Exploration of the SHRP2 Naturalistic Driving Study Data to Identify Factors Related to the Selection of Freeway Ramp Design Speed

Report: ATLAS-2017-18

Marcus A. Brewer
Shannon Barkwell

Texas A&M Transportation Institute

University of Michigan
2901 Baxter Rd. Room 124
Ann Arbor, MI 48109-2150

And

Texas A&M University
Texas A&M Transportation Institute
College Station, TX 77843-3135

March 2017

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the U.S. Department of Transportation's University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

ACKNOWLEDGMENTS

This research project was supported by the Center for Advancing Transportation Leadership and Safety (ATLAS Center). The ATLAS Center is supported by a grant from the U.S. Department of Transportation, Office of the Assistant Secretary for Research and Transportation, University Transportation Centers Program (DTRT13-G-UTC54). The ATLAS Center is a collaboration between the University of Michigan Transportation Research Institute (UMTRI) and the Texas A&M Transportation Institute (TTI).

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
ATLAS-2017-18		

4. Title and Subtitle	5. Report Date
Exploration of the SHRP2 Naturalistic Driving Study Data to Identify Factors Related to the Selection of Freeway Ramp Design Speed	March 2017
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Marcus A. Brewer and Shannon Barkwell	

9. Performing Organization Name and Address	10. Work Unit no. (TRAIS)
Texas A&M Transportation Institute 2935 Research Parkway 3135 TAMU College Station, TX 77843-3135	11. Contract or Grant No. DTRT13-G-UTC54

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Advancing Transportation Leadership and Safety (ATLAS) Center 2901 Baxter Rd., Room 124, Ann Arbor, MI 48109-2150 U.S.A	14. Sponsoring Agency Code

15. Supplementary Notes

Supported by a grant from the U.S. Department of Transportation, OST-R, University Transportation Centers Program

16. Abstract

This research explored the second Strategic Highway Research Program (SHRP2) Naturalistic Driving Study (NDS) database for the potential to identify freeway entrance and exit ramps and teen drivers' behavior while traveling those ramps. This is in advance of a future task on NCHRP Project 15-56, the objective of which is to review current practices for selecting design speed on freeway ramps and, if beneficial, recommend changes to those practices. By exploring the features of the NDS dataset, researchers can a) consider a new tool for study site selection based on roadway characteristics and b) identify a potential new source of data that can either serve as a basis for analysis or serve as a comparison or validation of field data that researchers will collect through other methods.

Researchers reviewed each of the 1156 variables in the 21 data dictionaries in the NDS database, as well as the seven components of the related Roadway Information Database (RID), to identify variables with potential for use in identifying freeway ramps and obtaining further information on driver and vehicle characteristics while traveling on those ramps. Researchers also conducted a query of the NDS database to look for all of the crash, near-crash, and crash-relevant events in the NDS database that could have occurred on ramps, identifying 939 events from 917 trips. A detailed review of the records from those 939 events revealed that only 49 occurred on a freeway ramp, 48 of which were categorized as near-crashes and one was a crash in which the subject driver drove over road debris.

Results from these reviews led researchers to conclude that further exploration of the questions relating design speed to vehicle performance and driver behaviors would require the use of, and purchase of, the more detailed dataset that must be requested from the NDS project administrators. Additional conclusions and recommendations from the research team are also offered within the report.

17. Key Words	18. Distribution Statement
Freeway ramp, design speed, safety, operations, teen driver behavior, crashes, Naturalistic Driving Study, Roadway Information Database	Unlimited

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	50	

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

CHAPTER 1
INTRODUCTION

OBJECTIVE OF THE RESEARCH

This research was tasked with exploring the second Strategic Highway Research Program (SHRP2) Naturalistic Driving Study (NDS) database for the potential to identify freeway entrance and exit ramps and teen drivers' behavior while traveling those ramps. This is in advance of a future task on National Cooperative Highway Research Project (NCHRP) Project 15-56, the objective of which is to review current practices for selecting design speed on freeway ramps and, if beneficial, recommend changes to those practices. The NCHRP project considers whether our current practices produce ramp design speeds that are consistent with the operating speeds that drivers actually choose, and if not, what changes should be made. The NCHRP 15-56 research team identified a selection of freeway ramps as possible study sites at which to collect data. That team also collected speed data and other variables on those ramps to compare actual speeds with the design elements of the ramp that influence the selection of a design speed.

By exploring the features of the NDS dataset, researchers can a) consider a new tool for study site selection based on roadway characteristics and b) identify a potential new source of data that can either serve as a basis for analysis or serve as a comparison or validation of field data that researchers will collect through other methods. It will also provide a potential resource for research on other projects to explore driver behavior, especially teen driver behavior, and its relationships to roadway characteristics and other external influences.

REPORT ORGANIZATION

This report is organized with four chapters and an appendix, which are described as follows:

- Chapter 1 is this introductory chapter.
- Chapter 2 contains a discussion of the approach used by the research team to explore the datasets related to the SHRP2 NDS and identify variables of potential relevance.
- Chapter 3 describes the results of the research team's query of the NDS dataset for events occurring on freeway ramps.
- Chapter 4 contains the researchers' conclusions and recommendations on use of the NDS dataset for further research on freeway ramps.
- The appendix lists the variables contained in the SHRP2 database that were reviewed and explored by the research team.

CHAPTER 2
RESEARCH APPROACH AND METHODS

INITIAL EXPLORATION OF NDS DATASET

The first task in this project provided the research team the opportunity to familiarize themselves with the contents and supporting information of the NDS database. The researchers began with establishing user accounts on the InSight Data Access Website ([*1*], image of homepage shown in Figure 1) and gaining access to the data, forums, and background information on the website. The research team also conducted a review of relevant literature to provide context to the research question and the researchers' activities.

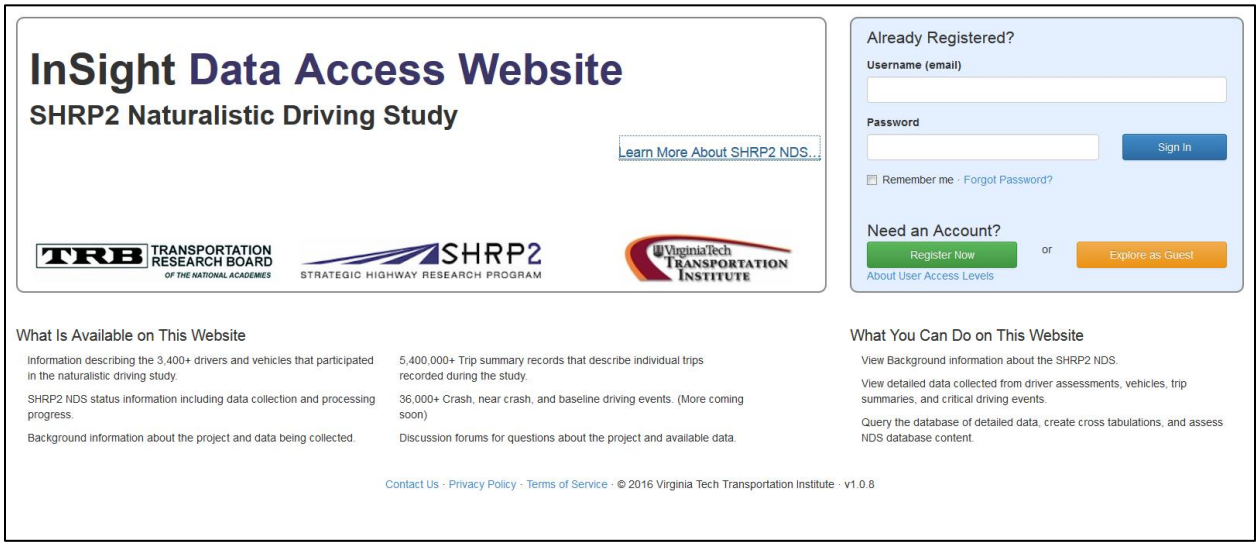


Figure 1. Screenshot of SHRP2 NDS InSight Home Page (*1*).

Literature Review

Geometric Design

Because the research question involves a comparison with the existing AASHTO policy on ramp design speed, it is appropriate to begin with a review of that guidance. Section 2.3.6 of the 2011 *Green Book* (*2*) states that:

> Design speed is a selected speed used to determine the various geometric design features of the roadway. The selected design speed should be a logical one with respect to the anticipated operating speed, topography, the adjacent land use, and the functional classification of the highway. In selection of design speed, every effort should be made to attain a desired combination of safety, mobility, and efficiency within the constraints of environmental quality, economics, aesthetics, and social or political impacts. Once the design speed is selected, all of the pertinent highway features should be related to it to obtain a balanced design. Above-minimum design criteria for specific design elements should be used, where practical, particularly on high-speed facilities. On lower speed facilities,

> use of above-minimum design criteria may encourage travel at speeds higher than the design speed. Some design features, such as curvature, superelevation, and sight distance, are directly related to, and vary appreciably with, design speed. Other features, such as widths of lanes and shoulders and clearances to walls and rails, are not directly related to design speed, but they do affect vehicle speeds. Thus, when a change is made in design speed, many elements of the highway design will change accordingly.

Supplementing this basic text, the American Association of State Highway and Transportation Officials (AASHTO) policy also explains that the selected design speed should be consistent with the speeds that drivers are likely to expect on a given highway facility and should fit the travel desires and habits of all drivers expected to use the particular facility. It is also desirable that the running speed of a large proportion of drivers be lower than the design speed.

Referring specifically to guidance on selecting a design speed for ramps, Section 10.9.6 of the *Green Book* (*2*) states that it is desirable for ramp design speeds to approximate the low-volume running speed on the intersecting highways, but that this is not always practical. Thus, lower design speeds may be selected but should not be less than the lower range of speeds shown in *Green Book* Table 10-1 (see Table 1). AASHTO policy provides further guidance on selecting appropriate design speed values from *Green Book* Table 10-1 based on various conditions and ramp types.

Table 1. Guide Values for Ramp Design Speed as Related to Highway Design Speed (*2*).

U.S. Customary										
Highway design speed (mph)	30	35	40	45	50	55	60	65	70	75
Ramp design speed (mph)										
Upper range (85%)	25	30	35	40	45	48	50	55	60	65
Middle range (70%)	20	25	30	33	35	40	45	45	50	55
Lower range (50%)	15	18	20	23	25	28	30	30	35	40
Corresponding minimum radius (ft)	See *Green Book* Table 3-7									

The *Green Book* also states that the guide values for ramp design speed in *Green Book* Table 10-1 only apply to the sharpest or controlling ramp curve, which is usually on the ramp proper, and the speed values in *Green Book* Table 10-1 do not pertain to the ramp terminals. The ramp terminals are to be properly transitioned and provided with speed-change facilities adequate for the speed of the highway being considered.

In NCHRP Project 17-45, Bonneson et al. (*3*) developed crash prediction methodologies for freeways and interchanges. These methodologies were recently incorporated into the *Highway Safety Manual* as a supplement (*4*) to the original three-volume edition published in 2010 (*5*). The general form of the safety prediction factor (SPF) for estimating the crash frequency for a ramp is shown in Equation 1:

$$N = L_r \times \exp [a + b \times \ln(c\ AADT_r) + d\ (c \times AADT_r)] \quad (1)$$

Where: N = crash frequency per year on the ramp.
L_r = ramp length (mi).
$AADT_r$ = average annual daily traffic volume on the ramp (veh/day).
a, b, c, d = regression coefficients.

The SPF uses different regression coefficients for one-lane and two-lane ramps, for fatal-and-injury and property damage only crashes, and for multiple-and single-vehicle crashes. The crash modification factors (CMFs) developed for use with the SPFs account for the following factors on ramp segments:

- Horizontal curvature.
- Lane width.
- Right shoulder width.
- Left shoulder width.
- Right side barrier.
- Left side barrier.
- Lane addition or drop.
- Ramp speed-change lane.

For horizontal curvature, the base condition is a tangent ramp proper, and the CMF value is a function of the radius of curvature, the average entry speed for the curve, and the proportion of the ramp proper with a curvilinear alignment. The CMF value predicts an increase in crashes as the radius of curvature decreases, the average entry speed increases, and the proportion of the ramp proper with a curvilinear alignment increases.

Several previous studies have investigated the relationship of geometric design elements and the safety performance of ramps. Selected relevant findings from those studies are summarized as follows:

- Exit ramps have higher crash rates than entrance ramps (*6*, *7*).
- Ramps show increasing crash rates with increasing degrees of curvature (*6*).
- When comparing four types of exit ramps (Type 1: parallel from a tangent single-lane exit ramp; Type 2: single-lane exit ramp without a taper; Type 3: two-lane exit ramp with an optional lane; and Type 4: two-lane exit ramp without an optional lane), the Type 1 exit ramp had the best safety performance in terms of lowest crash frequency and crash rate (*8*).

Key geometric variables and site characteristics that contribute to the safety performance of interchange ramps and speed-change lanes include (*7, 9, 10*):

- Freeway volume.
- Ramp volume.
- Speed of right freeway lane.
- Area type (urban or rural).

- Ramp type (entrance or exit ramp).
- Ramp configuration.
- Length of ramp.
- Length of speed-change lane (SCL).

