DRIVER DISTRACTION IN COMMERCIAL VEHICLE OPERATIONS

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

September 2009

FOREWORD

The Federal Motor Carrier Safety Administration awarded a contract to investigate driver distraction in commercial motor vehicle drivers. The purpose of this study was to characterize driver inattention in safety-critical and baseline events and to determine the relative risk of driving while distracted. The purpose of this report was to document the method, results, and conclusions from this study.

NOTICE

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16. Abstract

This study investigated the impact of driver distraction in commercial motor vehicle (CMV) operations. Data from two earlier naturalistic studies were combined to create a data set of 203 CMV drivers and 55 trucks from seven trucking fleets operating at 16 locations. A total of 4,452 safety-critical events (i.e., crashes, near-crashes, crash-relevant conflicts, and unintentional lane deviations) were identified in the data set, along with 19,888 baseline (uneventful, routine driving) epochs. Data analyses included odds ratio calculations and population attributable risk estimates. Key findings were that drivers were engaged in non-driving related tasks in 71 percent of crashes, 46 percent of near-crashes, and 60 percent of all safety-critical events. Also, performing highly complex tasks while driving lead to a significant increase in risk. Eye glance analyses examined driver eye location while performing tasks while operating a CMV. Tasks associated with high odds ratios (increased risk) were also associated with high eyes off forward road times. This suggests that tasks that draw the driver's visual attention away from the forward roadway should be minimized or avoided. Based on the results of the analyses, a number of recommendations are presented that may help address the issue of driver distraction in CMV operations.

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SI* (MODERN METRIC) CONVERSION FACTORS

Table of APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME	Note: Volumes greater than 1000 L shall be shown in m^3	
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE	Temperature is in exact degrees	
°F	Fahrenheit	5 × (F-32) ÷ 9 or (F-32) ÷ 1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		Force and Pressure or Stress		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

Table of APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE	Temperature is in exact degrees	
°C	Celsius	1.8C + 32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		Force & Pressure or Stress		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003, Section 508-accessible version September 2009)

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LIST OF ACRONYMS

Acronym	Definition
ANOVA	analysis of variance
CB radio	Citizens Band radio
CMV	commercial motor vehicle
DART	data analysis and reduction tool
DAS	data acquisition system
DDWS FOT	Drowsy Driver Warning System Field Operational Test
EYESOFF	eyes off roadway
EYETRANS	eye transition
GPS	global positioning system
GVWR	gross vehicle weight rating
FMCSA	Federal Motor Carrier Safety Administration
LCL	lower confidence limit
LOS	level of service
L/SH	local/short haul
LTCCS	Large Truck Crash Causation Study
NHTSA	National Highway Traffic Safety Administration
NTDS	Naturalistic Truck Driving Study
OR	odds ratio
ORD	observer rating of drowsiness
PAR	population attributable risk
SD	standard deviation
TTC	time to collision
UCL	upper confidence limit
USDOT	U. S. Department of Transportation

EXECUTIVE SUMMARY

Promoting safe operation of commercial motor vehicles (CMVs) and reducing the number and severity of crashes on U.S. roadways is critical to the mission of the Federal Motor Carrier Safety Administration (FMCSA). The most recently published crash data indicate that 41,059 people were killed in road crashes in 2007 (FMCSA, 2009a). Of these fatalities, 12 percent (4,808) involved large trucks. Although this represented a net decrease in fatalities, down 7.5 percent from 1998 to 2007, it represents far too many deaths for our nation's road users.

In direct support of FMCSA's mission, the current study involved a detailed investigation of CMV "driver distraction," a prominent type of "driver error" known to contribute to motor vehicle crashes. Past research has suggested that driver distraction and driving inattention may be involved in 78 percent of light-vehicle crashes (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006). It should be noted that most of the research that has been conducted to investigate driver distraction has occurred with light-vehicle (e.g., passenger automobile) drivers and, as such, the impact of driver distraction of CMV crashes has not been well-understood.

The purpose of the current study was to address this gap in the literature by investigating driver distraction in CMV operations. To accomplish this, data from two large-scale CMV naturalistic truck driving studies (Hanowski et al., 2008; Blanco et al., in press) were combined and analyzed. Naturalistic data collection is a method used to study driver behavior and performance by installing sensors and video cameras in fleet trucks and providing these vehicles to truck drivers to use as part of their normal revenue-producing deliveries. Taken together, these data sets represent 203 CMV drivers, seven trucking fleets, and 16 fleet locations. In terms of data, the data set used includes approximately 3 million miles of continuously collected kinematic and video data, and represents the most comprehensive naturalistic CMV driving set in the world.

DRIVER DISTRACTION IN CMV SAFETY-CRITICAL EVENTS

To investigate distracting tasks that were present in the CMV data set, the data were filtered for safety-critical events. These events are defined as crashes, near-crashes, crash-relevant conflicts (less severe near-crashes), and unintentional lane deviations. This filtering process, using kinematic data thresholds and video review and validation, resulted in 4,452 safety-critical events: 21 crashes, 197 near-crashes, 3,019 crash-relevant conflicts, and 1,215 unintentional lane deviations. These safety-critical events were combined into a single data set. In addition, 19,888 baseline epochs (uneventful, routine driving) of normal driving were randomly selected. The amount of time a driver was in the study was used to weight the frequency of baseline epochs per driver. As such, drivers who were in the study for a longer duration (e.g., 12 weeks) had more baseline epochs than drivers in the study for less time (e.g., 8 weeks).

Following the method used in Klauer et al. (2006), of the 4,452 safety-critical events, 81.5 percent had some type of driver distraction listed as a potential contributing factor. Table 1 displays the percentage of *any* secondary and/or tertiary tasks that were present in all safety-critical events and all events where the Vehicle 1 driver (i.e., the participant driver) was judged to be at-fault in the safety-critical event. Tasks were categorized as tertiary (non-driving related) and secondary (driving related, but not required for vehicle control; Ablassmeier, Poitschke, Wallhoff, Bengler, & Rigoll, 2007).

Table 1. Frequency and Percentage of Any Secondary and/or Tertiary Task in "All" and "Vehicle 1 At-Fault" Events

Event Type	All Safety-Critical Events	Frequency and Percent of All Safety-Critical Events	All Vehicle 1 At-Fault Events	Frequency and Percent of All Vehicle 1 At-Fault Events
All safety-critical events	81.5%	n = 4,452 (100.0%)	83.4%	n = 3,618 (100.0%)
Crashes	100.0%	n = 21 (0.5%)	100.0%	n = 10 (0.3%)
Near-crashes	78.7%	n = 197 (4.4%)	83.0%	n = 112 (3.1%)
Crash-relevant conflicts	79.1%	n = 3,019 (67.8%)	81.1%	n = 2,281 (63.0%)
Unintentional lane deviations	87.7%	n = 1,215 (27.3%)	87.7%	n = 1,215 (33.6%)
Baseline epochs	76.9%	n = 19,888 (100.0%)	76.9%	n = 19,888 (100.0%)

Though a breakdown of each Event Type is provided in Table 1, caution must be used in interpreting individual Event Types. While Klauer et al. (2006) found that 78 percent of crashes contained at least one type of inattention category (i.e., secondary task distraction; driving-related inattention to forward roadway; drowsiness; and non-specific eye glance away from the forward roadway), the current study, following the Klauer et al. method, found that 100 percent of crashes contained at least one type of inattention task (either secondary or tertiary). It is important to point out a few caveats in comparing these two studies. First, and perhaps most importantly, the percentages in Table 1 include *any* task that was present within the 6-s interval; often times the task was driving-related such as checking the side mirror. Because Klauer et al. included checking mirrors as a distraction type, this approach was followed in the current study. However, based on training received by CMV drivers, who are instructed to check mirrors every 5–8 s (FMCSA, 2009b), it would be expected that video of the drivers would show them regularly checking their mirrors. This would, in turn, inflate the percentages seen in the current study and may not represent an accurate picture of "driver distraction" in CMV operations.

A second caveat when comparing the results from the Klauer et al. (2006) study and the current study is the data collection time frames of the studies. The Klauer et al. study was conducted from January 2003 to July 2004, while the Drowsy Driver Warning System Field Operational Test (DDWS FOT) was conducted from May 2004 to September 2005 (Hanowski et al., 2008), and the Naturalistic Truck Driving Study (NTDS) study was conducted from November 2005 to May 2007 (Blanco et al., in press). Because of these time period differences, the specific types of distraction across studies were similar, but not identical. For example, as will be described, a key finding in the current study was the high risk associated with texting. However, because texting is a relatively recent phenomenon, there were *no* cases of texting in the Klauer et al. study. However, we know that light-vehicle drivers engage in texting. As such, if the Klauer et al. study were conducted in present times, it would be expected that the distraction percentages may be different (or, at least, texting would be represented).

Third, while the distraction categories used were similar across studies, they were not exactly the same and the current study had additional non-driving related distractions (e.g., texting, using calculator, using dispatching device) that were not cited in Klauer et al. (2006).

Finally, it should be noted that crashes were a rare occurrence in the current study (<0.5 percent of all safety-critical events). Klauer et al. (2006) had 69 crashes in the light-vehicle data set; approximately three times as many collected in the CMV data sets. Also, the majority of the crashes in the CMV data sets were relatively minor, including deer hits (n = 5) and contact with an object (e.g., construction cone, piece of debris) in the road or on the side of the road (n = 9).

Collectively, these caveats underline the need for caution when comparing results from the current study with Klauer et al. (2006) and interpreting the results of individual event types, particularly those with small sample sizes (crashes). Table 2 provides an alternative approach, which the authors believe to be more appropriate, to evaluating the impact of driver distraction in the current CMV study.

Table 2 shows the percentage of all safety-critical events, and events where the Vehicle 1 driver (i.e., the participant driver) was judged to be at-fault, and where the driver was engaged in a non-driving related, tertiary, task. As shown, driver distraction due to non-driving related tertiary tasks was a contributing factor in 71 percent of crashes, 46 percent of near-crashes, and 60 percent of all events. Table 2 may capture the effects of "driver distraction" as many people think of it. That is, the events in Table 2 represent driving while also engaged in a non-driving related activity such as using a cell-phone, texting, eating, etc. As noted, Klauer et al. (2006) did not distinguish between secondary and tertiary tasks in the light-vehicle study so a direct comparison to the light-vehicle data is not possible.

Table 2. Frequency and Percentage of Any Tertiary Tasks in "All" and "Vehicle 1 At-Fault" Events

Event Type	All Safety-Critical Events	Frequency and Percent of All Safety-Critical Events	All Vehicle 1 At-Fault Events	Frequency and Percent of All Vehicle 1 At-Fault Events
All safety-critical events	59.9%	n = 4,452 (100.0%)	63.9%	n = 3,618 (100.0%)
Crashes	71.4%	n = 21 (0.5%)	40.0%	n = 10 (0.3%)
Near-crashes	46.2%	n = 197 (4.4%)	50.0%	n = 112 (3.1%)
Crash-relevant conflicts	53.6%	n = 3,019 (67.8%)	57.4%	n = 2,281 (63.0%)
Unintentional lane deviations	77.5%	n = 1,215 (27.3%)	77.5%	n = 1,215 (33.6%)
Baseline epochs	56.5%	n = 19,888 (100.0%)	56.5%	n = 19,888 (100.0%)

Three research questions were identified as critical to the current analysis effort:

- Research Question 1: What are the types and frequency of tasks which drivers engage in prior to involvement in safety-critical events? What are the odds ratios (OR) and the population attributable risk (PAR) percentages for each task type?
- Research Question 2: What environmental conditions are associated with driver choice of engagement in tasks? What are the odds of being in a safety-critical event while engaging in tasks while encountering these conditions?
- Research Question 3: What are the odds ratios of eyes-off-forward-roadway? Does eyes-off-forward-roadway significantly affect safety and/or driving performance?

RISK ASSOCIATED WITH DISTRACTING TASKS

Odds ratio analyses were calculated to identify tasks that were high risk. That is, tasks that were associated with an increased likelihood of involvement in a safety-critical event compared to uneventful baseline driving. Odds of occurrence were defined as the probability of event occurrence (safety-critical event) divided by the probability of non-occurrence (baseline epoch). These probability estimates were conditioned on the presence/absence of the behavior of interest and then compared via ratios. For a given task, an odds ratio of 1.0 indicated the outcome was equally likely to occur given the condition (i.e., equally likely to occur in the safety-critical event data as in the baseline, uneventful/routine driving data). An odds ratio greater than 1.0 indicated the outcome was more likely to occur given the presence of the task, and odds ratios of less than 1.0 indicated the outcome was less likely to occur (Pedhazur, 1997). When considering odds ratios, it was also important to look at calculated confidence limits. Along with an odds ratio statistic, lower confidence limits (LCL) and upper confidence limits (UCL) were calculated. To interpret the odds ratio, the range of the LCL and UCL must not include 1.0 to be considered statistically significant (a 95 percent confidence interval was used in this study). Table 3 shows the results from the analyses that included all safety-critical events (similar findings resulted from analyses of events where the truck driver was judged to have been at-fault). Tasks were considered individually, but were also grouped by tertiary and secondary classifiers. For tertiary tasks, the level of complexity of the task (as outlined by Klauer et al., 2006) was used as a grouping factor. Odds ratios, along with the LCL and UCL are shown in Table 3. Large odds ratios (greater than 1.0) that have LCL and UCL ranges that do not include 1.0 indicate that the task is risky. As shown in Table 3, the most risky behavior identified was “text message on cell phone,” with a significant odds ratio of 23.2 (as the LCL and UCL range does not include 1.0). This means that drivers who text message while driving were 23.2 times more likely to be involved in a safety-critical event, compared to a baseline epoch, than if they were not text messaging while driving.

Table 3. Odds Ratios and 95% Confidence Intervals to Assess Likelihood of a Safety-Critical Event While Engaging In Tertiary Tasks for All Events

TASK	Odds Ratio	LCL	UCL
Complex Tertiary Task			
Text message on cell phone	**23.24***	9.69	55.73
Other—Complex (e.g., cleaning side mirror, rummaging through a grocery bag)	**10.07***	3.10	32.71
Interact with/look at dispatching device	**9.93***	7.49	13.16
Write on pad, notebook, etc.	**8.98***	4.73	17.08
Use calculator	**8.21***	3.03	22.21
Look at map	**7.02***	4.62	10.69
Dial cell phone	**5.93***	4.57	7.69
Read book, newspaper, paperwork, etc.	**3.97***	3.02	5.22
Moderate Tertiary Task			
Use/reach for other electronic device (e.g. video camera, 2-way radio)	**6.72***	2.74	16.44
Other—Moderate (e.g., opening a pill bottle to take medicine, exercising in the cab)	**5.86***	2.84	12.07
Personal grooming	**4.48***	2.01	9.97
Reach for object in vehicle	**3.09***	2.75	3.48
Look back in Sleeper Berth	**2.30***	1.30	4.07
Talk or listen to hand-held phone	1.04	0.89	1.22
Eating	1.01	0.83	1.21
Smoking-related behavior—reaching, lighting, extinguishing	**0.60***	0.40	0.89
Talk or listen to CB radio	**0.55***	0.41	0.75
Look at outside vehicle, animal, person, object, or undetermined	**0.54***	0.50	0.60
Talk or listen to hands-free phone	**0.44***	0.35	0.55
Simple Tertiary Task			
Put on/remove/adjust sunglasses or reading glasses	**3.63***	2.37	5.58
Adjust instrument panel	**1.25***	1.06	1.47
Remove/adjust jewelry	1.68	0.44	6.32
Other—Simple (e.g., opening and closing driver's door)	2.23	0.41	12.20
Put on/remove/adjust hat	1.31	0.69	2.49
Use chewing tobacco	1.02	0.51	2.02
Put on/remove/adjust seat belt	1.26	0.60	2.64
Talk/sing/dance with no indication of passenger	1.05	0.90	1.22
Smoking-related behavior—cigarette in hand or mouth	0.97	0.82	1.14
Drink from a container	0.97	0.72	1.30
Other personal hygiene	**0.67***	0.59	0.75
Bite nails/cuticles	**0.45***	0.28	0.73
Interact with or look at other occupant(s)	**0.35***	0.22	0.55
Secondary Task			
Look at left-side mirror/out left window	**1.09***	1.01	1.17
Look at right-side mirror/out right window	0.95	0.86	1.05
Check speedometer	**0.32***	0.28	0.38

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Several other tasks had significantly high odds ratios. Interacting with a dispatching device (the dispatching devices observed in this data set featured a small keyboard, which drivers often placed on their steering wheel and typed with one or both hands while driving) (OR = 9.9) and dialing a cell phone (OR = 5.9) were two noteworthy complex tertiary tasks associated with substantially elevated risk in being involved in a safety-critical event. Reaching for objects—electronic devices such as a video camera (OR = 6.7) or other objects (OR = 3.1)—is noteworthy because of their common occurrence as found in the PAR analysis (highlighted later).

An interesting finding from the analyses was the result for cell phone use. As indicated, reaching for or dialing a cell phone was indicated to be a high-risk task. However, talking or listening on a hand-held phone was found to have an odds ratio that was not significantly different than 1.0 (thus, it did not elevate the likelihood of being involved in a safety-critical event). Furthermore, talking or listening on a hands-free phone (defined as the driver talking into a headset when it was apparent he/she was not talking to a passenger) provided a significant protective effect (OR = 0.4), as did Citizens Band (CB) radio use (OR = 0.6). It is noteworthy that recent empirical studies have shown benefits of hands-free phone interfaces (Shutko, Mayer, Laansoo, & Tijerina, 2009). This finding from the current study may provide support for “hands-free” cell phone policies and regulations; as of August 2009, six States have banned hand-held cell phone use, but allow hands-free cell phone use; however, no State has banned hands-free cell phone use (Governor’s Highway Safety Association, 2009). Furthermore, the positive findings for “listening and talking” are consistent with results of two recent naturalistic studies with light-vehicle drivers. In the first study, protective effects (defined as decreasing the risk of a safety-critical event) were found for moderately complex tasks, which included talking/listening to handheld devices (F. Guo, personal communication, July 7, 2009). In the second study, when drivers were using a cell phone, they had lower speed variance (i.e., speeds changed more smoothly) and they maintained their eyes on the forward roadway (Sayer, Devonshire, & Flannagan, 2007). One hypothesis for the results in the current study is that reaching for a phone and dialing a phone, like texting, requires manual manipulation (i.e., hand off wheel) and substantial visual attention to complete the task. This visual attention is directed away from the forward roadway such that the driver is not effectively, or safely, operating the CMV. Listening and talking, on the other hand, does not draw the eyes away from the forward road. However, this hypothesis does not consider the impact that “cognitive distraction” may have with listening and talking tasks and further research is required to investigate this finding. Nonetheless, based on the analysis of safety-critical events from the current study, talking/listening was not found to be a risk factor.

POPULATION ATTRIBUTABLE RISK FOR DISTRACTING TASKS

Odds ratios and confidence limits only inform part of the story, that is, which tasks are shown to increase the likelihood of involvement in a safety-critical event. The other part of the story considers the frequency of occurrence of each task (i.e., which task, if removed, would reduce the percentage of safety-critical events). For example, tasks that are rare occurrences (as indicated by low PAR percentages), even though they might be risky, may not significantly increase crashes in the population, nor would their elimination reduce crashes by much. Table 4 shows the results from the PAR analysis for the tertiary and secondary tasks with an odds ratio greater than 1.0. As shown in Table 4, tasks are ordered from largest PAR percentage to smallest

PAR percentage. Specific tasks with the largest PAR percentage included: reaching for an object (PAR = 7.6), interacting with a dispatching device (PAR = 3.1), and dialing a cell phone (PAR = 2.5). Why were the PAR percentages for these tasks greater than the other tasks? The reason was that these tasks were commonly performed by drivers in the current study. Text messaging, on the other hand, though it had a very high odds ratio, was a task performed infrequently by drivers in the current study, thus it does not have a high PAR percentage. However, this does not mean that it should be ignored. On the contrary, it suggests that if texting while driving becomes more prevalent, the frequency of safety-critical events is likely to increase.

Table 4. Population Attributable Risk and 95% Confidence Intervals for Driver Tasks across All Events

Task	PAR Percentage	LCL	UCL
Complex Tertiary Task	**27.46**	**27.24**	**27.67**
Interact with/look at dispatching device	3.13	2.84	3.42
Dial cell phone	2.46	2.02	2.91
Read book, newspaper, paperwork, etc.	1.65	0.96	2.34
Look at map	1.08	0.48	1.68
Text message on cell phone	0.67	0.29	1.04
Write on pad, notebook, etc.	0.56	-0.16	1.28
Use calculator	0.22	-1.00	1.43
Other—Complex (e.g., cleaning side mirror, rummaging through a grocery bag)	0.18	-0.99	1.35
Moderate Tertiary Task	**11.77**	**11.32**	**12.23**
Reach for object in vehicle	7.64	7.27	8.02
Other—Moderate (e.g., opening a pill bottle to take medicine, exercising in the cab)	0.32	-0.92	1.55
Use/reach for other electronic device	0.23	-1.10	1.56
Personal grooming	0.21	-1.58	2.00
Look back in sleeper berth	0.23	-2.24	2.70
Talk or listen to hand-held phone	0.18	-1.29	1.64
Eating	0.02	-1.80	1.83
Simple Tertiary Task	**5.96**	**5.20**	**6.73**
Adjust instrument panel	0.82	-0.47	2.11
Put on/remove/adjust sunglasses or reading glasses	0.62	-0.56	1.80
Talk/sing/dance with no indication of passenger	0.23	-1.12	1.59
Put on/remove/adjust hat	0.06	-4.85	4.98
Use chewing tobacco	0.00	-6.75	6.76
Put on/remove/adjust seat belt	0.04	-5.84	5.92
Remove/adjust jewelry	0.03	-7.89	7.95
Other—Simple (e.g., opening and closing driver's door)	0.02	-7.57	7.62
Secondary Task	**11.71**	**11.29**	**12.13**
Look at left-side mirror/out left window	2.25	1.77	2.75

VISUAL DEMAND FOR DISTRACTING TASKS

The eye glance analyses conducted on the various tasks provided the needed "why" for the findings in the odds ratio analysis. Put simply, tasks that draw drivers' eyes away from the forward roadway were those with high odds ratios. For example, texting, which had the highest odds ratio of 23.2, also had the longest duration of eyes off forward roadway (4.6 s over a 6-s interval). This equates to a driver traveling the length of a football field, at 55 mi/h, without looking at the roadway. Other high visual attention tasks included those that involved the driver interacting with technology: calculator (4.4 s), dispatching device (4.1 s), and cell phone dialing (3.8 s).

Technology-related tasks were not the only ones with high visual demands. Non-technology tasks, including mundane or common activities, with high visual demands included: writing (4.2 s), reading a book/newspaper/other (4.3 s), looking at a map (3.9 s), and reaching for an object (2.9 s).

LONG GLANCES AND SHORT GLANCES

Eye glance analysis was conducted to determine, during the 6-s interval, the drivers' mean duration of eyes off forward roadway (i.e., any time the driver's eyes were not on the forward roadway, either from a single glance or multiple glances). In the current study, CMV drivers' mean duration of eyes off forward roadway was 2.1 s prior to the onset of a crash, 1.7 s prior to the onset of a near-crash, 1.6 s prior to the onset of a crash-relevant conflict, and 1.2 s during the baseline epoch. Klauer et al. (2006) reported that light-vehicle drivers' mean duration of eyes off forward roadway was 1.8 s prior to the onset of a crash, 1.3 s prior to the onset of a near-crash, 1.1 s prior to the onset of a crash-relevant conflict, and 0.9 s during the baseline epoch.

One of the analyses in the current study calculated the odds ratios of the total time eyes off forward roadway for five different time durations. Table 5 illustrates the odds ratios across "All" events in each of the five time durations. As noted, the total eyes off forward roadway time was measured over a 6-s interval for safety-critical events and baseline epochs. Not surprising, longer glances of more than 1.5 s were associated with high risk (OR= 1.3) and very long glances of more than 2 s had the highest risk (OR = 2.9). These findings (i.e., that long eye glance durations away from the forward roadway increase risk) were consistent with light-vehicle results (Klauer et al., 2006). For example, Klauer et al. reported that light-vehicle drivers were 2.19 times more likely to be involved in a crash/near-crash (compared to a baseline epoch) when total eyes off forward roadway time was greater than 2 s.

Table 5. Odds Ratios and 95% Confidence Intervals for All Events to Assess Likelihood of a Safety-Critical Event While Eyes Off Forward Roadway

Total Eyes Off Forward Roadway	Odds Ratio	LCL	UCL
Less than or equal to 0.5 s	**1.36***	1.16	1.58
Greater than 0.5 s but less than or equal to 1.0 s	0.91	0.80	1.03
Greater than 1.0 s but less than or equal to 1.5 s	1.07	0.94	1.23
Greater than 1.5 s but less than or equal to 2.0 s	**1.29***	1.12	1.49
Greater than 2.0 s	**2.93***	2.65	3.23

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold

An additional significant result was found for very short total eyes off road durations (less than or equal to 0.5 s). Klauer et al. (2006) found a similar trend with light-vehicle drivers; however, the odds ratio in the Klauer et al. study was not statistically significant. As shown in Table 5, a significant odds ratio was found when the total time eyes off forward roadway was less than or equal to 0.5 s (OR = 1.4). Though this may be a spurious finding, one possible explanation is the scanning behavior of CMV drivers is likely to be different than the scanning behavior of light-vehicle drivers. More specifically, CMV drivers are taught to continually monitor their environment and regularly scan their mirrors (FMCSA, 2009b). Moreover, large trucks have many blind spots and it can be difficult for CMV drivers to locate other vehicles in their mirrors. It is possible these mirror-checking behaviors lasted longer than 0.5 s in the current study and more complex tasks required many short duration glances. There is some support for this contention in the eye glance analyses results as the mean length of longest glance for secondary tasks (e.g., checking mirrors) was greater than 0.5s: 2.8 s for crashes, 1.5 s for near-crashes, 1.1 s for crash-relevant conflicts and 1.5 s for unintentional lane deviations (discussed in section 5.5.4.6). Also, the mean number of glances away from the forward roadway was 2.7 for near-crashes, 3.1 for crash-relevant conflicts, and 3.2 for unintentional lane deviations when complex tertiary tasks were considered compared to 1.3 for crashes, 1.6 for near-crashes, 1.7 for crash-relevant conflicts and 2.3 for unintentional lane deviations when moderate tertiary tasks were considered (see sections 5.5.3.1 and 5.5.3.2). It is also possible that the significant finding for glances under 0.5 s was because drivers may have been in situations (e.g., following too closely behind a lead vehicle) that would require longer and more frequent glances to monitor the forward roadway. Such situations would likely result in more safety-critical events and may help explain the significant odds ratio. Further analysis would be required to test these hypotheses. The data set is available to conduct a more detailed eye glance analysis with drivers who rarely scanned the driving environment and/or mirrors (i.e., primarily focused on the forward roadway). Such an analysis could investigate the risk implications of not regularly scanning the driving environment. At this point, it is an interesting finding and would require further research.

FINAL CONSIDERATIONS

One of the objectives in this study was to compare results between this CMV study and the light-vehicle study performed by Klauer et al. (2006). Though a few comparisons have been described, perhaps the most important finding, common across both studies, is that driver distraction is prevalent in both light vehicles and CMV operations. It is difficult to make clear comparisons across studies because of the caveats noted previously, including: mirror check as a distraction type and the expected mirror use differences between light-vehicle and CMV drivers, different data collection time frames, different distraction types, and small number of crashes in the CMV study. Nonetheless, an important take-away is that driver distraction is an important contributing factor in safety-critical events for both light-vehicle drivers and CMV drivers.

The current study resulted in a number of important findings related to driver distraction and CMV driver safety. Because this is one of the first naturalistic studies focused on CMV drivers, it will be important to conduct follow-on research to assess the robustness of these findings. As outlined, many of the results were consistent with previous distraction studies with light-vehicle drivers. However, there were also some results, such as the high risk associated with short glances, that may be novel to CMV operations.

Finally, it is important to highlight that some results of the current study and other recent naturalistic driving studies (e.g., Klauer et al., 2006; Sayer et al., 2007) are at odds with results obtained from simulator studies (e.g., Beede & Kass, 2006; Strayer, Drews, & Johnston, 2003). Future research may explore the reasons why such studies often do not reflect studies conducted in actual driving conditions (i.e., the full context of the driving environment). It may be, as Sayer et al. note, that controlled investigations cannot account for driver choice behavior and risk perception as it actually occurs in real-world driving. If this assessment is accurate, the generalizability of simulator findings, at least in some cases, may be greatly limited outside of the simulated environment.

SUMMARY FINDINGS AND RECOMMENDATIONS

The following findings and recommendations by the authors to address driver distraction in CMV operations were formulated through a review of this study. These findings and recommendations provide a summarized list of critical issues and are ordered from general recommendations (e.g., maintain eyes on forward roadway) to more specific recommendations (e.g., no texting). These recommendations focus on improving CMV safety by reducing driver distraction and are intended to provide key take-aways for fleet-safety managers on how they might improve safety by applying the findings from the current study. The authors found and recommended that:

- Fleet safety managers engage and educate their drivers, and discuss the importance of being attentive and not engaging in distracting tasks or behaviors. Even routine types of behaviors (e.g., reaching for an object, putting on sunglasses, or adjusting the instrument panel) can distract and may lead to a safety-critical event.

- Fleet safety managers develop policies to minimize or eliminate the use of in-vehicle devices while driving. The authors also urge fleet safety managers to be cognizant of devices that drivers may bring in the truck cab and use while driving. These may seem innocuous (e.g., calculator), but may increase crash risk, if used while driving.
- Drivers not use dispatching devices while driving and that fleet safety managers educate drivers on the danger of interacting with these devices while driving. Similar to manually dialing a cell phone, if drivers must interact with a dispatching device, the authors recommend that drivers do so only when the truck is stopped.
- Drivers not text while driving. This is a relatively new phenomenon, but data from the current study clearly show an increased risk when drivers text while driving.
- Drivers not manually dial cell phones while driving. If a call must be made, the authors suggest that drivers pull off the road to a safe area, and then dial to make the phone call. Another option, requiring further study, is the use of voice-activated, hands-free dialing, which would allow the driver to maintain eyes on the forward roadway. However, this approach may have implications for “cognitive distraction” (though visual distraction would be expected to be reduced).
- Drivers not read, write, or look at maps while driving. What may seem like quick, commonly performed tasks, such as reading, writing, and looking at maps, were found to significantly draw visual attention away from the forward roadway. These activities, which may be integral to the driver’s job, are not integral to operating the vehicle and the authors recommend that such tasks never be performed while the vehicle is on and in motion.
- Drivers not be prohibited from talking on a cell phone or CB radio as this was not found to increase risk. Regarding cell phones, the findings from the current study clearly indicated that manual device interaction, and the associated high eyes off forward road time, were the key factors to increased risk. Though “visual distraction” is foremost in manual device interaction, potential “cognitive distraction” of talking/listening was not measured in the current study. However, based on the analysis of safety-critical events from the current study, talking or listening were not risk factors.
- Designers of dispatching devices consider the increased risk associated with using their devices and work to develop more user-friendly interfaces that do not draw the driver’s eyes from the forward roadway. Possible solutions include a hands-free interface and/or blocking manual use while the vehicle is in motion.
- Designers of instrument panels consider the increased risk of adjusting panel controls. The authors suggest that designs be intuitive, user-friendly, and not require long glances away from the forward roadway.
- Further research be undertaken into the protective effects of performing certain tasks. Identifying the characteristics of tasks that had protective effects may lead to safety countermeasures.

1. INTRODUCTION

1.1 PROJECT OVERVIEW

The objective of this study was to characterize commercial motor vehicle (CMV) driver inattention in crashes, near-crashes, crash-relevant conflicts, unintentional lane deviations, and baseline (i.e., uneventful, routine driving) epochs that were recorded in two studies sponsored by the Federal Motor Carrier Safety Administration (FMCSA): the Drowsy Driver Warning System Field Operational Test (DDWS FOT) (Hanowski et al., 2008) and the Naturalistic Truck Driving Study (NTDS) (Blanco et al., in press). The characterization of these events focused on identifying *secondary* and *tertiary* tasks (i.e., tasks that may divert the driver's attention away from the *primary* task of driving) and other activities that drivers engaged in prior to events as well as the frequency and percentage of these secondary tasks, tertiary tasks, and other activities. As outlined by Ablassmeier et al. (2007), secondary tasks are related to the driving task (e.g., turn-signal use), but are not necessary to keeping the vehicle on course; tertiary tasks are extraneous tasks (e.g., eating) that are not related to driving.

1.1.1 Overview of Commercial Motor Vehicle Crash Statistics

In the Federal Motor Carrier Safety Regulations (2007), a CMV is defined as a self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle meets any of these standards:

- Has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 4,536 kg (10,001 pounds) or more, whichever is greater.
- Is designed or used to transport more than eight passengers (including the driver) for compensation.
- Is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation.
- Is used in transporting material found by the Secretary of Transportation to be hazardous under 49 U.S.C. 5103 and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR, subtitle B, chapter I, subchapter C.

In 2007, 413,000 large trucks were involved in traffic crashes in the U.S. and 4,584 were involved in fatal crashes; 4,808 people were killed in these crashes (National Highway Traffic Safety Administration, 2008). Of the fatalities resulting from a large truck crash, 75 percent of those killed were occupants of other vehicles, 8 percent were non-occupants, and 17 percent were occupants of large trucks. Thus, trucking safety impacts all road users, and all who share the road with large trucks will benefit from the identification of issues and contributing factors associated with these crashes. Only with a clear understanding of the factors that contribute to crashes can countermeasures, aimed at improving safety, be identified, developed, and deployed.

1.2 DRIVER ERROR

For any given safety-critical event (e.g., crashes, near-crashes, crash-relevant conflicts, and unintentional lane deviations), various contributing factors may play a role. These factors include environmental, vehicle, and driver factors. Research has found that driver factors (including driver errors) are by far the most prominent contributing factor in traffic crashes (Treat et al., 1977; Wierwille et al., 2002). The focus of the current study was to investigate the role that one type of driver error, driver distraction, plays in large-truck safety-critical events. The next section describes why driver distraction is a key contributing factor in safety-critical events, while section 2 provides several definitions of driver distraction, taken from the literature, and highlights key distraction-related studies.

1.2.1 Driver Distraction as a Contributing Factor in Critical Events

Driver distraction occurs when inattention leads to a delay in recognition of information necessary to accomplish the driving task. Crash database analyses have estimated that driver distraction is a primary contributing factor in 25–30 percent of crashes (Wang, Knipling, & Goodman, 1996). This statistic was based on police accident reports completed at the crash scene. In these cases, the investigating police officer indicated "distraction" or "inattention" on the report if the driver admitted to being distracted/inattentive and/or if distraction/ inattentiveness was readily apparent based on eyewitness observation. Because this method has the potential for recording inaccurate or incomplete information, most transportation researchers believe the actual percentage of distraction-related crashes may be higher than 25 to 30 percent.

A study by Hanowski, Perez, and Dingus (2005) investigated CMV driver distraction by studying distraction-related critical events with instrumented vehicles on normal, revenue-producing deliveries (i.e., a naturalistic approach). Hanowski et al. analyzed 178 distraction-related critical events and identified 34 unique distraction types. Further, they found that a small percentage of the participating drivers were responsible for a disproportionate number of these distraction-related critical events. Analysis of the video data collected prior to, during, and after the critical event found that the duration of the secondary or tertiary task, along with the visual demand associated with performing that task, contributed to the occurrence of distraction-related critical events. There were several limitations with the Hanowski et al. study. Most significant was the lack of exposure data (i.e., the analysis did not compare the critical event data to baseline, or normal/normative/uneventful driving data).

A noteworthy light-vehicle naturalistic study that did include exposure data was conducted using 100 instrumented light vehicles (i.e., passenger automobiles) (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006). The “100-Car Study” found that driving inattention was present in 78 percent of light-vehicle crashes (n = 69). This finding was much higher than the 25–30 percent identified in previous crash database analyses (Wang et al., 1996). The naturalistic approach used by Klauer et al. (2006) provided an example of how the limitations in crash databases may be overcome to generate an accurate, more valid picture of the real impact of driver distraction.

At present, information related to the impact of driver distraction on CMV safety-critical events is unclear. Klauer et al. (2006) described prior research using naturalistic data from light vehicles to investigate the issue of driver distraction; however, little research is directed at investigating this issue in CMVs. The objective of the current study was to fill this gap using data from two

FMCSA-sponsored CMV studies (Hanowski et al., 2008; Blanco et al., in press), which provided a large, naturalistic data set that allowed researchers to study pre-critical event driver behavior and assess the impact that driver distraction has on critical event occurrence.

Before outlining the methods used to analyze these two CMV data sets, it is worthwhile to highlight previous key research that has focused on assessing driver distraction. The information gleaned from this literature review informed the development of the methodology used to analyze the data in the current study.

2. REVIEW OF THE LITERATURE

2.1 DEFINING DRIVER DISTRACTION

The literature defines "driver distraction" several different ways. Smiley (2005, p. 1) defined it as "misallocated attention." Ranney, Mazzai, Garrott, and Goodman (2000, p. 1) indicated that "driver distraction may be characterized as any activity that takes a driver's attention away from the task of driving." Ranney et al. grouped driver distraction into four separate categories: visual, auditory, biomechanical, and cognitive distraction. Stutts et al. (2005, p. 1094) defined driver distraction as "an object or event that draws one's attention from the task of driving."

Pettitt, Burnett, and Stevens (2005) argued for a more comprehensive definition of distraction in order to compare data across studies and assist in the categorization of crash data. For this study, the authors compared several different definitions of distraction to determine what components need to be strengthened or added. The following definitions of distraction were used for comparison by Pettitt et al.:

- Something that distracts the attention and prevents concentration (Pollarad, 1994; p. 234).
- Attention given to a non-driving related activity, typically to the detriment of driving performance (International Organization for Standardization, 2007).
- A driver is delayed in the recognition of information needed to safely accomplish the driving task because some event, activity, object or person within or outside the vehicle compelled or tended to induce the driver's shifting attention away from the driving task (American Automobile Association Foundation for Traffic Safety, as cited in Young, Regan, & Hammer [2003]).

After comparing the definitions above, Pettitt et al. (2005) indicated that a more comprehensive definition of distraction included the following four components: the difference between distraction and inattention; the recognition that distraction can be internal or external to the vehicle; that distraction can be categorized into four types (visual, cognitive, biomechanical, and auditory); and the effect of distraction on the driving task.

In order to develop a new, more comprehensive definition, Pettitt et al. (2005) assessed a work-related road traffic crash database that contained data on 2,114 vehicle crashes from 1996 to 2004 in the Midlands region of the United Kingdom. The authors grouped the data in several different ways, including: across all crashes, all distraction-related crashes, all distraction crashes without inattention by crash severity (slight damage, serious damage, and fatal), and all distraction sources (internal versus external).

The results illustrated the importance of differentiating between distraction and inattention. For example, when grouping all crashes together, 5 percent were shown to be fatal; however, when grouping all distraction-related crashes (including inattention), 8 percent were shown to be fatal. And, when grouping all distraction-related crashes (excluding inattention), 4 percent were shown to be fatal. In addition, when all crashes were grouped by the distraction source, 30 percent of the distractions were found to be external, while 15 percent were found to be internal.

From these results, Pettitt et al. (2005) developed a new, more comprehensive definition of distraction that accounted for all four key components, which indicated that driver distraction occurred:

- When a driver is delayed in the recognition of information necessary to safely maintain the lateral and longitudinal control of the vehicle (the driving task) (Impact).
- Due to some event, activity, object or person, within or outside the vehicle (Agent).
- That compels or tends to induce the driver's shifting attention away from fundamental driving tasks (Mechanism).
- By compromising the driver's auditory, biomechanical, cognitive or visual faculties, or combinations thereof (Type) (Pettitt et al., 2005; p. 11).

A study by Hanowski et al. (2005) used the concepts from Pettitt et al. (2005) and provided a definition that could be implemented in the analysis of naturalistic driving data. In addition to providing a definition of driver distraction that could guide naturalistic data analysis, Hanowski et al. developed a taxonomy (Table 6) of secondary/tertiary tasks by analyzing naturalistic critical incident data. To accomplish this, video of critical incidents collected during a naturalistic heavy-vehicle study were reviewed to determine what behaviors the driver engaged in prior to the occurrence of a critical incident. These behaviors reflect the Agents and underlying Mechanisms, as described by Pettitt et al., that can distract and lead to a safety-critical event (or Impact).

In the current study, safety-critical events (Impact) and baseline epochs (i.e., normative routine driving) were filtered from a continuous CMV naturalistic data set and reviewed for potential distractions (Agents). Because the data set included video of the driver, biomechanical and visual distraction was the Type of distraction evaluated. As there was no audio with the video recording, auditory distraction could not be investigated. In addition, as described later, though it may be possible to investigate cognitive distraction, it was not considered in the current study.

Table 6. Distraction Taxonomy

Distraction	Definition
Talking on CB radio	Driver is holding CB to mouth and talking; usually looking forward; one hand off the wheel
Adjusting CB	Driver is adjusting knobs, with right arm extended up, on CB receiver located on ceiling at the front and center of cab; glancing at CB periodically; one hand off the wheel
Looking at CB	Driver is looking up at CB receiver located on ceiling at the front and center of cab; both hands on the wheel
Adjusting radio	Driver is reaching to the music radio, on center console of cab, adjusting station or volume; glancing at radio periodically; one hand off the wheel
Looking at radio	Driver is looking at the music radio, down and to the right, on center console of cab; both hands on the wheel
Dialing cell phone	Driver is looking down at cell phone in hands, dialing number; one hand off the wheel
Plugging in cell phone	Driver is plugging in battery charger to bottom of cell phone; usually looking at the phone; one hand off the wheel
Talking on cell phone	Driver is holding cell phone up to ear and talking on it; usually looking forward; one hand off the wheel
Answering ringing cell phone/Looking at cell phone display	Driver is answering ringing cell phone; reaches to middle console, picks up phone, looks down at phone several times, but never puts it to ear; one hand off the wheel
Phone call/hanging up cell phone	Driver makes phone call and is hanging up cell phone; reaches down to floor to put phone back; usually looks down; one hand off the wheel
Lighting cigarette	Driver is lighting a cigarette; often looking at cigarette; one or both hands off the wheel
Getting cigarette	Driver is removing a cigarette from rest of pack; often looking at pack; one hand off the wheel
Blowing smoke	Driver has head turned, blowing smoke out the window; usually holding cigarette with one hand off the wheel
Drinking	Driver is drinking out of a soda bottle or mug; usually looking forward; one hand off the wheel
Getting Food	Driver is getting food out of a bag in his/her lap; often looking at bag/food; one or both hands off the wheel
Eating/Talking	Driver is eating food and looking at passenger; one hand off the wheel
Talking to passenger	Driver is talking to another person in the cab; sometimes looking to the right at passenger; both hands on the wheel
Reaching in pocket	Driver is reaching for something in either front shirt pocket or back pant pocket; usually looking forward but moving around in seat; one hand off the wheel
Reaching to floor	Driver is reaching for something either on the floor of the cab (down and to the right) or somewhere in the cab; usually looking forward; takes one hand off the wheel
Looking at paperwork	Driver is holding paperwork on steering wheel and is looking down at it; one or both hands off the wheel
Looking at floor	Driver is looking at/for something on the floor (down and to the right); both hands on the wheel
Looking at instrument panel	Driver is looking down, through steering wheel, at instrument panel containing speedometer and gauges; both hands on the wheel

Distraction	Definition
Looking down	Driver is looking down; either in lap at something unknown, or at hands; may have one or both hands off the wheel
Looking up	Driver is looking up at the visor; both hands on the wheel
Toothpick/Visor mirror	Driver is looking up in the visor mirror, while picking teeth with a toothpick; one hand off the wheel
Looking right—outside	Driver has head turned to the right, either looking in passenger side mirror, or out passenger window; usually both hands are on the wheel
Looking left—outside	Driver has head turned to the left, either looking in driver side mirror, or out driver window; usually both hands are on the wheel
Looking outside	Driver is looking at a road sign, something along side of the road, or another car, but is still looking out front window; both hands on the wheel
Adjusting in seat	Driver is adjusting himself/herself in driver seat; usually looking forward; both hands on the wheel
Taking off jacket	Driver is taking off jacket; usually looking forward; one hand off the wheel
Let go of wheel	Driver is looking forward but does not have either hand on wheel while dancing in seat; is not holding anything
Wiping dash	Driver is wiping off dash of cab with a cloth; usually looking at dash; one hand off the wheel
Rubbing face	Driver is wiping face off or rubbing eyes; usually looking forward but eyes may close for a few moments; one hand off the wheel
Brushing hair	Driver is using a hairbrush to brush hair; looking forward; one hand off the wheel
Coughing	Driver is coughing; usually closes eyes for a short period of time; both hands on the wheel
Yawning	Driver is yawning; usually closes eyes for a short period of time; both hands on the wheel

Source: Hanowski, Perez, and Dingus (2005)

2.2 KEY DISTRACTION STUDIES

The following section reviews several key distraction studies from the extant literature. Although most of these studies provide data from light vehicles only (due to the lack of heavy-vehicle studies in this area), they demonstrate past and present issues related to driver distraction and the contention that driver distraction will continue with the proliferation of new in-vehicle technologies. See the Annotated Bibliography for a list of distraction studies from the literature search.

One of the earliest, and perhaps most cited, driver distraction studies was conducted by Indiana University by Treat et al. (1977). Data were collected between 1972 and 1975 and grouped into three "levels." Level A was a collection of baseline data and included vehicle registration and driver's license information as well as surveys from the general population. Level B was a data set collected from police accident reports. Investigators identified crashes by listening to police scanners and then went to the scene of the crash to collect data. A total of 2,258 crashes were investigated (crashes involving heavy vehicles and vehicles pulling trailers were *not* included). Level C data was an in-depth investigation of Level B data and included 420 crashes. For each crash in Level C, there was an investigation of human, environment, and vehicle factors that may have contributed to the crash. The drivers were interviewed by a psychologist or sociologist and participated in dynamic vision and driver knowledge tests. An automotive engineer also inspected the vehicle(s) involved in the crash. The data from these crashes were divided into three sections: accident summary, identification of causal factors, and a probability assessment to determine how likely the factor was the reason for the accident.

The results of this study found that human factors were most often (71–93 percent) cited as the cause in the crashes, followed by environment (12–34 percent) and vehicle factors (5–13 percent). Five major categories of human direct causes were identified: recognition errors, decision errors, performance errors, critical non-performance errors, and non-accident/intentional involvement. In addition, five specific human causes were identified: improper lookout (18–23 percent), excessive speed (8–17 percent), inattention (10–15 percent), improper evasive action (5–13 percent), and internal distraction (6–9 percent). It can be seen that two of the five specific human causes were related to inattention and distraction, indicating their prevalence during vehicle crashes.

