and LDiff > 0 when the indicator is U. Correspondingly, UDiff > 0 except when the performance indicator is L. Note also that the mean values of average Diff (MDiff) increase from L to M and from M to U. For right-front passengers in primary law States, the performance of one ESBR system could not be classified due to a sample size of one vehicle; the same was true of three systems for right-front passengers in secondary law States.

Table 13. Difference statistics by type of occupant, seat belt use law, and ESBR performance*

Occupant	Seat Belt Law	ESBR Performance	N	Belt	PredBelt	LDiff	MDiff	UDiff
Driver	Secondary		16,659	0.882	0.882	-0.023	0.000	0.023
		Lower than predicted	3,700	0.848	0.885	-0.057	-0.037	-0.017
		Not different than predicted	10,569	0.887	0.882	-0.020	0.005	0.030
		Higher than predicted	2,390	0.913	0.878	0.016	0.034	0.053
	Primary		18,516	0.976	0.976	-0.010	0.000	0.010
		Lower than predicted	1,500	0.975	0.984	-0.016	-0.008	-0.000
		Not different than predicted	15,583	0.975	0.976	-0.011	-0.001	0.010
		Higher than predicted	1,433	0.990	0.975	0.008	0.015	0.021
Right-Front Passenger	Secondary		4,084	0.894	0.894	-0.046	0.000	0.046
		N/A	3	1.000	0.828	N/A	0.172	N/A
		Lower than predicted	278	0.835	0.879	-0.088	-0.045	-0.001
		Not different than predicted	2,805	0.886	0.894	-0.062	-0.008	0.045
		Higher than predicted	998	0.936	0.901	0.009	0.035	0.062
	Primary		4,812	0.971	0.971	-0.021	0.000	0.021
		N/A	1	1.000	0.951	N/A	0.049	N/A
		Lower than predicted	0	N/A	N/A	N/A	N/A	N/A
		Not different than predicted	3,783	0.966	0.970	-0.029	-0.004	0.020
		Higher than predicted	1,028	0.989	0.973	0.006	0.016	0.026

**Belt: Average observed belt use; PredBelt: Average covariate-predicted belt use; LDiff/MDiff/UDiff: Mean lower bound, average, and upper bound for AvgDiff.*

Appendix Table C4 presents the three-way classification of ESBR systems in terms of level of belt use: L/M/U respectively denote lower, same, or higher belt use levels than predicted by the covariates for the four combinations of type of occupant and belt use law. The numbers of ESBR systems classified as under-/over-performing (L/U) systems are 3/7 and 1/9 for drivers and right-front passengers, respectively, in secondary law States and 1/12 and 0/9 for drivers and right-front passengers in primary law States.

Appendix Tables C5a – C5d present averages and lower and upper 95 percent confidence interval limits for the differences between observed and average covariate-predicted belt use by occupant type in secondary and in primary belt use law States for each of the ESBR systems in this study.

A few variables describing overall ESBR system characteristics—Euro_NCAP, D_SIT, P_SIT, D_Stages, and P_Stages—are examined in the analyses that follow. Euro_NCAP is a binary variable with values of 1 and 0 denoting compliance and non-compliance, respectively, of the ESBR system with the Euro New Car Assessment Programme standard. D_Stages and P_Stages represent the number of ESBR driver and passenger stages, respectively, with values ranging from 0 (passenger only) to 3. The variables D_SIT and P_SIT capture information about the presence of sound (S), icon (I), and text (T) features, at any stage, for the driver and passenger, respectively. These complex variables are each comprised of three characters with the first character representing whether the ESBR system has a sound feature (0=no, 1=yes), the second character representing presence of an icon feature, and the last character representing presence of a text feature. For example, a D_SIT value of "010" indicates that the ESBR system has a driver icon but no sound or text features for the driver at any stage. A D_SIT value of "111" indicates that the system has driver sound, icon, and text features at one or more stages. Tables 14a- 14e present the frequency distribution of these various ESBR characteristics for drivers and right-front passengers in States with a primary belt use law and with a secondary belt use law.

Table 14a. Frequency distribution of summary driver ESBR characteristics by type of occupant and seat belt use law

Driver Effect	All	Driver		Right-Front Passenger	
		Secondary	Primary	Secondary	Primary
All	44,071	16,659	18,516	4,084	4,812
Icon, no sound or text	4,062	1,551	1,688	374	449
Sound and icon, no text	32,470	12,304	13,541	3,087	3,538
Sound, icon, and text	7,207	2,804	3,287	623	825

Table 14b. Frequency distribution of summary driver ESBR stages by type of occupant and seat belt use law

Driver Stages	All	Driver		Right-Front Passenger	
		Secondary	Primary	Secondary	Primary
All	44,071	16,659	18,516	4,084	4,812
1 stage	18,151	6,974	7,513	1,691	1,973
2 stages	10,795	4,244	4,430	1,037	1,084
3 stages	15,125	5,441	6,573	1,356	1,755

Table 14c. Frequency distribution of summary Euro New Car Assessment Programme compliance by type of occupant and seat belt use law

Euro New Car Assessment Programme Compliance	All	Driver		Right-Front Passenger	
		Secondary	Primary	Secondary	Primary
All	44,071	16,659	18,516	4,084	4,812
No	17,699	6,512	7,628	1,587	1,972
Yes	26,372	10,147	10,888	2,497	2,840

Table 14d. Frequency distribution of summary passenger ESBR characteristics by type of occupant and seat belt use law

Passenger Effect	All	Driver		Right-Front Passenger	
		Secondary	Primary	Secondary	Primary
All	44,071	16,659	18,516	4,084	4,812
No passenger ESBR system	4,216	1,711	1,611	466	428
Icon, no sound or text	5,626	2,155	2,348	510	613
Sound and icon, no text	27,882	10,418	11,813	2,569	3,082
Sound, icon, and text	6,347	2,375	2,744	539	689

Table 14e. Frequency distribution of summary passenger ESBR stages by type of occupant and seat belt use law

Passenger Stages	All	Driver		Right-Front Passenger	
		Secondary	Primary	Secondary	Primary
All	44,071	16,659	18,516	4,084	4,812
No passenger ESBR system	4,216	1,711	1,611	466	428
1 stage	15,343	5,788	6,517	1,337	1,701
2 stages	9,528	3,773	3,873	934	948
3 stages	14,984	5,387	6,515	1,347	1,735

In Tables 15-20, three sets of ESBR systems are identified by the letters L, M, and U (as 0previously described). L-systems have significantly lower belt use rates than predicted by the covariates. U-systems have significantly higher belt use rates than predicted by the covariates. M-systems have belt use rates that are not significantly different than the rate predicted by the covariates. ESBRs were classified separately by occupant type in States with a primary belt use law and with a secondary belt use law.

Table 15 shows the Euro New Car Assessment Programme compliance status of observed vehicles for ESBRs with relatively low (L), average (M), and high (U) seat belt use rates.

- Among ESBRs with significantly lower than covariate-predicted belt use (L), 50 percent of observations were in vehicles that meet the Euro New Car Assessment Programme standard.
- Among ESBRs with belt use not significantly different than covariate-predicted belt use (M), 57 percent of observations were in vehicles that meet the Euro New Car Assessment Programme standard.
- Among ESBRs with significantly higher than covariate-predicted belt use (U), 85 percent of observations were in vehicles that meet the Euro New Car Assessment Programme standard.