Recent studies have developed safety prediction models related to freeways and ramps. Bonneson and Pratt (*11*) examined freeway safety trends using data from Texas to develop safety prediction models for freeway segments, including CMFs that accounted for the presence of ramp entrances and weaving sections. The ramp entrance CMF is described by Equation 2:

$$CMF_{enr|agg} = \left(1 - P_{enr}\right) + P_{enr} e^{1529/L_{enr}} \quad (2)$$

Where: $CMF_{enr|agg}$ = aggregated ramp entrance CMF.
P_{enr} = proportion of freeway segment length adjacent to a ramp entrance.
L_{enr} = average ramp entrance length (ft).

Equation 2 is applied to a freeway segment that may have one or more ramp entrances along its length, and yields an aggregated CMF value based on all ramp entrances on the segment. The CMF is illustrated in Figure 2. As shown, the presence of a ramp entrance always increases crash frequency, and the magnitude of the increase is greater if the ramp entrance length is shorter. A similar CMF was developed for weaving sections.

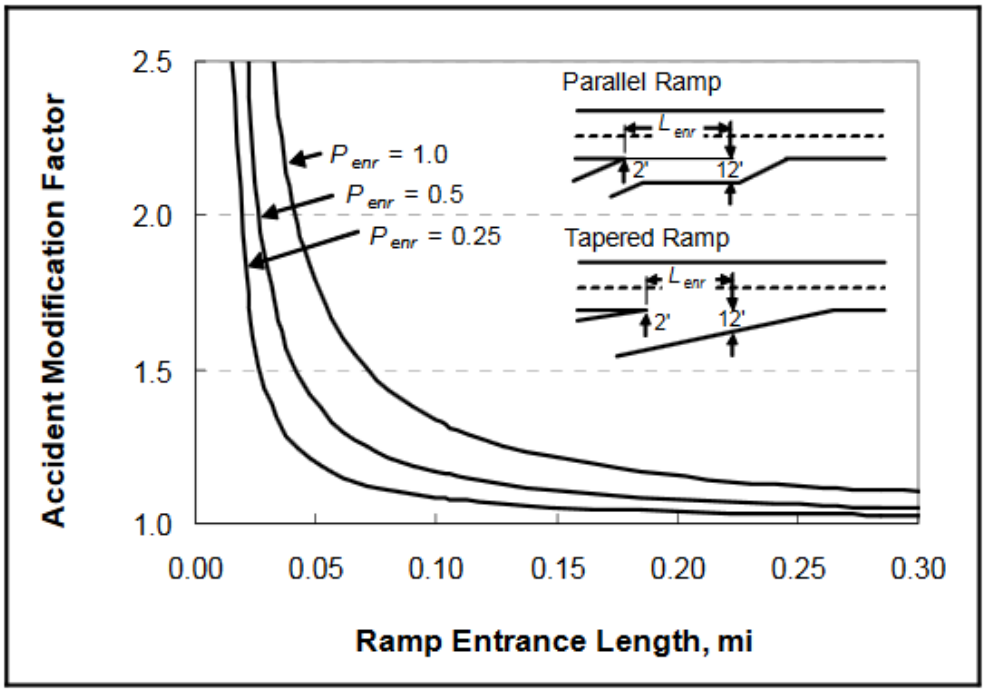
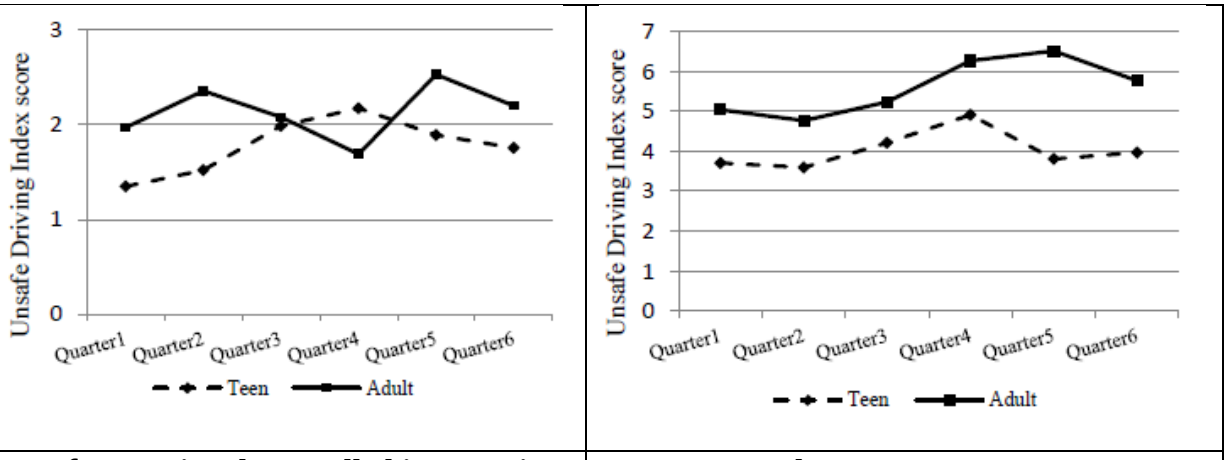


Figure 2. Aggregated Ramp Entrance CMF (*11*).

Driver Behavior

Pradhan et al. (*12*) studied the differences in various aspects of driving behaviors between young and experienced drivers, using data from the Naturalistic Teen Driving Study from pre-selected complex driving environments including left turns at signalized four-way intersections and merges onto freeways. The researchers sought to explore the differences in safe driving behavior between teenagers and adults in complex driving situations using a naturalistic driving approach and to explore the evolution over time (18 months) of teenagers' driving behavior in such situations. Both safe driving behaviors and their trajectories over time were assessed by a measure derived from multiple data sources and named the Unsafe Driving Index, which was designed to reflect safety error, such that safe driving behavior would score fewer points and unsafe driving would result in more points. The researchers found that teenagers scored lower than adults on the Unsafe Driving Index for most of the study period, and the difference in scores was statistically significant for the first two three-month periods in the study. Teenagers' Index score increased at both intersections and freeways, but while the teenagers' scores were similar to or worse than adults during the third and fourth three-month periods, the teen drivers' scores were always lower than adults' scores for freeway merging, and the scores in the final two quarters were similar to the first two quarters (see Figure 3).



a. Left-turn signal controlled intersection | **b. Merge ramps**

Figure 3. Unsafe Driving Index Scores from Teens and Adults over Six Quarters (*12*).

Another recent study investigated drivers' actual thinking process and actions when merging or passing through freeway ramps merging areas. Kondyli and Elefteriadou (*13*) developed a ramp-merging model that considered the merging process as perceived by drivers. They conducted a series of focus group meetings and observed drivers' merging behavior in in-vehicle experiments. In-vehicle data included consideration of drivers' gap acceptance behavior and merging turbulence due to vehicle interactions, both of which were included as components in the resulting model. The gap-acceptance component of the model considered effects of different merging conditions, while the component that focused on driver behavior predicted vehicle interactions on the freeway with merging vehicles, considering different driver types. A merging turbulence model that evaluated the effect of vehicle interactions on traffic flow was also developed.

In a related study, Kondyli and Elefteriadou (*14*) concluded that younger drivers were more aggressive drivers compared to older age groups. The steps involved in the observed merging process were similar to those described in the focus groups in the previous study. In merge maneuvers with subjects as both freeway drivers and as merging drivers, more cooperative merges took place when the freeway drivers changed lanes instead of decelerating. Kondyli and Elefteriadou also concluded that drivers make more use of the acceleration lane at tapered on-ramps that parallel on-ramps, with higher merging speeds.

A study by Brewer et al. (*15*) reviewed existing design guidelines and practices, as well as modern driver behavior and vehicle performance, to develop improved design guidance for freeway ramp terminals. Based on the findings from that study, they concluded the following:

- The assumption in the AASHTO *Green Book* that drivers decelerate in gear (i.e., coast) for 3 s was not applicable to the drivers in this study, unless it includes the time to remove the driver's foot from the accelerator pedal.
- In uncongested or lightly congested conditions, a typical glance into a mirror or over the shoulder by a driver merging onto the freeway was about 2.5 to 3.0 s, and drivers typically made three glances on entrance ramps.
- The *Green Book* procedure for calculating the recommended length of SCL on freeway exit ramps may be recommending lengths that are too short for the behavior of subject drivers and their performance in the contemporary vehicles if all deceleration is to be completed within the taper and SCL.
- The *Green Book* procedure for calculating the recommended length of SCLs on freeway entrance ramps provided sufficient lengths for merging by subject drivers under uncongested and lightly congested conditions when the taper area was used to complete the maneuver.

Based on the findings of the aforementioned studies, additional research would be beneficial to identify factors related to interactions of freeway ramp design speed with teen drivers' behaviors. An example of such a future study would equip cameras in the vehicles of teen drivers to facilitate data collection of their behaviors on ramps.

NDS Data

The initial exploration of the NDS data and the associated InSight website was a high-level review to determine what kinds of data were available within the information provided through InSight and what additional information might be available through access to the full NDS database. The InSight website provides access to four categories of data: Vehicles, Drivers, Trips, and Events.

The Vehicle dataset contains 30 variables on the characteristics of the vehicles that NDS participants used during the study. These variables include characteristics such as the vehicle's make and model year, status of tires and battery, and technology items (e.g., factory navigation system) that were part of the vehicle.

The Drivers dataset contains variables from 16 data dictionaries. These data dictionaries document the drivers' demographics, physical ability and driving skills, mental well-being,

medical conditions, and feedback from the participants' experience in the study. A total of 577 variables are contained within the following 16 data dictionaries:

- Driver Demographic Questionnaire.
- Driving History Questionnaire.
- Driving Knowledge Survey.
- Visual and Cognitive Tests.
- Conners' Continuous Performance Test.
- Clock Drawing Assessment.
- Physical Strength Tests.
- Barkley's ADHD Screening Test.
- Risk Perception Questionnaire.
- Risk Taking Questionnaire.
- Sensation Seeking Scale Survey.
- Driver Behavior Questionnaire.
- Medical Conditions and Mediations.
- Sleep Habits Questionnaire.
- Medical Conditions and Mediations – Exit.
- Driver Exit Interview.

The Trips dataset contains 247 variables from two data dictionaries: Trip Summary and Time Series. The Trip Summary variables summarize the characteristics of continuous data files collected during the SHRP2 NDS for each trip taken during the study; this dataset provides information about the types of trips that exist in the continuous time series database (e.g., trip duration, day of week, time of day, maximum speed). The Time Series data are a set of variables collected from vehicles by the SHRP2 NDS on-board data acquisition system; these data are collected continuously while the vehicle is running from the vehicle data network and various sensors.

The Events dataset provides documentation about the conditions present when an event (i.e., a crash) occurred. A Post-Crash Interview is administered after a crash has occurred, and there are 226 variables in the Post-Crash Interview data dictionary. This data dictionary documents items such as number and position of vehicle occupants; status of vehicle steering, brake, accelerator, and other components; driver's condition (impaired, fatigued, medicated, distracted, etc.); and injury severity. The Event Detail Table lists all crashes, near crashes, and baseline events that have been identified and analyzed using the event analysis protocol. This data dictionary contains 76 variables on the conditions surrounding each crash, such as roadway alignment, lighting, weather, and proximal events.

The initial review of the listings of these variables showed very little that could be directly tied to freeway ramps. Because the Trips dataset on the InSight website summarizes the data for each trip, it is not possible to determine exactly where the participating vehicles were during the entirety of the trip based on the data available through InSight. However, additional options may exist to provide a means of identifying freeway ramps within the data; those options will be discussed within the detailed exploration of the data.

NDS Forum Inquiry

In an attempt to streamline the search and exploration process and focus the research team's efforts on developing usable strategies, researchers also explored the Forum contained within the InSight website. There was no existing discussion string that appeared related to the topic of data on freeway ramps, so researchers started a new discussion to ask the administrators for advice on how to identify data that were recorded on a freeway ramp. The response received was that for crashes, near-crashes, and baselines, the Relation to Junction variable might have potential. To look for a wider set of trips that included travel on ramps, the administrator suggested starting with the Roadway Inventory Database (RID) to identify ramps; once locations of interest were selected, a query in NDS could find trips that traverse those locations.

DETAILED EXPLORATION OF NDS AND RID DATASETS

Using the information obtained through the initial exploration of the NDS dataset on the InSight website, the researchers then focused on exploring the more promising data dictionaries and variables of the dataset, in conjunction with the supplemental RID dataset.

Exploration of Design-Related Variables

Description of Variables

The most critical element in conducting a comparison between the NDS data and the site characteristics is being able to identify ramps in the NDS data. With that in mind, a review of each of the variables in each data dictionary was conducted to assess the potential for using it to identify ramps, along with key geometric and related variables that could be associated with design speed. The data variables available through the InSight website are categorized into 19 data dictionaries within four datasets: Vehicles, Drivers, Trips, and Events.

The Vehicles dataset is a collection of variables that describe each vehicle that was instrumented for data collection in the SHRP2 NDS project. Each row of the dataset provides descriptive information about the type and condition of the vehicle. Information about integrated technologies on the vehicle is also included. Individual vehicle records may be linked to multiple participants if more than one member of a household participated in the program. The 30 variables in the Vehicles dataset are listed in the appendix.

The Drivers dataset contains 16 data dictionaries, documenting a wide variety of characteristics on the subject drivers participating in the study. The data dictionaries are listed below; the variables in each data dictionary are summarized in the following discussion, while complete lists of Drivers dataset variables are provided in the appendix:

- Driver Demographic.
- Driving History Questionnaire.
- Driving Knowledge Survey.
- Visual and Cognitive Tests.
- Conner's Continuous Performance.
- Clock Drawing Assessment.