A second key distraction study, conducted by Goodman, Tijerina, Bents, and Wierwille (1999), provided more up-to-date research looking at the then-growing use of cell phones while driving. The cell phone has since become an integral and, for some, essential communication tool. The CTIA–The Wireless Association (2007) reported approximately 50 million U.S. cell phone users in 1996; this number skyrocketed to an estimated 241 million U.S. cell phone subscribers in 2007. Approximately 85 percent of cell phone owners use their cell phones while driving and the rate of cell phone-related crashes has increased over the years (Goodman et al., 1999). Several researchers have also found that cell phone use while driving increases the risk of having a crash (Redelmeier & Tibshirani, 1997; Goodman et al.; Laberge-Nadeau et al., 2003; Strayer et al., 2003). The dangers of cell phone use while driving may not be limited to the manipulation of the cell phone itself (i.e., answering a cell phone, holding a cell phone, etc.), but may also relate to the cognitive processing while engaged in a conversation (Redelmeier & Tibshirani, 1997; Goodman et al.; Strayer & Johnston, 2001; Harbluk, Noy, & Eizenman, 2002; Strayer et al., 2003; Patten, Kircher, Östlund, & Nilsson, 2004). Though cognitive processing may play a role, naturalistic data (Klauer et al., 2006) clearly show that keeping a driver's eyes on the forward roadway is a critical component in safe driving and avoiding vehicle crashes (Hanowski, 2009). Therefore, any evaluation of driver distraction must consider the impact that secondary and/or tertiary tasks have on drawing the driver's eyes away from the forward roadway.

Goodman et al. (1999) investigated North Carolina police accident report data in order to determine the rate of cell phone use during traffic crashes. The authors developed a list of key words that police officers may have used in a police accident report to describe the use of a cell phone. These terms included "answer," "cell," "handset," and "ring." Databases were retrieved from 1989, 1992, 1993, 1994, and the first part of 1995 (limited data prohibited use of the 1990 and 1991 databases). A database search using the list of key words noted above was conducted. Each narrative was carefully reviewed to determine if cell phone use was present during the crash. If cell phone use was present during the crash, the valid narratives from the police accident reports were classified into categories. The results of that study showed that the task with the highest frequency of being reported across all years was "using cellular telephone" (i.e., talking on a cell phone). In 1989, 6 crashes were related to talking on a cell phone, 8 crashes in 1992, 5 crashes in 1993, 12 crashes in 1994, and 11 crashes in 1995. The overall trend of all cell phone-related tasks (e.g., answering a cell phone, dialing a cell phone, reaching for a cell phone, etc.) increased over time (13.2 total cell phone-related crashes in 1989 and 30 cell phone-related crashes in 1995), reinforcing the need for additional research to support the association between these tasks and traffic safety. As noted, analyses on heavy-vehicle drivers were not included, so the extent to which these data compare to the CMV industry is unknown.

A final distraction study worth noting is the Large Truck Crash Causation Study (LTCCS), which assessed the causal factor as well as associated factors for fatal crashes involving large trucks (FMCSA, 2005). Considered the most comprehensive safety database for crashes involving large trucks, the LTCCS collected data on crashes at 24 sites in 17 states from 2001 through 2003. Investigators traveled to crash sites to collect crash scene data and conducted thorough interviews with drivers about their conditions before the crash and inspected the trucks. Critical events, critical reason, and other crash-associated factors to assess crash risk are coded in the LTCCS. Each of these terms is defined below:

- Critical Event: The action or event that put the vehicle or vehicles on a course that made the collision unavoidable. The critical event is assigned to the vehicle that took the action that made the crash inevitable.
- Critical Reason: The immediate reason for the critical event (i.e., the failure leading to the critical event). The critical reason is assigned to the vehicle coded with the critical event in the crash. It can be coded as a driver error, vehicle failure, or environmental condition (roadway or weather).
- Associated Factors: The person, vehicle, and environmental conditions present at the time of the crash. No judgment is made as to whether any factor is related to the reason for a particular crash, just whether the factor was present. The list of the many factors that can be coded provides enough information to describe the circumstances of the crash.

The results of the LTCCS indicate that 9 percent of the crashes studied were attributed to driver inattention, 8 percent were attributed to an external distraction (i.e., the driver was looking at something outside of his/her truck), and 2 percent were attributed to an internal distraction. It is important to note that these driver errors were determined to be the causal factor of the crash (i.e., had they not been present, the crash would not have happened), but if these driver errors had also been considered as an associated factor, they would likely result in higher percentages.

2.3 NATURALISTIC DATA COLLECTION

As noted earlier, much of the distraction-while-driving research is based on police accident reports. This section describes the naturalistic data collection method and explains how it addresses several of the inherent limitations of a database analysis approach that relies on police accident reports.

While police accident reports provide useful information to assess crash occurrence, these reports were not designed to determine, with reliability, issues related to pre-crash driver behavior or eye-glance patterns. For example, police-reported data is retrieved after a crash has occurred. Police officers attempt to re-create the crash scene by interviewing drivers and witnesses. However, drivers may not remember details of what happened prior to the crash (e.g., reaching for the radio, feeling drowsy, looking away from the forward road) or may be hesitant to report it to the officer for fear of embarrassment or getting in additional trouble. Additionally, crashes are rare occurrences, compared to near-crashes or other close-calls, providing only a limited amount of data to use for such research.

Underlining the importance of naturalistic data is a conclusion made by Sayer et al. (2007) after conducting a naturalistic driving study with 36 light-vehicle drivers. The authors noted that the driver behavior observed in a real-world environment was not necessarily consistent with what was observed in controlled data collection environments (e.g., test track or driving simulator). As such, naturalistic data is a key method for understanding driver behavior as controlled studies cannot account for the effects of driver choice and perceived risk (Sayer et al.).

A naturalistic data collection method has been used in several studies (Hanowski, Wierwille, Garness & Dingus, 2000; Klauer et al., 2006; Hanowski et al., 2008; Blanco et al., in press) to provide a more complete picture of the driver's behavior prior to a crash. In the naturalistic approach research participants are asked to drive an instrumented vehicle as they would drive their personal/company vehicle. Each vehicle typically contains several video cameras (e.g., recording views of the face, over-the-shoulder, front view, rear-view, right/left side view, and foot pedals) and vehicle sensors to collect data on vehicle speed, global positioning system (GPS), braking intensity, steering input, forward range to a lead vehicle, and many additional measures. These data are generally collected continuously; that is, the data collection system is started as soon as the vehicle ignition starts and continues to record until the vehicle is turned off. This enlightening method enables researchers to see video of exactly what the driver was doing prior to a crash, in addition to assessing the driving environment (e.g., road type, traffic conditions, weather conditions, etc.). Continuous data collection also provides a greater amount of data for use in analyses as it captures more than just crash data. For instance, all near-crashes and close calls are recorded as well as baseline (normative/uneventful) data to be used as a comparison or control.

One of the first large-scale studies to use this data collection method was the 100-Car Study (Klauer et al., 2006). In this study, naturalistic data were collected over an 18-month period from 100 light vehicles in the Washington, DC, metropolitan area. The purpose of the study was to collect information on critical events. The naturalistic data collection method allowed researchers to obtain specific pre-crash data from video cameras installed inside the vehicle. The data set for that analysis included all crashes (n = 69) and near-crashes (n = 761) as well as 20,000 baseline epochs of normal driving to use for comparison. During the data reduction process, data analysts were able to mark various distracting tasks and behaviors that occurred prior to a critical event. In addition, eye glance analysis was conducted prior to each crash. Results showed that 78 percent of light-vehicle crashes and 65 percent of near-crashes contained at least one of the four types of inattention listed below:

- Secondary task distraction—Driver behavior that diverts the driver's attention away from the driving task. This may include talking/listening to hand-held device, eating, talking to a passenger, etc.
- Driver drowsiness—Driver behavior that includes eye closures, minimal body/eye movement, repeated yawning, etc.

- Driving-related inattention to the forward roadway—Driver behavior that is directly related to the driving task, but diverts driver's attention away from the forward field of view. This includes checking the speedometer, checking blind spots, observing adjacent traffic prior to or during a lane change, looking for a parking spot, and checking mirrors.
- Non-specific eye glance away from the forward roadway—Driver behavior that includes moments when the driver glances, usually momentarily, away from the roadway, but at no discernable object, person, or known location.

During this study, an eye glance analysis was also conducted to determine eyes off forward roadway time. Data analysts reviewed all crashes, near-crashes, and 5,000 of the 20,000 baseline epochs to determine eye glance position for 5 s prior to the event and 1 s after the event (6 s prior to the trigger for baseline epochs). Crashes and near-crashes where the driver was not considered to be at-fault or where the driver was rear-ended by another vehicle were not included in the analysis. Odds ratios were calculated using the eye-glance data and showed that more than 18 percent of at-fault crashes and near-crashes in an urban environment were attributed to eyes off the forward roadway.

The 100-Car Study gathered a great deal of useful data because of the continuous, naturalistic data-collection methodology. A similar distraction-analysis approach was used in this current study; however, naturalistic CMV data, rather than light-vehicle data, were used.

2.4 DISTRACTION-RELATED STUDIES USING NATURALISTIC DATA COLLECTION IN HEAVY VEHICLES

Several CMV studies have used the naturalistic data collection method. The following section outlines three key CMV distraction studies using the naturalistic data collection approach.

Hanowski et al. (2005) conducted the first known distraction-related analysis using naturalistic CMV data. The data were collected in a previous study in which approximately 140,000 miles of naturalistic data were collected from 41 different CMV drivers (Dingus et al., 2002). Each participant drove an instrumented heavy vehicle for approximately 10 days. The data collected included video of the driver's face, the forward roadway and adjacent lanes, along with performance data such as speed, braking, and steering. Data were not collected continuously; rather, only critical events were recorded based on a trigger method. For example, if the driver's longitudinal acceleration was greater than or equal to the pre-set threshold for that measure (i.e., indicating hard braking), the data recording system would save buffered data for a period of time surrounding the event. This method led to a set of 2,737 safety-related critical events that were later used for analysis.

During the first step of the analysis, the critical event data were reviewed and 178 distraction-related events were identified and categorized (and the main cause of the distraction was noted). Next, exposure data were determined. Baseline data were collected by having the driver press a button and provide a self-assessment of drowsiness at timed intervals. Baseline epochs were selected for each driver based on the number of critical events from each driver. For example, if a driver had between 4 and 9 distraction-related events, one baseline epoch was selected; if a driver had between 10 and 20 distraction-related events, 2 baseline epochs were selected; and if drivers had more than 20 distraction-related events, 3 baseline epochs were selected. The final step in the analysis was to conduct eye glance analysis on the 20 s surrounding the critical event (10 s prior to the trigger and 10 s after the trigger). Trained data analysts reviewed the video and marked the glance location and duration during the 20-second interval.

Thirty-six different distraction types across the 178 distraction-related critical events were identified, as shown in Table 6. Thirty-three of the 41 drivers had one or more distraction-related critical events and two of the drivers accounted for 24 percent of the total distraction-related events. This distribution of distraction-related critical events was consistent with a second study in which it was found that a relatively small number of the drivers (6 percent) were responsible for a disproportionate number of the distraction-related critical events (24 percent; Hanowski et al., 2000). Study results also showed that tertiary tasks can impact a driver's situation awareness (eyes on the road) and, potentially, adversely affect other road users.

A second study by Barr, Yang, Hanowski, and Olson (2005) investigated the prevalence of driver drowsiness in local/short-haul (L/SH) drivers and the relationship between drowsiness and distraction. This was a data mining effort using data previously collected, as outlined in Hanowski et al. (2000). Data from 42 L/SH drivers were analyzed, totaling approximately 900 hours of continuous video. Barr et al. reviewed the entire video library and identified 2,745 drowsy events (i.e., the driver exhibited some form of drowsiness such as yawning, heavy eyes, slow eye closures, rubbing the face/eyes). The drowsy event began with the first indication of driver drowsiness and continued until the driver displayed some sort of "alerting behavior." Each drowsy event in the Barr et al. study was reviewed by data analysts who were instructed to watch the driver's face and body language for 1 min prior to the event trigger and record an observer rating of drowsiness (ORD).

ORD is a subjective measurement of drowsiness developed by Wierwille and Ellsworth (1994), who described it as signs indicative of drowsiness that include rubbing the face or eyes, facial contortions, moving restlessly in the seat, and slow eyelid closures. Data analysts in Barr et al. (2005) were trained to look for these signs of drowsiness and make a subjective, but specific, assessment of the level of drowsiness. After watching the video data, data analysts classified each drowsy episode into one of the following categories:

- ORD 2: slightly drowsy.
- ORD 3: moderately drowsy.
- ORD 4: very drowsy.
- ORD 5: extremely drowsy.

An ORD rating of 1 indicated a baseline (non-drowsy) epoch. It should be noted that an event with an ORD 5 indicated there was an observable impact on the driver's performance (e.g., a lane deviation) due to drowsiness.

Once all drowsy events were identified and classified, a sample of drowsy and baseline epochs were selected for analysis. All high-severity events (ORD 4, n = 160; and ORD 5, n = 125) were included in the sample, along with an equal number of baseline epochs (baseline epochs were matched based on time of day, road type/conditions and weather conditions). The remaining events were comprised of an equal number of ORD 2 and ORD 3 events and a 3 to 1 ratio of drowsy-to-baseline epochs were used. The final data set contained 607 drowsy events and 393 baseline epochs. Once the events were selected, each event was analyzed for 3 min prior to the alerting event. During this 3-min period, the following measures were determined: PERCLOS (percent closure of eyes is a measure of drowsiness), EYETRANS (eye transition measures inattention), and EYESOFF (eyes off roadway measures inattention). PERCLOS was defined as the percentage of time the driver's eyes were closed or nearly closed over a 3-min interval. EYETRANS was defined as the number of eye transitions made by the driver over a 3-min interval, and EYESOFF was the proportion of time the driver looked away from the forward roadway over a 3-min interval. Environmental, road, and traffic conditions were also recorded during the interval.

Although the main objective of the Barr et al. (2005) study was to investigate driver fatigue/drowsiness in L/SH drivers, an additional analysis was conducted to determine the relationship between driver drowsiness and distraction. More specifically, researchers assessed whether a driver was more likely to be distracted while he/she was drowsy. An analysis of variance (ANOVA) was conducted on the mean values of EYETRANS and EYESOFF for drowsy versus baseline epochs to assess driver distraction. Results showed that both EYETRANS and EYESOFF were higher during baseline or alert driving than during periods of drowsiness, indicating that drivers scanned the environment more often while alert and may have experienced gaze concentration (Reagan, Lee, & Young, 2009) while drowsy. This also suggested that drivers did not engage in distracting behaviors (e.g., tuning the radio, reading, etc.) while drowsy. Next, a detailed video analysis was performed on a sample of 300 events, including ORD 4 and 5 events along with matching baseline epochs, to compare the frequency of distracting behaviors during baseline epochs and drowsy events. The results of this analysis showed that drivers engaged in the most distracting behaviors (such as reading paperwork, using a cell phone, or eating) only during baseline and/or alert driving. It was also found that drivers engaged in some distracting behaviors (e.g., taking a drink, smoking a cigarette) as an alerting activity to reduce and/or end their drowsiness episode.

The most recent CMV distraction study was a preliminary analysis using data from the DDWS FOT (Hickman et al., in press). Note that, along with a more recent naturalistic truck study, the complete DDWS FOT data set was used in this current study. Using naturalistic data collected during the DDWS FOT, continuous data were collected from 95 heavy-vehicle drivers from May 2004 through May 2005. Participants were volunteer drivers who each drove an instrumented heavy vehicle for up to 4 months. Each vehicle was instrumented with four video cameras (recording views of the face, forward, right lane, and left lane) and various sensors that collected information such as the truck's speed, braking intensity, and steering patterns.

The data were collected and processed using the Data Analysis and Reduction Tool (DART) software program. Driving behaviors, such as hard braking, sharp steering movements, and close time-to-collisions, were flagged in DART for later review by data analysts. Video and kinematic data from flagged critical events were reviewed to ensure they represented actual safety-significant events and then categorized into one of three categories: crash, near-crash, or crash-relevant conflicts. The total of these three types resulted in 915 safety-critical events. An additional 1,072 baseline epochs were created to represent normal driving (one baseline epoch was randomly selected for each week a participant drove an instrumented truck). Data reduction was performed on all 915 safety-critical events and 1,072 baseline epochs. Data analysts reviewed each safety-critical event and baseline epoch and provided information—such as the cause of the conflict between vehicles, animals, pedestrians, etc. (critical events only); number of vehicles involved; potential distracting behaviors; road and traffic conditions; and weather conditions (a complete list of variables can be found in Hickman et al., in press).

Of particular interest to the current study was the variable "potential distracting behaviors." Data analysts were instructed to watch the video for 10 s prior to the event trigger (i.e., an evasive maneuver by the driver, such as hard braking, steering, etc.) and note up to four potentially distracting behaviors that occurred (in no particular order). The most frequent behaviors coded during safety-critical events were "look at left-side mirror/out left side window" (34.8 percent) and "look at right-side mirror/out right side window" (25.1 percent).

2.5 SUMMARY

As noted earlier, 413,000 large trucks were involved in traffic crashes in 2007, killing 4,808 people (National Highway Traffic Safety Administration, 2008). Between 25 percent (Wang et al., 1996) and 78 percent (Klauer et al., 2006) of light-vehicle crashes were believed to have been related to some form of driver distraction. This discrepancy suggests the naturalistic approach, through the availability of video "instant replay," provides a more thorough assessment of pre-event driver behavior than can be determined through police accident report databases.

The benefits of the naturalistic data collection method in assessing pre-event driver behavior was demonstrated in the studies described above. With continuous, naturalistic data it was possible to view the driver in his/her normal driving/working environment and assess the driver's tasks, behaviors, and environment prior to a critical event. Also, as highlighted by Sayer et al. (2007), naturalistic studies provide understanding of driver choice and perceived risk in actual real-world driving situations. As such, it may be expected that some results found in laboratory and simulators studies may not be replicated in real-world driving.

The current study used data from two CMV naturalistic studies, totaling approximately 60,000 hours and 3 million miles of continuous data (Hanowski et al., 2008; Blanco et al., in press), which provided an extremely rich data set and followed the safety-critical event and baseline analysis method highlighted previously by Klauer et al. (2006) in the 100-Car Study.

Previous research using naturalistic data and critical events has been conducted for light vehicles to better understand the adverse impact of driver distraction on crashes and near-crashes, especially as the use of in-vehicle technologies increases; however, little published research focuses on CMV driver distraction. As such, it is unclear the extent to which driver distraction is a problem in CMVs. For example, CMV drivers have many opportunities to be distracted due to work-related technologies in their vehicles (e.g., cell phones, Citizens Band [CB] radios, navigation devices, and messaging systems). To underscore this point, Llaneras, Singer, and Bowers-Carnahan (2005) found that 48 percent of the CMV drivers they interviewed admitted to having a close call while using a device while driving. However, the same study found that CMV industry personnel and drivers believed that truck drivers made good decisions as to when it was safe to use these devices (when compared to light-vehicle drivers) due to their professionalism and high level of safety training.

The current study followed, to a large extent, the analysis approach used in the 100-Car Study (Klauer et al., 2006) to identify the secondary/tertiary tasks and other activities that drivers engaged in prior to involvement in critical events. The impact of these driver distractions was assessed and compared to baseline driving (uneventful data). As noted, the current study characterized crashes, near-crashes, crash-relevant conflicts, unintentional lane deviations and baseline epochs that were recorded in the DDWS FOT and the NTDS. The goal of this study was to gain a better understanding of the impact of driver distraction on CMV crashes, near-crashes, and lane keeping.

3. OVERVIEW OF DDWS FOT AND NTDS

The current project was a secondary analysis, or data mining effort, using two recently completed naturalistic heavy-vehicle data collection studies, including the DDWS FOT (Hanowski et al., 2008) and NTDS (Blanco et al., in press). Below is a detailed description of each of these two studies.

3.1 DROWSY DRIVER WARNING SYSTEM FIELD OPERATIONAL TEST

3.1.1 Project Overview

The DDWS FOT was a naturalistic data collection study in which data were collected for 18 months from 103 CMV drivers. The purpose of the DDWS FOT was to determine the safety benefits and operational capabilities, limitations, and characteristics of a DDWS that monitored drivers' drowsiness. The methodological details of the project are described below and have been abstracted from the DDWS FOT Phase I report (Hickman et al., in press) and the DDWS FOT draft final report (Hanowski et al., 2008).

3.1.2 Experimental Design

Data were collected from 103 drivers; 24 drivers were randomly assigned to the Control group and 79 drivers were randomly assigned to the Experimental group. The experimental design for the Control group was A^9, while the Experimental group followed an A^2B^9 design. In this design, A refers to the Baseline (passive) condition and B refers to the Treatment condition. The superscripts refer to the number of weeks each participant drove an instrumented truck. In the Baseline condition, the DDWS monitored the driver, but did not provide any alerts (either auditory or visual). Conversely, the DDWS monitored the driver and provided the driver with alerts in the Treatment condition.

3.1.3 Participants and Setting

Three for-hire companies participated in this study (a for-hire company transports goods for several customers for a fee). Driver volunteers were selected based on the following qualifications: a significant proportion of their driving was at night, they did not wear glasses while driving, they had a low risk of dropping out or leaving the company, and they passed vision and hearing tests. The first two qualifications were important as the DDWS device being tested did not work in the daytime or with drivers wearing glasses.

One hundred and three drivers participated in this study; 102 were male drivers and one was a female driver. Their average age was 40.0 years old (SD = 8.24 years), with ages ranging from 24 to 60 years old. Drivers had an average of 10.6 years of total self-reported driving experience (SD = 8.37 years), which ranged from 0.5 to 42 years of driving experience.

Drivers were employed at one of three fleets at nine different locations. Fleets A and B were line-haul operations, whereby a driver typically returned to the home base once per 24-hour period (5 days per week). For example, these drivers may have taken their truck out in the evening of Day 1, drove to their delivery location, delivered their load, and returned to their home base the morning of Day 2. They would leave again in the evening of Day 2 and repeat the process to complete their work week. Fleet C was involved in over-the-road, truckload operations. For the over-the-road drivers, a typical schedule may have included starting on Sunday evening and returning to their home base the following Friday afternoon.

3.1.4 Data Collection Process

Three types of data were collected by the data acquisition system (DAS): video, dynamic performance (i.e., kinematic), and audio. Each driver drove for approximately 60 h in a 7-day period. Approximately 48,000 driving-data hours covering 2.4 million miles traveled were collected. Forty-six trucks were instrumented with the DAS and the DDWS. Typically, drivers would rotate into an instrumented truck, and each driver drove, on average, for 12 weeks.

3.1.4.1 Data Acquisition System

The DAS computer received and stored data from a network of sensors distributed around the vehicle. The DAS consisted of five major components: an encased unit that housed the computer and external hard drive, dynamic sensors, vehicle network, incident box, and video cameras. In addition, the DAS interfaced with the DDWS and recorded data from it. Each component was active when the vehicle ignition system was turned on. The system remained active and recorded data as long as the engine was on and the vehicle was in motion. The system shut down in an orderly manner when the ignition was turned off. The system paused if the vehicle ceased motion for 10 min or longer.

There were three main DAS output files: truck dynamic performance data file, digital video, and audio. These files were stored on the DAS's external hard drive. The truck performance file contained the kinematic driver input measures (e.g., lateral and longitudinal acceleration, braking) and the truck-related measures (e.g., GPS, light level). The digital video file contained the video recorded continuously during the trip. The audio file resulted from the driver pressing the Critical Incident Button, which enabled drivers to comment on incidents they believed were notable.

Vehicle Network: The Society of Automotive Engineers' J1587 defines the format of messages and data collected by large truck on-board microprocessors. These microprocessors are installed in the vehicle at the truck manufacturing facility. Thus, the vehicle network refers to a from-the-factory on-board data collection system. Depending upon the truck model, year, and manufacturer, several data network protocols or standards are used with heavy-vehicles. An interface was developed to access the data from the network and merge it into the DAS data set. Typical measures found on the vehicle network of most trucks include, but are not limited to: vehicle speed, distance since vehicle start-up, ignition signal, throttle position, and brake pressure. In addition to the truck network measures, other driver input measures that were collected with sensors include right and left turn-signal use, and headlight status (on/off).

Incident Box: The Incident Box contained a light meter that recorded the in-cab ambient illumination level. Note that the ambient light level was also measured. The incident box also contained an incident pushbutton which the participants were instructed to push when they were involved in a safety-critical event. When pushed, the button opened an audio channel for 30 s during which the driver could provide a verbal report of what occurred.

Video Cameras: Digital video cameras were used to continuously record the driver and the driving environment. Four video cameras were multiplexed into a single image. The four camera views were: forward, driver's face, rear-facing-left, and rear-facing-right. The forward and rear-facing camera views provided good coverage of the driving environment. The face view provided coverage of the driver's face and will allow researchers to conduct eye glance analysis and manual PERCLOS assessment. Figure 1 shows the camera positions and approximate fields-of-view for the four cameras used in the study.

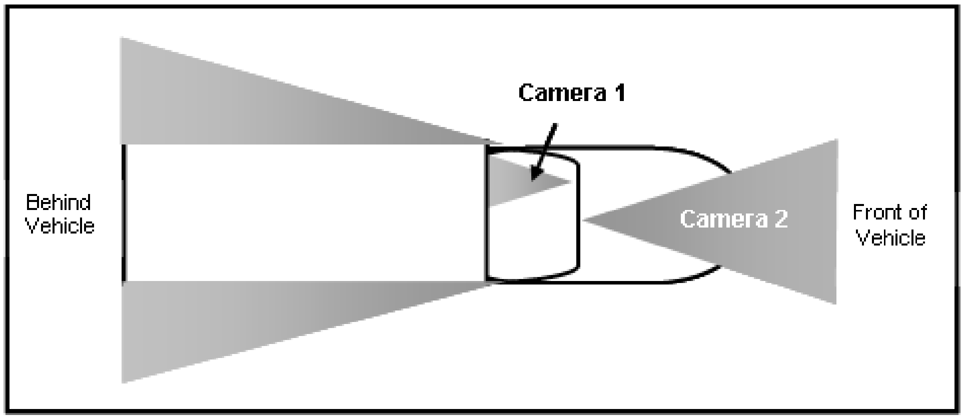

Figure 1. Diagram. Camera Directions and Approximate Fields of View

As shown in Figure 2, the four camera images were multiplexed into a single image. The top left quadrant in Figure 2 displays the driver's face, while the top right quadrant displays the forward view out the truck's windshield. The bottom right and left quadrants in Figure 2 display the rear-facing-left and rear-facing-right views, respectively. A time-stamp (.mpg frame number) was included in the .mpg data file, but not displayed on the screen. The frame number was used to time-synchronize the video (in .mpg format) and the truck/performance data (in .dat format).

Figure 2. Photo. Split-Screen Presentation of the Four Camera Views

The digital video files did not contain continuous audio. However, as noted previously, the driver could press an Incident Pushbutton and record a verbal comment for 30 s. This audio data was recorded together with the video data.

3.1.5 Data Reduction

As noted, the DDWS FOT collected naturalistic data from 103 participants, totaling approximately 2.2 million driving miles. Once these data were collected, trained data analysts identified safety-critical events (i.e., crashes, near-crashes, and crash-relevant conflicts) that occurred during data collection. To do this, the data were processed through a specialized software program to flag potential events of interest based on trigger threshold values (Table 7).

Table 7. Trigger Values Used in the DDWS FOT

Trigger Type	Trigger Values
Longitudinal Acceleration (hard braking)	Deceleration greater than or equal to -0.35 *g*[†]. Speed greater than or equal to 15 mi/h. Deceleration greater than or equal to -0.5 *g*. Speed less than or equal to 15 mi/h.
Time-to-Collision	A forward time-to-collision (TTC) value of less than or equal to 1.8 s, coupled with a range of less than or equal to 150 ft, a target speed of greater than or equal to 5 mi/h, a yaw rate of less than or equal to │4°/sec│, and an azimuth of less than or equal to │0.8°│. A forward TTC value of less than or equal to 1.8 s, coupled with a deceleration greater than or equal to -0.35 *g*, a forward range of less than or equal to 150 ft, a yaw rate of less than or equal to │4°/sec│, and an azimuth of less than or equal to │0.8°│.
Swerve*	Swerve value of greater than or equal to 3 rad/s². Speed greater than or equal to 15 mi/h.
Critical Incident Button	Activated by the driver upon pressing a button, located by the driver's visor, when an incident occurred that he/she deemed critical.
Analyst Identified	Event that was identified by a data analyst viewing video footage; no other trigger listed above identified the event (i.e., Longitudinal Acceleration, TTC, etc.).

* The swerve variable looks for a large change in yaw rate in a short amount of time where the heading of the vehicle returns to its original heading when the swerve starts.

† The lowercase and italicized letter "*g*" is the force of gravity.

Next, data analysts identified valid safety-critical events and removed spurious events (i.e., invalid safety-critical events), resulting in 1,217 valid safety-critical events. Details of this filtering process are described in more detail in section 4. Once the valid safety-critical events were identified, data analysts answered specific questions for each event (e.g., type of conflict, potential distractions, driver behaviors, and road and environmental conditions).

3.2 NATURALISTIC TRUCK DRIVING STUDY

3.2.1 Project Overview

This study collected naturalistic data to investigate CMV crash risk by identifying safety-critical events. The details of the NTDS described below are abstracted from the NTDS draft final report (Blanco et al., in press).

3.2.2 Experimental Design

As this was an on-road driving study conducted in normal operations, there were no experimental manipulations. Each participant in this on-road study was observed for approximately 4 consecutive work weeks. One hundred participants were recruited from four different trucking fleets across seven terminals and one to three trucks at each trucking fleet were instrumented (nine trucks total). After a participant finished 4 consecutive weeks of data collection, another participant started driving the instrumented truck.

3.2.3 Participants and Setting

Four companies and 100 drivers participated in this study. From this total, 95 were male drivers and five were female drivers. The average age of the drivers was 44.5 years old (SD = 12.20 years), with ages ranging from 21 to 73 years old. Drivers had an average of 9.1 years of total self-reported driving experience (SD = 10.46 years), which ranged from 0.1 to 54 years of driving experience. Drivers were employed at one of four carriers at seven different locations. Fleets A, B, and C were line-haul operations, while Fleet D was involved in over-the-road, truckload operations.

3.2.4 Data Collection Process

Three forms of data were collected by the NTDS DAS: video, dynamic performance, and audio. Each driver drove for approximately 45 h in a 7-day period. Approximately 14,500 driving-data hours covering 735,000 miles traveled were collected. Nine trucks were instrumented with the DAS. Each truck was driven by 6–14 different drivers for approximately 4 weeks each.

3.2.4.1 Data Acquisition System

Many aspects of the DAS were identical in the DDWS FOT and the NTDS. The DAS in the NTDS was comprised of the same five components in the DAS used in the DDWS FOT, including an encased unit that housed the computer and external hard drive, dynamic sensors (identical as the DDWS FOT except with a more robust lane tracker), vehicle network, incident box, and video cameras, with the exception of one additional camera view described below. No DDWS was included.

Lane Tracker: A lane tracker was included in the DAS, and consisted of a single analog black-and-white camera, a personal computer (PC) with a frame grabber card, and an interface-to-vehicle network for obtaining ground speed (note the “grabbed” video frames were not stored, but were processed algorithmically in real time to calculate the vehicle position relative to road lane markings). Once installed, software automatically calibrated itself to determine camera position (no elaborate calibration procedure was required). The following variables were reported:

- Distance from center of truck to left and right lane markings (estimated max error < 6 inches, average error < 2 inches).
- Angular offset between truck centerline and road centerline (estimated max error < 1 deg).
- Approximate road curvature.
- Confidence in reported values for each marking found.
- Marking characteristics, such as dashed vs. solid and double vs. single.
- Status information, such as in-lane or solid line crossed.

Video Cameras: Data analysts in the DDWS FOT reported that the drivers would often reach for an object outside the camera view, thus they were unable to determine what the driver was trying to reach. As such, an additional camera view looking over the drivers' shoulder into their lap was added in the NTDS (this can be seen in the lower left quadrant in Figure 3). This view provided information on many potentially distracting behaviors the driver was engaging in (e.g., eating, reading, and using electronic devices). The top left quadrant in Figure 3 displays the driver's face, while the top right quadrant displays the forward view. The bottom right quadrant in Figure 3 is split and displays the rear-facing-right and rear-facing-left views. The quality of the video data was also improved in the NTDS to provide clearer video for data reduction.

Figure 3. Photo. Five Camera Images Multiplexed Into a Single Image

3.2.5 Data Reduction

The NTDS data reduction process was similar to that of the DDWS FOT. The first step was to process the data using modified trigger values (Table 8) to flag potential events of interest. The lane deviation trigger in the NTDS was not included in the DDWS FOT.

Table 8. Trigger Values Used in the NTDS

Trigger Type	Trigger Values
Longitudinal Acceleration (hard braking)	Deceleration greater than or equal to -0.20 *g*. Speed greater than or equal to 1 mi/h (1.6 km/h).
Time-to-Collision	A forward TTC value of less than or equal to 2 s, coupled with a range of less than or equal to 250 ft, a target speed of greater than or equal to 5 mi/h (8 km/h), a gyro rate of less than or equal to $\lvert 6°/s \rvert$, and an azimuth of less than or equal to $\lvert 0.12° \rvert$.
Swerve*	Swerve value of greater than or equal to 2 rad/s^2. Speed greater than or equal to 5 mi/h (8.05 km/h).
Lane Deviation	Lane tracker status = abort. Distance from center of lane to outside of lane line < 44 inches
Critical Incident Button	Activated by the driver upon pressing a button, located by the driver's visor, when an incident occurred that he/she deemed critical.
Analyst Identified	Event that was identified by a data analyst viewing video footage; no other trigger listed above identified the event (i.e., Longitudinal Acceleration, TTC, etc.).

*The swerve variable looks for a large change in yaw rate in a short amount of time where the heading of the vehicle returns to its original heading when the swerve starts.

The remaining data reduction steps were identical to those described in the DDWS FOT data reduction. There were a total of 2,899 valid safety-critical events in the NTDS. Trained data analysts used a data coding directory to reduce all these safety-critical events.

4. DATA REDUCTION

4.1 CHARACTERIZE SAFETY-CRITICAL EVENTS

As noted, the current study involved combining naturalistic data sets from two CMV studies. Part of this process involved processing each data set with the same set of sensor trigger values in order to identify safety-critical events across data sets that had the same trigger signatures. Each valid safety-critical event was classified as a crash, near-crash, crash-relevant conflict (Hickman et al., in press), or unintentional lane deviation (Blanco et al., in press) as defined below.

- Crash: Any contact with an object, either moving or fixed, at any speed. Included other vehicles, roadside barriers, objects on or off of the roadway, pedestrians, pedalcyclists, or animals.
- Near-crash: Any circumstance that required a rapid, evasive maneuver (e.g., hard braking, steering) by the subject vehicle or any other vehicle, pedestrian, pedalcyclist, or animal, in order to avoid a crash.
- Crash-relevant conflict: Any circumstance that required a crash-avoidance response on the part of the subject vehicle, any other vehicle, pedestrian, pedalcyclist, or animal that is less severe than a rapid evasive maneuver (as defined above), but greater in severity than a normal maneuver. A crash-avoidance response can include braking, steering, accelerating, or any combination of control inputs.
- Unintentional lane deviation: Any circumstance where the subject vehicle crosses over a solid lane line (e.g., onto the shoulder) where no hazard (e.g., guardrail, ditch, vehicle, etc.) is present.

The methods used in this current study to complete the data reduction on safety-critical events are described below.

4.1.1 Running the Event Trigger Program

To find safety-critical events of interest, DART was used to scan the data set for notable actions, including hard braking, quick steering maneuvers, short times-to-collision (TTC), and lane deviations. To identify these actions, threshold values (called “triggers”) were created to flag instances in the video and quantitative data where the threshold values were met or exceeded.

Since the trigger threshold values between the DDWS FOT and NTDS data sets differed, it was important to obtain a common set of threshold values for comparison across data sets. The lower trigger threshold values used in the NTDS was used to process the DDWS FOT data set. For example, in the DDWS FOT data set, a longitudinal acceleration trigger (to identify hard braking events) was initially created when a driver braked at or exceeded -0.35 g. However, in the NTDS data set, a longitudinal acceleration trigger was created any time a driver braked at or exceeded -0.20 g. So that each data set would have the same safety-critical event signatures -0.20 g was used for both data sets.

In the original DDWS FOT study, trigger threshold values were selected based on values used in the 100-Car Study (Klauer et al., 2006) and from suggestions from the software programmers who developed DART and were familiar with the data. Before data reduction began on the NTDS, a sensitivity analysis was conducted on various trigger values to determine the best combination of values to obtain the fewest number of false alarms (i.e., triggers created with no conflict threat) and missed valid events. Table 9 shows a comparison of the original trigger values that were used in the DDWS FOT data set during the Phase I study (Hickman et al., in press), NTDS (Blanco et al, in press), and the new trigger values that were used in the current study. As can be seen in Table 9, the longitudinal acceleration, time-to-collision, and swerve triggers in the DDWS FOT were different than those used in the NTDS. Thus, the trigger values in the DDWS FOT were revised to be the same as those used in the NTDS; this resulted in the creation of an additional 221,687 triggers (potential events). It should also be noted that instrumented trucks in the NTDS were equipped with a lane tracking device that was not reliable in the DDWS FOT; therefore, valid lane deviation triggers were present in the NTDS data set but not in the DDWS FOT data set.

Table 9. Comparison of the Trigger Values Used in the DDWS FOT Phase I Analysis, NTDS, and the current study

Trigger Type	Trigger Values Used in Phase I of the DDWS FOT	Trigger Values Used in the NTDS	Trigger Values Used in the Current Study
Longitudinal Acceleration	Deceleration greater than or equal to -0.35 *g*. Speed greater than or equal to 15 mi/h. Deceleration greater than or equal to -0.5 *g*. Speed less than or equal to 15 mi/h.	Deceleration greater than or equal to -0.20 *g*. Speed greater than or equal to 1 mi/h (1.6 km/h).	Deceleration greater than or equal to -0.20 *g*. Speed greater than or equal to 1 mi/h (1.6 km/h).
Time-to-Collision	A forward TTC value of less than or equal to 1.8 s, coupled with a range of less than or equal to 150 ft, a target speed of greater than or equal to 5 mi/h, a yaw rate of less than or equal to $\lvert 4°/sec \rvert$, and an azimuth of less than or equal to $\lvert 0.8° \rvert$. A forward TTC value of less than or equal to 1.8 s, coupled with an acceleration or deceleration greater than or equal to $\lvert 0.35\, g \rvert$, a forward range of less than or equal to 150 ft, a yaw rate of less than or equal to $\lvert 4°/sec \rvert$, and an azimuth of less than or equal to $\lvert 0.8° \rvert$.	A forward TTC value of less than or equal to 2 s, coupled with a range of less than or equal to 250 ft, a target speed of greater than or equal to 5 mi/h (8 km/h), a gyro rate of less than or equal to $\lvert 6°/s \rvert$, and an azimuth of less than or equal to $\lvert 0.12° \rvert$.	A forward TTC value of less than or equal to 2 s, coupled with a range of less than or equal to 250 ft, a target speed of greater than or equal to 5 mi/h (8 km/h), a gyro rate of less than or equal to $\lvert 6°/s \rvert$, and an azimuth of less than or equal to $\lvert 0.12° \rvert$.
Swerve	Swerve value of greater than or equal to 3 rad/s². Speed greater than or equal to 15 mi/h.	Swerve value of greater than or equal to 2 rad/s². Speed greater than or equal to 5 mi/h (8.05 km/h).	Swerve value of greater than or equal to 2 rad/s². Speed greater than or equal to 5 mi/h (8.05 km/h).

Trigger Type	Trigger Values Used in Phase I of the DDWS FOT	Trigger Values Used in the NTDS	Trigger Values Used in the Current Study
Lane Deviation	Lane tracker data not available.	Lane tracker status = abort. Distance from center of lane to outside of lane line less than 44 inches.	Lane tracker status = abort. Distance from center of lane to outside of lane line less than 44 inches.
Critical Incident Button	Activated by the driver upon pressing a button, located by the driver's visor, when an incident occurred that he/she deemed critical.	Activated by the driver upon pressing a button, located by the driver's visor, when an incident occurred that he/she deemed critical.	Activated by the driver upon pressing a button, located by the driver's visor, when an incident occurred that he/she deemed critical.
Analyst Identified (AI)	Event that was identified by a data analyst viewing video footage; no other trigger listed above identified the event (i.e., Longitudinal Acceleration, TTC, etc.).	Event that was identified by a data analyst viewing video footage; no other trigger listed above identified the event (i.e., Longitudinal Acceleration, TTC, etc.).	Event that was identified by a data analyst viewing video footage; no other trigger listed above identified the event (i.e., Longitudinal Acceleration, TTC, etc.).

4.1.2 Checking the Validity of the Additional Triggered Events

The software scanned the data set and potential safety-critical events of interest were identified for review, based on the trigger criteria. A 75-s epoch was created for each identified safety-critical event (60 s prior to trigger, 15 s after trigger). The result of the automatic scan was a data set that included both valid and invalid events.

Valid events were those events where recorded dynamic-motion values actually occurred and were verifiable in the video and other sensor data (also identified by Critical Incident Button or Analyst Identified). Invalid events were those events where sensor readings were spurious due to a transient spike or some other anomaly such as driving over a pothole (false positive). The validity of all events was determined through video review.

During this process, an additional 534 valid events were identified in the DDWS FOT data set (2 crashes, 16 near-crashes, and 516 crash-relevant conflicts). Events determined to be invalid were not analyzed further. Valid events were analyzed further and classified as conflicts or non-conflicts. Conflicts were valid events that also represented a traffic conflict (i.e., crash, near-crash, crash-relevant conflict, unintentional lane deviation). Non-conflicts were events that were not safety-critical per se, even though their trigger values were valid ("true trigger"). Non-conflicts were analogous to nuisance alarms—where the threshold value for that particular event was set ineffectually. Examples of valid events that were non-conflicts included hard braking by a driver in the absence of a specific crash threat or a high swerve value from a lane change not resulting in any loss-of-control, lane departure, or proximity to other vehicles. While such situations may have reflected at-risk driving habits and styles, they did not result in a discernible crash-relevant conflict. To determine the validity of the events, data analysts observed the recorded video and data plots of the various sensor measures associated with each 75-s epoch.

4.1.3 Applying the Data Directory to the Validated Events

An event coding Data Directory was used to reduce and analyze all new valid safety-critical events in the DDWS FOT (as was used in Phase I of the DDWS FOT and NTDS). See appendix A for the data coding directory used in the DDWS FOT and NTDS. This data directory was originally developed for the Phase I analysis (Hickman et al., in press) and also used in the NTDS analysis (Blanco et al., in press). The DART software presented the data analyst with a series of variables consisting either of a blank space for entry of specific comments (e.g., Element #39, Event Comments) or provided pull-down menus for the analyst to select the most applicable code (i.e., number corresponding to a data element). Different variables had different coding rules. For most variables, only one code was selected; however, for a few variables, the data analyst could select up to four codes that were applicable. For example, analysts could select multiple Potential Distraction Behaviors (e.g., Element #25, Potential Distractions).

The DART software automatically coded many of the variables. These automatically coded variables reflect data recorded from sensors in the instrumented vehicle (e.g., vehicle number, driver subject number, date, and time). Although these variables were coded automatically by DART, they are listed in the Data Directory to provide readers with a full picture of the variables that were available to support analyses of the data (see appendix A).

4.1.3.1 Drowsiness

It is important to discuss the method used to determine drowsiness during the data reduction process. Because the focus of this study was on “driver distraction” and the Klauer et al. (2006) method was used as a model approach, each of the video segments surrounding an event were reduced to 6 s. Video review derived measures of drowsiness, such as PERCLOS or ORD (Wierwille & Ellsworth, 1994), require at least 1-min of video review. As data were collected continuously, this data is available for a data mining effort that might focus specifically on drowsiness (i.e., it is possible, in a future effort, to conduct PERCLOS and ORD analysis on this naturalistic data). Reducing the video to 6 s was suitable for investigating secondary and tertiary tasks that the driver was engaged in immediately prior to or during an event. However, the 6-s duration precluded conducting PERCLOS or ORD analysis. Note that it was initially decided that a high-level assessment of driver drowsiness would be performed by analysts by viewing the 6-s video segment and providing a subjective “yes” or “no” indication of the presence of drowsiness. However, this was dropped as a measure of interest because it was later decided that 6 s was not a sufficient duration to reliably assess the drowsiness state of a driver. Future research is recommended to more fully address this issue.

4.2 CHARACTERIZE 20,000 BASELINE EPOCHS

In addition to the safety-critical events described above, approximately 20,000 baseline epochs (i.e., uneventful driving) were created. The creation of a baseline data set enabled the current study to describe and characterize “normal” driving for the study sample, thereby infer the increased or decreased risk associated with various conditions and driver tasks with comparisons between the control (baseline) data set and the safety-critical event data set. For example, if 20 percent of safety-critical events but only 10 percent of baseline epochs occurred during rain, one could infer that rain was associated with an increased safety-critical event rate, and therefore, increased risk. Baseline epochs were defined as follows (Hickman et al., in press):

> Baseline epoch: Brief time periods (e.g., 6 s) that are randomly selected from the recorded data set. Baseline epochs will be described using many of the same variables and data elements used to describe and classify crashes, near-crashes, and crash-relevant conflicts. Examples of such variables included ambient weather, roadway type, and driver behaviors.

A random sampling method was used to obtain baseline epochs. Baseline epochs were selected based on driver exposure. That is, the more time a given driver spent in the study, the more baseline epochs that driver had included in the baseline data set. In addition, all baseline epochs involved the truck traveling at a minimum speed of 15 mi/h. More specifically, the proportion of an individual driver's driving time (when the truck was traveling faster than 15 mi/h) was divided by the total driving time across the DDWS FOT and NTDS (when the truck was traveling faster than 15 mi/h) and multiplied by 100 percent. This percentage reflected an individual driver's exposure and was used to determine the frequency of baseline epochs needed (i.e., 1 percent exposure reflected 200 baseline epochs). As with safety-critical events, data analysts used the Baseline Epoch Data Directory to reduce and analyze baseline epochs. See appendix B for the Baseline Epoch Data Directory used in the current study.

4.2.1 Quality Control

Because of the large number of baseline epochs that were reduced, it was necessary to implement quality control to ensure accurate coding among data analysts. Data analysts were trained on how to code the baseline epochs using the Baseline Epoch Data Directory (appendix B). Data analysts were typically trained at the beginning of their shift and then asked to spend the remaining time of their shift (e.g., usually 2–3 hours) working on data reduction. After their first day of work, the data analyst's manager (i.e., an experienced data analyst) checked 100 percent of the work completed on that day and left comments in a log regarding any mistakes. On the following day, data analysts were asked to review all mistakes and make corrections before working on new baseline epochs. The quality control schedule was as follows: check 100 percent of the work completed by data analysts each day during the first two days, check 20 percent of the work completed by data analysts each day for the following five days, and check 10 percent of work completed by data analysts each day for the remainder of the data reduction process. If it became apparent that a data analyst was making the same mistake over multiple days, the data analyst's manager would have a brief meeting with the data analyst to discuss the issue(s) and formulate a corrective action plan that involved re-training (e.g., review of additional video examples). The data analysts would then re-review all events done prior to the meeting and make any necessary corrections.