Table 15. Association between Euro New Car Assessment Programme compliance and ESBR performance for all drivers and right-front passengers regardless of seat belt use law

ESBR Performance	Not Euro New Car Assessment Programme Compliant (%)	Euro New Car Assessment Programme Compliant (%)	All (%)
N/A	3 (75.00)	1 (25.00)	4 (100.00)
Lower than predicted	2,750 (50.20)	2,728 (49.80)	5,478 (100.00)
Not different than predicted	14,093 (43.05)	18,647 (56.95)	32,740 (100.00)
Higher than predicted	853 (14.58)	4,996 (85.42)	5,849 (100.00)
All	17,699	26,372	44,071

Table 16 shows that in secondary law States, ESBR systems meeting the Euro New Car Assessment Programme standard did not result in systematically increased belt use rates for drivers and right-front passengers. However, among the systems performing worse than expected, those that meet the standard did have a higher belt use rate (88%) for drivers in secondary law States than those that do not meet the standard (83%).

Table 16. Driver and right-front passenger average belt use proportions by type of seat belt use law, Euro New Car Assessment Programme compliance, and ESBR performance

Occupant	Seat Belt Law	Euro New Car Assessment Programme Compliance	ESBR Performance			
			N/A	Lower than predicted	Not different than predicted	Higher than predicted
Driver	Secondary	No	N/A	0.83	0.88	0.93
		Yes	N/A	0.88	0.89	0.91
	Primary	No	N/A	N/A	0.97	1.00
		Yes	N/A	0.98	0.98	0.99
Right – Front Passenger	Secondary	No	1.00	0.83	0.88	1.00
		Yes	1.00	N/A	0.89	0.93
	Primary	No	1.00	N/A	0.96	1.00
		Yes	N/A	N/A	0.97	0.99

The majority (73%) of observed vehicles with under-performing ESBR systems have three driver stages, while the majority (64%) of those with over-performing systems have a single driver stage (Table 17). The results for right-front passengers are presented in Table 18. Although the relationship between ESBR system performance and number of passenger stages is less clear, it does not appear that having three stages increased right-front passenger belt use.

Table 17. Association between number of driver stages and ESBR driver performance

ESBR Performance	One Driver Stage (%)	Two Driver Stages (%)	Three Driver Stages (%)	All (%)
Lower than predicted	1,402 (26.96)	0 (0.00)	3,798 (73.04)	**5,200 (100.00)**
Not different from predicted	10,620 (40.61)	7,995 (30.57)	7,537 (28.82)	**26,152 (100.00)**
Higher than predicted	2,465 (64.48)	679 (17.76)	679 (17.76)	**3,823 (100.00)**
All	**14,487**	**8,674**	**12,014**	**35,175**

Table 18. Association between number of passenger stages and ESBR passenger performance

ESBR Performance	No Passenger Stages (%)	One Passenger Stage (%)	Two Passenger Stages (%)	Three Passenger Stages (%)	All (%)
N/A	2 (50.00)	0 (0.00)	2 (50.00)	0 (0.00)	**4 (100.00)**
Lower than predicted	0 (0.00)	0 (0.00)	0 (0.00)	278 (100.00)	**278 (100.00)**
Not different from predicted	869 (13.19)	2,391 (36.29)	561 (8.52)	2,767 (42.00)	**6,588 (100.00)**
Higher than predicted	23 (1.14)	647 (31.93)	1,319 (65.10)	37 (1.83)	**2,026 (100.00)**
All	**894**	**3,038**	**1,882**	**3,082**	**8,896**

Seventy-five percent of the observed vehicles with over-performing ESBR systems for drivers have sound, icon, and text features (Table 19). Among vehicles with under-performing driver systems, none have all three of these features. For right-front passengers (Table 20), it also appears that having all three features—sound, icon, and text—is associated with ESBR systems having better than predicted seat belt use rates.

Table 19. Association between driver sound/icon/text and ESBR driver performance

ESBR Performance	Icon, No Sound or Text (%)	Sound, Icon, No Text (%)	Sound, Icon, and Text (%)	All (%)
Lower than predicted	1,402 (26.96)	3,798 (73.04)	0 (0.00)	**5,200 (100.00)**
Not different from predicted	1,837 (7.02)	21,096 (80.67)	3,219 (12.31)	**26,152 (100.00)**
Higher than predicted	0 (0.00)	951 (24.88)	2,872 (75.12)	**3,823 (100.00)**
All	**3,239**	**25,845**	**6,091**	**35,175**

Table 20. Association between passenger sound/icon/text and ESBR right-front passenger performance

ESBR Performance	No Sound, Icon, or Text	Icon, No Sound or Text (%)	Sound, Icon, No Text (%)	Sound, Icon, and Text (%)	All (%)
N/A	2 (50.00)	1 (25.00)	1 (25.00)	0 (0.00)	**4 (100.00)**
Lower than predicted	0 (0.00)	0 (0.00)	278 (100.00)	0 (0.00)	**278 (100.00)**
Not different from predicted	869 (13.19)	1,092 (16.58)	4,006 (60.81)	621 (9.43)	**6,588 (100.00)**
Higher than predicted	23 (1.14)	30 (1.48)	1,366 (67.42)	607 (29.96)	**2,026 (100.00)**
All	**894**	**1,123**	**5,651**	**1,228**	**8,896**

5.2.3 Additional Analysis

Data screening indicated that some of the predictors were highly related. Almost all drivers (93%) using ESBR systems with driver sound, icon, and text features were in vehicles that complied the Euro New Car Assessment Programme standard. Furthermore, none of the drivers using ESBR systems with only the driver icon feature were in vehicles that meet the standard. This association created statistical challenges to separating the effects of Euro New Car Assessment Programme from the effects associated with sound, icon, and text features. As a result of these challenges, analyses in this section excluded Euro New Car Assessment Programme to focus analyses on the effects of sound, icon, and text features.

In a separate set of analyses, we employed logistic regression models that included some combination of the variables D_SIT (P_SIT) and D_Stages (P_Stages) as predictors of belt use, in addition to the covariates representing occupant characteristics (e.g., age and gender), vehicle attributes (e.g., type and model year of vehicle), and situational determinants (e.g., location and time of observation, local laws, weather). These results are based on separate models for drivers and right-front passengers in secondary and in primary belt use law States.

The models for drivers included two additional predictor variables: D_SIT and D_Stages. For the passenger models, including the variables P_SIT and P_Stages together was problematic because P_SIT = "000" and P_Stages = 0 identify the same set of observations (i.e., right-front passengers in vehicles with no passenger ESBR system). For this reason, a new variable, P_Stages_SIT, was formed by crossing the number of stages and sound/icon/text variables for passengers. So, for example, a P_Stages_SIT value of "2_110" indicates that the ESBR passenger system has two stages, with sound and icon features at one or both stages but no text element for the passenger at any stage. Therefore, the passenger models included P_Stages_SIT as an additional predictor variable.

Tables 21a - 21d present a logistic regression analyses that focus on the addition of sound, icon, and text features as the additional predictor of belt use. This shows odds ratio estimates and their 95 percent confidence interval limits, where bolded rows correspond to statistically significant effects (at the .05 level).[5] For drivers in secondary belt use law States, the driver sound/icon/text variable and the number of driver stages had statistically significant effects. For drivers in secondary law States the effect of 2 versus 1 driver stages was significant at the .05 level.

