

**SHRP2 Naturalistic Driving Study  
Phase I Summary  
State College, Pennsylvania  
Data Collection Site**

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<b>16. Abstract</b> The SHRP2 Naturalistic Driving Study is the largest naturalistic driving study undertaken, collecting data from six sites around the United States, including State College, Pa. Recruitment and admission of human subjects into the study is described, emphasizing the efforts to protect the confidentiality of subjects. Assessments relating to the driving task that are conducted on subjects are explained in detail for procedure and purpose. The instrumentation of the vehicle is also explained in detail with illustrations. In the process of enrolling subjects in the study, several trends were noted, including a high prevalence of Toyota Priuses in those interested in participating. Finally, the eventual role the data set will have for transportation research is discussed.			
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SHRP2 Naturalistic Driving Study, Phase I Summary  
State College, Pa. Data Collection Site

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## Problem

Each year in the United States more than 30,000 people are killed and 2 million injured in road-related crashes. Of those fatalities, about 1,200 of them occur in the State of Pennsylvania (NHTSA, 2011). The Centers for Disease Control and Prevention (CDC) reports that vehicle crashes are the number two killer of individuals under age 35, second only to suicide. The CDC also reports trauma as the number four killer of individuals of all ages (Heron, 2012). The number of deaths and the number of human hours lost to injury and illness related to crashes create a mandate for research.

The Naturalistic Driving Study (NDS) is a large research effort directed at improving highway safety in the United States. Naturalistic driving has two key advantages compared to more traditional data sources. The first is detailed and accurate pre-crash information, including information on driving behavior. The second advantage is exposure information. If a crash occurs, it will be observed in the context of a history of the driver's behavior (Campbell, 2012). So the study will help researchers gain a deeper understanding of the interaction between the driver, vehicle, and roadway and lead to safer roadways, vehicles, and driver training programs.

Naturalistic observations enable researchers to obtain information not easily available through other means. For example, after-the-fact crash investigations are unable determine accurately a driver's behavior before the crash (Campbell, 2012). Essentially, there is little context when crashes are reviewed from a database that can only reliably explain the results of the crash.

This NDS is part of the larger Second Strategic Highway Research Program (SHRP2). SHRP2 was developed to fund the most pressing needs related to the highway system in the United States. Research projects are divided into four program areas: renewal, reliability, capacity, and safety. The NDS is the primary research activity in the safety program area. SHRP2 is currently authorized through March 2015 with funding of \$232.5 million, with \$67 million allocated to the NDS (SHRP2).

## Approach

The SHRP 2 Naturalistic Driving Study will look at how people normally drive by installing cameras and sensors in people's own vehicles. NDS data collection sites in Bloomington, Ind., Buffalo, N.Y., Durham, N.C., Seattle, Wash., State College, Pa., and Tampa, Fla. intend to enroll up to 3,100 individuals to collect 3,500 human years of driving data. The State College site strives to have 150 instrumented vehicles on the road at any given time (Campbell, 2012). Each of these NDS sites reports back to the Virginia Tech Transportation Institute (Virginia Tech), which acts as a central coordination command for the project.

Setting State College apart, it is the only NDS data collection site where the majority of the area is rural. The study area is comprised of 10 counties in the geographical center of Pennsylvania: Blair, Cambria, Centre, Clearfield, Clinton, Huntingdon, Juniata, Mifflin, Snyder, and Union. The largest communities in this area are Altoona (population 46,329), State College

(population 42,499), and Johnstown (population 20,814) (U.S. Census, 2010). The study area is situated in both the Ridge and Valley and the Appalachian Plateau provinces of the Appalachian Mountains. This enables collection of data in rugged, mountainous environments as well as sweeping, rolling valleys.

In a naturalistic driving study, study participants are observed unobtrusively in a natural setting, usually their own vehicle, for a long period of time. In this study, the period ranges from 4 months to over 2 years. When the vehicle is turned on, observations are continuously taken from the variety of different devices in the vehicle.

Technology has only recently enabled true naturalistic driving studies. Yet, the output of the 100-Car Study performed by the Virginia Tech Transportation Institute indicated this is a reasonable and feasible way to study drivers in the natural driving environment. As indicated previously, naturalistic driving generates information that differs from more traditional sources, enabling a type of analysis previously unavailable to researchers.

Prior to installation, subjects read and sign forms consenting to participation in the study. The consent forms describe all aspects of the study in detail. Subjects and the assessment staff each sign a copy of the consent form, enabling both the subject and staff to retain an original, signed copy of the consent form. Once the consent forms are signed, the vehicle team is able to begin instrumenting the vehicle and the subject team may begin performing the human subject assessment.