Once all baseline epochs were coded, an additional 10 percent of the baselines epochs that had not been previously reviewed during quality control were assessed for accuracy (with appropriate changes made where necessary). The same procedure was used to assess eye glance quality control.

4.3 EYE GLANCE REDUCTION

To measure visual attention (or inattention), eye glance analysis was conducted for all safety-critical events and baseline epochs in the DDWS FOT and NTDS for a period of 6 s, following the approach outlined in Klauer et al. (2006). For safety-critical events, this 6 s was broken into 5 s prior to the onset of the safety-critical event and 1 s after. For baseline epochs, the entire 6-s epoch was analyzed. Data analysts viewed the video through DART and held down the appropriate letter/key when the drivers' eye glance was in a specific direction. The following eye glance locations were adapted from Klauer et al. (2006) and were used in the current analysis:

- Forward.
- Right mirror/out right window.
- Left mirror/out left window.
- External object—through front windshield.
- Instrument panel (including speedometer, radio and heating, ventilating, and air conditioning-HVAC).
- Cell phone.
- Interior object (e.g., food/drink, map, seatbelt, door/window control, CB radio, passenger, etc.).
- Eyes closed (eyes had to be closed for at least 5 syncs; 10 syncs = 1 s).
- Other.
- No eyes visible—glance location unknown.
- No eyes visible—eyes are off road.

Each glance location was assigned a different letter (i.e., on the keyboard) as shown in Figure 4 below. For example, the data analysts would input an "f" when the driver was looking at the forward roadway.

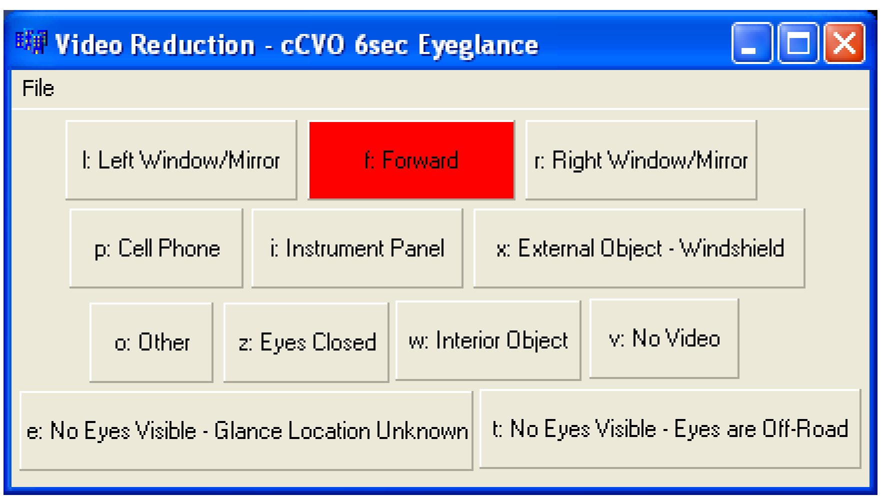

Figure 4. Image. Eye Glance Location Window in DART

Though these various eye glance locations were assessed as part of the eye glance reduction process, it was determined that the key location to assess (visual) attention was Forward; that is, eyes on the forward roadway. Therefore, for the statistical analyses conducted, all locations other than Forward were grouped together (and considered "inattention" to the forward roadway). Although it would have been optimal to consider glances to the mirrors also, it was difficult through the video review to reliably assess mirror glances separate from glances out the windows; as such, these categories were grouped together (e.g., "Right mirror/out right window"). Not being able to reliably discern between mirror glances and looking out the side windows is a limitation of the current study.

4.4 DRIVER TASKS AND INATTENTION

Across both the safety-critical event and baseline epoch data sets, driver tasks—depending on the context, these can also be considered "behaviors;"for consistency, the term "task" will be used throughout— that were identified during the 6-s interval were grouped into one of two task categories: (1) secondary and (2) tertiary. As outlined by Ablassmeier et al. (2007), secondary and tertiary tasks, in addition to primary tasks, comprise a complete taxonomy of driving tasks. As noted previously, the primary task for a driver is driving (i.e., operating the vehicle). Secondary tasks are related to the driving task (e.g., turn-signal use), but are not necessary to keeping the vehicle on course. Tertiary tasks are extraneous tasks (e.g., eating) that are not related to driving. Appendix C lists all tasks and definitions, grouped into secondary and tertiary task categories that were identified in the DDWS and NTDS data sets. Note that these do not necessarily represent the universe of secondary and tertiary tasks, but only those that were observed in the video from the DDWS FOT and NTDS data sets. The Klauer et al. (2006) categorization scheme, used in the 100-Car study with light-vehicle data, was employed as much as possible in the grouping of CMV driver tasks in the current study.

Once each task had been grouped into a secondary or tertiary category, the task category was broken down further into three distinct groups based on the manual/visual complexity of the task: simple, moderate, or complex (Klauer et al., 2006). These three categories were defined by Klauer et al.:

> Complex tertiary tasks are defined as a task that requires either multiple steps, multiple eye glances away from the forward roadway, and/or multiple button presses (Dingus, Antin, Hulse, & Wierwille, 1989). Moderate tertiary tasks are those that require, at most, two glances away from the roadway and/or at most two button presses. Simple tertiary tasks are those that require none or one button press and/or one glance away from the forward roadway. (p. 25)

Examples of specific tasks in each category are shown in Table 10. The key point to note is that though analyses considered individual behaviors and tasks, grouping strategies were also used to parse the data. This provided both detailed (i.e., at the task level) and higher-level (i.e., at the task category level) approaches in assessing CMV driver behavior and inattention.

Table 10. Assignment of Task Categories into Three Levels of Manual/Visual Complexity

Simple	Moderate	Complex
Talk/sing/dance with no indication of passenger	Reach for object in vehicle	Use calculator
Interact with/look at other occupant(s)	Look back in sleeper berth	Read book, newspaper, paperwork, etc.
Put on/remove/adjust seat belt	Talk/listen to hand-held phone	Look at map
Put on/remove/adjust sunglasses or glasses	Talk/listen to hands-free phone	Write on pad, notebook, etc.
Put on/remove/adjust hat	Talk/listen to CB radio	Dial cell phone
Drink from a container	Use/reach for other device	Text message on cell phone
Smoking-related—cigarette in hand or mouth	Eating	Interact with/look at dispatching device
Use chewing tobacco	Smoking-related—reaching, lighting, extinguishing	
Bite nails/cuticles	Personal grooming	
Remove/adjust jewelry	Look at outside vehicle, animal, object, etc.	
Other personal hygiene		
Adjust instrument panel		

4.5 RESEARCH QUESTIONS

Once the safety-critical event and baseline data had been reduced, the data were ready to conduct statistical analyses and answer key research questions related to driver distraction. More specifically, these data were used to answer the specific research questions listed below. Section 5 provides the results of each question.

- Research Question 1: What are the types and frequency of tasks which drivers engage in prior to involvement in safety-critical events? What are the odds ratios and the PAR percentage for each task type?
- Research Question 2: What are the environmental conditions associated with driver choice of engagement in tasks? What are the odds of being in a safety-critical event while engaging in tasks while encountering these conditions?
- Research Question 3: What are the odds ratios of eyes-off-forward-roadway? Does eyes-off-forward-roadway significantly affect safety and/or driving performance?

5. DATA ANALYSIS AND RESULTS

Once all safety-critical events and baseline epochs were characterized, and associated tasks had been identified, statistical analyses were performed to assess the risk associated with the various tasks and the visual impact (i.e., eyes off road time) associated with each task. The data analysis procedures followed those outlined in the 100-Car Study (Klauer et al., 2006). Odds ratios were calculated to approximate relative safety-critical event risk compared to normal, baseline driving for various driver tasks. In addition, population attributable risk (PAR) calculations were used to determine what percentage of safety-critical events occurring in the population was attributable to driver distraction. Definitions of odds ratios and PAR, adapted from Klauer et al., are included later in this section.

5.1 DATA ANALYSIS CAVEATS

Several caveats regarding the data analyses are presented below. As previously noted, the data set used in the current analysis was comprised of two separate data sets, which differed on several points. First, the DDWS FOT data collection took place from May 2004 to September 2005, while the NTDS data collection took place from November 2005 to May 2007. While cell phones were capable of text messaging during the DDWS FOT, text messaging has since become a prevalent communication behavior on cell phones. Thus, there were far more instances of text messaging in the NTDS data set than in the DDWS FOT data. Therefore, it is important to keep in mind that, across the two data sets, technology use by drivers was seen to have changed substantially over this short time span.

Second, the NTDS had an additional camera view that was not present in the DDWS FOT. An over-the-shoulder camera installed in each instrumented vehicle in the NTDS recorded the driver's steering wheel, hands, and lap, thereby providing the data analysts with more detailed information as to what the driver was doing at any given time. In the DDWS FOT data analysts could only see the driver's face and shoulders. This is important to note as drivers would often hold an object (e.g., cell phone, map, calculator, dispatching device, etc.) in their lap that may not have been visible in the DDWS FOT, but would be visible in the NTDS data. As such, it may appear that drivers in the NTDS were more distracted by known (or identifiable) devices than drivers in the DDWS FOT.

Third, because the primary purpose of the DDWS FOT was to test equipment that only worked at night, most DDWS FOT drivers typically drove in the middle of the night, on divided highways, in low levels of traffic. Because of these conditions, drivers may not have engaged in as many distracting behaviors, such as talking on a cell phone or reading paperwork. However, this is a hypothesis and an open question.

Lastly, drivers' attention was measured by assessing the amount of time the driver's eyes were looking at the forward roadway. This was considered an objective, proxy measure of driver attention. However, this does not preclude the possible effects of cognitive processing while engaged in distracting behaviors (e.g., Goodman et al., 1999; Strayer et al., 2003). Though cognitive processing may play a role, naturalistic data (Klauer et al., 2006) clearly show that keeping a driver's eyes on the forward roadway is a critical component in safe driving and avoiding vehicle crashes (Hanowski, 2009). Therefore, any evaluation of driver distraction must consider the impact of the secondary and/or tertiary tasks have on drawing the driver's eyes away from the forward roadway

5.2 DATA ANALYSIS METHODS

5.2.1 Odds Ratios

Odds ratios were calculated to approximate relative safety-critical event risk compared to normal, baseline driving for various driver tasks. The odds ratio is a way of comparing the odds of some outcome (e.g., a crash) occurring, given the presence of some predictor factor, condition, or classification (e.g., CB use). It is usually a comparison of the presence of a condition to its absence (e.g., driver inattention versus no driver inattention). As shown in Table 11, an odds ratio is a measure of association commonly employed in the analysis of 2 × 2 contingency tables (Agresti, 1996).

Table 11. 2 × 2 Contingency Table Used to Calculate Odds Ratio

	Driver Inattention	No Driver Inattention
Incidence Occurrence	N_{11}	N_{12}
No Incidence Occurrence	n_{21}	n_{22}

Odds of occurrence are defined as the probability of event occurrence (safety-critical event) divided by the probability of non-occurrence (baseline epoch). The following formula was used to perform the calculation to determine the odds ratio in order to assess the increase (or decrease) in the probability of having a safety-critical event, compared to a baseline epoch, in the presence of driver inattention versus no driver inattention:

$$\text{Odds Ratio} = (n_{11})(n_{22})/(n_{21})(n_{12})$$

Odds ratios of 1.0 indicate the outcome is equally likely to occur given the condition. An odds ratio greater than 1.0 indicates the outcome is more likely to occur given the condition. Odds ratios of less than 1.0 indicate the outcome is less likely to occur (Pedhazur, 1997). The hypothetical data presented in Table 12 will be used to illustrate how odds ratios are calculated. For this hypothetical example, assume there were a total of 100 safety-critical events and 100 baseline epochs. The driver was found to be talking on a cell phone while driving during 45 of the safety-critical events, while the driver was talking on the cell phone while driving in 23 of the baseline epochs.

Table 12. Odds Ratio Example

	Cell Phone Use	No Cell Phone Use
Safety-critical events	45 (A)	55 (B)
Baseline epochs	23 (C)	77 (D)

The formula for this calculation would be as follows:

$$OR = \frac{A \times D}{B \times C} \tag{1a}$$

$$OR = \frac{45 \times 77}{23 \times 55} \tag{1b}$$

$$OR = 2.74 \tag{1c}$$

In order to determine if the odds ratio of 2.74 is significant, a 95 percent confidence interval is calculated, including the upper confidence limits (UCL) and lower confidence limits (LCL). The formulas to calculate the UCL and LCL are shown below:

$$UCL = OR \times e^{1.96\sqrt{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}}} \tag{2a}$$

$$UCL = 2.74 \times e^{1.96\sqrt{\frac{1}{45}+\frac{1}{55}+\frac{1}{23}+\frac{1}{77}}} \tag{2b}$$

$$UCL = 5.04 \tag{2c}$$

$$LCL = OR \times e^{-1.96\sqrt{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}}} \tag{3a}$$

$$LCL = 2.74 \times e^{-1.96\sqrt{\frac{1}{45}+\frac{1}{55}+\frac{1}{23}+\frac{1}{77}}} \tag{3b}$$

$$LCL = 1.49 \tag{3c}$$

Since 1.0 is not included between the LCL and the UCL, the odds ratio is significantly different than 1.0. Thus, we are 95 percent certain the true odds ratio lies somewhere between 1.49 and 5.04. Therefore, this example using data from Table 12 can be interpreted that drivers who talk on a cell phone while driving were 2.74 times more likely to be involved in a safety-critical event, compared to a baseline epoch, than if they were not talking on a cell phone while driving.

5.2.2 Population Attributable Risk

PAR is defined as the “risk of disease in the total population (p_t) minus the risk in the unexposed group (p_u)” (Sahai & Khurshid, 1996; p. 205). For each odds ratio with an outcome greater than 1.0, the PAR percentage was also calculated. While the odds ratio is measured at the *individual* level, the PAR is measured at the *population* level. This analysis provided an assessment of the percentage of safety-critical events that are occurring in the population and that are directly attributable to the specific behavior measured (i.e., driver inattention).

The PAR percentage is defined as the "proportion of the risk to the disease in the study population that is attributable to the exposure, and thus could be avoided by limiting the exposure to the risk factor" (Sahai & Khurshid, 1996; p. 205). Since the disease, or safety-critical events, occur rarely in the population, odds ratios may be substituted for relative risk and the PAR percentage is calculated as follows:

$$PAR\ \ percentage = \frac{(P_e(OR-1))}{(1+P_e(OR-1))}\times 100 \tag{4a}$$

Where: P_e = population exposure estimate (e.g., number of baseline epochs with complex tertiary task/total number of baseline epochs) and OR = odds ratio estimate for a safety-critical event

This calculation provides a percentage value which can then be generalized to the entire population. For example, if drivers who talk on cell phones while driving are two times as likely to be involved in a safety-critical event as when not talking on a cell phone, but cell phone use while driving is a rare occurrence in the entire population, this is explained by calculating the PAR percentage. Again, using the hypothetical data presented in Table 13, the PAR percentage is calculated below where:

$$P_e = \frac{23\,baseline\ epochs\ with\ cell\ \ phone\ use\ while\ driving\ \ present}{100\,total\ baseline\ epochs} = 0.23 \tag{4b}$$

$$OR = 2.74 \tag{4c}$$

$$PAR\ \ percentage = \frac{(0.23(2.74-1))}{(1+0.23(2.74-1))}\times 100 \tag{4d}$$

$$PAR\ \ percentage = 18.70 \tag{4e}$$

In order to interpret the PAR percentage, the estimated sample variance and the UCL and LCL must first be calculated. Table 13 displays the hypothetical data used above in the odds ratio example; these data will be used to explain the calculations shown below.

Table 13. Population Attributable Risk—Confidence Limits Example

	Cell Phone Use	No Cell Phone Use	Row Total
Safety-critical events	45 (A)	55 (B)	100 (m_1)
Baseline epochs	23 (C)	77 (D)	100 (m_2)
Column Total	68 (n_1)	132 (n_2)	(n)

First, it is necessary to calculate the estimated sample variance using the following formula:

$$Var(PAR\ \ percentage) = \left(\frac{Bm_2}{Dm_1}\right)^2 \left[\frac{A}{Bm_1} + \frac{C}{Dm_2}\right] \times 100 \tag{5a}$$

$$Var(PAR\ \ percentage) = \left(\frac{55 \times 100}{77 \times 100}\right)^2 \left[\frac{45}{55 \times 100} + \frac{23}{77 \times 100}\right] \times 100 \tag{5b}$$

$$Var(PAR\ \ percentage) = 0.57 \tag{5c}$$

Next, the 95 percent UCL and LCL can be calculated using the estimated sample variance. This formula is as follows:

$$UCL = PAR\ \ percentage + 1.96\sqrt{Var(PAR\ \ percentage)} \tag{6a}$$

$$UCL = 18.70 + 1.96\sqrt{0.57} \tag{6b}$$

$$UCL = 20.18 \tag{6c}$$

$$LCL = PAR\ \ percentage - 1.96\sqrt{Var(PAR\ \ percentage)} \tag{7a}$$

$$LCL = 18.70 - 1.96\sqrt{0.57} \tag{7b}$$

$$LCL = 17.22 \tag{7c}$$

Therefore, it can be reported that cell phone use while driving leads to a safety-critical event in 17–20 percent of the population when compared to driving while not using a cell phone.

5.3 RESEARCH QUESTION 1: WHAT ARE THE TYPES AND FREQUENCY OF TASKS IN WHICH DRIVERS ENGAGE PRIOR TO INVOLVEMENT IN SAFETY-CRITICAL EVENTS? WHAT ARE THE ODDS RATIOS AND THE PAR PERCENTAGE FOR EACH TASK TYPE?

5.3.1 Frequency of Tasks

As noted in the previous chapter, each task was grouped into one of two task categories: secondary and tertiary. Additionally, tertiary tasks were further grouped by manual/visual complexity into complex, moderate, and simple (defined on page 31). Table 14 shows the percentage of safety-critical events that involved any type of distraction based on the list of distractions used in this study (see appendix C). These percentages reflect events when the driver was involved in any secondary or tertiary task in the 6-s interval. That is, a driver could be talking on a cell phone, checking a side mirror, or scratching an ear, and that would be reflected in the results.

Following the method used in Klauer et al. (2006), of the 4,452 safety-critical events, 81.5 percent had some type of driver distraction listed as a potential contributing factor. Table 14 displays the percentage of any secondary and/or tertiary tasks that were present in all safety-critical events and all events where the Vehicle 1 driver (i.e., the participant driver) was judged to be at-fault in the safety-critical event.

Table 14. Frequency and Percentage of Any Secondary and/or Tertiary Task in "All" and "Vehicle 1 At-Fault" Events

Event Type	All Safety-Critical Events	Frequency and Percent of All Safety-Critical Events	All Vehicle 1 At-Fault (V1) Events	Frequency and Percent of All Vehicle 1 At-Fault (V1) Events
All safety-critical events	81.5%	n = 4,452 (100.0%)	83.4%	n = 3,618 (100.0%)
Crashes	100.0%	n = 21 (0.5%)	100.0%	n = 10 (0.3%)
Near-crashes	78.7%	n = 197 (4.4%)	83.0%	n = 112 (3.1%)
Crash-relevant conflicts	79.1%	n = 3,019 (67.8%)	81.1%	n = 2,281 (63.0%)
Unintentional lane deviations	87.7%	n = 1,215 (27.3%)	87.7%	n = 1,215 (33.6%)
Baseline epochs	76.9%	n = 19,888 (100.0%)	76.9%	n = 19,888 (100.0%)

Though a breakdown of each Event Type is provided in Table 14, caution must be used in interpreting individual Event Types. While Klauer et al. (2006) found that 78 percent of crashes contained at least one type of inattention category (i.e., secondary task distraction; driving-related inattention to forward roadway; drowsiness; and non-specific eye glance away from the forward roadway), the current study, following the Klauer et al. method, found that 100 percent of crashes contained at least one type of inattention task (either secondary or tertiary). It is important to point out a few caveats in comparing these two studies. First, and perhaps most importantly, the percentages in Table 14 include any task that was present within the 6-s interval; often the task was driving-related such as checking the side mirror. Because Klauer et al. included checking mirrors as a distraction type, this approach was followed in the current study. However, based on training received by CMV drivers, who are instructed to check mirrors every 5–8 s (FMCSA, 2009b), it would be expected that video of the drivers would show them regularly checking their mirrors. This would, in turn, inflate the percentages seen in the current study and may not represent an accurate picture of "driver distraction."

A second caveat when comparing the results from the Klauer et al. (2006) study and the current study is the data collection time frames of the studies. The Klauer et al. study was conducted from January 2003 to July 2004, while the DDWS FOT was conducted from May 2004 to September 2005 and the NTDS study was conducted from November 2005 to May 2007. Because of these time period differences, the specific types of distraction across studies were similar, but not identical. For example, as will be described, a key finding in the current CMV study was the high risk associated with texting. However, because texting is a relatively recent phenomenon, there were no cases of texting in the Klauer et al. study. However, we know that light-vehicle drivers do engage in texting. As such, if the Klauer et al. study were conducted in present times, it would be expected that the distraction percentages may be different (or, at least, texting would be represented).

Third, while the distraction categories used were similar across studies, they were not exactly the same and the current study had additional non-driving related distractions (e.g., texting, use calculator, using dispatching device) that were not cited in Klauer et al. (2006).

Finally, it should be noted that crashes were a rare occurrence in the current study (less than 0.5 percent of all safety-critical events). Klauer et al. (2006) had 69 crashes in the light-vehicle data set; approximately three times as many collected in the CMV data sets. Also, the majority of the crashes in the CMV data sets were relatively minor including deer hits (n = 5), contact with an object (e.g., construction cone, piece of debris) in the road or on the side of the road (n = 9). Collectively, these caveats underline the need for caution when comparing results from the current study with Klauer et al. and interpreting the results of individual event types, particularly those with small sample sizes (crashes). Table 15 provides an alternative approach, which the authors believe to be more appropriate, to evaluating the impact of driver distraction.

Table 15 shows the percentage of all safety-critical events, and events where the Vehicle 1 driver was judged to be at-fault, where the driver was engaged in a non-driving related, tertiary task. As shown, driver distraction due to non-driving related tertiary tasks was a contributing factor in 71 percent of crashes, 46 percent of near-crashes, and 60 percent of all events. Table 15 may capture the effects of "driver distraction" as many people think of it. That is, these events represent driving while also engaged in a non-driving related activity (e.g., using a cell phone, texting, eating).

Table 15. Frequency and Percentage of Any Tertiary Tasks in "All" and "Vehicle 1 At-Fault" Events

Event Type	All Safety-Critical Events	Frequency and Percent of All Safety-Critical Events	All Vehicle 1 At-Fault (V1) Events	Frequency and Percent of All Vehicle 1 At-Fault (V1) Events
All safety-critical events	59.9%	n = 4,452 (100.0%)	63.9%	n = 3,618 (100.0%)
Crashes	71.4%	n = 21 (0.5%)	40.0%	n = 10 (0.3%)
Near-crashes	46.2%	n = 197 (4.4%)	50.0%	n = 112 (3.1%)
Crash-relevant conflicts	53.6%	n = 3,019 (67.8%)	57.4%	n = 2,281 (63.0%)
Unintentional lane deviations	77.5%	n = 1,215 (27.3%)	77.5%	n = 1,215 (33.6%)
Baseline epochs	56.5%	n = 19,888 (100.0%)	56.5%	n = 19,888 (100.0%)

5.3.2 Odds Ratios of Driver Tasks

5.3.2.1 Task Categories

In order to approximate safety-critical event risk, compared to normal, baseline driving, odds ratios were calculated on the different task categories. Odds ratios for each task category (tertiary task [complex, moderate, and simple] and secondary task) were calculated with the absence and presence of each task category.

Each of these calculations was performed across all safety-critical events* (n = 4,452) and on those events where the Vehicle 1 driver was judged to be at-fault in the safety-critical event† (n = 3,618). The results from these calculations are in Table 16, which shows the odds ratios, LCL, UCL, frequency of safety-critical events, and frequency of baseline epochs for each driver task (i.e., complex tertiary task, moderate tertiary task, simple tertiary tasks, and secondary tasks) across "All" and "Vehicle 1 At-Fault" safety-critical events.

"All" Events: As shown in Table 16, odds ratios were significant for all four driver task types when "All" events were considered. As compared to baseline epochs, drivers were 10.4 times more likely to be involved in a safety-critical event while engaging in a complex tertiary task. For moderate tertiary, simple tertiary, and secondary tasks, the increased likelihood was 1.3, 1.2, and 1.3, respectively.

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* Analyses that included all safety-critical events are referred to as 'All' from here on.

† Analyses that included all safety-critical events where the Vehicle 1 driver was judged to be at-fault in the safety -critical event are referred to as 'Vehicle 1 At-Fault' from here on.

"Vehicle 1 At-Fault": When "Vehicle 1 At-Fault" events were considered, odds ratios were also significant for all four driver task types. As compared to baseline epochs, drivers were 14.0 times more likely to be involved in a safety-critical event while engaging in a complex tertiary task. For moderate tertiary, simple tertiary, and secondary tasks, the increased likelihood was 1.6, 1.4, and 1.3, respectively.

Table 16. Odds Ratios and 95% Confidence Intervals to Assess Likelihood of a Safety-Critical Event While Engaging In a Task across "All" and "Vehicle 1 At-Fault" (V1) Events

Task	ALL Odds Ratio	ALL LCL	ALL UCL	ALL Frequency of Safety-Critical Events	ALL Frequency of Baselines	V1 Odds Ratio	V1 LCL	V1 UCL	V1 Frequency of Safety-Critical Events	V1 Frequency of Baselines
Complex Tertiary Task	**10.34***	8.55	12.50	359	194	**13.92***	11.50	16.92	353	194
Moderate Tertiary Task	**1.30***	1.17	1.44	876	3,776	**1.55***	1.38	1.74	763	3,776
Simple Tertiary Task	**1.22***	1.07	1.39	408	1,869	**1.41***	1.22	1.62	344	1,869
Secondary Task	**1.32***	1.20	1.47	964	4,066	**1.33***	1.18	1.50	707	4,066

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.3.2.2 Manual/Visual Complexity

Odds ratios were calculated for each tertiary task (each tertiary task is operationally defined in appendix C). Because of the small sample size for some of these tasks, each task of interest may occur in addition to another task during a safety-critical event or baseline epoch (i.e., if the task of interest is talking on a hands-free phone, the driver may also be smoking at the same time); therefore the results should be interpreted considering that at least the particular task was present.

"All" Events: The results for these calculations are presented in Table 17 and suggest that engaging in any, and all, of the complex tertiary tasks increased the risk of being involved in a safety-critical event when compared to baseline epoch. While most of the tasks listed in Table 17 are self-evident from their title (e.g., text messaging on a cell phone), some of the tasks may not be as obvious. For example, the "Other—Complex" tertiary task was used to describe tasks that the driver engaged in that were not part of the task list, but were considered a complex task and worth noting (e.g., the driver cleaning his/her side mirror, rummaging through a grocery bag). The "Other—Moderate" tertiary task was used to describe tasks that the driver engaged in that were not part of the task list, but were considered a moderate task and worth noting (e.g., taking medicine by opening a pill bottle and taking a pill, exercising in the cab). The "Other—Simple" tertiary task was used to describe other tasks that the driver engaged in that were not part of the task list, but were considered a simple task and worth noting (e.g., the driver opening and closing the driver-side door). Lastly, some incidents of "personal grooming" included a driver shaving his head with an electric razor and drivers brushing their hair with a comb or brush; incidents of "use/reach for other electronic device" included reaching for or using a digital camera or video camera.

A few highlights from Table 17 show that texting was a significant safety risk. Drivers were 23.2 times more likely to be involved in a safety-critical event while text messaging. Using a dispatching device increased risk significantly by 9.9 times, while writing, using a calculator, looking at a map, dialing a cell phone, and reading significantly increased risk by 9.0, 8.2, 7.0, 5.9, and 4.0, respectively.

Table 17. Odds Ratios and 95% Confidence Intervals to Assess Likelihood of a Safety-Critical Event While Engaging In Tasks across "All" and "Vehicle 1 At-Fault" (V1) Events

Task	ALL Odds Ratio	ALL LCL	ALL UCL	ALL Frequency of Safety-Critical Events	ALL Frequency of Baselines	V1 Odds Ratio	V1 LCL	V1 UCL	V1 Frequency of Safety-Critical Events	V1 Frequency of Baselines
Complex Tertiary Task										
Text message on cell phone	**23.24***	9.69	55.73	31	6	**27.71***	11.52	66.61	30	6
Other—Complex *(e.g., cleaning side mirror, rummaging through a grocery bag)*	**10.07***	3.10	32.71	9	4	**12.40***	3.82	40.28	9	4
Interact with/look at dispatching device	**9.93***	7.49	13.16	155	72	**11.90***	8.97	15.80	150	72
Write on pad, notebook, etc.	**8.98***	4.73	17.08	28	14	**11.07***	5.82	21.05	28	14
Use calculator	**8.21***	3.03	22.21	11	6	**10.11***	3.73	27.34	11	6
Look at map	**7.02***	4.62	10.69	56	36	**8.67***	5.70	13.20	56	36
Dial cell phone	**5.93***	4.57	7.69	132	102	**7.06***	5.42	9.18	127	102
Read book, newspaper, paperwork, etc.	**3.97***	3.02	5.22	98	112	**4.76***	3.61	6.27	95	112
Moderate Tertiary Task										
Use/reach for other electronic device	**6.72***	2.74	16.44	12	8	**7.58***	3.05	18.85	11	8
Other—Moderate *(e.g., opening a pill bottle to take medicine, exercising in the cab)*	**5.86***	2.84	12.07	17	13	**7.22***	3.50	14.87	17	13
Personal grooming	**4.48***	2.01	9.97	12	12	**5.05***	2.23	11.46	11	12
Reach for object in vehicle	**3.09***	2.75	3.48	503	787	**3.65***	3.24	4.12	473	787
Look back in Sleeper Berth	**2.30***	1.30	4.07	18	35	**2.52***	1.39	4.56	16	35
Talk or listen to hand-held phone	1.04	0.89	1.22	195	837	1.16	0.99	1.37	176	837
Eating	1.01	0.83	1.21	137	609	1.16	0.96	1.41	128	609
Smoking-related behavior—reaching, lighting, extinguishing	**0.60***	0.40	0.89	28	208	**0.63***	0.41	0.97	24	208
Talk or listen to CB radio	**0.55***	0.41	0.75	50	399	**0.46***	0.33	0.66	34	399
Look at outside vehicle, animal, person, object, or undetermined	**0.54***	0.50	0.60	625	4,590	**0.51***	0.46	0.57	483	4,590
Talk or listen to hands-free phone	**0.44***	0.35	0.55	91	901	**0.40***	0.31	0.51	67	901

Task	ALL Odds Ratio	ALL LCL	ALL UCL	ALL Frequency of Safety-Critical Events	ALL Frequency of Baselines	V1 Odds Ratio	V1 LCL	V1 UCL	V1 Frequency of Safety-Critical Events	V1 Frequency of Baselines
Simple Tertiary Task										
Put on/remove/adjust sunglasses or reading glasses	**3.63***	2.37	5.58	38	47	**4.00***	2.57	6.24	34	47
Adjust instrument panel	**1.25***	1.06	1.47	185	668	**1.38***	1.16	1.65	166	668
Remove/adjust jewelry	1.68	0.44	6.32	3	8	2.06	0.55	7.78	3	8
Other—Simple *(e.g., opening and closing driver's door)*	2.23	0.41	12.20	2	4	1.37	0.15	12.30	1	4
Put on/remove/adjust hat	1.31	0.69	2.49	12	41	1.34	0.67	2.68	10	41
Use chewing tobacco	1.02	0.51	2.02	10	44	1.12	0.55	2.31	9	44
Put on/remove/adjust seat belt	1.26	0.60	2.64	9	32	1.55	0.74	3.24	9	32
Talk/sing/dance with no indication of passenger	1.05	0.90	1.22	225	961	0.93	0.78	1.10	163	961
Smoking-related behavior—cigarette in hand or mouth	0.97	0.82	1.14	178	820	0.94	0.78	1.12	140	820
Drink from a container	0.97	0.72	1.30	54	249	1.13	0.83	1.53	51	249
Other personal hygiene	**0.67***	0.59	0.75	359	2,313	**0.73***	0.64	0.82	316	2,313
Bite nails/cuticles	**0.45***	0.28	0.73	18	178	**0.43***	0.25	0.74	14	178
Interact with or look at other occupant(s)	**0.35***	0.22	0.55	20	256	**0.36***	0.22	0.59	17	256
Secondary Task										
Look at left-side mirror/out left window	**1.09***	1.01	1.17	1,211	5,077	1.03	0.95	1.12	945	5,077
Look at right-side mirror/out right window	0.95	0.86	1.05	493	2,306	**0.74***	0.66	0.84	321	2,306
Check speedometer	**0.32***	0.28	0.38	166	2,127	**0.34***	0.29	0.41	142	2,127

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

The results in Table 17 showed that five of the moderate complexity tasks significantly increased the risk of being involved in a safety-critical event (again, as compared to baseline epochs). It is noteworthy that talking/listening to a cell phone was not associated with increased risk (though, as noted above, dialing a cell phone was). Other interesting results from this category are in regard to the protective effect (defined as decreasing the risk of a safety-critical event) of some tasks. That is, tasks that had an OR less than 1.0 (and a UCL of less than 1.0) indicated that engaging in the task or behavior provided a safety benefit. Smoking-related behaviors were found to be protective, as was talking or listening to a CB radio, and talking or listening with a hands-free phone (which was defined as the driver talking into a headset when it was apparent he/she was not talking to a passenger).

Two of the simple complexity tasks significantly increased risk, including interacting with eye wear and adjusting the instrument panel. Once again, certain tasks had a significant protective effect, including interacting with other occupants.

For secondary tasks, drivers were 1.1 times more likely to be involved in a safety-critical event (compared to a baseline epoch) while looking out the left-side mirror/out left window. The results also show that checking the speedometer had a protective effect and was considered a safe behavior.

"Vehicle 1 At-Fault": When "Vehicle 1 At-Fault" events were considered, all complex tertiary tasks were found to be significantly riskier. As when considering "All" events, "Vehicle 1 At-Fault" events where the driver was text messaging presented a substantial safety risk; drivers were 27.7 times more likely to be involved in a safety-critical event (compared to a baseline epoch) while text messaging. As noted, all other complex tertiary tasks were associated with a significant increase in risk.

For moderately complex and simple tasks, the results for the "Vehicle 1 At-Fault" events were similar to the "All" events data. However, when differences in risk ratios were found, they were usually more robust.

For secondary tasks, none of the tasks resulted in an increase in risk; however, a significant protective effect was found when drivers' looked at the right-side mirror/out right window or checked the speedometer. This suggests these activities may be indicative of scanning the driving environment and heightened situation awareness.

5.3.3 Population Attributable Risk

The last step in answering Research Question 1 was to calculate the PAR percentages. Recall that the PAR provides an assessment of the percentage of safety-critical events that occurred in the population and that were directly attributable to the specific task or behavior measured. The PAR was calculated on all odds ratios greater than 1.0; the results from these calculations are presented in Table 18.

Table 18. Population Attributable Risk and 95% Confidence Intervals for Driver Tasks across "All" and "Vehicle 1 At-Fault" (V1) Events

Task	ALL PAR Percentage	ALL LCL	ALL UCL	V1 PAR Percentage	V1 LCL	V1 UCL
Complex Tertiary Task	**27.46**	**27.24**	**27.67**	**34.38**	**34.20**	**34.56**
Interact with/look at dispatching device	3.13	2.84	3.42	3.80	3.55	4.04
Dial cell phone	2.46	2.02	2.91	3.01	2.64	3.39
Read book, newspaper, paperwork, etc.	1.65	0.96	2.34	2.07	1.49	2.66
Look at map	1.08	0.48	1.68	1.37	0.88	1.86
Text message on cell phone	0.67	0.29	1.04	0.80	0.48	1.12
Write on pad, notebook, etc.	0.56	-0.16	1.28	0.70	0.12	1.29
Use calculator	0.22	-1.00	1.43	0.27	-0.71	1.26
Other—Complex (e.g., cleaning side mirror, rummaging through a grocery bag)	0.18	-0.99	1.35	0.23	-0.72	1.18
Moderate Tertiary Task	**11.77**	**11.32**	**12.23**	**19.77**	**19.35**	**20.20**
Reach for object in vehicle	7.64	7.27	8.02	9.49	9.16	9.82
Other—Moderate (e.g., opening a pill bottle to take medicine, exercising in the cab)	0.32	-0.92	1.55	0.40	-0.60	1.41
Look back in sleeper berth	0.23	-2.24	2.70	0.27	-2.08	2.62
Use/reach for other electronic device	0.23	-1.10	1.56	0.26	-0.94	1.47
Personal grooming	0.21	-1.58	2.00	0.24	-1.38	1.87
Talk or listen to hand-held phone	0.18	-1.29	1.64	0.68	-0.69	2.06
Eating	0.02	-1.80	1.83	0.49	-1.13	2.11
Simple Tertiary Task	**5.96**	**5.20**	**6.73**	**10.56**	**9.83**	**11.30**
Adjust instrument panel	0.82	-0.47	2.11	1.27	0.06	2.49
Put on/remove/adjust sunglasses or reading glasses	0.62	-0.56	1.80	0.71	-0.40	1.81
Talk/sing/dance with no indication of passenger	0.23	-1.12	1.59	–	–	–
Put on/remove/adjust hat	0.06	-4.85	4.98	0.07	-5.08	5.22
Put on/remove/adjust seat belt	0.04	-5.84	5.92	0.09	-4.69	4.87
Remove/adjust jewelry	0.03	-7.89	7.95	0.04	-6.39	6.48
Other—Simple (e.g., opening and closing driver's door)	0.02	-7.57	7.62	0.01	-15.95	15.94
Use chewing tobacco	0.00	-6.75	6.76	0.03	-6.34	6.40
Drink from a container				0.16	-2.50	2.82
Secondary Task	**11.71**	**11.29**	**12.13**	**11.91**	**11.43**	**12.39**
Look at left-side mirror/out left window	2.25	1.77	2.75	0.80	0.21	1.38

Note that in Table 18, the tasks are listed, within each complexity category, from highest to lowest PAR. As shown in Table 18, combining all complex tasks resulted in a PAR percentage of 27.5, with a LCL of 27.2 and an UCL of 27.7. Interpreted from statistics, this indicates that engaging in a complex tertiary task led to 27 percent of the safety-critical events in the population when compared to driving while not engaged in a complex tertiary task. When looking at specific tasks, interacting with a dispatching device and dialing a cell phone resulted in the highest percentage of safety-critical events with PAR percentages of 3.1 and 2.5, respectively. Recall that text messaging was associated with the highest odds ratio in the previous analyses. When calculating the PAR percentage and confidence levels for text messaging, it can be seen that driving while texting leads to a safety-critical event in 0.3 to 1.0 percent of the population. This indicates that albeit dangerous (in the sense of increased risk), it is not a prominent activity. However, as texting becomes more commonplace, it would be expected that more safety-critical events will result.

For moderate complexity tertiary tasks, reaching for an object was associated with the highest PAR percentage of 7.7 (with LCL of 11.3 and UCL of 12.2). Because this is such a frequently occurring behavior, it is represented as a relatively high PAR percentage (in fact, this is the highest for any of the individual tasks across all complexity categories).

It should be noted that negative confidence level values in the table are, in some cases, the result of relatively few data points for a particular task; in other cases, when the original odds ratio was not significant, the PAR may be negative. As such, the resulting confidence level becomes unstable. When additional naturalistic data is added to the data set, and this additional data contains tasks that currently have negative confidence level for PAR analyses, the distribution will become more stable and a more accurate confidence level can be constructed.

5.3.4 Summary of Key Findings

The analysis of tasks resulting in driver distraction provided some intriguing findings. In general, the results showed that drivers engaging in any complex tertiary task will have an increased risk of being involved in a safety-critical event. In addition, several of the moderate complexity tertiary tasks and two of the simple tertiary tasks also resulted in elevated risk.

After examining specific tasks further, some stand out as being particularly risky for CMV drivers:

- Texting.
- Interacting with dispatching devices.
- Writing.
- Using a calculator.
- Looking at a map.
- Dialing a cell phone.
- Reading a book/newspaper.

In addition, the increased risk when reaching for electronic devices and other objects in the cab was also noteworthy.

Though many of the secondary and tertiary tasks could be performed by both light-vehicle and CMV drivers (such as cell phone use), several of the tertiary tasks are specific to CMV drivers. For example, interacting with a dispatching device was associated with an odds ratio of 9.93 for "All" events and 11.9 for "Vehicle 1 at-fault' events. Although this was a typical task for CMV drivers, as indicated by the PAR percentage, this tertiary task had one of the highest associated risks. These results indicate that this particular tertiary task should not be performed while driving and/or design improvements in the dispatch system are needed.

Another tertiary task that was prevalent with CMV drivers was CB radio use. Interestingly, CB radio use had a protective effect, indicating a safety benefit of using this device. CB radios are simply designed communication devices and the analyses indicated that drivers are able to use them while driving without increased risk of being involved in a safety-critical event. Drivers in the DDWS FOT and the NTDS typically kept these devices within close reach (within an arm length). Moreover, the protective effect, or decreased risk of being involved in a safety-critical event, found while using CB radios suggests that drivers may be more alert or attentive to driving (a hypothesis supported by the eye glance analysis shown later).

The use of cell phones while driving is a popular research topic and the current study provided an interesting perspective. Reaching for an electronic device and dialing a cell phone were both found to be high-risk behaviors. However, talking or listening to a hand-held phone was not associated with increased risk, and talking or listening to a hands-free phone had a protective effect (similar to a CB radio). Again, the current study did not assess the possible effects of cognitive processing while engaged in a cell phone conversation, which has been shown to be a distracting behavior by other researchers (Goodman et al., 1999; Strayer et al., 2003), though not in naturalistic studies. The positive findings for "listening and talking" are consistent with results of two naturalistic studies with light-vehicle drivers. In the first study, protective effects were found for moderately complex tasks, which included talking/listening to handheld devices (F. Guo, personal communication, July 7, 2009). In the second study, drivers' speed variance was better (i.e., speeds changed more smoothly) when drivers were using (i.e., talking or listening) a cell phone (Sayer et al., 2007).

The PAR percentages provided an interesting perspective and accounted for the increased risk of different tasks as well as the frequency with which drivers engaged in these tasks. As noted, drivers frequently interacted with dispatching devices and the increased risk, in combination with the frequency of use, indicated this task to be especially risky. Interacting with a dispatching device led to a safety-critical event in 3.6–4.0 percent of the population when compared to driving while not interacting with a dispatching device. Dialing a cell phone was also a common task for CMV drivers and was found to have a high PAR percentage. More specifically, the PAR percentage indicates which tasks, if removed, would provide the largest reduction in safety-critical events. Texting, though a high-risk behavior, was not a prominently occurring behavior during the data collection. However, it would be expected that safety-critical events that result from texting will increase in frequency as more drivers engage in this behavior.

5.4 RESEARCH QUESTION 2: WHAT ENVIRONMENTAL CONDITIONS ARE ASSOCIATED WITH DRIVER CHOICE OF ENGAGEMENT IN TASKS? WHAT ARE THE ODDS OF BEING IN A SAFETY-CRITICAL EVENT WHILE ENGAGING IN TASKS WHILE ENCOUNTERING THESE CONDITIONS?

The second research question focused on task involvement as a function of environmental conditions. As a follow-up, an odds ratio analysis was performed to approximate the increased risk of being involved in a safety-critical event, as compared to baseline epoch, while engaging in various tasks in different environmental conditions.

The eight environmental conditions listed below were assessed for each safety-critical event and baseline epoch during data reduction:

- Lighting Levels.
- Weather Conditions.
- Roadway Surface Conditions.
- Relation to Junction.
- Trafficway Flow.
- Roadway Alignment.
- Road Profile.
- Traffic Density.

For each environmental condition, a frequency table was created. From this table, odds ratios and 95 percent confidence limits were calculated. The odds ratios provide information as to whether a driver was more likely to be involved in a safety-critical event, compared to a baseline epoch, while engaged in a task during specific environmental conditions compared to not being engaged in a task in that environment. The following tasks were considered:

- All tasks.
- Tertiary tasks.
  - Complex tertiary tasks.
  - Moderate tertiary tasks.
  - Simple tertiary tasks.
- Secondary tasks.

Odds ratios were calculated with the absence or presence of each task category. The data were parsed for analysis in two ways: “All” events and “Vehicle 1 At-Fault” events. Each of the eight environmental conditions was considered in turn.

5.4.1 Lighting Levels

Lighting levels indicate the atmospheric light condition during the safety-critical event or baseline epoch. Note that "Dark but lighted" indicates the atmospheric lighting conditions were dark; however, the road had active artificial lighting. The lighting level at the time of the safety-critical event or baseline epoch was assessed. Data analysts were instructed to use the video data as well as the time stamp from the data files to assist in determining the appropriate lighting level. During data reduction, data analysts selected one of the five lighting conditions:

- Daylight.
- Dark.
- Dark but lighted (i.e., street lights).
- Dawn.
- Dusk.

Table 19 shows the frequency of tertiary and secondary tasks during safety-critical events and baseline epochs across "All" and "Vehicle 1 At-Fault" events for each lighting level.

Table 19. The Frequency of Tertiary and Secondary Tasks during Safety-Critical Events and Baseline Epochs Across "All" and "Vehicle 1 At-Fault" Events for each Lighting Level

Lighting Levels	ALL Frequency of Tertiary Task Safety-Critical Events	ALL Frequency of Secondary Task Safety-Critical Events	ALL Frequency of Tertiary Task Baselines	ALL Frequency of Secondary Task Baselines	V1 Frequency of Tertiary Task Safety-Critical Events	V1 Frequency of Secondary Task Safety-Critical Events	V1 Frequency of Tertiary Task Baselines	V1 Frequency of Secondary Task Baselines
Daylight	1,586	800	4,004	2,305	1,431	581	4,004	2,305
Dark	302	92	2,502	1,327	265	71	2,502	1,327
Dark but lighted	46	46	405	261	29	33	405	261
Dawn	8	9	84	68	8	9	84	68
Dusk	20	17	166	105	16	13	166	105

Table 20–Table 25 show the results of the odds ratio calculations for each lighting level analysis. Table 20 displays the odds ratio calculations for engaging in a secondary and/or tertiary task across “All” and “Vehicle 1 At-Fault” events for each lighting level. The results in Table 20 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two of the five lighting conditions. When “All” events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight. When “Vehicle 1 At-Fault” events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight and 1.3 times more likely when driving in the dark.