Table 21a. Odds ratio estimates and 95 percent confidence intervals for sound/icon/text and number of stages for drivers in secondary law States

Driver Effect	Odds Ratio Estimate	Lower Confidence Limit	Upper Confidence Limit
Sound and icon, no text vs Icon, no sound or text	**1.385**	**1.161**	**1 .652**
Sound, icon, and text vs Icon, no sound or text	**1.827**	**1.509**	**2.212**
Sound, icon, and text vs Sound and icon, no text	**1.319**	**1.124**	**1.548**
2 stages vs 1 stage	**1.163**	**1.009**	**1.341**
3 stages vs 1 stage	0.968	0.845	1.108
3 stages vs 2 stage	**0.832**	**0.73**	**0.948**

[5]The parameter estimates for the right-front passenger belt use model in primary law States should be interpreted with caution (due to a warning message in the output from the SAS procedure). We attempted to run the model using the stepwise selection method but the ESBR feature variables were not retained in the final model.

Table 21b. Odds ratio estimates and 95 percent confidence intervals for sound/icon/text and number of stages for drivers in primary law States

Driver Effect	Odds Ratio Estimate	Lower Confidence Limit	Upper Confidence Limit
Sound and icon, no text vs Icon, no sound or text	0.983	0.689	1.401
Sound, icon, and text vs Icon, no sound or text	1.359	0.938	1.969
Sound, icon, and text vs Sound and icon, no text	**1.383**	**1.021**	**1.873**
2 stages vs 1 stage	**1.395**	**1.045**	**1.861**
3 stages vs 1 stage	1.161	0.888	1.518
3 stages vs 2 stage	0.832	0.635	1.091

Table 21c. Odds ratio estimates and 95 percent confidence intervals for sound/icon/text and number of stages for right-front passengers in secondary law States

Passenger Effect	Odds Ratio Estimate	Lower Confidence Limit	Upper Confidence Limit
1 stage – Icon, no sound or text vs No passenger ESBR system	0.793	0.531	1.186
1 stage – Sound and icon, no text vs No passenger ESBR system	1.034	0.630	1.696
1 stage – Sound, icon, and text vs No passenger ESBR system	1.327	0.864	2.037
2 stages – Icon, no sound or text vs No passenger ESBR system	>999.999	<0.001	>999.999
2 stages – Sound and icon, no text vs No passenger ESBR system	1.334	0.909	1.957
3 stages – Sound and icon, no text vs No passenger ESBR system	0.939	0.667	1.320
1 stage – Sound and icon, no text vs 1 stage – Icon, no sound or text	1.303	0.814	2.087
1 stage – Sound, icon, and text vs 1 stage – Icon, no sound or text	**1.673**	**1.107**	**2.527**
1 stage – Sound, icon, and text vs 1 stage – Sound and icon, no text	1.284	0.780	2.113
2 stages – Icon, no sound or text vs 1 stage – Icon, no sound or text	>999.999	<0.001	>999.999
2 stages – Icon, no sound or text vs 1 stage – Sound and icon, no text	>999.999	<0.001	>999.999
2 stages – Icon, no sound or text vs 1 stage – Sound, icon, and text	>999.999	<0.001	>999.999
2 stages – Sound and icon, no text vs 1 stage – Icon, no sound or text	**1.681**	**1.172**	**2.411**
2 stages – Sound and icon, no text vs 1 stage – Sound and icon, no text	1.290	0.818	2.035
2 stages – Sound and icon, no text vs 1 stage – Sound, icon, and text	1.005	0.676	1.493
2 stages – Sound and icon, no text vs 2 stages - Icon, no sound or text	<0.001	<0.001	>999.999
3 stages – Sound and icon, no text vs 1 stage – Icon, no sound or text	1.183	0.859	1.629
3 stages – Sound and icon, no text vs 1 stage – Sound and icon, no text	0.908	0.592	1.393
3 stages – Sound and icon, no text vs 1 stage – Sound, icon, and text	0.707	0.495	1.011
3 stages – Sound and icon, no text vs 2 stages – Icon, no sound or text	<0.001	<0.001	>999.999
3 stages – Sound and icon, no text vs 2 stages – Sound and icon, no text	**0.704**	**0.523**	**0.948**

Table 21d. Odds ratio estimates and 95 percent confidence intervals for sound/icon/text and number of stages for right-front passengers in primary law States

Passenger Effect	Odds Ratio Estimate	Lower Confidence Limit	Upper Confidence Limit
1 stage – Icon, no sound or text vs No passenger ESBR system	0.725	0.338	1.555
1 stage – Sound and icon, no text vs No passenger ESBR system	1.194	0.486	2.936
1 stage – Sound, icon, and text vs No passenger ESBR system	0.967	0.446	2.094
2 stages – Icon, no sound or text vs No passenger ESBR system	0.403	0.045	3.588
2 stages – Sound and icon, no text vs No passenger ESBR system	1.413	0.635	3.144
3 stages – Sound and icon, no text vs No passenger ESBR system	0.725	0.369	1.424
1 stage – Sound and icon, no text vs 1 stage – Icon, no sound or text	1.647	0.757	3.584
1 stage – Sound, icon, and text vs 1 stage – Icon, no sound or text	1.333	0.711	2.501
1 stage – Sound, icon, and text vs 1 stage – Sound and icon, no text	0.810	0.367	1.787
2 stages – Icon, no sound or text vs 1 stage – Icon, no sound or text	0.556	0.066	4.702
2 stages – Icon, no sound or text vs 1 stage – Sound and icon, no text	0.338	0.038	2.997
2 stages – Icon, no sound or text vs 1 stage – Sound, icon, and text	0.417	0.049	3.561
2 stages – Sound and icon, no text vs 1 stage – Icon, no sound or text	**1.948**	**1.005**	**3.776**
2 stages – Sound and icon, no text vs 1 stage – Sound and icon, no text	1.183	0.522	2.679
2 stages – Sound and icon, no text vs 1 stage – Sound, icon, and text	1.461	0.740	2.886
2 stages – Sound and icon, no text vs 2 stages - Icon, no sound or text	3.502	0.408	30.058
3 stages – Sound and icon, no text vs 1 stage – Icon, no sound or text	0.999	0.601	1.663
3 stages – Sound and icon, no text vs 1 stage – Sound and icon, no text	0.607	0.301	1.222
3 stages – Sound and icon, no text vs 1 stage – Sound, icon, and text	0.750	0.442	1.272
3 stages – Sound and icon, no text vs 2 stages – Icon, no sound or text	1.796	0.218	14.801
3 stages – Sound and icon, no text vs 2 stages – Sound and icon, no text	**0.513**	**0.290**	**0.907**

Conclusions

6.1 General Observations of Seat Belt Use

The observational data collection resulted in a total number of vehicle observations (69,984) that well exceeded the planned estimate (50,000). Of the observed vehicles, 98.5 percent had a valid license plate match, and of those, 90.4 percent then were matched with a valid VIN. Thus, there were 61,074 observations for which driver and right-front passenger seat belt use observations could potentially be linked with a specific vehicle's make, model, and model year. OEM-supplied detail on the ESBR features for the vehicles' make, model, and model years was available for most cases, and the degree of detail varied among the OEM responses. Thirty-nine unique ESBR systems were linked to vehicle observations, but some of the differences among "unique" systems were minor. The number of vehicles observed for specific systems varied from 2 to 4,638.