This research is approved by the institutional review boards at the National Academies, Virginia Tech, and on-site at Penn State (Campbell, 2012). Additionally, this research has a Certificate of Confidentiality from the National Institutes of Health. This certificate protects identifiable research information from forced disclosure. Because of the nature of the research, observing individuals in their vehicles and potentially engaging in illegal or unsafe behavior, it is important for subjects to know their data is protected in the event of a crash, traffic court, or other condition where the data collected by the study could be considered as a source of evidence.

All of the data collected by the instrumented vehicles is encrypted and stored anonymously, subjects and vehicles are all referred to by their numbers in the study. Because of the possibility of multiple drivers being associated with an individual vehicle, vehicle and subject numbers are not the same. This means that in the event the instrumentation is stolen or an unauthorized person attempts to access the data they will not be able.

As a final layer of data protection, none of the collected data is reviewed locally. Hard drives are sent back to Virginia Tech for processing by an organization separate from the data collection sites. No one who works directly with human participants in this study handles the collected data from the instrumented vehicles.

## **Methodology**

The product of the SHRP2 Naturalistic Driving study is a database of information collected from human subjects. It is expected to generate one petabyte of data. The cornerstone

of the data set is having video, from multiple vantage points, of any traffic incidents that may occur during the study. This information is supplemented with information collected from the subject during the intake and assessment as well as de-installation procedures. Then, at the end of their participation, subjects are asked to respond to two more surveys to account for any possible changes during the study on topics such as increased awareness of driving safety and changes to medical conditions and medications. First, the subject intake and assessment procedures will be described, followed by the interaction with subjects once they are installed, then the de-installation procedures.

## **Subject Intake and Assessment**

Once subjects agree to participate in the Naturalistic Driving Study, they come to the installation and assessment facility in State College, Pa. After they sign the consent forms, described in the previous section, and while their vehicle is installed, project staff performs several assessments with each subject. It is important to point out that the project staff members' administrating assessments do not share the results of any assessments with the participants, nor do they diagnose or speculate on the relationship between performance on the assessments and medical conditions. Unless cited otherwise, descriptions of procedures and surveys originate from the SHRP2 Naturalistic Driving Study Assessment Training that took place in September 2010 and/or from the information provided to participants for each test. A description of each of these assessments follows.

Clock Drawing Test: This test is a standard in health care to diagnose dementia in primary care settings. According to research by Kirby et al. (2001), the Clock Drawing Test (CDT) was able to detect dementia in 76 percent of dementia cases. Recording the results of the CDT and connecting them to the subject identification number enables this potentially insightful information on mental status to be available in analysis of any vehicle events.

To perform this assessment, the subject is presented with an 8.5" by 11" sheet of paper with a circle drawn on it. Subjects are asked to write numbers inside the circle to complete the face of the clock. Once this task is complete, the subject is asked to add hands to the clock to illustrate the time "10 minutes after 11."

Connors Continuous Performance Test II: This test is commonly used to assist in the diagnoses of Attention Deficit and Hyperactivity Disorder (ADHD). How it works is that during the test, white letters will appear on a black background. When any letter appears on the screen except for "X" the subject must press the space bar.

First the subject gets to practice the technique. This practice period is not measured and does not contribute to the final scoring. Once the subject has practiced, the test itself is 15 minutes in duration.

The report generated by the program looks at inattentiveness, impulsivity, and vigilance. For each of these measures there are several contributing factors. For ease of analysis, it is clearly indicated if that factor detects an attention issue. Factors contributing to inattentiveness are the number of omissions, number of commissions, hit rate, standard error of hit rate, variability, detectability, and hit rate change. Factors contributing to impulsivity are commissions



and hit rate. Finally, factors contributing to understanding of vigilance are hit rate block change and hit rate standard block change.

Vision Tests: To evaluate vision, an Optec 6500P, produced by Stereo Optical, is used. This device has the capability to perform a comprehensive visual screening in minimal time under a variety of conditions, including monocular, binocular, near, distance, daytime, and nighttime. The Optec 6500P can also perform a peripheral vision test (Campbell, 2012).

Numerous tests are performed, including three contrast sensitivity tests. Each of the contrast sensitivity tests alternates with another vision test. The first test is for visual acuity. Visual acuity refers to the acuteness or clearness of vision. This is dependent on the retinal focus within the eye and then interpretive capabilities of the brain. Normal visual acuity is typically referred to as 20/20 vision. A number of factors can influence visual acuity, including nearsightedness, farsightedness, damage to the retina, and diseases of the eye.