Table 20. Odds Ratios and 95% Confidence Intervals for the Interaction of Any Secondary and/or Tertiary Tasks by Lighting Level across “All” and “Vehicle 1 At-Fault” (V1) Events

Lighting Levels	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Daylight	**1.19***	1.08	1.32	**1.37***	1.22	1.53
Dark	1.13	0.95	1.36	**1.34***	1.09	1.64
Dark but lighted	1.35	0.84	2.15	1.40	0.79	2.48
Dawn	0.56	0.28	1.12	0.64	0.31	1.33
Dusk	1.24	0.65	2.37	0.99	0.50	1.95

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 21 displays the odds ratio calculations for engaging in any tertiary task across “All” and “Vehicle 1 At-Fault” events for each lighting level. The results in Table 21 suggest that engaging in any of the tertiary tasks significantly increased the risk of a driver being involved in a safety-critical event in two of the five lighting conditions. When “All” events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight and 1.4 times more likely when driving in the dark. When “Vehicle 1 At-Fault” events were considered, drivers were 1.8 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight and 1.7 times more likely when driving in the dark.

Table 21. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Lighting Level across “All” and “Vehicle 1 At-Fault” (V1) Events

Lighting Levels	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Daylight	**1.41***	1.26	1.57	**1.75***	1.55	1.97
Dark	**1.42***	1.17	1.73	**1.73***	1.38	2.15
Dark but lighted	1.27	0.75	2.14	1.23	0.65	2.33
Dawn	0.45	0.18	1.12	0.52	0.20	1.33
Dusk	1.04	0.50	2.17	0.90	0.41	1.97

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 22 displays the odds ratio calculations for engaging in any complex tertiary task across “All” and “Vehicle 1 At-Fault” events for each lighting level. The results in Table 22 suggest that engaging in a complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in four of the five lighting conditions. This was true when "All" and "Vehicle 1 At-Fault" events were considered. Complex tertiary tasks resulted in significant odds ratios in all but one of the lighting conditions. Odds ratios for the dusk category was particularly high, indicating drivers were 21.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving at dusk when considering "All" events and 18.7 times more likely for "Vehicle 1 At-Fault" events.

Table 22. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Lighting Level across "All" and "Vehicle 1 At-Fault" (V1) Events

Lighting Levels	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Daylight	**8.55***	6.83	10.70	**11.55***	9.18	14.54
Dark	**8.36***	5.33	13.10	**11.60***	7.33	18.35
Dark but lighted	**7.45***	2.44	22.78	**11.42***	3.59	36.32
Dawn	2.37	0.20	27.82	2.73	0.23	32.36
Dusk	**21.54***	3.79	122.40	**18.67***	3.09	112.79

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 23 displays the odds ratio calculations for engaging in any moderate tertiary task across "All" and "Vehicle 1 At-Fault" events for each lighting level. The results in Table 23 suggest that engaging in any of the moderate tertiary tasks significantly increased the risk of a driver being involved in a safety-critical event in two of the five lighting conditions. When "All" events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight. When "Vehicle 1 At-Fault" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight and 1.3 times more likely when driving in the dark.

Table 23. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Lighting Level across "All" and "Vehicle 1 At-Fault" (V1) Events

Lighting Levels	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Daylight	**1.20***	1.06	1.36	**1.46***	1.28	1.68
Dark	1.12	0.88	1.42	**1.33***	1.02	1.74
Dark but lighted	0.91	0.49	1.70	0.63	0.27	1.46
Dawn	0.57	0.18	1.86	0.66	0.20	2.19
Dusk	0.70	0.27	1.83	0.54	0.18	1.60

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 24 displays the odds ratio calculations for engaging in any simple tertiary task across "All" and "Vehicle 1 At-Fault" events for each lighting level. The results in Table 24 suggest that engaging in any of the simple tertiary tasks significantly increased the risk of a driver being involved in a safety-critical event in two of the five lighting conditions. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in the dark. When "Vehicle 1 At-Fault" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight and 1.6 times more likely when driving in the dark.

Table 24. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Lighting Level across "All" and "Vehicle 1 At-Fault" (V1) Events

Lighting Levels	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Daylight	1.16	0.99	1.36	**1.37***	1.15	1.62
Dark	**1.42***	1.09	1.85	**1.60***	1.19	2.15
Dark but lighted	1.28	0.59	2.81	1.38	0.54	3.49
Dawn	0.13	0.02	1.04	0.15	0.02	1.21
Dusk	0.96	0.32	2.84	0.83	0.25	2.71

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 25 displays the odds ratio calculations for engaging in any secondary task across "All" and "Vehicle 1 At-Fault" events for each lighting level. The results in Table 25 suggest that engaging in any of the secondary tasks significantly increased the risk of a driver being involved in a safety-critical event in two of the five lighting conditions. When "All" events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight and 2.0 times more likely when driving in dark, but lighted, conditions. When "Vehicle 1 At-Fault" events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in daylight and 2.2 times more likely when driving dark, but lighted, conditions.

Table 25. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Lighting Level across "All" and "Vehicle 1 At-Fault" (V1) Events

Lighting Levels	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Daylight	**1.23***	1.09	1.39	**1.23***	1.07	1.41
Dark	0.81	0.63	1.06	0.87	0.65	1.18
Dark but lighted	**1.97***	1.16	3.34	**2.17***	1.15	4.08
Dawn	0.63	0.26	1.53	0.72	0.29	1.80
Dusk	1.39	0.65	3.01	1.16	0.50	2.65

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.2 Weather Conditions

Weather conditions indicate the atmospheric weather conditions at the time of the safety-critical events or baseline epoch. Data analysts were instructed to use the video data to assist in determining the appropriate weather condition. During data reduction, data analysts selected one of eight weather conditions:

- No adverse conditions.
- Rain.
- Sleet.
- Snow.

- Fog.
- Rain and fog.
- Sleet and fog.
- Other (smog, smoke, sand/dust, crosswind, hail).

Table 26 shows the frequency of tertiary and secondary tasks during safety-critical events and baseline epochs across “All” and “Vehicle 1 At-Fault” events for six weather conditions. Those conditions that were not observed are not included. As can be seen, most of the data were collected in “No adverse conditions” and “Rain.”

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Table 26. The Frequency of Secondary and Tertiary Tasks during Safety-Critical Events and Baseline Epochs across "All" and "Vehicle 1 At-Fault" (V1) Events for each Weather Condition

Weather Conditions	ALL Frequency of Tertiary Task Safety-Critical Events	ALL Frequency of Secondary Task Safety-Critical Events	ALL Frequency of Tertiary Task Baselines	ALL Frequency of Secondary Task Baselines	V1 Frequency of Tertiary Task Safety-Critical Events	V1 Frequency of Secondary Task Safety-Critical Events	V1 Frequency of Tertiary Task Baselines	V1 Frequency of Secondary Task Baselines
No adverse conditions	1,860	902	6,564	3,693	1,658	659	6,564	3,693
Rain	85	54	557	339	75	41	557	339
Sleet	0	1	1	1	0	1	1	1
Snow	9	1	17	14	8	0	17	14
Fog	8	5	15	15	8	5	15	15
Rain and fog	0	1	7	4	0	1	7	4

Table 27–Table 32 present the results of the odds ratio calculations for six weather conditions. Table 27 displays the odds ratio calculations for engaging in any secondary and/or tertiary task across "All" and "Vehicle 1 At-Fault" events for each weather condition. The results in Table 27 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two weather conditions. When "All" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions and 1.4 times more likely when driving in the rain. When "Vehicle 1 At-Fault" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions and 2.1 times more likely when driving in the rain.

Table 27. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary and/or Tertiary Tasks by Weather Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Weather Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
No adverse conditions	**1.31***	1.21	1.43	**1.48***	1.34	1.63
Rain	**1.44***	1.01	2.06	**2.10***	1.34	3.27
Sleet	1.00	0.03	29.81	1.00	0.03	29.81
Snow	1.33	0.33	5.42	1.71	0.34	8.74
Fog	2.56	0.52	12.51	2.39	0.49	11.74
Rain and fog	0.25	0.01	4.92	–	–	–

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 28 displays the odds ratio calculations for engaging in any tertiary task across "All" and "Vehicle 1 At-Fault" events for four weather conditions. The results in Table 28 suggest that engaging in any tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two weather conditions. When "All" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, and 1.5 times more likely when driving in the rain. When "Vehicle 1 At-Fault" events were considered, drivers were 1.8 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, and 2.2 times more likely when driving in the rain.

Table 28. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Weather Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Weather Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
No adverse conditions	**1.52***	1.39	1.67	**1.84***	1.66	2.04
Rain	**1.48***	1.00	2.19	**2.23***	1.38	3.59
Snow	2.12	0.47	9.50	2.82	0.51	15.72
Fog	4.00	0.73	22.04	4.00	0.73	22.04

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 29 displays the odds ratio calculations for engaging in any complex tertiary task across "All" and "Vehicle 1 At-Fault" events for three weather conditions. The results in Table 29 suggest that engaging in any complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two weather conditions. When "All" events were considered, drivers were 10.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, and 6.7 more likely when driving in the rain. When "Vehicle 1 At-Fault" events were considered, drivers were 13.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, and 11.5 times more likely when driving in the rain.

Table 29. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Weather Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Weather Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
No adverse conditions	**10.45***	8.59	12.71	**13.92***	11.39	17.02
Rain	**6.70***	2.70	16.63	**11.45***	4.45	29.45
Fog	3.75	0.22	62.76	3.75	0.22	62.76

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 30 displays the odds ratio calculations for engaging in any moderate tertiary task across "All" and "Vehicle 1 At-Fault" events for four weather conditions. The results in Table 30 suggest that engaging in any moderate tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three weather conditions. When "All" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, and 7.5 times more likely when driving in the fog. When "Vehicle 1 At-Fault" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, 2.3 times more likely when driving in the rain, and 7.5 times more likely when driving in the fog.

Table 30. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Weather Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Weather Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
No adverse conditions	**1.27***	1.14	1.41	**1.49***	1.33	1.68
Rain	1.51	0.96	2.39	**2.29***	1.34	3.90
Snow	1.82	0.35	9.45	2.73	0.44	17.05
Fog	**7.50***	1.17	48.15	**7.50***	1.17	48.15

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 31 displays the odds ratio calculations for engaging in any simple tertiary task across "All" and "Vehicle 1 At-Fault" events for three weather conditions. The results in Table 31 suggest that engaging in any simple tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one weather condition. When "All" events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions. When "Vehicle 1 At-Fault" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions.

Table 31. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Weather Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Weather Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
No adverse conditions	**1.23***	1.07	1.41	**1.41***	1.22	1.63
Rain	1.12	0.63	1.98	1.60	0.83	3.10
Snow	2.00	0.24	16.61	1.50	0.11	21.31

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 32 displays the odds ratio calculations for engaging in any secondary task across "All" and "Vehicle 1 At-Fault" events for six weather conditions. The results in Table 32 suggest that engaging in any secondary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two weather conditions. When "All" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, and 1.5 times more likely when driving in the rain. When "Vehicle 1 At-Fault" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in no adverse weather conditions, and 2.0 times more likely when driving in the rain.

Table 32. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Weather Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Weather Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
No adverse conditions	**1.31**	1.18	1.46	**1.30***	1.15	1.47
Rain	**1.54**	1.00	2.37	**2.00***	1.18	3.38
Sleet	2.00	0.05	78.25	2.00	0.05	78.25
Snow	0.29	0.03	3.12			
Fog	2.50	0.42	14.96	2.50	0.42	14.96
Rain and fog	1.00	0.05	22.18	–	–	–

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.3 Roadway Surface Conditions

The roadway surface condition indicates the condition of the road during the safety-critical event or baseline epoch. The roadway surface conditions at the time of the safety-critical event or baseline epoch were assessed. Data analysts were instructed to use the video data to assist in determining the appropriate roadway surface condition. During data reduction, data analysts selected one of six roadway surface conditions:

- Dry.
- Wet.
- Snow or slush.
- Ice.
- Sand, oil, dirt.
- Other.

Table 33 shows the frequency of secondary and tertiary task during safety-critical events and baselines epochs across “All” and “Vehicle 1 At-Fault” events for four roadway surface conditions. Those conditions that were not observed are not included. As shown in Table 33, most of the events occurred on either dry or wet roads.

Table 33. The Frequency of Secondary and Tertiary Task during Safety-Critical Events and Baseline Epochs across "All" and "Vehicle 1 At-Fault" (V1) Event for each Roadway Surface Condition

Roadway Surface Conditions	Frequency of ALL Tertiary Task Safety-Critical Events	Frequency of ALL Secondary Task Safety-Critical Events	Frequency ALL of Tertiary Task Baselines	Frequency of ALL Secondary Task Baselines	Frequency of V1 Tertiary Task Safety-Critical Events	Frequency of V1 Secondary Task Safety-Critical Events	Frequency of V1 Tertiary Task Baselines	Frequency of V1 Secondary Task Baselines
Dry	1,849	896	6,466	3,638	1,652	655	6,466	3,638
Wet	104	66	677	413	89	51	677	413
Snow/Slush	9	2	18	15	8	1	18	15
Sand, oil, dirt	0	1	0	0	0	1	0	0

Table 34–Table 39 present the results of the odds ratio calculations for each roadway surface condition. Table 34 displays the odds ratio calculations for engaging in any secondary and/or tertiary task across “All” and “Vehicle 1 At-Fault” events for three roadway surface conditions. The results in Table 34 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two roadway surface conditions. When “All” events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface. When “Vehicle 1 At-Fault” events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface, and 1.7 times more likely when driving on a wet roadway surface.

Table 34. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary and/or Tertiary Tasks by Roadway Surface Condition across “All” and “Vehicle 1 At-Fault” (V1) Events

Roadway Surface Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Dry	**1.33***	1.22	1.45	**1.50***	1.36	1.65
Wet	1.23	0.91	1.67	**1.69***	1.16	2.46
Snow/Slush	1.14	0.36	3.61	1.54	0.39	6.12

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 35 displays the odds ratio calculations for engaging in any tertiary task across “All” and “Vehicle 1 At-Fault” events for three roadway surface conditions. The results in Table 35 suggest that engaging in any tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two roadway surface conditions. When “All” events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface. When “Vehicle 1 At-Fault” events were considered, drivers were 1.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface, and 1.8 times more likely when driving on a wet roadway surface.

Table 35. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Roadway Surface Condition across “All” and “Vehicle 1 At-Fault” (V1) Events

Roadway Surface Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Dry	**1.55***	1.41	1.70	**1.87***	1.69	2.07
Wet	1.24	0.88	1.75	**1.77***	1.17	2.66
Snow/Slush	1.60	0.44	5.78	2.37	0.54	10.50

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 36 displays the odds ratio calculations for engaging in any complex tertiary task across “All” and “Vehicle 1 At-Fault” events for two roadway surface conditions. The results in Table 36 suggest that engaging in any complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two roadway surface conditions. When “All” events were considered, drivers were 10.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface, and 5.6 times more likely when driving on a wet roadway surface. When "Vehicle 1 At-Fault" events were considered, drivers were 14.0 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface, and 8.4 times more likely when driving on a wet roadway surface.

Table 36. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Roadway Surface Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Surface Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Dry	**10.56***	8.67	12.85	**14.06***	11.49	17.20
Wet	**5.57***	2.47	12.58	**8.39***	3.55	19.86

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 37 displays the odds ratio calculations for engaging in any moderate tertiary task across "All" and "Vehicle 1 At-Fault" events for three roadway surface conditions. The results in Table 37 suggest that engaging in any moderate tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two roadway surface conditions. When "All" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface. When "Vehicle 1 At-Fault" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface, and 1.9 times more likely when driving on a wet roadway surface.

Table 37. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Roadway Surface Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Surface Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Dry	**1.29***	1.16	1.44	**1.52***	1.35	1.71
Wet	1.32	0.89	1.96	**1.87***	1.18	2.97
Snow/Slush	1.45	0.34	6.25	2.42	0.48	12.30

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 38 displays the odds ratio calculations for engaging in any simple tertiary task across "All" and "Vehicle 1 At-Fault" events for three roadway surface conditions. The results in Table 38 suggest that engaging in any simple tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one roadway surface condition. When "All" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface. When "Vehicle 1 At-Fault" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface.

Table 38. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Roadway Surface Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Surface Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Dry	**1.25***	1.09	1.43	**1.43***	1.23	1.65
Wet	0.86	0.51	1.45	1.22	0.68	2.21
Snow/Slush	1.60	0.22	11.50	1.33	0.11	16.48

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 39 displays the odds ratio calculations for engaging in any secondary task across "All" and "Vehicle 1 At-Fault" events for three roadway surface conditions. The results in Table 39 suggest that engaging in any secondary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two roadway surface conditions. When "All" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface. When "Vehicle 1 At-Fault" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a dry roadway surface, and 1.7 times more likely when driving on a wet roadway surface.

Table 39. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Roadway Surface Condition across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Surface Conditions	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Dry	**1.33***	1.20	1.48	**1.32***	1.17	1.49
Wet	1.30	0.89	1.89	**1.66***	1.06	2.60
Snow/Slush	0.43	0.07	2.54	0.36	0.03	3.80

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.4 Relation to Junction

The relation to junction indicates an intersection or the connection between a driveway access and a roadway other than a driveway access during the safety-critical event or baseline epoch. The relation to junction at the time of the safety-critical event or baseline epoch was assessed. Data analysts were instructed to use the video data to assist in determining the appropriate relation to junction. During data reduction, data analysts selected one of the ten relation to junction options:

- Non-junction.
- Intersection.
- Intersection-related.
- Driveway, alley access, etc.
- Parking lot.
- Entrance/exit ramp.
- Rail grade crossing.

- Bridge.
- Crossover-related.
- Other.

Table 40 shows the frequency of secondary and tertiary tasks during safety-critical events and baseline epochs across “All” and “Vehicle 1 At-Fault” events for each relation to junction. Those conditions that were not observed are not included. As can be seen in Table 40, most of the events occurred on non-junctions.

Table 40. The Frequency of Secondary and Tertiary Tasks during Safety-Critical Events and Baseline Epochs across "All" and "Vehicle 1 At-Fault" (V1) for each Relation to Junction

Relation to Junction	Frequency of ALL Tertiary Task Safety-Critical Events	Frequency of ALL Secondary Task Safety-Critical Events	Frequency of ALL Tertiary Task Baselines	Frequency of ALL Secondary Task Baselines	Frequency of V1 Tertiary Task Safety-Critical Events	Frequency of V1 Secondary Task Safety-Critical Events	Frequency of V1 Tertiary Task Baselines	Frequency of V1 Secondary Task Baselines
Non-junction	1,712	614	6,825	3,852	1,576	504	6,825	3,852
Intersection	20	42	39	18	13	19	39	18
Intersection-related	142	175	66	30	102	114	66	30
Driveway, alley access, etc.	3	1	3	0	2	1	3	0
Parking lot	3	20	12	3	2	9	12	3
Entrance/exit ramp	57	94	94	95	33	49	94	95
Rail grade crossing	3	1	0	1	2	0	0	1
Bridge	16	2	113	56	15	2	113	56
Crossover-related	2	1	0	2	1	1	0	2
Other	4	14	9	9	3	8	9	9

Table 41–Table 46 present the results of the odds ratio calculations for each relation to junction. Table 41 displays the odds ratio calculations for engaging in any secondary and/or tertiary task across "All" and "Vehicle 1 At-Fault" events for nine relation to junction options. The results in Table 41 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one relation to junction option. Further, Table 41 illustrates that engaging in any task significantly decreased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one relation to junction option. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction. When "Vehicle 1 At-Fault" events were considered, drivers were 1.7 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction. and 0.6 times less likely when driving on a entrance/exit ramp.

Table 41. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary and/or Tertiary Tasks by Relation to Junction across "All" and "Vehicle 1 At-Fault" (V1) Events

Relation to Junction	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Non-junction	**1.44***	1.31	1.58	**1.70***	1.53	1.89
Intersection	0.77	0.38	1.54	1.00	0.40	2.51
Intersection-related	0.96	0.64	1.45	0.86	0.56	1.32
Parking lot	2.57	0.43	15.41	2.48	0.25	24.65
Entrance/exit ramp	0.72	0.48	1.07	**0.62***	0.39	0.98
Bridge	1.53	0.57	4.13	1.42	0.52	3.86
Crossover-related	1.00	0.05	18.91	1.50	0.06	40.63
Other	0.84	0.26	2.71	2.07	0.37	11.49
Driveway, alley access, etc.	1.00	0.45	22.18	0.75	0.03	17.51

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 42 suggests that engaging in any tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one relation to junction option. Further, Table 42 illustrates that engaging in any tertiary task significantly decreased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two relation to junction options. When "All" events were considered, drivers were 1.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction, 0.4 times less likely when driving in an intersection, and 0.5 times less likely when driving on an entrance/exit ramp. When "Vehicle 1 At-Fault" events were considered, drivers were 2.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction and 0.5 times less likely when driving on a entrance/exit ramp. Note that the low frequencies in many of the junction categories make it difficult to read too much into these findings.

Table 42. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Relation to Junction across "All" and "Vehicle 1 At-Fault" (V1) Events

Relation to Junction	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Non-junction	**1.85***	1.67	2.04	**2.25***	2.02	2.52
Intersection	**0.42***	0.18	0.96	0.75	0.26	2.13
Intersection-related	0.72	0.46	1.15	0.69	0.42	1.11
Driveway, alley access, etc.	1.00	0.04	24.55	0.67	0.02	18.06
Parking lot	0.50	0.06	4.15	0.67	0.05	9.47
Entrance/exit ramp	**0.51***	0.03	0.84	**0.47***	0.27	0.83
Bridge	1.73	0.60	4.94	1.62	0.56	4.67
Other	0.39	0.08	1.84	1.17	0.15	9.01

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 43 displays the odds ratio calculations for engaging in any complex tertiary task across "All" and "Vehicle 1 At-Fault" events for four relation to junction options. The results in Table 43 suggest that engaging in any complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two relation to junction options. When "All" events were considered, drivers were 13.8 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction, and 9.2 more likely when driving on a bridge. When "Vehicle 1 At-Fault" events were considered, drivers were 18.1 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction, and 9.2 times more likely when driving on a bridge. Note that the low frequencies in many junction categories make it difficult to read too much into these findings.

Table 43. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Relation to Junction across "All" and "Vehicle 1 At-Fault" (V1) Events

Relation to Junction	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Non-junction	**13.77**	11.30	16.78	**18.05***	14.74	22.11
Intersection-related	1.68	0.19	14.82	1.33	0.13	13.21
Entrance/exit ramp	0.42	0.04	4.79	0.67	0.06	7.65
Bridge	**9.15**	1.59	52.80	**9.15***	1.59	52.80

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 44 displays the odds ratio calculations for engaging in any moderate tertiary task across "All" and "Vehicle 1 At-Fault" events for seven relation to junction options. The results in Table 44 suggest that engaging in any moderate tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one relation to junction option. Further, Table 44 illustrates that engaging in any moderate tertiary task significantly decreased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three relation to junction options. When "All" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction, 0.3 times less likely when driving in an intersection, 0.5 times less likely when driving in an intersection-related junction, and 0.4 times less likely when driving on an entrance/exit ramp. When "Vehicle 1 At-Fault" events were considered, drivers were 1.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction, 0.3 times less likely when driving in an intersection, 0.6 times less likely when driving in an intersection-related junction, and 0.3 times less likely when driving on an entrance/exit ramp. Note that the low frequencies in many of the junction categories make it difficult to read too much into these findings.

Table 44. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Relation to Junction across "All" and "Vehicle 1 At-Fault" (V1) Events

Relation to Junction	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Non-junction	**1.55***	1.38	1.74	**1.86***	1.64	2.12
Intersection	**0.25***	0.10	0.67	**0.31***	0.08	1.18
Intersection-related	**0.54***	0.32	0.92	**0.55***	0.32	0.96
Parking lot	0.86	0.10	7.51	1.14	0.08	16.95
Entrance/exit ramp	**0.43***	0.25	0.75	**0.34***	0.17	0.67
Bridge	1.48	0.46	4.77	1.29	0.39	4.29
Other	0.35	0.05	2.41	0.70	0.05	10.01

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 45 displays the odds ratio calculations for engaging in any simple tertiary task across "All" and "Vehicle 1 At-Fault" events for five relation to junction options. The results in Table 45 suggest that engaging in any simple tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one relation to junction option. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction. When "Vehicle 1 At-Fault" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction. Note that the low frequencies in many of the junction categories make it difficult to read too much into these findings.

Table 45. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Relation to Junction across "All" and "Vehicle 1 At-Fault" (V1) Events

Relation to Junction	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Non-junction	**1.38***	1.19	1.59	**1.59***	1.36	1.85
Intersection	1.23	0.30	5.03	2.81	0.59	13.34
Intersection-related	1.24	0.61	2.52	1.16	0.55	2.44
Entrance/exit ramp	0.62	0.29	1.36	0.64	0.26	1.55
Bridge	0.98	0.18	5.37	0.98	0.18	5.37

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 46 displays the odds ratio calculations for engaging in any secondary task across "All" and "Vehicle 1 At-Fault" events for eight relation to junction options. The results in Table 46 suggest that engaging in any secondary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three relation to junction options. When

"All" events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction, 2.0 times more likely when driving on an intersection-related junction, and 13.3 times more likely when driving in a parking lot. When "Vehicle 1 At-Fault" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a non-junction. Note that the low frequencies in many of the junction categories make it difficult to read too much into these findings.

Table 46. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Relation to Junction across "All" and "Vehicle 1 At-Fault" (V1) Events

Relation to Junction	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Non-junction	**1.17***	1.04	1.32	**1.28***	1.12	1.46
Intersection	1.91	0.83	4.39	2.38	0.83	6.81
Intersection-related	**1.96***	1.16	3.32	1.69	0.98	2.92
Parking lot	**13.33***	1.65	107.43	12.00	0.94	153.89
Entrance/exit ramp	0.84	0.53	1.32	0.69	0.41	1.18
Bridge	0.44	0.08	2.34	0.44	0.08	2.34
Crossover-related	0.25	0.01	7.45	0.50	0.01	19.56
Other	1.36	0.37	5.07	3.11	0.50	19.54

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.5 Trafficway Flow

The trafficway flow indicates whether the safety-critical event or baseline epoch occurred on a trafficway that was not physically divided or was divided with a median strip (with or without a traffic barrier), and whether it served one-way or two-way traffic. The trafficway flow at the time of the safety-critical event or baseline epoch was assessed. Data analysts were instructed to use the video data to assist in determining the appropriate relation to junction. During data reduction, data analysts selected one of the four trafficway flow options:

- Not physically divided (center 2-way left turn lane).
- Not physically divided (2-way trafficway).
- Divided (median strip or barrier).
- One-way trafficway.

Table 47 shows the frequency of secondary and tertiary tasks during safety-critical events and baseline epochs across "All" and "Vehicle 1 At-Fault" events for each trafficway flow. Those conditions that were not observed are not included. As shown in Table 47, most data were collected on divided roadways.

Table 47. The Frequency of Secondary and Tertiary Tasks during Safety-Critical Events and Baseline Epochs across "All" and "Vehicle 1 At-Fault" (V1) Events for each Trafficway Flow Condition

Trafficway Flow	Frequency of ALL Tertiary Task Safety-Critical Events	Frequency of ALL Secondary Task Safety-Critical Events	Frequency of ALL Tertiary Task Baselines	Frequency of ALL Secondary Task Baselines	Frequency of V1 Tertiary Task Safety-Critical Events	Frequency of V1 Secondary Task Safety-Critical Events	Frequency V1 of Tertiary Task Baselines	Frequency of V1 Secondary Task Baselines
Not physically divided (center 2-way turn lane)	41	33	110	43	32	23	110	43
Not physically divided (2-way trafficway)	253	204	590	315	185	118	590	315
Divided (median strip or barrier)	1,654	706	6,368	3,634	1,519	550	6,368	3,634
One-way trafficway	14	21	93	74	13	16	93	74

Table 48–Table 53 present the results of the odds ratio calculations for each trafficway flow. Table 48 displays the odds ratio calculations for engaging in any secondary and/or tertiary task across "All" and "Vehicle 1 At-Fault" events for each trafficway flow option. The results in Table 48 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one trafficway flow option. When "All" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway. When "Vehicle 1 At-Fault" events were considered, drivers were 1.7 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway.

Table 48. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary and/or Tertiary Tasks by Trafficway Flow across "All" and "Vehicle 1 At-Fault" (V1) Events

Trafficway Flow	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Not physically divided (center 2-way turn lane)	0.79	0.45	1.38	0.71	0.39	1.30
Not physically divided (2-way trafficway)	1.04	0.85	1.27	1.00	0.79	1.27
Divided (median strip or barrier)	**1.45***	1.32	1.59	**1.69***	1.52	1.88
One-way trafficway	1.22	0.54	2.75	1.21	0.48	3.03

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 49 displays the odds ratio calculations for engaging in any tertiary task across "All" and "Vehicle 1 At-Fault" events for each trafficway flow option. The results in Table 49 suggest that engaging in any tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one trafficway flow option. When "All" events were considered, drivers were 1.7 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway. When "Vehicle 1 At-Fault" events were considered, drivers were 2.1 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway.

Table 49. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Trafficway Flow across "All" and "Vehicle 1 At-Fault" (V1) Events

Trafficway Flow	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Not physically divided (center 2-way turn lane)	0.75	0.40	1.38	0.70	0.36	1.37
Not physically divided (2-way trafficway)	1.00	0.79	1.25	1.09	0.84	1.41
Divided (median strip or barrier)	**1.74***	1.57	1.92	**2.14***	1.91	2.39
One-way trafficway	0.94	0.37	2.39	1.16	0.42	3.25

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 50 displays the odds ratio calculations for engaging in any complex tertiary task across "All" and "Vehicle 1 At-Fault" events for each trafficway flow. The results in Table 50 suggest that engaging in any complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two trafficway flow options. When "All" events were considered, drivers were 12.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway and 3.6 times more likely when driving on a not physically divided (2-way) trafficway. When "Vehicle 1 At-Fault" events were considered, drivers were 17.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway and 4.8 times more likely when driving on a not physically divided (2-way) trafficway.

Table 50. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Trafficway Flow across "All" and "Vehicle 1 At-Fault" (V1) Events

Trafficway Flow	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Not physically divided (center 2-way turn lane)	2.00	0.53	7.61	1.94	0.47	8.01
Not physically divided (2-way trafficway)	**3.63**	1.89	6.95	**4.77***	2.43	9.37
Divided (median strip or barrier)	**12.89***	10.51	15.80	**17.21***	13.96	21.22
One-way trafficway	2.08	0.19	22.58	2.78	0.25	31.13

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 51 displays the odds ratio calculations for engaging in any moderate tertiary task across "All" and "Vehicle 1 At-Fault" events for each trafficway flow. The results in Table 51 suggest that engaging in any moderate tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one trafficway flow option. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway. When "Vehicle 1 At-Fault" events were considered, drivers were 1.7 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway.

Table 51. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Trafficway Flow across "All" and "Vehicle 1 At-Fault" (V1) Events

Trafficway Flow	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Not physically divided (center 2-way turn lane)	0.54	0.26	1.14	0.53	0.24	1.19
Not physically divided (2-way trafficway)	0.97	0.74	1.27	1.04	0.77	1.43
Divided (median strip or barrier)	**1.44***	1.28	1.62	**1.74***	1.53	1.97
One-way trafficway	1.08	0.40	2.94	1.44	0.49	4.23

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 52 displays the odds ratio calculations for engaging in any simple tertiary task across “All” and “Vehicle 1 At-Fault” events for each trafficway flow. The results in Table 52 suggest that engaging in any simple tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one trafficway flow option. When “All” events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway. When “Vehicle 1 At-Fault” events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway.

Table 52. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Trafficway Flow across “All” and “Vehicle 1 At-Fault” (V1) Events

Trafficway Flow	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Not physically divided (center 2-way turn lane)	1.27	0.55	2.94	1.32	0.55	3.19
Not physically divided (2-way trafficway)	0.96	0.69	1.35	1.08	0.74	1.59
Divided (median strip or barrier)	**1.31***	1.13	1.52	**1.52***	1.30	1.78
One-way trafficway	0.60	0.12	3.04	0.40	0.05	3.50

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 53 displays the odds ratio calculations for engaging in any secondary task across “All” and “Vehicle 1 At-Fault” events for each trafficway flow. The results in Table 53 suggest that engaging in any secondary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two trafficway flow options. When “All” events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway, and 1.5 times more likely to be driving on a not physically divided (2-way) trafficway. When “Vehicle 1 At-Fault” events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a divided (median strip or barrier) trafficway.

Table 53. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Trafficway Flow across “All” and “Vehicle 1 At-Fault” (V1) Events

Trafficway Flow	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Not physically divided (center 2-way turn lane)	1.53	0.78	3.02	1.30	0.62	2.70
Not physically divided (2-way trafficway)	**1.50**	1.17	1.93	1.30	0.97	1.74
Divided (median strip or barrier)	**1.30***	1.15	1.46	**1.36***	1.19	1.55
One-way trafficway	1.77	0.73	4.32	1.80	0.66	4.92

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.6 Roadway Alignment

The roadway alignment condition indicates the alignment of the road during the safety-critical event or baseline epoch. The roadway alignment the time of the safety-critical event or baseline epoch was assessed. Data analysts were instructed to use the video data to assist in determining the appropriate roadway alignment. During data reduction, data analysts selected one of the four roadway alignments options:

- Straight.
- Curve right.
- Curve left.
- Unknown.

Table 54 shows the frequency of secondary and tertiary tasks during safety-critical events and baseline epochs across "All" and "Vehicle 1 At-Fault" events for three roadway alignment options. Those conditions that were not observed are not included. As can be seen in Table 54, most data were collected on straight roads.

Table 54. The Frequency of Secondary and Tertiary Tasks during Safety-Critical Events and Baseline Epochs across "All" and "Vehicle 1 At-Fault" (V1) Events for each Roadway Alignment

Roadway Alignment	Frequency of ALL Tertiary Task Safety-Critical Events	Frequency of ALL Secondary Task Safety-Critical Events	Frequency of ALL Tertiary Task Baselines	Frequency of ALL Secondary Task Baselines	Frequency of V1 Tertiary Task Safety-Critical Events	Frequency of V1 Secondary Task Safety-Critical Events	Frequency of V1 Tertiary Task Baselines	Frequency of V1 Secondary Task Baselines
Straight	1,763	890	6,510	3,637	1,568	647	6,510	3,637
Curve right	111	31	383	213	102	29	383	213
Curve left	88	43	268	216	79	31	268	216

Table 55–Table 60 present the results of the odds ratio calculations for each roadway alignment option. Table 55 displays the odds ratio calculations for engaging in any secondary and/or tertiary task across "All" and "Vehicle 1 At-Fault" events for three roadway alignment options. The results in Table 55 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one roadway alignment option. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment. When "Vehicle 1 At-Fault" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment.

Table 55. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary and/or Tertiary Tasks by Roadway Alignment across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Alignment	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Straight	**1.37***	1.25	1.49	**1.55***	1.40	1.71
Curve right	0.88	0.64	1.21	1.17	0.81	1.68
Curve left	1.29	0.88	1.89	1.32	0.87	1.99

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 56 displays the odds ratio calculations for engaging in any tertiary task across "All" and "Vehicle 1 At-Fault" events for three roadway alignment options. The results in Table 56 suggest that engaging in any tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three roadway alignment options. When "All" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment, and 1.8 times more likely when driving on a curve left roadway alignment. When "Vehicle 1 At-Fault" events were considered, drivers were 1.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment, 1.7 times more likely when driving on a curve right roadway alignment, and 1.9 times more likely when driving on a curve left roadway alignment.

Table 56. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Roadway Alignment across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Alignment	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Straight	**1.55***	1.41	1.70	**1.89***	1.70	2.10
Curve right	1.21	0.86	1.71	**1.67***	1.14	2.46
Curve left	**1.78***	1.18	2.70	**1.94***	1.24	3.02

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 57 displays the odds ratio calculations for engaging in any complex tertiary task across "All" and "Vehicle 1 At-Fault" events for three roadway alignment options. The results in

Table 57 suggest that engaging in any complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in all of the roadway alignment options. When “All” events were considered, drivers were 10.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment, 13.2 times more likely when driving on a curve right roadway alignment, and 10.0 times more likely when driving on a curve left roadway alignment. When “Vehicle 1 At-Fault” events were considered, drivers were 14.0 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment, 19.9 times more likely when driving on a curve right roadway alignment, and 12.1 times more likely when driving on a curve left roadway alignment.

Table 57. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Roadway Alignment across “All” and “Vehicle 1 At-Fault” (V1) Events

Roadway Alignment	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Straight	**10.35***	8.49	12.61	**13.91***	11.35	17.04
Curve right	**13.24***	5.09	34.46	**19.86***	7.52	52.47
Curve left	**9.95***	3.48	28.43	**12.06***	4.18	34.80

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 58 displays the odds ratio calculations for engaging in any moderate tertiary task across “All” and “Vehicle 1 At-Fault” events for three roadway alignment options. The results in Table 58 suggest that engaging in any moderate tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two roadway alignment options. When “All” events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment. When “Vehicle 1 At-Fault” events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment, and 1.5 times more likely when driving on a curve right roadway alignment.

Table 58. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Roadway Alignment across “All” and “Vehicle 1 At-Fault” (V1) Events

Roadway	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Straight	**1.30***	1.17	1.46	**1.55***	1.37	1.76
Curve right	1.17	0.78	1.74	**1.53***	0.98	2.39
Curve left	1.47	0.90	2.41	1.55	0.91	2.63

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 59 displays the odds ratio calculations for engaging in any simple tertiary task across “All” and “Vehicle 1 At-Fault” events for three roadway alignment options. The results in Table 59 suggest that engaging in any simple tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one roadway alignment option. When "All" events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment. When "Vehicle 1 At-Fault" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment.

Table 59. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Roadway Alignment across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Alignment	ALL Odds Ratio	ALL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Straight	**1.24***	1.08	1.43	**1.43***	1.23	1.66
Curve right	0.89	0.52	1.52	1.28	0.73	2.25
Curve left	1.34	0.72	2.48	1.26	0.64	2.49

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 60 displays the odds ratio calculations for engaging in any secondary task across "All" and "Vehicle 1 At-Fault" events for three roadway alignment options. The results in Table 60 suggest that engaging in any secondary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one roadway alignment option. Further, Table 60 shows that engaging in any secondary task significantly decreased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one roadway alignment option. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment and 0.6 times less likely when driving on a curve right roadway alignment. When "Vehicle 1 At-Fault" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a straight roadway alignment.

Table 60. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Roadway Alignment across "All" and "Vehicle 1 At-Fault" (V1) Events

Roadway Alignment	ALL Odds Ratio	ALL LCL	ALL	V1 Odds Ratio	V1 LCL	V1 UCL
Straight	**1.40***	1.26	1.56	**1.39***	1.23	1.58
Curve right	**0.61***	0.38	0.97	0.85	0.52	1.41
Curve left	1.08	0.68	1.73	0.94	0.56	1.60

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.7 Road Profile

The road profile condition indicates the profile of the road during the safety-critical event or baseline epoch. The road profile at the time of the safety-critical event or baseline epoch was assessed. Data analysts were instructed to use the video data to assist in determining the appropriate road profile. During data reduction, data analysts selected one of the five road profile options:

- Level.
- Grade up.
- Grade down.
- Hillcrest.
- Sag.

Table 61 shows the frequency of secondary and tertiary tasks during safety-critical events and baseline epochs across “All” and “Vehicle 1 At-Fault” events for each road profile. Those conditions that were not observed are not included. As shown in Table 61, most of the data were collected on level roads.

Table 61. The Frequency of Secondary and Tertiary Tasks during Safety-Critical Events and Baseline Epochs across "All" and "Vehicle 1 At-Fault" (V1) Events for each Road Profile

Road Profile	Frequency of ALL Tertiary Task Safety-Critical Events	Frequency of ALL Secondary Task Safety-Critical Events	Frequency of ALL Tertiary Task Baselines	Frequency of ALL Secondary Task Baselines	Frequency of V1 Tertiary Task Safety-Critical Events	Frequency of V1 Secondary Task Safety-Critical Events	Frequency of V1 Tertiary Task Baselines	Frequency of V1 Secondary Task Baselines
Level	1,856	913	7,049	3,982	1,649	664	7,049	3,982
Grade up	94	44	72	50	91	39	72	50
Grade down	12	7	34	31	9	4	34	31
Hillcrest	0	0	4	2	0	0	4	2
Sag	0	0	2	1	0	0	2	1

Table 62–Table 64 present the results of the odds ratio calculations for each road profile. Table 62 displays the odds ratio calculations for engaging in any secondary and/or tertiary task across “All” and “Vehicle 1 At-Fault” events for three road profile options. The results in Table 62 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one road profile option. Further, Table 62 shows that engaging in any task significantly decreased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one road profile option. When “All” events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile, and 0.3 times less likely while driving on a grade down road profile. When “Vehicle 1 At-Fault” events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile, and 0.3 times less likely while driving on a grade down road profile. Note that the low frequencies in many of the road profile categories make it difficult to read too much into these findings.

Table 62. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary and/or Tertiary Tasks by Road Profile across “All” and “Vehicle 1 At-Fault” (V1) Events

Road Profile	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Level	**1.35***	1.24	1.47	**1.53***	1.39	1.68
Grade up	1.05	0.66	1.68	1.33	0.81	2.20
Grade down	**0.34***	0.14	0.83	**0.31***	0.11	0.86

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 63 displays the odds ratio calculations for engaging in any tertiary task across “All” and “Vehicle 1 At-Fault” events for three road profiles. The results in Table 63 suggest that engaging in any tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two road profile options. When “All” events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile. When “Vehicle 1 At-Fault” events were considered, drivers were 1.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile, and 2.0 times more likely while driving on a grade up road profile. Note that the low frequencies in many of the road profile categories make it difficult to read too much into these findings.

Table 63. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Road Profile across “All” and “Vehicle 1 At-Fault” (V1) Events

Road Profile	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Level	**1.55***	1.41	1.70	**1.88***	1.70	2.09
Grade up	1.53	0.91	2.56	**2.02***	1.17	3.51
Grade down	0.55	0.20	1.49	0.56	0.18	1.72

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 64 displays the odds ratio calculations for engaging in any complex tertiary task across "All" and "Vehicle 1 At-Fault" events for two road profiles. The results in Table 64 suggest that engaging in any complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two road profile options. When "All" events were considered, drivers were 10.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile, and 24.6 times more likely while driving on a grade up road profile. When "Vehicle 1 At-Fault" events were considered, drivers were 13.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile, and 33.6 times more likely while driving on a grade up road profile. Note that the low frequencies in many of the road profile categories make it difficult to read too much into these findings.

Table 64. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Road Profile across "All" and "Vehicle 1 At-Fault" (V1) Events

Road Profile	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Level	**10.34***	8.53	12.54	**13.92***	11.41	16.97
Grade up	**24.59***	3.17	190.77	**33.60***	4.29	262.91

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 64 displays the odds ratio calculations for engaging in any moderate tertiary task across "All" and "Vehicle 1 At-Fault" events for three road profiles. The results in Table 64 suggest that engaging in any moderate tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one road profile option. When "All" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile. When "Vehicle 1 At-Fault" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile. Note that the low frequencies in many of the road profile categories make it difficult to read too much into these findings.

Table 65. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Road Profile across "All" and "Vehicle 1 At-Fault" (V1) Events

Road Profile	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Level	**1.32***	1.19	1.47	**1.57***	1.40	1.77
Grade up	1.05	0.57	1.95	1.35	0.71	2.59
Grade down	0.52	0.15	1.82	0.43	0.10	1.90

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 66 displays the odds ratio calculations for engaging in any simple tertiary task across "All" and "Vehicle 1 At-Fault" events for three road profiles. The results in Table 66 suggest that engaging in any simple tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one road profile option. When "All" events were considered, drivers were 1.2 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile. When "Vehicle 1 At-Fault" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile. Note that the low frequencies in many of the road profile categories make it difficult to read too much into these findings.

Table 66. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Road Profile across "All" and "Vehicle 1 At-Fault" (V1) Events

Road Profile	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Level	**1.22***	1.07	1.39	**1.40***	1.21	1.62
Grade up	1.17	0.58	2.36	1.53	0.74	3.19
Grade down	0.48	0.12	1.84	0.49	0.11	2.22

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 67 displays the odds ratio calculations for engaging in any secondary task across "All" and "Vehicle 1 At-Fault" events for three road profile options. The results in Table 67 suggest that engaging in any secondary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one road profile option. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile. When "Vehicle 1 At-Fault" events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving on a level road profile. Note that the low frequencies in many of the road profile categories make it difficult to read too much into these findings.

Table 67. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Road Profile across "All" and "Vehicle 1 At-Fault" (V1) Events

Road Profile	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
Level	**1.35***	1.21	1.50	**1.34***	1.19	1.51
Grade up	1.03	0.58	1.84	1.25	0.67	2.32
Grade down	0.35	0.11	1.07	0.27	0.07	1.05

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.8 Traffic Density

Traffic density is listed in increasing order from level of service (LOS) A to LOS F. LOS A is described as conditions where traffic flows at or above the posted speed limit and all motorists have complete mobility between lanes. LOS B is slightly more congested, with some impingement of maneuverability; two motorists might be forced to drive side by side, limiting lane changes. LOS C has more congestion than B, where ability to pass or change lanes is not always assured. In LOS D speeds are somewhat reduced, and motorists are hemmed in by other cars and trucks. LOS E is a marginal service state; flow becomes irregular and speed varies rapidly, but rarely reaches the posted limit. LOS F is the lowest measurement of efficiency for a road's performance. Flow is forced; every vehicle moves in lockstep with the vehicle in front of it, with frequent drops in speed to nearly 0 mi/h (Mannering, Kilareski, & Washburn, 2004). The LOS at the time of the safety-critical event or baseline epoch was assessed. Data analysts were instructed to use the video data to assist in determining the appropriate LOS. During data reduction, data analysts selected one of the six LOS options:

- LOS A: Free flow.
- LOS B: Flow with some restrictions.
- LOS C: Stable flow, maneuverability and speed are more restricted.
- LOS D: Unstable flow: temporary restrictions substantially slow driver.
- LOS E: Flow is unstable; vehicles are unable to pass, temporary stoppages, etc.
- LOS F: Forced traffic flow condition with low speeds and traffic volumes that are below capacity; queues forming in particular locations.

Table 68 shows the frequency of secondary and tertiary tasks during safety-critical events and baseline epochs across "All" and "Vehicle 1 At-Fault" events for each LOS. As can be seen in Table 68, most data were collected in LOS A and B.

