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Distraction Effects of In-Vehicle Tasks Requiring Number and Text Entry Using Auto Alliance's Principle 2.1B Verification Procedure

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7. Author(s)
Thomas A. Ranney, G. H. Scott Baldwin, & Ed Parmer, Transportation Research Center Inc.; John Martin, Ohio State University; Elizabeth N. Mazzae, National Highway Traffic Safety Administration

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16. Abstract
An experiment was conducted to assess the distraction potential of secondary tasks using the Alliance of Automotive Manufacturers' Principle 2.1B verification procedure implemented using specifications obtained from an Alliance member company. Secondary tasks included radio tuning, destination entry, 10-digit dialing, dialing via contact selection, and text messaging were performed using the original equipment systems of a 2010 Toyota Prius V and an iPhone 3GS smart phone. Sixty-three participants 35 to 54 years old drove a low-fidelity, PC-based simulator while performing the secondary tasks. The driving scenario required participants to maintain a 150-ft following distance behind a lead vehicle that was traveling at a constant speed of 50 mph. Alliance driving performance metrics included lane exceedance frequency and the standard deviation (SD) of car-following headway.

Text messaging was associated with the highest levels of driving performance degradation on both Alliance Principle 2.1B metrics, followed by destination entry. Radio tuning had the lowest levels of driving performance degradation. The two phone dialing tasks (contact selection and 10-digit number dialing) had approximately equivalent amounts of driving performance degradation. Both Alliance Principle 2.1B metrics were correlated with task duration. Use of a duration-adjusted metric revealed that text messaging was significantly more demanding than other secondary tasks and that other differences between tasks were due primarily to differences in task duration.

Results using smaller sample sizes were consistent with the expected loss of statistical power inherent in the use of small samples. Differences were also apparent between replications of samples of the same sizes. Based on the results of the current study, neither 20 nor 30 participants is sufficient to obtain consistent test outcome results.

Two sets of analyses compared present study outcomes with those from a previous study, which used a Dynamic Following and Detection (DFD) protocol that provided both Alliance Principle 2.1B and other vehicle control and visual target detection metrics. Results from the two Principle 2.1B verification procedure implementations were not consistent, despite the fact that both implementations were consistent with Alliance specifications. Differences in driving (car following) task demands appear to have contributed to this finding. The second comparison with previous study results used different metrics and their respective decision criteria. Decisions concerning the acceptability of specific number/text entry tasks based on Alliance Principle 2.1B metrics were not consistent with those made using DFD metrics. The two protocols provided consistent results on 7 of 10 planned comparisons. Different conclusions derive from three factors: (1) driving behaviors represented by the metrics, including target detection in the DFD protocol, (2) metric construction, reflecting the differential treatment of task duration, and (3) decision criteria. Alliance (duration-influenced) and DFD (duration-adjusted) metrics provide complementary information concerning distraction effects, a combination of which provides a better estimate of the total exposure to crash risk associated with secondary task performance than either metric type alone.

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EXECUTIVE SUMMARY

This report documents research by the National Highway Traffic Safety Administration to assess protocols developed for measurement of driver distraction associated with secondary tasks. The research supports NHTSA's development of guidelines on the topic of driver distraction by assessing available protocols and their related measures of secondary task effects on driving performance for their ability to provide meaningful information regarding which tasks are more distracting than others. Specifically, this work set out to examine a protocol developed by the Alliance of Automobile Manufacturers (Alliance)[1] and documented in its "Statement of Principles, Criteria and Verification Procedures on Driver Interactions With Advanced In-Vehicle Information and Communication Systems" (i.e., the "Alliance Guidelines"). NHTSA's objective was to evaluate the protocol for its ability to identify tasks that can be considered too disruptive to driving and to compare and contrast the protocol and related metrics to NHTSA's own Dynamic Following and Detection (DFD) protocol that was developed as an interpretation of the verification procedure for Alliance Principle 2.1B.

The Alliance Guidelines Principle 2.1 states that "Systems with visual displays should be designed such that the driver can complete the desired task with sequential glances that are brief enough not to adversely affect driving." The Alliance proposed two alternatives for assessing compliance with the principle, one focused on glance behavior (2.1A) and one focused on driving performance (2.1B). The focus of the current work is Alternative 2.1B. Alternative 2.1B requires a car-following task that can be carried out on roads, a test track, or in a driving simulator. Two categories of metrics are specified for assessing the effects of concurrent secondary task performance on driving performance, including lane keeping and car following headway. The two specific metrics are lane departure frequency and the standard deviation (SD) of car-following headway. Metrics are computed using data from the time intervals during which participants perform secondary tasks once. Task-related degradation on performance metrics is related to degradation on a (radio tuning) benchmark task performed under identical test conditions.

NHTSA research in recent years has led to the development of a driving simulator based Dynamic Following and Detection (DFD) protocol, which is consistent with the Principle 2.1B verification procedure specifications in the Alliance Guidelines. NHTSA's recently completed Manual Number and Text Entry (MNTE) study used the DFD protocol to assess the distraction levels associated with various secondary tasks involving manual character entry. Data obtained in that study were used to also compute the Alliance Principle 2.1B metrics. One goal of the present study was to determine whether an alternate implementation of the Alliance Principle 2.1B verification procedure, based on specifications beyond those contained in the Alliance Guidelines, would provide different results from the MNTE implementation. To facilitate this goal, additional methodological information, including driving simulator specifications, control software and data reduction and analysis specifications, was obtained from one Alliance member. The first specific objective was to evaluate the Alliance member company's implementation of the Alliance Principle 2.1B verification procedure for assessing the distraction potential of secondary tasks (using integrated and/or portable systems) involving manual number and text entry while driving.

[1] The Alliance of Automobile Manufacturers is a trade group of automobile manufacturers that operate in the United States.

The Alliance Principle 2.1B metrics differ from those used in the DFD protocol, both in the number of specific driving behaviors examined and in their construction. Both protocols consider longitudinal and lateral vehicle control, albeit with slightly different metrics. The DFD protocol includes two additional metrics focused on object and event detection, which is part of the DFD driving task but not part of the Alliance driving task.

Metric construction differences between Alliance and DFD metrics derive from the treatment of task duration. Alliance Principle 2.1B metrics are computed using data from intervals of different durations, while DFD metrics are computed using data taken from intervals of the same duration. The Alliance Principle 2.1B metrics thus combine differences in duration with differences in task demands, while DFD metrics normalize for differences in duration and represent only differences in secondary tasks demand. The second objective was to determine whether the respective metrics provided comparable answers to questions about which tasks are more distracting than others.

The use of guidelines requires decisions about the appropriate number of participants required to obtain valid test results. While Alliance Guideline Principle 2.1 provides general specifications, sample size is left for the user to determine. The MNTE study determined that samples of approximately size 40 are necessary to provide consistent results with the DFD metrics. The third specific objective of this study was to determine the effect of using different sample sizes with the Alliance member company's implementation of the 2.1B protocol.

Following the Alliance member company's implementation, a low-fidelity (PC-based) simulator test venue was used for this study. Sixty-three participants each completed one session in which they drove the simulator while performing a variety of number and text entry tasks using a single integrated system (radio tuning and navigation system destination entry by address) and one cell phone (10-digit dialing, dialing contact selection, and text messaging). As required per the 2.1B specification, test participants were unfamiliar with the systems being used to present the secondary tasks.

Study results showed that both Alliance Principle 2.1B metrics revealed strong and consistent differences among most secondary tasks. Text messaging was associated with the highest levels of driving performance degradation, followed by destination entry. Radio tuning had the lowest levels of driving performance degradation. The two phone dialing tasks (contact selection and 10-digit number dialing) were approximately equivalent in their effects on driving performance and were intermediate relative to the two extremes. The extent to which the observed differences were due to differences in task duration was explored by creating a duration-adjusted metric, lane exceedances per second. Analysis results using this metric revealed that text messaging was significantly different from other secondary tasks, but that other differences between tasks were not significant. Thus, text messaging was more distracting than all other tasks due to its higher level of task demand while differences among other tasks observed using the unadjusted Alliance metric (lane exceedance frequency) were due to differences in task duration.

A set of planned comparisons was performed repeatedly with samples of different sizes. Results of comparisons performed with smaller subsets differed from those obtained with the full sample. Lane exceedance frequency results were more consistent than those using SD headway across different sample sizes. Specifically, lane exceedance frequency test outcomes were consistent in 7 of 10 comparisons across different sample sizes. For SD headway, 4 of 10 comparisons revealed consistent outcomes across different sample sizes. Smaller sample sizes were associated with fewer significant test results, which is consistent with the expected effects of reduced statistical power associated with the use of smaller sample sizes. Analyses were also conducted to examine the effects of replication in which multiple samples of the same nominal size were used to assess test outcomes. The results of this comparison differed for the two Alliance Principle 2.1B metrics. Lane exceedance frequency test outcomes were more consistent across replications than were SD headway test outcomes. Replication results were generally similar for the N = 31/32 comparisons versus the N = 19/20 comparisons.

Two sets of analyses compared test outcomes from the present study with those from the MNTE study. First, Alliance Principle 2.1B metrics were computed using data from the two studies to assess the effects of procedural differences between the two Alliance Principle 2.1B verification procedure implementations. When data from single DFD trials were compared with 3-trial means from the present study, the results were in agreement for 7 of 10 comparisons (lane exceedance frequency) and 6 of 10 comparisons (SD headway). The use of 2-trial DFD means where they were available increased agreement from 6 to 8 for SD headway but had no effect on lane exceedance outcomes. Most comparisons that exhibited disagreement in outcome involved differences that were statistically significant in the current study but not significant in the DFD protocol. There were a number of methodological and procedural differences between the two protocols that may have contributed to these differences. The most prominent differences included:

1. Car-following task: The DFD car-following task was considerably more demanding than the Alliance member company's driving task. The effect of this difference was most apparent in differences between durations of identical tasks performed in the two protocols. For example, radio tuning required 14.5 seconds on average in the present study versus 25.6 seconds in the DFD protocol.
2. Lane exceedance determination: Factors that influenced lane exceedance frequency included vehicle width, lateral configuration of the roadway edges, and lane exceedance definition. The DFD protocol used a narrower vehicle width. The Alliance member company's 2.1B protocol implementation had slightly narrower lanes. In addition, the Alliance member company's implementation counted lane departures that were underway when the data collection interval began, while the DFD protocol only counted lane departures that were initiated during the data collection interval.
3. Data collection trials: The Alliance member company's implementation combined data from 3 trials to create mean values. The DFD protocol was limited in that only one trial was consistently available for the longer secondary tasks.

The second comparison between the present study and the MNTE study was between Alliance and DFD metrics and their respective decision criteria. For the Alliance Principle 2.1B metrics, differences were considered real when results for both metrics were consistent. For the DFD protocol, differences were considered real when results for 3 of 4 metrics were consistent. Application of these decision criteria produced a single decision for each planned comparison. The two protocols provided consistent results on 7 of the 10 planned comparisons.

Generally, the effects of distraction due to secondary task performance on roadway safety (total exposure to risk) are determined by the combination of the two task attributes: momentary task demands (distraction potential) and task duration. Higher momentary demands can occur when one task is more difficult (mentally challenging) or complex (more dimensions) and/or requires more concentrated attention (higher memory load) than another task. Task duration refers to the time required to complete the secondary task while driving. To the extent that secondary task performance involves regular switching of attention between driving and the secondary task, longer duration tasks can be expected to involve more time during which the drivers' attention is not directed toward driving. More demanding tasks can be expected to result in higher levels of driving performance degradation, independent of task duration, due to the higher drain of attentional resources away from driving and the increased difficulty of disengaging from the more demanding task. As shown in this study, secondary tasks take longer to perform under more demanding driving task conditions.

Experimental methods and the metrics to assess distraction effects have generally evolved along two paths. The Alliance Principle 2.1B metrics represent one path, in which metrics combine the effects of the task demand and duration. The second path is represented by the Lane Change Task (LCT) and the DFD metrics, which adjust for differences in task duration. As indicated by the present results, these two approaches can lead to slightly different conclusions about differences between pairs of secondary tasks. It would therefore be preferable if the two approaches could be reconciled to support a single conclusion about differences between secondary tasks. Theoretically, one approach toward such reconciliation would involve combining the effects of task demand and task duration by multiplying the expected momentary level of driving performance degradation, derived from duration-adjusted metrics, by the expected task duration to create a metric that represents the total amount of driving performance degradation expected over the course of one instance of secondary task performance. This hypothetical construction is conceptually similar to the Alliance Principle 2.1B metrics, which also represent the total degradation over one task instance. However, the use of independent estimates of each component has several potential benefits. First, the use of independent estimates of task demand and duration is more appropriate for statistical testing. Second, independent estimates may be more helpful in determining how to redesign a task.

The results support the following conclusions:

1. Text messaging was more distracting than all other number/text entry secondary tasks due to its longer duration and its increased level of task demand, as reflected in one duration-adjusted metric. Differences observed between other secondary tasks were due primarily to differences in task duration.
2. Results from two implementations of the Alliance Principle 2.1B verification procedure provided results that were not consistent, despite the fact that both implementations were consistent with specifications contained in the Alliance Guidelines. Differences in driving (car-following) task demands appear to have contributed to this finding.
3. Verification procedure implementation specifications in the Alliance Guidelines are not sufficiently detailed to ensure that the test protocol will provide consistent results across different implementations.
4. Test outcome results differed for samples of different size. The use of smaller samples revealed a pattern of results consistent with the expected loss of statistical power inherent in the use of smaller sample sizes. Differences were also apparent between replications of samples of the same sizes. Based on the results of the current study, neither 20 nor 30 participants is sufficient to obtain consistent test outcome results.

5. Decisions concerning the acceptability of specific number/text entry tasks based on Alliance Principle 2.1B metrics were not consistent with decisions made using DFD metrics. The different conclusions were attributable to three factors: (1) driving behaviors represented by the metrics, including target detection in the DFD protocol, (2) metric construction, reflecting the treatment of task duration, and (3) decision criteria.
6. Alliance (duration-influenced) and DFD (duration-adjusted) metrics provide complementary information about differences between secondary task distraction effects. A combination of these two types of information provides a better single estimate of the total exposure to crash risk associated with secondary task performance than either metric type alone.
7. Alliance Principle 2.1B metrics are influenced by differences in task duration. Use of these metrics alone makes it impossible to determine whether differences between tasks are due to differences in task demand or differences in task duration. DFD metrics reveal differences due to differences in task demand but provide no information about task duration.

1.0 INTRODUCTION

1.1 Background

The Alliance of Automobile Manufacturers developed a set of guidelines for managing driver workload and distraction associated with advanced in-vehicle information and communication systems (Alliance of Automobile Manufacturers, 2006). According to Alliance Principle 2.1, "Systems with visual displays should be designed such that the driver can complete the desired task with sequential glances that are brief enough not to adversely affect driving." The Alliance proposed two alternatives for assessing compliance, one focused on glance behavior (2.1A) and one focused on driving performance (2.1B). The latter alternative (2.1B) is the focus of the current work. Alternative 2.1B requires a driving task and identifies two driving performance measures (lateral position control and car-following headway). It outlines a test protocol in which task-related degradation on performance metrics is related to degradation on a (radio tuning) benchmark task performed under identical test conditions.

The recently completed Manual Number and Text Entry (MNTE) study (Ranney et al., 2011) used a Dynamic Following and Detection (DFD) protocol, which is consistent with the Alternative 2.1B specifications in the Alliance Guidelines. Data obtained in that study was used to compute the Alliance Principle 2.1B metrics. One goal of the present study was to determine whether an alternate implementation of the Alliance Principle 2.1B verification procedure would provide different results from the MNTE implementation. To facilitate an alternate implementation, additional methodological information, including driving simulator specifications, control software and data reduction and analysis specifications, was obtained from one Alliance member. Accordingly, the protocol used in the current study will be referred to as the Alliance member company's implementation of the Alliance Principle 2.1B verification procedure.

1.2 Research Objectives

The main objective of the work described in this report was to evaluate the use of the Alliance Principle 2.1B verification procedure and associated metrics for assessing the distraction potential of secondary tasks (using integrated and/or portable systems) involving manual number and text entry. Of particular interest was determination of the ability of the protocol to discriminate between secondary tasks and their impact on driving performance.

The Alliance Principle 2.1B metrics differ from those used in the DFD protocol, both in the number of specific driving behaviors examined and in their construction. Both protocols consider longitudinal and lateral vehicle control, albeit with slightly different metrics. The DFD protocol includes two additional metrics focused on object and event detection, which is part of the DFD driving task but not part of the Alliance driving task. Metric construction differences between Alliance and DFD metrics derive from the treatment of task duration. Alliance Principle 2.1B metrics are computed using data from intervals of different durations, while DFD metrics are computed using data taken from intervals of the same duration. The Alliance Principle 2.1B metrics thus combine differences in duration with differences in task demands, while DFD metrics normalize for differences in duration and represent only differences in demand among the secondary tasks. The second objective of this work was to determine whether the respective metrics provided comparable answers to questions about which tasks are more distracting than others.

The use of guidelines requires decisions about the appropriate number of participants to obtain valid test results. Alliance Guideline Principle 2.1 provides the following guidance: "Test samples include multiple test participants sufficient to control Type I (false-positive) and Type II (false-negative) error risks." (Auto Alliance, 2006). This specification alone is insufficient for determining appropriate sample sizes for testing. While consensus exists for the control of Type I error (alpha = .05 is typically used), it does not exist for the specification of power, which determines Type II error (Cohen, 1988). Sample size determination also requires consideration of a third factor, namely the size of an effect, which when found in an experimental setting, is taken to reflect a real effect in the population to which the results generalize (Cohen, 1988). This approach to sample size determination was considered in the aforementioned MNTE study (Ranney et al., 2011); there it was determined that samples of approximately size 40 were necessary to conclude that a difference that had a priori been considered meaningful on a particular driving performance metric would be statistically significant. With this as a starting point, data were obtained from 100 participants and the results from different subsets were compared for consistency. This approach is also taken in the present work. Here, data were obtained from 63 participants and comparisons were made among subsets of different sizes. The third specific objective was therefore to determine the effect of using different sample sizes with the particular Alliance Principle 2.1B verification procedure implementation used here.

The results of this work are intended to provide information to help NHTSA develop guidelines for the assessment of distraction potential associated with in-vehicle electronic information and communication systems in production vehicles or associated with portable devices. The present work will provide NHTSA with data to understand the criteria of acceptable performance for the metrics provided by the second alternative of Alliance Principle 2.1. The work will also provide information for use in comparing the advantages of these distraction measurement protocols and their suitability for use in conjunction with the NHTSA Driver Distraction Guidelines.