- Physical Strength Tests.
- Barkley's ADHD Screening Test.
- Risk Perception Questionnaire.
- Risk Taking Questionnaire.
- Sensation Seeking Scale Survey.
- Driver Behavior Questionnaire.
- Medical Conditions and Medications.
- Sleep Habits.
- Medical Conditions and Medications – Exit.
- Driver Exit Interview.

The Driver Demographic Questionnaire is an instrument designed to investigate various demographic information about the participant such as family life, years driving, and education. According to the InSight website (*1*), this questionnaire was administered to participants as they were inducted into the SHRP2 NDS. The questionnaire was administered electronically along with a battery of other driver assessments while the participant's vehicle was being installed with data collection equipment. There are 48 variables in the Driver Demographic Questionnaire, which largely describe characteristics of the participant driver and household as well as the gender, age, and driving ability of any additional residents in the participant's household.

The Driving History Questionnaire is an instrument designed to obtain information from participants about their driving record. The questions assess amount of driving experience, violations, crashes, and training received (*1*). There are 18 variables in the Driving History Questionnaire.

The Driving Knowledge Survey contains 21 variables (19 questions, plus participant ID and score) for a questionnaire compiled from a number of DMV driving knowledge tests that attempts to focus on nationally accepted laws/interpretations rather than state-specific ones (*1*).

Visual and Cognitive Tests document the results of a battery of vision tests conducted on drivers during the induction process. Contrast sensitivity, color perception, visual acuity, and peripheral vision were tested using a multipurpose vision-testing apparatus. Specialized software programs were also used to assess the useful field of view and ability to visualize missing information (*1*). There are 122 variables from the tests.

The Conner's Continuous Performance Test is described as a task-oriented computerized assessment of attention disorders and neurological functioning. Results indicate the likelihood that an individual has an attention disorder (*1*). There are 15 variables from that test.

The Clock Drawing Assessment is used as a screening tool to help identify possible signs of dementia or other neurological disorders. The participant was presented with pencil and paper; on the paper was a circle and nothing else. The participant was asked to draw numbers in the circle to make the circle look like the face of a clock and then draw the hands of the clock to read "10 after 11." The clock drawing was scored based on a six-point scoring system. Higher scores reflect a greater number of errors and more impairment. A score of $\geq$3 represents a cognitive deficit, while a score of 1 or 2 is considered normal (*1*). Three variables included the participant ID, the score, and additional details of the test.

The Physical Strengths dataset contains the results of several tests of physical strength, including left and right hand grip strength and a rapid pace walk test. Seven variables included the participant ID, strength of the right and left hands after first and second attempts, a declaration of dominant hand, and time it took for the participant to complete a 20-ft rapid pace walk (*1*).

Barkley's ADHD Screening Test operationalizes ADHD symptoms in terms of specific behaviors. Each of its six items is scored as either: Never or Rarely (0), Sometimes (1), Often (2), or Very Often (3). If the sum across all six items for an individual is greater than or equal to 7, then this is an indication that further clinical evaluation may be warranted (*1*). The sum is a separate variable named "Barkleys score," and an eighth variable contained the participant ID for documentation.

The Risk Perception Questionnaire was designed to gauge the participant's perception of dangerous or unsafe driving behaviors or scenarios (*1*). The 34 variables explore various situations a driver would encounter and estimates the participant's associated risk in each situation.

The Risk Taking Questionnaire was related to the Risk Perception Questionnaire, intended to measure how often the participant engages in unsafe or dangerous driving activities (*1*). The 35 Risk Taking variables are very similar to the Risk Perception variables.

The Sensation Seeking Scale Survey was compiled of questions to gauge the degree to which the participant engages in sensation seeking behavior. The 46 variables in the test measure the participant's sensory stimulation preferences (*1*).

The modified Manchester Driver Behavior Questionnaire is a self-reported driver behavior survey. The participant is asked to indicate how often he/she commits each of the 24 described errors (accidental) or violations (deliberate) (*1*).

The Medical Conditions and Medications Questionnaire is an instrument designed to obtain information from participants about their self-reported medical history. The 39 questions are focused on the identification of conditions that could affect driving performance and safety (*1*).

The Sleep Habits Questionnaire was a questionnaire designed to determine the participant's sleeping patterns, habits, and level of fatigue (*1*). One hundred variables documented various sleep-related behaviors and characteristics.

A duplicate Medical Conditions and Medications Exit Questionnaire was administered for drivers completing the study. This questionnaire had the same variables as the version administered at the beginning of the study. A Driver Exit Interview was also administered, designed to gain feedback from the participant's experience in the study (*1*). The Driver Exit Interview asked drivers whether they thought the study had affected their driving habits or whether they wanted to describe incidents that occurred while driving during the study. Sixteen variables were part of that interview.

The Trips dataset contains two components: the Trip Summary dataset and the Time Series dataset. The Trip Summary dataset is a collection of variables that summarize the characteristics of continuous data files collected during the SHRP2 NDS. Variables are organized into a table

where each row represents a summary record describing the content of an individual trip. The trip summary records were generated after a trip was incorporated into the SHRP2 NDS database and passed quality assurance processes. The 131 variables in this dataset (shown in the appendix) are intended to provide information about the types of trips that exist in the continuous time series database (e.g., trip duration, day of week, time of day, maximum speed) (*1*).

The Time Series dataset contains 115 variables collected from vehicles by the SHRP2 NDS on-board data acquisition system. The data were collected continuously while the vehicle was running, obtained from the vehicle data network and various sensors (*1*).

The Events dataset also contains two components: the Post-Crash Interview and the Event Detail Table. The Post-Crash Interview is administered after an accident has occurred (*1*). The dataset has 226 variables, many of which are similar to the items one would find on a thorough crash report from a law enforcement officer that documents vehicle maneuvers, passenger positions and demographics, and roadway conditions; additional items explore the subject driver's recent activities and potentially relevant medical conditions. The Event Detail Table consists of 76 variables in tabular form listing all crashes, near-crashes, and baseline events that have been identified and analyzed using the event analysis protocol (*1*). These 76 variables also have many similarities to those that could be found in an official crash report, along with items describing driver behaviors leading up to the crash.

Consideration of Variables

From a site location and geometric design point of view, 19 of the NDS data dictionaries (containing 910 variables) appeared to have little value for this effort; these 19 data dictionaries were primarily from the Events and Drivers datasets, along with the Vehicle dataset. The Trip Summary and Time Series data dictionaries contained 36 variables that could have potential for identifying ramp locations and characteristics, along with driver behaviors or vehicle conditions on those ramps. The usefulness of those variables, though, would depend on two factors: the ability to identify ramp locations in RID, and the purchase of detailed NDS data to be able to analyze corresponding variables on the ramp portions of trips instead of the data from trip summaries.

To determine whether the available information could be used on ramps, researchers explored the components of the RID database (*16*), of which there are seven, as shown in Figure 4: Mobile (a smaller, sample dataset collected by the study administrators) and six sets of state metadata (Florida, Indiana [route information and asset information], New York [roadway inventory and pavement data], North Carolina, Pennsylvania, and Washington). The Mobile database has potential usefulness for its ability to show a representation of the data without purchasing a large dataset. The 15 variables in the Mobile dataset include horizontal curve details, grade, superelevation, number of lanes, shoulder details, signing details, guardrail/barrier details, median presence, intersection details, and presence of rumble strips and lighting. The variables on curves, grade, and superelevation could be especially useful in comparing vehicle speeds to design speeds.

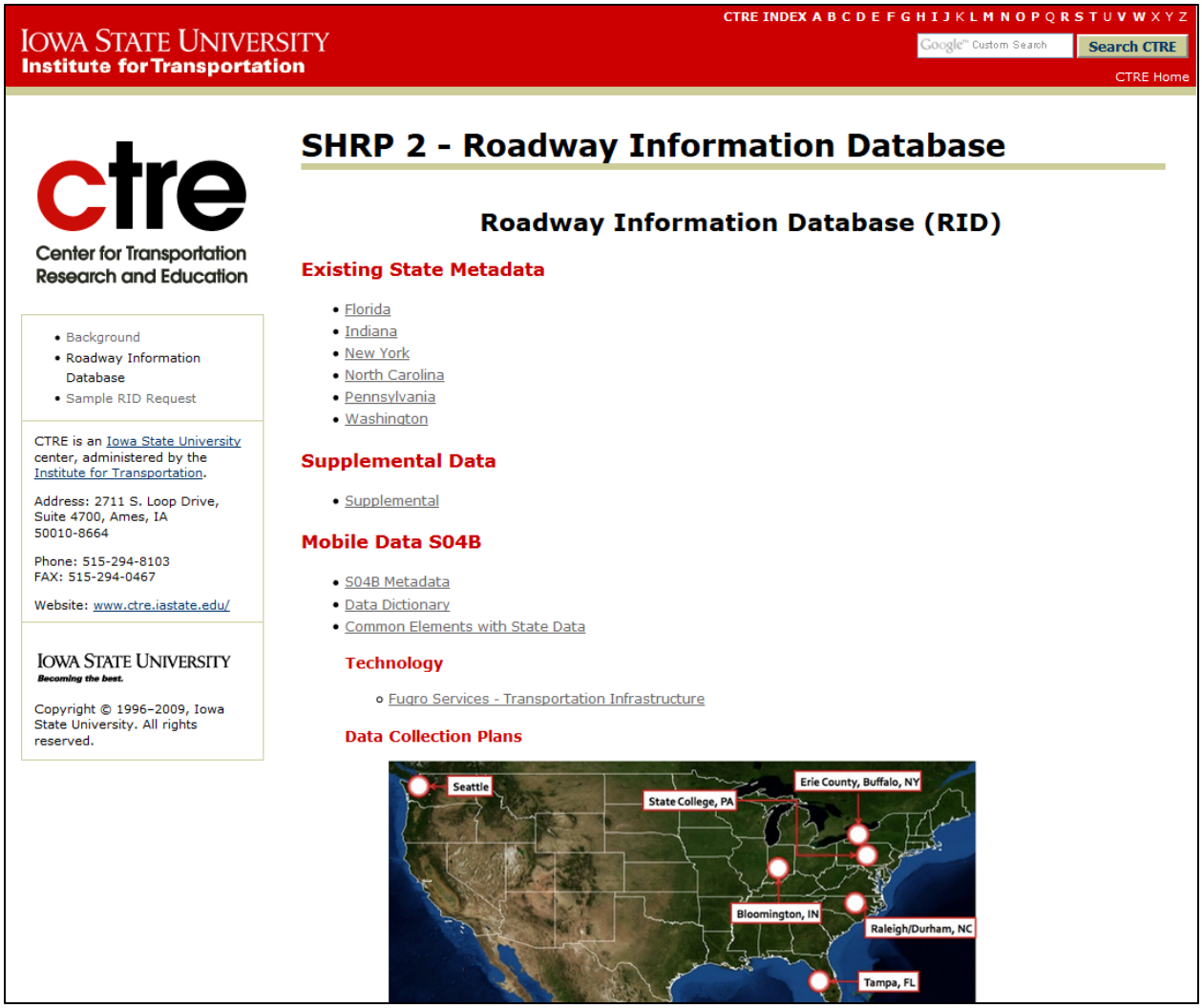


Figure 4. Screenshot of SHRP2 RID Home Page.

In the state metadata lists, the North Carolina and Washington sets did not have any variables that appeared to be useful in identifying freeway ramps without needing to associate a series of other variables in a lengthy query. The Florida metadata, however, contains a variable called Interchanges that can be used to quickly identify locations that contain ramps; in order to use that variable, it would be necessary to then determine the Link ID numbers of each ramp of interest to develop a list of locations for which specific trip information would be requested for purchase from NDS. Additional variables of interest in the Florida database include maximum speed limits, number of lanes, surface width, and annual average daily traffic.

The Route Information subset of the Indiana metadata contains variables described as RAMP_CODE, RAMP/Y-CONNECTOR, and secondary variables describing reference posts and ramp types within an interchange. These variables would greatly simplify the process of identifying ramps and their locations to request trip data from NDS. The Indiana data also contain an Asset Information component with variables including speed limit and degree of curve for comparison to design speed characteristics.

The Roadway Inventory component of the New York metadata contains a series of variables on ramps, which appears to be the most thorough description of ramps available in RID:

- Ramp_Entr: A ramp entering/intersecting with the roadway; located at the end milepoint of the segment.
- Ramp_Exit: A ramp for traffic exiting/leaving the roadway; located at the end milepoint of the segment.
- Roadway_Type: A code that describes the site as a ramp on a state system roadway.
- Ramp_Interchange_Code: An 11-character code representing an Interchange to which ramps are associated.
- Ramp_Alpha_Suffix: A single letter suffix attached to the Interchange code is used for a ramp designation (total of 12 characters). Each ramp is also assigned a unique, six-digit department of transportation (DOT) ID.
- Ramp_Orig_DOT_ID: DOT ID for the roadway from which the ramp begins.
- Ramp_Orig_Co_Order: County Order of the roadway segment on the roadway from which the ramp begins.
- Ramp_Orig_MP: Milepoint on the roadway from which the ramp begins.
- Ramp_Dest_DOT: DOT ID for the roadway at which the ramp ends.
- Ramp_Dest_Co_Order: County Order of the roadway segment on the roadway at which the ramp ends.
- Ramp_Dest_MP: Milepoint on the roadway from at the ramp ends.