Table 68. The Frequency of Secondary and Tertiary Tasks during Safety-Critical Events and Baseline Epochs across "All" and "Vehicle 1 At-Fault" (V1) Events for each LOS

Traffic Density	Frequency of ALL Tertiary Task Safety-Critical Events	Frequency of ALL Secondary Task Safety-Critical Events	Frequency of ALL Tertiary Task Baselines	Frequency of ALL Secondary Task Baselines	Frequency of V1 Tertiary Task Safety-Critical Events	Frequency of V1 Secondary Task Safety-Critical Events	Frequency of V1 Tertiary Task Baselines	Frequency of V1 Secondary Task Baselines
LOS A	1,356	411	5,539	3,060	1,249	309	5,539	3,060
LOS B	460	347	1,567	963	397	260	1,567	963
LOS C	114	134	50	40	86	90	50	40
LOS D	14	39	5	3	7	27	5	3
LOS E	13	23	0	0	9	15	0	0
LOS F	4	10	0	0	3	6	0	0

Table 69–Table 74 present the results of the odds ratio calculations for each LOS. Table 69 displays the odds ratio calculations for engaging in any secondary and/or tertiary task across "All" and "Vehicle 1 At-Fault" events for four LOS options. The results in Table 69 suggest that engaging in any secondary or tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three traffic density options. When "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density, 1.3 times more likely when driving in LOS B traffic density, and 1.7 times more likely when driving in LOS C traffic density. When "Vehicle 1 At-Fault" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density, 1.6 times more likely when driving in LOS B traffic density, and 2.0 times more likely when driving in LOS C traffic density. Note that the low frequencies in many of the LOS categories make it difficult to read too much into these findings.

Table 69. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary and/or Tertiary Tasks by Traffic Density across "All" and "Vehicle 1 At-Fault" (V1) Events

Traffic Density	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
LOS A	**1.40***	1.26	1.56	**1.53***	1.36	1.72
LOS B	**1.30***	1.11	1.53	**1.60***	1.32	1.93
LOS C	**1.65***	1.10	2.49	**2.03***	1.28	3.21
LOS D	0.46	0.12	1.71	0.51	0.13	2.00

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 70 displays the odds ratio calculations for engaging in any tertiary task across "All" and "Vehicle 1 At-Fault" events for four LOS options. The results in Table 70 suggest that engaging in any tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three LOS options. When "All" events were considered, drivers were 1.9 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density and 1.3 times more likely when driving in LOS B traffic density. When "Vehicle 1 At-Fault" events were considered, drivers were 2.1 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density, 1.7 times more likely when driving in LOS B traffic density, and 1.9 times more likely when driving in LOS C traffic density. Note that the low frequencies in many of the LOS categories make it difficult to read too much into these findings.

Table 70. Odds Ratios and 95% Confidence Intervals for the Interaction of Tertiary Tasks by Traffic Density across "All" and "Vehicle 1 At-Fault" (V1) Events

Traffic Density	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
LOS A	**1.85***	1.65	2.08	**2.14***	1.89	2.42
LOS B	**1.31***	1.10	1.57	**1.71***	1.40	2.10
LOS C	1.41	0.87	2.28	**1.87***	1.10	3.18
LOS D	0.28	0.06	1.34	0.23	0.04	1.25

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 71 displays the odds ratio calculations for engaging in any complex tertiary task across "All" and "Vehicle 1 At-Fault" events for three LOS options. The results in Table 71 suggest that engaging in any complex tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three LOS options. When "All" events were considered, drivers were 13.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density and 7.9 times more likely when driving in LOS B traffic density. When "Vehicle 1 At-Fault" events were considered, drivers were 16.7 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density, 11.8 times more likely when driving in LOS B traffic density, and 5.8 times more likely when driving in LOS C traffic density. Note that the low frequencies in many of the LOS categories make it difficult to read too much into these findings.

Table 71. Odds Ratios and 95% Confidence Intervals for the Interaction of Complex Tertiary Tasks by Traffic Density across "All" and "Vehicle 1 At-Fault" (V1) Events

Traffic Density	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
LOS A	**13.54***	10.83	16.94	**16.69***	13.28	20.98
LOS B	**7.94***	5.34	11.81	**11.83***	7.86	17.81
LOS C	3.29	0.91	11.87	**5.80***	1.59	21.20

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 72 displays the odds ratio calculations for engaging in any moderate tertiary task across "All" and "Vehicle 1 At-Fault" events for four LOS options. The results in Table 72 suggest that engaging in any moderate tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in three LOS options. When "All" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density. When "Vehicle 1 At-Fault" events were considered, drivers were 1.8 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density, 1.4 times more likely when driving in LOS B traffic density, and 2.0 times more likely when driving in LOS C traffic density. Note that the low frequencies in many of the LOS categories make it difficult to read too much into these findings.

Table 72. Odds Ratios and 95% Confidence Intervals for the Interaction of Moderate Tertiary Tasks by Traffic Density across "All" and "Vehicle 1 At-Fault" (V1) Events

Traffic Density	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
LOS A	**1.56***	1.37	1.77	**1.76***	1.52	2.02
LOS B	1.05	0.85	1.30	**1.35***	1.07	1.71
LOS C	1.44	0.80	2.61	**1.99***	1.05	3.77
LOS D	0.37	0.06	2.10	0.28	0.04	1.82

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 73 displays the odds ratio calculations for engaging in any simple tertiary task across "All" and "Vehicle 1 At-Fault" events for four LOS options. The results in Table 73 suggest that engaging in any simple tertiary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in one LOS option. When "All" events were considered, drivers were 1.5 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density. When "Vehicle 1 At-Fault" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS A traffic density. Note that the low frequencies in many of the LOS categories make it difficult to read too much into these findings.

Table 73. Odds Ratios and 95% Confidence Intervals for the Interaction of Simple Tertiary Tasks by Traffic Density across "All" and "Vehicle 1 At-Fault" (V1) Events

Traffic Density	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
LOS A	**1.46***	1.24	1.70	**1.62***	1.37	1.92
LOS B	1.15	0.87	1.53	1.35	0.98	1.86
LOS C	1.10	0.52	2.32	1.09	0.47	2.52
LOS D	0.30	0.02	3.86	0.33	0.02	4.93

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Table 74 displays the odds ratio calculations for engaging in any secondary task across "All" and "Vehicle 1 At-Fault" events for four LOS options. The results in Table 74 suggest that engaging in any secondary task significantly increased the risk of a driver being involved in a safety-critical event (compared to a baseline epoch) in two LOS options. When "All" events were considered, drivers were 1.6 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS B traffic density, and 2.1 times more likely when driving in LOS C traffic density. When "Vehicle 1 At-Fault" events were considered, drivers were 1.8 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when driving in LOS B traffic density, and 2.5 times more likely when driving in LOS C traffic density. Note that the low frequencies in many of the LOS categories make it difficult to read too much into these findings.

Table 74. Odds Ratios and 95% Confidence Intervals for the Interaction of Secondary Tasks by Traffic Density across "All" and "Vehicle 1 At-Fault" (V1) Events

Traffic Density	ALL Odds Ratio	ALL LCL	ALL UCL	V1 Odds Ratio	V1 LCL	V1 UCL
LOS A	1.02	0.88	1.17	0.96	0.82	1.12
LOS B	**1.61***	1.33	1.95	**1.83***	1.46	2.28
LOS C	**2.07***	1.26	3.41	**2.45***	1.42	4.23
LOS D	1.30	0.24	6.90	1.50	0.27	8.28

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

5.4.9 Summary

The exploration of the various environmental conditions provided some interesting findings; however, the authors concede there were not many obvious conclusions from this set of analyses. If anything, the results support the conclusions from Research Question 1; that is, complex tertiary tasks were associated with the highest risk, and this was not abated when the data were parsed as a function of different environmental condition. Because many of the environmental categories (or sub-categories) had few data points, significant findings tended to occur when the data set for an environmental category was sufficiently large (i.e., sufficient statistical power was obtained). As such, it is difficult to read too much into these results. The results may resonate with, or be of interest to, other researchers looking at relationships between tasks and the different environmental conditions.

5.5 RESEARCH QUESTION 3: WHAT ARE THE ODDS RATIOS OF EYES-OFF-FORWARD-ROADWAY? DOES EYES-OFF-FORWARD-ROADWAY SIGNIFICANTLY AFFECT SAFETY AND/OR DRIVING PERFORMANCE?

The third research question was directed at measuring visual distraction using eye glance analysis. To answer this research question, all safety-critical events (n = 3,565) and baseline epochs (n = 19,056) with valid eye glance data were included. Valid eye glance data meant that it was possible to conduct eye glance analysis on the entire 6 s (i.e., no shadows, camera malfunctions, or other issues blocking the view of the driver's eyes). Following the method outlined in Klauer et al. (2006), eye glance locations were determined for 5 s prior to the event onset (i.e., the initiating behavior such as a lead vehicle braking) and for 1 s after the event onset for all safety-critical events. The entire 6-s epoch was analyzed for all baseline epochs.

5.5.1 Eyes off Forward Roadway

Eyes off forward roadway was operationally defined as any time the driver was not looking forward, regardless of where he/she was looking. All non-forward glances (i.e., all non-forward eye glance locations) were combined to determine the total eyes off forward roadway time for each 6-s interval (i.e., this time duration could be made up of a single long glance, or multiple shorter glances). Total eyes off forward roadway time was grouped into five different time bins:

- Less than or equal to 0.5 s.
- Greater than 0.5 s but less than or equal to 1.0 s.
- Greater than 1.0 s but less than or equal to 1.5 s.
- Greater than 1.5 s but less than or equal to 2.0 s.
- Greater than 2.0 s.

To approximate whether there was an increased risk of being involved in a safety-critical event while looking away from the forward roadway, compared to a baseline epoch, odds ratios were calculated. The odds ratio for this analysis used the frequency of safety-critical events and baseline epochs where drivers' eyes were off the forward roadway and frequency of safety-critical events and baseline epochs where drivers' eyes were on the forward roadway. Table 75 illustrates the 2 × 2 contingency table used to calculate the odds ratios for the eyes off forward roadway time analysis.

Table 75. Contingency Tables Used to Calculate Eyes off Forward Roadway Odds Ratios

Event Type	Eyes Forward	Eyes off Forward Roadway	Total
Baseline Epoch	n_{11} (A)	n_{12} (B)	$n_{1.}$
Safety-Critical Event	n_{21} (C)	n_{22} (D)	$n_{2.}$
	$n_{.1}$	$n_{.2}$	$n_{..}$

Where:

A = frequency of baseline epochs where the driver's eyes were not off the forward roadway.

B = frequency of baseline epochs where the drivers' eyes were off the forward roadway.

C = frequency of safety-critical events where the driver's eyes were not off the forward roadway.

D = frequency of at-fault events where safety-critical events where the driver's eyes were off the forward roadway

Table 76 displays the results of the odds ratio calculations for each of the five eyes off forward roadway time bins across "All" events and "Vehicle 1 At-Fault" events. As shown in Table 76, the results indicate that three of the time periods for eyes off forward roadway, across "All" safety-critical events, had a significant odds ratio. More specifically, when "All" events were considered, drivers were 1.4 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when eyes off forward roadway was less than or equal to 0.5 s, 1.3 times more likely when eyes off forward roadway was greater than 1.5 s but less than or equal to 2.0 s, and 2.9 times more likely when eyes off forward roadway was greater than 2.0 s.

Table 76 also shows the odds ratios for each of the five eyes off forward roadway time groupings across all “Vehicle 1 At-Fault” safety-critical events. When “Vehicle 1 At-Fault” events were considered, drivers were 1.3 times more likely to be involved in a safety-critical event (compared to a baseline epoch) when eyes off forward roadway was less than or equal to 0.5 s, 1.2 times more likely when eyes off forward roadway was greater than or equal to 1.0 s and less than or equal to 1.5 s, 1.5 times more likely when eyes off forward roadway was greater than or equal to 1.5 s and less than or equal to 2.0 s, and 3.9 times more likely when eyes off forward roadway was greater than 2.0 s.

Table 76. Odds Ratios and 95% Confidence Intervals to Assess Likelihood of a Safety-Critical Event While Eyes Off Forward Roadway across “All” and “Vehicle 1 At-Fault” (V1) Events

Total Eyes Off Forward Roadway	ALL Odds Ratio	ALL LCL	ALL UCL	Frequency of ALL Safety-Critical Events	Frequency of ALL Baseline epochs	V1 Odds Ratio	V1 LCL	V1 UCL	Frequency of V1 Safety-Critical Events	Frequency of V1 Baseline epochs
Less than or equal to 0.5 s	**1.36***	1.16	1.58	268	1,537	**1.28***	1.06	1.53	175	1,537
Greater than 0.5 s but less than or equal to 1.0 s	0.91	0.80	1.03	434	3,712	0.94	0.81	1.09	311	3,712
Greater than 1.0 s but less than or equal to 1.5 s	1.07	0.94	1.23	343	2,483	**1.18***	1.01	1.38	262	2,482
Greater than 1.5 s but less than or equal to 2.0 s	**1.29***	1.12	1.49	317	1,903	**1.52***	1.30	1.79	259	1,903
Greater than 2.0 s	**2.93***	2.65	3.23	1,504	3,989	**3.85***	3.44	4.30	1,370	3,989

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Based on findings from light-vehicle drivers, all but one of these significant findings was consistent with the 100-Car Study (Klauer et al., 2006). For example, Klauer et al. found that longer glance times away from the forward roadway were associated with an increased likelihood of being involved in a crash or near-crash. The findings in the current study support the results reported by Klauer et al.; longer glances away from the forward roadway are inherently riskier. The current study illustrates that longer glances away from forward roadway (more than 2.0 s) were associated with a higher risk ratio. Note that the "Vehicle 1 At-Fault" analysis shows a linear increase in the odds ratio as the time bins increase from eyes off forward roadway greater than 1.0 s to greater than 2.0 s. However, the finding that eyes off forward roadway time less than or equal to 0.5 s was associated with an increase in involvement in a safety-critical event was not shown by Klauer et al.

How can this finding be explained? Keep in mind that the 100-Car Study was conducted with light-vehicle drivers. Driving a CMV driving imposes different challenges on a driver, particularly with regard to glance patterns. For example, CMV drivers are taught the importance of situation awareness and scanning the environment and mirrors (Smith System, 2009). Based on an ideal CMV driver eye scanning technique while driving, one possible explanation for the significant finding for glances under 0.5 s is that some drivers may have spent too much time looking forward and were not performing the necessary environmental scans (i.e., "gaze concentration"; Reagan et al., 2009). Follow-up analyses would be required to conduct a more extensive eye glance analysis with drivers who rarely scanned the environment and mirrors (i.e., primarily focused on the forward roadway) to investigate the risk implications of such behavior, but this serves as a potential hypothesis for this novel finding.

5.5.2 Duration of Eyes off Forward Roadway

Duration of eyes off forward roadway was operationally defined as the total length of time (either a single glance or multiple glances) the driver was not looking at the forward roadway during the 6-s interval during the safety-critical event or baseline epoch. The analyses in this section were grouped by event type (i.e., crash, near-crash, crash-relevant conflict, unintentional lane deviation, and baseline/routine events) across "All" and "Vehicle 1 At-Fault" events. These results include the following analyses:

- All tasks.
- All tertiary tasks.
  - Complex tertiary tasks.
  - Moderate tertiary tasks.
  - Simple tertiary tasks.
- Secondary tasks.

5.5.2.1 All Tasks

Figure 5 shows the mean duration of eyes off forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any task. A one-way analysis of variance (ANOVA) found a significant difference in the mean duration of eyes off forward roadway between the five event types across "All" events ($F_{(4, 22616)}$ = 451.02, p < 0.0001).

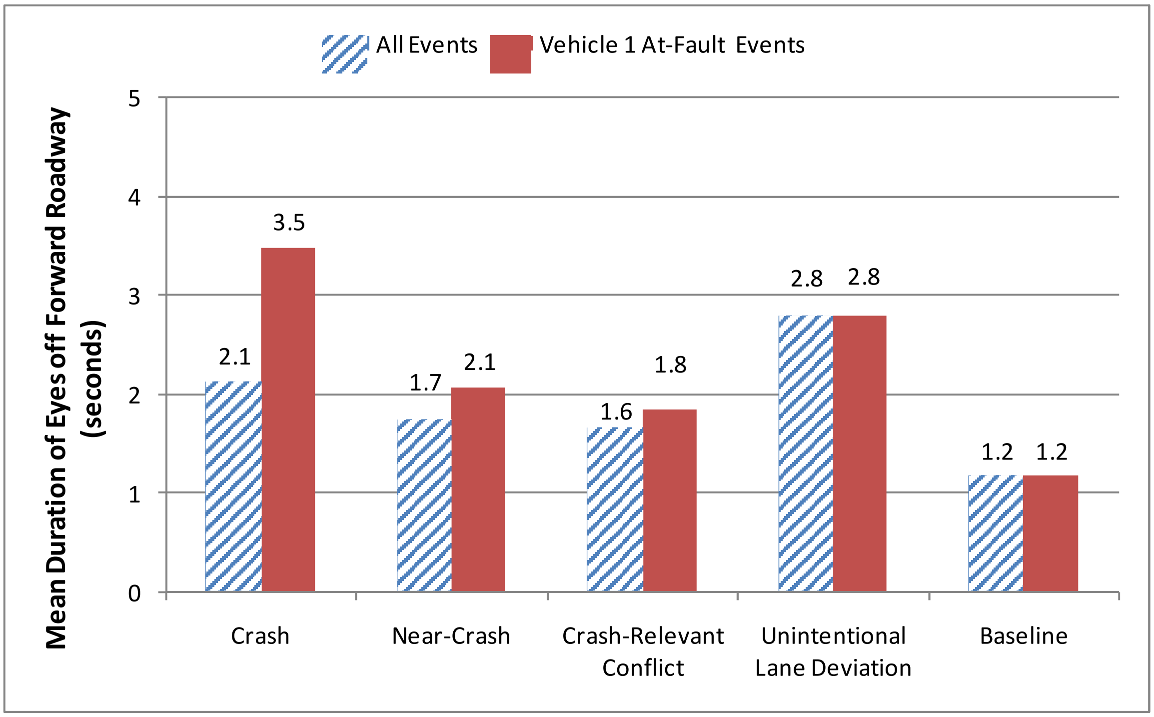


Figure 5. Graph. Mean Duration of Eyes off Forward Roadway by Event Type for All Tasks

As the ANOVA was significant, *post hoc* Tukey *t* tests were conducted on all pair-wise combinations of event types to determine simple effects. The results of all these pair-wise *t* tests can be found in appendix D. Simple effects tests indicated six significant combinations across "All" events. More specifically, Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.8 s) was significantly longer than near-crashes (1.7 s; $t_{(22616)} = 9.95$, $p < 0.0001$), crash-relevant conflicts (1.6 s; $t_{(22616)} = 23.81$, $p < 0.0001$), and baseline epochs (1.2 s; $t_{(22616)} = 39.30$, $p < 0.0001$). Crashes (2.1 s; $t_{(22616)} = 3.36$, $p = 0.007$), near-crashes (1.7 s; $t_{(22616)} = 5.76$, $p = 0.001$) and crash-relevant conflicts (1.6 s; $t_{(22616)} = 18.08$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baseline epochs (1.2 s).

Figure 5 also shows the mean duration of eyes off forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA also found a significant difference in the mean duration of eyes off forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 21913)} = 502.75$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.8 s) was significantly longer than near-crashes (2.1 s; $t_{(21913)} = 5.25$, $p < 0.0001$), crash-relevant conflicts (1.8 s; $t_{(21913)} = 18.95$, $p < 0.0001$), and baseline epochs (1.2 s; $t_{(21913)} = 39.51$, $p < 0.0001$). Crashes (3.5 s; $t_{(21913)} = 5.61$, $p < 0.0001$), near-crashes (2.1 s; $t_{(21913)} = 6.99$, $p < 0.0001$) and crash-relevant conflicts (1.8 s; $t_{(21913)} = 22.15$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baseline epochs (1.2 s). Crashes (3.5 s; $t_{(21913)} = 3.96$, $p = 0.001$) had significantly longer mean duration of eyes off forward roadway than crash-relevant conflicts (1.8 s).

5.5.2.2 All Tertiary Tasks

Figure 6 shows the mean duration of eyes off forward roadway for each event type across "All" events and "Vehicle 1 At-Fault" events for any tertiary task (i.e., any safety-critical event or baseline epoch with a complex, moderate, or a simple tertiary task). A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across "All" events ($F_{(4, 8277)} = 372.78$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (3.1 s) was significantly longer than crashes (1.1 s; $t_{(8277)} = 5.05$, $p < 0.0001$), near-crashes (1.8 s; $t_{(8277)} = 5.70$, $p < 0.0001$), crash-relevant conflicts (2.1 s; $t_{(8277)} = 14.81$, $p < 0.0001$), and baseline epochs (1.2 s; $t_{(8277)} = 34.97$, $p < 0.0001$). Both near-crashes (1.8 s; $t_{(8277)} = 3.10$, $p = 0.017$) and crash-relevant conflicts (2.1 s; $t_{(8277)} = 19.5$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baseline epochs (1.2 s).

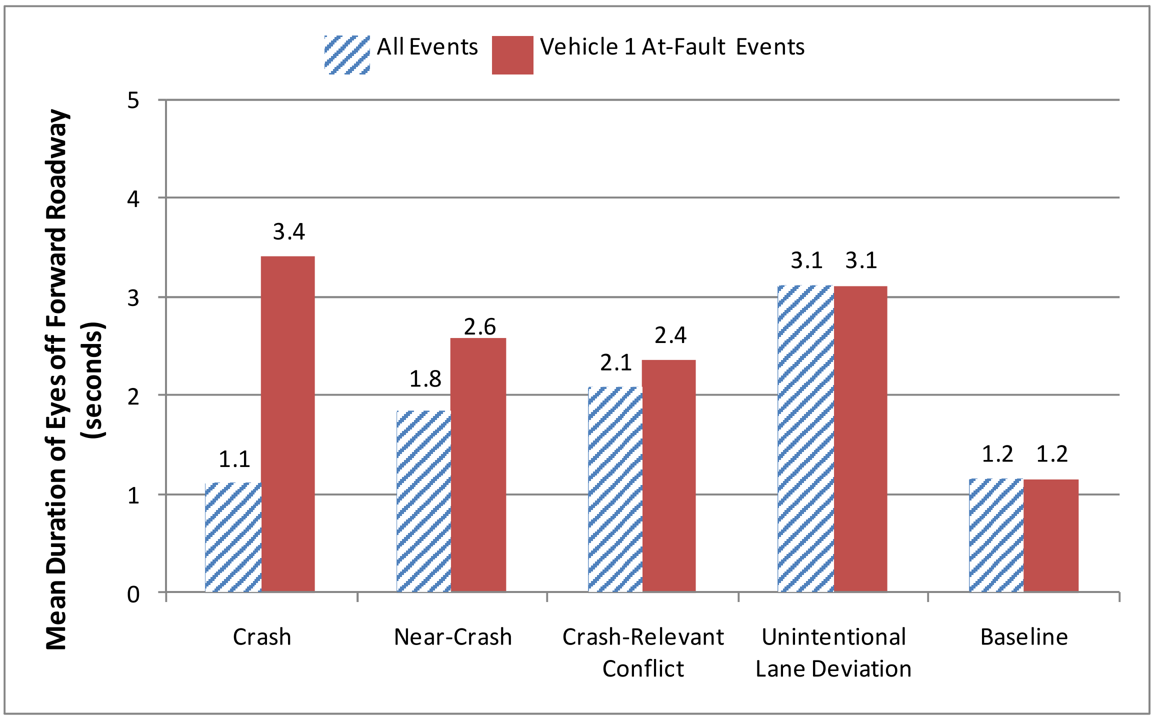


Figure 6. Graph. Mean Duration of Eyes off Forward Roadway by Event Type for All Tertiary Tasks

Figure 6 also shows the mean duration of eyes off forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 8098)} = 418.43$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (3.1 s) was significantly longer than crash-relevant conflicts (2.4 s; $t_{(8098)} = 10.46$, $p < 0.0001$), and baseline epochs (1.2 s; $t_{(8098)} = 35.19$, $p < 0.0001$). Both near-crashes (2.6 s; $t_{(8098)} = 5.11$, $p = < 0.0001$) and crash-relevant conflicts (2.4 s; $t_{(8098)} = 23.31$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway time than baseline epochs (1.2 s).

5.5.2.3 *Complex Tertiary Tasks*

Figure 7 shows the mean duration of eyes off forward roadway for four event types across "All" and "Vehicle 1 At-Fault" events for any complex tertiary tasks (i.e., any safety-critical event or baseline epoch with only a complex tertiary task). A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between four event types across "All" events ($F_{(3, 492)} = 5.74$, $p = 0.0007$). Tukey t tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (4.4 s) was significantly longer than baseline epochs (4.0 s; $t_{(492)} = 4.14$, $p = 0.0002$).

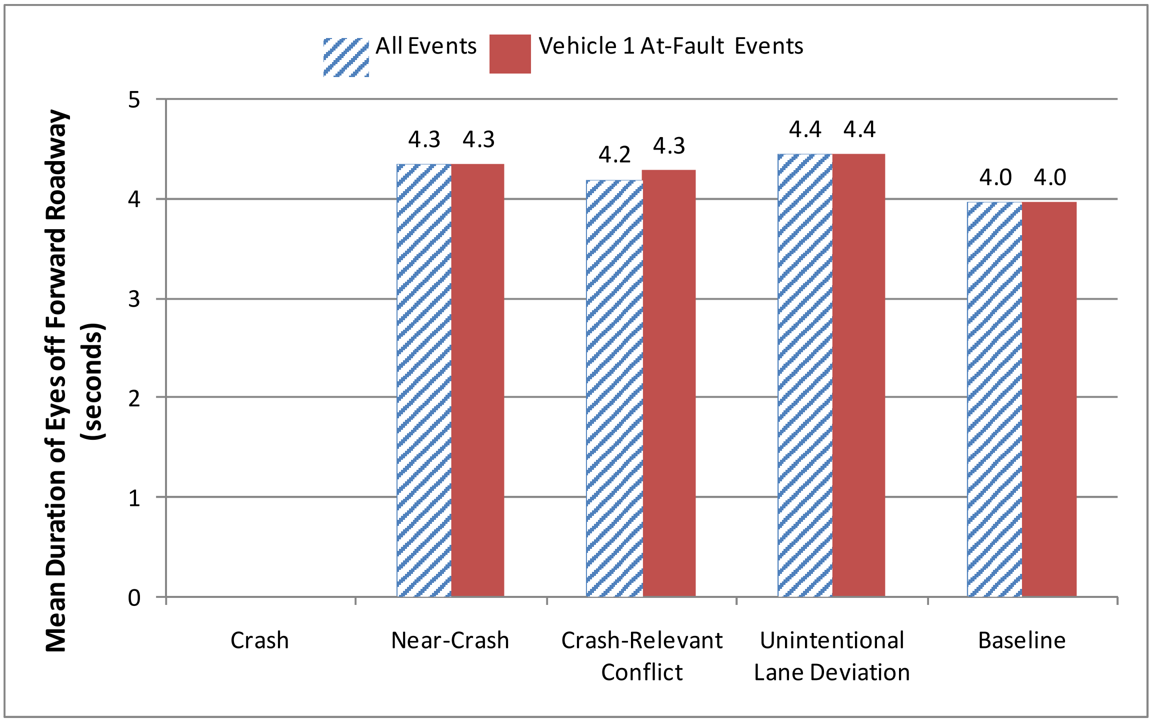


Figure 7. Graph. Mean Duration of Eyes off Forward Roadway by Event Type for Complex Tertiary Tasks

Figure 7 also shows the mean duration of eyes off forward roadway for four event types across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four event types across "Vehicle 1 At-Fault" events ($F_{(3, 487)} = 6.16$, $p = 0.0004$). Tukey t tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (4.4 s) was significantly longer than baseline epochs (4.0 s; $t_{(487)} = 4.23$, $p = 0.0002$).

5.5.2.4 *Complex Tertiary Task Breakout Analyses*

Additional ANOVAs were calculated on the eight specific complex tertiary tasks that were shown to be significant in Table 17. In conducting this analysis, the mean duration of eyes off forward roadway was calculated for four groupings:

- Safety-critical events with distraction of interest.
- Baseline epochs with distraction of interest.

- Safety-critical events without distraction of interest.
- Baseline epochs without distraction of interest.

Because of the small sample size for many of the complex tertiary tasks, any safety-critical event or baseline epoch with the complex tertiary task of interest was used. Therefore, it was possible that the safety-critical event or baseline epoch contained additional tasks (e.g., if the distraction of interest was talking on a hands-free phone, the driver may have also been taking a drink at the same time).

What is the reason for these four groupings? First, by comparing safety-critical events with the distraction of interest to baseline epochs with the distraction of interest, assessments can be made to determine the eye glance differences for distractions as a function of being involved, or not, in a safety-critical event. For example, consider safety-critical events that occurred when the driver was performing a cell phone dialing task. In this comparison, those safety-critical events were compared to baseline epochs (uneventful driving) where the driver was also dialing a cell phone.

Second, by comparing safety-critical events with the distraction of interest with safety-critical events without distraction of interest, assessments can be made to determine eye glance differences, across safety-critical events, for the distraction of interest. For example, consider safety-critical events that occurred when the driver was performing a cell phone dialing task. In this comparison, those safety-critical events are compared to other safety-critical events where the driver was not dialing a cell phone.

Third, by comparing safety-critical events with the distraction of interest with baseline epochs without distraction of interest, the comparison is made against uneventful driving that does not involve the distraction of interest. For example, consider safety-critical events that occurred when the driver was performing a cell phone dialing task. In this comparison, those safety-critical events were compared to baseline epochs where the driver was not dialing a cell phone. Note that rather than one comparison with a baseline condition, it was decided to include multiple comparisons to provide a more complete examination of all pertinent eye glance comparisons.

Text Message on Cell Phone: Figure 8 shows the mean duration of eyes off forward roadway across “All” and “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “All” events ($F_{(3, 22617)} = 455.45$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with text messaging (4.6 s) was significantly longer than events without text messaging (1.9 s; $t_{(22617)} = 11.29$, $p < 0.0001$) and baselines without text messaging (1.2 s; $t_{(22617)} = 14.65$, $p < 0.0001$). Baselines with text messaging (4.0 s) had a significantly longer mean duration of eyes off forward roadway than events without text messaging (1.9 s; $t_{(22617)} = 3.95$, $p = 0.001$) and baselines without text messaging (1.2 s; $t_{(22617)} = 5.47$, $p < 0.0001$). Events without text messaging (1.9 s; $t_{(22617)} = 33.75$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without text messaging (1.2 s).

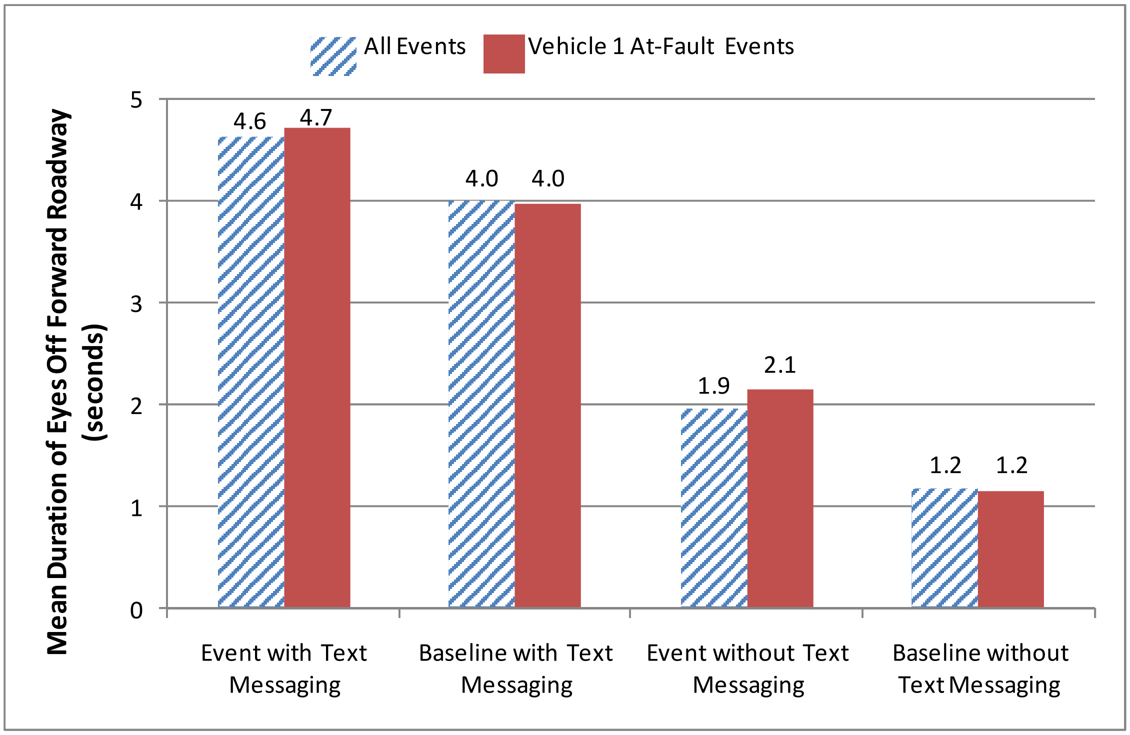


Figure 8. Graph. Mean Duration of Eyes off Forward Roadway for Text Message on Cell Phone

Figure 8 also shows the mean duration of eyes off forward roadway "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3,\ 21914)} = 590.78$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with text messaging (4.7 s) was significantly longer than events without text messaging (2.1 s; $t_{(21914)} = 10.81$, $p < 0.0001$) and baselines without text messaging (1.2 s; $t_{(21914)} = 15.03$, $p < 0.0001$). Baselines with text messaging (4.0 s) had a significantly longer mean duration of eyes off forward roadway than events without text messaging (2.1 s; $t_{(21914)} = 3.58$, $p = 0.002$) and baselines without text messaging (1.2 s; $t_{(21914)} = 5.52$, $p < 0.0001$). Events without text messaging (2.1 s; $t_{(21914)} = 39.17$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without text messaging (1.2 s).

Other—Complex Tertiary Tasks: Figure 9 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one–way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3,\ 22617)} = 418.47$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with other—complex tertiary task (4.4 s) was significantly longer than events without other—complex tertiary task (2.0 s; $t_{(22617)} = 5.46$, $p < 0.0001$) and baselines without other—complex tertiary task (1.2 s; $t_{(22617)} = 7.24$, $p < 0.0001$). Baselines with other—complex tertiary task (4.1 s) had a significantly longer mean duration of eyes off forward roadway than events without other—complex tertiary task (2.0 s; $t_{(22617)} = 3.45$, $p = 0.003$) and baselines without other—complex tertiary task (1.2 s; $t_{(22617)} = 4.70$, $p < 0.0001$). Events without other—complex tertiary task (2.0 s; $t_{(22617)} = 34.45$, p

< 0.0001) had a significantly longer mean duration of eyes off forward roadway than baselines without other—complex tertiary task (1.2 s).

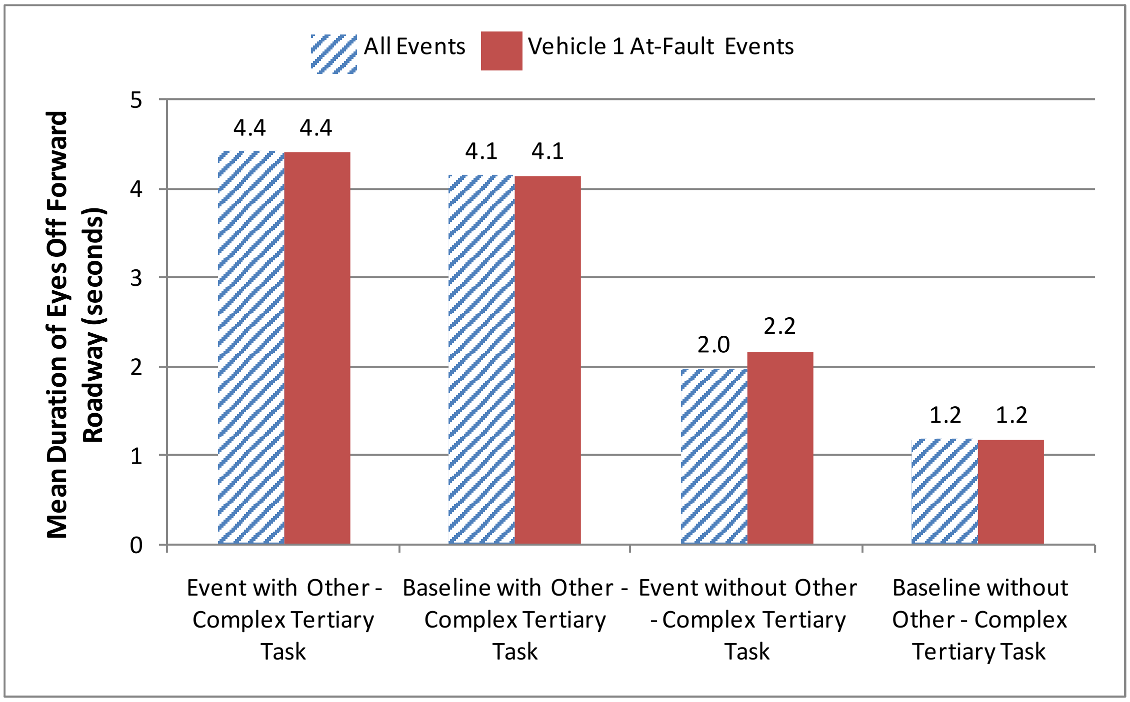


Figure 9. Graph. Mean Duration of Eyes off Forward Roadway for Other—Complex Tertiary Task

Figure 9 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 555.18$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with other—complex tertiary task (4.4 s) was significantly longer than events without other—complex tertiary task (2.2 s; $t_{(21914)} = 5.04$, $p < 0.0001$), and baselines without other—complex tertiary task (1.2 s; $t_{(21914)} = 7.31$, $p < 0.0001$). Baselines with other—complex tertiary task (4.1 s) had a significantly longer mean duration of eyes off forward roadway than events without other—complex tertiary task (2.0 s; $t_{(21914)} = 3.14$, $p = 0.009$) and baselines without other—complex tertiary task (1.2 s; $t_{(21914)} = 4.75$, $p < 0.0001$). Events without other—complex tertiary task (2.2 s; $t_{(21914)} = 39.95$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without other—complex tertiary task (1.2 s).

Interact with Dispatching Device: Figure 10 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 641.57$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with interact with dispatching device (4.1 s) was significantly longer than events without interact with dispatching device (1.9 s; $t_{(22617)} = 20.59$, $p < 0.0001$) and baselines without interact with dispatching device (1.2 s; $t_{(22617)} = 27.00$, $p < 0.0001$). Baselines with interact with dispatching device (3.7 s) had a significantly longer mean duration of eyes off forward roadway than events without interact with dispatching device (1.9 s; $t_{(22617)} = 27.64$, $p < 0.0001$) and baselines without interact with dispatching device (1.2 s; $t_{(22617)} = 16.23$, $p < 0.0001$). Events without interact with dispatching device (1.9 s; $t_{(22617)} = 31.28$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without interact with dispatching device (1.2 s).

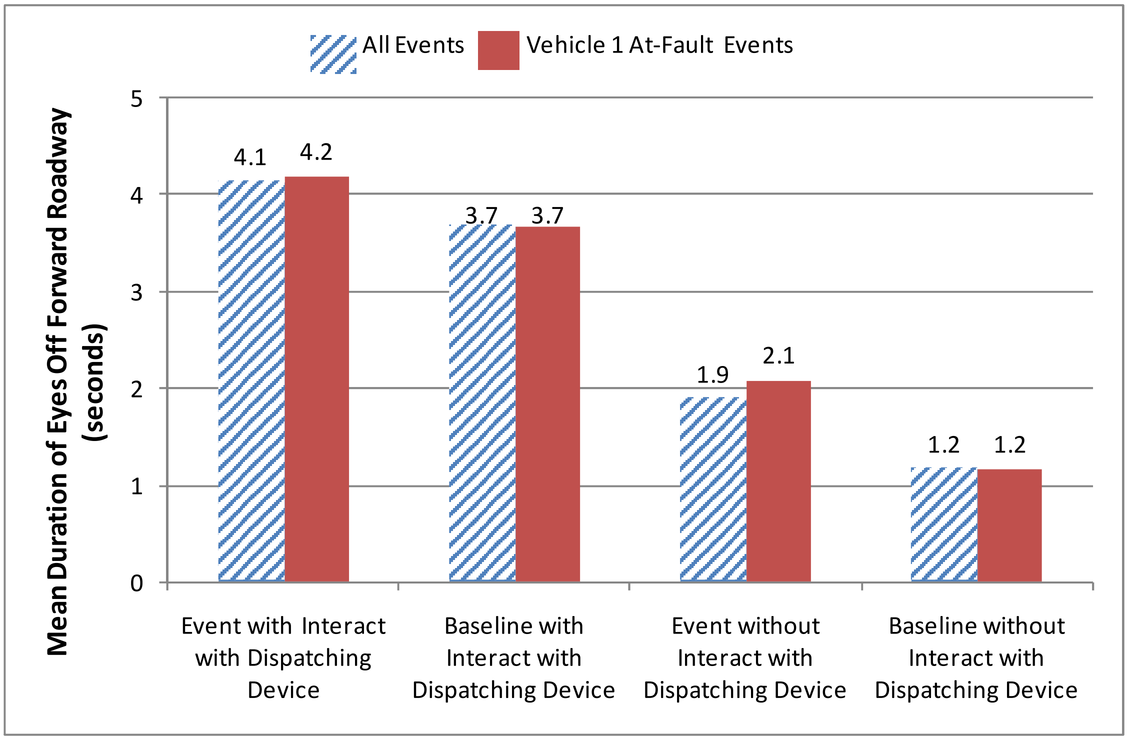


Figure 10. Graph. Mean Duration of Eyes off Forward Roadway for Interact with Dispatching Device

Figure 10 also shows the mean duration of eyes off forward roadway across “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “Vehicle 1 At-Fault” events ($F_{(3, 21914)} = 764.25$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with interact with dispatching device (4.2 s) was significantly longer than baselines with interact with dispatching device (3.7 s; $t_{(21914)} = 2.75$, $p = 0.030$), events without interact with dispatching device (2.1 s; $t_{(21914)} = 19.08$, $p < 0.0001$) and baselines without interact with dispatching device (1.2 s; $t_{(21914)} = 27.97$, $p < 0.0001$). Baselines with interact with dispatching device (3.7 s) had a significantly longer mean duration of eyes off forward roadway than events without interact with dispatching device (2.1 s; $t_{(21914)} = 10.27$, $p = 0.002$) and baselines without interact with dispatching device (1.2 s; $t_{(21914)} = 16.37$, $p < 0.0001$). Events without interact with dispatching device (2.1 s; $t_{(21914)} = 36.44$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without interact with dispatching device (1.2 s).

Write on pad, notepad, etc: Figure 11 shows the mean duration of eyes off forward roadway across “All” and “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “All” events ($F_{(3, 22617)} = 445.93$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with writing (4.2 s) was significantly longer than events without writing (1.9 s; $t_{(22617)} = 9.07$, $p < 0.0001$) and baselines without writing (1.2 s; $t_{(22617)} = 12.24$, $p < 0.0001$). Baselines with writing (3.5 s) had a significantly longer mean duration of eyes off forward roadway than events without writing (1.9 s; $t_{(22617)} = 4.62$, $p < 0.0001$) and baselines without writing (1.2 s; $t_{(22617)} = 6.96$, $p < 0.0001$). Events without writing (1.9 s; $t_{(22617)} = 34.01$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without writing (1.2 s).

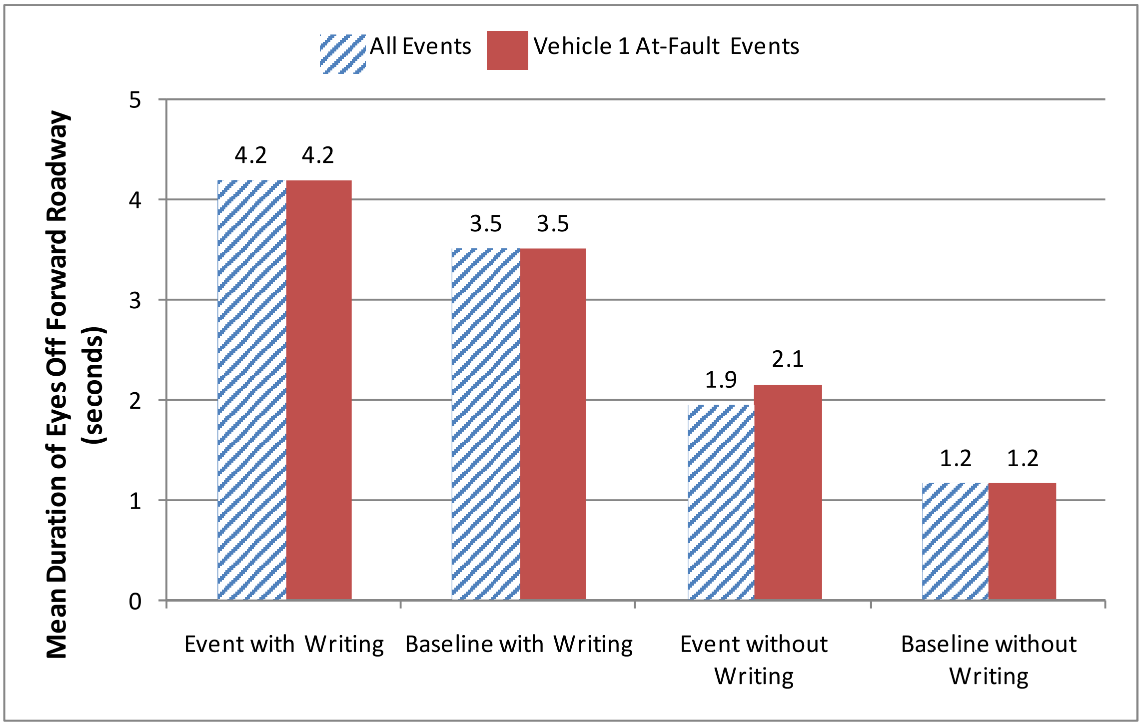


Figure 11. Graph. Mean Duration of Eyes Off Forward Roadway for Write on Pad, Notepad, etc.

Figure 11 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four event types across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 580.20$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with writing (4.2 s) was significantly longer than events without writing (2.1 s; $t_{(21914)} = 8.28$, $p < 0.0001$) and baselines without writing (1.2 s; $t_{(21914)} = 12.35$, $p < 0.0001$). Baselines with writing (3.5 s) had a significantly longer mean duration of eyes off forward roadway than events without writing (2.1 s; $t_{(21914)} = 4.05$, $p = 0.0003$) and baselines without writing (1.2 s; $t_{(21914)} = 7.03$, $p < 0.0001$). Events without writing (2.1 s; $t_{(21914)} = 39.45$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without writing (1.2 s).