2.0 METHOD

2.1 Approach

The study objectives were addressed in a single experiment, in which auditory stimuli were used to prompt participants to perform several secondary tasks while driving in a stationary passenger vehicle connected to driving simulator. Driving consisted of driving task that met the specifications contained in Alliance Principle 2.1B and was based on input from an Alliance member company. The driving task involved following a lead vehicle that was driving at constant speed. The experiment used the simulator and driving task to obtain data necessary to compute the Alliance Principle 2.1B metrics, which included lane exceedance frequency and standard deviation of headway. Methodological details are presented in the following sections.

Data for this experiment were collected between January and March of 2011.

2.2 Experimental Design

The experimental design had one factor, secondary task, which included the following levels:

1. Radio tuning (manual),
2. Navigation system destination entry,
3. Phone dialing (10-digit),
4. Phone contact dialing, and
5. Text messaging.

Manual radio tuning is the benchmark specified in Alliance Principle 2.1; destination entry is a benchmark that has been used in the DFD test protocol. The experiment used a repeated measures design, in which all participants completed all test conditions.

2.3 Participants

Sixty-four drivers 35 to 54 years old participated in the experiment. This age range was divided into two subgroups, 35 to 44 and 45 to 54, with each subgroup having an equal number of participants. While the Alliance Guidelines specify a test participant age range of 45 to 65, NHTSA's interest was to measure distraction for the age range representing the largest segment of drivers, i.e., middle-aged drivers. Gender was balanced within each age subgroup.

Participants were healthy, active drivers with valid driver's licenses and each had a minimum of 7,000 miles driven per year. Participants had normal or corrected to normal vision.[2] All participants reported having experience using cell phones while driving. Cell phone use was considered to be a surrogate for multitasking experience; drivers who were experienced phone users were expected to be more representative of drivers who would choose to perform secondary tasks while driving. Most of the participants were active users of text messaging and most were comfortable constructing text messages while driving. Ninety-one percent of the participants reported some previous experience with a navigation system. Appendix A includes additional demographic information provided during the screening process.

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[2] Vision quality was self-reported by the participants. Visual capabilities were not confirmed as part of the experimental protocol.

2.3.1 Recruitment

Participants were recruited using web-based networks (e.g., craigslist.org) and through advertisements placed in small local newspapers, including those in Marysville, Bellefontaine, and Kenton, Ohio. Respondents were asked a series of questions to ensure that they were licensed drivers with normal or corrected to normal vision, active users of text messaging, and regular users of a cell phone while driving. To facilitate recruitment, an online application procedure was implemented, which allowed participants to complete the screening questionnaire as a web-based form.

2.3.2 Payment for Participation

Compensation for participation consisted of the total of two amounts: (1) Base pay for participation ($110), and (2) mileage reimbursement for travel to and from the test facility ($0.51 per mile).

2.4 Apparatus

2.4.1 Laboratory

This experiment used a fixed-base driving simulator. The simulator was in a laboratory in NHTSA's Vehicle Research and Test Center. An enclosure was used to create a controlled visual and auditory environment in which to conduct testing. The enclosure had sound-proofed walls that were configured as shown in Figure 1. Figure 1 presents an overhead-view drawing of the simulator enclosure with the relative dimensions and layout of the vehicle and equipment inside. Overhead roof panels served to control light and ambient noise within the simulator enclosure. An experimenter station was positioned to the right rear of the test vehicle.

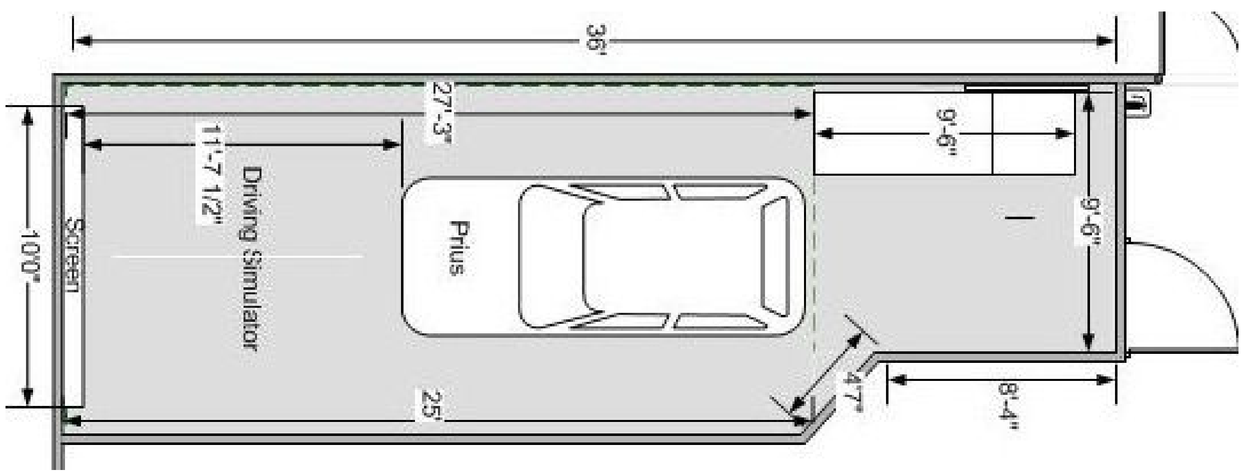

Figure 1. Dimensions and Basic Layout of Simulator Environment

2.4.2 Driving Simulator

Components of the fixed-base simulator included a production vehicle (2010 Toyota Prius V), an Intel Pentium 4 computer, a ceiling-mounted Infocus model LP815 digital projector (1024 x 768) positioned above the vehicle, and a forward projection screen (10 ft x 10 ft). The screen was located approximately 186 inches forward of an average driver's eye point. The STISIM Drive simulator software Version 2.06.03 was used.

The simulated vehicle was controlled using the original equipment (OE) Prius steering wheel, throttle pedal, and brake pedal. Sensors connected to the vehicle steering, brake and throttle measured and transmitted control inputs to the driving simulation. Specifically, a bracket (see Figure 2) was developed to couple either front tire of the test vehicle to a turn plate on the ground while the vehicle tires were off the ground. The test vehicle was supported by 5 jack stands. The bracket and turn plate assembly mounted to the front tire provided steering inputs to the driving simulator when the participant moved the steering wheel, allowing the simulator to run without the vehicle being running.

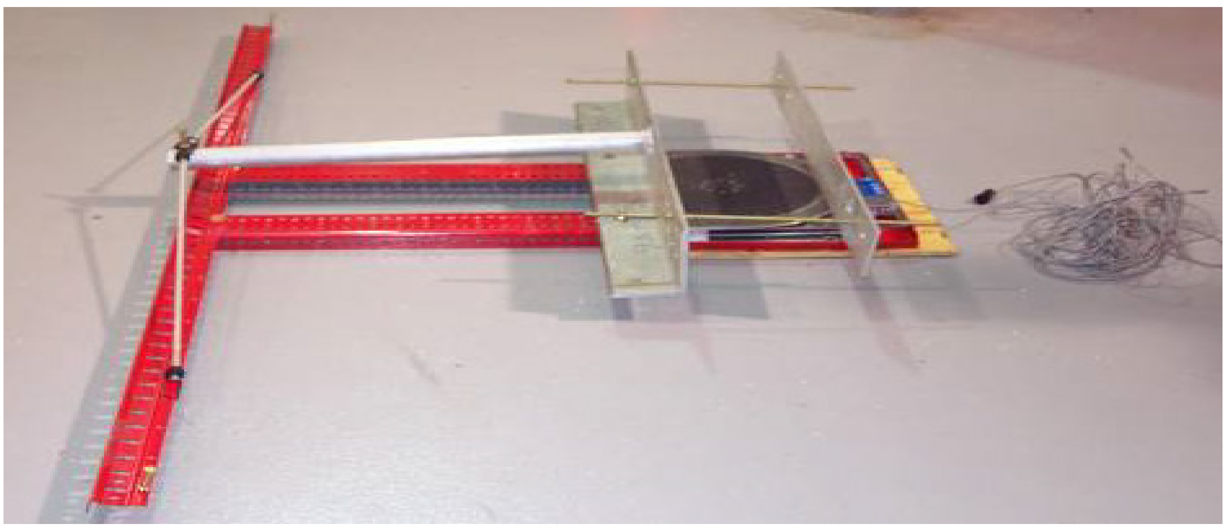

Figure 2. Apparatus for Recording Steering Wheel Movement

A vehicle data acquisition system was configured to collect steering wheel, brake and throttle position inputs. The system also collected video data from multiple camera locations, in addition to collecting data from STISIM, to permit time syncing of all the data in post processing routines. In addition, the STISIM simulation computer collected data for its respective performance measures during each task trial. Table 1 summarizes the primary data collected.

Table 1. Primary Data Collected

Data Channel	Description	Units
Vehicle Speed	Speed of subject vehicle	km/h or mph
Time Headway	Distance to the lead vehicle (inter-vehicle range divided by subject vehicle's velocity)	seconds
Lateral Position	Lateral position of the subject vehicle in reference to the simulated lanes	cm
Lane Departures	Number of lane exceedances by the subject vehicle	count
UTC Time	Time of day	HH:MM:SS

The original equipment speedometer of the Toyota Prius was not used since the vehicle was stationary and the engine was not running. The vehicle speed computed by the simulator software was presented on a small rectangular display positioned on top of the dashboard directly in front of the vehicle's speedometer, as shown in Figure 3. The speedometer display presented speed values with approximately the same size as did the OE speedometer.

A separate computer was used to generate auditory stimulus information for each secondary task. The simulator computer, secondary task computer and other experimenter materials were located at a control station located behind the vehicle on the passenger side (see Figure 1). A speaker and microphone system was used for communication between experimenters and participants.

2.5 Driving Scenario

The roadway scene and driving scenario specifications were provided by the Alliance member company based on their implementation of the Principle 2.1B protocol. The road scene consisted of a 4-lane divided highway with two (3.75 meters wide) lanes in each direction, separated by a grassy median. There were no cross roads. The posted speed limit was 50 mph. The roadway consisted of long straight sections connected by gradual curves that alternated to the right and left (curve onset every 4,000 meters; first curve started at 1,000 meters). The roadway curves consisted of three components: an entry and exit spiral that were both 200 meters in length to provide transition into and out of the curve, and a longitudinal length of the curved section of 500 meters. The constant roadway curvature value was set at 0.0005, which translates to a radius of 2,000 meters that created a very gradual turn.

Environmental conditions simulated were daytime dry road driving conditions with clouds. Traffic was simulated via autonomous vehicles programmed to travel in the left lane at speeds of faster than 50 mph, thereby encouraging the participant to keep the simulated vehicle in the right lane. If the simulated vehicle deviated over the right edge line, a rumble strip sound was activated. Scenario, roadway, and vehicle parameters are presented in Appendix D. Figure 3 shows the road scene with embedded center rearview mirror, traffic in the adjacent lane, and the speedometer.

Figure 3. Example of Road Scene, Traffic and Speedometer From Driver's Viewpoint

2.6 Driving Task

A car-following task was included in the driving scenario run on the STI simulator. This task required participants to maintain a constant following distance of 150 ft behind a lead vehicle. The lead vehicle drove at a constant speed during each task trial, a speed that was equal to the subject vehicle speed at task onset (target speed of 50 mph). Participants were instructed to follow the simulated lead vehicle while maintaining a distance of 150 ft and a speed of 50 mph. Participants were told that when they were "just driving," driving without performing a secondary task, the lead vehicle would remain at a distance of 150 ft ahead and move at speed of 50 mph regardless of the participant's speed or following distance.

Participants were given the following instructions to indicate what priorities they should keep in mind while driving in the experiment:

> "Safe driving is the highest priority! Drive in the right lane and do your best to maintain a speed of 50 mph and following distance of 150 ft behind the lead vehicle. It is important to drive 50 mph, because that is the target speed for the test. If your following distance increases during a task, it is OK to drive faster than 50 mph to catch up to the lead vehicle."

Complete driving task and car following instruction details can be found in Appendix C.

2.7 Secondary Tasks

The following specific manually performed number and text entry tasks were used in the experiment:

- Radio tuning (Alliance Principle 2.1 benchmark);
- Phone dialing, using contact list;
- Phone dialing, 10-digit;
- Navigation system destination entry by address (NHTSA/VRTC benchmark); and
- Text messaging (combined receipt and 1-word reply).

Destination entry and radio tuning tasks were performed using the original equipment navigation system and stereo in the test vehicle. Phone tasks were performed using one smart phone with a touch screen interface, an iPhone 3GS (32GB).

Destination entry by address is a complex and relatively difficult task that requires selecting entry modes [(state or region, if applicable), city, street and house number] and entering text and/or numbers in each mode. Phone dialing via contact selection is a relatively simple number entry task. Ten-digit phone dialing, which required more physical manipulation, was expected to be slightly more difficult, and text messaging was expected to be the most difficult of the phone tasks. Destination entry and phone dialing are realistic and well defined tasks.

Details of each secondary task as implemented here are provided in the following sections. Some secondary tasks involved an additional step at the end that served to return the device back to the point at which that task begins. This extra step at the end of the secondary task avoid the need for an experimenter to reset the device state between each secondary task trial.

2.7.1 Radio Tuning

Radio tuning was selected as a secondary task based on the fact that it is a widely accepted task for Americans. In addition, the Alliance Guidelines include the use of manual radio tuning as a reference task. The Alliance's rationale for radio tuning as the reference task is that traditional, manual radio tuning is a typical in-vehicle task that average drivers perform and involves use of an in-vehicle device that has been present in motor vehicles for more than 80 years. The Alliance further asserts that based on these points, manual radio tuning represents a plausible benchmark for driver distraction potential beyond which new devices, functions, and features should not go (Auto Alliance, 2006). Manual radio tuning was used in this study to facilitate relative comparisons of distraction affects between radio tuning and the other secondary tasks that were considered to be more demanding.

Radio tuning as implemented in this study involved the steps of selecting the audio function of the OE stereo, selecting the frequency band by pressing the AM or FM button, and then using the tuning knob to adjust the frequency.

2.7.1 Phone Dialing via Contact Selection

Using the iPhone 3GS, participants were instructed to perform contact list dialing using the following steps:

1) Press the "Contacts" icon located near the bottom center of the screen. This will open a list of contacts, which is organized alphabetically by last name and then first name.
2) Scroll through this list to find a specific contact.
3) Open the specific contact by touching the name.
4) Press the phone number shown beneath the contact's name to dial it.

5) When a screen appears saying "[contact name] Calling Mobile," immediately touch the red "End Call" icon,
6) Next press the blue "all contacts" icon at the top left of the screen to return to the initial contacts screen.
7) Last, press the rounded square button below the screen to return to the main icon screen.

2.7.2 Phone Dialing Using 10 Digits

Using the iPhone 3GS, participants were instructed to perform 10-digit dialing using the following steps:

1) Press the "Phone" icon located at the lower left of the touch screen to display a numeric keypad.
2) Using the numeric keypad dial the 10-digit number.
3) If the number was correctly entered, touch the green "Call" icon and then immediately touch the red "End Call" icon which will appear at the bottom of the screen.
4) Last, press the rounded square button below the screen to return to the main icon screen.

2.7.3 Navigation System Destination Entry

Destination entry by address is a complex and relatively difficult task that requires selecting entry modes [(state or region, if applicable), city, street and house number] and entering text and/or numbers in each mode. In this case, participants were asked to enter destinations by manually entering the city, street name, and house number in response to auditory stimulus prompts, e.g., "Please enter the destination: 10502 W. Capitol Dr., Milwaukee, WI. Go."

The specific steps that participants were instructed to perform to accomplish the destination entry task were as follows:

1) Press the "DEST" icon to the right of Prius video screen.
2) Four icons will be displayed in the middle of the video screen. Press the icon labeled "Address." The system will display three options for destination entry.
3) Press the "City" button. A keyboard will appear on the screen.
4) Enter the city name on the on-screen keyboard until the system displays a list. Select the city from the list by pressing the bar on which the city name is displayed. If the list has more than 5 matches and the target city is not displayed, you will use the arrow buttons located to the right of the list to move up or down in the list to find the correct city. If the system does not display a list after you've typed the full city name, press the "OK" button on the lower right of the display and then select the city from the resulting list.
5) Once you have selected a city, the Street Name screen will appear. Enter the street name on the on-screen keyboard. As you enter the letters a list of streets will appear. Select the correct street name from the list by pressing the bar on which the street name is displayed. If the wrong list appears, use the "Back" and "Delete" buttons to correct any errors.
6) Once you have selected a street, the House Number screen will appear. Enter the house number on the numeric keyboard. Press the "OK" button.
7) A map screen containing the address and an "info" button at the top will appear. Press the "info" button to look at the full address and verify that the city, street, and house number are correct. If it is correct, return to "just driving" and await the next requested task. Otherwise use the "Back" and "Delete" buttons to go back and correct any mistakes.

2.7.4 Text Messaging

Text messaging represents a range of possible activities and the difficulty of this task depends on how it is implemented. The text messaging task used in this experiment was a phrase-completion task, derived from the television game show "Wheel of Fortune" paradigm. In each text message, participants were given a meaningful, well known phrase (e.g., movie title, famous saying, song lyrics), with one or more words missing. The task was to open and read each message and then create and send a text message reply that contained the missing word. This task embodies the essential characteristics of real-world text messaging, including interpreting brief real-world phrases and creating replies to emphasize brevity. The task is repeatable, allows task difficulty to be systematically varied, and allows performance to be scored. The task is inherently engaging, thus simulating one of the more salient features of real-world text messaging. The stimulus phrases used in the experiment and correct responses are presented in Table 2.

Table 2. Text Message Phrases with Missing Word

Message	Message Length	Response	Response Length
Getting away with ******	24	murder	6
Time ***** when you're having fun	33	flies	5
Whatever ****** your boat	25	floats	6
Little Red ****** Hood	22	Riding	6
The Wicked ***** of the West	28	Witch	5

Because the missing word task was used with participants from different age groups, it was expected that some stimuli would be more familiar to some participants than others. If participants could not readily complete a phrase, they were instructed to send a brief message to indicate that they did not know the answer (e.g., "don't know," "not sure"). The phone was preloaded with a set of inbound messages to avoid having to rely on a real-world telecommunications system for timely delivery of messages. Participants were instructed to perform the task as follows:

> "In this task, you will use the iPhone for text messaging. You will perform this task by retrieving a text message, and then creating a text message in reply to it. The audible prompt for this task will be "Please read and reply to the text message from (name). Go."