Belt use rates observed in this study were high, and rates were highest in States with primary seat belt use laws. The belt use rate for the primary law States was 97.6 percent for drivers and 97.1 percent for right-front passengers. In States without a primary law, the observed rates were 88.2 percent for drivers and 89.4 percent for right-front passengers. The overall use rates (driver and right-front passenger) were 97.5 percent in primary law States and 88.4 percent in States without a primary law. These rates are higher than comparable numbers from NOPUS, which observed 2015 rates of 92.1 percent in primary law States and 83.0 percent in States without a primary law (Pickrell & Li, 2016). The difference between primary and secondary law States was identical in this study (9.1%) and in the NOPUS findings (9.1%). Driver and right-front seat passenger belt use rates were similar in this study for both primary law and secondary law States. The higher seat belt use rates observed in this study, relative to NOPUS, may be due to a variety of factors. For example, the present study was confined to vehicles entering particular types of sites in urban and suburban locations, whereas NOPUS included rural sites and observed vehicles in active traffic. In addition, the NOPUS estimates are based on a probability-based sample design and weighted to be nationally representative. The NOPUS seat belt use estimates are also time-based rather than person-based (i.e., they represent the percentage of time on the road that vehicle occupants are belted).

The high rates of observed seat belt use have implications for analysis of the effects of ESBR characteristics. Because belt use rates were so high in primary law States, there was essentially a ceiling effect that limited the magnitude of potential ESBR benefits and the ability to detect them statistically. Thus, essentially half the data collected in this study provided little ability to discriminate among systems. It was useful to include both primary law and secondary law States to assess the magnitude of benefits and whether ESBR features act differently under such States. However, in any subsequent observational study that attempts to differentiate ESBR systems, it may be beneficial to focus on conditions that are associated with low rates of seat belt use. This might include secondary law States, rural locations, different types of sites, and other times of day. Lower seat belt use rates may make differences among systems more discriminable and may be more directly related to the locus of potential safety benefits.

6.2 Relation of ESBR Features to Seat Belt Use

Because of the difference in overall belt use rates in primary law and secondary law States (i.e., high rates in primary law States), the effects of ESBR systems were analyzed separately for the two categories of belt use law. The effects of a particular system were also analyzed separately for drivers and right-front seat passengers. Therefore, there were four parallel assessments of ESBR systems: (a) primary law/driver, (b) secondary law/driver, (c) primary law/passenger, and (d) secondary law/passenger. Right-front passengers were present in only about one-fourth of the observed vehicles, so there was less statistical power for the right-front passenger cases. The analyses focused on the difference between observed seat belt use rates versus predicted rates based on covariates (i.e., driver, vehicle, and environmental) excluding ESBR features.

As shown in Table 22 with secondary belt use law States, the frequency-weighted average driver belt use rate varied between 84.8 percent in vehicles equipped with under-performing ESBRs (N = 3) and 91.3 percent in vehicles equipped with over-performing ESBRs (N = 7). In primary belt use law States, the comparable range of variation for drivers was smaller, between 97.5 percent (N = 1) and 99.0 percent (N = 12). Similar to drivers in secondary law States, the average belt use rates for right-front passengers varied between 83.5 percent (N= 1) for under-performing systems and 93.6 percent for over-performing systems (N = 9). The comparable range for right-front passengers in primary belt use law States is not interpretable due to lack of data. Note that a belt use proportion of 1.000 means that all the observed occupants were belted, and these estimates were based on very few observations.

Table22. Summary statistics for weighted use rates of belts by occupant, State law, and comparative predicted-to-actual ESBR performance

Occupant	Seat Belt Law	ESBR Performance	Number of ESBR Systems	Minimum	Mean	Maximum	Standard Error
Driver	Secondary	Lower than predicted	3	0.821	0.848	0.875	0.015
		Not different than predicted	28	0.625	0.887	1.000	0.004
		Higher than predicted	7	0.901	0.913	1.000	0.007
	Primary	Lower than predicted	1	0.975	0.975	0.975	N/A
		Not different than predicted	26	0.875	0.975	1.000	0.002
		Higher than predicted	12	0.986	0.990	1.000	0.002
Right-Front Passenger	Secondary	N/A	3	1.000	1.000	1.000	0
		Lower than predicted	1	0.835	0.835	0.835	N/A
		Not different than predicted	24	0.500	0.886	1.000	0.007

Occupant	Seat Belt Law	ESBR Performance	Number of ESBR Systems	Minimum	Mean	Maximum	Standard Error
		Higher than predicted	9	0.924	0.936	1.000	0.007
	Primary	N/A	1	1.000	1.000	1.000	N/A
		Lower than predicted	0	N/A	N/A	N/A	N/A
		Not different than predicted	25	0.875	0.966	1.000	0.002
		Higher than predicted	9	0.983	0.989	1.000	0.002

Table 23 identifies ESBR systems with an observed belt use rate that was significantly different than predicted by the covariates. For drivers in secondary belt use law States (see Table 22), the average belt use rate ranged between 82 percent and 88 percent for the under-performing systems (N = 3) and between 90 percent and 100 percent for the over-performing systems (N = 7). The comparable range for right-front passengers in those States was 92 percent to 100 percent for over-performing systems (N = 9) and there was no variation for under-performing systems due to only one ESBR system receiving this classification. Note that upper proportion limits of 1.000 were based on small sample sizes, often just a single observation. In States with a primary belt use law, there was virtually no variation among under-performing or among over-performing ESBR systems, regardless of occupant type.

Table 23. ESBRs with significantly worse (L) or better (U) than predicted belt use rates by type of occupant and seat belt use law

ESBR System ID	Driver		Right-Front Passenger	
	Secondary	Primary	Secondary	Primary
001	U			
002		U	U	
003			U	U
004	L		L	
005	U		U	
007			U	U
010			U	
011		U		U
016		U	U	U
017				U
020	L			
023	U			
024		U	U	U
026			U	U
028		U		
029	U	U	U	

ESBR System ID	Driver		Right-Front Passenger	
	Secondary	Primary	Secondary	Primary
030	U	U		
031	U	U		
032		U		U
033	L	L		
034		U		
043	U	U		
044		U		U

No obvious features emerged from qualitative examination of the particularly stronger or weaker systems. However, three derived variables were developed as a basis for system classification. These were:

- Combination of sound, icon, and text features,
- Number of warning stages, and
- Euro New Car Assessment Programme compliance.[6]

Systems with sound, icon, and text had generally higher seat belt use rates than systems without all of these features. For drivers in secondary belt use law States, the sound/icon/text systems were significantly better than the systems without sound or text. The effect of number of stages was more ambiguous. However, interpretation is not straightforward. Regarding the Euro New Car Assessment Programme, it was difficult to separate any effects of this variable from the analysis of sound, icon, and text features. For example, while about 60 percent of observed vehicles are Euro New Car Assessment Programmecompliant, this was the case for 93 percent of vehicles with a driver sound/icon/text system and 86 percent of those with a two-stage driver system. Therefore, there were statistical challenges to examining all variables in the same model, and this analysis focused on the impact of various combinations of sound, icon, and text features.

In summary, the presence and magnitude of the benefits associated with specific ESBR systems are dependent upon whether the State has a primary seat belt use law or not. Systems that include sound and text elements, along with those that are Euro New Car Assessment Programme compliant, appear to be generally more effective.

[6] Due to the high association with sound, icon, and text features, there were statistical challenges with separating differences of Euro New Car Assessment Programme compliance from the analysis of sound, icon, and text features, so this component was excluded from the data analysis.

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APPENDIX A: Data Collection Field Guide

Westat | An Employee-Owned Research Corporation

1600 Research Boulevard
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fax: 301-294-2040
www.westat.com

To Whom It May Concern,

The bearer of this letter is a professional, trained data collector for Westat, a research company in Rockville, Maryland.