Use Calculator: Figure 12 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 417.33$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with use calculator (4.4 s) was significantly longer than events without use calculator (2.0 s; $t_{(22617)} = 6.11$, $p < 0.0001$) and baselines without use calculator (1.2 s; $t_{(22617)} = 8.10$, $p < 0.0001$). Baselines with use calculator (3.1 s) had a significantly longer mean duration of eyes off forward roadway than baselines without use calculator (1.2 s; $t_{(22617)} = 3.37$, $p = 0.004$). Events without use calculator (2.0 s; $t_{(22617)} = 34.37$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without use calculator (1.2 s).

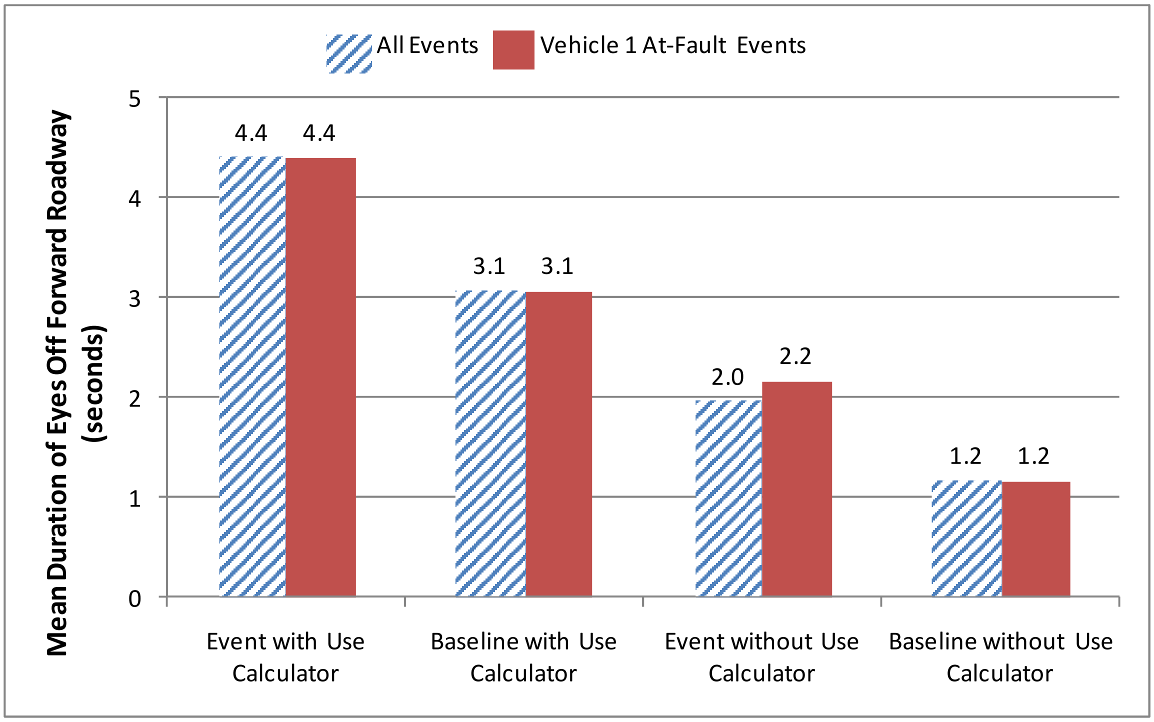


Figure 12. Graph. Mean Duration of Eyes off Forward Roadway for Use Calculator

Figure 12 also shows the mean duration of eyes off forward roadway across “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “Vehicle 1 At-Fault” events ($F_{(3, 21914)} = 553.55$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with use calculator (4.2 s) was significantly longer than events without use calculator (2.2 s; $t_{(21914)} = 5.64$, $p < 0.0001$) and baselines without use calculator (1.2 s; $t_{(21914)} = 8.18$, $p < 0.0001$). Baselines with use calculator (3.1 s) had a significantly longer mean duration of eyes off forward roadway than events without use calculator (2.2 s; $t_{(21914)} = 1.61$, $p < 0.0001$) and baselines without use calculator (1.2 s; $t_{(21914)} = 3.40$, $p < 0.0001$). Events without use calculator (2.2 s; $t_{(21914)} = 39.86$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without use calculator (1.2 s).

Look at Map: Figure 13 shows the mean duration of eyes off forward roadway across “All” and “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “All” events ($F_{(3, 22617)} = 479.07$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with look at map (3.9s) was significantly longer than events without look at map (1.9 s; $t_{(22617)} = 10.02$, $p < 0.0001$) and baselines without look at map (1.2 s; $t_{(22617)} = 14.13$, $p < 0.0001$). Baselines with look at map (3.6 s) had a significantly longer mean duration of eyes off forward roadway than events without look at map (1.9 s; $t_{(22617)} = 7.55$, $p < 0.0001$) and baselines without look at map (1.2 s; $t_{(22617)} = 11.14$, $p < 0.0001$). Events without look at map (1.9 s; $t_{(22617)} = 33.18$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without look at map (1.2 s).

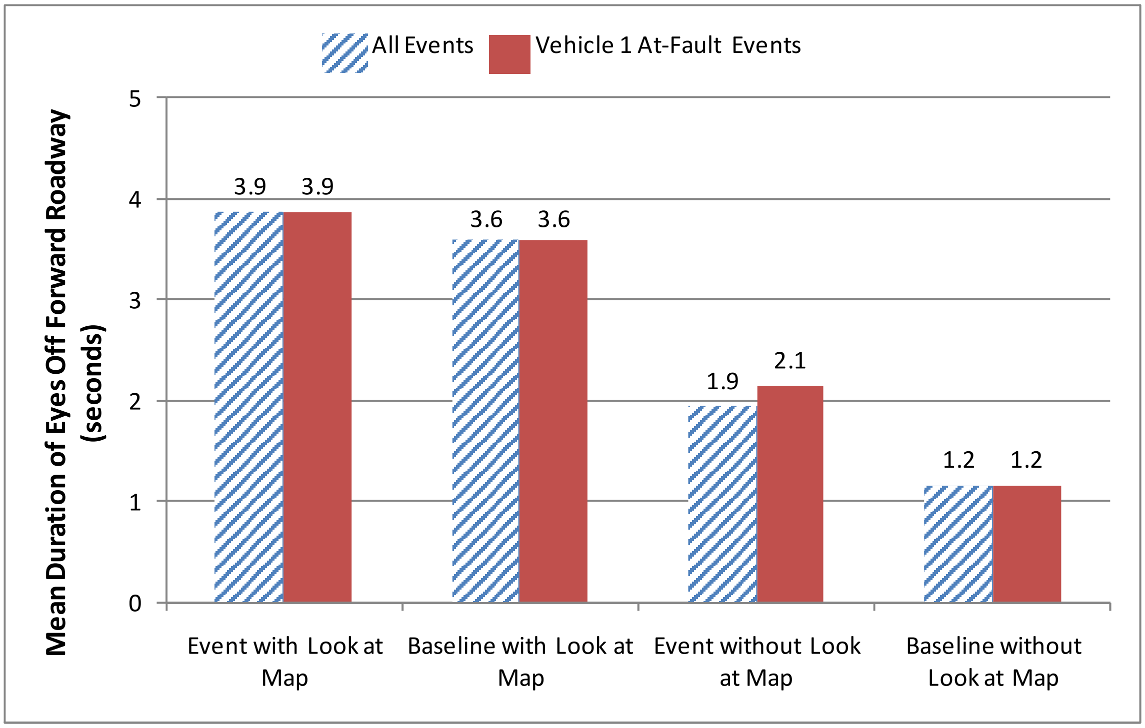


Figure 13. Graph. Mean Duration of Eyes off Forward Roadway for Look at Map

Figure 13 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 612.42$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with look at map (3.9 s) was significantly longer than events without look at map (2.1 s; $t_{(21914)} = 9.02$, $p < 0.0001$) and baselines without look at map (1.2 s; $t_{(21914)} = 14.26$, $p < 0.0001$). Baselines with look at map (3.6 s) had a significantly longer mean duration of eyes off forward roadway than events without look at map (2.1 s; $t_{(21914)} = 6.67$, $p = 0.002$) and baselines without look at map (1.2 s; $t_{(21914)} = 11.25$, $p < 0.0001$). Events without look at map (2.1 s; $t_{(21914)} = 39.23$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without look at map (1.2 s).

Dial Cell Phone: Figure 14 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" event for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings types across "All" events ($F_{(3, 22617)} = 587.76$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with dial cell phone (3.8 s) was significantly longer than baselines with dial cell phone (3.2 s; $t_{(22617)} = 3.43$, $p = 0.003$), events without dial cell phone (1.9 s; $t_{(22617)} = 16.28$, $p < 0.0001$) and baselines without dial cell phone (1.2 s; $t_{(22617)} = 22.98$, $p < 0.0001$). Baselines with dial cell phone (3.2 s) had a significantly longer mean duration of eyes off forward roadway than events without dial cell phone (1.9 s; $t_{(22617)} = 10.36$, $p < 0.0001$) and baselines without dial cell phone (1.2 s; $t_{(22617)} = 16.41$, $p < 0.0001$). Events without dial cell phone (1.9 s; $t_{(22617)} = 32.29$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without dial cell phone (1.2 s).

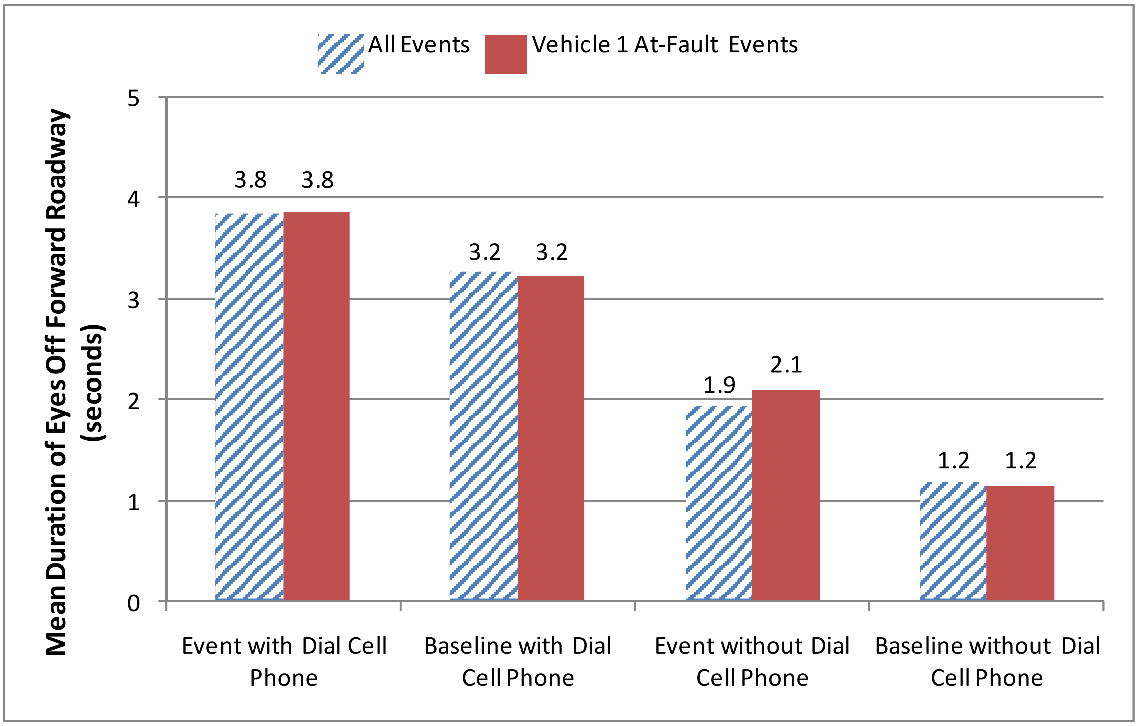


Figure 14. Graph. Mean Duration of Eyes off Forward Roadway for Dial Cell Phone

Figure 14 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four grouping across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 714.63$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with dial cell phone (3.8 s) was significantly longer than baselines with dial cell phone (3.2 s; $t_{(21914)} = 3.74$, $p = 0.001$), events without dial cell phone (2.1 s; $t_{(21914)} = 14.81$, $p < 0.0001$) and baselines without dial cell phone (1.2 s; $t_{(21914)} = 23.23$, $p < 0.0001$). Baselines with dial cell phone (3.2 s) had a significantly longer mean duration of eyes off forward roadway than events without dial cell phone (2.1 s; $t_{(21914)} = 8.82$, $p < 0.0001$) and baselines without dial cell phone (1.2 s; $t_{(21914)} = 16.56$, $p < 0.0001$). Events without dial cell phone (2.1 s; $t_{(21914)} = 37.56$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without dial cell phone (1.2 s).

Read book, newspaper, paperwork, etc: Figure 15 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four grouping across "All" events ($F_{(3, 22617)} = 667.68$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with reading (4.3 s) was significantly longer than events without reading (1.9 s; $t_{(22617)} = 17.37$, $p < 0.0001$) and baselines without reading (1.1 s; $t_{(22617)} = 23.11$, $p < 0.0001$). Baselines with reading (3.8 s) had a significantly longer mean duration of eyes off forward roadway than events without reading (1.9 s; $t_{(22617)} = 15.23$, $p < 0.0001$) and baselines without reading (1.1 s; $t_{(22617)} = 21.45$, $p < 0.0001$). Events without reading (1.9 s; $t_{(22617)} = 33.02$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without reading (1.1 s).

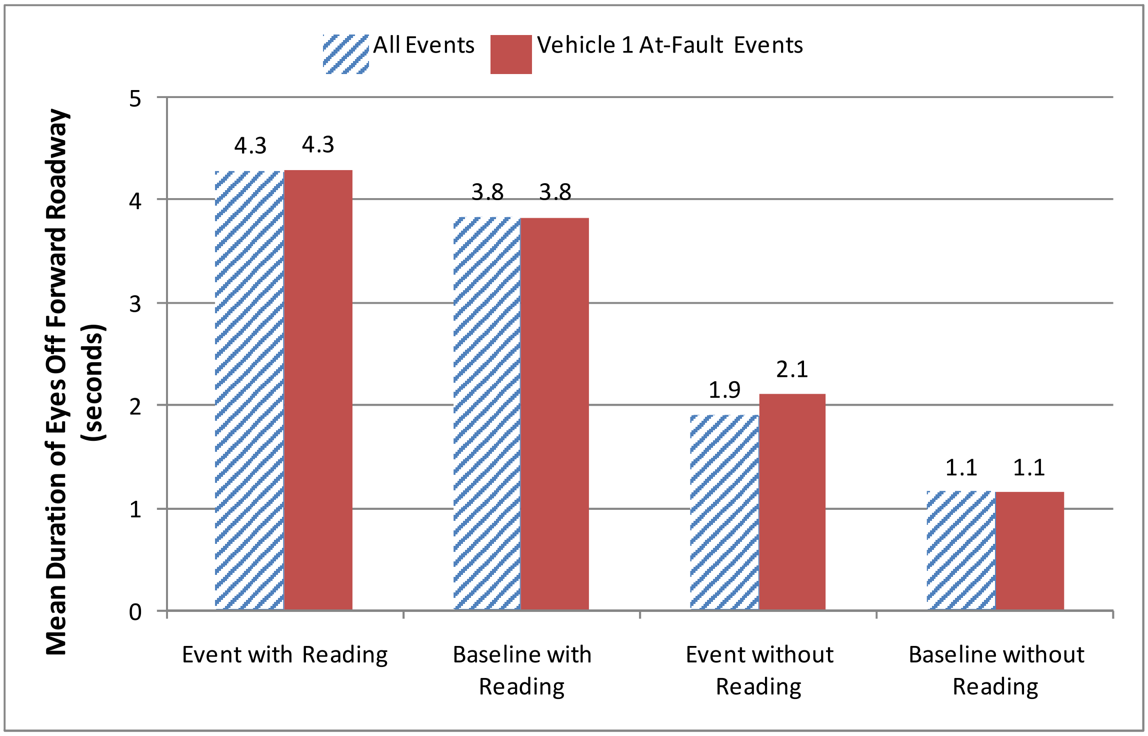


Figure 15. Graph. Mean Duration of Eyes off Forward Roadway for Read Book, Newspaper, Paperwork, etc.

Figure 15 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 797.25$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with reading (4.3 s) was significantly longer than events without reading (2.1 s; $t_{(21914)} = 15.98$, $p < 0.0001$) and baselines without reading (1.1 s; $t_{(21914)} = 23.26$, $p < 0.0001$). Baselines with reading (3.8 s) had a significantly longer mean duration of eyes off forward roadway than events without reading (2.1 s; $t_{(21914)} = 13.72$, $p < 0.0001$) and baselines without reading (1.2 s; $t_{(21914)} = 23.65$, $p < 0.0001$). Events without reading (2.1 s; $t_{(21914)} = 38.32$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without reading (1.1 s).

5.5.2.5 Moderate Tertiary Tasks

Figure 16 shows the mean duration of eyes off forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any moderate tertiary task (i.e., any safety-critical event or baseline with only a moderate tertiary task). A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across "All" events ($F_{(4, 4218)} = 97.22$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.6 s) was significantly longer than crashes (1.5 s; $t_{(4218)} = 2.78$, $p = 0.044$), near-crashes (1.6 s; $t_{(4218)} = 3.72$, $p = 0.002$), crash-relevant conflicts (1.7 s; $t_{(4218)} = 8.68$, $p < 0.0001$) and baseline epochs (1.1 s; $t_{(4218)} = 17.51$, $p < 0.0001$). Crash-relevant conflicts (1.7 s; $t_{(4218)} = 10.15$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway time than baseline epochs (1.1 s).

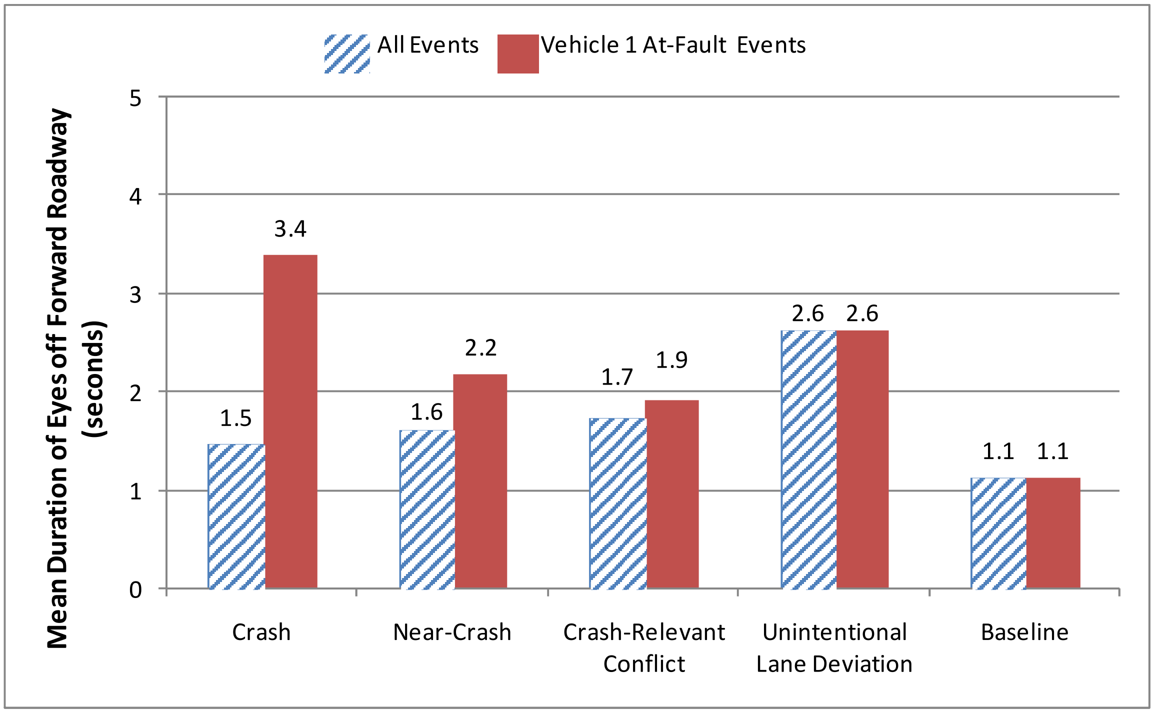


Figure 16. Graph. Mean Duration of Eyes off Forward Roadway by Event Type for Moderate Tertiary Tasks

Figure 16 also shows the mean duration of eyes off forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 4123)} = 111.95$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.6 s) was significantly longer than crash-relevant conflicts (1.7 s; $t_{(4123)} = 6.42$, $p < 0.0001$) and baseline epochs (1.1 s; $t_{(4123)} = 17.57$, $p < 0.0001$). Crashes (3.4 s; $t_{(4123)} = 2.83$, $p = 0.038$), near-crashes (2.2 s; $t_{(4123)} = 3.37$, $p = 0.007$) and crash-relevant conflicts (1.9 s; $t_{(4123)} = 12.19$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway time than baseline epochs (1.1 s).

5.5.2.6 Moderate Tertiary Task Breakout Analyses

Additional ANOVAs were calculated on the nine specific moderate tertiary tasks that were shown to be significant in Table 17. In conducting this analysis, the mean duration of eyes off forward roadway was calculated for the following four groupings:

- Safety-critical events with distraction of interest.
- Baseline epochs with distraction of interest.
- Safety-critical events without distraction of interest.
- Baseline epochs without distraction of interest.

Because of the small sample size for many of the moderate tertiary tasks, any safety-critical event or baseline epoch with the moderate tertiary task of interest was used. Therefore, it was possible that the safety-critical event or baseline epoch contained additional tasks (e.g., if the distraction of interest were talking on a hands-free phone, the driver may have also been taking a drink at the same time).

Use/Reach for Other Electronic Device: Figure 17 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 411.9$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with use/reach for other device (4.1 s) was significantly longer than baselines with use/reach for other device (1.2 s; $t_{(22617)} = 5.07$, $p < 0.0001$), events without use/reach for other device (2.0 s; $t_{(22617)} = 5.76$, $p < 0.0001$) and baselines without use/reach for other device (1.2 s; $t_{(22617)} = 7.85$, $p < 0.0001$). Events without use/reach for other device (2.0 s; $t_{(22617)} = 34.34$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without use/reach for other device (1.2 s).

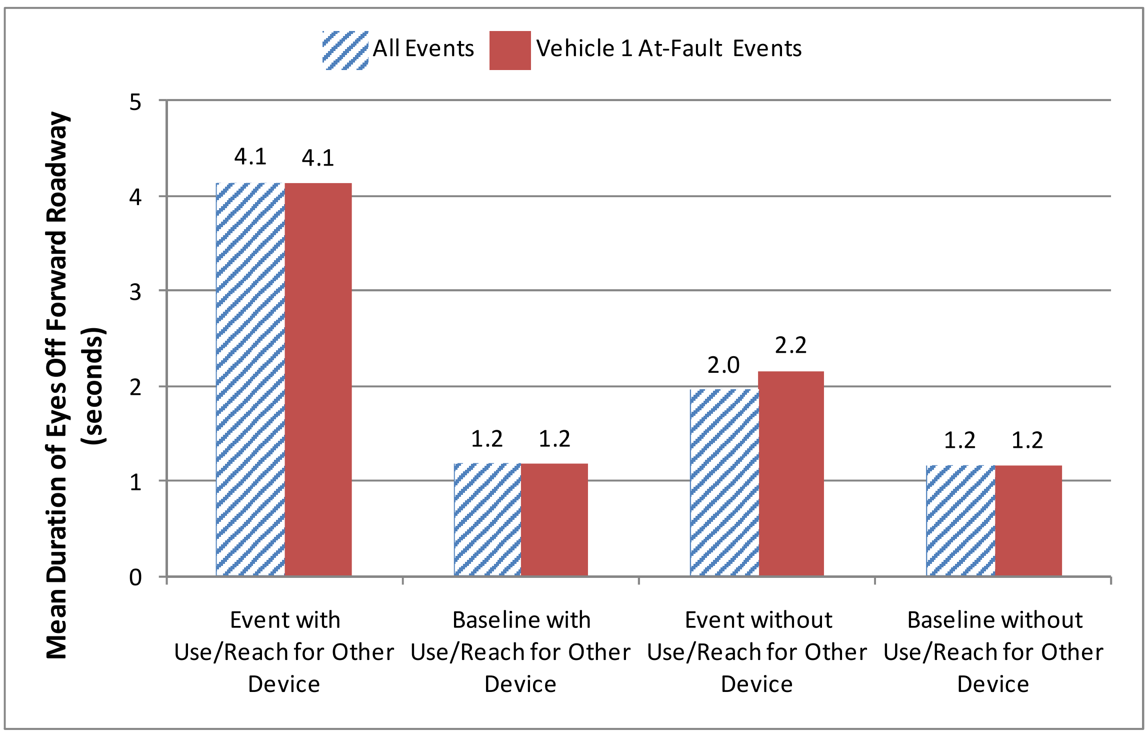


Figure 17. Graph. Mean Duration of Eyes off Forward Roadway for Use/Reach for Other Electronic Device

Figure 17 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 546.90$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with use/reach for other device (4.1 s) was significantly longer than baselines with use/reach for other device (1.2 s; $t_{(21914)} = 4.99$, $p < 0.0001$), events without use/reach for other device (2.2 s; $t_{(21914)} = 4.98$, $p < 0.0001$) and baselines without use/reach for other device (1.2 s; $t_{(21914)} = 7.52$, $p < 0.0001$). Events without use/reach for other device (2.2 s; $t_{(21914)} = 39.86$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without use/reach for other device (1.2 s).

Other—Moderate Tertiary Tasks: Figure 18 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway difference between the four groupings across "All" events ($F_{(3, 22617)} = 407.56$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with other—moderate tertiary task (3.3 s) was significantly longer than baselines with other—moderate tertiary task (1.2 s; $t_{(22617)} = 2.72$, $p = 0.033$), events without other—moderate tertiary task (2.0 s; $t_{(22617)} = 4.19$, $p = 0.0002$) and baselines without other—moderate tertiary task (1.2 s; $t_{(22617)} = 6.70$, $p < 0.0001$). Events without other—moderate tertiary task (2.0 s; $t_{(22617)} = 34.36$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without other—moderate tertiary task (1.2 s).

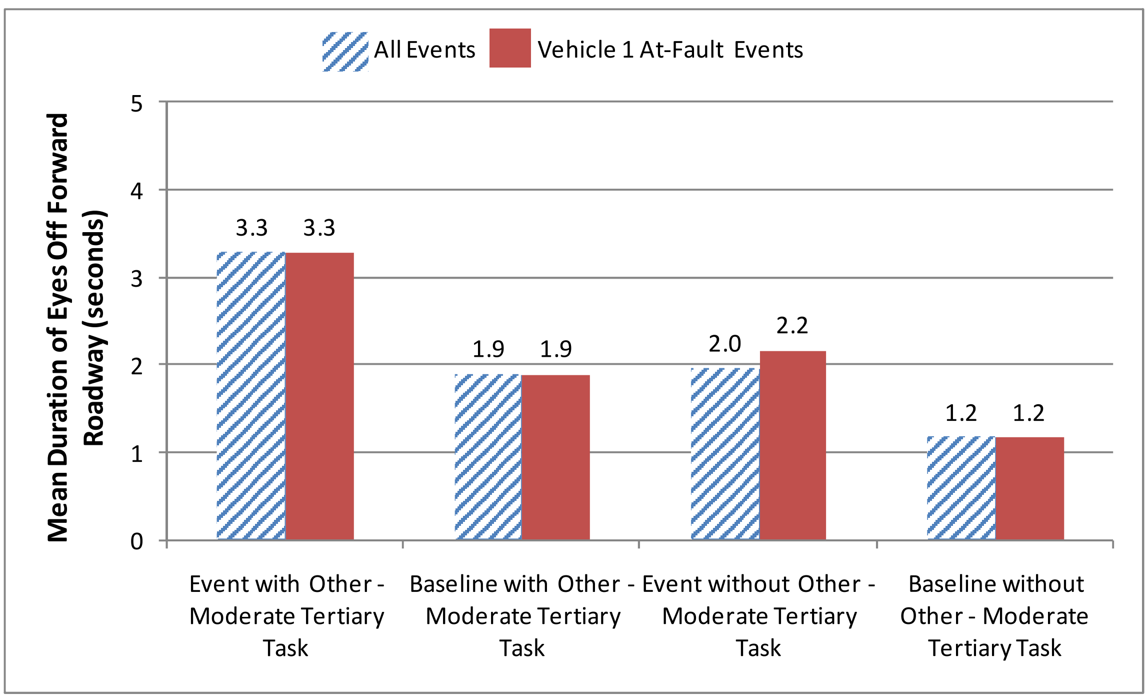


Figure 18. Graph. Mean Duration of Eyes off Forward Roadway for Other—Moderate Tertiary Task

Figure 18 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3,\,21914)} = 543.77$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with other—moderate tertiary task (3.3 s) was significantly longer than baselines with other—moderate tertiary task (1.2 s; $t_{(21914)} = 2.75$, $p = 0.030$), events without other—moderate tertiary task (2.2 s; $t_{(21914)} = 3.56$, $p = 0.002$) and baselines without other—moderate tertiary task (1.2 s; $t_{(21914)} = 6.76$, $p < 0.0001$). Events without other—moderate tertiary task (2.2 s; $t_{(21914)} = 39.86$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without other—moderate tertiary task (1.2 s).

Personal Grooming: Figure 19 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3,\,22617)} = 408.53$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with personal grooming (3.7 s) was significantly longer than baselines with personal grooming (1.2 s; $t_{(22617)} = 5.66$, $p < 0.0001$), events without personal grooming (2.0 s; $t_{(22617)} = 4.71$, $p < 0.0001$), and baselines without personal grooming (1.2 s; $t_{(22617)} = 6.80$, $p < 0.0001$). Baselines with personal grooming (0.7 s) had a significantly longer mean duration of eyes off forward roadway than events without personal grooming (1.9 s; $t_{(22617)} = 3.29$, $p = 0.006$). Events without personal grooming (1.9 s; $t_{(22617)} = 34.37$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without personal grooming (1.2 s).

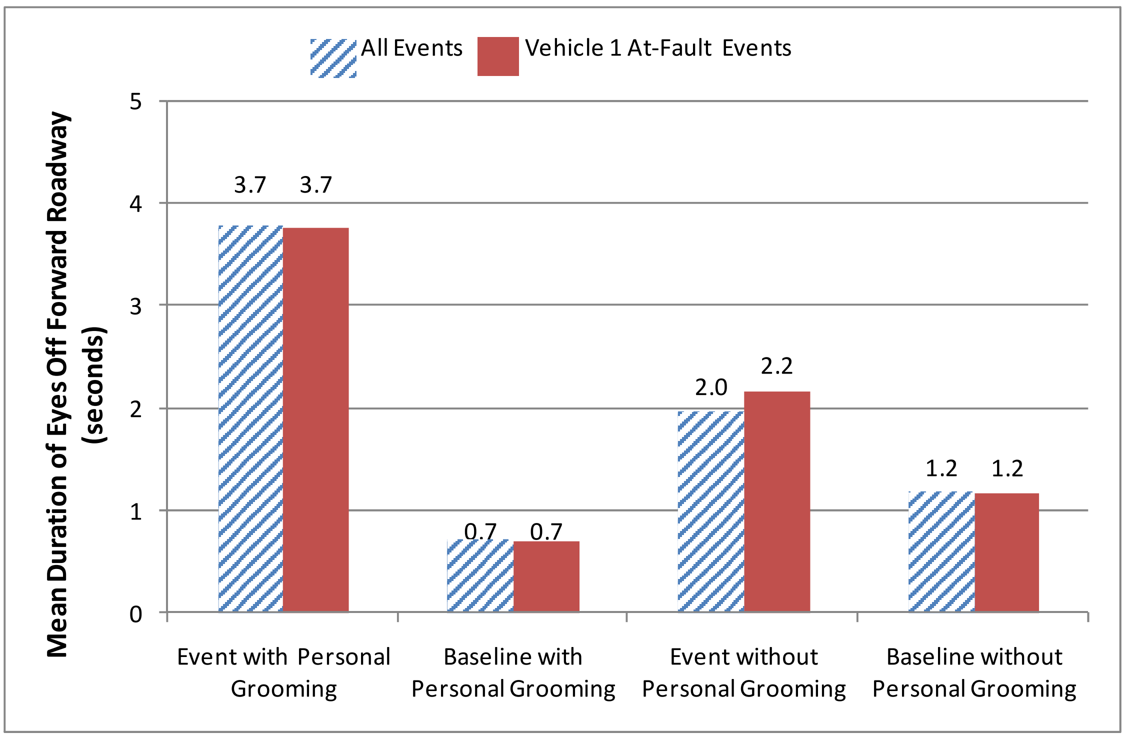


Figure 19. Graph. Mean Duration of Eyes off Forward Roadway for Use/Reach for Personal Grooming

Figure 19 also shows the mean duration of eyes off forward roadway across “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across Vehicle 1 at-fault’ events ($F_{(3, 21914)} = 544.87$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with personal grooming (3.7 s) was significantly longer than baselines with personal grooming (1.2 s; $t_{(21914)} = 5.72$, $p < 0.0001$), events without personal grooming (2.2 s; $t_{(21914)} = 4.20$, $p = 0.0002$), and baselines without personal grooming (1.2 s; $t_{(21914)} = 3.87$, $p = 0.001$). Events without personal grooming (1.9 s; $t_{(21914)} = 39.84$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without personal grooming (1.2 s).

Reach for Object in Vehicle: Figure 20 shows the mean duration of eyes off forward roadway across “All” and “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “All” events ($F_{(3, 22617)} = 522.95$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with reach for object (2.9 s) was significantly longer than baselines with reach for object (1.9 s; $t_{(22617)} = 11.41$, $p < 0.0001$), events without reach for object (1.9 s; $t_{(22617)} = 12.21$, $p < 0.0001$), and baselines without reach for object (1.1 s; $t_{(22617)} = 22.28$, $p < 0.0001$). Baselines with reach for object (1.8 s) had a significantly longer mean duration of eyes off forward roadway than baselines without reach for object (1.1 s; $t_{(22617)} = 14.16$, $p < 0.0001$). Events without reach for object (1.9 s; $t_{(22617)} = 31.68$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without reach for object (1.1 s).

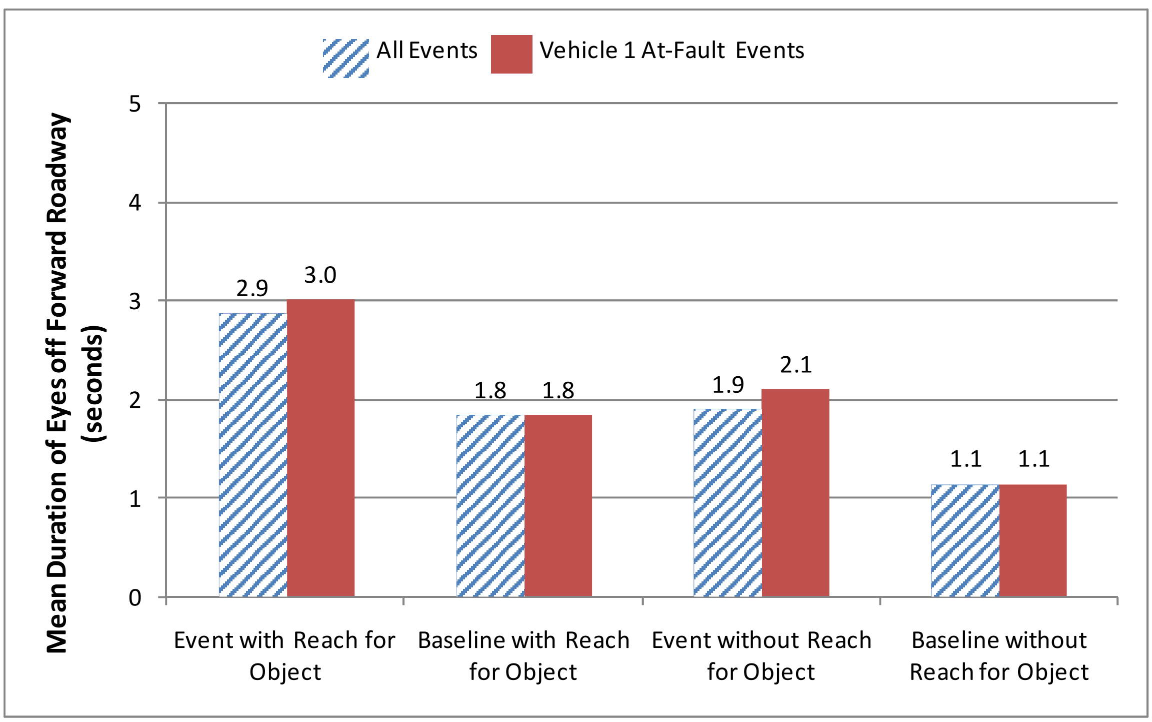


Figure 20. Graph. Mean Duration of Eyes off Forward Roadway for Use/Reach for Reach for Object in Vehicle

Figure 20 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across Vehicle 1 at-fault' events ($F_{(3, 21914)} = 654.32$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with reach for object (3.0 s) was significantly longer than baselines with reach for object (3.0 s; $t_{(21914)} = 12.68$, $p < 0.0001$), events without reach for object (2.1 s; $t_{(21914)} = 10.99$, $p < 0.0001$), and baselines without reach for object (1.2 s; $t_{(21914)} = 23.41$, $p < 0.0001$). Baselines with reach for object (1.8 s) had a significantly longer mean duration of eyes off forward roadway than events without reach for object (2.1 s; $t_{(21914)} = 4.89$, $p < 0.0001$) and baselines without reach for object (1.8 s; $t_{(21914)} = 14.29$, $p < 0.0001$). Events without reach for object (2.1 s; $t_{(21914)} = 36.75$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without reach for object (1.1 s).

Look Back in Sleeper Berth: Figure 21 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 414.46$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with look back in sleeper berth (3.4 s) was significantly longer than baselines with look back in sleeper berth (2.4 s; $t_{(22617)} = 11.41$, $p < 0.0001$), events without look back in sleeper berth (2.0 s; $t_{(22617)} = 12.21$, $p < 0.0001$) and baselines without look back in sleeper berth (1.2 s; $t_{(22617)} = 22.28$, $p < 0.0001$). Baselines with look back in sleeper berth (3.4 s) had a significantly longer mean duration of eyes off forward roadway than baselines without look back in sleeper berth (1.2 s; $t_{(22617)} = 14.16$, $p < 0.0001$). Events without look back in sleeper berth (2.0 s; $t_{(22617)} = 31.68$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without look back in sleeper berth (1.2 s).

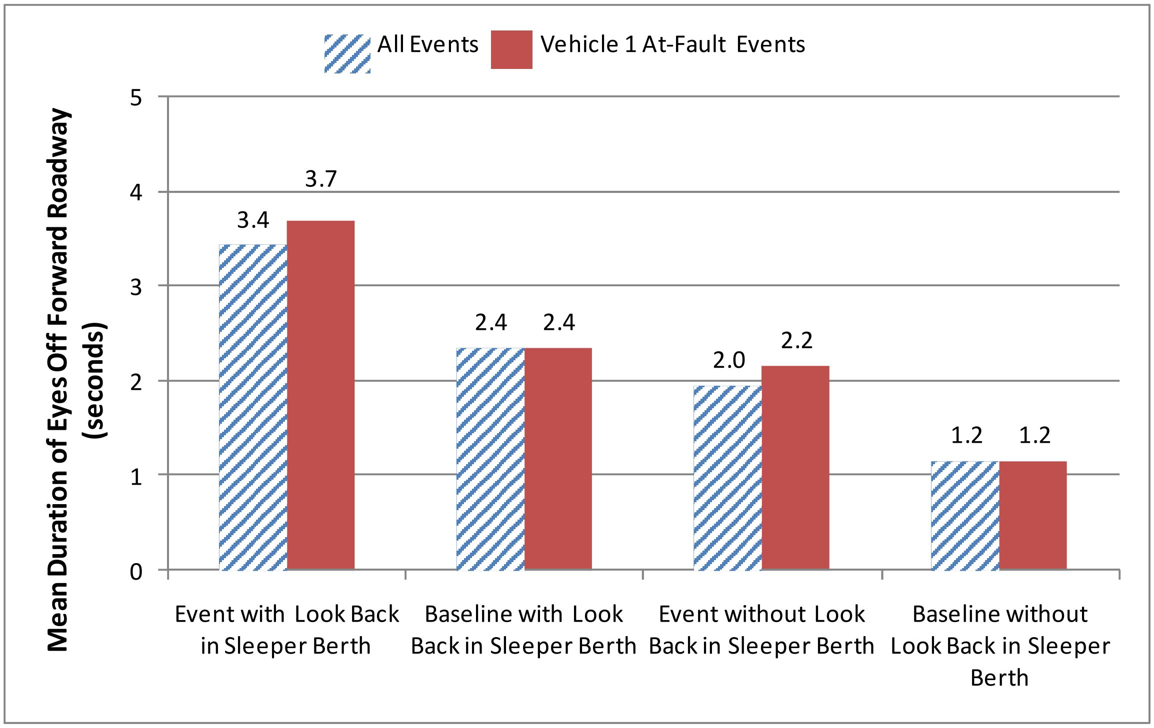


Figure 21. Graph. Mean Duration of Eyes off Forward Roadway for Use/Reach for Look Back in Sleeper Berth

Figure 21 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 21914)} = 552.80$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with look back in sleeper berth (3.7 s) was significantly longer than baselines with look back in sleeper berth (2.4 s; $t_{(21914)} = 3.12$, $p = 0.010$), events without look back in sleeper berth (2.2 s; $t_{(21914)} = 4.41$, $p < 0.0001$) and baselines without look back in sleeper berth (1.2 s; $t_{(21914)} = 7.31$, $p < 0.0001$). Baselines with look back in sleeper berth (3.7 s) had a significantly longer mean duration of eyes off forward roadway than baselines without look back in sleeper berth (1.2 s; $t_{(21914)} = 4.67$, $p < 0.0001$). Events without look back in sleeper berth (2.2 s; $t_{(21914)} = 39.91$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without look back in sleeper berth (1.2 s).

Smoking-Related—Lighting: Figure 22 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 409.63$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with smoking-related—lighting (1.6 s) was significantly longer than baselines without smoking-related—lighting (1.2 s; $t_{(22617)} = 2.92$, $p = 0.019$). Baselines with smoking-related—lighting (1.0 s) had a significantly shorter mean duration of eyes off forward roadway than events without smoking-related—lighting (2.0 s; $t_{(22617)} = 3.70$, $p = 0.001$) and baselines without smoking-related—

lighting (1.2 s; $t_{(22617)} = 5.17$, $p < 0.0001$). Events without smoking-related—lighting (2.0 s; $t_{(22617)} = 34.77$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without smoking-related—lighting (1.2 s).

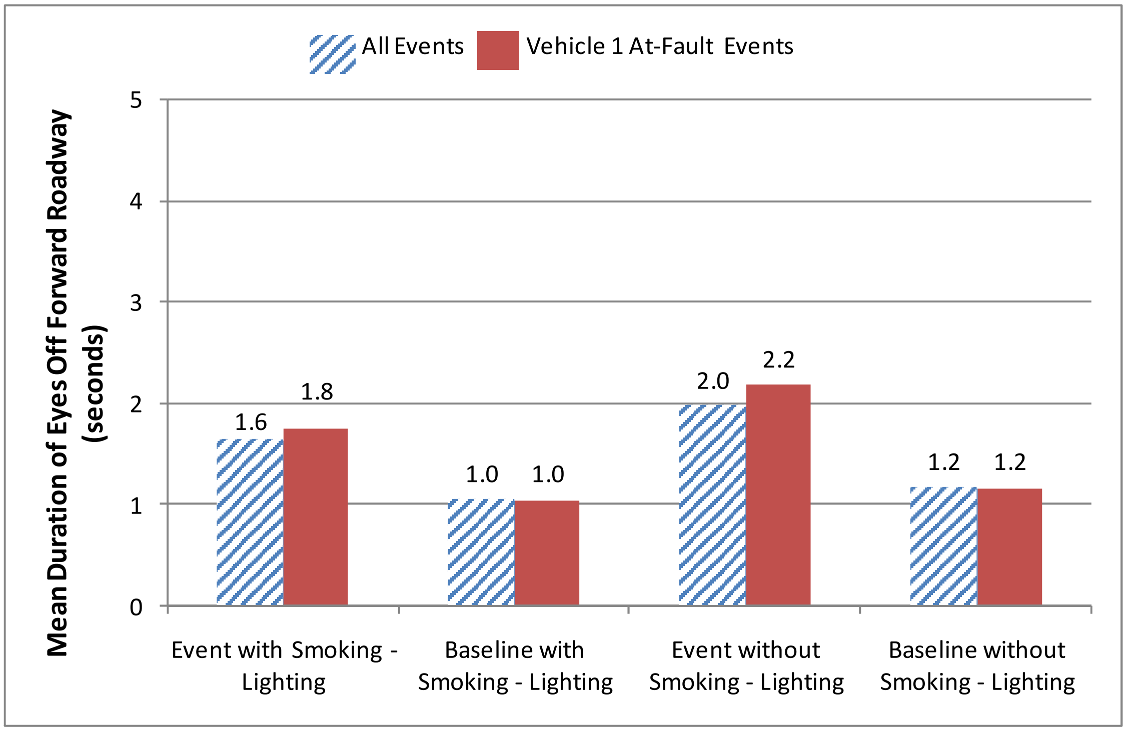


Figure 22. Graph. Mean Duration of Eyes off Forward Roadway for Smoking-Related—Lighting

Figure 22 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 547.88$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with smoking—lighting (1.8 s) was significantly longer than baselines without smoking—lighting (1.2 s; $t_{(21914)} = 3.67$, $p = 0.001$). Baselines with smoking—lighting (1.0 s) had a significantly shorter mean duration of eyes off forward roadway than events without smoking—lighting (2.2 s; $t_{(21914)} = 5.99$, $p = 0.001$) and baselines without smoking—lighting (1.2 s; $t_{(21914)} = 5.22$, $p < 0.0001$). Events without smoking—lighting (2.2 s; $t_{(21914)} = 40.24$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without smoking—lighting (1.2 s).

Talk/Listen to CB Radio: Figure 23 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 409.31$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with talk/listen to CB (1.3 s) was significantly shorter than events without talk/listen to CB (2.0 s; $t_{(22617)} = 3.46$, $p = 0.003$). Baselines with talk/listen to CB (0.9 s) had a significantly shorter mean duration of eyes off forward roadway than events without talk/listen to CB (2.0 s; $t_{(22617)} = 15.17$, $p <$

0.0001) and baselines without talk/listen to CB (1.2 s; $t_{(22617)} = 3.73$, $p = 0.001$). Events without talk/listen to CB (2.0 s; $t_{(22617)} = 34.58$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without talk/listen to CB (1.2 s).