Taken together, these variables would provide a relatively thorough description of the location of each ramp within the database and could be used to develop a list of sites to request from the full NDS dataset. However, the actual roadway inventory data are not available through the RID website; they must be requested from the RID administrators and then processed for site identification. After identifying ramps in New York, Indiana, and Florida, a purchase request for the detailed NDS trip data would provide a rich dataset to look at speeds and other roadway and vehicle characteristics on specific trips through those ramps, which could be compared to as-built plans and other information on the design of the ramps for an evaluation of the similarity between the ramps' design speeds as designed or built and the actual speeds selected by drivers.

Query of NDS Database

Based on the details described in the previous section, the research team queried the NDS database with a selection of variables that showed the most promise in identifying locations of ramps with the associated roadway and trip characteristics. Because details of the trips in the database were unavailable, researchers relied on the data in the Trip Summaries.

Using the Query tool provided in the InSight website, researchers looked for all of the crash events in the NDS database that could have occurred on ramps. To do that, the query was set up with the parameters shown in Table 2. Site Names were all of the states from RID; the not NULL value was used to remove any events that were not coded in a particular state. Trip Day of Week was similarly coded to include all seven days of the week but omit any event that was not coded to a particular day. All values of Trip ID and Event ID were included in order to search the entire NDS database. For Event Severity, only the most severe events were included: crash, near-crash,

and crash-relevant (non-conflict and baseline events were excluded, as were NULL and Not Applicable codes). Finally, in order to focus on trips that took place on ramps, the query specified that the trip had to have at least 0.5 percent of the trip take place on an urban or rural freeway; this eliminated any trip that did not include traveling on an entrance and/or exit ramp.

Table 2. Query Parameters Used to Search for Events on Ramps.

Data Dictionary	Variable	Values
Vehicle	Site Name	[Not NULL]
Trip Summary	Trip Day of Week	[Not NULL]
Trip Summary	Trip ID	All Values
Event > Event Detail Table	Event ID	All Values
Event > Event Detail Table	Event Severity	Crash, Near-Crash, Crash-Relevant
Trip Summary	% Urb Frwy	> 0.5
Trip Summary	% Rur Frwy	> 0.5

The completed query searched for events that contained all of the first five variables listed in Table 2 that also had either of the last two variables. Figure 5 shows the graphical representation of this query as shown on the InSight website (*1*).

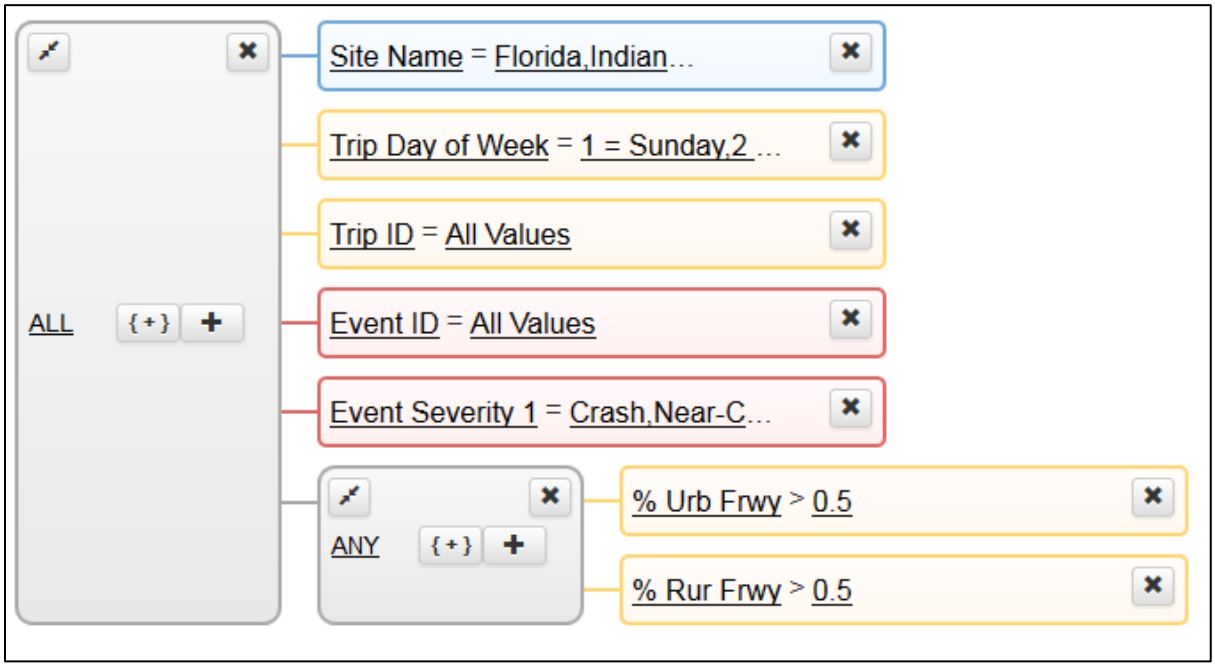


Figure 5. Graphical Representation of InSight Query (*1*).

The research team also subdivided this query to search for events within specific states and specific severities. Additional queries using different combinations of variables were considered, but this combination was the one with the most potential in identifying all of the events of interest. Chapter 3 presents query results and the findings from analyzing those results.

Exploration of Behavior-Related Variables

A similar effort to review variables from a safety and behavioral perspective was also conducted. In that review, researchers also found that, by itself, the no-cost NDS data available through the InSight website was insufficient to identify variables of interest for further analysis, but the trip summary and driver variables in that dataset indicated that there would be variables of interest in the detailed data that could be requested for purchase. Thus, advancing this project to the next phase would require purchasing data for future explorations of behavior variables, especially for drivers in the age range of 16–19, to include:

- Secondary tasks while driving often.
- Driving sleepy.
- Speeding 10–20 mph over the limit.

CHAPTER 3
RESEARCH RESULTS

INITIAL QUERY RESULTS

The query of the InSight NDS database defined by the parameters in Table 2 and Figure 5 produced a set of results that contained 939 events, as shown in Figure 6, a reproduction of the summary displayed on the InSight website (*1*).

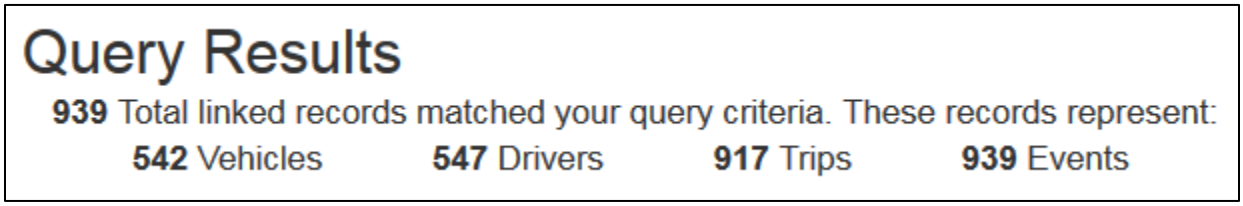
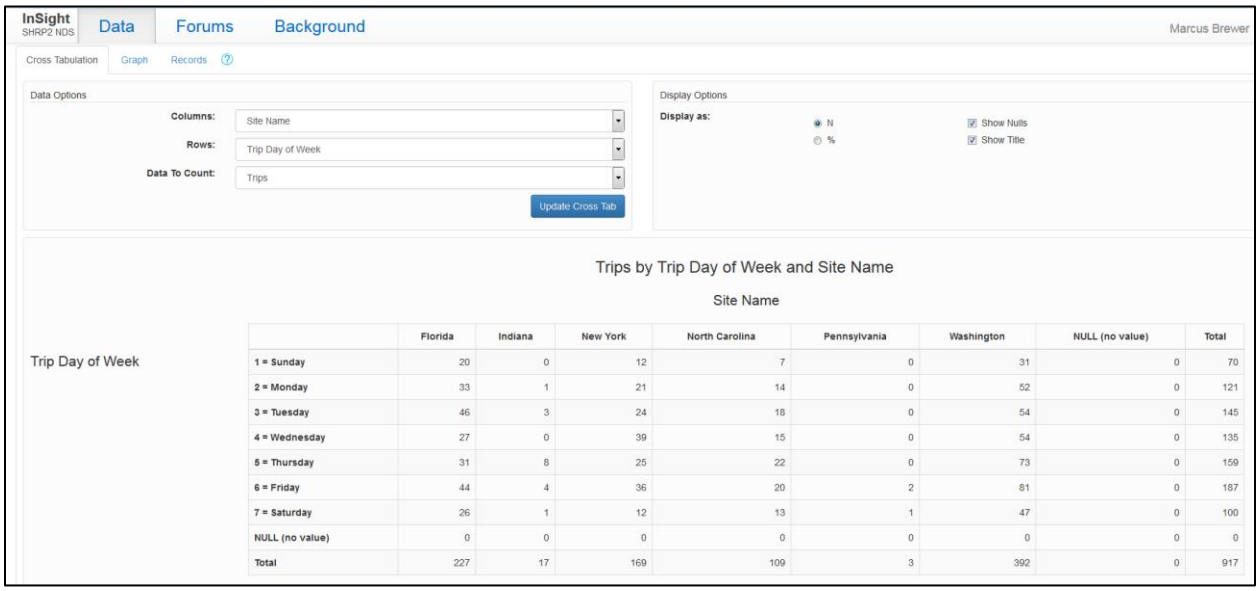


Figure 6. Results from InSight Query (*1*).

The query results page on the InSight website provides multiple methods of viewing the obtained results. The default page shows a cross-tabulation of the first two variables in the query list; in this case, it showed the 917 trips by day of week and state (see Figure 7). This table can be redefined to show any combination of two variables that the user desires to display. Reformatting the table with different variables provides an easy way to show the distribution of basic parameters; Table 3 and Table 4 show the two distributions by state.



Trip Day of Week	Florida	Indiana	New York	North Carolina	Pennsylvania	Washington	NULL (no value)	Total
1 = Sunday	20	0	12	7	0	31	0	70
2 = Monday	33	1	21	14	0	52	0	121
3 = Tuesday	46	3	24	18	0	54	0	145
4 = Wednesday	27	0	39	15	0	54	0	135
5 = Thursday	31	8	25	22	0	73	0	159
6 = Friday	44	4	36	20	2	81	0	187
7 = Saturday	26	1	12	13	1	47	0	100
NULL (no value)	0	0	0	0	0	0	0	0
Total	227	17	169	109	3	392	0	917

Figure 7. Default Cross-Tabulation of Query Results (*1*).

Table 3. Query Results by State.

State	Vehicles	Drivers	Trips	Events
Florida	135	134	227	236
Indiana	12	12	17	17
New York	110	111	169	169
North Carolina	81	81	109	109
Pennsylvania	3	3	3	3
Washington	201	206	392	405
Total	542	547	917	939

Table 4. Event Severity by State.

State	Crash	Near-Crash	Crash-Relevant	Total
Florida	1	234	1	236
Indiana	0	17	0	17
New York	0	168	1	169
North Carolina	0	108	1	109
Pennsylvania	0	3	0	3
Washington	2	401	2	405
Total	3	931	5	939

The results in Table 3 show that almost half of the events occurred in Washington, which is roughly proportional to the number of trips, vehicles, and drivers in the database. Table 4 shows that the vast majority of events (approximately 99.1 percent) were classified as near-crashes; there was not an actual collision in those events, but severe braking and/or avoidance maneuvers had to take place in order to avoid collisions.

The InSight website also shows graphs of query results, using the same default variables with the option to change variables to show any combination desired by the user. Figure 8 shows in graphical form the number of events by day of week and state that were shown in Figure 7. Arguably, though, the most useful display of results is in the actual records of each event. The event record shows a portion of video recorded through the vehicle's front windshield; a smoothed plot of time series data of key variables, such as speed, acceleration, brake use, and distance into trip; and an entry in a table showing the variables used in the query. In this case, the variables table showed the Trip ID, Day of Week, Site, Event ID, Event Severity, and % Urban and Rural Freeway. The display of time series data can be substituted with a summary of the event analysis, containing some information similar to a crash report, such as direction of vehicle travel, type of event, driver actions, weather/road conditions, and a narrative that describes in paragraph form the activities that occurred. Figure 9 shows a screenshot of a record from a ramp event with time series data, and Figure 10 shows the same event with event analysis.