The specific task steps to perform the text messaging task were as follows:

1) If the phone is locked or displays a blank screen, unlock the phone by pressing the button below the screen (that has a rounded square symbol on it). Next, place your thumb on the arrow on the screen and slide it all the way to the right. A set of icons will appear. If the icons do not appear, press the same button at any time to display the main icon screen. Keep in mind that you may have to do this at other times if the screen times out during the drive.
2) Touch the "Messages" icon at the bottom of the screen. This icon is green and shows a white cartoon balloon. A list of messages will appear.
3) Touch the desired message. The messages will be identified by the names of the fictitious senders of the message. The message will contain a well known phrase which

is missing one or more key words. The task is to determine what word or words are missing and then reply to the message by supplying the missing words required to complete the well known phrase.

   a. If you don't know the answer, please create a reply message that says something like "Don't know" or "Not sure." It is important that you reply in some way to each message.
   b. If you select the wrong message, you can return to the list by touching the "Messages" icon at the upper left of the screen.

4) At the bottom of the screen, left of the blue "Send" icon is a white space. Touch this white space and a keyboard will appear. Enter the missing words and then touch the blue "Send" icon located to the right of the text you have entered.
   a. If you make an error use the "Delete" icon on the screen (just to the right of the bottom row of letters). You need not type the entire phrase, but only those words which are missing.
5) After sending each message, touch the blue "Messages" icon at the upper left of the screen to return to the initial message screen and then press the rounded square button below the screen to return to the main icon screen.

2.8 Secondary Task Training

Each task was explained to the participant by an experimenter sitting in the front passenger seat of the vehicle. The experimenter then demonstrated how to perform the task (with no concurrent driving). After demonstrating a task, the experimenter allowed the participant to practice the task (with no concurrent driving) until they felt comfortable performing the task. The experimenter gave detailed task instructions and assistance if necessary. The participant was permitted to perform as many attempts as necessary until he/she felt comfortable performing the task. Typically, only two practice trials were needed for each secondary task type.

The participant was instructed that they would be prompted to begin a task trial using a standard phrase consisting of the instruction: Please (do this task) followed by the word "Go." For example, when performing the radio tuning task, the participant would hear a prompt such as "Please enter FM band 92.9. Go." Participants were instructed that upon hearing the word "go," they should work as quickly and accurately as possible to complete the task without letting vehicle speed and following distance performance deteriorate too much. Participants were then reminded that safe driving was the highest priority. Participants were permitted to ask for information to be repeated if they forgot some instruction. They were also instructed that data entry errors should be corrected before moving on.

2.9 Procedure

Each participant completed one session, which lasted approximately two hours. All testing was done in a single vehicle. Upon arrival, the participant was asked to read and sign the "Participant Informed Consent Form" (Appendix B), thereby giving informed consent to participate in the study. The participant was then escorted to the experimental vehicle and given an overview of the vehicle controls and displays, including adjustment of the seat position. (For the complete details of the procedural steps and experimenter scripts described briefly in this section, see Appendix C.)

Next, the participant was given instructions and practice driving the simulator during a simulator familiarization drive, which gave them practice with the car following task. Once the familiarization drive was complete, the participant was given training on the secondary (non-driving) tasks as was outlined in Section 2.8. Once secondary task training was complete, data collection began.

Each participant's data collection consisted of one drive in which 26 successive trials involving both secondary task and driving task performance. Unknown to the participant, the first 2 trials for each of the 5 task types were solely for practice. The 10 practice trials were randomized as a group for each participant. After these initial 10 trials were completed, the participant was given a brief break in which the vehicle was stopped and the simulator was paused. After the break, the participant completed the 16 remaining trials. These trials were also randomized; each participant completed 3 of each of the 5 task types for a total of 15 trials and 1 baseline trial, in which no secondary task was performed during the 3-minute driving interval.

The experimenters were positioned at a control station behind the vehicle during data collection. Communication with the participant was accomplished by a speaker and microphone system. Secondary task stimuli were presented via pre-recorded auditory tracks at the onset of each trial. The participant was allowed to ask for the task information to be repeated as often as necessary to complete the task.

At the completion of data collection, the participant was asked to complete a simulator sickness questionnaire to determine if rest was required before being allowed to drive home. The participant was then given compensation, after which the experimenter answered questions and accompanied the participant to his or her personal vehicle.

2.10 Alliance Principle 2.1 and Other Metrics

Alliance Principle 2.1 metrics were computed for each of the 15 instances of a secondary task completed as main trials. The Alliance Principle 2.1 metrics collected in this experiment include the following:

Lateral Position Control. Alliance Principle 2.1B refers to three metrics that characterize lane keeping, including the number of lane departure events and the distributions of extent and integral of lane exceedances. Based on discussions with the Alliance, only lane exceedance frequency was used for analyses in this study.

Headway Maintenance. According to the Alliance Principle 2.1B, car-following headway is calculated as the inter-vehicle range divided by the subject vehicle velocity, which produces a measurement in units of seconds. The metric used for analysis was the standard deviation (SD) of headway.

3.0 RESULTS

3.1 Overview of Data Analysis

The analyses had several objectives. The first objective was to examine the effects of the various number/text entry tasks on the Alliance Principle 2.1B metrics as computed from the Alliance member company implementation of the Alliance verification procedure. The second objective was to determine the effects of using samples of different sizes for testing. The third objective was to compare the present results with those obtained in the recently-completed Manual Number Text Entry (MNTE) study (Ranney et al., 2011). These objectives are addressed in the following sections.

Based on the repeated-measures design, all participants completed all secondary task conditions. Although data was obtained from 64 participants, data from one participant was not usable. Because participants were assigned to subsets in advance, this affected some of the analyses using smaller subsets. Some samples include one fewer participant than had been planned (e.g., 19 versus 20). The term “nominal sample size” will be used to refer to planned sample sizes. Analyses conducted to compare the present data with MNTE data used a subset of the MNTE data that was matched as much as possible to present data. In the earlier study, the same set of secondary tasks was used in a repeated-measures design similar to that used in the present study. The similar structures allowed direct comparison of results between the two data sets.

The focus of the analysis was on determining the relative amounts of performance degradation associated with the various secondary tasks. Accordingly, the data were analyzed using a set of 10 planned comparisons, each of which compared a pair of secondary tasks. Analyses were conducted separately for each metric and for each combination of sample subset and metric. Each planned comparison involved a paired t-test, computed by the SAS Mixed procedure. Probability values were adjusted for family-wise error by using Hochberg’s step-up method (Westfall, Tobias, Rom, Wolfinger, & Hochberg, 2003). This method is a sequentially rejective method, which provides increased statistical power over the single-step methods (e.g., Bonferroni) when the focus is on hypothesis testing. The test first considers the least significant p-value among a family of tests. If this is significant ($p \leq \alpha$), then all differences are considered significant at this level. If not, then the next least significant result is compared with $\alpha/2$. If $p \leq \alpha/2$, then all remaining tests are adjusted to this level. The sequence continues in this manner, using $\alpha/3$, etc. Adjusted p values of less than .05 were considered to be statistically significant. Adjusted p values between .05 and .10 were considered marginal and discussed where applicable.

3.2 Results From 2.1B Metrics Using Alliance Verification Procedure

Figure 4 and Figure 5 present the mean values (with standard error [SE]) across 5 trials for the two Alliance Principle 2.1B metrics for each secondary task used in the experiment. For each metric, higher values indicate higher levels of driving performance degradation and thus increasing distraction effects.

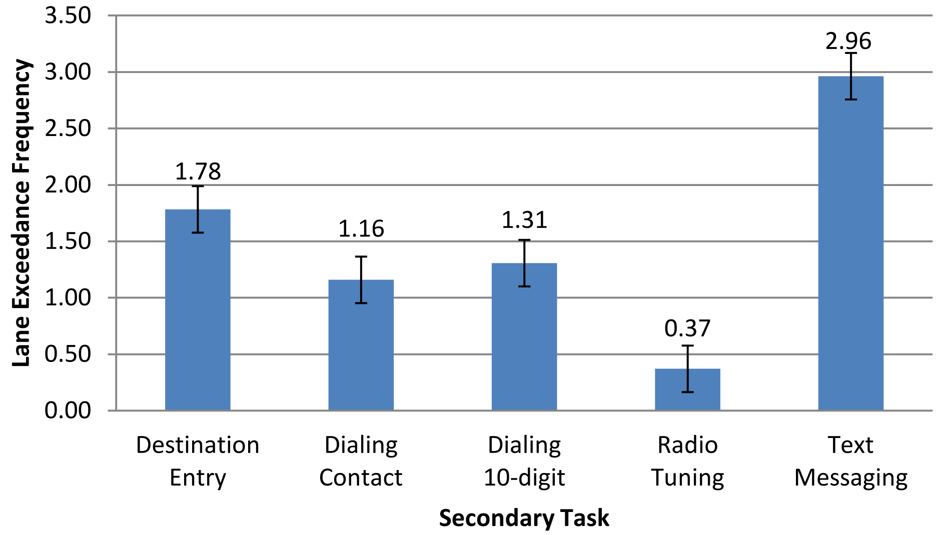

Figure 4. Mean (± SE) Lane Exceedance Frequency

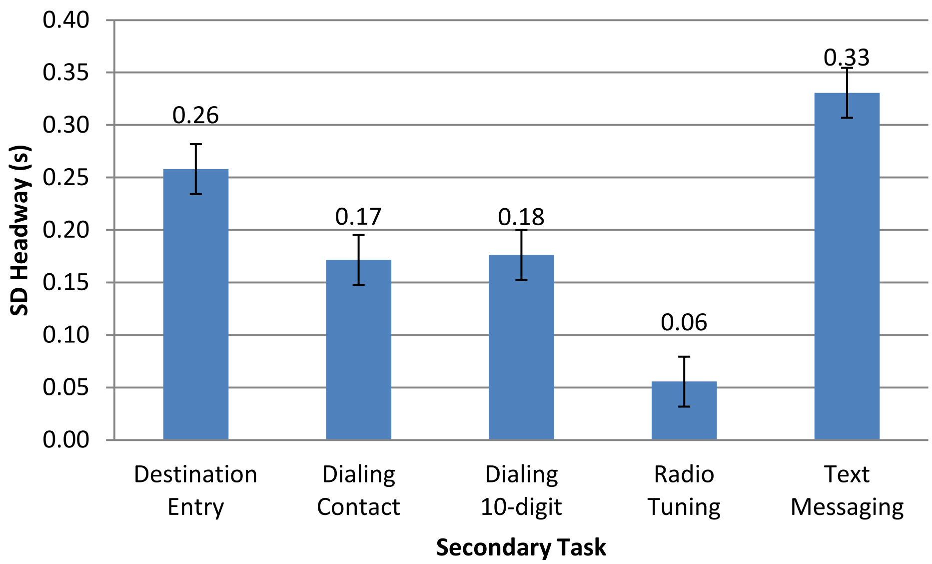

Figure 5. Mean (± SE) SD Headway (Seconds)

The respective mean patterns across secondary tasks are consistent for the two metrics; text messaging had the highest levels of performance degradation, followed by destination entry. Radio tuning had the lowest levels of performance degradation. The levels associated with dialing and contact phone tasks were approximately equal and intermediate relative to the two extremes. Figure 6 presents the mean duration values for each secondary task.

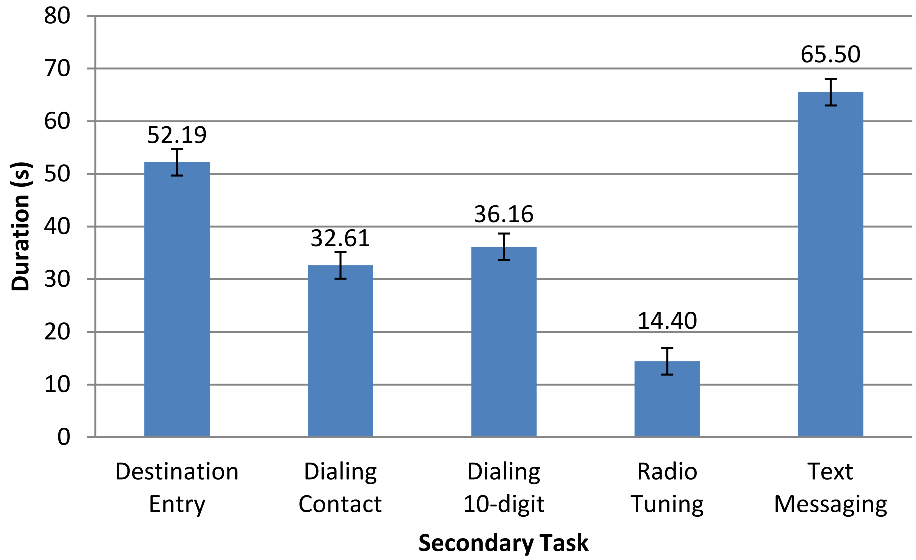

Figure 6. Mean (± SE) Task Duration (Seconds)

The similarity of the pattern of task duration means to the patterns of metric mean values suggests that the differences among secondary tasks in the two driving performance metrics may be due, at least in part, to differences in task duration. Accordingly, correlation coefficients were computed to assess the amount of common variance among these three measures. The correlations were computed using individual trials (3 trials per participant for each task), since each trial had unique duration and metric values. The correlation coefficients are shown in Table 3.

Table 3. Correlations Between Metrics and Task Duration (N = 945)

	Lane Exceedance	**SD Headway**
Duration	0.62	0.58
Lane Exceedance	--	0.43

Both Alliance Principle 2.1B metrics revealed relatively strong correlations with task duration; the correlation between the two metrics was weaker.

To further explore the influence of task duration in one Alliance metric, lane exceedance frequency values were divided by their associated task durations to obtain a duration-adjusted metric, lane exceedances per second. The mean values for this duration-adjusted metric are presented in Figure 7.

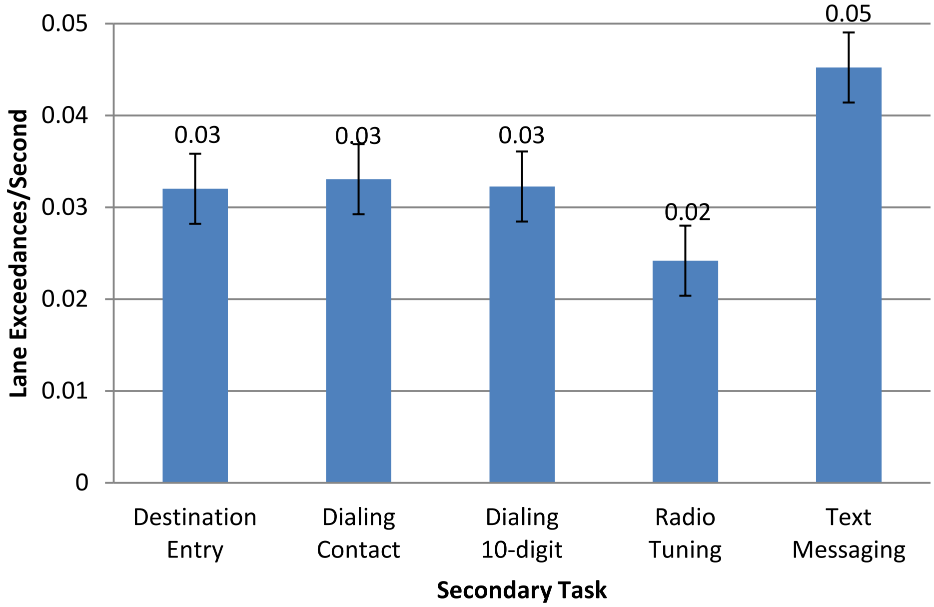

Figure 7. Mean (± SE) Lane Exceedances per Second by Secondary Task

When comparing raw values in Figure 7 to Figure 4, adjusting the lane exceedance frequencies for differences in task duration appears to have had the effect of attenuating the differences between secondary tasks that were apparent in the raw metric. The correlation between this adjusted metric and task duration was r = .19, indicating that the adjustment eliminated much of the influence of duration in the raw metric. The effects of this adjustment on test outcome will be examined statistically in the following section on planned comparisons.

3.3 Planned Comparisons

To address the major questions concerning the distraction potential associated with the various number/text entry tasks, analyses were performed based on the following planned comparisons:

1. Dialing contact versus destination entry,
2. Dialing contact versus dialing 10-digit,
3. Dialing contact versus radio tuning,
4. Dialing contact versus text messaging,
5. Destination entry versus dialing10-digit,
6. Destination entry versus radio tuning,
7. Destination entry versus text messaging,
8. Dialing 10-digit versus radio tuning,
9. Dialing 10-digit versus text messaging, and
10. Radio tuning versus text messaging.

Separate *F* tests were computed for each planned comparison for each metric. Probability values were adjusted for family-wise error by using Hochberg's step-up method (Westfall, Tobias, Rom, Wolfinger, & Hochberg, 2003). Adjusted *p* values of less than .05 were considered to be statistically significant. Adjusted *p* values between .05 and .10 were considered marginal and discussed where applicable.

Table 4 presents the results of statistical tests for the two Alliance Principle 2.1B metrics, plus the duration-adjusted lane exceedances per second, which was discussed above.

Table 4. Results of Planned Comparisons for Alliance Principle 2.1B Metrics and Duration-Adjusted Metric

	Comparison	**Lane Exceedance Frequency**	**SD Headway**	**Lane Exceedance Adjusted***
1	Dialing contact versus Destination entry	0.01	0.007	0.95
2	Dialing contact versus Dialing 10-digit	0.50	0.83	0.95
3	Dialing contact versus Radio tuning	0.002	< 0.0001	0.10
4	Dialing contact versus Text messaging	< 0.0001	< 0.0001	0.008
5	Destination entry versus Dialing 10-digit	0.06	0.007	0.95
6	Destination entry versus Radio tuning	< 0.0001	< 0.0001	0.14
7	Destination entry versus Text messaging	< 0.0001	0.007	0.004
8	Dialing 10-digit versus Radio tuning	0.0001	< 0.0001	0.14
9	Dialing 10-digit versus Text messaging	< 0.0001	< 0.0001	0.004
10	Radio tuning versus Text messaging	< 0.0001	< 0.0001	< 0.0001

*This metric is not part of the Alliance Principle 2.1B

Based on the $p < .05$ criterion, the statistical test results were the same for the two Alliance Principle 2.1B metrics for 9 of the 10 comparisons. The one exception (Comparison 5) found that destination entry was associated with higher SD headway than dialing, while the difference in lane exceedance frequency was weaker, revealing only marginal significance.

The third column presents the test results for the duration-adjusted lane exceedance metric. The effect of the adjustment on test outcome was significant; four of eight comparisons that were statistically significant when the raw lane exceedance metric was used (Comparisons 1, 3, 6 and 8) were no longer statistically significant when the adjusted metric was used as the basis for comparison. When lane exceedance frequency values were adjusted by task duration, text messaging remained the only task that differed from the others. The results support the following conclusions:

1. Differences between text messaging and other tasks are due to the combination of differences in task demands and task duration.
2. Differences among tasks not including text messaging are likely due primarily to differences in task duration.