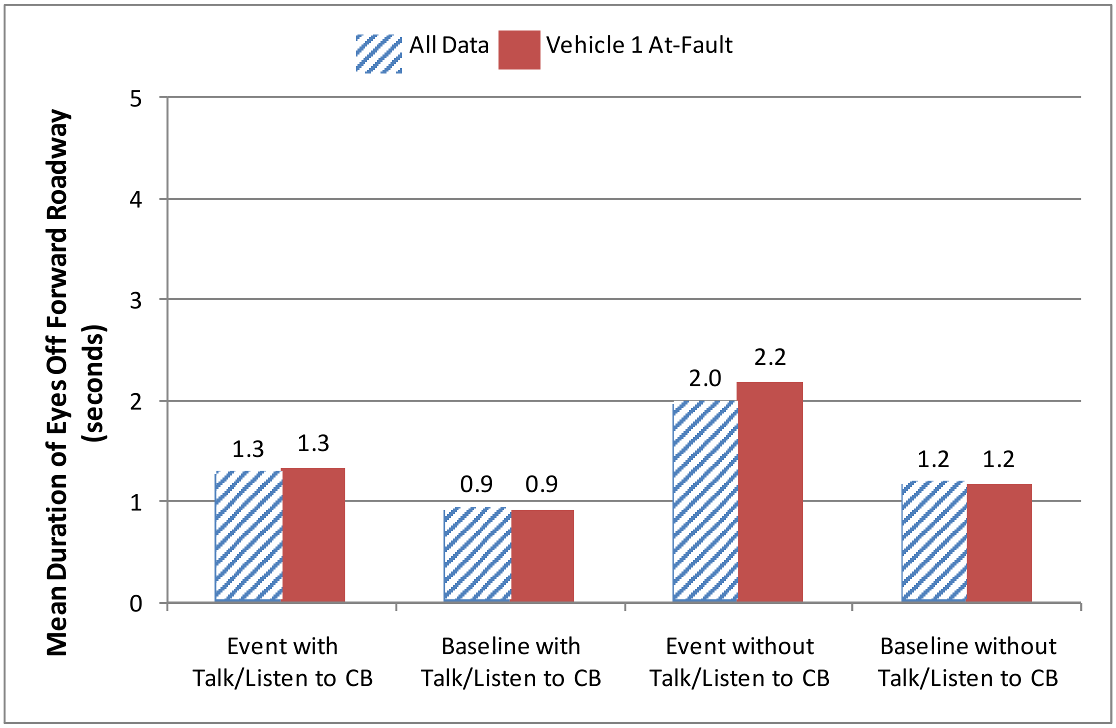


Figure 23. Graph. Mean Duration of Eyes off Forward Roadway for Talk/Listen to CB Radio

Figure 23 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 547.38$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with talk/listen to CB (1.3 s) was significantly shorter than events without talk/listen to CB (2.2 s; $t_{(21914)} = 3.46$, $p = 0.003$). Baselines with talk/listen to CB (0.9 s) had a significantly shorter mean duration of eyes off forward roadway than events without talk/listen to CB (2.2 s; $t_{(21914)} = 18.16$, $p < 0.0001$) and baselines without talk/listen to CB (1.2 s; $t_{(21914)} = 3.76$, $p = 0.001$). Events without talk/listen to CB (2.2 s; $t_{(21914)} = 40.11$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without talk/listen to CB (1.2 s).

Look Outside Vehicle: Figure 24 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 764.49$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with external distraction (2.0 s) was significantly longer than baselines with external distraction (1.7 s; $t_{(22617)} = 6.19$, $p < 0.0001$) and baselines without external distraction (1.0 s; $t_{(22617)} = 19.04$, $p < 0.0001$). Baselines with external distraction (1.7 s) had a significantly shorter mean duration of eyes off forward roadway than events without external distraction (1.9 s; $t_{(22617)} = 9.05$, $p < 0.0001$) and a significantly longer mean duration of eyes off forward roadway than baselines without external distraction (1.0 s; $t_{(22617)} = 32.18$, $p < 0.0001$). Events without external distraction (1.9 s; $t_{(22617)} = 38.28$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without external distraction (1.0 s).

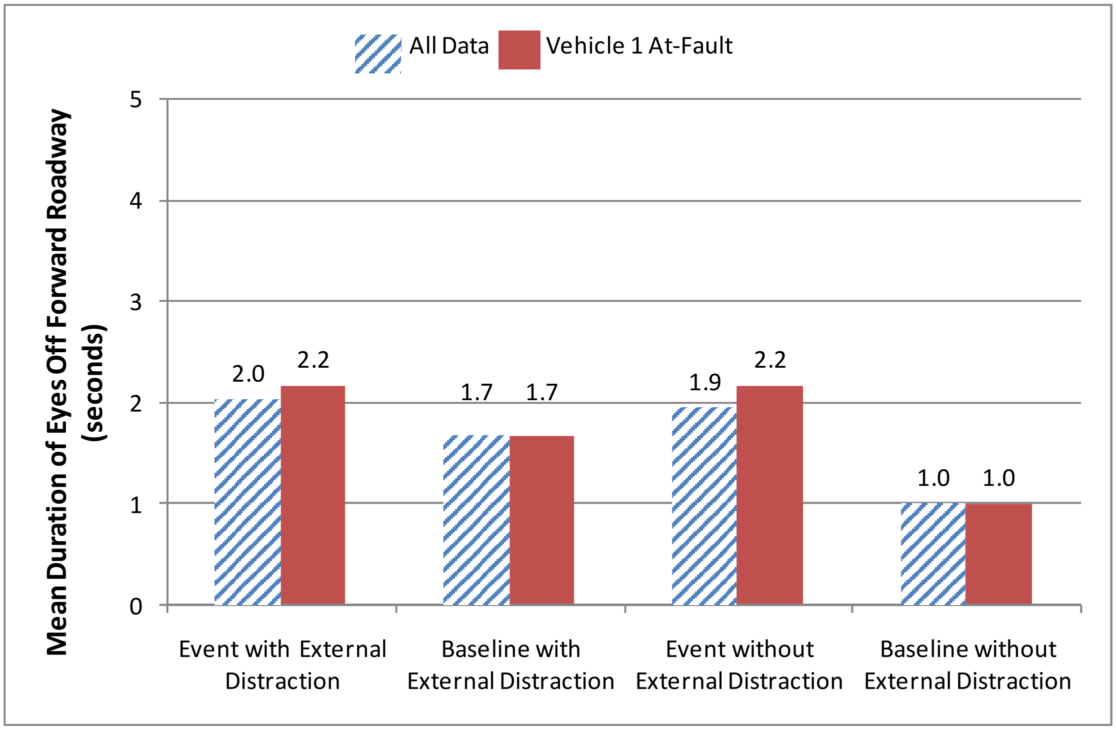


Figure 24. Graph. Mean Duration of Eyes off Forward Roadway for External Distraction

Figure 24 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3,\ 21914)} = 916.66$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with external distraction (2.2 s) was significantly longer than baselines with external distraction (1.7 s; $t_{(21914)} = 7.74$, $p < 0.0001$) and baselines without external distraction (1.0 s; $t_{(21914)} = 19.16$, $p < 0.0001$). Baselines with external distraction (1.7 s) had a significantly shorter mean duration of eyes off forward roadway than events without external distraction (2.2 s; $t_{(21914)} = 15.77$, $p < 0.0001$) and a significantly longer mean duration of eyes off forward roadway than baselines without external distraction (1.0 s; $t_{(22617)} = 32.53$, $p < 0.0001$). Events without external distraction (2.2 s; $t_{(21914)} = 43.7$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without external distraction (1.0 s).

Talk/Listen to Hands-Free Phone: Figure 25 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3,\ 22617)} = 404.72$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with talk/listen to hands-free phone (1.6 s) was significantly longer than baselines with talk/listen to hands-free phone (1.0 s; $t_{(22617)} = 4.01$, $p = 0.0004$) and baselines without talk/listen to hands-free phone (1.2 s; $t_{(22617)} = 3.33$, $p = 0.005$). Baselines with talk/listen to hands-free phone (1.0 s) had a significantly shorter mean duration of eyes off forward roadway than events without talk/listen to hands-free phone (2.0 s; $t_{(22617)} = 19.32$, $p < 0.0001$) and baselines without talk/listen to hands-free phone (1.2 s; $t_{(22617)} = 2.76$, $p = 0.030$). Events without talk/listen to hands-free phone (2.0 s; $t_{(22617)} = 34.28$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without talk/listen to hands-free phone (1.2 s).

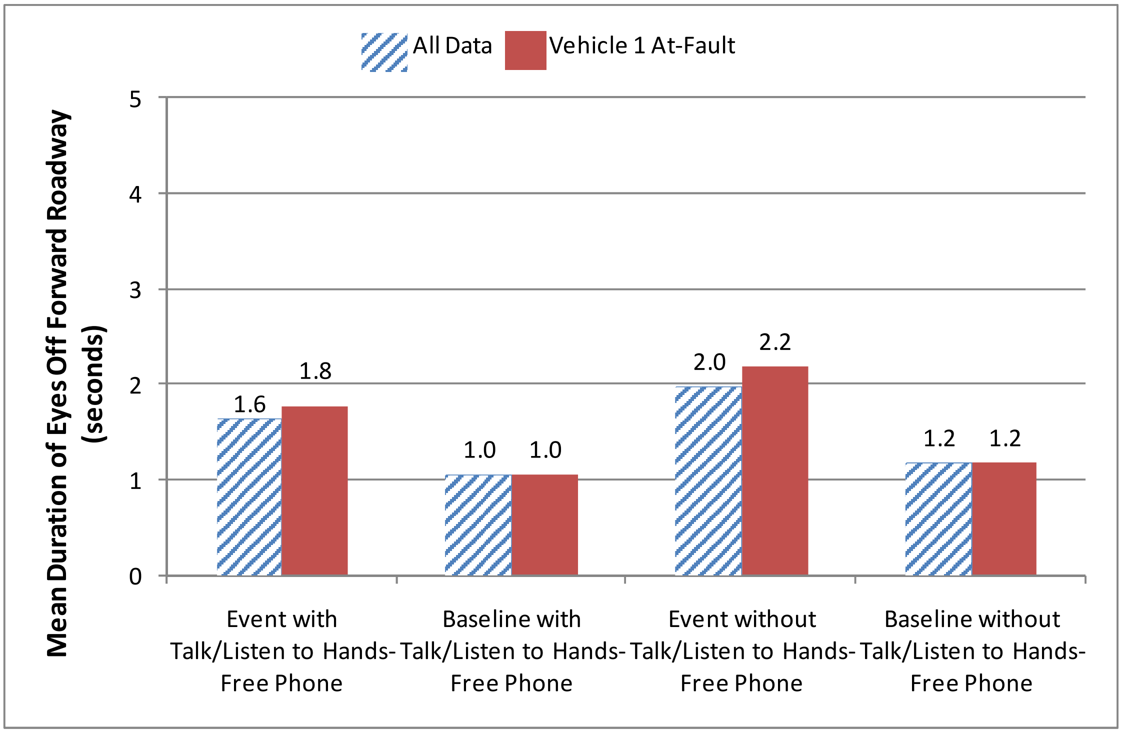


Figure 25. Graph. Mean Duration of Eyes off Forward Roadway for Talk/Listen to Hands-Free Phone

Figure 25 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 543.03$, $p < 0.0001$). More specifically, Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with talk/listen to hands-free phone (1.8 s) was significantly longer than baselines with talk/listen to hands-free phone (1.0 s; $t_{(21914)} = 4.12$, $p = 0.0002$) and baselines without talk/listen to hands-free phone (1.2 s; $t_{(21914)} = 3.52$, $p = 0.002$). Baselines with talk/listen to hands-free phone (1.0 s) had a significantly shorter mean duration of eyes off forward roadway than events without talk/listen to hands-free phone (2.2 s; $t_{(21914)} = 23.39$, $p < 0.0001$) and baselines without talk/listen to hands-free phone (1.2 s; $t_{(21914)} = 2.79$, $p = 0.027$). Events without talk/listen to hands-free phone (2.2 s; $t_{(21914)} = 39.83$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without talk/listen to hands-free phone (1.2 s).

5.5.2.7 Simple Tertiary Tasks

Figure 26 shows the mean duration of eyes off forward roadway for each event type across “All” and “Vehicle 1 At-Fault” events for any simple tertiary tasks (i.e., any safety-critical event or baseline epoch with only a simple tertiary task). A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across “All” events ($F_{(4, 2063)} = 60.04$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.2 s) was significantly longer than crashes (0.1 s; $t_{(2063)} = 3.29$, $p = 0.009$), crash-relevant conflicts (1.2 s; $t_{(2063)} = 7.64$, $p < 0.0001$) and baseline epochs (0.7 s; $t_{(2063)} = 14.35$, $p < 0.0001$). Crash-relevant conflicts (1.2 s; $t_{(2063)} = 6.79$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baseline epochs (0.7 s).

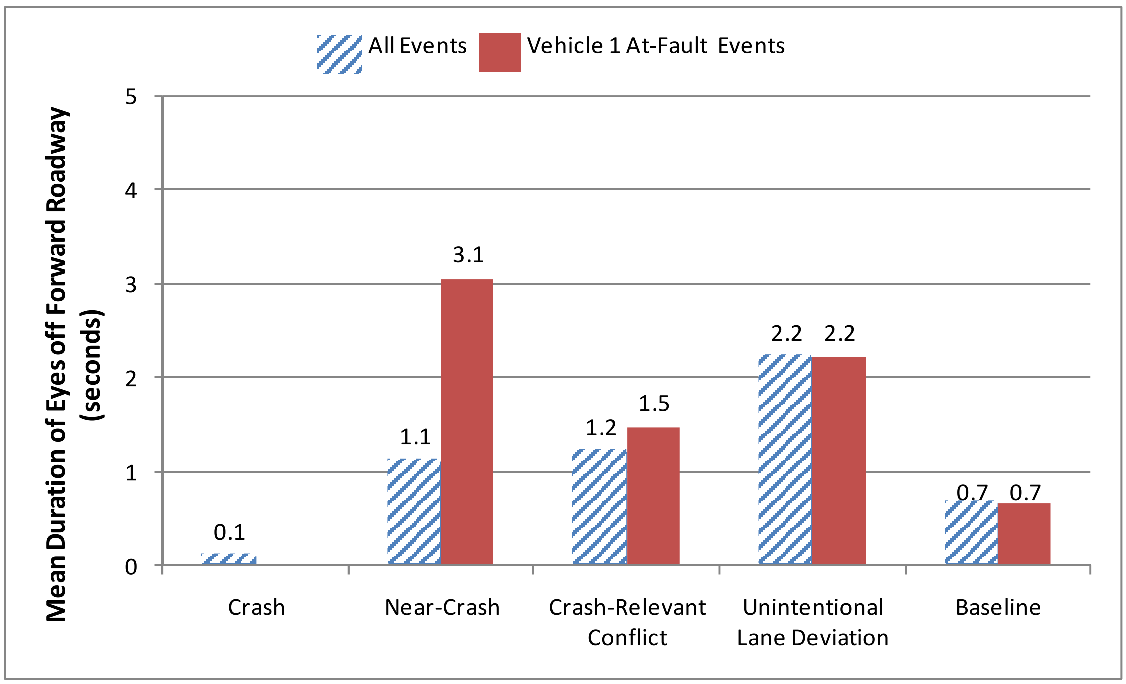


Figure 26. Graph. Mean Duration of Eyes off Forward Roadway by Event Type for Simple Tertiary Tasks

Figure 26 also shows the mean duration of eyes off forward roadway for each event type across “Vehicle 1 At-Fault” events. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across “Vehicle 1 At-Fault” events ($F_{(3, 2009)} = 92.04$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.2 s) was significantly longer than crash-relevant conflicts (1.5 s; $t_{(2009)} = 5.39$, $p < 0.0001$) and baseline epochs (0.7 s; $t_{(2009)} = 14.37$, $p < 0.0001$). Near-crashes (3.1 s; $t_{(2009)} = 3.10$, $p = 0.011$) and crash-relevant conflicts (1.5 s; $t_{(2009)} = 8.79$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway time than baseline epochs (0.7 s).

5.5.2.8 Simple Tertiary Task Breakout Analyses

Additional ANOVAs were calculated on the five specific simple tertiary tasks that were shown to be significant in Table 17. In conducting this analysis, the mean duration of eyes off forward roadway was calculated for the following four groupings:

- Safety-critical events with distraction of interest.
- Baseline epochs with distraction of interest.
- Safety-critical events without distraction of interest.
- Baseline epochs without distraction of interest.

Because of the small sample size for many of the simple tertiary tasks, any safety-critical event or baseline epoch with the moderate tertiary task of interest was used. Therefore, it was possible that the safety-critical event or baseline epoch contained additional tasks (e.g., if the distraction of interest was talking on a hands-free phone, the driver may have also been taking a drink at the same time).

Put on/remove/adjust Sunglasses or Glasses: Figure 27 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 401.01$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with put on/remove/adjust sunglasses or glasses (2.3 s) was significantly longer than baselines with put on/remove/adjust sunglasses or glasses (1.3 s; $t_{(22617)} = 3.24$, $p = 0.007$) and baselines without put on/remove/adjust sunglasses or glasses (1.2 s; $t_{(22617)} = 4.59$, $p < 0.0001$). Baselines with put on/remove/adjust sunglasses or glasses (1.3 s) had a significantly shorter mean duration of eyes off forward roadway than events without put on/remove/adjust sunglasses or glasses (2.0 s; $t_{(22617)} = 3.46$, $p = 0.003$). Events without put on/remove/adjust sunglasses or glasses (2.0 s; $t_{(22617)} = 34.44$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without put on/remove/adjust sunglasses or glasses (1.2 s).

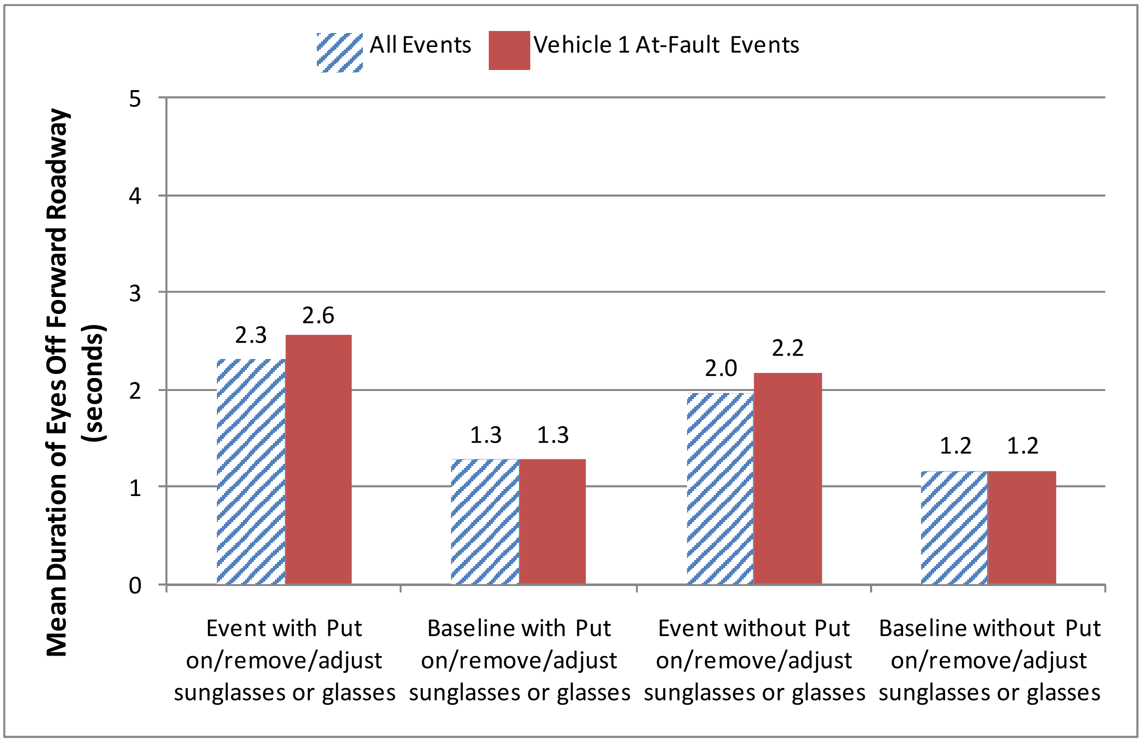


Figure 27. Graph. Mean Duration of Eyes off Forward Roadway for Put on/remove/adjust Sunglasses or Glasses

Figure 27 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across Vehicle 1 at-fault' events ($F_{(3, 21914)} = 538.94$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with put on/remove/adjust sunglasses or glasses (2.6 s) was significantly longer than baselines with put on/remove/adjust sunglasses or glasses (1.3 s; $t_{(21914)} = 3.95$, $p = 0.001$) and baselines without put on/remove/adjust sunglasses or glasses (1.2 s; $t_{(21914)} = 5.35$, $p < 0.0001$). Baselines with put on/remove/adjust sunglasses or glasses (1.3 s) had a significantly shorter mean duration of eyes off forward roadway than events without put on/remove/adjust sunglasses or glasses (2.2 s; $t_{(21914)} = 4.55$, $p < 0.0001$). Events without put on/remove/adjust sunglasses or glasses (2.2 s; $t_{(21914)} = 39.92$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without put on/remove/adjust sunglasses or glasses (1.2 s).

Adjust Instrument Panel: Figure 28 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 531.85$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with adjust instrument panel (2.6 s) was significantly longer than baselines with adjust instrument panel (2.0 s; $t_{(22617)} = 5.31$, $p < 0.0001$), events without adjust instrument panel (1.9 s; $t_{(22617)} = 6.78$, $p < 0.0001$) and baselines without adjust instrument panel (1.1 s; $t_{(22617)} = 14.61$, $p < 0.0001$). Baselines with adjust instrument panel (2.0 s) had a significantly longer mean duration of eyes off forward roadway than baselines without adjust instrument panel (1.1 s; $t_{(22617)} = 18.14$, $p <$

0.0001). Events without adjust instrument panel (1.9 s; $t_{(22617)} = 34.29$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without adjust instrument panel (1.1 s).

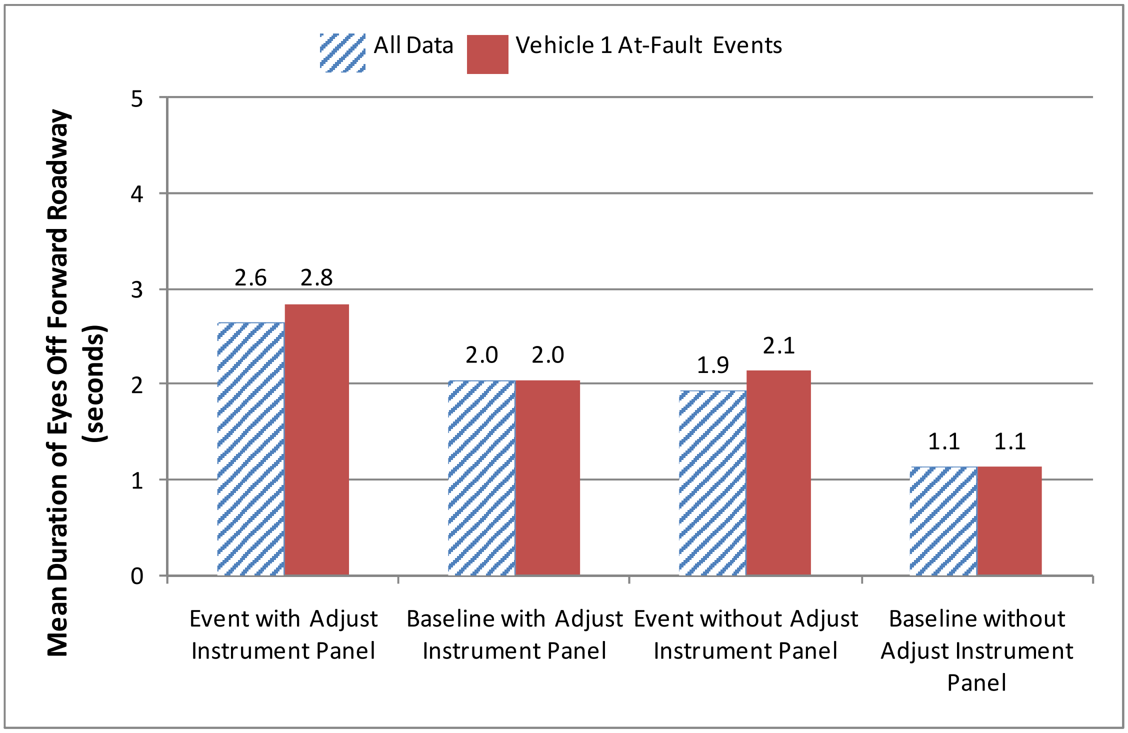


Figure 28. Graph. Mean Duration of Eyes off Forward Roadway for Adjust Instrument Panel

Figure 28 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 672.75$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with adjust instrument panel (2.8 s) was significantly longer than baselines with adjust instrument panel (2.0 s; $t_{(21914)} = 6.80$, $p < 0.0001$), events without adjust instrument panel (2.1 s; $t_{(21914)} = 6.39$, $p = 0.0002$) and baselines without adjust instrument panel (1.1 s; $t_{(21914)} = 15.74$, $p < 0.0001$). Baselines with adjust instrument panel (2.0 s) had a significantly longer mean duration of eyes off forward roadway than baselines without adjust instrument panel (1.1 s; $t_{(21914)} = 18.32$, $p < 0.0001$). Events without adjust instrument panel (2.1 s; $t_{(21914)} = 39.56$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without adjust instrument panel (1.1 s).

Other Personal Hygiene: Figure 29 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 411.11$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with other personal hygiene (1.6 s) was significantly longer than baselines with other personal hygiene (1.1 s; $t_{(22617)} = 5.84$, $p < 0.0001$) and baselines without other personal hygiene (1.2 s; $t_{(22617)} = 5.45$, $p < 0.0001$) and was significantly shorter than events without other personal hygiene (2.0 s; $t_{(22617)}$ =

5.24, $p < 0.0001$). Baselines with other personal hygiene (1.1 s) had a significantly shorter mean duration of eyes off forward roadway than events without other personal hygiene (2.2 s; $t_{(22617)} = 25.06$, $p < 0.0001$). Events without other personal hygiene (2.0 s; $t_{(22617)} = 34.28$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without other personal hygiene (1.2 s).

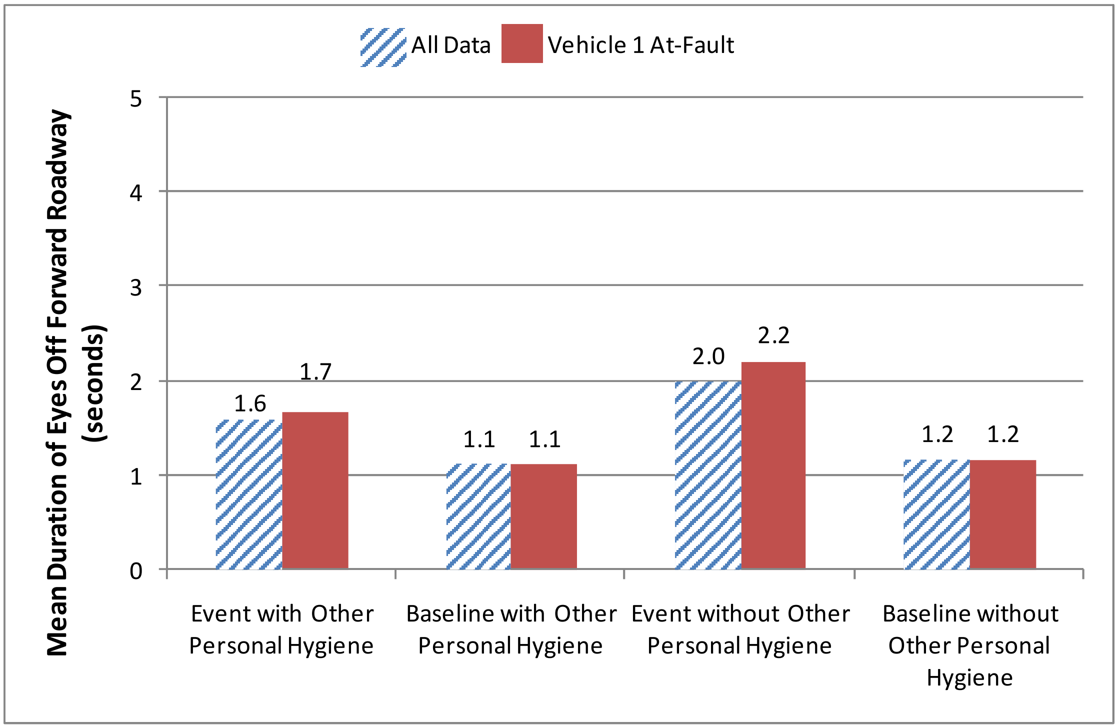


Figure 29. Graph. Mean Duration of Eyes off Forward Roadway for Other Personal Hygiene

Figure 29 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 553.95$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with other personal hygiene (1.7 s) was significantly longer than baselines with other personal hygiene (1.1 s; $t_{(21914)} = 6.72$, $p < 0.0001$) and baselines without other personal hygiene (1.2 s; $t_{(21914)} = 6.38$, $p < 0.0001$) and was significantly shorter than events without other personal hygiene (2.2 s; $t_{(21914)} = 6.40$, $p < 0.0001$). Baselines with other personal hygiene (1.1 s) had a significantly shorter mean duration of eyes off forward roadway than events without other personal hygiene (2.2 s; $t_{(21914)} = 30.23$, $p < 0.0001$). Events without other personal hygiene (2.2 s; $t_{(21914)} = 39.89$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without other personal hygiene (1.2 s).

Bite Nails: Figure 30 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 408.55$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with bite nails (1.1 s) was significantly longer than events without bite nails (2.0 s; $t_{(22617)} = 2.77$, $p = 0.029$). Baselines with bite nails

(0.8 s) had a significantly shorter mean duration of eyes off forward roadway than events without bite nails (2.0 s; $t_{(22617)} = 12.01$, $p < 0.0001$) and baselines without bite nails (1.2 s; $t_{(22617)} = 4.00$, $p < 0.0001$). Events without bite nails (0.8 s; $t_{(22617)} = 34.6$, $p = 0.0004$) had a significantly shorter mean duration of eyes off forward roadway than baselines without bite nails (1.2 s).

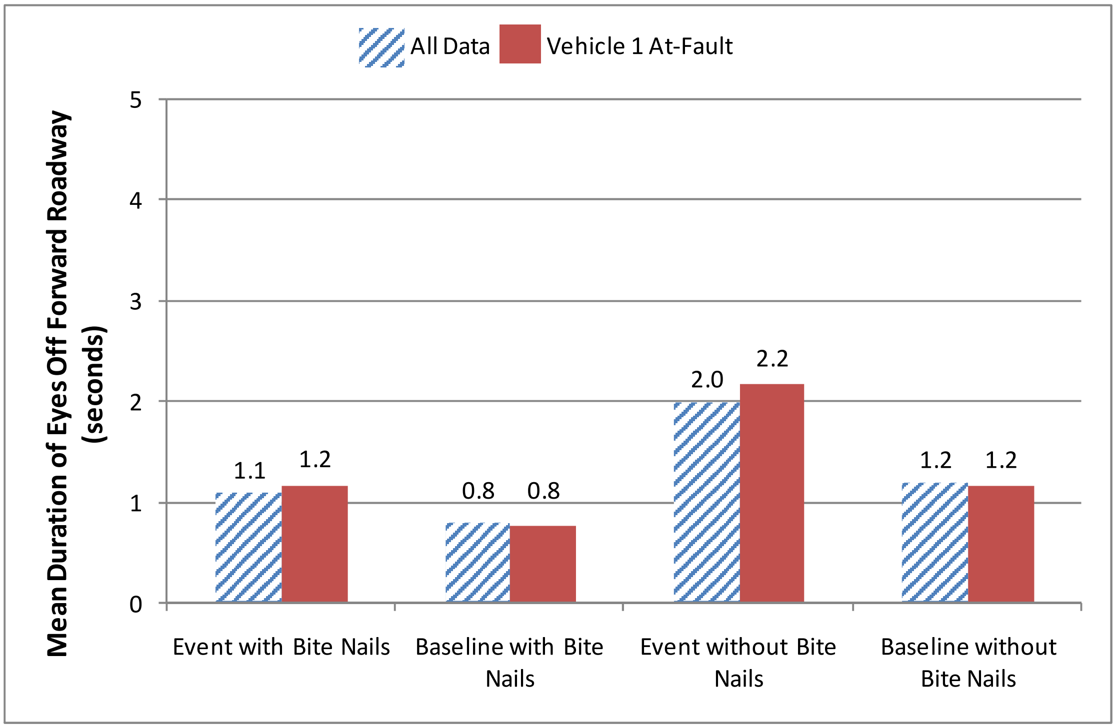


Figure 30. Graph. Mean Duration of Eyes off Forward Roadway for Bite Nails

Figure 30 also shows the mean duration of eyes off forward roadway across “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “Vehicle 1 At-Fault” events ($F_{(3, 21914)} = 546.38$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with bite nails (1.2 s) was significantly shorter than events without bite nails (2.2 s; $t_{(21914)} = 2.65$, $p = 0.041$). Baselines with bite nails (0.8 s) had a significantly shorter mean duration of eyes off forward roadway than events without bite nails (2.2 s; $t_{(21914)} = 14.18$, $p < 0.0001$) and baselines without bite nails (1.2 s; $t_{(21914)} = 4.04$, $p <$ 0.0001). Events without bite nails (0.8 s; $t_{(21914)} = 40.12$, $p < 0.0001$) had a significantly shorter mean duration of eyes off forward roadway than baselines without bite nails (1.2 s).

Interact with Other Occupant(s): Figure 31 shows the mean duration of eyes off forward roadway across “All” and “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “All” events ($F_{(3, 22617)} = 408.93$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with interact with other occupant (2.0 s) was significantly longer than baselines without interact with other occupant (1.2 s; $t_{(22617)} = 2.73$, $p = 0.032$). Baselines without interact with other occupant (1.2 s) had a significantly shorter mean duration of eyes off forward roadway than events without interact with other occupant (2.0 s; $t_{(22617)} = 34.79$, $p < 0.0001$) and baselines with interact with other occupant (1.6 s; $t_{(22617)} = 4.98$, $p < 0.0001$). Events without interact with other occupant (2.0 s; $t_{(22617)} = 34.79$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without interact with other occupant (1.2 s).

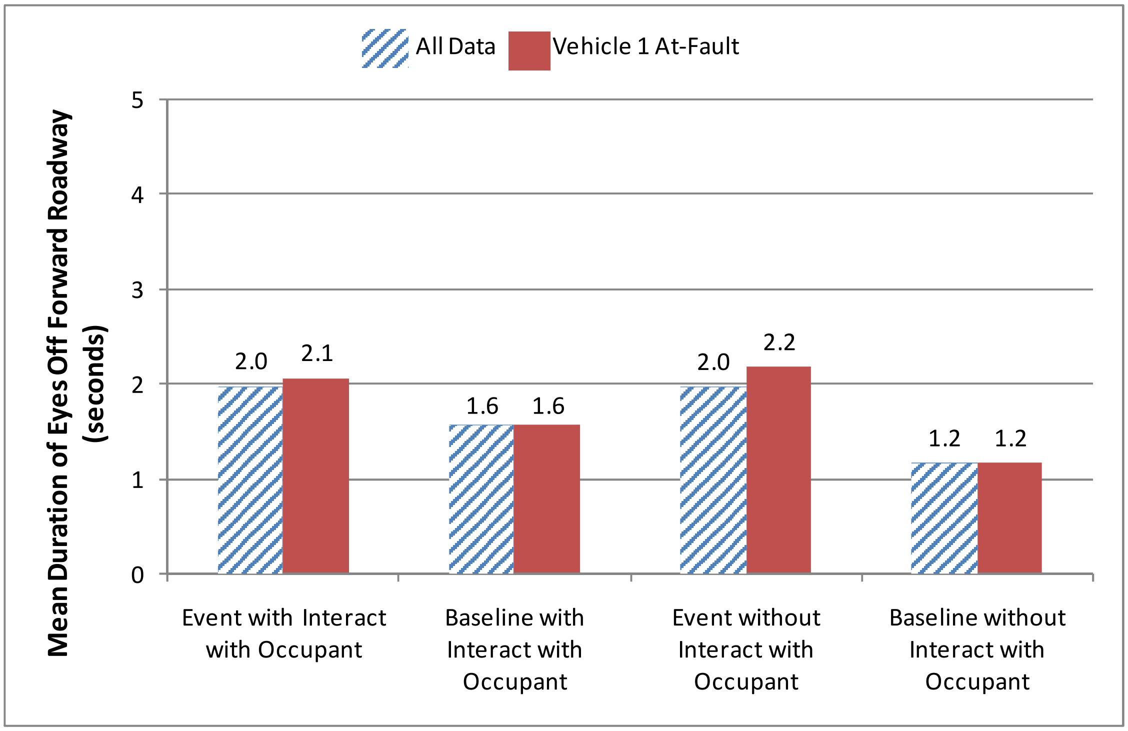


Figure 31. Graph. Mean Duration of Eyes off Forward Roadway for Interact with Other Occupant(s)

Figure 31 also shows the mean duration of eyes off forward roadway across "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "Vehicle 1 At-Fault" events ($F_{(3, 21914)} = 547.11$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with interact with other occupant (2.1 s) was significantly shorter than baselines without interact with other occupant (2.2 s; $t_{(21914)} = 2.78$, $p = 0.028$). Baselines without interact with other occupant (1.2 s) had a significantly shorter mean duration of eyes off forward roadway than events without interact with other occupant (2.2 s; $t_{(21914)} = 40.30$, $p < 0.0001$) and baselines with interact with other occupant (1.6 s; $t_{(21914)} = 5.03$, $p < 0.0001$). Events without interact with other occupant (2.2 s; $t_{(21914)} = 40.30$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without interact with other occupant (1.2 s).

5.5.2.9 Secondary Tasks

Figure 32 shows the mean duration of eyes off forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any secondary task (i.e., any safety-critical event or baseline epoch with only a secondary task). A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across "All" events ($F_{(4, 4704)} = 37.40$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.4 s) was significantly longer crash-relevant conflicts (1.8 s; $t_{(4704)} = 5.72$, $p < 0.0001$) and baseline epochs (1.5 s; $t_{(4704)} = 8.73$, $p < 0.0001$). Crashes (3.4 s; $t_{(4704)} = 4.41$, $p = 0.0001$), near-crashes (2.3 s; $t_{(4704)} = 5.29$, $p < 0.0001$), and crash-relevant conflicts (1.8 s; $t_{(4704)} = 6.10$, $p < 0.0001$ had a significantly longer mean duration of eyes off forward roadway than baseline epochs (1.5 s). Crashes (3.4 s; $t_{(4704)} = 3.76$, $p = 0.0002$) and near-crashes (2.3 s; $t_{(4704)} = 3.29$, $p = 0.009$) had a significantly longer mean duration of eyes off forward roadway than crash-relevant conflicts (1.8 s).

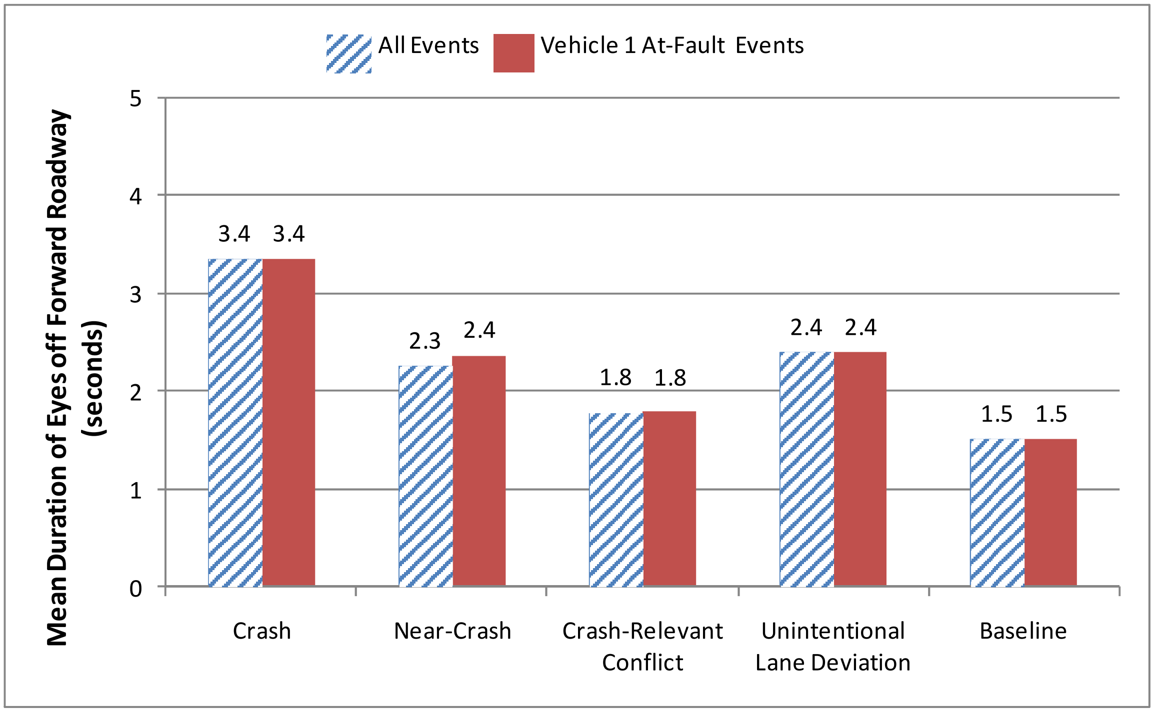


Figure 32. Graph. Mean Duration of Eyes off Forward Roadway by Event Type for Secondary Tasks

Figure 32 also shows the mean duration of eyes off forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 4495)} = 36.65$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during unintentional lane deviations (2.4 s) was significantly longer crash-relevant conflicts (1.8 s; $t_{(4495)} = 5.47$, $p < 0.0001$) and baseline epochs (1.5 s; $t_{(4495)} = 8.89$, $p < 0.0001$). Crashes (3.4 s; $t_{(4495)} = 4.49$, $p < 0.0001$), near-crashes (2.4 s; $t_{(4495)} = 4.82$, $p < 0.0001$), and crash-relevant conflicts (1.8 s; $t_{(4495)} = 5.73$, $p < 0.0001$ had a significantly longer mean duration of eyes off forward roadway than baseline epochs (1.5 s). Crashes (3.4 s; $t_{(4495)} = 3.77$, $p = 0.0002$) and near-crashes (2.4 s; $t_{(4495)} = 3.10$, $p = 0.017$) had a significantly longer mean duration of eyes off forward roadway than crash-relevant conflicts (1.8 s).

5.5.2.10 Secondary Task Breakout Analyses

Additional ANOVAs were calculated on the three specific secondary tasks that were shown to be significant in Table 17. In conducting this analysis, the mean duration of eyes off forward roadway was calculated for the following four groupings:

- Safety-critical events with distraction of interest.
- Baseline epochs with distraction of interest.
- Safety-critical events without distraction of interest.
- Baseline epochs without distraction of interest.

Look at Left-side Mirror/Out Left Window: Figure 33 shows the mean duration of eyes off forward roadway across “All” and “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “All” events ($F_{(3,\ 22617)} = 883.63$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with left-side mirror/window (2.1 s) was significantly longer than baselines with left-side mirror/window (1.7 s; $t_{(22617)} = 8.58$, $p < 0.0001$), events without left-side mirror/window (1.9 s; $t_{(22617)} = 3.90$, $p = 0.0006$) and baselines without left-side mirror/window (1.0 s; $t_{(22617)} = 27.67$, $p < 0.0001$). Baselines with left-side mirror/window (1.7 s) had a significantly shorter mean duration of eyes off forward roadway than events without left-side mirror/window (1.9 s; $t_{(22617)} = 6.33$, $p < 0.0001$) and a significantly longer mean duration of eyes off forward roadway than baselines without left-side mirror/window (1.0 s; $t_{(22617)} = 36.90$, $p < 0.0001$). Events without left-side mirror/window (1.9 s; $t_{(22617)} = 35.89$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without left-side mirror/window (1.0 s).

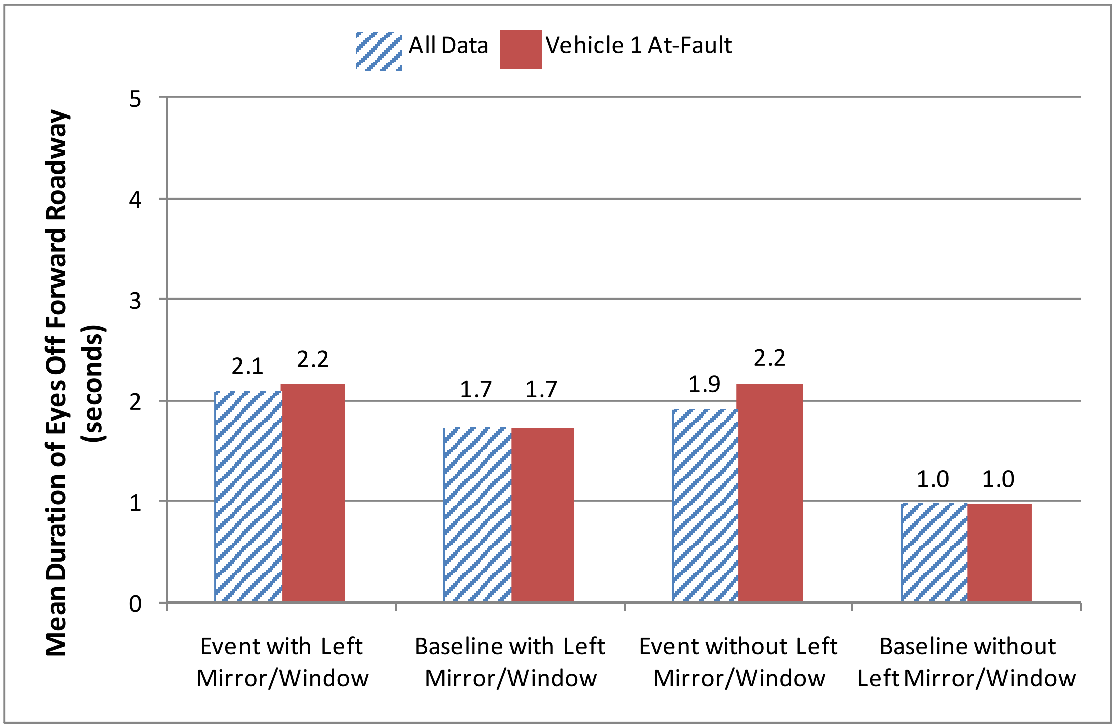


Figure 33. Graph. Mean Duration of Eyes off Forward Roadway for Look at Left-side Mirror/Out Left Window

Figure 33 also shows the mean duration of eyes off forward roadway across “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “Vehicle 1 At-

Fault" events ($F_{(3, 21914)} = 1036.10$, $p < 0.0001$). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with left-side mirror/window (2.2 s) was significantly longer than baselines with left-side mirror/window (1.7 s; $t_{(21914)} = 9.21$, $p < 0.0001$) and baselines without left-side mirror/window (1.2 s; $t_{(21914)} = 26.30$, $p < 0.0001$). Baselines with left-side mirror/window (1.7 s) had a significantly shorter mean duration of eyes off forward roadway than events without left-side mirror/window (2.2 s; $t_{(21914)} = 14.25$, $p < 0.0001$) and a significantly longer mean duration of eyes off forward roadway than baselines without left-side mirror/window (1.2 s; $t_{(21914)} = 37.30$, $p = 0.001$). Events without left-side mirror/window (2.2 s; $t_{(21914)} = 42.45$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without left-side mirror/window (1.2 s).