Contrast sensitivity under nighttime conditions is the following test. This test requires that subjects look into the Optec machine and identify the direction that lines in one of nine patches are pointing. Each eye is tested and measured individually over five slides, each with nine patches. The frequency of the lines changes between slides and the contrast (darkness versus lightness) is reduced from patch to patch in each slide. There are two additional contrast sensitivity tests performed in alternating succession with the following tests. These additional contrast sensitivity tests evaluate contrast sensitivity in daylight conditions and nighttime conditions with glare present.

After the first contrast sensitivity test is the evaluation for depth perception. In this test, a slide with “bull’s eye” type depictions is presented to the subject. Each depiction includes some degree of three-dimensionality or depth. The subject is asked whether or not a depiction has any depth until the subject reaches a depiction that does not appear to be “coming at them” or having any three-dimensional effect. The number of images in which they can see depth indicates their ability to perceive depth. Depth perception is important in judging vehicle speeds, acceptable gaps for turning in and out of traffic, stopping distance, and related activities in the driving task.

Color blindness is evaluated with a slide featuring eight circles. Each of the eight circles is composed of many very small circles in different shades of the same color. Seven of these circles have a number in them and the remaining circle has no number in it. Subjects are asked to identify the number they see in each circle. They are scored on their accuracy in identifying the correct number. The correct answer for the circle with no number in it is for them to identify that there is indeed no number present.

The final vision test evaluates peripheral vision in each eye. For this test, the subject will look into the Optec machine with one eye turned off, so they can only see the slide with one eye. At this point, the individual performing the assessment will press four buttons that will make a small light appear at some place in the peripheral field. The subject is asked to indicate when they see one of the lights. After one eye is evaluated, the test is repeated with the other eye.

Grip Test: Using a hand dynamometer, subjects’ grip strength is evaluated. Subjects are first asked to squeeze the dynamometer with their right hand as tightly as possible. Once they

start squeezing, the individual performing the assessment encourages them to try just a little bit harder. Often the subject will be able to grip the device just a little bit more tightly. This procedure is repeated three more times: left hand, right hand, and left hand. The grip test is important because it has been found that grip strength of less than 30 lb per hand has a negative effect on steering capabilities.

Leg Strength and Mobility: By timing the subject walking as quickly as they can 10 feet in one direction and 10 feet back to their starting point, the subject's leg strength and mobility is evaluated. Pertaining to the vehicle, leg strength and mobility indicates how well a driver may interact with the pedals in their vehicle under ordinary and emergency conditions.

Visualization of Missing Information: This cognitive test presents a sample completed image and four incomplete images. To complete the test the subject must indicate which of the four incomplete images could be completed by only adding lines. After a prolonged period of time, it requires that subjects select an image. If at this point the subject does not select an image, the test continues and the lack of response is recorded with a negative effect on the subject's score. Evaluated by this test is the subject's ability to anticipate and recognize hazards even if not all of the information is available.

Visual Search with Divided Attention: In this test, an image of a car or a truck is presented in the center of the screen and a smaller image of either a car or truck is presented in one of eight peripheral locations. In this test, subjects are asked to identify whether the image in the center of the screen is a car or a truck and they are asked where on the periphery the second image appeared. The more accurate the responses are from the subject, the faster the images appear and disappear from the screen. This test is intended to gain insight as to how well a driver can focus both on the road ahead of them and on the signage and other cues that may be present in the greater environment.

Visual Information Processing Speed: This test is very similar to a connect-the-dots puzzle. The first part of the test has a screen with numbers from 1 to 25 scattered throughout the screen. The subject must press each number in order on the screen as quickly as possible. The second part of the test is similar, except with numbers 1 to 13 and letters A to L. Subjects start by pressing the number 1 followed by the letter A and continue to alternate between numbers and letters in sequence as quickly as possible. This test is measuring the speed at which information from all over the screen may be processed similar to an individual having to process information from all over the field of view while operating a motor vehicle.

Surveys: The final component of the intake and assessment procedures is a series of surveys that gather information about the subject ranging from demographics to additional cognitive information. Most subjects completed the battery of surveys in 45 to 60 minutes. Each of the surveys is described in greater detail below.

*Barkley's Quick Screen* is used in clinical settings to help identify adults with ADHD. It is comprised of 18 yes or no questions and addresses three different areas: current symptoms of ADHD, areas of impairment, and childhood symptoms of ADHD.