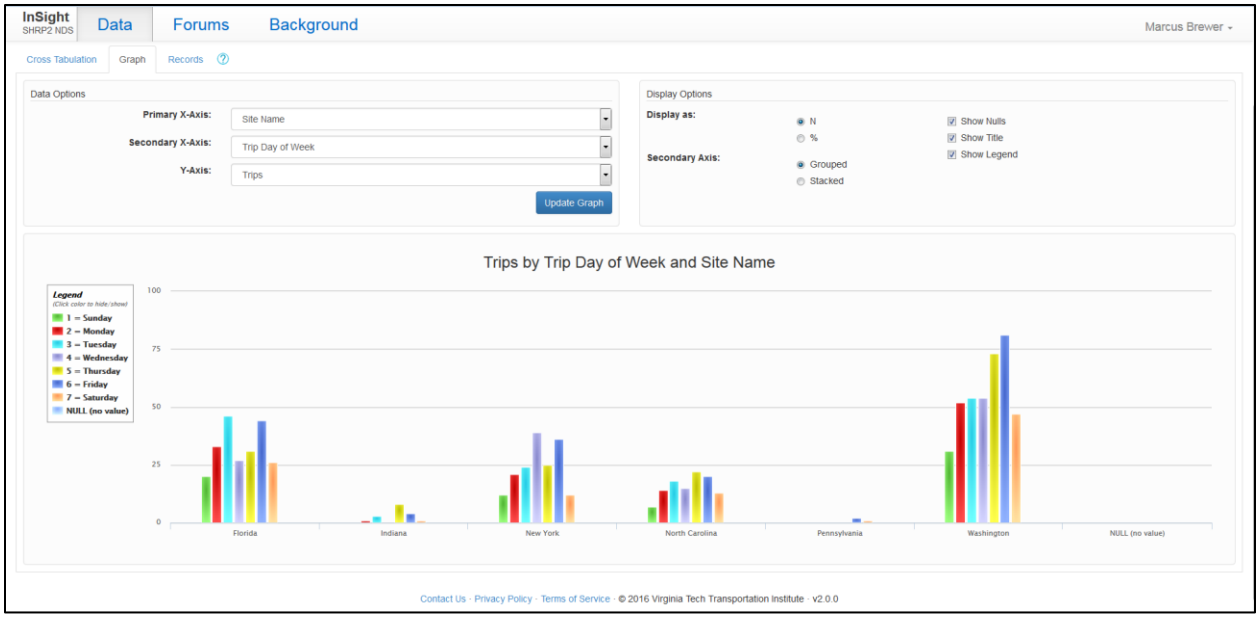


Figure 8. Default Graph of Query Results (*1*).

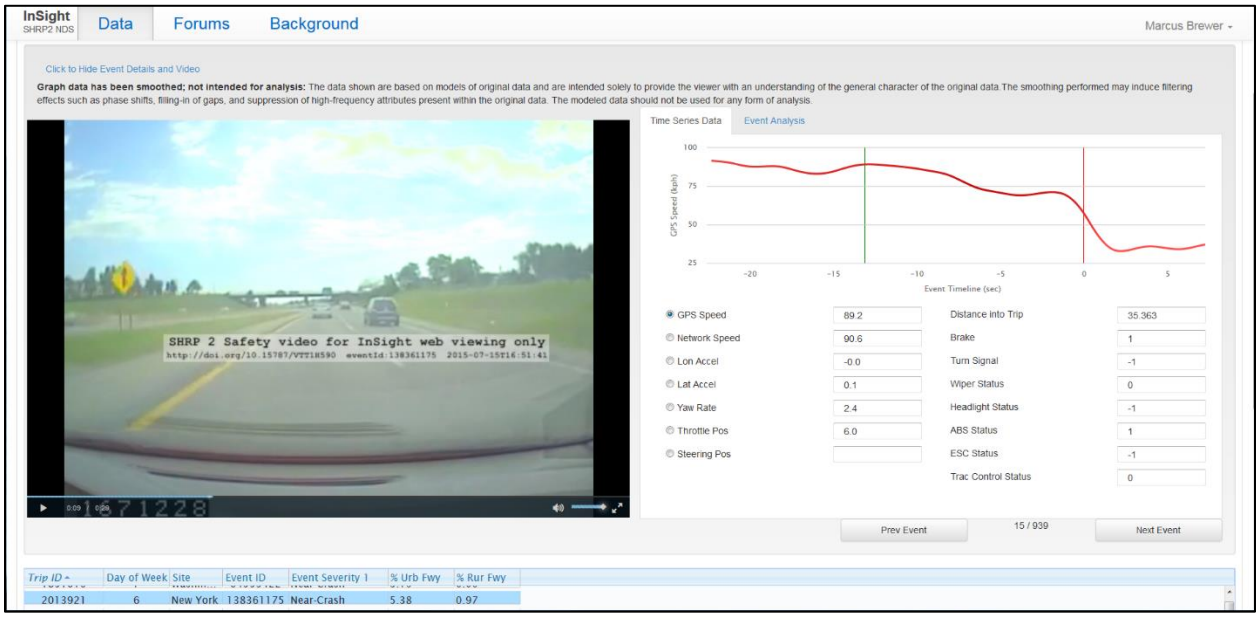


Figure 9. Screenshot of Ramp Event with Time Series Data in Query Results (*1*).

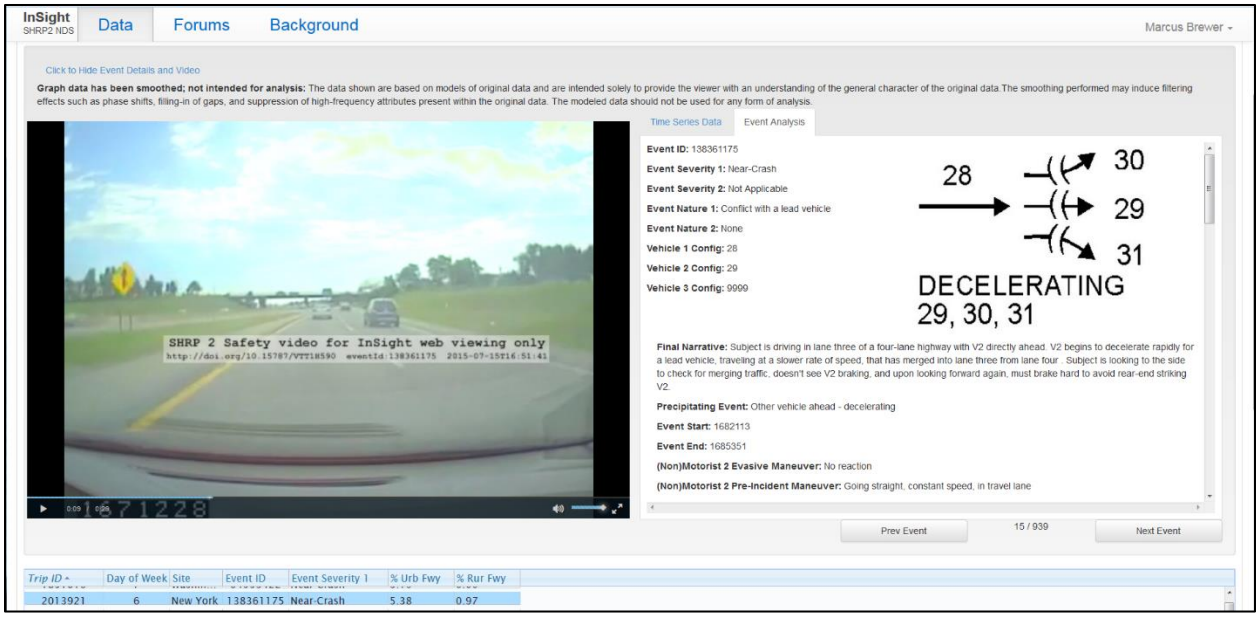


Figure 10. Screenshot of Ramp Event with Event Analysis in Query Results (*1*).

DETAILED QUERY RESULTS

The videos and narratives in the event records allowed a more detailed exploration of the 939 events produced by the query results. The research team viewed the video and read the narrative for each of the 939 events to determine how many events were actually relevant to the original problem statement of vehicles traveling at speeds incompatible with the ramp design speed.

A review of the videos and narratives indicated that only 49 of the 939 events (5.2 percent) actually took place on a freeway ramp. This percentage was a bit lower than expected, but still somewhat intuitive as the query parameters searched for almost every trip that included some nonzero amount of freeway travel. It is reasonable to assume that, with those parameters, a number of events will be returned that occurred on city streets and private drives, near the beginning or end of the recorded trips. It should also be expected that a substantial number of events would occur on the main lanes of the freeway, simply because more of the trip takes place there than on ramps, which increases the corresponding exposure and likelihood of an event. Thus, the actual number of events on freeway ramps was quite low.

Based on the records, nine of the events took place each in Florida, New York, and North Carolina. One event occurred in Pennsylvania, and the remaining 21 events happened in Washington. This distribution also roughly corresponds with the proportionality of events found in the entire set of query results in Table 3.

Of the 49 events on ramps, only one was labeled as a crash; the remaining 48 events were described as near-crashes. Near-crashes were almost completely populated by one of two scenarios: a driver attempted to change lanes in front of the subject driver, or the subject driver did not sufficiently brake while approaching slowed or stopped traffic in front of the subject vehicle. In both scenarios, the subject driver had to use emergency braking or avoidance maneuver to prevent a collision. Typically the latter scenario was enabled by driver inattention

(e.g., using a communications device, talking to passengers, reaching for an object elsewhere in the car, or changing a setting on the vehicle's controls). The cause of the former scenario was not always evident, though the narratives did describe multiple events in which a road rage conflict induced the subject driver and an adjacent driver to make inappropriate lane changes and/or apply the brakes while in front of another vehicle. One trip in Florida had three recorded near-crash events within two minutes, caused by the subject vehicle following the lead vehicle too closely through a ramp.

The only event labeled a crash occurred in Washington. The narrative states that the "subject vehicle (SV) is traveling on an exit ramp off a highway at a constant speed, when an object appears in the middle of the road. SV brakes and steers right, attempting to avoid the object. However, the subject strikes the object with his left tires, before continuing to his destination." There was no collision with another vehicle or with any traffic control devices, only with the object in the road, which could have been a piece of a tire from another vehicle. The subject vehicle was not disabled, and the crash was described as minor.

Researchers also found some interesting comments and items within the event records while reviewing the video and narratives. It is perhaps to be expected that with this many events to review with the associated video, vehicle data, and other supporting information, some errors are going to be found in the final dataset. That was the case in these query results. One event that did not take place on a ramp has a narrative stating that the driver was traveling 122 mph, but the time series data graph shows a speed of around 100 km/h, or 60 mph; it is unclear whether the person recording the data incorrectly converted speeds from metric to U.S. units, or whether it was a different type of error. Also, a near-crash on a ramp was described in the narrative as "Subject vehicle and V2 are both entering a highway through two separate entrance ramps. V2 is on an exit ramp to the subject's left that must yield for the SV's ramp. SV and V2 both meet where V2's lane ends and V2 has to merge. SV must brake to avoid a collision, and V2 also brakes allowing the SV to move ahead." The video clearly indicates that the subject vehicle is on an entrance ramp (not exit) and that the second vehicle is on the subject's right (not left). There were also numerous instances in which the person writing the narrative used incorrect terminology (e.g., "an undivided interstate," "a single lane stretch that has just forked off from the rest of the interstate"), but the actual conditions could still be determined from the video and other supporting information. Finally, there were a small selection of duplicate items in the events list; this could be a result of multiple reviewers documenting the same event without cross-checking the data entry across reviewers. As with the incorrect terminology, these duplicates were easily processed, but it did add some time to the review task to make sure that each event was viewed by the research team.

In the research team's opinion, the key finding from the review of the ramp events is twofold:

1. It is possible to find events on ramps in the NDS dataset and review the details of them, but it requires processing a great deal of non-ramp data to identify those events.
2. Within the NDS dataset there does not appear to be a substantial crash problem on freeway ramps, though the available trip summary data does not lend itself to a thorough connection to ramp design details as described in this project's problem statement.

CHAPTER 4
CONCLUSIONS AND RECOMMENDATIONS

Based on the activities conducted as part of this research, the authors conclude the following:

- There is a need to compare existing design speed guidance with current vehicle performance to determine whether revisions to certain aspects of the freeway ramp design speed selection process would be beneficial. While efforts are ongoing in an NCHRP research project to accomplish this, some sources of information, such as naturalistic driving data, may be particularly useful in accomplishing that comparison.
- There is also a need to better understand the behavior of drivers, especially teen drivers, on freeway ramps to determine whether the design process needs to take certain behavioral aspects into account or whether additional driver education on proper methods of navigating freeway ramps would improve safety and operations.
- The SHRP2 Naturalistic Driving Study provides a wealth of information on trips taken by more than 3400 drivers and vehicles, but the trip summary data made available for free through the InSight website does not provide the level of detail needed to make a thorough comparison between driver/vehicle characteristics and ramp design criteria. A request for the detailed data must be made (and the dataset itself purchased) in order to conduct the research needed for the comparison.
- Similarly, a tremendous amount of roadway metadata was collected for the RID component of the SHRP2 project, but the datasets themselves are not actually available through the RID website and must be requested from administrators. The research team believes, though, that there are sufficient RID metadata variables in at least three of the states to help efficiently identify ramps as study sites for use in requesting NDS trip data.