3.4 Alliance Test Outcomes

The Alliance Principle 2.1B verification procedure is intended to determine whether tasks differ in their potential for distraction from the radio tuning benchmark task. Four of the 10 planned comparisons involved comparisons of visual/manual tasks with radio tuning. The outcomes of these tests are summarized in 0.

Table 5. Alliance Metric and Adjusted Lane Exceedance Test Outcomes

Comparison	Task	Lane Exceedance Frequency	SD Headway	Lane Exceedance Adjusted*
3	Dialing contact	More	More	Same
6	Destination entry	More	More	Same
8	Dialing 10-digit	More	More	Same
10	Text messaging	More	More	More

*This metric is not part of the Alliance Principle 2.1B

The table entries indicate the test outcome for each task on each metric. The "More" entries indicate that the test outcome revealed significantly more performance degradation for the task than for the benchmark task; the "same" entries indicate no statistical difference. Thus the "same" entries indicate conformity with Alternative B. Note that none of the secondary tasks meet the criteria for both parts of the Alliance Principle 2.1B metrics (first 2 columns), reflecting the fact that all had significantly higher levels of driving performance degradation than radio tuning. However, the extent to which the lane exceedance frequency outcomes are determined by differences in task duration can be seen by comparing the duration-adjusted metric outcomes with those for the raw lane exceedance metric. With the adjusted metric, three of the tasks met the criteria, which means that their distraction effects were no worse than those for radio tuning, when the effects of task duration were taken out of the metrics.

3.5 Effects of Different Sample Sizes and Replications

The second objective of the analysis was to compare the test outcomes using the two Alliance Principle 2.1B metrics with different sample sizes. This objective had two components. The first component was to determine whether test outcomes with smaller subsets were consistent with the test outcomes based on the entire sample (N = 63). The second component was to determine whether the test outcomes were consistent across repeated testing of small size samples (N = 20, 32). To address this objective, sample was divided first into two subsets, each nominally comprising half of the sample. Subsequently, the sample was divided into three subsets of N = 20, nominally comprising approximately one-third of the entire sample. The resulting subsets include the following:

1. N = 32
2. N = 31
3. N = 20
4. N = 19
5. N = 20

Subsets 1 and 2 were non-overlapping and together comprise the entire sample. Similarly, samples 3, 4, and 5 were non-overlapping. Subset 2 was intended to have data from 32 participants and Subset 4 was intended to have data from 20 participants; their reduced size reflects the loss of data from one participant, who had been assigned to both subsets. The use of multiple subsets of the same nominal size allows examination of the effects of replication(i.e., test-retest reliability).

<u>Lane Exceedance Frequency</u>. The results for lane exceedance frequency are presented in Table 6. Table entries represent the adjusted statistical test probability values, such that values less than 0.05 are considered to represent statistically significant differences.

Table 6. Results of Planned Comparisons for Different Sample Sizes and Replications (Lane Exceedance Frequency)

	Comparison	**N = 63**	**N = 32 (1)**	**N = 31 (2)**	**N = 20 (3)**	**N = 19 (4)**	**N = 20 (5)**	**Total**
1	Dialing contact versus Destination entry	0.01	0.16	0.09	0.16	0.39	0.26	1
2	Dialing contact versus Dialing 10-digit	0.50	0.39	0.89	0.37	0.61	0.26	0
3	Dialing contact versus Radio tuning	0.002	0.10	0.03	0.37	0.39	0.01	3
4	Dialing contact versus Text messaging	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0009	6
5	Destination entry versus Dialing 10-digit	0.06	0.39	0.09	0.37	0.61	0.08	0
6	Destination entry versus Radio tuning	< 0.0001	0.0003	< 0.0001	0.003	0.02	0.0002	6
7	Destination entry versus Text messaging	< 0.0001	0.001	0.002	0.04	0.004	0.03	6
8	Dialing 10-digit versus Radio tuning	0.0001	0.005	0.04	0.08	0.06	0.11	3
9	Dialing 10-digit versus Text messaging	< 0.0001	< 0.0001	< 0.0001	0.001	0.0008	< 0.0001	6
10	Radio tuning versus Text messaging	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	6

All comparisons with probability values greater than 0.05 indicate there was no statistically significant difference present. The rightmost (Total) column is the number of statistically significant test results in the row. Total values of 0 and 6 indicate fully consistent test results for this comparison across sample sizes and test replications. Seven of the ten planned comparisons revealed consistent test results (Total = 0 or 6) across the entire range of sample sizes and replications for this metric. The three remaining comparisons (1, 3 and 8) revealed varying levels of disagreement among the test outcomes. Of potential concern for the use of smaller sample sizes are comparisons for which the largest sample size showed a different result from the others. This pattern was apparent for these three comparisons, each of which revealed a significant difference with the largest sample size (N = 63) and non-significant differences with at least some of the smaller sample sizes. The pattern of test outcomes for Comparison 8 reveals a progressive change consistent with reduced statistical power as the sample size decreases. Two of the three comparisons revealing discrepant outcomes with different sample sizes (3 and 8) are among the four comparisons involving radio tuning that are central to the use of the Alliance Principle 2.1B metrics.

0 presents the number of planned comparisons with the same outcome for each pairwise combination of the 6 samples shown in Table 6. For this metric, a value of 10 indicates identical test outcomes for all planned comparisons. Smaller numbers indicate less agreement. Differences between pairs of tests using nominally identical sample sizes are indicated by the shaded cells.

Table 7. Planned Comparisons Test Outcome Agreement (Lane Exceedance)

	N = 32 (1)	N = 31 (2)	N = 20 (3)	N = 19 (4)	N = 20 (5)
N = 63	8	9	7	8	8
N = 32 (1)		9	9	9	8
N = 32 (2)			8	8	9
N = 20 (3)				10	9
N = 19 (4)					9

Shaded cells indicate replication effects.

For present purposes, agreement values of 9 or10 are considered good; 7-8, marginal; and 6 or less, unacceptable. Of primary interest is the level of agreement among the smaller samples and the full sample (N = 63). These comparisons are shown in the top row of 0. Overall, the average level of agreement of the smaller samples with the large sample was 8 of 10. The large subsamples (N = 32, 31) had marginally higher agreement (8 and 9) with the full sample (N = 63) than did the smaller subsamples (N = 20, 19), for which the agreement levels were 7, 8 and 8.

Considering the effects of replication, agreement among smaller sample sizes was minimally higher (10, 9 and 9) than for the larger subsample (9).

Table 8 presents the statistical test results for the SD Headway metric. Table 9 presents the pairwise test outcome number of agreements for the different sample sizes.

Table 8. Results of Planned Comparisons for Different Sample Sizes and Replications (SD Headway)

	Comparison	**N = 63**	**N = 32 (1)**	**N = 31 (2)**	**N = 20 (3)**	**N = 19 (4)**	**N = 20 (5)**	**Total**
1	Dialing contact versus Destination entry	0.007	0.0006	0.32	0.08	0.054	0.52	2
2	Dialing contact versus Dialing 10-digit	0.83	0.24	0.52	0.24	0.36	0.45	0
3	Dialing contact versus Radio tuning	< 0.0001	0.007	0.008	0.11	0.23	0.03	4
4	Dialing contact versus Text messaging	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.005	0.18	5
5	Destination entry versus Dialing 10-digit	0.007	0.05	0.12	0.24	0.34	0.33	2
6	Destination entry versus Radio tuning	< 0.0001	< 0.0001	< 0.0001	0.0002	0.0002	0.005	6
7	Destination entry versus Text messaging	0.007	0.26	0.03	0.08	0.36	0.37	2
8	Dialing 10-digit versus Radio tuning	< 0.0001	< 0.0001	0.04	0.008	0.03	0.34	5
9	Dialing 10-digit versus Text messaging	< 0.0001	0.002	< 0.0001	0.003	0.07	0.008	5
10	Radio tuning versus Text messaging	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	6

Results for this metric reflected less agreement among the test outcomes for different subsets of the sample than for the lane exceedance metric; for SD Headway, only 3 of 10 comparisons (Comparisons 3, 6, and 10) had fully consistent test outcomes across the various samples. Three comparisons had 5 of 6 in agreement; in each of these cases (Comparisons 4, 8 and 9) the test result for one of the smaller sample sizes deviated from the other sample results. Four of the comparisons (Comparisons 1, 3, 5 and 7) revealed agreement among 2-4 of 6 tests. Frequencies in this range represent the highest levels of disagreement among the different tests. For three of these four comparisons, the pattern of results indicates that differences that were strongly significant with the full sample were split among the larger subsamples and consistently not apparent among the smaller subsamples. This pattern of differences is consistent with decreasing statistical power that derives from use of smaller samples.

Table 9. Planned Comparison Test Outcome Agreement (SD Headway)

	N = 32 (1)	N = 31 (2)	N = 20 (3)	N = 19 (4)	N = 20 (5)
N = 64	9	8	6	5	5
N = 32 (1)		7	7	6	6
N = 31 (2)			8	7	7
N = 20 (3)				9	7
N = 19 (4)					6

Shaded cells indicate replication effects.

From Table 9, the topmost row indicates that the smaller sample sizes have increasing levels of disagreement with the larger sample for this metric; two of the small samples revealed agreement among only 5 of the 10 comparisons. Based on the shaded cells in Table 9, the level of agreement among samples of the same size was considerably less for this metric than for the lane exceedance metric.

3.6 Comparison With DFD Analysis of Same Metrics

The third analysis objective was to compare the results of the Alliance Principle 2.1B metrics obtained using the Alliance member company implementation of the 2.1B protocol with those same metrics obtained using the DFD protocol from the MNTE study (Ranney et al., 2011). Analyses were performed using a subset of the MNTE data, which was selected to match the characteristics of the 2.1B data sample. Specifically, participants were selected to be 35 to 54 years old. This resulted in N = 60 MNTE participants versus N = 63 in the 2.1B sample. Similarly, the subset of MNTE phone tasks performed with the same single phone that was used in the 2.1B protocol was selected for comparison. The DFD protocol did not provide multiple trials for all tasks for all participants. For longer tasks, including destination entry and text messaging, participants were consistently unable to complete more than 1 task trial during the 2.5-minute data collection interval used in that study. Two subsets of data were created from the MNTE data: (1) data from a single trial of each secondary task, and (2) means from two trials for those tasks that had two complete trials. Two additional subsets were created from the data obtained using the 2.1B protocol in the present study: (3) means from three separate trials for each task, and (4) data from a single task trial. The mean lane exceedance frequencies for these four trial combinations are presented in Figure 8.

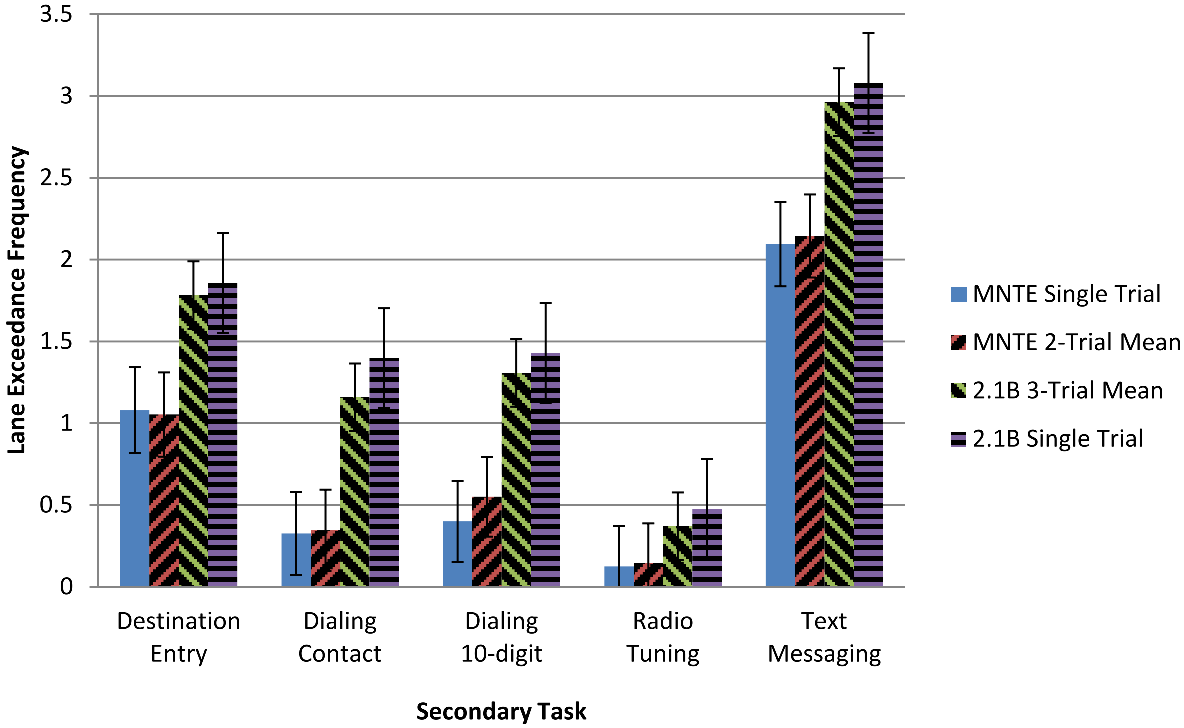

Figure 8. Mean (± SE) Lane Exceedance Frequencies by Secondary Task and Test Venue

The 2.1B means were consistently greater than the MNTE means for this metric. This difference most likely reflects differences between the protocols in the vehicle width and lane markings. The effects of these differences are considered in more detail later in this section. To assess the effects of these differences on test outcomes, the 10 planned comparisons were performed using these four sets of data. The results of these tests are presented in 0. The Total column reports the number of outcomes that attained statistical significance for each comparison.

Table 10. Planned Comparisons Using 2.1B versus MNTE Protocol Data (Lane Exceedance Frequency)

	Comparison	2.1B Protocol N = 64 3 trials	2.1B Protocol N = 63 1 trial	MNTE Protocol N = 60 1 trial	MNTE Protocol N = 60 2 trials	Total
1	Dialing contact versus Destination entry	0.01	0.50	0.15	0.16	1
2	Dialing contact versus Dialing 10-digit	0.50	0.93	0.82	0.52	0
3	Dialing contact versus Radio tuning	0.002	0.054	0.82	0.52	1
4	Dialing contact versus Text messaging	< 0.0001	< 0.0001	< 0.0001	< 0.0001	4
5	Destination entry versus Dialing 10-digit	0.06	0.50	0.19	0.49	0
6	Destination entry versus Radio tuning	< 0.0001	0.002	0.03	0.03	4
7	Destination entry versus Text messaging	< 0.0001	0.007	0.03	0.008	4
8	Dialing 10-digit versus Radio tuning	0.0001	0.054	0.82	0.52	1
9	Dialing 10-digit versus Text messaging	< 0.0001	0.0001	< 0.0001	< 0.0001	4
10	Radio tuning versus Text messaging	< 0.0001	< 0.0001	< 0.0001	< 0.0001	4

The agreement among test outcomes for each pair of samples is presented in Table 11.

Table 11. Test Outcome Agreement Frequency (Lane Exceedance)

	2.1B 1 trial	MNTE 1 trial	MNTE 2 trials
2.1B 3 trials	7	7	7
2.1B 1 trial		10	10
NTE 1 trial			10

Considering data from the MNTE study, results of the single-trial versus two-trial means were fully consistent with respect to the test outcome. Similarly, the MNTE single-trial results were fully consistent with the Alliance single-trial results; however the results of the Alliance (2.1B) 3-trial means were less consistent with the other three conditions. Results of the 2.1B and the MNTE testing were consistent on 7 of 10 comparisons; Comparisons 1, 3 and 8 were not consistent. For each of these, the difference was found to be statistically significant for the Alliance 3-trial means but not for the other trial combinations.

SD Headway results were compared in the same manner. Means for the four trial conditions are presented in Figure 9.

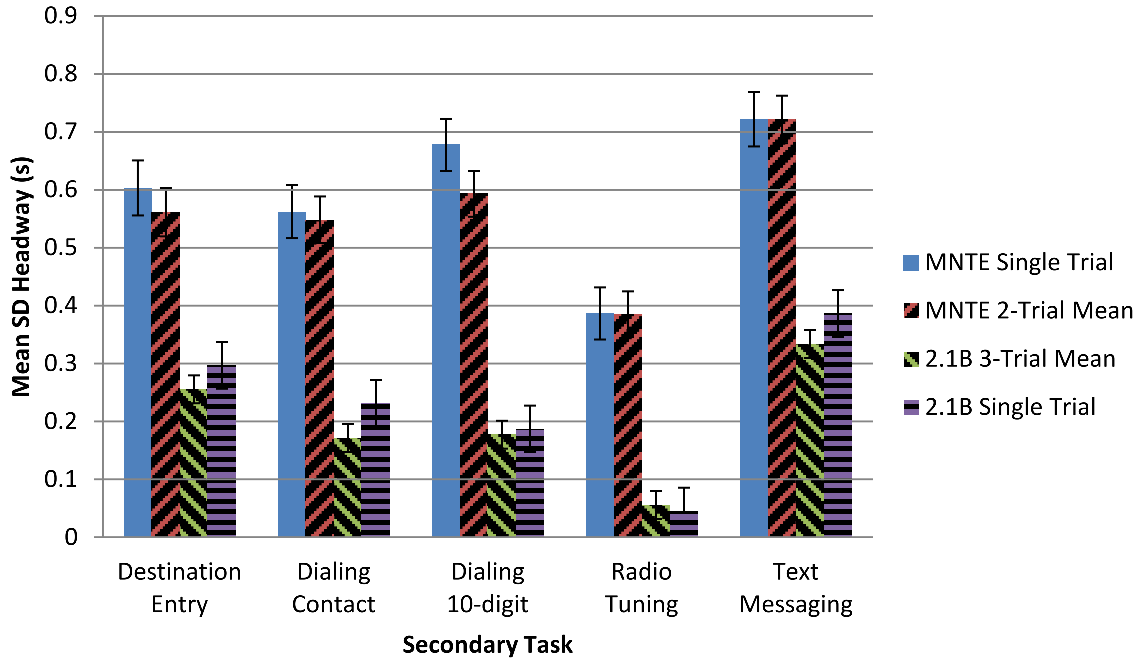

Figure 9. Mean (± SE) SD Headway by Secondary Task and Test Venue

For this metric, the DFD protocol mean values appear to be consistently higher than those associated with The Alliance member company (2.1B) protocol. These differences derive directly from the differences in car-following tasks used in the two protocols; while the Alliance Principle 2.1B verification procedure used a constant lead vehicle speed, the DFD protocol used a constantly varying lead vehicle speed. Analyses were performed to determine whether the differences in car-following task demands affected the test outcomes. The set of 10 planned comparisons was computed for each of the four sets of trial means shown in Figure 9. The statistical test results for the planned comparisons are presented in Table 12 and Table 13.