The *SHRP2 NDS Demographic Questionnaire* seeks to learn more about the subject. It asks demographic questions, including gender, date of birth, ethnicity, race, country of origin, highest level of education, marital status, household status (e.g., live alone, one-parent household, two-parent household), whether or not they rent or own their home, how long they have lived in their current home, employment status, occupation, income, number of people living in the home, and the ZIP code of primary residence. In addition to these demographic questions, the survey asks about vehicles and driving history. These questions include number of miles driven in the previous year, whether or not the study vehicle is used for business purposes, how long the study vehicle has been in the subject's possession, and at what age the subject was first able to drive alone (obtained a driver's license).

The *Driving History Questionnaire* seeks more specific information on subject driving history. It asks subjects to select a range of annual miles driven, enter the number of years they have been driving, to select one or more types of driving training they received prior to their license, to select the number of traffic violations they have had in the past year, to select the number of crashes they have been involved in over the past year, and whether or not the subject has had car insurance over the past six months.

The *Driving Knowledge* survey reads similar to a written driving exam, similar to those administered when individuals first apply for a learner's permit. The questions ask basic questions about general driving rules, traffic control devices, and driving under specific conditions (e.g., driving at night).

*Frequency of Risky Behavior Questionnaire* asks drivers to rate their propensity to engage in risky driving behaviors over the past 12 months. The subject may indicate that they never, rarely, sometimes, or often engage in the risky behavior. Some of the behaviors in the survey include driving when sleepy, failing to stop at a stop sign, make illegal turns, follow emergency vehicles when they are operating with lights and sirens, pass on the right or on the shoulder, drink alcohol and/or use recreational drugs while driving, and drive to relieve stress or tension.

The *Medical Conditions & Medications Questionnaire* asks the subject general questions about their personal health characteristics and medications. Subjects are first asked to indicate their height, weight, and neck size. This is followed by a list of conditions that may impact driving; here, the subject is asked to select all of those for which they have been diagnosed. The questionnaire continues to ask about conditions pertaining to specific features and systems in the body: vision, hearing, heart conditions, neurological conditions, vascular, sleep, respiratory, metabolic conditions, renal conditions, musculoskeletal, history of cancer, and psychiatric conditions. After completing the medical history, the subject is asked about prescription medication use. Finally, subjects are asked about the relationship between their medical condition and ability to drive. Key questions in this section ask whether or not a subject has been told by a physician that their condition may not be compatible with driving or if the subject has changed their driving habits due to their condition.

The *Modified Manchester Driver Behavior Questionnaire* is interested in understanding two facets of driving: errors and violations. Errors are actions not planned (e.g., a mistake) while violations are deliberate actions deviating from safe driving habits (e.g., drinking alcohol while driving). The modified questionnaire has improved the usefulness of the results of the survey while still capturing meaningful information relating to errors and violations, but also lapses in memory (Freeman, Davey, & Wishart, 2010). From the questionnaire, an error may be misreading a sign and then traveling the wrong way down a one-way street. An example of a violation is driving even though you realize you have consumed too much alcohol. An example of a lapse is forgetting where you parked your car.

*Integrated Systems Feature Identification* asks subjects what types of technologies are present inside their vehicle. Here the subject is asked if the following is present in their vehicle: integrated cell phone system (e.g., Bluetooth), factory-installed navigation system, OnStar (or similar product), and/or an auxiliary or USB input to connect an iPod or MP3 music player.

The *Perception of Risk Questionnaire* asks subjects to rate how engaging in a certain driving behavior would affect their risk of being involved in a crash. Ratings are on a scale from one (no greater risk) to nine (much greater risk). Activities included in the questionnaire include, but are not limited to: running red lights, changing lanes suddenly to get ahead in traffic, making illegal turns, and taking more risks because you are in a hurry.

Developed by Marvin Zuckerman, the *Sensation Seeking Scale* is intended to evaluate the amount of sensation or stimulation sought out by individuals in their lives. Zuckerman and his research team found high sensation seekers tend to seek high levels of stimulation in their daily lives (1964). Additional research by Roberti has found correlation between high sensation seekers and speeding as well as disregard for traffic control devices (2004). This survey is structured by giving the subject two statements relating to the same general topic and the subject must choose the statement that represents them more accurately. For example, a subject would have to choose A or B: (A) I usually don't enjoy a movie or play where I can predict what will happen in advance; (B) I don't mind watching a movie or play where I can predict what will happen in advance.