This data collector is currently working on the data collection phase of the Enhanced Seat Belt Reminder System Study. The National Highway Traffic Safety Administration is sponsoring this study. The data collection phase consists of observing shoulder seatbelt use in selected cities across the country.

This city has been selected as one of the eight areas across the United States that will be surveyed. Information from this study will be used to determine seatbelt use by drivers and occupants in passenger vehicles.

You may call me at 1-800-937-8281 extension 4898 if you have any questions.

Sincerely,

Adele Polson
Project Manager
Westat

2 ESBR 2015

SPOTTER CARD

VEHICLE COLOR	White Red Blue Silver Green Black Other
VEHICLE TYPE	Car Pickup Other
DRIVER AGE	Young (16-24) Adult (25-69) Senior (70+) ???
DRIVER GENDER	Male Female ???
DRIVER BELT STATUS	Yes No ???
PASSENGER AGE	Youth (8-15) Young (16-24) Adult (25-69) Senior (70+) ???
PASSENGER GENDER	Male Female ???
PASSENGER BELT STATUS	Yes No ???
EXTRA OCCUPANT	
LICENSE PLATE STATE	
LICENSE PLATE	

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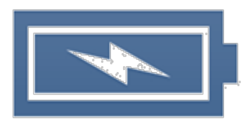
Adele Polson Project Manager Westat

PREPARING FOR DATA COLLECTION

Things to Bring

- Sunscreen and bug repellant
- Hat or visor
- Poncho
- Comfortable, closed-toe shoes
- Cooler with snacks and drinks
- Money for tolls and parking meters
- Hand sanitizer
- Field Guide with Authorization Letter
- Legal pad and a pen
- All ESBR equipment



Things to Do

- Fill gas tank nightly (on the way home)
- ABC: Always Be Charging!
- Use your tablet to check the weather during the day to be prepared for storms
- Have a standard response ready when someone asks, “What are you doing?”

SITE SETUP

- Before collecting data, identify a good observation location.
  - Drive around the site. If there are multiple entrances, find the entrance with the highest volume.
  - Look for a location where vehicles are entering slowly (i.e., stop sign, speed bump).
- If there is not enough volume or the site is closed, or partially closed, find an alternate.
  - The alternate site must be the same site type as the original.
  - Observe the alternate site for a few minutes to determine if there is enough volume.
  - Enter alternate site information into the tablet using the assigned Site ID.
- If you are scheduled to visit a site multiple times (the Site ID is repeated with a –2 or –3), and it's low volume, finish the first site visit but then look for an alternate with higher volume for the subsequent visits.
- In the event of heavy rain, abandon the site and reschedule.
  - When rescheduling a site, try to keep the same time of day and the same type of day.
  - Confirm the new date and time with your QC Monitor.

DATA COLLECTION

- Before you begin data collection, determine who will be the Spotter and who will be the Recorder.
  - Spotter: Observes and calls out vehicle information, occupant characteristics, and the license plate.
  - Recorder: Records vehicle information, occupant characteristics, and the license plate in the tablet.
- You will record the driver and all front occupants, except children under the age of 8 or those in child restraint seats.
  - If there is more than one front passenger, check the box marked "Extra Occupant". You do not need to record occupant characteristics for this passenger.
- Observe all non-commercial vehicles (i.e., vehicles without a logo).
- Give priority to vehicles in your state.
- Quality is always better than quantity.
- Collect data for two hours at each site. The tablet will let you know when you are finished.

DEFINITIONS

DRIVER & PASSENGER RESTRAINT	**Belted**	The shoulder belt is across the front of the occupant.
	Unbelted	The shoulder belt is not used or is behind the occupant.
	Unknown/???	It is unknown whether the occupant is belted or unbelted. *This is a last resort option.* If you think you know, then indicate your best guess instead.
	No Passenger	There is no one in the passenger seat, or the occupant is < 8 or in a child restraint.
	Extra Occupant	There is more than one front passenger.
OOPS	**No Vehicle**	Select if you incorrectly began recording vehicle information when there was no vehicle to observe, or if the vehicle was not from your PSU state or nearby states, as indicated by the license plate entry screen on the tablet.
	Incorrect Entry	Select if you incorrectly recorded information about the vehicle or the occupants.
	No Mistake	Select if you accidently pressed OOPS.
DEMO-GRAPHICS	**Age Gender**	Use your judgment.

ESBR MAP FEATURES

- County Border
- Water Body
- Military Base
- Shopping Centre
- Park
- PSU

- Small River/Stream
- International Border
- States Border
- Railroad
- Major Highway
- Highway
- Major Road
- Local Road
- Ramp

Site Symbols

10/03/15	10/10/15
10/04/15	10/11/15
10/05/15	10/13/15
10/06/15	10/14/15
10/07/15	10/15/15
10/08/15	10/16/15
10/09/15	10/17/15

DATA TRANSMISSION PROCEDURES

1. Press the Home Button
2. Confirm you have a Cell or WiFi connection:
   - Look for or in the notification area
   - If you do not have a connection, see the “Connecting to a Cell Network” and/or “Connecting to a WiFi Network” instructions
3. Tap the Icon to open the Transmit App
4. Tap the **Connect** Button and wait for the button to change to **Authorized**
5. Tap the **Sync Files** Button and wait for the program to tell you “All Files Sent” and “All Files Received”
   - If the program tells you “Files Remain in Data Folder,” exit the Transmit App and repeat steps 2-5

3\. Tap the **Exit** Button and absolute power off the tablet

CONNECTING TO A CELL NETWORK

1. Press the Home Button
2. If in airplane mode , swipe down “Quick Settings” from the top-right, press the Airplane Icon →
3. Confirm you have adequate cell strength (3 or 4 bars is best)

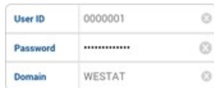
CONNECTING TO A WIFI NETWORK

1. Press the Home Button
2. Swipe down "Quick Settings" from the top-right, push and hold until you see
3. Tap to show the list of WiFi networks
4. From the WiFi networks list, tap the network you want to connect to
5. Determine the type of WiFi network you are trying to connect to:

UNSECURED NETWORK	PASSWORD PROTECTED NETWORK	GATEKEEPER NETWORK
6. Press the Home Button 7. Confirm WiFi connection	6. When prompted, enter the password for the network 7. Press the Home Button 8. Confirm WiFi connection	6. Press the Home Button 7. Tap the Internet Icon 8. Fill out the gatekeeper page 9. Press the Home Button 10. Confirm WiFi connection

TIMESHEET APP PROCEDURES

1. **Confirm you have a Cell or WiFi connection:**
   - **Look for or in the notification area**
2. **From the ESBR Program Welcome Screen, tap "Timesheet"**
3. **Read agreement and tap "I agree"**
4. **Enter Username and Password**



5. **Tap "Log In" or "Go"**
6. **Tap the appropriate date**

7. **Select hours worked by scrolling in the Hours box**

8. **Tap "Done"**
9. **Confirm that you are using the correct charge code:**
   - **Charge code: 8928.11.04**
10. **Tap "Save" in the top left corner**

11. **Tap "More" in the bottom right corner**

12. **Tap "Logout"**

GUIDELINES FOR RECORDING LICENSE PLATES

- **You will only record vehicles in your PSU state or nearby states (as indicated by the buttons on the license plate entry screen in the tablet).**
  - **If you begin observing a vehicle from a state other than those listed in the tablet, select "Oops," then "No Vehicle."**

Do not observe vehicles with temporary license plates.