The findings from these research activities suggest several potential research needs that could be addressed in future projects (both within and external to the ATLAS Center program) to increase the amount and quality of available data, as well as the information gained from the data:

- A future project would compare the detailed NDS data (i.e., trip details instead of trip summaries) to ramp characteristics to determine whether the NDS drivers were operating at speeds consistent with the design speeds suggested from the characteristics of those ramps. This would require either using NDS data purchased for other ATLAS Center projects (if the future project is funded by ATLAS) or making an additional purchase of NDS data. It would also require acquisition of the detailed roadway and ramp characteristics (e.g., curve radii, lane and shoulder widths, design speeds, posted speed limits or advisory speeds, super elevation) for the roads and ramps that the NDS drivers used in their observed routes. Some of these characteristics might be obtained through RID, but it is likely that contacting the various state DOTs for as-built plans and other resources would provide more useful information.
- Further research is needed to identify factors related to interactions of freeway ramp design speed with teen drivers' behaviors. This would likely be effectively accomplished through a future study that would equip vehicles of teen drivers with cameras to facilitate data collection of their behaviors on ramps. A future project could focus on data of teen

drivers in near crashes and crashes on freeway ramps. The key research questions could be as follows:
    - Was this event caused by driver behavior or road design?
    - If behavior was found to be the cause of the event: Was it speeding, cell phone, or drowsiness? Or is it lack of driver education on proper methods for navigating freeway ramps safely?
    - If behavior was not the cause of the event then research team would focus on road design.
- As the SHRP2 NDS dataset continues to be processed, refined, and released for further investigation, an effort to specifically code the presence of freeway ramps within the trip data would be especially beneficial. While it is anticipated that this would be a large undertaking, the benefits of readily identifying ramps within data queries and requests would greatly accelerate the use of the data in future research to investigate not only ramp design speed selection guidelines but also other ramp-related issues such as run-off-road crashes, merge and diverge maneuver characteristics, and wrong-way driving incidents.
- While the NDS InSight website specifies that the data available there are generally based on trip summaries and more detailed data must be requested and purchased, the RID website is much less clear on the subject. For example, sections of the RID website promote existing state metadata supplemental data, and mobile data, but links take the user to lists of variables, not the actual data. A page entitled “Sample RID Data Request” does not actually show the user what a data request looks like, but rather describes a sample of data made available through a link at the bottom of the page, with little instruction on how to use it once downloaded. The procedure for obtaining the actual data is not described, and the user must assume that they need to contact the website administrator to ask for the desired data, which may or may not be available in the quantity or format desired. The RID website would benefit from an additional section or page to describe exactly what data are available through the website and what data are available upon request, along with instructions on how to open the data files, the format of the files, and whether requested data files are free or available for purchase.

APPENDIX
LIST OF SHRP2 VARIABLES

This appendix contains a listing of all of the data variables collected as part of the SHRP2 Naturalistic Driving Study. The variables are listed by dataset components. The 21 datasets are as follows:

Vehicle
Driver Demographic
Driving History Questionnaire
Driving Knowledge Survey
Visual and Cognitive Tests
Conner's Continuous Performance
Clock Drawing Assessment
Physical Strength Tests
Barkley's ADHD Screening Test
Risk Perception Questionnaire
Risk Taking Questionnaire
Sensation Seeking Scale Survey
Driver Behavior Questionnaire
Medical Conditions and Medications
Sleep Habits
Medical Conditions and Medications – Exit
Driver Exit Interview
Trip Summary
Time Series
Post-Crash Interview
Event Detail

The variables within each of the preceding datasets are listed in the remainder of this appendix.

<u>Vehicle variables (30)</u>

Vehicle ID
Vehicle Classification
Advanced Technology Vehicle
Model Year
Vehicle Make
Site Name
Powertrain
Left Front Tread Depth
Left Rear Tread Depth
Right Front Tread Depth
Right Rear Tread Depth
Left Front Pressure
Left Rear Pressure
Right Front Pressure
Right Rear Pressure
Battery Voltage
Battery Amps
Battery Condition
Battery Year
Integrated Cell Phone
Controls Location
Speech Recognition
Phonebook Access
Phonebook Display Location
Factory Navigation
Navigation Display Location
OnStar
Accept Nomadics
Nomadics Method
Music Control

Driver Demographic Questionnaire variables (48)

Participant ID
Gender
Age Group
Ethnicity
Race
Birth Country
Education
Marital Status
Head-of-Household
Home Ownership
Work Status
Income
Number in Household
First Additional Resident Gender
First Additional Resident Age
First Additional Resident Drive
Second Additional Resident Gender
Second Additional Resident Age
Second Additional Resident Drive
Third Additional Resident Gender
Third Additional Resident Age
Third Additional Resident Drive
Fourth Additional Resident Gender
Fourth Additional Resident Age
Fourth Additional Resident Drive
Fifth Additional Resident Gender
Fifth Additional Resident Age
Fifth Additional Resident Drive
Sixth Additional Resident Gender
Sixth Additional Resident Age
Sixth Additional Resident Drive
Seventh Additional Resident Gender
Seventh Additional Resident Age
Seventh Additional Resident Drive
Eighth Additional Resident Gender
Eighth Additional Resident Age
Eighth Additional Resident Drive
Number of Vehicles in Household
Vehicle 1 Classification
Vehicle 2 Classification
Vehicle 3 Classification
Vehicle 4 Classification
Vehicle 5 Classification
Time at Residence
Driver Mileage Last Year
Business Use of Study Vehicle
Length of Vehicle Ownership
Participant Receive License

Driving History Questionnaire variables (18)

Participant ID
Average Annual Mileage
Years Driving
Training
Number Violations
Violation Types
Number of Crashes
Crash 1 Severity
Crash 1 Fault
Crash 2 Severity
Crash 2 Fault
Crash 3 Severity
Crash 3 Fault
Crash 4 Severity
Crash 4 Fault
Crash 5 Severity
Crash 5 Fault
Insurance Status

Driving Knowledge Survey variables (21)

Participant ID
Night Driving
Yellow Lights
Green Arrows
Emergency Vehicles
Dimming Lights
Merge Signs
Curve Signs
Police Officer
Right of Way
Fire Hydrants
Traffic Controls
Yellow Lines
Entering Expressways
Blind Spots
Drowsiness
City Driving
Light Changes
Run off Road
Bicycles
Number Correct (out of 19)

Visual and Cognitive Test variables (122)

Participant ID
Day Far Acuity Both Eyes
Day Near Acuity Both Eyes
Night Contrast Right Eye Row A
Night Contrast Right Eye Row B
Night Contrast Right Eye Row C
Night Contrast Right Eye Row D
Night Contrast Right Eye Row E
Night Contrast Left Eye Row A
Night Contrast Left Eye Row B
Night Contrast Left Eye Row C
Night Contrast Left Eye Row D
Night Contrast Left Eye Row E
Depth Perception
Day Contrast Right Eye Row A
Day Contrast Right Eye Row B
Day Contrast Right Eye Row C
Day Contrast Right Eye Row D
Day Contrast Right Eye Row E
Day Contrast Left Eye Row A
Day Contrast Left Eye Row B
Day Contrast Left Eye Row C
Day Contrast Left Eye Row D
Day Contrast Left Eye Row E
Color Score First Circle
Color Score Second Circle
Color Score Third Circle
Color Score Fourth Circle
Color Score Fifth Circle
Color Score Sixth Circle
Color Scoring Notes
Night Contrast Glare Right Eye Row A
Night Contrast Glare Right Eye Row B
Night Contrast Glare Right Eye Row C
Night Contrast Glare Right Eye Row D
Night Contrast Glare Right Eye Row E
Night Contrast Glare Left Eye Row A
Night Contrast Glare Left Eye Row B
Night Contrast Glare Left Eye Row C
Night Contrast Glare Left Eye Row D
Night Contrast Glare Left Eye Row E
Day Left 1.5 Contrast Sensitivity
Day Left 1.5 Contrast Patch
Day Left 3 Contrast Sensitivity
Day Left 3 Contrast Patch
Day Left 6 Contrast Sensitivity
Day Left 6 Contrast Patch
Day Left 12 Contrast Sensitivity
Day Left 12 Contrast Patch
Day Left 18 Contrast Sensitivity
Day Left 18 Contrast Patch
Day Right 1.5 Contrast Sensitivity
Day Right 1.5 Contrast Patch
Day Right 3 Contrast Sensitivity
Day Right 3 Contrast Patch
Day Right 6 Contrast Sensitivity
Day Right 6 Contrast Patch
Day Right 12 Contrast Sensitivity

Day Right 12 Contrast Patch
Day Right 18 Contrast Sensitivity
Day Right 18 Contrast Patch
Night Glare Left 1.5 Contrast Sensitivity
Night Glare Left 1.5 Contrast Patch
Night Glare Left 3 Contrast Sensitivity
Night Glare Left 3 Contrast Patch
Night Glare Left 6 Contrast Sensitivity
Night Glare Left 6 Contrast Patch
Night Glare Left 12 Contrast Sensitivity
Night Glare Left 12 Contrast Patch
Night Glare Left 18 Contrast Sensitivity
Night Glare Left 18 Contrast Patch
Night Glare Right 1.5 Contrast Sensitivity
Night Glare Right 1.5 Contrast Patch
Night Glare Right 3 Contrast Sensitivity
Night Glare Right 3 Contrast Patch
Night Glare Right 6 Contrast Sensitivity
Night Glare Right 6 Contrast Patch
Night Glare Right 12 Contrast Sensitivity
Night Glare Right 12 Contrast Patch
Night Glare Right 18 Contrast Sensitivity
Night Glare Right 18 Contrast Patch
Night Left 1.5 Contrast Sensitivity
Night Left 1.5 Contrast Patch
Night Left 3 Contrast Sensitivity
Night Left 3 Contrast Patch
Night Left 6 Contrast Sensitivity
Night Left 6 Contrast Patch
Night Left 12 Contrast Sensitivity
Night Left 12 Contrast Patch
Night Left 18 Contrast Sensitivity
Night Left 18 Contrast Patch
Night Right 1.5 Contrast Sensitivity
Night Right 1.5 Contrast Patch
Night Right 3 Contrast Sensitivity
Night Right 3 Contrast Patch
Night Right 6 Contrast Sensitivity
Night Right 6 Contrast Patch
Night Right 12 Contrast Sensitivity
Night Right 12 Contrast Patch
Night Right 18 Contrast Sensitivity
Night Right 18 Contrast Patch
Peripheral Vision Right Eye
Peripheral Vision Left Eye
VMI Raw Score
Impairment Level - VMI
Visual Search Test A Raw Score
Visual Search Test B Raw Score
Visual Search Summary Raw Score
Impairment Level - Visual Search
VSA Age Percentile Rank
VSA Age-Ed Percentile Rank
VSB Age Percentile Rank
VSB Age-Ed Percentile Rank
Vis Search Age Percentile Rank
Vis Search Age-Ed Percentile Rank
UFOV Raw Score
Impairment Level - UFOV
UFOV Age Percentile Rank
UFOV Age-Ed Percentile Rank
Cog-Vis Assess Age Bin
Cog-Vis Assess Age-Ed Bin
Cog-Vis Assess Ed Bin

Conner's Continuous Performance Test variables (15)

Participant ID
ADHD Confidence Index
Clinical Report
General TScore Omissions
General TScore Commissions
General TScore HitRT
General TScore HitSE
General TScore VarSE
General TScore DPrime
General TScore Beta
General TScore Perseverations
General TScore HitRTBlock
General TScore HitSEBlock
General TScore HitRTIsi
General TScore HitSEIsi

Clock Drawing Assessment variables (3)

Participant ID
Clock Drawing
Clock Drawing Score

Physical Strength Tests variables (7)

Participant ID
Right Hand Strength First Try
Left Hand Strength First Try
Right Hand Strength Second Try
Left Hand Strength Second Try
Dominant Hand
Raw Walk Time

Barkley's ADHD Screening Test variables (8)

Participant ID
Easily Distracted
Difficulty Organizing
Loses Objects
Quick Screen – Difficulty Waiting Turn
Feels Restless
Difficulty Enjoying Leisure Activities
Barkleys Score

Risk Perception Questionnaire variables (34)

Participant ID
Red Light
Driving Sleepy
Risks for Fun
Sudden Lane Changes
Running Stop Sign
Speeding for Thrill
Failure to Yield
Illegal Turns
Tailgating
Following Active Emergency Vehicles
In a Hurry
Bad Weather
Risk of Passing on Right
First off the Line
Yellow Light Acceleration
Driving after taking Drugs or Alcohol
Driving While taking Drugs or Alcohol
Road Rage
Driving to Reduce Tension
Secondary Tasks
Eyes off Road
Passenger Interaction
Racing
Checking Rearview Mirror
Speeding less than 20 MPH Over Limit
Speeding more than 20 MPH Over Limit
Not Yielding to Pedestrians
Not Wearing Safety Belt
Not Signaling
Worn Tires
Visual Obstructions
Rolling Stop
Risk Perception Score

Risk Taking Questionnaire variables (35)

Participant ID
Run Red Lights Past 12mo
Drive Sleepy
Take Risks for Fun Often
Change Lane Suddenly
Run Stop Sign Often
Speed for Thrill Often
Fail to Yield
Make Illegal Turns
Tailgate
Follow Emergency Vehicles
Take Risks Because of Hurry
Failure to Adjust
Pass on Right
First off Line Past 12mo
Accelerate at Yellow Light
Drive after Drugs
Using Drugs While Driving
Road Rage Past 12mo
Drive for Enjoyment
Secondary Tasks While Driving Often
Adjust CD Player
Eyes off Road to Passenger
Race Other Cars Past 12mo
Merge without Checking Rearview Mirror
Speed 10-20 MPH Over
Speed 20+ MPH Over
Not Yield to Pedestrians
Not Use Belt
Not Use Signal
Use Worn Tires Often
Pass When Visibility Obscured
Roll Through Stop Sign
CARDS Frequency of Risky Behavior Score
Modified CARDS Frequency of Risky Behavior Score

Sensation Seeking Scale variables (46)

Participant ID
Wild Party
Rewatching Movies
Mountain Climbing
Body Odors
Meeting New People
Exploring City
Communication
Predictable Movie Plot
Marijuana Use
Illicit Drug Use
Dangerous Activities
Contact with Swingers
Recreational Drug Use
Try New Foods
Home Movies
Water Skiing
Surfing
Trip Planning
Friend Personality
Learn to Fly
Scuba Diving
Views on Homosexuality
Parachuting
Unpredictable Friends
New Experiences
Perception of Art
Staying at Home
High Dive
Date Personalities
Alcohol at Party
Social Sin
Sexual Experience Before Marriage
Jet Set Lifestyle
Witty Friends
Sex in Movies
Social Drinking
Style of Dress
Sailing
Patience
Skiing
Boredom Summary Metric
Disinhibition Summary Metric
Experience Seeking Summary Metric
Thrill Seeking Summary
SSS Total Score