Finally, the subject completes the *Sleep Questionnaire*. This survey first asks about the types of work and the regularity of hours worked for the subject. Then the survey asks about sleeping habits and sleeping problems. The survey specifically asks whether or not the subject has fallen asleep while driving or stopped in traffic in the past month and in the past year. The survey also asks about caffeine, alcohol, tobacco, and sleep aid consumption habits. Several questions are targeted toward subjects who may be engaged in shift work, and addresses those who may frequently vary between day and night shifts. Finally, the survey asks about overall sleep quality, likelihood of falling asleep while performing routine activities (e.g., watching TV), if others have commented on their sleep (e.g., stopped breathing, snoring), and overall how well rested they feel.

This concludes the subject assessment process of the driving study. At this point the consent forms are signed; installation of the vehicle instrumentation on the subject vehicle has

been occurring in parallel to the assessment. The equipment and procedure for that is explained in the following section.

## Vehicle Data Collection

The data acquisition system (DAS) is the entire data collection system. Its three most conspicuous components are the head unit, the main unit (hard drive), and the radar unit mounted to the front license plate frame on instrumented vehicles. But there are smaller devices and wiring that bring these units together and communicate their status to the study sites to enable prompt maintenance.

The DAS was developed with some specific characteristics in mind to facilitate high-quality data collection. First, the DAS is compatible with most vehicles. In some vehicles not all data points may be accessed or collected, and other vehicles require different wiring but, overall, the DAS is able to collect the same data from most vehicles. Second, the DAS system is designed to be unobtrusive, non-invasive, and correspondingly non-distracting. These characteristics help drivers adjust to the equipment in their vehicle and do not interfere with safe driving. Finally, when the DAS is removed, there are no permanent changes to the vehicle.

The head unit performs three unique functions. There are four cameras on the head unit: one looking out the front windshield, one looking at the driver's face, one camera looking down at the driver's hands, and one camera looking into the cabin of the vehicle. Each camera records continuous video except for the camera capturing the entire vehicle interior; it periodically takes a still photograph of the vehicle cabin to see if there are passengers present (SHRP2, 2010). Because the passengers have mostly likely not consented for participation in the study, this photograph is blurred in a way rendering it impossible to identify the passengers (Campbell, 2012).

In the event of an incident, there is a red button on the bottom of the head unit that the subject may press, the incident push button. When pressed, this button will record 30 seconds of audio so the subject can explain the nature of the incident. Regardless of any audio recorded, pressing the incident button is recorded and acts as a flag in the data (SHRP2, 2010). The head unit also has an ambient atmospheric analyzer that is capable of detecting the presence of alcohol in the air (SHRP2, 2010). The following photograph illustrates the placement of the head unit behind the rear view mirror in a car.



Figure 1: Mounting of the head unit in an instrumented vehicle (SHRP2, 2010)

The hard drive, referred to as the main unit, stores all of the data collected by the devices in the vehicle (SHRP2, 2010). Periodically, the status of the hard drive and quantity of data stored on it is broadcast to Virginia Tech and ultimately to the appropriate driving study site to arrange for a maintenance visit. During this maintenance visit, the full hard drive is replaced with an empty hard drive. This maintenance typically occurs every four to six months (Campbell, 2012). The hard drive is intended to store about a year's worth of data collected from the vehicle.

The main unit is about the size of a book and is mounted in the trunk of the vehicle. The main unit is a hard drive encased in a rugged cage that can tolerate the environment of the trunk and most of the things a subject may store in a truck. The only caution subjects need to be given regarding the main unit is to not get it wet. Figure 2 shows one possible placement of the main unit in the trunk of a vehicle.

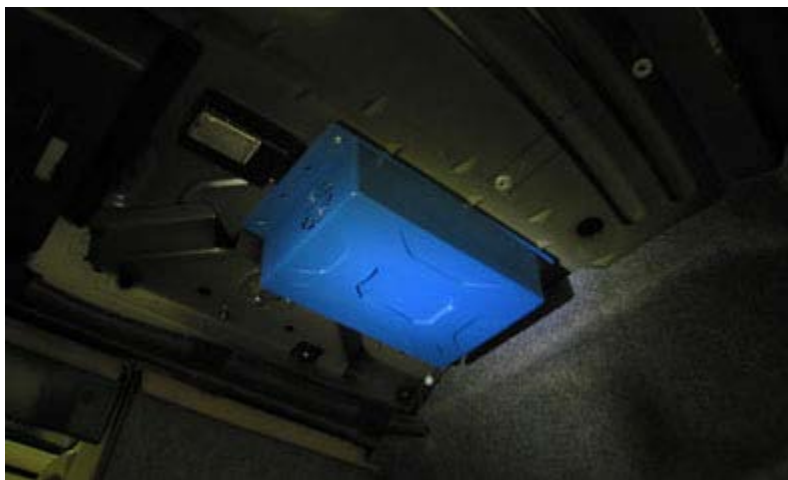


Figure 2: Main unit positioned in the trunk of a vehicle (SHRP2, 2010)

A radar unit is mounted on the front bumper of each study vehicle. This radar is able to collect information about the environment around the vehicle, such as the distance between the instrumented vehicle and other vehicles in traffic (SHRP2, 2010). The data collected by the front radar unit are transmitted wirelessly to the main unit (Campbell, 2012). It is important to note that, due to legislation in states like Virginia, this device does not function as a radar detector.