When recording the license plate, type the letters and numbers using the keyboard on the tablet.

-
  - **To add a code, enter the license plate characters FOLLOWED BY TWO FORWARD SLASHES and the code.**
  - **You must add a code if the license plate is a specialty plate and all numeric.**

542651//LIGHTHOUSE

- 

Helpful tip: The Spotter may write down the license plate in order to recall it correctly for the Recorder.

SAMPLE LICENSE PLATES

Standard plate is highlighted.

ARIZONA LICENSE PLATE RULES

Rule	License Plate Example	Record
Do not record hyphens or spaces.		CG49063
		CUNAZ
The letter O and the number 0 are interchangeable. Record either.		OMT7651 *or* 0MT7651

***Please note that the state of Arizona only requires plates on the rear of the vehicle.**

ARIZONA LICENSE PLATE CODES

For the following plates, please include the plate code in the license plate entry screen on the tablet. Follow this format: LICENSEPLATE//PLATECODE

License Plate	Plate Code	Record
	**HANDI** ***note: Include the code for this standard plate only. Other handicap specialty plates do not have a code.**	A1963//HANDI
	**ASU**	F0704//ASU
	**A**	JE562L//A
	**NAU**	S5423T//NAU

CALIFORNIA LICENSE PLATE RULES

Rule	License Plate Example	Record
Record spaces.		YOUR PL8
Both the letter O and the number 0 are used. It is important to record the correct character.		OLHOOPR
		6MBV006
Record the letters “DP” (disabled person) or “DV” (disabled veteran) at the end of handicapped license plates.		66564DP

COMMON LICENSE PLATES

Standard plates are highlighted.

COLORADO LICENSE PLATE RULES

Rule	License Plate Example	Record
Always include hyphens and spaces.		026-UAT
		IBD RLZ
Both the letter O and the number 0 are used. It is important to record the correct character.		507-KLV
For specialty plates, add a space where the symbol is located.		481 GKN

COMMON LICENSE PLATES

Standard plates are highlighted.

IOWA LICENSE PLATE RULES

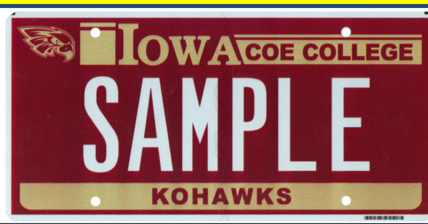
Rule	License Plate Example	Record
For non-personalized plates, do not record symbols, hyphens, or other characters.		142BPZ
		C1234
For personalized plates, record spaces. If a plate contains a space, and you are unsure whether the plate is personalized, record the space.		SC FAN

IOWA LICENSE PLATE RULES

Rule	License Plate Example	Record
Both the letter O and the number 0 are used. It is important to record the correct character.		020ZAC
Newer plates show the European zero (Ø). Note the serial formats may help distinguish between 0 and O. The format is usually “123 ABC” or “ABC 123”.		778AOS

COMMON LICENSE PLATES

Standard plates are highlighted.



MARYLAND LICENSE PLATE RULES

<table>
<tr><th>Rule</th><th>License Plate Example</th><th>Record</th></tr>
<tr><td rowspan="4">Plates can contain two or three stacked letters that should be recorded from top to bottom–left to right. All stacked letters must be recorded.</td><td>
</td><td>9AF9043</td></tr>
<tr><td>
</td><td>09736CC</td></tr>
<tr><td>
</td><td>MDZ0069</td></tr>
<tr><td>
</td><td>DSA0001</td></tr>
</table>

MARYLAND LICENSE PLATE RULES

Rule	License Plate Example	Record
Do not record symbols, hyphens, dashes, or slashes.		67X 517
Record spaces and add a space for symbols.		22399HP
Both the letter O and the number 0 are used. It is important to record the correct character.		MLV 096
		OUR BAY

COMMON LICENSE PLATES

Standard plates are highlighted.

NEBRASKA LICENSE PLATE RULES

Rule	License Plate Example	Record
Do not record hyphens or spaces.		14C947
		RXH696
Plates do not contain the letter O. If you see an 0, record it as the number 0.		SJT580

NEBRASKA LICENSE PLATE CODES

For the following plates, please include the plate code in the license plate entry screen on the tablet. Follow this format: LICENSEPLATE//PLATECODE

License Plate	Plate Code	Record
2535	**HANDI**	2535//HANDI
	**BIGRED**	59KJLA//BIGRED
242D J	**CREIGHTON**	242DJ//CREIGHTO N

NEBRASKA LICENSE PLATE CODES

License Plate	Plate Code	Record
RR-H751	**DAV**	RRH751//DAV
HTX 402	**PURPLE**	HTX402//PURP LE
2035	**PEARL**	2035//PEARL
14-C849	**POW**	14C849//POW

NEBRASKA LICENSE PLATE CODES

License Plate	Plate Code	Record
	**MIL** ***note: This code applies to all military plates.**	444CC//MIL
	**FIRE**	225BB//FIRE
NAH-458	**HERO**	NAH458//HERO
	**TRAIN**	223BB//TRAIN

NEBRASKA LICENSE PLATE CODES

License Plate	Plate Code	Record
	**SPECIAL**	123AB//SPECIAL
15240	**HIST**	15240//HIST
NØGWA	**RADIO**	N0GWA//RADIO
	**150**	111QQ//150

NEBRASKA LICENSE PLATE CODES

License Plate	Plate Code	Record
	**BEEF**	224BB//BEEF
	**FARM**	2451//FARM
	**AGRO**	94123//AGRO

TEXAS LICENSE PLATE RULES

Rule	License Plate Example	Record
Do not record spaces, hyphens, prefixes, or special characters.		CK3H547
		1XLHH
The letter O and the number 0 are interchangeable. You may record either.		ANPC0M *or* ANPCOM

COMMON LICENSE PLATES

Standard plates are highlighted.

VIRGINIA LICENSE PLATE RULES

<table>
<tr><th>Rule</th><th>License Plate Example</th><th>Record</th></tr>
<tr><td rowspan="2">Do not record hyphens or spaces.</td><td>
</td><td>XKF6302</td></tr>
<tr><td>
</td><td>MRWILL</td></tr>
<tr><td>Both the letter O and the number 0 are used. It is important to record the correct character.</td><td>
</td><td>CT2260</td></tr>
</table>

VIRGINIA LICENSE PLATE CODES

<table>
<tr><th>Rule</th><th>License Plate Example</th><th>Record</th></tr>
<tr><td rowspan="3">For all numeric specialty plates, you must add a code.