Table 12. Planned Comparisons Using 2.1B Versus MNTE Protocol Data (SD Headway)

	Comparison	**2.1B Protocol N = 63 3 trials**	**2.1B Protocol N = 63 1 trial**	**MNTE Protocol N = 60 1 trial**	**MNTE Protocol N = 60 2 trials**	**Total**
1	Dialing contact versus Destination entry	0.007	0.34	0.49	0.80	1
2	Dialing contact versus Dialing 10-digit	0.83	0.35	0.21	0.80	0
3	Dialing contact versus Radio tuning	< 0.0001	0.0008	0.02	0.008	4
4	Dialing contact versus Text messaging	< 0.0001	0.007	0.05	0.006	4
5	Destination entry versus Dialing 10-digit	0.007	0.09	0.49	0.80	1
6	Destination entry versus Radio tuning	< 0.0001	< 0.0001	0.002	0.006	4
7	Destination entry versus Text messaging	0.007	0.18	0.21	0.01	2
8	Dialing 10-digit versus Radio tuning	< 0.0001	0.02	< 0.0001	0.0003	4
9	Dialing 10-digit versus Text messaging	< 0.0001	0.0003	0.49	0.05	3
10	Radio tuning versus Text messaging	< 0.0001	< 0.0001	< 0.0001	< 0.0001	4

The agreement among test outcomes for each sample pair is presented in Table 13.

Table 13. Test Outcome Agreement (SD Headway)

	2.1B 1 trial	MNTE 1 trial	MNTE 2 trials
2.1B 3 trials	7	6	8
2.1B 1 trial		9	9
NTE 1 trial			8

Based on the Total column of Table 12, 6 of the 10 comparisons had consistent results (Total = 0 or 4). The remaining 4 comparisons had some inconsistency across the test conditions. Considering the test outcome agreements among conditions, the Alliance member company single-trial results exhibited highest consistency with the MNTE single and 2-trial results. The Alliance (2.1B) 3-trial means differed from the other three conditions most consistently.

3.7 Effects of Edge Line Configuration and Vehicle Width

Differences between the DFD and the Alliance member company (2.1B) protocols influenced the criteria for determining lane exceedances. First, the Alliance implementation of the 2.1B protocol used a vehicle width of 1.770 meters while the DFD protocol used a vehicle width of 1.585 meters.[3] Second, while the nominal lane width was the same in both protocols, the Alliance Principle 2.1B lane departure criterion included pavement markings on both sides of the road, while the DFD protocol did not. In the Alliance member company 2.1B protocol implementation, the left side lane marking extended slightly beyond the lane boundary, thus having the effect of adding 0.05 meters to the lane width on that side. The right side lane marking was located slightly inside the right side lane boundary, which had the effect of reducing the effective lane width by 0.10 meters on that side. The net effect was a slightly narrower lane in the Alliance member company 2.1B protocol implementation. Finally, the Alliance computational algorithm counted lane exceedances that began slightly prior to the beginning of the data collection interval if they continued into the data collection interval, while the DFD computational algorithm did not. Both protocols defined a lane departure as occurring when any part of the vehicle's calculated tire position extended beyond the outside edge of the lane boundary. These factors are summarized in Table 14. To separate the effects of these factors, lane exceedance frequencies were computed in three different ways as shown in Table 14.

Table 14. Lane Width Configuration Factors

Configuration	Lane Width	Vehicle Width	Tire Position Lane Departure Criterion	Lane Departure Timing Criterion
DFD with 1.585 m wide vehicle	3.75 meters	1.585 meters	Any part of tire extends beyond lane boundary	After data collection onset
DFD with 1.770 m wide vehicle	3.75 meters	1.77 meters	Any part of tire extends beyond lane boundary	After data collection onset
Alliance 1.770 m wide vehicle	3.70 meters	1.77 meters	Any part of tire extends beyond lane boundary	Prior to initiation of data collection allowed

[3] The Alliance 2.1 B protocol does not specify a required vehicle width.

Figure 10 presents the mean and SE lane exceedance frequency values by secondary task for these three computational approaches.

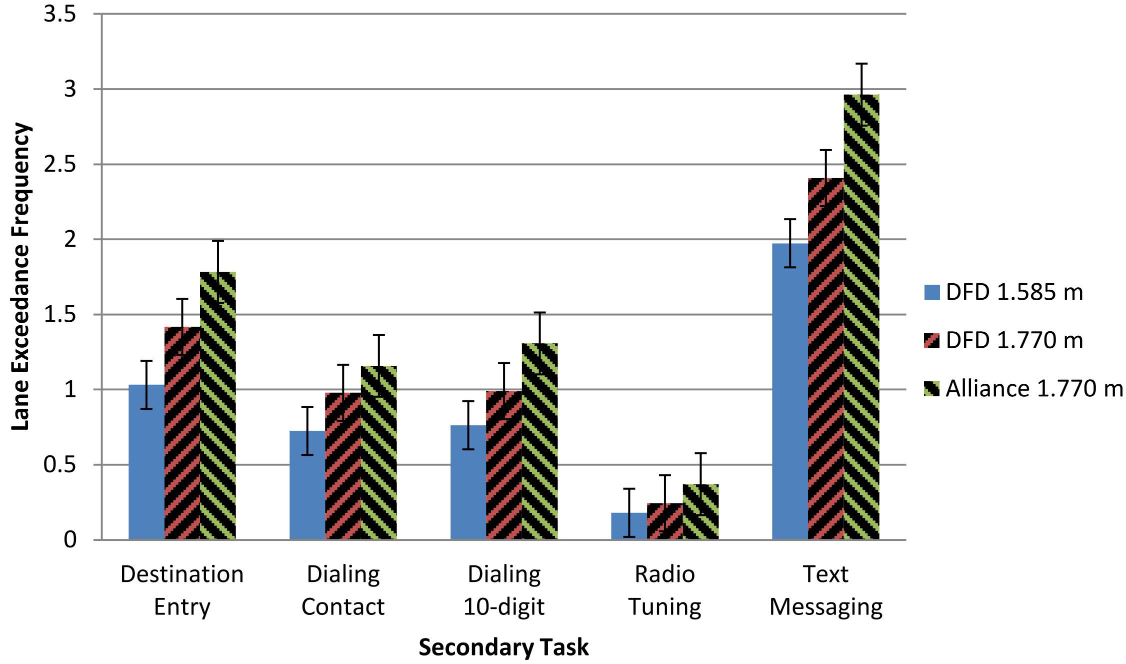

Figure 10. Mean (± SE) Lane Exceedance Frequencies for 3 Computational Approaches

The effects of vehicle width alone are evident in comparing the two DFD frequencies. The use of the narrow vehicle width likely reduced the number of lane departure events for all conditions. The effect of the other factors, including different lane widths and initiation criterion are evident in the comparison of the DFD 1770 versus Alliance 1770 bars, which show that the Alliance member company criteria had consistently more lane departure events that the DFD criterion.

The three combinations of lane width and computational approach were used to perform the planned comparisons to identify differences between the various secondary tasks. The results are presented in Table 15.

Table 15. Effects of Vehicle Width and Computational Approach on Differences Between Secondary Tasks Lane Exceedance Frequency (N = 63)

	Comparison	DFD 1585	DFD 1770	Alliance 1770	Total
1	Dialing contact versus Destination entry	0.26	0.07	0.01	1
2	Dialing contact versus Dialing 10-digit	0.84	0.96	0.50	0
3	Dialing contact versus Radio tuning	0.01	0.001	0.002	3
4	Dialing contact versus Text messaging	< 0.0001	< 0.0001	< 0.0001	3
5	Destination entry versus Dialing 10-	0.26	0.07	0.06	0

	digit				
6	Destination entry versus Radio tuning	< 0.0001	< 0.0001	< 0.0001	3
7	Destination entry versus Text messaging	< 0.0001	0.0001	< 0.0001	3
8	Dialing 10-digit versus Radio tuning	0.006	0.001	0.0001	3
9	Dialing 10-digit versus Text messaging	< 0.0001	< 0.0001	< 0.0001	3
10	Radio tuning versus Text messaging	< 0.0001	< 0.0001	< 0.0001	3

Ignoring the marginally significant results, the results are generally in agreement, with one exception. The first comparison, between Dialing contact and Destination entry, is statistically different using the Alliance approach, but not for the DFD approach.

3.8 Comparison With DFD Analysis Using Different Metrics

One objective of the study was to compare the Alliance Principle 2.1B verification procedure test outcome results with those obtained using the DFD protocol. The 10 planned comparisons were used for this purpose. The DFD protocol used four metrics, each of which summarized one aspect of driving performance over a 2.5-minute data collection interval:

1. Standard Deviation of Lane Position, SDLP. This measure represents the variability of the simulated vehicle's lateral position.
2. Car-following delay. This measure represents the response lag in seconds during car following, based on changes in following distance. Cross correlation is used to compute the delay. Details of the analyses based on cross correlation are presented in Ranney et al, (2011).
3. Target detection response time. Drivers responded via button press to approximately 20 simple targets during each driving trial. Mean response time is computed for the correctly detected targets on each trial.
4. Target detection proportion correct. This measure represents the proportion of detection task targets detected correctly on a given trial.

Table 16 presents a summary of the test outcomes for the DFD metrics from the MNTE study and the 2.1B metrics from the present study, including the conclusions concerning the existence of a difference based on the respective test criteria. The final column is an overall assessment of whether or not the test outcomes were in agreement.

DFD outcome values represent the proportions of the four DFD metrics that revealed statistically significant differences. The DFD criterion used in the MNTE study was that 3 of 4 metrics must demonstrate differences to conclude that such a difference exists. Accordingly the DFD Difference column in Table 16 indicates "Yes" when at least 3 metrics revealed a difference. The 2.1B outcomes are based on the two Alliance metrics. The Alliance Principle 2.1B verification procedure requires that test outcomes for both metrics be consistent in showing differences. Accordingly, the 2.1B difference column indicates "Yes" when 2 metrics revealed a difference. As shown in Table 16, test outcomes were in agreement in 7 of 10 comparisons. The outcomes for comparisons 1, 6 and 9 were not in agreement.

Table 16. Summary of Planned Comparison Outcomes for DFD and 2.1B Metrics

	Comparison	DFD Outcome	DFD Difference?	2.1B Outcome	2.1B Difference?	Agree?
1	Dialing contact versus Destination entry	0/4	No	2/2	Yes	No
2	Dialing contact versus Dialing 10-digit	0/4	No	0/2	No	Yes
3	Dialing contact versus Radio tuning	3/4	Yes	2/2	Yes	Yes
4	Dialing contact versus Text messaging	3/4	Yes	2/2	Yes	Yes
5	Destination entry versus Dialing 10-digit	1/4	No	1/2	No	Yes
6	Destination entry versus Radio tuning	1/4	No	2/2	Yes	No
7	Destination entry versus Text messaging	3/4	Yes	2/2	Yes	Yes
8	Dialing 10-digit versus Radio tuning	4/4	Yes	2/2	Yes	Yes
9	Dialing 10-digit versus Text messaging	0/4	No	2/2	Yes	No
10	Radio tuning versus Text messaging	3/4	Yes	2/2	Yes	Yes

As shown in Table 16, test outcomes were in agreement in 7 of 10 comparisons. The outcomes for comparisons 1, 6 and 9 were not in agreement.

3.9 Task Duration Differences

As shown in Figure 11, task durations were consistently longer in the DFD Protocol. This was particularly true for the destination entry task, for which the DFD mean task duration was approximately 45 percent longer than the duration in the 2.1B protocol. The main difference between these protocols and therefore the most likely reason for this difference in task duration was the differences between the two protocols in driving task demands. The 2.1B driving task was considerably less demanding than the DFD driving task, thus affording drivers the opportunity to devote more concentrated attention to the secondary task, leading to faster completion times, shown as shorter durations.

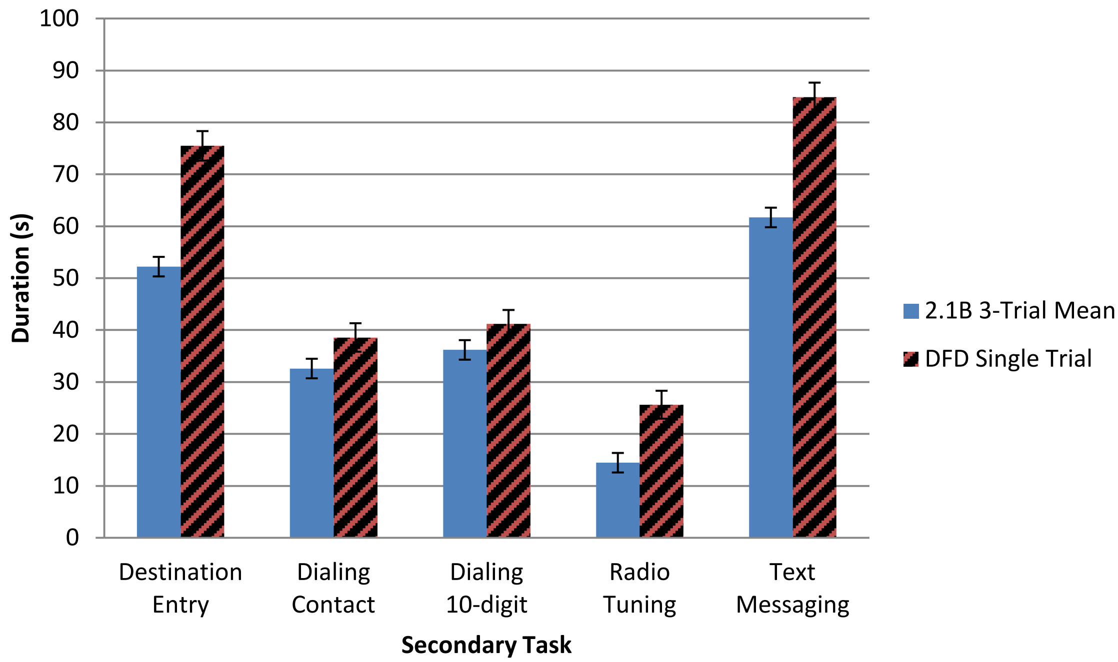

Figure 11. Mean (± SE) Duration by Secondary Task and Test Venue

Table 17 shows the mean secondary task durations by test venue, along with the percentage increase in duration of the DFD protocol over the 2.1B protocol.

Table 17. Mean Durations by Test Venue With Percent Increase in DFD Protocol

	2.1B	**DFD**	**% Increase**
Dialing contact	32.60	38.58	18
Destination entry	52.22	75.48	45
Dialing 10-digit	36.19	41.18	14
Radio tuning	14.46	25.62	77
Text messaging	61.70	84.85	38

4.0 DISCUSSION

The Alliance Guideline Alternative 2.1B specifies two categories of metrics for assessing the effects of concurrent secondary task performance on driving performance, including lane keeping and car following headway. The two specific metrics are lane departure frequency and the SD of headway, respectively. Metrics are computed using data from the time intervals during which participants perform secondary tasks once. The Alliance Guidelines also provide general specifications for the testing required to obtain data necessary to compute these metrics; they specify that testing should be carried out using a car-following task on roads, a test track, or in a driving simulator. While this allows for a wide range of test conditions, the present study was intended to be a replication of one specific vehicle manufacturer's implementation of the Alliance Principle 2.1B verification procedure using detailed specifications obtained from one that manufacturer.

A simulator test venue was selected for this study. Data were obtained from 63 participants performing a variety of number and text entry tasks using a single integrated system and one cell phone. Secondary tasks included radio tuning, destination entry by address, phone dialing, phone contact selection, and text messaging. The Alliance Principle 2.1B metrics both revealed strong and consistent differences among all secondary tasks. Text messaging was associated with the highest levels of driving performance degradation, followed by destination entry. Radio tuning had the lowest levels of driving performance degradation. The two phone dialing tasks (contact selection and 10-digit number dialing) were approximately equivalent in their effects on driving performance and were intermediate relative to the two extremes.

A set of planned comparisons was performed repeatedly with samples of different sizes. The results of comparisons performed with smaller subsets differed from those obtained with the full sample. Results of comparisons using lane exceedance frequency were more consistent than those using SD headway across different sample sizes. Specifically, lane exceedance frequency test outcomes were consistent in 7 of 10 comparisons across different sample sizes. For SD headway, 4 of 10 comparisons revealed consistent outcomes across different sample sizes. Smaller sample sizes were associated with fewer significant test results, which is consistent with the reduced statistical power of smaller sample sizes. Analyses were also conducted to examine the effects of replication in which multiple samples of the same nominal size were used to assess test outcomes. The results of this comparison differed for the two Alliance Principle 2.1B metrics. Lane exceedance frequency test outcomes were more consistent across replications than were SD headway test outcomes. Replication results were generally similar for the N = 31/32 comparisons versus the N = 19/20 comparisons.

The Alliance Guidelines state that for verification of Principle 2.1B, the "Test sample size should be sufficient to control for both Type I (false positive) and Type II (false negative) error risks." When determining an appropriate sample size for testing associated with guidelines of this sort, users may consider both the reasonableness of test effort as well as the robustness (i.e., statistical power) of the results. While many consider 20 participants to be a reasonable sample size, prior NHTSA research using the DFD protocol found that a sample size of approximately 80 participants was necessary to attain statistical power of 0.8 for a particular metric. In the current study, 60 participants was anticipated to be large enough to reveal issues (e.g., test-retest reliability) that might arise with use of smaller (N = 20 or 30) samples. However, neither the full sample of 63 participants tested nor any of the smaller subsets would likely provide power of 0.8, which is necessary to provide adequate control of Type 2 error (Cohen, 1988). Based on the results of the current study, neither 20 nor 30 participants is sufficient to obtain consistent test outcome results.

Two sets of analyses compared test outcomes from the present study with those from the recently completed MNTE study (Ranney et al., 2011). The first set compared Alliance Principle 2.1B metrics computed using data from the respective studies to assess the effects of procedural differences between the two protocol implementations. When the results from a single DFD trial were compared with the results from 3 trials in the present study, the results were in agreement for 7 of 10 comparisons (lane exceedance frequency) and 6 of 10 comparisons (SD headway). The use of means from 2 trials where they were available in the DFD study increased agreement from 6 to 8 for SD headway but had no effect on lane exceedance outcomes. Most comparisons that exhibited disagreement in outcome involved differences that were statistically significant in the current study but not significant in the DFD protocol. There were a number of differences between the two protocols that may have contributed to these differences. Although the present experiment was not designed to allow determination of the reasons for these differences, additional analyses were conducted to explore several of these possibilities. The following are among the factors that may have contributed to the different test outcomes:

1. Car-following task: The DFD protocol used a variable lead vehicle speed signal, while the Alliance member company implementation of the Alliance 2.1 protocol used a constant lead vehicle speed. The DFD car-following task was considerably more demanding than the Alliance member company task. The effect of this difference was most apparent in differences between durations of identical tasks performed in the two protocols. For example, radio tuning required 14.5 seconds on average in the present study, versus 25.6 seconds in the DFD protocol.