Figure 3: Placement of radar on front license plate frame (SHRP2, 2010)

In addition to these components that are visible on and inside the vehicle, there is wiring connecting many of the components to the main unit in the trunk of the car. This wiring is all out of sight of the driver and passengers in the vehicle. The purpose of this wiring is to reliably collect data from the different devices and sensors installed in the vehicle.

Additionally, there is a cellular antenna placed in the rear window of the vehicle. This antenna communicates information about the status of the hard drive to the SHRP2 program. Once the hard drive is 70-percent full it begins to ask that a maintenance visit be scheduled to replace the full hard drive with an empty one. Figure 4 illustrates an example placement and wiring of each component of an instrumented study vehicle.

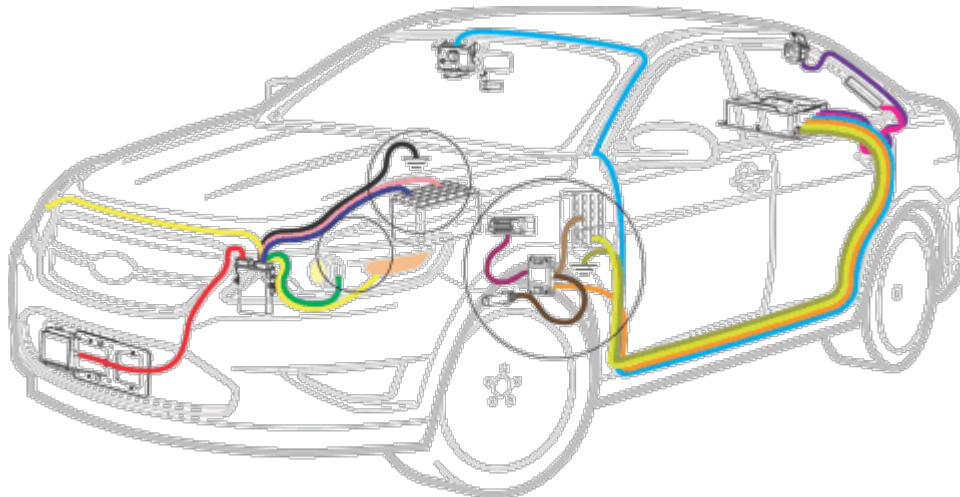


Figure 4: Diagram of the location of devices and wiring in instrumented vehicles

## Subject Follow Up

Once subjects are enrolled in the study, there are four primary reasons the project staff follows up with them: routine maintenance, payment, crashes, and de-installation. Virginia Tech has issued guidelines to NDS sites on how to manage each of these interactions, and as the study has developed and grown, procedures have adjusted and adapted as well.

For routine maintenance, there is an automated system that connects the vehicle with Virginia Tech, which is connected with each of the Naturalistic Driving Study sites. The most common source of maintenance demands is main units filling up with data. When this occurs, through the antenna mounted on the rear window, a message is sent out that a maintenance call must be scheduled.

Maintenance calls are scheduled by subject-related staff at a time and place of convenience to the subject. Given the rural nature and large geographical footprint of the State College NDS site, this is of particular importance to participants. Typically, two maintenance calls will be scheduled in a day. More maintenance calls in a day places a time strain on the vehicle team and increases the risk of having to reschedule maintenance visits with study participants.

Payment for participation is described in depth in the consent form signed by the study participant. Checks are mailed to participants on the schedule outlined in their consent form. Originally, when subjects were enrolled for only 1- or 2-year periods, they received three checks per year. As the study progressed, subjects were enrolled for more variable time periods or given the opportunity to extend their participation. All subjects are paid at a rate of \$500 per year, which is pro-rated for the number of months of participation (Campbell, 2012).

Another primary reason for contacting enrolled participants prior to de-installation is if they are involved in a crash. Each NDS site requests that participants involved in crashes contact the site at a specially designated telephone number. This telephone number is printed on a letter



that subjects are instructed to keep in their glove box. Additionally, the instrumentation in the vehicle is designed to detect if the vehicle is involved in crashes under certain conditions.