You do not need to add a code for the standard plate:

</td><td>
</td><td>192763//400</td></tr>
<tr><td>
</td><td>542651//LIGHTHOUSE</td></tr>
<tr><td>
</td><td>4705//TERRORISM</td></tr>
</table>

APPENDIX B: Additional Analysis Documentation

Table B1. Average belt use rate by type of occupant and seat belt use law

Occupant	Seat Belt Law	N	Belt Use
Driver	Secondary	16,659	0.882
	Primary	18,516	0.976
Right-Front Passenger	Secondary	4,084	0.894
	Primary	4,812	0.971

Table B2. Covariates used in analyses

Covariate	Definition	Values
D_Age (P_Age)	Driver (right-front passenger) age range	1=0-15 2=16-24 3=25-69 4=70+
D_Male (P_Male)	Driver (right-front passenger) gender	0=Female 1=Male
MY	Vehicle model year (centered)	Range of values
MY2	Vehicle model year (centered and then squared)	Range of values
Area	Type of area	1=Urban 2=Suburban 3=Rural
Site_Type	Type of site	1=Mall 2=Shopping center 3=Office park 4=Parking 5=Attraction
Vehicle_Type	Type of vehicle	1=Car 2=Other 3=Pick-up
DayofWeek	Day of week	1=Sunday 2=Monday … 7=Saturday
Weather	Weather	1=Clear 2=Light fog 3=Light precipitation
State_Abbr	State abbreviation	Two-character State abbreviation

Table B3. Covariates statistically significant at .05 level in logistic regression models (see Table 11)

Variable	Driver		Right-Front Passenger	
	Primary	Secondary	Primary	Secondary
D_Age	*	*		*
D_Male(D_Age)	*	*		
P_Age			*	
P_Male(P_Age)			*	
MY		*	*	
MY2			*	
Area			*	
Site_Type		*		
Vehicle_Type	*	*	*	
DayofWeek				
Weather				
State_Abbr	*	*	*	*

Table B4 classifies ESBR systems as worse (L), not different (M), or better (U) than predicted by the covariates for drivers and for right-front passengers in secondary and in primary belt use law States.

Table B4. ESBR system performance classification by type of occupant and seat belt use law

ESBR System ID	Driver		Right-Front Passenger	
	Secondary	Primary	Secondary	Primary
001	U	M	M	M
002	M	U	U	M
003	M	M	U	U
004	L	M	L	M
005	U	M	U	M
006	M	M	M	M
007	M	M	U	U
008	M	M	M	M
009	M	M	M	M
010	M	M	U	M
011	M	U	M	U
013	M	M	N/A (N=1)	M
015	N/A (N=0)	M	N/A (N=0)	N/A (N=0)
016	M	U	U	U
017	M	M	M	U
019	M	M	M	M
020	L	M	M	M
022	M	M	M	M

Table B4. ESBR system performance classification by type of occupant and seat belt use law (cont.)

ESBR System ID	Driver		Right-Front Passenger	
	Secondary	Primary	Secondary	Primary
023	U	M	M	M
024	M	U	U	U
025	M	M	M	M
026	M	M	U	U
027	M	M	M	M
028	M	U	N/A (N=1)	N/A (N=0)
029	U	U	U	N/A (N=1)
030	U	U	N/A (N=1)	N/A (N=0)
031	U	U	M	N/A (N=0)
032	M	U	M	U
033	L	L	M	M
034	M	U	M	M
035	M	M	M	M
036	M	M	M	M
038	M	M	M	M
039	M	M	M	M
040	M	M	M	M
041	M	M	M	M
043	U	U	N/A (N=0)	M
044	M	U	M	U
045	M	M	M	M

Table B5a. Averages and 95 percent confidence interval limits for differences between observed and average covariate-predicted belt use by ESBR for drivers in law secondary States

ESBR System ID	N	ESBR Performance	LDiff	AvgDiff	UDiff
001	369	U	0.021	0.047	0.073
002	49	M	-0.041	0.030	0.100
003	1,982	M	-0.001	0.013	0.026
004	1,070	L	-0.069	-0.047	-0.024
005	1,393	U	0.011	0.027	0.042
006	8	M	-0.667	-0.242	0.182
007	54	M	-0.204	-0.095	0.014
008	445	M	-0.018	0.010	0.039
009	343	M	-0.057	-0.021	0.016
010	26	M	-0.175	-0.034	0.107
011	16	M	-0.079	0.052	0.183
013	7	M	-0.296	-0.009	0.278
016	18	M	-0.100	0.021	0.142
017	42	M	-0.087	0.013	0.113
019	149	M	-0.107	-0.045	0.017
020	1,402	L	-0.059	-0.040	-0.021
022	2,102	M	-0.002	0.011	0.025
023	592	U	0.019	0.040	0.060
024	52	M	-0.039	0.026	0.090
025	623	M	-0.041	-0.014	0.013
026	371	M	-0.016	0.013	0.042
027	40	M	-0.088	0.021	0.130
028	2	M	-0.507	0.168	0.843
029	11	U	0.149	0.214	0.279
030	6	U	0.055	0.107	0.159
031	16	U	0.071	0.087	0.103
032	263	M	-0.003	0.028	0.059
033	1,228	L	-0.043	-0.025	-0.006
034	12	M	-0.150	0.026	0.202
035	716	M	-0.005	0.017	0.039
036	660	M	-0.019	0.005	0.028
038	277	M	-0.068	-0.027	0.013
039	732	M	-0.024	0.000	0.024
040	418	M	-0.033	-0.005	0.024
041	180	M	-0.086	-0.036	0.014
043	3	U	0.068	0.086	0.103
044	841	M	-0.007	0.013	0.032
045	141	M	-0.029	0.021	0.071

Table B5b. Averages and 95 percent confidence interval limits for differences between observed and estimated average belt use by ESBR for drivers in primary law States

ESBR System ID	N	ESBR Performance	LDiff	AvgDiff	UDiff
001	445	M	-0.006	0.008	0.022
002	53	U	0.015	0.019	0.023
003	2,220	M	-0.001	0.004	0.009
004	946	M	-0.004	0.004	0.011
005	1,545	M	-0.008	0.000	0.008
006	10	M	-0.305	-0.079	0.146
007	83	M	-0.076	-0.029	0.018
008	479	M	-0.015	-0.000	0.014
009	449	M	-0.031	-0.012	0.006
010	48	M	-0.076	-0.019	0.039
011	28	U	0.018	0.023	0.028
013	16	M	-0.274	-0.097	0.080
015	2	M	-0.037	0.021	0.078
016	22	U	0.011	0.015	0.019
017	48	M	-0.141	-0.060	0.022
019	121	M	-0.012	0.011	0.034
020	1,567	M	-0.014	-0.006	0.003
022	2,536	M	-0.004	0.002	0.008
023	1,009	M	-0.008	0.002	0.012
024	75	U	0.014	0.017	0.021
025	684	M	-0.007	0.005	0.017
026	211	M	-0.005	0.009	0.022
027	46	M	-0.023	0.021	0.066
028	3	U	0.011	0.017	0.024
029	11	U	0.024	0.044	0.064
030	5	U	0.009	0.023	0.037
031	9	U	0.008	0.016	0.024
032	149	U	0.018	0.021	0.023
033	1,500	L	-0.016	-0.008	-0.000
034	9	U	0.006	0.014	0.022
035	710	M	-0.011	0.000	0.011
036	645	M	-0.023	-0.009	0.005
038	289	M	-0.033	-0.013	0.007
039	658	M	-0.007	0.003	0.012
040	473	M	-0.010	0.002	0.014
041	204	M	-0.056	-0.028	0.000
043	9	U	0.014	0.031	0.047
044	1,060	U	0.006	0.013	0.020
045	139	M	-0.055	-0.021	0.014

Table B5c. Averages and 95 percent confidence interval limits for differences between observed and estimated average belt use by ESBR for right-front passengers in secondary law States