2. Lane exceedance determination: Lane exceedance frequency was found to vary as a function of the differences in vehicle width used in the two experiments, differences in the lateral configuration of the roadway edges, and in differences in definition of a lane exceedance. The DFD protocol used a narrower vehicle width, which led to fewer lane departures generally. The Alliance member company implementation of the Alliance Principle 2.1B verification procedure had lane markings located inside the lane width on the right side, which created a slightly narrower lane. The Alliance member company implementation also counted lane departures that were underway when the data collection interval began, while the DFD protocol only counted lane departures that were initiated during the data collection interval.

3. Data collection trials: The Alliance member company implementation combined data from 3 trials to create mean values. The DFD protocol was limited in that only one trial was consistently available for the longer secondary tasks. The number of trials used to compute metric values did appear to have an effect on test outcome.

There are numerous additional methodological differences between the Alliance member company and MNTE implementations of the Alliance Principle 2.1B verification procedure that may also have contributed to these differences. They are summarized in Table 18.

Table 18. Methodological Differences Between Two Alliance Principle 2.1B Verification Procedure Implementations

Methodological Factor	Alliance Principle 2.1B Implementation	MNTE Implementation
Instructions	Simple general instructions: constant speed, driving has priority over secondary task	Detailed instructions concerning relative importance of all tasks
Compensation	None	Study participation compensation based on test duration; Performance-based incentives also given either as (specified) reward or (unspecified) completion bonus
Driving task	Car following	Car following plus visual target detection task
Car following task	Constant lead vehicle speed	Variable lead vehicle speed plus auditory warning if following distance exceeded acceptable range
Roadway characteristics	Rumble strips on right roadside	No lane departure feedback
Other traffic	Same direction, adjacent lane	Opposite direction, not in adjacent lane
Speed	50 mph*	45 – 65 mph*
Car following distance	150 ft	120 ft
Stimulus presentation	Auditory instructions, drivers must ask for repeat if needed	Visual display, information always available if needed
Secondary task instruction	All task instructions given before testing	Task instructions given as part of task block
Secondary task order	Mixed presentation of tasks within same drive, randomized order	Tasks tested separately in blocks, block order varied systematically
Secondary task timing	Experimenter input required	Participant signals end directly via touch screen

*Not consistent with Alliance Guideline specifications.

The effects of these procedural differences on metric values and test outcomes are unknown.

The second comparison between the present study and the MNTE study results used data from the Alliance Principle 2.1B metrics obtained in this study and the DFD metrics obtained in the MNTE study (Ranney et al., 2011). This comparison involved the use of the respective decision criteria associated with these metrics. For the Alliance Principle 2.1B metrics, differences were considered real when results for both metrics were consistent. For the DFD protocol, differences were considered real when results from 3 of 4 metrics were consistent. Application of these decision criteria thus produced a single decision for each planned comparison. It was determined that the two protocols provided consistent results on 7 of the 10 planned comparisons. The specific comparisons that did not reach agreement are summarized in Table 19.

Table 19. Comparison of Performance Degradation Among Different Metrics

	Comparison	Alliance Conclusion	MNTE Conclusion
1	Dialing contact versus Destination	Destination entry > Dialing contact	Destination entry = Contact
6	Destination entry versus Radio	Destination entry > Radio tuning	Destination entry = Radio tuning
9	Dialing 10-digit versus Text messaging	Dialing 10-digit< Text messaging	Dialing 10-digit = Text messaging

Differences between test outcomes based on Alliance and DFD metrics derive from differences in the construction of the metrics, the most important of which is the treatment of differences in task duration. DFD metrics are computed from data taken from intervals of equal duration; differences in these metrics reflect differences in the average momentary level of task demand between tasks and are not influenced by differences in task duration. In contrast, Alliance Principle 2.1B metrics are computed using data from intervals of different durations, thus combining effects of task duration and task demand. The construction of Alliance Principle 2.1B metrics is presumably based on the assumption that real-world distraction effects are determined by the combined effects of task demand and task duration; however this approach creates several problems for analysis and interpretation, which have been discussed elsewhere (Ranney et al., 2011).

Analyses conducted in this study demonstrated the extent to which task duration influenced one Alliance metric and the effect of eliminating this influence. First, both Alliance Principle 2.1B metrics were found to have moderately strong correlations with task duration. Second, to minimize the influence of task duration, lane exceedance metric values were divided by their associated task durations to create a normalized lane exceedance metric, lane exceedances per second. Analyses conducted with this adjusted metric revealed smaller differences between conditions, several of which were no longer statistically significant. Thus, at least some of the differences evident in the raw metric were due entirely to differences in task duration. In the context of the specific tasks, the results support the following conclusions:

1. When contact dialing and destination entry were performed repeatedly over a fixed time interval, the momentary level of distraction potential, reflected in the mean levels of degraded driving performance, was not different for these two tasks. When the tasks were performed once, the contact dialing required considerably less time than destination entry.
2. When performed repeatedly, radio tuning and destination entry had the same associated momentary levels of driving performance degradation, while one instance of radio tuning could generally be completed in much less time than one instance of destination entry.
3. Phone dialing and text messaging were associated with the same level of momentary driving performance degradation. Dialing was generally completed more quickly than a text messaging task that required opening a message, thinking about a reply, entering the reply and sending the reply message.

More generally, the effects of distraction due to secondary task performance on roadway safety (total exposure to risk) are determined by the combination of the two task attributes: momentary task demands and task duration. The momentary demands of a task have been referred to as distraction potential. Higher momentary demands can occur when one task is more difficult (mentally challenging) or complex (more dimensions) and/or requires more concentrated attention (higher memory load) than another task. Task duration refers to the time required to complete the secondary task. To the extent that secondary task performance involves regular switching of attention between driving and the secondary task, longer duration tasks can be expected to involve more time during which the drivers' attention is not directed toward driving. More demanding tasks can be expected to result in higher levels of driving performance degradation, independent of task duration, due to the higher drain of attentional resources away from driving and the increased difficulty of disengaging from the more demanding task. As shown in this study, secondary task durations differ as a function of primary task demands. Generally, secondary tasks take longer to perform under more demanding driving task conditions.

Experimental methods and the associated metrics to assess distraction effects have generally evolved along two paths. The Alliance Principle 2.1B metrics represent one path, in which metrics combine the effects of the task demand and duration. The second path is represented by the Lane Change Task (LCT) (Mattes & Hallén, 2009) and the DFD metrics, which adjust for differences in task duration. As indicated by the present results, these two approaches can lead to slightly different conclusions about differences between pairs of secondary tasks. It would therefore be preferable if the two approaches could be reconciled to support a single conclusion about differences between secondary tasks. Theoretically, one approach toward such reconciliation would involve combining the effects of a task demand and task duration by multiplying the expected momentary level of driving performance degradation, derived from duration-adjusted metrics, by the expected task duration to create a metric that represents the total amount of driving performance degradation expected over the course of one instance of secondary task performance. This hypothetical construction is conceptually similar to the Alliance Principle 2.1B metrics, which also represent the total degradation over one task instance; however, it has several benefits over the Alliance approach. First, it provides independent estimates of each component, which may be helpful in determining how to redesign a task. Second, the use of duration-adjusted estimates of task demand effects is methodologically better than using data from tasks that have large differences in durations.

5.0 CONCLUSIONS

The main objective of the work described in this report was to evaluate the Alliance Principle 2.1B verification procedure and associated metrics for assessing the distraction potential of secondary tasks (using integrated and/or portable systems) involving manual number and text entry. Of particular interest was determination of the ability of the protocol to discriminate between secondary tasks and their impact on driving performance. The second objective of this work was to determine whether the respective metrics provided comparable answers to questions about which tasks are more distracting than others. The third objective was to determine the effect of using different sample sizes with the particular Alliance Principle 2.1B verification procedure implementation used here.

Sixty-three participants, ages 35-54, completed a single session in which they drove a 2010 Toyota Prius V connected to a low-fidelity (PC-based) simulator while performing the secondary tasks. The test protocol required participants to maintain a constant following distance behind a lead vehicle that was traveling at a constant speed (50 mph). Alliance driving performance metrics included lane exceedance frequency and the SD of car-following headway.

The results support the following conclusions:

1. Text messaging, as implemented in this study, was more distracting than all other number/text entry secondary tasks due to its longer duration and its increased level of task demand, as reflected in one duration-adjusted metric. Differences observed between other secondary tasks were due primarily to differences in task duration.
2. Results from two implementations of the Alliance Principle 2.1B verification procedure provided results that were not consistent, despite the fact that both implementations were largely consistent with specifications contained in the Alliance Guidelines. Differences in driving (primary) task demands appear to have contributed to this finding.
3. The present results imply that implementation specifications in the Alliance Guidelines are not sufficiently detailed to ensure that the verification procedure will provide consistent results across different implementations.
4. Test outcome results differed for samples of different size. The use of smaller samples revealed a pattern of results consistent with the expected loss of statistical power inherent in the use of smaller sample sizes. Differences were also apparent between replications of samples of the same sizes. As would be expected, the use of larger sample sizes provided better results. Based on the results of the current study, neither 20 nor 30 participants is sufficient to obtain consistent test outcome results.
5. Decisions concerning the acceptability of specific manual number/text entry tasks based on Alliance Principle 2.1B metrics were not consistent with decisions made using DFD metrics. Different conclusions derive from some combination of three factors: (1) driving behaviors represented by the metrics, including target detection in the DFD protocol, (2) metric construction, reflecting the treatment of task duration, and (3) decision criteria.
6. Real-world distraction effects are determined by the combined effects of task demand and task duration. Alliance (duration-influenced) and DFD (duration-adjusted) metrics provide complementary information about differences between secondary task distraction

effects. A combination of these two types of information provides a more complete estimate of the total exposure to crash risk associated with secondary task performance.

7. Alliance Principle 2.1B metrics are influenced by differences in task duration. Use of these metrics alone makes it impossible to determine whether differences between tasks are due to differences in task demand or differences in task duration. DFD metrics reveal differences due to differences in task demand but provide no information about task duration.

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Appendix A: Subject Demographic Data

The phone / internet screening tool provided basic information about the participants, as well as, some information about their respective experiences with cell phones, navigation systems and text messaging. The tables below attempt to quantify that information reported by the participants during the phone or internet screening interviews. The information is quantified for all participants, showing a breakdown by age group.

Table A1 shows a breakdown of participant age information.

Table A1. Participant Age Information

	Participant Age (Years)		
Age Group (n)	**Mean**	**SD**	**Range**
All (64)	43.7	6.1	(35, 54)
35 to 44 (32)	38.3	2.9	(35, 44)
45 to 54 (32)	49.0	2.8	(45, 54)

Table A2 shows a breakdown of participant height information.

Table A2. Participant Height Information

	Participant Height (Inches)		
Age Group (n)	**Mean**	**SD**	**Range**
All (64)	68	3.8	(59, 78)
35 to 44 (32)	68	4.4	(59, 78)
45 to 54 (32)	68	3.1	(63, 74)

Table A3 shows whether or not the participant's job involves any type of driving.

Table A3. Does Your Job Involve Any Type of Driving

	Participants Whose Job Involves Driving	
Age Group (n)	**Yes**	**No**
All (64)	43	21
35 to 44 (32)	20	12
45 to 54 (32)	23	9

Table A4 shows the approximate number of years of driving experience.

Table A4. Number of Years of Driving Experience

	Driving Experience (Years)		
Age Group (n)	**Mean**	**SD**	**Range**
All (64)	27	7	(11, 38)
35 to 44 (32)	22	3	(11, 27)
45 to 54 (32)	33	3	(26, 38)

Table A5 shows the approximate number of miles driven per year.

Table A5. Approximate Number of Miles Driven Each Year

	Driving Experience (Thousands of Miles Per Year)					
Age Group (n)	**7-10**	**10-15**	**15-20**	**20-30**	**30-40**	**>40**
All (64)	8	27	12	11	5	1
35 to 44 (32)	5	12	4	6	1	4
45 to 54 (32)	3	15	8	5	0	1

Participants were asked how comfortable they were with multi-tasking while driving, using a scale from 0 to 10, with 0 being the least comfortable. Table A6 shows those results.

Table A6. Comfort Level Associated With Multi-Tasking While Driving

	Multi-Tasking Comfort Level (0 to 10 scale, 0 = Least Comfortable)		
Age Group (n)	**Mean**	**SD**	**Range**
All (64)	8.9	1.2	(3, 10)
35 to 44 (32)	8.8	1.5	(3, 10)
45 to 54 (32)	8.9	0.9	(7, 10)

Table A7 shows whether or not the participants use a cell phone while driving.

Table A7. Do You Use a Cellular Phone While Driving?

	Use of a Cell Phone While Driving	
Age Group (n)	**Yes**	**No**
All (64)	64	0
35 to 44 (32)	32	0
45 to 54 (32)	32	0

Participants were asked how long they have used a cellular phone while driving. Table A8 shows those results.

Table A8. Number of Years Using Cellular Phone While Driving

	Cell Phone While Driving (Years)			
Age Group (n)	**1-2**	**3-5**	**5-10**	**>10**
All (64)	4	11	32	17
35 to 44 (32)	2	6	16	8
45 to 54 (32)	2	5	16	9

Participants were asked what percentage of their normal driving time was spent using a cellular phone. Table A9 shows those results.

Table A9. Percentage of Time Using Cellular Phone During Normal Driving

	Percentage of Time Using Phone During Normal Driving		
Age Group (n)	**Mean**	**SD**	**Range**
All (64)	36%	25%	(2%, 100%)
35 to 44 (32)	34%	24%	(2%, 90%)
45 to 54 (32)	38%	27%	(2%, 100%)

Table A10 shows whether or not the participants regularly communicate using text messages. The question on the screening form required a “Yes” or “No” response to the question: “Do you regularly communicate using text messages?” However, all five of those who answered “No” to this question, said they sometimes use text messages when they were later asked over the phone whether they ever send text messages. Thus, those participants sometimes communicate using text messages, but not what they would consider to be regularly.

Table A10. Do You Regularly Communicate Using Text Messages

	Communicate Regularly Using Text Messages	
Age Group (n)	**Yes**	**No**
All (64)	59	5
35 to 44 (32)	31	1
45 to 54 (32)	28	4

In the tables that follow (where n = 59), these questions were asked only of those respondents who answered “Yes” to the question: “Do you regularly communicate using text messages?” After receiving a “No” response to this question, the internet screening form would not have presented these conditional questions to the respondents.

Participants were asked: “On average, how many text messages do you send during a single day?” The results are shown in 0 below.

Table A11.Average Number of Text Messages Sent Each Day

	Number of Text Messages Sent Per Day		
Age Group (n)	**Mean**	**SD**	**Range**
All (59)	26.3	33.2	(1, 100)
35 to 44 (31)	23.9	27.1	(2, 100)
45 to 54 (28)	29.0	39.1	(1, 200)

Participants were asked: "Are you comfortable creating text messages while driving?" Table A12 shows whether or not the participants are comfortable creating text messages while driving.

Table A12.Comfortable Creating Text Messages While Driving

	Comfortable Text Messaging While Driving	
Age Group (n)	**Yes**	**No**
All (59)	37	22
35 to 44 (31)	18	13
45 to 54 (28)	19	9

Being comfortable creating text messages while driving was not made a prerequisite for participation. In follow-up phone calls, it was determined that many people who responded "No" to this question would admit to text messaging while driving occasionally, but had been reluctant to answer "Yes" on the screening form, suggesting it is something that perhaps they shouldn't be doing while driving.

Table A13 shows what type of keyboard (full QWERTY keyboard or numeric keypad) participants normally use for creating text messages.

Table A13.Type of Keyboard Participants Normally Use for Creating Text Messages

	Type of Keyboard Used for Text Messaging	
Age Group (n)	**QWERTY**	**Number**
All (59)	42	17
35 to 44 (31)	22	9
45 to 54 (28)	20	8

Table A14 shows whether the participants keyboard on their phones are comprised of hard buttons or a touch screen.

Table A14.Keyboard Interface on Personal Phone

	Keyboard Interface on Personal Phone	
Age Group (n)	**Buttons**	**Touch Screen**
All (59)	42	17
35 to 44 (31)	23	8
45 to 54 (28)	19	9

Table A15 shows the number of participants who use a navigation system, computer or other similar device in their personal vehicles.

Table A15.Use Navigation System, Computer or Similar Device in Personal Vehicle

	Navigation System, Computer or Similar Device in Personal Vehicle	
Age Group (n)	**Yes**	**No**
All (64)	32	32
35 to 44 (32)	17	15
45 to 54 (32)	15	17

Table A16 shows the number of participants who have ever used a navigation system to obtain route guidance directions while driving.

Table A16.Used Navigation System to Obtain Route Guidance Directions While Driving

	Obtained Route Guidance Directions While Driving	
Age Group (n)	**Yes**	**No**
All (64)	58	6
35 to 44 (32)	30	2
45 to 54 (32)	28	4

Appendix B: Participant Informed Consent Form

PARTICIPANT INFORMED CONSENT FORM

STUDY TITLE: Distraction Effects of Number and Text Entry

STUDY INVESTIGATOR: Thomas A. Ranney, Ph.D.

STUDY SITE: Transportation Research Center Inc.
10820 State Route 347
East Liberty, OH, 43319

TELEPHONE: 1-800-262-8309

SPONSOR: U.S. Department of Transportation
National Highway Traffic Safety Administration (NHTSA)

You are being asked to participate in a research study. Your participation in this research is strictly voluntary, meaning that you may or may not choose to take part. To decide whether or not you want to be part of this research, the risks and possible benefits of this study are described in this form so that you can make an informed decision. This process is known as informed consent. This consent form describes the purpose, procedures, possible benefits and risks of the study. This form also explains how your information will be used and who may see it. You are being asked to take part in this study because the study investigator feels that you meet the qualifications of the study.

The study investigator or study staff will answer any questions you may have about this form or about the study. Please read this document carefully and do not hesitate to ask anything about this information. This form may contain words that you do not understand. Please ask the study investigator or study staff to explain the words or information that you do not understand. After reading the consent form, if you would like to participate, you will be asked to sign this form. You will be given a signed copy of your consent to take home and keep for your records.

PURPOSE

This research study is being conducted by the National Highway Traffic Safety Administration (NHTSA). The purpose of this study is to evaluate the different tools that researchers use to measure the level of distraction caused by "in-vehicle technologies" and portable devices such as cell phones. The latest in-vehicle technologies and some cell phones provide services such as access to the Internet and navigation systems (for maps and driving directions), as well as the ability to send and receive e-mails and text messages. As new in-vehicle technologies are developed and marketed, there is a concern that these systems may interfere with driving. NHTSA is conducting this research study to determine the best way to collect data (information) on the use of in-vehicle technologies while driving.