Driver Behavior Questionnaire variables (25)

Participant ID
Wrong Gear
Impatiently Pass on the Right
Tailgating Often
Pass a Turning Vehicle
Forget Where Car Is Parked
Wrong Switch
No Recollection
Run Red Light
Miss Pedestrians
Often Road Rage
Wrong Way
Disregards Speed Limits
Miss Pedalcyclist
Miss Lead Vehicle
Driving Above Alcohol Limit
Roadway Aversion
Underestimate Speed of Oncoming Traffic
Hit Something While Backing
Wrong Destination
Wrong Lane at Intersection
Miss Yield Signs
Fail to Check Rearview Mirror
Involved in Racing
Brake Aggressively

Medical Conditions and Medications Questionnaire variables (40)

Participant ID
Height
Weight
Neck Size
Vision Conditions
Other Vision Conditions
Vision Correction
Driving Vision Correction
Hearing Conditions
Other Hearing Conditions
Heart Conditions
Other Heart Conditions
Brain Conditions
Other Brain Conditions
Vascular Conditions
Other Vascular Conditions
Nervous System and Sleep Conditions
Other Nervous System and Sleep Conditions
Respiratory Conditions
Other Respiratory Conditions
Metabolic Conditions
Other Metabolic Conditions
Chronic Kidney Failure
Other Kidney Conditions
Limited Flexibility
Severe Arthritis
Artificial Limbs
Paralysis
Muscle and Movement Disorders
Other Musculoskeletal Disorders
Walking Aids
Cancer
Psychiatric Conditions
Other Psychiatric Conditions
Prescribed Medications
Multiple Medical Conditions
Multiple Medications
Age-Related Conditions
Gave Up Driving
Other Medical Conditions

Sleep Habits Questionnaire variables (100)

Participant ID
Current Work Status
Sleep Status When Working Outside the Home
Bed Time When Working Outside the Home
Wake Time When Working Outside the Home
Sleep Status When Working From the Home
Bed Time When Working From the Home
Wake Time When Working From the Home
Sleep Schedule
Average Sleep Hours When Working
Average Sleep Hours When Not Working
Average Sleep Needed
Sleeper Type
Sleep In Recliner or Sitting
Nap Frequency
Nap Length
Sleepy During Daytime
Nod Off Last Month Stopped
Nod Off Last Month Driving
Nod Off Last Year Stopped
Nod Off Last Year Driving
Last Week Caffeine Servings
Typical Week Caffeine Servings
Last Week Caffeine Intake Pattern
Typical Week Caffeine Intake Pattern
Last Week Alcohol Servings
Typical Week Alcohol Servings
Tobacco Use
Tobacco Use Frequency
Use Sleep Aids Last Month
Use Sleep Aids Typical Month
Sleep Aid Type
Frequency Awake More Than 30 Hours
Frequency Awake Between 24 and 30 Hours
Frequency Awake Between 20 and 24 Hours
Occupation
Frequency Night Shifts Last Year
Children At Home
Children At Home Less Than Two
Children At Home Three To Five
Children At Home Six To Ten
Children At Home Eleven To Thirteen
Children At Home Fourteen To Eighteen
Children At Home Older Than Eighteen
Awakened By Children Last Month
Hours Awakened By Children Last Month
Frequency Awakened By Children Last Month
Work Shifts Last Week
Hours Spent Working the Past Week
Hours Spent Sleeping the Past Week
Days Off Last Week
Last Week Typical
Why Last Week Not Typical
Work Shifts Two Weeks Ago
Hours Spent Working the Week Two Weeks Ago
Hours Spent Sleeping the Week Two Weeks Ago
Days Off Two Weeks Ago
Two Weeks Ago Typical
Why Two Weeks Ago Not Typical
Work Shifts Three Weeks Ago
Hours Spent Working the Week Three Weeks Ago
Hours Spent Sleeping the Week Three Weeks Ago
Days Off Three Weeks Ago
Three Weeks Ago Typical
Why Three Weeks Ago Not Typical
Work Shifts Four Weeks Ago
Hours Spent Working the Week Four Weeks Ago
Hours Spent Sleeping the Week Four Weeks Ago
Days Off Four Weeks Ago
Four Weeks Ago Typical
Why Four Weeks Ago Not Typical
Greatest Number Continuous Hours Worked Last Month
Frequency Work Start Before Five AM
Doze While Reading
Doze While Watching TV
Doze In a Public Place
Doze As A Passenger
Doze While Lying Down

Doze While Talking to Someone
Doze While In A Car Stopped Temporarily
Doze While Working the Night Shift
Doze While Working the Day Shift
Snoring
Snoring Loudness
Snoring Frequency
Snoring Bother Others
Quit Breathing During Sleep
Quit Breathing During Sleep Frequency
Fatigued Upon Waking
Fatigued While Awake
Nod Off While Driving
Nod Off While Driving Frequency
Time To Fall Asleep
Awakenings At Night
Awake Earlier Than Want
Sleep Duration
Quality Of Sleep
Well Being While Awake
Functioning While Awake
Sleepiness While Awake

Medical Conditions and Medications Questionnaire – Exit variables (40)

Participant ID – Exit
Height – Exit
Weight – Exit
Neck Size – Exit
Vision Conditions – Exit
Other Vision Conditions – Exit
Vision Correction – Exit
Driving Vision Correction – Exit
Hearing Conditions – Exit
Other Hearing Conditions – Exit
Heart Conditions – Exit
Other Heart Conditions – Exit
Brain Conditions – Exit
Other Brain Conditions – Exit
Vascular Conditions – Exit
Other Vascular Conditions – Exit
Nervous System and Sleep Conditions – Exit
Other Nervous System and Sleep Conditions – Exit
Respiratory Conditions – Exit
Other Respiratory Conditions – Exit
Metabolic Conditions – Exit
Other Metabolic Conditions – Exit
Chronic Kidney Failure – Exit
Other Kidney Conditions – Exit
Limited Flexibility – Exit
Severe Arthritis – Exit
Artificial Limbs – Exit
Paralysis – Exit
Muscle and Movement Disorders – Exit
Other Musculoskeletal Disorders – Exit
Walking Aids – Exit
Cancer – Exit
Psychiatric Conditions – Exit
Other Psychiatric Conditions – Exit
Prescribed Medications – Exit
Multiple Medical Conditions – Exit
Multiple Medications – Exit
Age-Related Conditions – Exit
Gave Up Driving – Exit
Other Medical Conditions– Exit

Driver Exit Interview variables (16)

Participant ID
Life Stress
Stress Affects Driving
Altered Driving Behavior
What Way Altered
How Safe Comparison
Driving Ability
Restrict Driving
Restriction Description
Giving Up Driving
Critical Incident Explanation
Critical Incident Date
Critical Incident Time
Critical Incident Description
Rating of Experiences During Study
Bring to Attention

Trip Summary variables (131)

Trip ID
Trip Start UTC Hour of Day
Trip Start UTC Month
Trip End UTC Hour of Day
Trip Start Local Time Hour of Day
Trip Start Month Local
Trip End Local Time Hour of Day
Trip Day of Week
Trip Day Number in Study
Trip Duration
Trip Distance
Trip Centroid Latitude
Trip Centroid Longitude
Trip Origin Altitude
Trip Destination Altitude
Max Speed
Mean Speed
Time Moving
Time Not Moving
Maximum Acceleration
Maximum Deceleration
Maximum Lateral Acceleration
Minimum Lateral Acceleration
Maximum Turn Rate
Minimum Turn Rate
Number of Longitudinal Accels > Threshold
Number of Longitudinal Decels > Threshold
Number of Lateral Accels > Threshold
Brake Activations
Lane Tracker Right Side High Quality Time
Lane Tracker Left Side High Quality Time
Face Tracker High Quality Time
Trip Distance Origin to Destination
ABS Available
ABS Activation
Turn Signal Available
Turn Signal Activations
Traction Control Available
Traction Control Activation
Vehicle Network Supports Seatbelt
Seatbelt Usage Percentage
Vehicle Network Supports Wipers
Time Wipers Used
Vehicle Network Supports Lights Activation
Lights Usage Percentage
Vehicle Network Supports Cruise Control
Time Cruise Control Used
Time at 0–10 mph
Time at 10–20 mph
Time at 20–30 mph
Time at 30–40 mph
Time at 40–50 mph
Time at 50–60 mph
Time at 60–70 mph
Time at 70–80 mph
Time at > 80 mph
Distance at 0–10 mph
Distance at 10–20 mph
Distance at 20–30 mph
Distance at 30–40 mph
Distance at 40–50 mph
Distance at 50–60 mph
Distance at 60–70 mph
Distance at 70–80 mph
Distance at > 80 mph
Vehicle Model Year
Alcohol Flag
Cell Phone Flag
% HSIS Derived Rd Class
% Urb Frwy
% Urb Frwy < 4 Lns
% Urb 2 Ln
% Urb Multi Div Non-Frwy
% Urb Multi Undiv Non-Frwy
% Rur Frwy
% Rur Frwy < 4 Lns
% Rur 2 Ln
% Rur Multi Div Non-Frwy
% Rur Multi Undiv Non-Frwy
% Other Class
% Mobile Van Cov
% State Data Cov
% No Spd Lim Data
% Spd Lim 35 or Less
% Spd Lim 40–50
% Spd Lim 55–65
% Spd Lim 70 or Greater
Time Where Radar Targets = 0

Time Where Radar Targets = 1
Time Where Radar Targets = 2
Time Where Radar Targets = 3
Time Where Radar Targets = 4
Time Where Radar Targets = 5
Time Where Radar Targets = 6+
Distance Where Radar Targets = 0
Distance Where Radar Targets = 1
Distance Where Radar Targets = 2
Distance Where Radar Targets = 3
Distance Where Radar Targets = 4
Distance Where Radar Targets = 5
Distance Where Radar Targets = 6+
Time With Lead Vehicle
Time Where Headway 0.0–0.5 s
Time Where Headway 0.5–1.0 s
Time Where Headway 1.0–1.5 s
Time Where Headway 1.5–2.0 s
Time Where Headway 2.0–2.5 s
Time Where Headway 2.5–3.0 s
Time Where Headway 3.0–3.5 s
Time Where Headway > 3.5 s
Distance with Lead Vehicle
Distance Where Headway 0.0–0.5 s
Distance Where Headway 0.5–1.0 s
Distance Where Headway 1.0–1.5 s
Distance Where Headway 1.5–2.0 s
Distance Where Headway 2.0–2.5 s
Distance Where Headway 2.5–3.0 s
Distance Where Headway 3.0–3.5 s
Distance Where Headway > 3.5 s
Minimum TTC Lead 0–10 mph
Minimum TTC Lead 10–20 mph
Minimum TTC Lead 20–30 mph
Minimum TTC Lead 30–40 mph
Minimum TTC Lead 40–50 mph
Minimum TTC Lead >= 50 mph
Minimum TTC 0–10 mph
Minimum TTC 10–20 mph
Minimum TTC 20–30 mph
Minimum TTC 30–40 mph
Minimum TTC 40–50 mph
Minimum TTC >= 50 mph

Time Series variables (115)

Speed, GPS
Speed, Vehicle Network
Acceleration, x-axis
Acceleration, y-axis
Yaw Rate, z-axis
Pedal, Accelerator Position
Steering Wheel Position
Distance
Pedal, Brake
Turn Signal
Wiper Setting
Headlight Setting
ABS Activation
Electronic Stability Control
Traction Control
Acceleration, x-axis fast
Acceleration, y-axis fast
Acceleration, z-axis
Acceleration, z-axis fast
Airbag, Driver
Alcohol
Cruise Control
Day
Dilution of Precision, Position
Driver Button Flag
Elevation, GPS
Engine RPM
Epoch State
Head Confidence
Head Position X
Head Position X Baseline
Head Position Y
Head Position Y Baseline
Head Position Z
Head Position Z Baseline
Head Rotation X
Head Rotation X Baseline
Head Rotation Y
Head Rotation Y Baseline
Head Rotation Z
Head Rotation Z Baseline
Heading, GPS
Illuminance, Ambient
Lane Marking, Distance, Left
Lane Marking, Distance, Right
Lane Marking, Probability, Right
Lane Marking, Type, Left
Lane Marking, Type, Right
Lane Markings, Probability, Left
Lane Position Offset
Lane Width
Latitude
Location
Longitude
Month
Number of Satellites
Pitch Rate, y-axis
Pitch Rate, y-axis fast
PRNDL
Radar, Range Rate Forward X Track 0
Radar, Range Rate Forward X Track 1
Radar, Range Rate Forward X Track 2
Radar, Range Rate Forward X Track 3
Radar, Range Rate Forward X Track 4
Radar, Range Rate Forward X Track 5
Radar, Range Rate Forward X Track 6
Radar, Range Rate Forward X Track 7
Radar, Range Rate Forward Y Track 0
Radar, Range Rate Forward Y Track 1
Radar, Range Rate Forward Y Track 2
Radar, Range Rate Forward Y Track 3
Radar, Range Rate Forward Y Track 4
Radar, Range Rate Forward Y Track 5
Radar, Range Rate Forward Y Track 6
Radar, Range Rate Forward Y Track 7
Radar, Range, Forward X Track 0
Radar, Range, Forward X Track 1
Radar, Range, Forward X Track 2
Radar, Range, Forward X Track 3
Radar, Range, Forward X Track 4
Radar, Range, Forward X Track 5
Radar, Range, Forward X Track 6
Radar, Range, Forward X Track 7
Radar, Range, Forward Y Track 0
Radar, Range, Forward Y Track 1
Radar, Range, Forward Y Track 2
Radar, Range, Forward Y Track 3
Radar, Range, Forward Y Track 4