Once aware of a crash, details of the crash are entered into a rubric. The results of that rubric describe what activities must be performed in that specific crash investigation. The rubric designates all crashes as either a Level I or Level II. For a Level I investigation, the following activities must be completed: participant interview, participant questionnaire, mapping using Google Earth or Google Maps, photographs of the vehicle, and photos retrieved from the main unit (this final task is completed by Virginia Tech). For a Level II investigation, each of the Level I activities is completed, plus the following: a site visit to collect pertinent measurements, photographs of the crash site, and drawing of a site diagram in Easy Street Draw.

The final reason for communication with study participants is to arrange for de-installation when they near completion of their time in the study. These procedures are described in the following section.

### **De-Installation Procedures**

Near the end of their scheduled participation, subjects are contacted by project staff and are scheduled at a time convenient to the subject to return to the facility where their vehicle was instrumented to have the data collection devices removed. As with the installation procedures, there are human subject and vehicle-related activities.

De-installing the vehicle involves removing of the devices from the vehicle. This includes not only the larger devices, but also all of the wiring. When removing this equipment, special attention is given to returning the vehicle back to the condition it was in at the time of installation.

While equipment is being removed from the vehicle, the subject has two surveys to complete. The first survey is the same as the Medication Conditions & Medications survey administered at installation. This survey is administered so if there are any changes to the physical condition of the subject during the study, they are known. The other survey administered asks subjects questions about how the study may have affected their driving habits, perception of other drivers, and thoughts on driving.

### **Findings**

The product of this research is a database of driving information. While the primary interest of the research is safety and to examine crashes, the resulting database may also yield important data for understanding traffic characteristics like car following. The database may also enable researchers to make new inferences between human characteristics (e.g., medical conditions, sensation seeking) and driving habits.

### **Crashes**

For each crash in the study, the following information will be known once the recorded data are processed: the events occurring inside the vehicle prior to the crash, if the driver

appeared to be distracted or fatigued, what behaviors were or were not exhibited by the driver prior to the crash, what metrics were recorded by the vehicle immediately before and after the crash (e.g., speed, trajectory, and braking), and the environmental conditions.

At the conclusion of the first phase, five crashes had occurred involving vehicles from the State College site. Of these crashes, four were coded as Level I crashes and the fifth crash did not require any investigation. The following activities were completed in the investigation of the Level I crashes: a participant interview conducted by subject staff, a questionnaire completed by the participant, mapping using Google Earth or Google Maps, and photographing of the vehicle. Additionally, when Virginia Tech obtains the main unit from the vehicle, images collected at the time of the crash will be retrieved.

The crashes occurred in a number of different settings and were of multiple types. The crashes are listed and described in general terms below:

- Crash occurred in a shopping center parking lot; minor damage to the vehicle.
- Vehicle was rear ended while it was waiting for a school bus to load and unload.
- Crash occurred when another vehicle failed to stop at a stop sign and damaged the left front quarter-panel of the vehicle.
- Vehicle hit a deer, but damage was minimal and no investigation was warranted by the crash rubric.
- Vehicle hit a deer traveling on a highway with a posted speed limit of 55 mph; moderate damage was noted on the hood and driver-side door of the vehicle.

Additional crashes have occurred at the State College site in Phase II of the study. It has been noted that more crashes have occurred already in Phase II than occurred during Phase I. This illustrates the randomness of crashes, which makes crashes so inherently difficult to study.

Once the data collection period of the study has concluded, emphasis will be shifted to coding and analyzing the data by Virginia Tech and those who have been granted access to the naturalistic driving data set based on the merits of their proposed research. It is at this point where the information provided by the subjects in the assessment procedures may be paired with their recorded data for analysis.

## Participants

At the conclusion of Phase I of the driving study, 221 human subjects were either actively participating or had participated in the driving study; 116 subjects were actively participating and driving their instrumented vehicles; 98 of these subjects had completed their time in the study; 7 subjects had begun participation in the study but had decided to end their participation early.

There were two main reasons why those seven subjects elected to end their participation in the study prior to the end of the term they had consented for. Firstly, after the equipment was installed, some vehicles reported an increase in radio interference and occasionally interference with in-vehicle technologies like Bluetooth. The other reason is personal matters. Some subjects relocated from the study area on short notice. Near the conclusion of Phase I, issues with

interference with tire pressure monitoring systems were discussed. This would lead to additional vehicles being de-installed prior to the end of their term.