Participant's Initials ____________

STUDY REQUIREMENTS

You are being asked to participate in this research study because:

- You are 35-54 years of age,
- You have a valid, unrestricted U. S. driver's license (except for restrictions concerning corrective eyeglasses and contact lenses),
- You have a minimum of two years driving experience,
- You drive at least 7,000 miles per year, and
- You are in good general health.

NUMBER OF STUDY SITES AND STUDY PARTICIPANTS

This study will take place at one research site (Transportation Research Center Inc.) and will include approximately 80 men and women.

STUDY PROCEDURES

Before participating in this research study, you will be asked to read this Participant Informed Consent Form in its entirety. After all of your questions have been answered, you will be asked to sign this form to show that you voluntarily consent to participate in this research study.

Your participation in this research study will consist of one session lasting approximately 2.75 hours. During this session you will be asked to complete specific driving objectives while performing different in-vehicle tasks. A member of the study staff will give you detailed instructions and will accompany you at all times during your participation in this research study.

Simulated Driving:

During your session you will be asked to drive a fixed-base simulator. A fixed-based simulator is a machine that imitates the conditions of driving in real life, but does not move. The simulator will be connected to the study vehicle, which will be a recent model-year passenger vehicle (sedan, minivan, or SUV). While driving the simulator, you will sit in the driver's seat of the study vehicle. The study vehicle will have its engine turned off. You will control the simulator by moving the steering wheel and the gas and brake pedals of the study vehicle.

The study vehicle will be equipped with sensors to collect information on your steering, braking and gas pedal usage. The sensors are located so that they will not affect your driving. The information collected by these sensors is recorded so that it can be analyzed at a later time. A large screen in front of the study vehicle will display a computer-generated image of the virtual road on which you will be driving.

Participant's Initials ____________

Driving Objectives:

While operating the simulator, you will be asked to perform specific driving tasks. These tasks will involve activities such as following a car.

In-Vehicle Tasks:

While completing the driving objectives you will be asked to perform specific in-vehicle tasks. The in-vehicle tasks will consist both of tasks using the integrated stereo and navigation system in the study vehicle and tasks using a cell phone.

Summary of Study Procedures:

The following procedures will take place at your session:

- After signing this consent form, you will be given instructions, training, and practice time for driving the simulator and performing the in-vehicle tasks.
- You will then complete a number of short tests. Each test will involve car following plus in-vehicle tasks. You will be asked to complete approximately 26 tests (including all tests completed during training and practice).
- After completing the test drives, the session will end and your participation in this research study will be complete.

NEW INFORMATION

We do not anticipate that any changes to procedures will take place during this study. However, any new information developed during the course of the research that may affect your willingness to participate will be provided to you.

RISKS

Most people enjoy driving in the simulator and do not experience any discomfort. However, a small number of participants experience symptoms of discomfort associated with simulator disorientation. Previous studies with similar driving intensities and simulator setups have produced mild to moderate disorientation effects such as slight uneasiness, warmth, or eyestrain for a small number of participants. These effects typically last for only a short time, usually 10 – 15 minutes after leaving the simulator. If you ask to quit driving as a result of discomfort, you will be allowed to quit at once. You will be asked to sit and rest before leaving, while consuming a beverage and a snack. There is no evidence that driving ability is hampered in any way; therefore, if you show minimal or no signs of discomfort, you should be able to drive home. If you experience anything other than slight effects, transportation will be arranged through other means. This outcome is considered unlikely since studies in similar devices have shown only mild effects in recent investigations and evidence shows that symptoms decrease rapidly after simulator exposure is complete.

Participant's Initials ___________

There are no known physical or psychological risks associated with participation in this study beyond those described above.

BENEFITS

This research study will provide data on driver behavior and in-vehicle task performance that will be used by researchers to provide a scientific basis for developing recommendations or standards for performing in-vehicle tasks while driving. Your participation in this study will provide data that may help develop these recommendations or standards.

You are not expected to receive direct benefit from your participation in this research study.

ALTERNATIVES

This study is for research purposes only. Your alternative is to not participate.

CONDITIONS OF PARTICPATION, WITHDRAWAL, AND TERMINATION

Participation in this research is voluntary. By agreeing to participate, you agree to operate the research vehicle in accordance with all instructions provided by the study staff. If you fail to follow instructions, or if you behave in a dangerous manner, you may be terminated from the study. You may withdraw your consent and discontinue participation in the study at any time without penalty.

Regarding employees who participate in the study, there will be no privilege given for participating in this research study. Likewise, there will be no penalty or drawbacks associated with not participating. Participation is strictly voluntary and will not be tied to any preferential treatment or promotion within the company.

COSTS TO YOU

Other that the time you contribute, there will be no costs to you.

COMPENSATION

You will receive a minimum of $110.00 for the time you spend at the data collection facility. If any delays in testing occur that require your participation to last longer than 2.75 hours, you will be paid at the rate of $26.75 per hour for the additional time.

You will receive mileage reimbursement for mileage to and from the data collection site.

If you voluntarily withdraw or are terminated from this study, you will be compensated for the number of hours that you participated in the study.

Participant's Initials ___________

USE OF INFORMATION COLLECTED

In the course of this study, the following data will be collected:

- Engineering data (such as the information recorded by the study vehicle sensors)
- Video/audio data (such as the information recorded by the video cameras)

Information NHTSA may release:

The **engineering data** collected and recorded in this study will include performance scores based on the data. This data will be analyzed along with data gathered from other participants. NHTSA may publicly release this data in final reports or other publication or media for scientific, education, research, or outreach purposes.

The **video/audio data** recorded in this study includes your video-recorded likeness and all in-vehicle audio (including your voice). The video/audio data may include information regarding your driving performance. Video and in-vehicle audio will be used to examine your driving performance and other task performance while driving. NHTSA may publicly release video image data (in continuous video or still formats) and associated audio data, either separately or in association with the appropriate engineering data for scientific, educational, research or outreach purposes.

Information NHTSA may not release:

Any release of **engineering data** or **video/audio data** shall not include release of your name. However, in the event of a court action, NHTSA may not be able to prevent release of your name or other personal identifying information. NHTSA will not release any information collected regarding your health and driving record.

QUESTIONS

Any questions you have about the study can be answered by Thomas Ranney, Ph.D., or the study staff by calling 1-800-262-8309.

If you have any questions regarding your rights as a research participant, or if you have questions, concerns, complaints about the research, would like information, or would like to offer input, you may contact: Rev. Paul E. Gamber, J.D., Chairman of Sterling Institutional Review Board, 6300 Powers Ferry Road, Suite 600-351, Atlanta, Georgia 30339 (mailing address) at telephone number 1-888-636-1062 (toll free).

Participant's Initials ___________

INFORMED CONSENT

By signing the informed consent statement contained in this document, you agree that your participation is voluntary and that the terms of this agreement have been explained to you. Also, by signing the informed consent statement, you agree to operate the study vehicle in accordance with all instructions provided by the study staff. You may withdraw your consent and discontinue participation in the study at any time without penalty.

NHTSA will retain a signed copy of this Informed Consent form. A copy of this form will also be provided to you.

Participant's Initials ___________

INFORMED CONSENT STATEMENT

I certify that:

- I have a valid, U. S. driver's license.
- All personal and vehicle information as well as information regarding my normal daily driving habits provided by me to NHTSA, and/or Transportation Research Center Inc. (TRC) employees associated with this study during the pre-participation phone interview and the introductory briefing was true and accurate to the best of my knowledge.
- I have been informed about the study in which I am about to participate.
- I have been told how much time and compensation are involved.
- I have been told that the purpose of this study is to evaluate the tools that researchers use to measure driving and in-vehicle task performance.
- I agree to operate the research vehicle in accordance with all instructions provided to me by the study staff.

I have been told that:

- The study will be conducted on a fixed-base driving simulator and that the risk of discomfort associated with simulator disorientation is minimal.
- For scientific, educational, research, or outreach purposes, video images of my driving, which will contain views of my face and accompanying audio data, may be used or disclosed by NHTSA, but my name and any health data or driving record information will not be used or disclosed by NHTSA.
- My participation is voluntary and I may refuse to participate or withdraw my consent and stop taking part at any time without penalty or loss of benefits to which I may be entitled.
- I have the right to ask questions at any time and that I may contact the study investigator, Thomas Ranney, Ph.D., or the study staff at 800-262-8309 for information about the study and my rights.
- I have been given adequate time to read this informed consent form. I hereby consent to take part in this research study.

I, ____, voluntarily consent to participate.
(*Printed Name of Participant*)

____

Signature of Participant Date

____

Signature of Person Explaining Consent Date

Participant's Initials ____________

INFORMATION DISCLOSURE

By signing the information disclosure statement contained in this document, you agree that the National Highway Traffic Safety Administration (NHTSA) and its authorized contractors and agents will have the right to use the NHTSA engineering data and the NHTSA video data for scientific, educational, research, or outreach purposes, including dissemination or publication of your likeness in video or still photo format, but that neither NHTSA nor its authorized contractors or agents shall release your name; and you have been told that, in the event of court action, NHTSA may not be able to prevent release of your name or other personal identifying information. NTHSA will not release any information collected regarding your health and driving record, either by questionnaire or medical examination. Your permission to disclose this information will not expire on a specific date.

I, ____, grant permission to
(Printed Name of Participant)
the National Highway Traffic Safety Administration (NHTSA) to use, publish, or otherwise disseminate NHTSA engineering data and NHTSA video image data, as defined in the Participant Informed Consent Form (including continuous video and still photo formats derived from the video recording), and associated with the appropriate engineering data for scientific, educational, research, or outreach purposes. I have been told that such use may involve widespread distribution to the public and may involve dissemination of my likeness in video or still photo formats, but will not result in release of my name or other identifying personal information by NHTSA or its authorized contractors or agents. I have been told that my permission to disclose this information will not expire on a specific date.

____

Signature of Participant Date

____

Signature of Person Explaining Consent Date

Participant's Initials ___________

Appendix C: Experimenter Test Procedures and Scripts

1. Pre-Briefing

- Information summary and informed consent form

2. Introduction to the Driving Simulator & Driving Practice

Allow participant to become familiar with the operation of the simulator.

- Verbally describe the simulator.
    - "This vehicle is a Toyota Prius, which is connected to a driving simulator so we can collect driving performance data for our study. We have added sensors to the steering wheel, accelerator, and brake pedals. These sensors allow us to run the driving simulator without having the vehicle turned on. Driver control inputs are recorded by these sensors and input to the simulator to change the roadway image projected on the screen in front of the vehicle. Please get into the driver's seat, put on the seat belt, and adjust the seat to your comfort level. You should also make sure that you can reach the buttons on the center console. The seat controls are under the front and on the lower left side of the seat. There is no need to adjust the mirrors as you will not be using them for this experiment. No shifting is required in this vehicle."
- Start the simulation (STISIM).
    - "Now I will start the simulator. Your vehicle appears stopped on the left side of the road.
- Verbally explain the driving task and practice driving without tasks:
    - "First, I'd like you to practice "just driving" to get a feel for the simulator. The phrase "just driving" will be used to refer to driving without performing any other task such as dialing a phone."
    - "Press the accelerator until the vehicle begins to move. Drive the vehicle onto the roadway and accelerate to a speed of 50 mph. …Try making a lane change, decelerating, braking." For this practice drive, you do not need to worry about the other traffic present, for they are transparent at this time.
    - "Now move the vehicle into the right lane and stay in that lane. I will identify a vehicle ahead of you that you will follow while driving. I'll refer to this as the "lead vehicle" because it is leading you through the drive. You should try to follow this vehicle at a distance of 150 ft, which is the distance you see between the vehicles now. Try to maintain this following distance throughout all the driving you will be doing today. When you are "just driving," the lead vehicle will stay at a distance of 150 ft ahead of your vehicle. While performing a requested non-driving task, the lead vehicle will drive at 50 mph regardless of your speed or following distance."
    - "Safe driving is the highest priority! Drive in the right lane and do your best to maintain a speed of 50 mph and following distance of 150 ft behind the lead vehicle. It is important to drive 50 mph, because that is the target speed for the test. If your following distance increases during a task, it is OK to drive faster than 50 mph to catch up to the lead vehicle."
    - "Do you have any questions? OK, now I will let you drive like this for a little while to practice car following."
    - "OK you may bring the vehicle to a stop. Next I will train you on the non-driving tasks."

- Stop and Restart the simulation after the vehicle has come to a stop (label STI output file).

3. Secondary (non-driving) Task Training (Instruction without driving)
All tasks are first explained and then demonstrated by the experimenter. The experimenter sits next to the subject and gives assistance, showing the steps, etc. The experimenter moves to the next step only if he is sure that the participant understood the task. Following the demonstration, the participant attempts the task while the experimenter gives detailed instructions and assistance if necessary. The participant can do as many attempts as necessary until they feel comfortable performing the task. After this training, the participant feels comfortable doing the tasks, but he/she may not remember the exact sequence of the steps.

- "The tasks you will perform today will involve either a hand-held device, such as dialing a cell phone, or a function of the Prius like the original equipment navigation system. I will first demonstrate how to perform a particular task and then let you practice it until you are comfortable performing the task without help. For each trial, you will enter information that I will give you, like a phone number or street address.
- During testing, I will cue you to begin a trial using a standard phrase consisting of the instruction: ***Please do (this task)*** followed by the word ***Go***. For example, when performing the radio tuning task, you will hear something like "**Please enter FM band 92.9. Go**." As soon as you hear the word "go," you should work as quickly and accurately as possible to complete the task without letting your speed and following distance performance deteriorate too much. Remember that safe driving is the highest priority. If you forget the information you are supposed to enter, you can ask for it to be repeated. If you make a mistake while performing a non-driving task, please try to correct the error before moving on.
- Do you have any questions before I give you instructions on the specific tasks you will be performing?"

Radio Tuning
"In this task you will tune the radio to a designated frequency. This vehicle has 3 ways to tune the radio: a tuning knob at the upper right corner of the radio/navigation module, buttons on the steering wheel, and virtual buttons on the touch screen. However, for this task you should only use the tuning knob and Audio/AM/FM buttons on the console when asked to tune the radio (no touch screen, no steering wheel buttons).

(Start on CD or Aux) > Audio > AM or FM > Frequency Up / Down

1) While driving, once you achieve a steady speed of 50 mph, you will hear an audible request to tune to a certain radio frequency. The request will sound like, "Please enter AM band 1210. Go"
2) To tune the radio, first press the "Audio" button located to the lower left of the Prius video screen. The audio display will then appear on the video screen.
3) Select the frequency band by pressing the AM or FM button to the left of the video screen. The current frequency is displayed on the upper right of the screen. If you select the wrong band, press the button for the appropriate band.
4) Use the tuning knob, to the upper right of the screen, to adjust the frequency. When you have reached the frequency that was requested, return to "just driving" and listen for the next requested task.

If you make an error, return to the main audio screen by pressing the "Audio" button and the frequency band (AM or FM) that you need. If you pause while tuning the radio, after about 20 seconds of inactivity, the display will revert to the MAP display. If this occurs, press the "Audio" button again to return to the audio screen.

If you forget the station you are supposed to enter, you can ask for it to be repeated.

Would you like any part of the instructions repeated? Any other questions before we practice this task?"

Practice Trials:

- AM 1590
- FM 102.3

<u>Navigation System Destination Entry by Address</u>

"In this task you will enter destinations into the navigation system by specifying the city, street name, and house number. The destinations will be presented audibly using the request format, "Please enter the destination: 10502 W Capitol Dr., Milwaukee, WI. Go."

1) While driving, once you achieve a steady speed of 50 mph, you will hear an audible request to enter a destination.
2) Press the "DEST" icon to the right of Prius video screen.
3) Four icons will be displayed in the middle of the video screen. Press the icon labeled "Address." The system will display three options for destination entry.
4) We will always enter the city first. Press the "City" button. A keyboard will appear on the screen. Enter the city name on the on-screen keyboard until the system displays a list. Select the city from the list by pressing the bar on which the city name is displayed. If the list has more than 5 matches and the target city is not displayed, you will use the arrow buttons located to the right of the list to move up or down in the list to find the correct city. If the system does not display a list after you've typed the full city name, press the "OK" button on the lower right of the display and then select the city from the resulting list.
5) Two buttons can help you correct errors. If you make an error during keyboard entry, pressing the "Delete" button (a left-pointing arrow in the upper right portion of the on-screen keyboard) will erase the most recently entered letter, one at a time. If the system has already generated a list, pressing the "Back" button (a U-shaped arrow pointing left at the top right portion of the screen) will allow you to go back to the previous screen. This "Back" button is available on every screen.
6) Once you have selected a city, the Street Name screen will appear. Enter the street name on the on-screen keyboard. As you enter the letters a list of streets will appear. Select the correct street name from the list by pressing the bar on which the street name is displayed. If the wrong list appears, use the "Back" and "Delete" buttons to correct any errors.
7) Once you have selected a street, the House Number screen will appear. Enter the house number on the numeric keyboard. Press the "OK" button.
8) A map screen containing the address and an "info" button at the top will appear. Press the "info" button to look at the full address and verify that the city, street and house number are correct. If it is correct, return to "just driving" and await the next requested task. Otherwise use the "Back" and "Delete" buttons to go back and correct any mistakes.

A note about street names: many street names will include designations like North, South, East, West or Road, Street, Avenue, Boulevard, Place, and Highway. You do not need to enter these designations. Just enter the name of the street. When you have entered the full address, the system will present a list of valid matches and prompt you to select one. If the address is incorrect, use the "Back and "Delete" buttons to fix the error.
Remember that if you forget the address you are supposed to enter, you can ask for it to be repeated. Would you like any part of the instructions repeated? Any other questions before we practice this task?"

Practice Trials:

- 10798 Dixie Hwy, Louisville, KY
- 16387 E Warren Ave, Detroit, MI

<u>iPhone 10-Digit Dialing Task</u>

"In this task, you will use an iPhone to dial 10-digit phone numbers. The phone number dialing task will use the same audible request format. When you hear the prompt, you should enter the phone number starting with the 3-digit area code followed by the 7-digit number.

1) While driving, once you achieve a steady speed of 50 mph, you will hear an audible request to dial a 10-digit phone number, such as, "Please dial 937-666-4511. Go."
2) If the phone is locked or displays a blank screen, unlock the phone by pressing the button below the screen (that has a rounded square symbol on it). Next, place your thumb on the arrow on the screen and slide it all the way to the right. A set of icons will appear. If the icons do not appear, press the same button at any time to display the main icon screen. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Touch the "Phone" icon located at the lower left of the touch screen. A numeric keypad will appear.
4) Dial the 10-digit number using this numeric keypad.
    a. If you make an error use the "Delete" icon on the screen (just to the right of the green "Call" icon) to erase an incorrect number or numbers. If the keypad disappears, touch the "Keypad" icon (a drawing of nine squares) on the bottom row of the screen.
5) If the number is correct, touch the green "Call" icon and then immediately touch the red "End Call" icon which will appear at the bottom of the screen. Press the rounded square button below the screen to return to the main icon screen.
6) At this point the task is complete and you should return to "just driving" and wait for the next task request to be announced.
7) If you make an error, press the rounded square button below the screen to return to the main icon screen and start over. If the screen goes blank, press the same button, then place your thumb on the arrow on the screen and slide it all the way to the right to unlock the screen.