Radar, Range, Forward Y Track 5
Radar, Range, Forward Y Track 6
Radar, Range, Forward Y Track 7
Radar, Target Identification Track 0
Radar, Target Identification Track 1
Radar, Target Identification Track 2
Radar, Target Identification Track 3
Radar, Target Identification Track 4
Radar, Target Identification Track 5
Radar, Target Identification Track 6
Radar, Target Identification Track 7
Roll Rate, x-axis
Roll Rate, x-axis fast
Seatbelt, Driver
Subject_ID
Temperature, Interior
Time
Timestamp
Vehicle_id
Video Dashboard and Steering Wheel View
Video Frame
Video, Driver and Left Side View
Video, Forward Roadway
Video, Occupancy Snapshot
Video, Rear View
Yaw Rate, z-axis fast
Year

Post-Crash Interview variables (226)

Participant ID
Event ID
Driver Narrative
Occupant Narrative
Elapsed Days
Incident City
Incident State
Incident Date
Incident Time
Hour of Day
Driver Seat Belt Use
Driver Age
Age Group
Driver Weight
Driver Height
Driver Gender
Number of Passengers
Passenger 1 Seating
Passenger 1 Seat Belt Use
Passenger 1 Age
Passenger 1 Age Group
Passenger 1 Weight
Passenger 1 Height
Passenger 1 Gender
Passenger 2 Seating
Passenger 2 Seat Belt Use
Passenger 2 Age
Passenger 2 Age Group
Passenger 2 Weight
Passenger 2 Height
Passenger 2 Gender
Passenger 3 Seating
Passenger 3 Seat Belt Use
Passenger 3 Age
Passenger 3 Age Group
Passenger 3 Weight
Passenger 3 Height
Passenger 3 Gender
Passenger 4 Seating
Passenger 4 Seat Belt Use
Passenger 4 Age
Passenger 4 Age Group
Passenger 4 Weight
Passenger 4 Height
Passenger 4 Gender
Passenger 5 Seating
Passenger 5 Seat Belt Use
Passenger 5 Age
Passenger 5 Age Group
Passenger 5 Weight
Passenger 5 Height
Passenger 5 Gender
Passenger 6 Seating
Passenger 6 Seat Belt Use
Passenger 6 Age
Passenger 6 Age Group
Passenger 6 Weight
Passenger 6 Height

Passenger 6 Gender
Passenger 7 Seating
Passenger 7 Seat Belt Use
Passenger 7 Age
Passenger 7 Age Group
Passenger 7 Weight
Passenger 7 Height
Passenger 7 Gender
Travel Lane
Travel Speed
Pre-Impact Intent
Turn Signal Use
Sign Presence
Traffic Control Device
Regulatory Signs Near Site
School Zone Signs Near Site
Warning Signs Near Site
Other Signs Present
Active R-Road Grade Crossing Near Site
Passive R-Road Grade Crossing Near Site
Other R-Road Crossing Signs Near Site
Other Control Devices Near Site
Traffic Signal Operation
Weather Condition
Weather Influence
Pre-Crash Vehicle Movement
Number of Lateral Movements
First Vehicle Lateral Movement
Second Vehicle Lateral Movement
Third Vehicle Lateral Movement
Fourth Vehicle Lateral Movement
Fifth Vehicle Lateral Movement
Sixth Vehicle Lateral Movement
Seventh Vehicle Lateral Movement
Eighth Vehicle Lateral Movement
Ninth Vehicle Lateral Movement
Tenth Vehicle Lateral Movement
Avoidance Actions
Brake Use
Vehicle Avoidance Activation
Pre-Crash Vehicle Location
Vehicle Location at Crash
Roll Over
Roll Direction
Roll Turns
Roll Cause
Cargo Presence
Cargo Shift
Timing of Shift
Cargo Location
Cargo Shift Reason
Jackknife
Jackknife Timing
Vehicle Fire
Fire Timing
Pre-Impact Fire
Activity Prior to Crash
Passenger Conversation
Relationship Conversing Passenger
Nature of the Conversation
Driver Using Cell Phone Prior to Crash
Cell Phone Present Before Crash
Type of Cell Phone
Driver Glance Location Prior to Crash
How Driver Tracked Distraction Source
Pre-Crash Driver Activity
Driver Glance Location at Onset of Crash
Appendage Position
Driver Awareness
Other Vehicle Direction
Other Vehicle Proximity
Vehicle Speed Comparison
Line of Sight Clarity
Line of Sight Obstruction
Pre-Intersection Timing
Trip Origin
Trip Start Time
Trip Destination
Trip Purpose
Trip Urgency
Pre-Crash Miles Driven
Driver's Urgency
Urgency Reason
Driver Personal Concerns
Driver Personal Concerns Immediately Prior to Crash
Driver Arguments In Last 6 Hours
Driver Arguments In Last 12 Hours
Driver Work-Related Stress
General Health
Health at Time of Crash
Pre-Existing Conditions

Pre-Existing Conditions Influence
Driver Medications Taken in Last 24 Hrs
Which Medications Driver Taken In Last 24 Hours
Driver Requires Corrective Lenses
Driver Visual Condition
Driver Using Lenses at Time of Crash
Driver Using Sunglasses at Crash
Driver Using Rx Sunglasses at Crash
Driver Wear Hearing Aid
Driver Wearing Hearing Aid at Crash
Sleep Apnea Diagnosis
Sleep Apnea Treatment
Driver Strenuous Activity
Driver Strenuous Activity Description
Driver Strenuous Rec Activity
Driver Strenuous Rec Activity Description
Driver Hours Sleep Last 24 Hours
Driver Last Sleep Location
Driver Last Sleep Beginning Day
Driver Last Sleep Beginning Time
Driver Last Sleep End Day
Driver Last Sleep End Time
How Driver Normally Feels Upon Waking
Normal Sleep Duration
Sleep or Work Schedule Rotate Last Week
Shortest Day Worked Last Week
Longest Day Worked Last Week
Total Hours Worked Last Week
Average Daily Hours Worked Last Week
Days Since Last Day Off
How Driver Felt When Started Trip
Roadway Familiarity
Total Years Driving Experience
Driver's Ed
Driver's Ed Type
Years Driving Current Vehicle Class
Driver Take Specific Education for Current Class of Vehicle
Specific Education Type
Time Since Last Driver's Ed
Times Driven Vehicle In Last 3 Months
Comfort Level With Vehicle
Comfort Level With Cargo Load
Comfort Level With Passenger Load
Vehicle Condition - Brakes
Vehicle Condition - Engine
Vehicle Condition - Headlights
Vehicle Condition - Steering
Vehicle Condition - Suspension
Vehicle Condition - Tires
Vehicle Condition - Transmission
Vehicle Condition - Wiring
Windshield Condition
Wiper Condition
Wiper State
Headlight State
License State
License Validity
License Restrictions
License Endorsements
Driver's Race
Driver's Ethnic Background
EMS
EMS Service
EMS Contact
EMS Auto Response
EMS Arrival Time
EMS Agency
Injury Occurrence
Medical Attention
Injury Severity
Injury Specification
Out Patient
Hospital Transport
Work / School Missed
Interview Completion Date
Interview Completion Crash Type

Event Detail Table variables (76)

Event ID
Participant ID
Event Severity 1
Event Severity 2
Event Start
Subject Reaction Start
Impact or Proximity Time
Event End
Pre-Incident Maneuver
Maneuver Judgment
Precipitating Event
Vehicle 1 (Subject) Configuration
Vehicle 2 Configuration
Vehicle 3 Configuration
Event Nature 1
Incident Type 1
Crash Severity 1
V1 Evasive Maneuver 1
V1 Post-Maneuver Control 1
Event Nature 2
Incident Type 2
Crash Severity 2
V1 Evasive Maneuver 2
V1 Post-Maneuver Control 2
Airbag Deployment
Vehicle Rollover
Driver Behavior 1
Driver Behavior 2
Driver Behavior 3
Driver Impairments
Front Seat Passengers
Rear Seat Passengers
Secondary Task 1
Secondary Task 1 Start Time
Secondary Task 1 End Time
Secondary Task 1 Outcome
Secondary Task 2
Secondary Task 2 Start Time
Secondary Task 2 End Time
Secondary Task 2 Outcome
Secondary Task 3
Secondary Task 3 Start Time
Secondary Task 3 End Time
Secondary Task 3 Outcome
Hands on the Wheel
Driver Seatbelt Use
Vehicle Contributing Factors
Infrastructure
Visual Obstructions
Lighting
Weather
Surface Condition
Traffic Flow
Contiguous Travel Lanes
Through Travel Lanes
V1 Lane Occupied
Traffic Density
Traffic Control
Relation to Junction
Intersection Influence
Alignment
Grade
Locality
Construction Zone
Number of Other Motorists/Non-Motorists
Number of Objects/Animals
Fault
Motorist/Non-Motorist/Animal/Object 2 Location
Motorist/Non-Motorist/Animal/Object 2 Type
Motorist/Non-Motorist 2 Pre-Incident Maneuver
Motorist/Non-Motorist 2 Evasive Maneuver
Motorist/Non-Motorist/Animal/Object 3 Location
Motorist/Non-Motorist/Animal/Object 3 Type
Motorist/Non-Motorist 3 Pre-Incident Maneuver
Motorist/Non-Motorist 3 Evasive Maneuver
Final Narrative

REFERENCES

1 Transportation Research Board of the National Academies of Science. (2013). The 2nd Strategic Highway Research Program Naturalistic Driving Study Dataset. Available from the SHRP2 NDS InSight Data Dissemination web site: https://insight.shrp2nds.us.

2 American Association of State Highway and Transportation Officials. *A Policy on Geometric Design of Highways and Streets*. Washington, D.C., 2011.

3 Bonneson, J.A., S. Geedipally, M.P. Pratt, and D. Lord. *Safety Prediction Methodology and Analysis Tool for Freeways and Interchanges*. Final Report for NCHRP Project 17-45, Transportation Research Board of the National Academies, Washington, D.C., 2012. http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP17-45_FR.pdf. Accessed July 27, 2016.

4 American Association of State Highway and Transportation Officials. *Highway Safety Manual (Supplement)*. Washington, D.C., 2014.

5 American Association of State Highway and Transportation Officials. *Highway Safety Manual*. Washington, D.C., 2010.

6 Twomey, J.M., M.L. Heckman, J.C. Hayward and R.J. Zuk. Accidents and Safety Associated with Interchanges. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1385*, Transportation Research Board of the National Academies, Washington, D.C., 1993, pp. 100–105.

7 Khorashadi, A. *Effect of Ramp Type and Geometry on Accidents*. Report FHWA/CA/TE-98/13. California Department of Transportation, Sacramento, California, 1998.

8 Lu, J.J., L. Lu, P. Liu, H. Chen, and T. Guo. *Safety and Operational Performance of Four Types of Exit Ramps on Florida's Freeways (Final Report)*. Florida Department of Transportation, Tallahassee, Florida, 2010.

9 Bauer, K.M. and D.W. Harwood. *Statistical Models of Accidents on Interchange Ramps and Speed-Change Lanes*. Report FHWA-RD-97-106. Federal Highway Administration, Washington, D.C., 1998.

10 Yi, H., and T.E. Mulinazzi, Observed Distribution Patterns of On-Ramp Merge Lengths on Urban Freeways. In *Transportation Research Record: Journal of the Transportation Research Board, No. 2023*, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 120–129.

11 Bonneson, J., and M. Pratt. *Roadway Safety Design Workbook*. Report FHWA/TX-09-0-4703-P2, Texas Transportation Institute, College Station, Texas, 2009.

12 Pradhan, A.K., L. Kaigang, J.P. Ehsani, M.C. Ouimet, S.G. Klauer, and B.G. Simons-Morton. Measuring Young Drivers' Behaviors During Complex Driving Situations. *Proceedings of the 7th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*. Public Policy Center, The University of Iowa, Iowa City, Iowa, 2013, pp. 460–466.

13 Kondyli, A. and L. Elefteriadou. Modeling Driver Behavior at Freeway-Ramp Merges. In *Transportation Research Record: Journal of the Transportation Research Board, No. 2249*, Transportation Research Board of the National Academies, Washington, D.C., 2011, pp. 29–37.

14 Kondyli, A., and L. Elefteriadou. Driver Behavior at Freeway-Ramp Merging Areas Based on Instrumented Vehicle Observations. Presented at the 89th Annual Meeting of the Transportation Research Board, Washington, D.C., 2010.
15 Brewer, M.A., K. Fitzpatrick, and J. Stanley. Driver Behavior on Speed-Change Lanes at Freeway Ramp Terminals. In *Transportation Research Record: Journal of the Transportation Research Board, No. 2223*, Transportation Research Board of the National Academies, Washington, D.C., 2011, pp. 54–62.
16 Center for Transportation Research and Education. *SHRP2 – Roadway Information Database homepage*. Institute for Transportation, Iowa State University, Ames, Iowa, 2014. http://www.ctre.iastate.edu/shrp2-rid/rid.cfm Accessed July 27, 2016.