In the process of recruiting and installing subjects, a few trends became apparent. Firstly, the Toyota Prius was the most common vehicle installed and the most common vehicle owned by prospective participants. The most common demographic segment responding to recruitment measures was women between the ages of 51 and 65.

In order to have a sample representative of the overall population, quotas were placed on different demographic groups so, overall, there is a representative balance in the subjects actually enrolled in the study. The most difficult groups to recruit were both males and females in the age ranges of 16 to 17, 18 to 20, and over 76. For the younger age groups it was hypothesized that requiring a parent to authorize participation (if under 18), requiring a driver's license (a learner's permit is insufficient for participation), and requiring written permission from the vehicle owner if it was not the subject could have been discouraging.

The following chart illustrates the breakdown of participants by county. Centre County had the greatest number of participants, 140. Juniata County had the fewest participants. The 9 participants from other counties represented participants who may be university students or live in the study area during the duration of the study but do not consider themselves permanent area residents. All participants live in Pennsylvania.

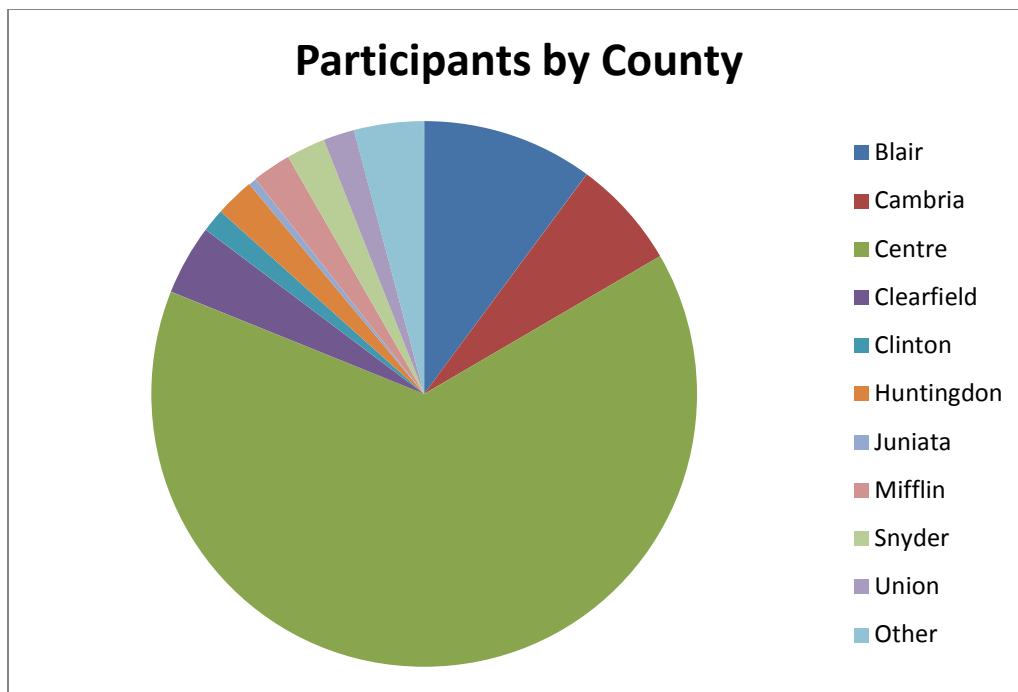


Figure 5: State College, Pa. participants by county

## Conclusions

The data generated by the SHRP2 Naturalistic Driving Study will provide a wealth of information capable of being used to help answer pressing research questions in the field of

transportation. The work in the first stage of the Naturalistic Driving Study is foundational to the overall success of the final database. According to SHRP2, the data set is predicted to provide the basis for transportation safety research for the next 20 years.

There are challenges with this type of data and the amount of it being collected. Screening, coding, and examining the video is time intensive and has subjective elements. Furthermore, as the data are analyzed and research is conducted, we may discover that different events and actions observed mean different things. An event that is considered a crash surrogate now may not be in the future.

Furthermore, crashes are rare occurrences. Yet, in crash databases, that is the only information available to researchers. With the naturalistic driving information database, researchers will have access to events coded as near crashes or surrogate events that could add depth to understanding the nature of crashes (Campbell, 2012).

Each day, from all six NDS sites around the United States, five participant years of driving are collected. By the end of the study, a total of 3,700 participant years of data will be collected from 2,600 different participants from around the United States (Campbell, 2012). The research community is now very close to getting a look at driving in ways that technology would not have enabled much more than 10 years ago.

As the driving study continues into Phase II, the data set will grow, more crash and near-crash events will accumulate, and the ability of the data set to provide meaningful insight regarding transportation safety issues will improve.

## Resources

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