Remember that if you forget the phone number you are supposed to enter, you can ask for it to be repeated.
Would you like any part of the instructions repeated? Any other questions before we practice this task?"

Practice Trials:

- 419-740-1267
- 937-597-3788

iPhone Contact Calling Task

"In this task, you will use an iPhone to dial a phone number by selecting a designated contact. The contact names are fictitious and are preloaded into the phone. Names of contacts will be announced using the request, "Please call (first name, last name). Go."

1) Once you have achieved a steady speed of 50 mph, the first requested contact will be announced.
2) If the phone is locked or displays a blank screen, unlock the phone by pressing the button below the screen (that has a rounded square symbol on it). Next, place your thumb on the arrow on the screen and slide it all the way to the right. A set of icons will appear. If the icons do not appear, press the same button at any time to display the main icon screen. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Touch the "Contacts" icon located near the bottom center of the screen. This will open a list of contacts, which is organized alphabetically by last name and then first name. You will need to scroll through this list to find the correct contact.
4) When you have located the desired name, open the contact by touching the name. If you select the wrong contact, you can return to the list by touching the "All Contacts" icon at the top of the screen.
5) Beneath the contact's name is a phone number. Touch the number to dial it. A screen will appear saying "[contact name] Calling Mobile." Once you see this, you can immediately touch the red "End Call" icon and then press the blue "all contacts" icon at the top left of the screen to return to the initial contacts screen, then press the rounded square button below the screen to return to the main icon screen.
6) At this point the task is complete and you should return to "just driving" and wait for the next task request to be announced.
7) If you make an error, press the rounded square button below the screen to return to the main icon screen and start over. If the screen goes blank, press the same button, then place your thumb on the arrow on the screen and slide it all the way to the right to unlock the screen.

Remember that if you forget the contact name you are supposed to call, you can ask for it to be repeated.

Would you like any part of the instructions repeated? Any other questions before we practice this task?"

Practice Trials:

- Barbara Davis
- Paul Williams

<u>iPhone Text Messaging Task</u>

"In this task, you will use the iPhone for text messaging. You will perform this task by retrieving a text message, and then creating a text message in reply to it. The audible prompt for this task will be "Please read and reply to the text message from (name). Go." (Exp: use Kevin Moore for demonstration)

1) So, once you have achieved a steady speed of 50 mph, you will hear a request indicating the name of a person whose text message you are to read.
2) If the phone is locked or displays a blank screen, unlock the phone by pressing the button below the screen (that has a rounded square symbol on it). Next, place your thumb on the arrow on the screen and slide it all the way to the right. A set of icons will appear. If the icons do not appear, press the same button at any time to display the main icon screen. Keep in mind that you may have to do this at other times if the screen times out during the drive.
3) Touch the "Messages" icon at the bottom of the screen. This icon is green and shows a white cartoon balloon. A list of messages will appear.
4) Touch the desired message. The messages will be identified by the names of the fictitious senders of the message. The message will contain a well known phrase which is missing one or more key words. The task is to determine what word or words are missing and then reply to the message by supplying the missing words required to complete the well known phrase.
    a. If you don't know the answer, please create a reply message that says something like "Don't know" or "Not sure." It is important that you reply in some way to each message.
    b. If you select the wrong message, you can return to the list by touching the "Messages" icon at the upper left of the screen.
5) At the bottom of the screen, left of the blue "Send" icon is a white space. Touch this white space and a keyboard will appear. Enter the missing words and then touch the blue "Send" icon located to the right of the text you have entered.
    a. If you make an error use the "Delete" icon on the screen (just to the right of the bottom row of letters). You need not type the entire phrase, but only those words which are missing.
6) After sending each message, touch the blue "Messages" icon at the upper left of the screen to return to the initial message screen and then press the rounded square button below the screen to return to the main icon screen.
7) At this point the task is complete and you should return to "just driving" until the next audible request is announced.

If you make an error, press the rounded square button below the screen to return to the main icon screen and start over. If the screen goes blank, press the same button, then place your thumb on the arrow on the screen and slide it all the way to the right to unlock the screen.
Remember that if you forget the text message you are supposed to reply to, you can ask for it to be repeated.
Would you like any part of the instructions repeated? Any other questions before we practice this task?"

Practice Trials:

- Jennifer Campbell
- Dorothy Watson

4. Driving with Tasks:

- STISim cues the experimenter to request non-driving task trials of each task in randomized order.
- Instruction: "Now we will begin the testing where you will drive and perform non-driving tasks at the same time. If you need a break at any time, let us know; we can stop the vehicle and pause the simulator. There is a scheduled break after 10 task trials. Before we begin the first drive, let me quickly remind you of the instructions:
  - You will begin by moving the vehicle into the right lane and attaining the speed of 50 mph. I will identify a "lead vehicle" ahead of you that you will follow while driving, keeping as best you can a distance of 150 ft and speed of 50 mph.
  - Once you reach a steady speed of 50 mph, I will cue you to begin a trial using the standard phrase: ***Please do (this task)*** followed by the word ***Go***. As soon as you hear the word "go," you should work as quickly and accurately as possible to complete the task without letting speed and following distance performance deteriorate too much. Remember that safe driving is the highest priority. If you forget the information you are supposed to enter, you can ask for it to be repeated. If you make a mistake while performing a non-driving task, please try to correct the error before moving on. After you enter the information completely, return to "just driving" and wait for the next task request to be announced. If your speed has strayed from 50 mph during a trial, you will be asked to return to 50 mph before beginning the next task trial. You will perform 10 task trials and then there will be a brief break before we continue.
  - Do you have any questions before we begin the drive?"

- **Start the simulation.** "Press the accelerator to begin driving, move the vehicle onto the roadway and get up to a speed of 50 mph. Drive in the right lane and do your best to maintain a speed of 50 mph and following distance of 150 ft behind the lead vehicle."

- STISim cues the experimenter to request trials of each task in randomized order.
- If the subject is driving at 50 mph, the command is given to start the task. If not traveling at 50 mph, the participant is reminded to drive at 50 mph and the command is given once 50 mph is achieved.
- The experimenter can give the participant help during these trials.
- Participant is not told that the first two trials of each task are only for practice.

For each trial:

- **The task is announced: e.g., "Please dial phone number xxx-xxx-xxxx. Go."**
- **Upon hearing the word "Go," the experimenter presses "ALT Q" to start data capture and this forces the LV to travel at the current speed, which is why it is important for them to be going exactly 50 mph. Do not wait for the participant to begin the task before pressing ALT Q.**
- **The participant can ask for repeat of the stimulus. Be ready to play the correct repeated .wav file.**
- **Upon completion of the non-driving task, the experimenter presses "ALT Q" to stop the data capture.**

- Between task trials, there is few-second period during which the subject continues to drive and the LV is entrained to the SV before the next trial is prompted. If the subject slows down or speeds up during this period, the experimenter should remind the participant to drive at 50 mph.

- **Break.** After completing the 10 trials, have the participant stop the vehicle in the right lane, then **pause** the simulator. Offer a restroom break as appropriate.

- **Resume driving.** "Now we're going to resume driving. Press the accelerator to begin driving and get up to a speed of 50 mph. Drive in the right lane and do your best to maintain a speed of 50 mph and following distance of 150 ft behind the lead vehicle."
- End. After completing the 15 trials, the testing is over; have the participant stop the vehicle in the right lane, then **stop** the simulator.

5. Post-Brief

"That brings us to the end of the experiment. Now I'd like you to complete a questionnaire to describe how you are feeling physically after having driven the simulator."

- Administer simulator sickness questionnaire.
- Offer a copy of the ICF to the participant to take home with them.

"Do you have any questions? If not, then I'll go over your pay.

Your reimbursement for mileage is $_______ ($0.51 per mile).

Pay for completing the test within 2.75 hrs is $110."

If longer than 2.75 total hrs: "We kept you for longer than 2.75 hours, so for that extra time you will be paid at a rate of $26.75 per hour, which means another $______. We will mail a check for this additional amount to you."

"Here is a check for 2.75 hours of your time and mileage in the amount of $_________.

I would like to thank you for your participation. The data that we have collected is valuable to help us understand distraction and driving behavior.

Do you have any other questions regarding your participation today?"

Appendix D: Simulation Parameters

The following is a list of scenario, roadway and vehicle parameters contained within the STISIM configuration file that was used for this experiment.

StisimConfig_VRTC.Cfg

Date: February 10, 2011
Time: 3:26 PM

Dynamics Settings:
- Yaw rate scale factor = .00008
- Oversteer coefficient = 0
- Acceleration limit = .5
- Deceleration limit =-.65
- Coefficient of drag = .0001
- Yaw instability = .1
- Speed instability = 0
- Steering dead band = 1
- Yaw instability lag = .25
- Idle throttle setting = 0
- Power train parameters:
    - Transmission type = Automatic
    - Clutch required = On
    - Use automatic transmission shifter = Off
    - Use E Shift manual shifting = Off
    - Engine idle gain = 185
    - Linear engine torque gain = .25
    - Second order engine torque gain =-.0001
    - Engine drag coefficient =-.3
    - Engine idle RPM = 1000
    - Clutch pedal input byte = 0
    - Reverse:
        - Gear ratio = 0
        - Up-shift = 20
        - Maximum tachometer value = 4000
        - Gear byte value = 0
    - Gear 1:
        - Gear ratio = 1.5
        - Up-shift = 40.23
        - Maximum tachometer value = 5000
        - Gear byte value = 0
    - Gear 2:
        - Gear ratio = .8
        - Up-shift = 64.37
        - Maximum tachometer value = 5000
        - Gear byte value = 0
    - Gear 3:

        - Gear ratio = .75
        - Up-shift = 85.29
        - Maximum tachometer value = 5000
        - Gear byte value = 0
    - Gear 4:
        - Gear ratio = .7
        - Up-shift = 209.21
        - Maximum tachometer value = 6000
        - Gear byte value = 0
- Steering feel and output gains:
    - Steering feel - Disabled
    - Speedometer gain = 0
    - Tachometer gain = 0

Graphics Settings:
- Desired frame rate - 30
- Screen resolution - 1024 x 768
- Display option - Single monitor
- Monitor startup delay = 0
- Far clipping plane = 700
- Center system screen sizing:
    - Left = 0
    - Right = 1
    - Top = .875
    - Bottom = .125

Initialize Settings:
- Speed limit = 300
- Lateral position = 3
- Maximum divided attention display time = 5
- Maximum digital input response time = 5
- Longitudinal offset distance at start of run = 0
- Warm up distance = 0
- Distance off road before crash occurs = 10
- Sign post lateral position = 3.5
- Crash buffer distance = 10
- Random option = completely random

I/O Control Settings:
- Digital I/O - Disabled
- Controller type - Analog
- Steering axis - 1
- Throttle axis - 2
- Braking axis - 2
- Steering gain = .094736
- Minimum throttle count = 3687
- Maximum throttle count = 2187
- Minimum brake count = 62

Maximum brake count = 2187
Inactivity shutdown time = 3600
Divided attention horn = 0
Divided attention left = 0
Divided attention right = 0
Vehicle Horn = 0
Left turn indicator = 0
Right turn indicator = 0
View left = 0
View right = 0
Drive/Reverse = 0
Pause = 0
Cruise control = 0
Start button = Left turn indicator
Maximum view angle = 90
View angle rate = 180

Other Settings:
Parameter units - Metric
Driver's side of road - Right
System priority - Real-time
Collect time to collision data - Enabled
Prompt for driver information - Disabled
Data file directory - C:\STISIM\MTC\Versuche\DistractionTestingOct2010\Output data\
Driver information directory name -
C:\STISIM\MTC\Versuche\DistractionTestingOct2010\Output data\
Startup instructions bitmap file -
Auditory startup instructions -
Volume = 10
Divided attention symbols - Disabled
Serial communication data:
Communication Port - COM1
Baud rate - 19200
Parity - None
Data bits - 8
Stop bits - 1
Open Module Parameters:
Module name =
C:\STISIM\MTC\Versuche\DistractionTestingOct2010\OpenModule\project.dll
Parameter file =
C:\STISIM\MTC\Versuche\DistractionTestingOct2010\OpenModule\parameter.om

Post Run Settings:
Display data header - Enabled
Display divided attention data - Disabled
Display performance data - Enabled
Display mistakes - Enabled
Display individual mistakes - Enabled

Exit program after run - Disabled
Display pass/fail screen - Disabled
Display summary at end of run - Disabled
Print summary at end of run - Disabled
Organization name = none
Simulation reference time = 100
Run completion reward = 10
Reference time reward/penalty = 1
Accident penalties = 1
Ticket penalties = 1
Divided attention reward/penalty = .25
Mean divided attention response time = 2.5

Roadway Scenery Settings:
Background - Mountains
Ambient lighting = 1
Diffuse lighting = .5
Gamma correction = 2
Atmospheric conditions - Disabled

Sound Settings:
Master volume - 100
WAV file volume - 100
Crash auditory - Enabled
Crash file - C:\Stisim\Sound\car_crash.wav
Volume = 6
Crash reset - Position and speed
Siren file - C:\STISIM\Sound\Siren1.wav
Speeding - Off
Stop signs - Off
Traffic lights - Off
Only with police - Off
Volume = 10
Engine - Enabled
Engine file - C:\STISIM\Sound\RPM1400.WAV
Volume = 10
Brake tire screech - Enabled
Brake tire screech file - C:\STISIM\Sound\screech2.wav
Volume = 1
Screech threshold = 1.6
Cornering tire screech - Enabled
Cornering tire screech file - C:\STISIM\Sound\screech3.wav
Volume = 1
Screech threshold = 1.6
Off road - Enabled
Off road file - C:\STISIM\Sound\Gravel.Wav
Volume = 10

Horn - Enabled
Horn file - C:\STISIM\Sound\Horn.wav
Volume = 10

Vehicle Settings:
Speedometer - None
Vehicle cab option - None
Vehicle cab motion - Disabled
U Turns - Enabled
Drive/Reverse indicator - Disabled
Width = 1.77
Length = 4.572
Maximum speed = 72
Time display - Enabled
Display on the right
Medium font size
Center mirror - Enabled
Left = .65
Right = .95
Top = .8
Bottom = .65
Horizontal angle = 0
Vertical angle = 0
X position = .1524
Y position = 0
Z position = 1.0668
Field of view = 18
Left mirror - Disabled
Right mirror - Disabled
Turn signals - Enabled
Blink rate = .67
Minimum display time = 1.3
Top position = .25
Left position = .05
Right position = .85
Sound file = C:\STISIM\Sound\TurnSignal.Wav
Volume setting = 10

View and Playback Settings:
Driver's eye position and orientation:
Longitudinal = 0
Lateral =-.38
Vertical = 1.06
Heading = 0
Pitch = 0
Alternate eye position and orientation:
Longitudinal = 10
Lateral =-25

Vertical = 50
Heading = 0
Pitch = 0
Translate with vehicle = Enabled
View locked to vehicle = Enabled
Initial view at start = Driver

Simulation Colors (Red, Green, Blue attributes):
Color 1 = 0, 0, 0
Color 2 = 0, 0, 128
Color 3 = 0, 128, 0
Color 4 = 0, 128, 128
Color 5 = 128, 0, 0
Color 6 = 128, 0, 128
Color 7 = 128, 128, 0
Color 8 = 192, 192, 192
Color 9 = 128, 128, 128
Color 10 = 0, 0, 255
Color 11 = 0, 255, 0
Color 12 = 0, 255, 255
Color 13 = 255, 0, 0
Color 14 = 255, 0, 255
Color 15 = 255, 255, 0
Color 16 = 255, 255, 255
Color 17 = 222, 222, 222
Color 18 = 80, 50, 0
Color 19 = 150, 157, 55
Color 20 = 255, 128, 0
Color 21 = 0, 0, 0
Color 22 = 0, 0, 0
Color 23 = 0, 0, 0
Color 24 = 0, 0, 0
Color 25 = 0, 0, 0
Color 26 = 0, 0, 0
Color 27 = 0, 0, 0
Color 28 = 0, 0, 0
Color 29 = 0, 0, 0
Color 30 = 0, 0, 0
Color 31 = 0, 0, 0
Color 32 = 0, 0, 0
Color 33 = 0, 0, 0
Color 34 = 0, 0, 0
Color 35 = 0, 0, 0
Color 36 = 0, 0, 0
Color 37 = 0, 0, 0
Color 38 = 0, 0, 0
Color 39 = 0, 0, 0

Color 40 = 0, 0, 0
Color 41 = 0, 0, 0
Color 42 = 0, 0, 0
Color 43 = 0, 0, 0
Color 44 = 0, 0, 0
Color 45 = 0, 0, 0
Color 46 = 0, 0, 0
Color 47 = 0, 0, 0
Color 48 = 0, 0, 0
Color 49 = 0, 0, 0
Color 50 = 0, 0, 0
Color 51 = 0, 0, 0
Color 52 = 0, 0, 0
Color 53 = 0, 0, 0
Color 54 = 0, 0, 0
Color 55 = 0, 0, 0
Color 56 = 0, 0, 0
Color 57 = 0, 0, 0
Color 58 = 0, 0, 0
Color 59 = 0, 0, 0
Color 60 = 128, 255, 0
Color 61 = 128, 255, 0
Color 62 = 128, 255, 0
Color 63 = 128, 255, 0
Color 64 = 128, 255, 0

Object Colors and Textures (Color or Texture, Width):
Fog = 8
Ground = C:\STISIM\Data\Textures\Grass04.Jpg, 100
Roadway = C:\STISIM\Data\Textures\Road01.Jpg, 5
Roadway centerline = 16
Roadway lane markers = 16
Roadway edge lines = 16
Speedometer bar = 10
Hood = 1
Divided attention boxes = 8
Divided attention symbols = 13
Speedometer text = 16
Speedometer text background = 1
Roadway shoulder = C:\STISIM\Data\Textures\Road01.Jpg, 5
Roadway fore slope = C:\STISIM\Data\Textures\Grass04.Jpg, 100
Roadway median = C:\STISIM\Data\Textures\Grass04.Jpg, 100
Turn signal indicators = 63
Far ground = 19

General Settings:
Display collision blocks = Disabled
Disable output file warning = Enabled

DOT HS 811 571
February 2012

U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

www.nhtsa.gov