ESBR System ID	N	ESBR Performance	LDiff	AvgDiff	UDiff
001	66	M	-0.049	0.027	0.103
002	19	U	0.061	0.080	0.100
003	540	U	0.008	0.029	0.050
004	278	L	-0.088	-0.045	-0.001
005	317	U	0.002	0.030	0.059
006	2	M	-6.318	-0.375	5.568
007	8	U	0.059	0.080	0.101
008	107	M	-0.106	-0.039	0.028
009	71	M	-0.046	0.021	0.088
010	6	U	0.046	0.107	0.167
011	5	M	-1.018	-0.300	0.418
013	1	N/A	N/A	0.077	N/A
016	7	U	0.061	0.090	0.119
017	14	M	-0.261	-0.046	0.168
019	41	M	-0.239	-0.099	0.040
020	333	M	-0.067	-0.030	0.007
022	518	M	-0.018	0.007	0.033
023	141	M	-0.031	0.016	0.062
024	16	U	0.053	0.072	0.091
025	118	M	-0.037	0.018	0.073
026	81	U	0.008	0.051	0.095
027	6	M	-0.717	-0.188	0.340
028	1	N/A	N/A	0.301	N/A
029	4	U	0.012	0.275	0.538
030	1	N/A	N/A	0.138	N/A
031	2	M	-0.049	0.038	0.124
032	66	M	-0.051	0.014	0.078
033	323	M	-0.064	-0.030	0.005
034	2	M	-0.059	0.076	0.211
035	173	M	-0.059	-0.010	0.040
036	149	M	-0.075	-0.024	0.028
038	65	M	-0.112	-0.029	0.054
039	220	M	-0.035	0.006	0.047
040	108	M	-0.052	0.002	0.056
041	53	M	-0.090	-0.009	0.072
044	192	M	-0.039	0.003	0.046
045	30	M	-0.054	0.042	0.138

Table B5d. Averages and 95 percent confidence interval limits for differences between observed and estimated average belt use by ESBR for front-right passengers in primary law States

ESBR System ID	N	ESBR Performance	LDiff	AvgDiff	UDiff
001	111	M	-0.007	0.018	0.043
002	14	M	-0.196	-0.045	0.106
003	580	U	0.007	0.015	0.023
004	224	M	-0.051	-0.024	0.003
005	377	M	-0.027	-0.008	0.011
006	2	M	-0.403	0.045	0.494
007	22	U	0.022	0.030	0.037
008	116	M	-0.047	-0.009	0.029
009	104	M	-0.028	0.005	0.037
010	8	M	-0.390	-0.104	0.182
011	10	U	0.013	0.016	0.020
013	5	M	-0.000	0.020	0.041
016	7	U	0.013	0.015	0.018
017	10	U	0.010	0.031	0.051
019	41	M	-0.042	0.007	0.056
020	408	M	-0.020	-0.003	0.015
022	669	M	-0.013	0.000	0.013
023	286	M	-0.029	-0.006	0.016
024	21	U	0.014	0.023	0.032
025	134	M	-0.032	0.001	0.033
026	47	U	0.014	0.019	0.023
027	18	M	-0.220	-0.065	0.090
029	1	N/A	N/A	0.049	N/A
032	41	U	0.015	0.022	0.029
033	431	M	-0.026	-0.009	0.008
034	2	M	-0.027	0.013	0.053
035	197	M	-0.008	0.012	0.032
036	175	M	-0.051	-0.019	0.013
038	75	M	-0.037	-0.001	0.035
039	155	M	-0.018	0.004	0.025
040	139	M	-0.016	0.008	0.032
041	67	M	-0.069	-0.019	0.031
043	3	M	-0.039	0.047	0.133
044	290	U	0.001	0.016	0.031
045	22	M	-0.107	-0.014	0.080

Tables B6-B8 present crosstabs of the variables Euro_NCAP, P_SIT, and P_Stages for observed right-front seat passengers.

Table B6. Frequency distribution of Euro New Car Assessment Programme compliance by passenger sound/icon/text

Euro New Car Assessment Programme Compliance	No Sound, Icon, or Text		Icon, No Sound or Text		Sound, Icon, No Text		Sound, Icon, and Text		All
	N	%	N	%	N	%	N	%	
No	112	12.53	799	71.15	2,596	45.94	52	4.23	**3,559**
Yes	782	87.47	324	28.85	3,055	54.06	1,176	95.77	**5,337**
All	**894**	**100.00**	**1,123**	**100.00**	**5,651**	**100.00**	**1,228**	**100.00**	**8,896**

Table B7. Frequency distribution of Euro New Car Assessment Programme compliance by number of passenger stages

Euro New Car Assessment Programme Compliance	No Passenger Stages		One Passenger Stage		Two Passenger Stages		Three Passenger Stages		All
	N	%	N	%	N	%	N	%	
No	112	12.53	847	27.88	272	14.45	2,328	75.54	**3,559**
Yes	782	87.47	2,191	72.12	1,610	85.55	754	24.46	**5,337**
All	**894**	**100.00**	**3,038**	**100.00**	**1,882**	**100.00**	**3,082**	**100.00**	**8,896**

Table B8. Frequency distribution of passenger sound/icon/text by number of passenger stages

Passenger Sound/Icon/ Text	No Passenger Stages		One Passenger Stage		Two Passenger Stages		Three Passenger Stages		All
	N	%	N	%	N	%	N	%	
No Sound, Icon, or Text	894	100.00	0	0.00	0	0.00	0	0.00	**894**
Icon, No Sound or Text	0	0.00	1,089	35.85	34	1.81	0	0.00	**1,123**
Sound and Icon, No Text	0	0.00	721	23.73	1,848	98.19	3,082	100.00	**5,651**
Sound, Icon, and Text	0	0.00	1,228	40.42	0	0.00	0	0.00	**1,228**
All	**894**	**100.00**	**3,038**	**100.00**	**1,882**	**100.00**	**3,082**	**100.00**	**8,896**

Driver belt use rates (Table B9) in secondary belt use law States in under-performing (L) and over-performing (U) ESBR-equipped vehicles varied between 84.8 percent and 91.3 percent. In primary belt use law States, the comparable variation was between 97.5 percent and 99.0 percent.

Table B9. Average driver belt use proportions by seat belt use law and ESBR performance

Seat Belt Law	ESBR Performance	N	Driver Belt Use
Overall		**35,175**	**0.932**
	Lower than predicted	5,200	0.884
	Not different than predicted	26,152	0.939
	Higher than predicted	3,823	0.942
Secondary		**16,659**	**0.882**
	Lower than predicted	3,700	0.848
	Not different than predicted	10,569	0.887
	Higher than predicted	2,390	0.913
Primary		**18,516**	**0.976**
	Lower than predicted	1,500	0.975
	Not different than predicted	15,583	0.975
	Higher than predicted	1,433	0.990

Right-front passenger belt use rates (Table B10) in secondary belt use law States in under-performing (L) and over-performing (U) ESBR-equipped vehicles varied between 83.5 percent and 93.6 percent. In primary belt use law States the analyses did not identify any under-performing (L) ESBR-equipped vehicles. In over-performing vehicles (U), the average right-front passenger belt use rate was 98.9 percent.

Table B10. Average right-front passenger belt use proportions by seat belt use law and ESBR performance

Seat Belt Law	ESBR Performance	N	Right-Front Passenger Belt Use
Overall		**8,896**	**0.936**
	N/A	4	1.000
	Lower than predicted	278	0.835
	Not different than predicted	6588	0.932
	Higher than predicted	2,026	0.963
Secondary		**4,084**	**0.894**
	N/A	3	1.000
	Lower than predicted	278	0.835
	Not different than predicted	2,805	0.886
	Higher than predicted	998	0.936
Primary		**4,812**	**0.971**
	N/A	1	1.000
	Lower than predicted	0	N/A
	Not different than predicted	3,783	0.966
	Higher than predicted	1,028	0.989

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November 2021

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