Look at Right-Side Mirror/Out Right Window: Figure 34 shows the mean duration of eyes off forward roadway across "All" and "Vehicle 1 At-Fault" events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across "All" events ($F_{(3, 22617)} = 741.57$, $p <$ 0.0001). Tukey *t* tests indicated that the mean duration of eyes off forward roadway during events with right-side mirror/window (2.2 s) was significantly longer than baselines without right-side mirror/window (1.1 s; $t_{(22617)} = 4.64$, $p < 0.0001$), events without right-side mirror/window (1.9 s; $t_{(22617)} = 4.81$, $p < 0.0001$) and baselines without right-side mirror/window (1.1 s; $t_{(22617)} = 18.93$, $p < 0.0001$). Baselines with right-side mirror/window (1.9 s) had a significantly longer mean duration of eyes off forward roadway than baselines without right-side mirror/window (1.2 s; $t_{(22617)} = 30.81$, $p < 0.0001$). Events without right-side mirror/window (1.9 s; $t_{(22617)} = 35.97$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without right-side mirror/window (1.1 s).

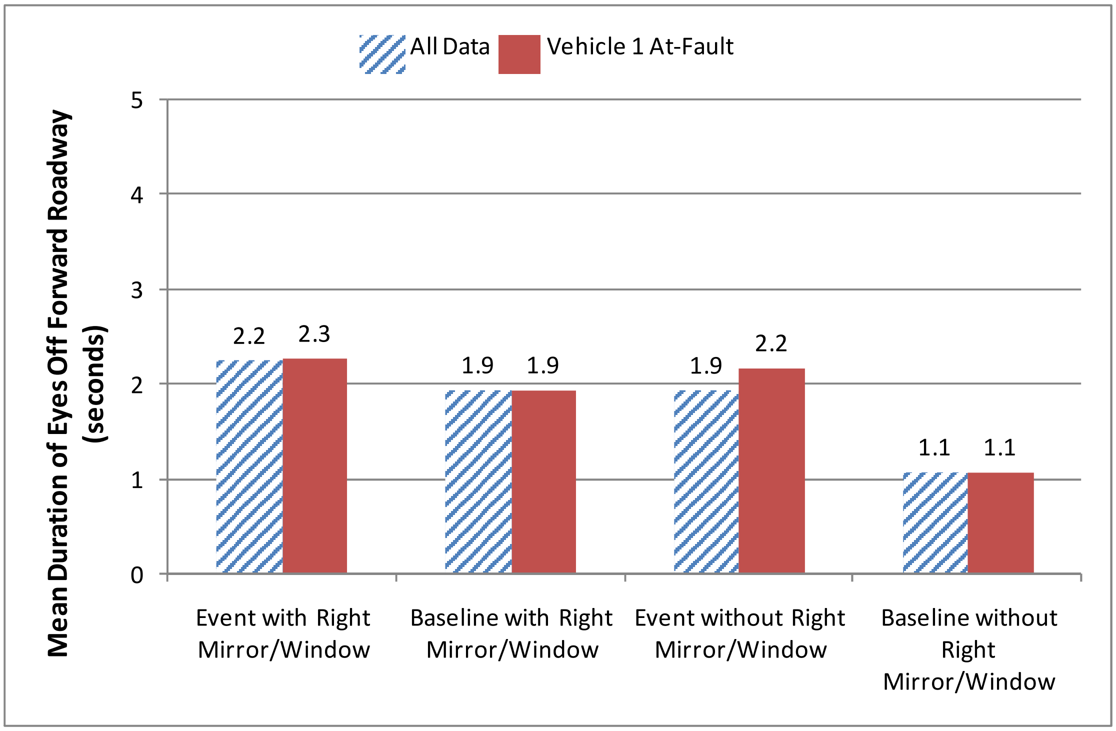


Figure 34. Graph. Mean Duration of Eyes off Forward Roadway for Look at Right-side Mirror/Out Right Window

Figure 34 also shows the mean duration of eyes off forward roadway across “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “Vehicle 1 At-Fault” events ($F_{(3, 21914)} = 885.3$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with right-side mirror/window (2.3 s) was significantly longer than baselines with right-side mirror/window (1.1 s; $t_{(21914)} = 4.14$, $p < 0.0002$) and baselines without right-side mirror/window (1.1 s; $t_{(21914)} = 15.68$, $p < 0.0001$). Baselines with right-side mirror/window (1.9 s) had a significantly longer mean duration of eyes off forward roadway than events without right-side mirror/window (1.9 s; $t_{(21914)} = 6.53$, $p < 0.0001$) and baselines without right-side mirror/window (1.1 s; $t_{(21914)} = 31.13$, $p < 0.0001$). Events without right-side mirror/window (1.9 s; $t_{(21914)} = 42.57$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without right-side mirror/window (1.1 s).

Check Speedometer: Figure 35 shows the mean duration of eyes off forward roadway across “All” and “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “All” events ($F_{(3, 22617)} = 523.43$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with check speedometer (1.9 s) was significantly longer than baselines without check speedometer (1.1 s; $t_{(22617)} = 7.26$, $p < 0.0001$). Events without check speedometer (2.0 s) had a significantly longer mean duration of eyes off forward roadway than baselines with check speedometer (1.6 s; $t_{(22617)} = 9.10$, $p < 0.0001$) and baselines without check speedometer (1.1 s; $t_{(22617)} = 36.71$, $p < 0.0001$). Baselines with check speedometer (1.6 s; $t_{(22617)} = 18.71$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without check speedometer (1.1 s).

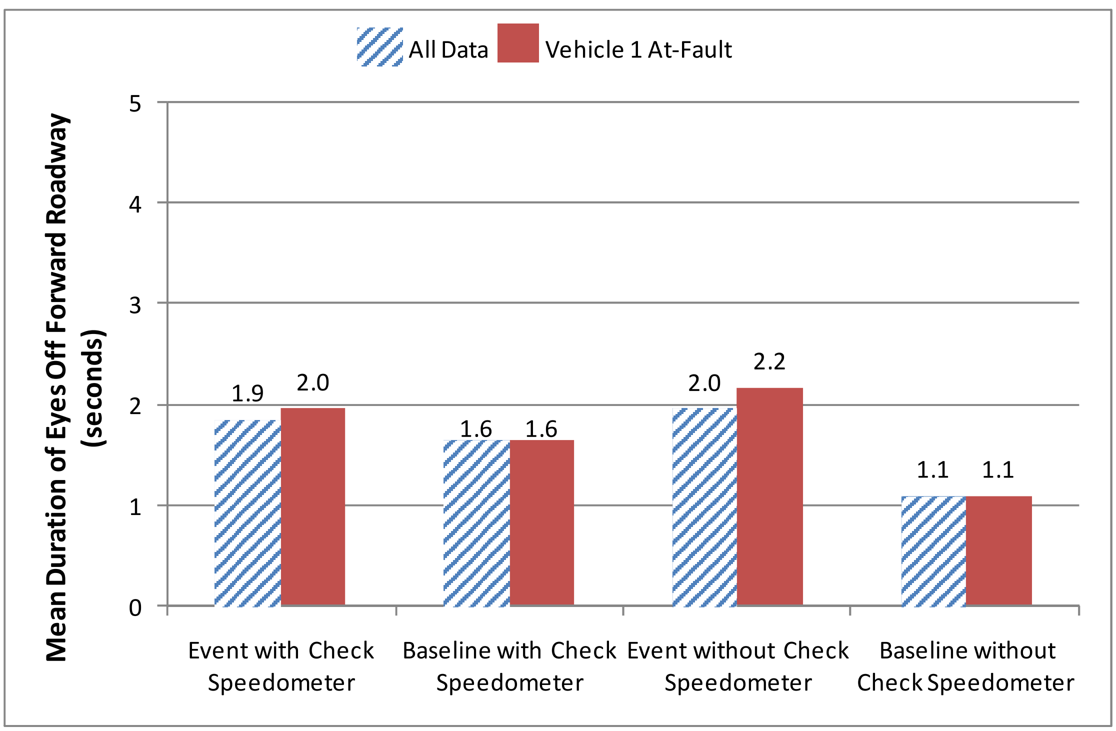


Figure 35. Graph. Mean Duration of Eyes off Forward Roadway for Check Speedometer

Figure 35 also shows the mean duration of eyes off forward roadway across “Vehicle 1 At-Fault” events for each of the four groupings. A one-way ANOVA found a significant difference in the mean duration of eyes off forward roadway between the four groupings across “Vehicle 1 At-Fault” events ($F_{(3, 21914)} = 667.02$, $p < 0.0001$). Tukey t tests indicated that the mean duration of eyes off forward roadway during events with check speedometer (2.1 s) was significantly longer than baselines with check speedometer (1.6 s; $t_{(21914)} = 2.78$, $p = 0.028$) and baselines without check speedometer (1.1 s; $t_{(21914)} = 7.68$, $p < 0.0001$). Events without check speedometer (2.2 s) had a significantly longer mean duration of eyes off forward roadway than baselines with check speedometer (1.6 s; $t_{(21914)} = 14.71$, $p < 0.0001$) and baselines without check speedometer (1.1 s; $t_{(21914)} = 42.12$, $p < 0.0001$). Baselines with check speedometer (1.6 s; $t_{(21914)} = 18.90$, $p < 0.0001$) had a significantly longer mean duration of eyes off forward roadway than baselines without check speedometer (1.1 s).

5.5.3 Number of Glances Away From Forward Roadway

Number of glances away from forward roadway was operationally defined as the number of glances away from the forward roadway during the 6-s interval or epoch period. This may include partial glances at either the beginning or end of the 6-s interval. A glance was operationally defined as any time the driver took his/her eyes off of the forward roadway, regardless of where he/she looked. For example, if the driver looked forward-right window-forward, that was considered one glance. In addition, if the driver looked forward-cell phone-right window-forward, that was also considered one glance.

As in section 3.2 above, the analyses in this section were grouped by event type (i.e., crash, near-crash, crash-relevant conflict, etc.) across “All” and “Vehicle 1 At-Fault” events. These results are presented in Tables 36–41 and include the following analyses:

- All tasks.
- All tertiary tasks.
  - Complex tertiary tasks.
  - Moderate tertiary tasks.
  - Simple tertiary tasks.
- Secondary tasks.
- All Tasks.

Figure 36 shows the mean number of glances away from forward roadway for each event type across “All” and “Vehicle 1 At-Fault” events for any task. A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across “All” events ($F_{(4, 22616)} = 186.61$, $p < 0.0001$). Tukey t tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.3) was significantly higher than near-crashes (1.5; $t_{(22616)} = 7.58$, $p < 0.0001$), crash-relevant conflicts (1.6; $t_{(22616)} = 14.82$, $p < 0.0001$), and baseline epochs (1.3; $t_{(22616)} = 25.16$, $p < 0.0001$). Crash-relevant conflicts (1.5) had a significantly higher number of glances away from forward roadway than baseline epochs (1.3; $t_{(22616)} = 12.31$, $p < 0.0001$).

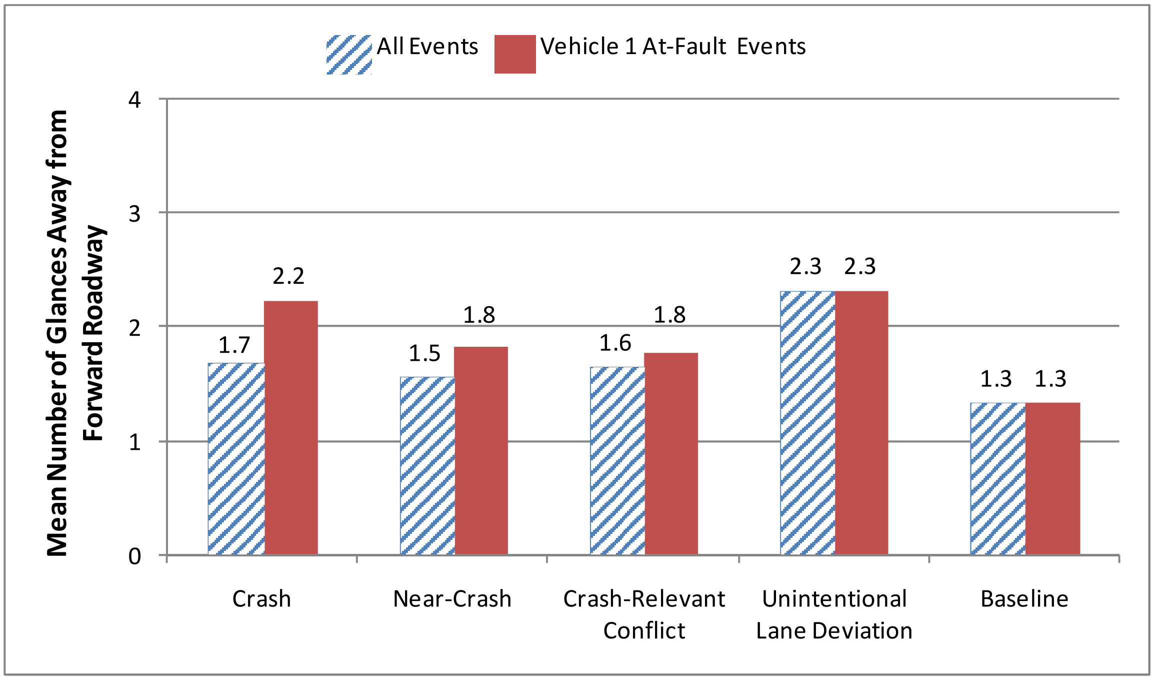


Figure 36. Graph. Mean Number of Glances Away from Forward Roadway by Event Type for All Tasks

Figure 36 also shows the mean number of glances away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 21996)} = 209.90$, $p < 0.0001$). Tukey *t* tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.3) was significantly higher than near-crashes (1.8; $t_{(21996)} = 3.80$, $p = 0.001$), crash-relevant conflicts (1.8; $t_{(21996)} = 11.30$, $p < 0.0001$), and baseline epochs (1.3; $t_{(21996)} = 25.19$, $p < 0.0001$). Both near-crashes (1.8 s; $t_{(21996)} = 3.98$, $p = 0.001$) and crash-relevant conflicts (1.8; $t_{(21996)} = 15.38$, $p < 0.0001$) had a significantly higher number of glances away from forward roadway than baseline epochs (1.3).

All Tertiary Tasks

Figure 37 shows the mean number of glances away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any tertiary task (i.e., any safety-critical event or baseline epoch with a complex, moderate, or simple tertiary task). A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across "All" events ($F_{(4, 8722)} = 188.54$, $p < 0.0001$). Tukey *t* tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.5) was significantly higher than crashes (1.0; $t_{(8722)} = 4.26$, $p = 0.0002$), near-crashes (1.7; $t_{(8722)} = 4.09$, $p = 0.0004$), crash-relevant conflicts (1.9; $t_{(8722)} = 10.11$, $p < 0.0001$), and baseline epochs (1.3; $t_{(8722)} = 24.66$, $p < 0.0001$). Crash-relevant conflicts (1.9; $t_{(8722)} = 16.92$, $p < 0.0001$) had a significantly higher number of glances away from forward roadway than baseline epochs (1.3).

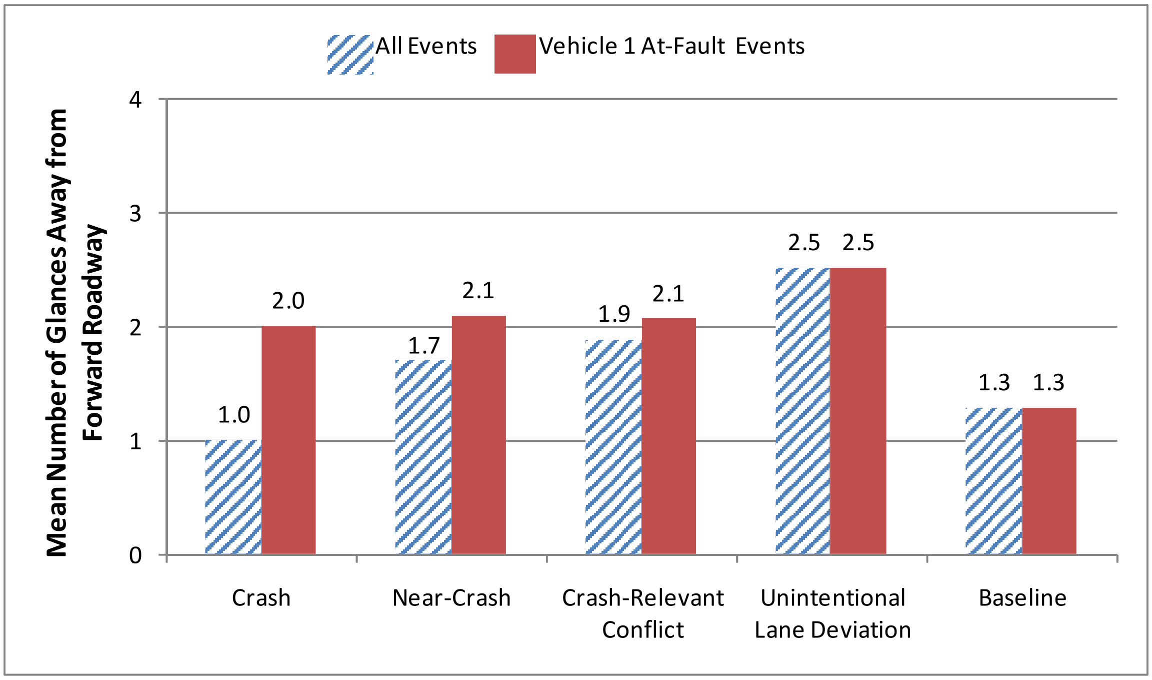


Figure 37. Graph. Mean Number of Glances Away from Forward Roadway by Event Type for All Tertiary Tasks

Figure 37 also shows the mean number of glances away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 8098)} = 209.37$, $p < 0.0001$). Tukey *t* tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.5) was significantly higher than crash-relevant conflicts (2.1; $t_{(8098)} = 6.94$, $p < 0.0001$) and baseline epochs (1.3; $t_{(8098)} = 24.71$, $p < 0.0001$). Crash-relevant conflicts (2.1; $t_{(8098)} = 16.92$, $p < 0.0001$) had a significantly higher mean number of glances away from forward roadway than baseline epochs (1.3).

5.5.3.1 Complex Tertiary Tasks

Figure 38 shows the mean number of glances away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any complex tertiary tasks (i.e., any safety-critical event or baseline epoch with only a complex tertiary task). A one-way ANOVA did not find a significant difference in the mean number of glances away from forward roadway between the four event types across "All" events ($F_{(3, 492)} = 2.14$, $p = 0.0948$).

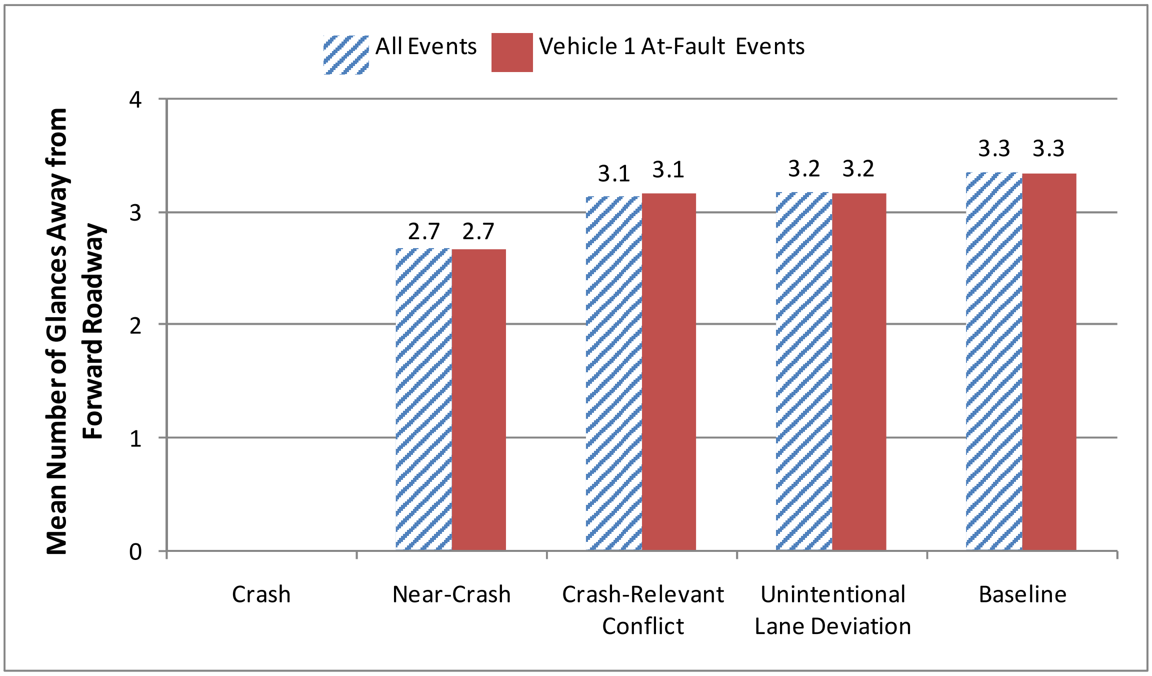


Figure 38. Graph. Mean Number of Glances Away from Forward Roadway by Event Type for Complex Tertiary Tasks

Figure 38 also shows the mean number of glances away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA did not find a significant difference in the mean number of glances away from forward roadway between the four event types across "Vehicle 1 At-Fault" events ($F_{(3, 487)} = 1.84$, $p = 0.1388$).

5.5.3.2 Moderate Tertiary Tasks

Figure 39 shows the mean number of glances away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any moderate tertiary tasks (i.e., any safety-critical event or baseline epoch with only a moderate tertiary task). A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across "All" events ($F_{(4, 4218)} = 48.08$, $p < 0.0001$). Tukey *t* tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.3) was significantly higher than crash-relevant conflicts (1.7; $t_{(4218)} = 6.61$, $p < 0.0001$) and baseline epochs (1.3 s; $t_{(4218)} = 12.56$, $p < 0.0001$). Crash-relevant conflicts (1.7; $t_{(4218)} = 6.64$, $p < 0.0001$) had a significantly higher mean number of glances away from forward roadway than baseline epochs (1.3).

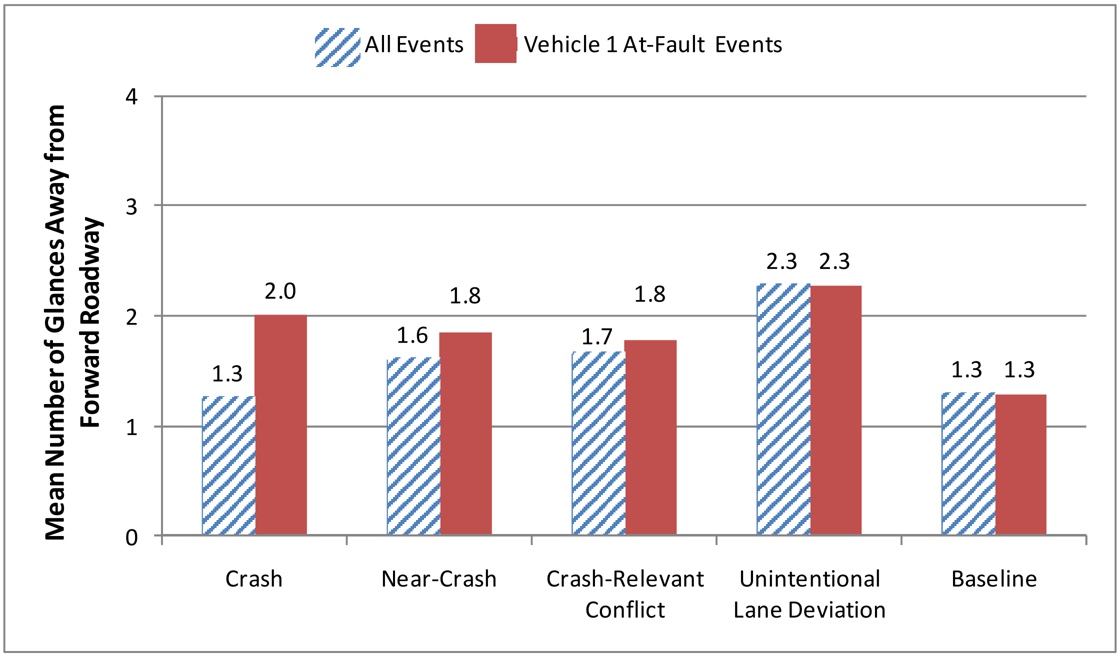


Figure 39. Graph. Mean Number of Glances Away from Forward Roadway by Event Type for Moderate Tertiary Tasks

Figure 39 also shows the mean number of glances away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference between the five event types across "Vehicle 1 At-Fault" events ($F_{(3,\ 4123)} = 52.70$, $p < 0.0001$). Tukey t tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.3) was significantly higher than crash-relevant conflicts (1.8; $t_{(4123)} = 5.15$, $p < 0.0001$) and baseline epochs (1.2; $t_{(4123)} = 12.56$, $p < 0.0001$). Crash-relevant conflicts (1.8; $t_{(4123)} = 7.83$, $p < 0.0001$) had a significantly higher mean number of glances away from forward roadway than baseline epochs (1.3).

5.5.3.3 Simple Tertiary Tasks

Figure 40 shows the mean number of glances away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any simple tertiary tasks (i.e., any safety-critical event or baseline epoch with only a simple tertiary task). A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across "All" events ($F_{(4,\ 2063)} = 38.10$, $p < 0.0001$). Tukey t tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.0) was significantly higher than crash-relevant conflicts (1.3; $t_{(2063)} = 6.61$, $p < 0.0001$) and baseline epochs (0.8; $t_{(2063)} = 12.56$, $p < 0.0001$). Crash-relevant conflicts (1.3 s; $t_{(2063)} = 6.64$, $p < 0.0001$) had a significantly higher mean number of glances away from forward roadway than baseline epochs (0.8).

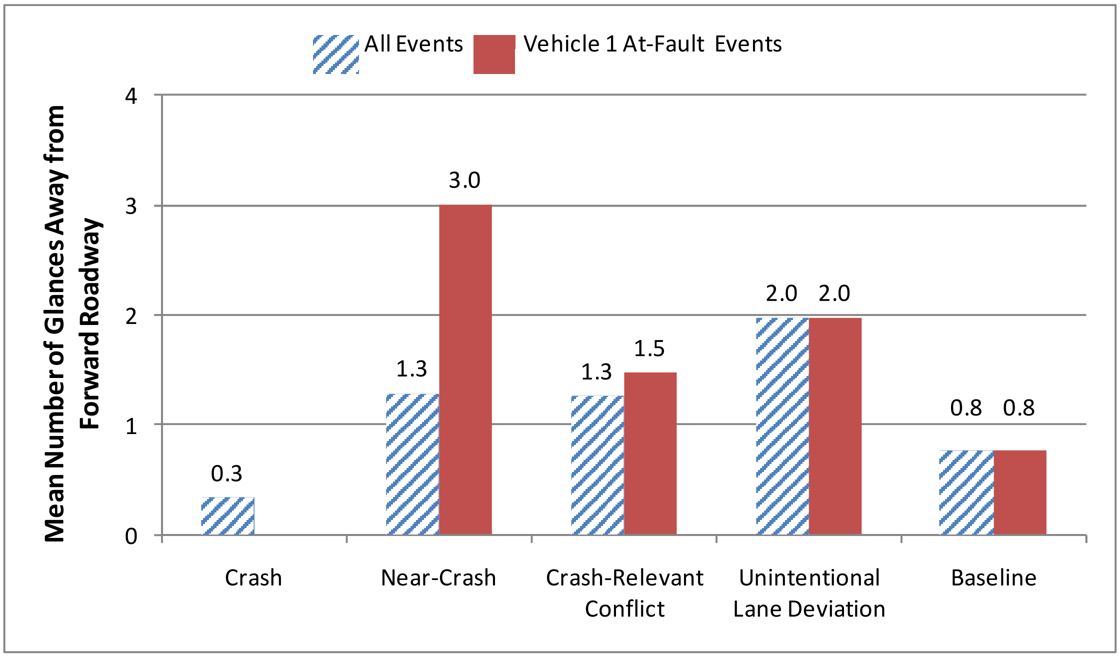


Figure 40. Graph. Mean Number of Glances Away from Forward Roadway by Event Type for Simple Tertiary Tasks

Figure 40 also shows the mean number of glances away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the four event types across "Vehicle 1 At-Fault" events ($F_{(3, 2009)} = 59.50$, $p < 0.0001$). Tukey *t* tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.0) was significantly higher than crash-relevant conflicts (1.5; $t_{(2009)} = 5.15$, $p < 0.0001$) and baseline epochs (0.8; $t_{(2009)} = 12.56$, $p < 0.0001$). Crash-relevant conflicts (1.5 s; $t_{(2009)} = 7.83$, $p < 0.0001$) had a significantly higher mean number of glances away from forward roadway than baseline epochs (0.8).

5.5.3.4 *Secondary Tasks*

Figure 41 shows the mean number of glances away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any secondary tasks (i.e., any safety-critical event or baseline epochs with only a secondary task). A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across "All" events ($F_{(4, 4704)} = 8.77$, $p < 0.0001$). Tukey *t* tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.1; $t_{(4704)} = 4.38$, $p = 0.001$) and crash-relevant conflicts (1.9 s; $t_{(4704)} = 4.07$, $p = 0.001$) was significantly higher than baseline epochs (1.7).

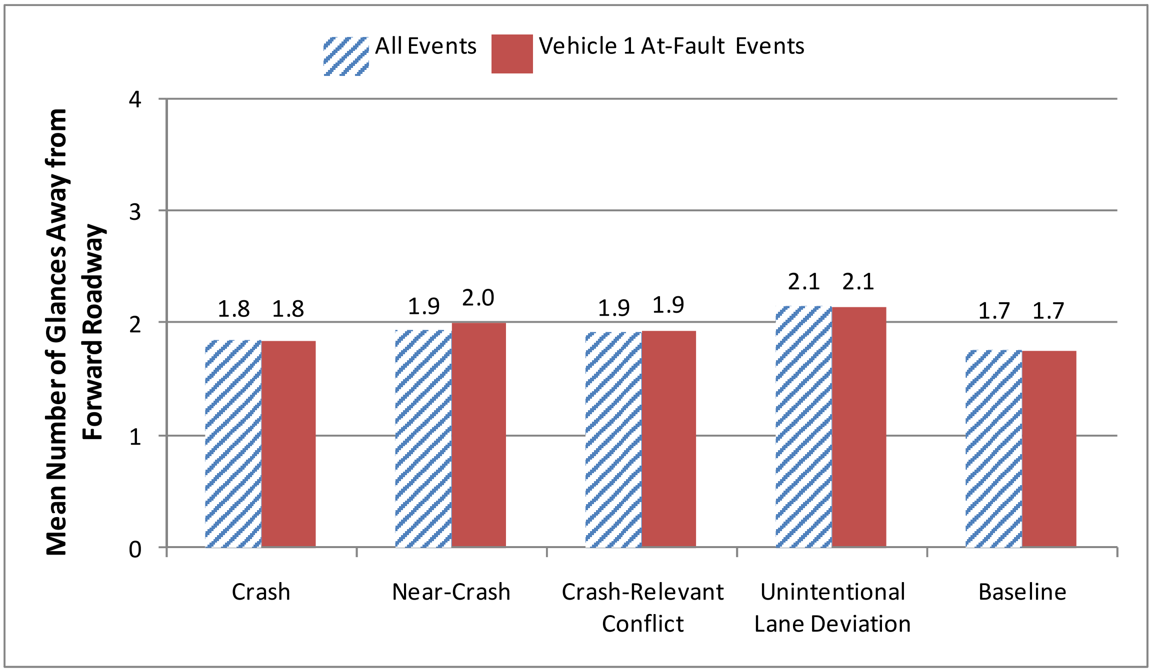


Figure 41. Graph. Mean Number of Glances Away from Forward Roadway by Event Type for Secondary Tasks

Figure 41 also shows the mean number of glances away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean number of glances away from forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 4495)} = 9.13$, $p < 0.0001$). Tukey t tests indicated that the mean number of glances away from forward roadway during unintentional lane deviations (2.1; $t_{(4495)} = 4.39$, $p = 0.0001$) and crash-relevant conflicts (1.9 s; $t_{(4495)} = 4.13$, $p = 0.0004$) was significantly higher than baseline epochs (1.7).

5.5.4 Length of Longest Glance Away From Forward Roadway

Length of longest glance away from forward roadway was operationally defined as the longest single glance (defined in section 3.3) where the driver was not looking forward during the 6-s safety-critical event or baseline epoch. As in the previous analysis, this may include partial glances at either the beginning or end of the 6-s interval. The analyses in this section were grouped by event type (i.e., crash, near-crash, crash-relevant conflict, etc.) across "All" and "Vehicle 1 At-Fault" events. These results are presented in Figures 42–47 and include the following analyses:

- All tasks.
- All tertiary tasks.
  - Complex tertiary tasks.
  - Moderate tertiary tasks.
  - Simple tertiary tasks.
- Secondary task.

5.5.4.1 All Tasks

Figure 42 shows the mean length of longest glance away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any task. A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "All" events ($F_{(4, 22616)} = 314.37$, $p < 0.0001$). Tukey t tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.5 s) was significantly longer than near-crashes (1.1 s; $t_{(22616)} = 6.51$, $p < 0.0001$), crash-relevant conflicts (1.0 s; $t_{(22616)} = 19.57$, $p < 0.0001$), and baselines (0.8 s; $t_{(22616)} = 32.36$, $p < 0.0001$). Crashes (1.6 s) were significantly longer than crash-relevant conflicts (1.0 s; $t_{(22616)} = 3.58$, $p = 0.003$) and baselines (1.6 s; $t_{(22616)} = 5.00$, $p < 0.0001$). Both near-crashes (1.1 s; $t_{(22616)} = 6.56$, $p = 0.001$) and crash-relevant conflicts (1.0 s; $t_{(22616)} = 14.93$, $p < 0.0001$) had a significantly longer mean length of longest glance away from forward roadway than baselines (0.8 s).

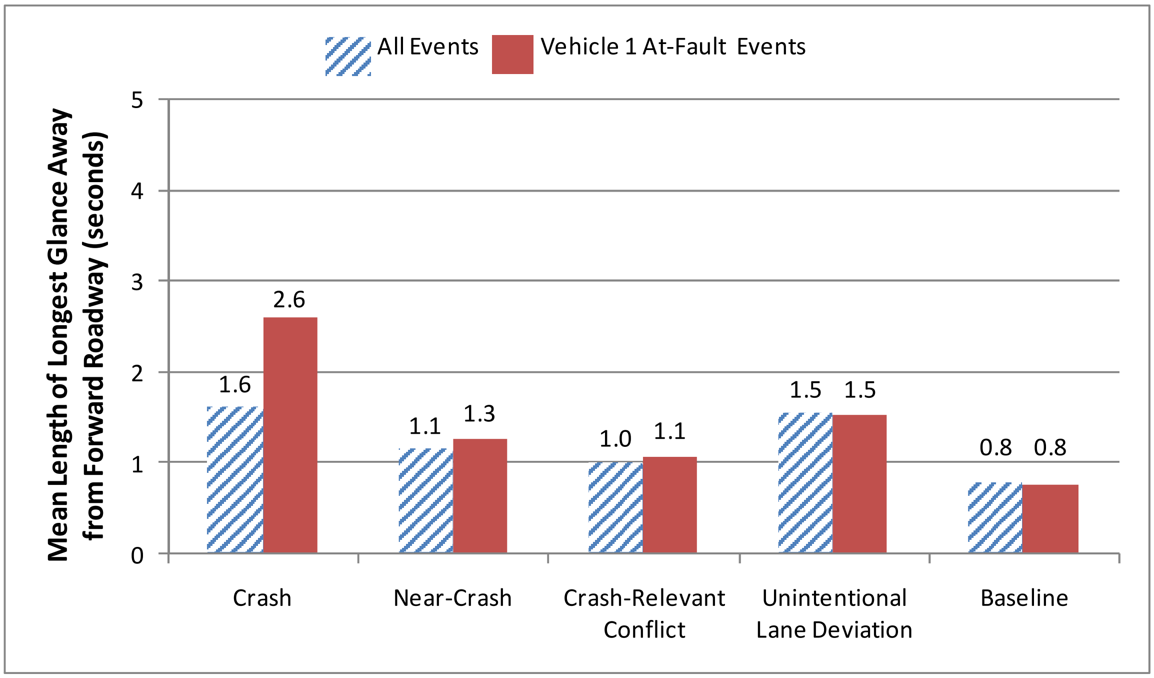


Figure 42. Graph. Mean Length of Longest Glance Away from Forward Roadway by Event Type for All Tasks

Figure 42 also shows the mean length of longest glance away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 21913)} = 355.35$, $p < 0.0001$). Tukey t tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.5 s) was significantly longer than near-crashes (1.3 s; $t_{(21913)} = 3.36$, $p = 0.007$), crash-relevant conflicts (1.1 s; $t_{(21913)} = 15.90$, $p < 0.0001$), and baselines (0.8 s; $t_{(21913)} = 32.76$, $p < 0.0001$). Crashes (2.6 s; $t_{(21913)} = 7.75$, $p < 0.0001$), near-crashes (1.3 s; $t_{(21913)} = 6.83$, $p < 0.0001$) and crash-relevant conflicts (1.1 s; $t_{(21913)} = 18.07$, $p < 0.0001$) had a significantly longer mean length of longest glance away from forward roadway than baselines (0.8 s). Crashes (2.6 s) had a significantly longer mean length of longest glance away from forward roadway than near-crashes (1.3 s; $t_{(21913)} = 5.36$, $p < 0.0001$), crash-relevant conflicts (1.0 s; $t_{(21913)} = 3.43$, $p = 0.0006$), and unintentional lane deviations (1.5 s; $t_{(21913)} = 4.49$, $p < 0.0001$).

5.5.4.2 All Tertiary Tasks

Figure 43 shows the mean length of longest glance away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any tertiary task (i.e., any safety-critical event or baseline epoch with a complex, moderate, or simple tertiary task). A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "All" events ($F_{(4, 8722)} = 232.83$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.6 s) was significantly longer than crashes (0.9 s; $t_{(8722)} = 3.20$, $p = 0.012$), near-crashes (1.1 s; $t_{(8722)} = 4.03$, $p = 0.001$), crash-relevant conflicts (1.2 s; $t_{(8722)} = 11.75$, $p < 0.0001$), and baselines (0.8 s; $t_{(8722)} = 27.64$, $p < 0.0001$). Both near-crashes (1.2 s; $t_{(8722)} = 2.93$, $p = 0.028$) and crash-relevant conflicts (1.2 s; $t_{(8722)} = 15.35$, $p < 0.0001$) had a significantly longer mean length of longest glance away from forward roadway than baselines (0.8 s).

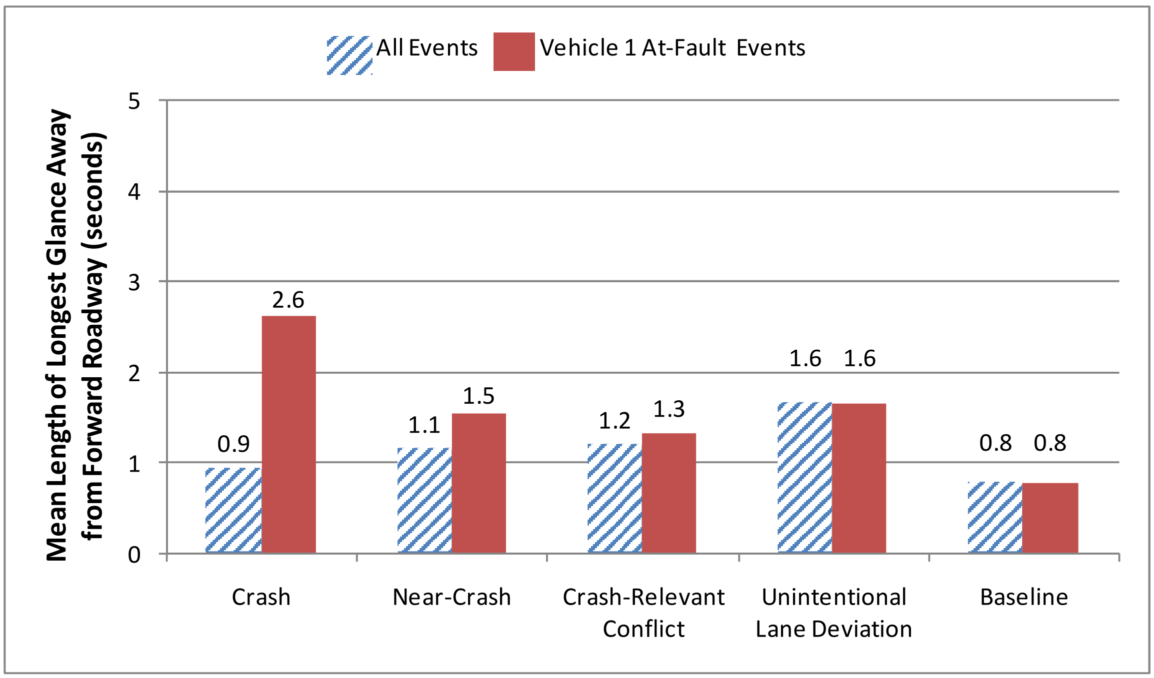


Figure 43. Graph. Mean Length of Longest Glance Away from Forward Roadway by Event Type for All Tertiary Tasks

Figure 43 also shows the mean length of longest glance away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 8098)} = 264.63$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.6 s) was significantly longer than crash-relevant conflicts (1.3 s; $t_{(8098)} = 8.19$, $p < 0.0001$), and baselines (0.8 s; $t_{(8098)} = 27.76$, $p < 0.0001$). Crashes (2.6 s; $t_{(8098)} = 3.50$, $p = 0.004$), near-crashes (1.5 s; $t_{(8098)} = 4.87$, $p = < 0.0001$) and crash-relevant conflicts (1.3

s; $t_{(8098)} = 18.48$, $p < 0.0001$) had a significantly longer mean length of longest glance away from forward roadway than baselines (0.8 s).

5.5.4.3 *Complex Tertiary Tasks*

Figure 44 shows the mean length of longest glance away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any complex tertiary task (i.e., any safety-critical event or baseline epoch with only a complex tertiary task). A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the four event types across "All" events ($F_{(3, 492)} = 8.40$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (2.2 s; $t_{(492)} = 4.57$, $p < 0.0001$) and crash-relevant conflicts (2.1 s; $t_{(492)} = 3.16$, $p = 0.009$) was significantly longer than baselines (1.8 s).

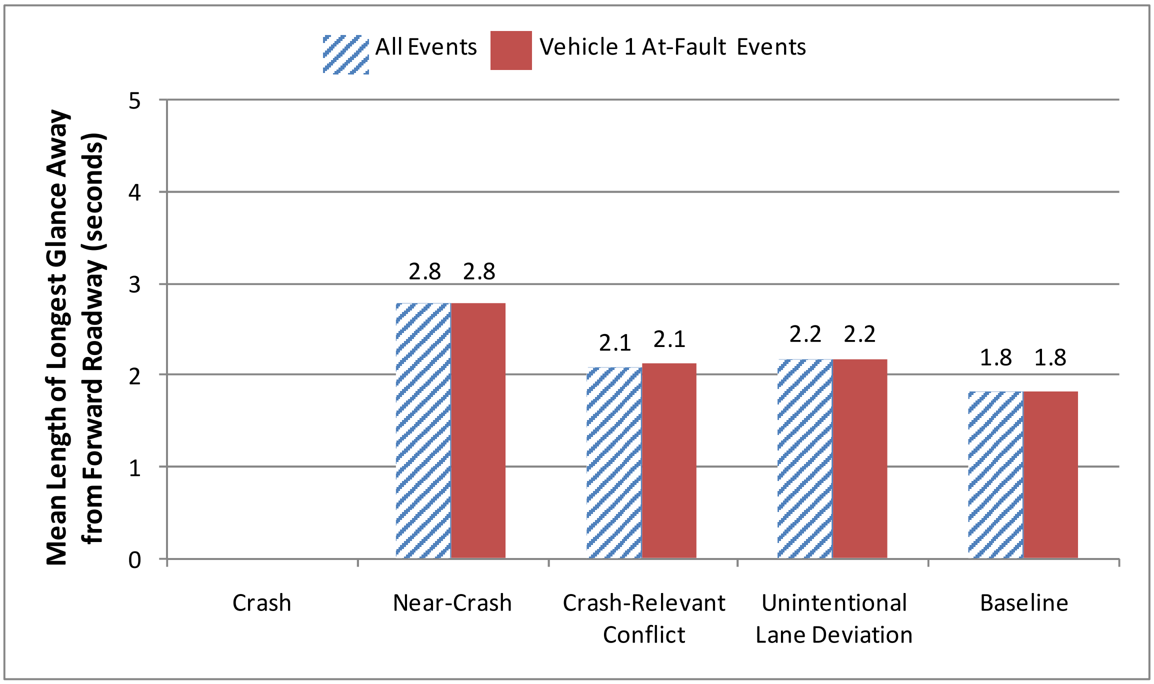


Figure 44. Graph. Mean Length of Longest Glance Away from Forward Roadway by Event Type for Complex Tertiary Tasks

Figure 44 also shows the mean length of longest glance away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the four event types across "Vehicle 1 At-Fault" events ($F_{(3, 487)} = 8.95$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (2.2 s; $t_{(487)} = 4.59$, $p < 0.0001$) and crash-relevant conflicts (2.1 s; $t_{(487)} = 3.60$, $p = 0.002$) was significantly longer than baselines (1.8 s).

5.5.4.4 *Moderate Tertiary Tasks*

Figure 45 shows the mean length of longest glance away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any moderate tertiary task (i.e., any safety-critical event or baseline epoch with only a moderate tertiary task). A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "All" events ($F_{(4, 4218)} = 55.58$, $p < 0.0001$). Tukey t tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.5 s) was significantly longer than near-crashes (1.0 s; $t_{(4218)} = 2.75$, $p = 0.048$), crash-relevant conflicts (1.1 s; $t_{(4218)} = 5.88$, $p < 0.0001$), and baselines (0.8 s; $t_{(4218)} = 12.83$, $p < 0.0001$). Crash-relevant conflicts (1.1 s) had a significantly longer mean length of longest glance away from forward roadway than baselines (0.8 s; $t_{(4218)} = 8.24$, $p < 0.0001$).

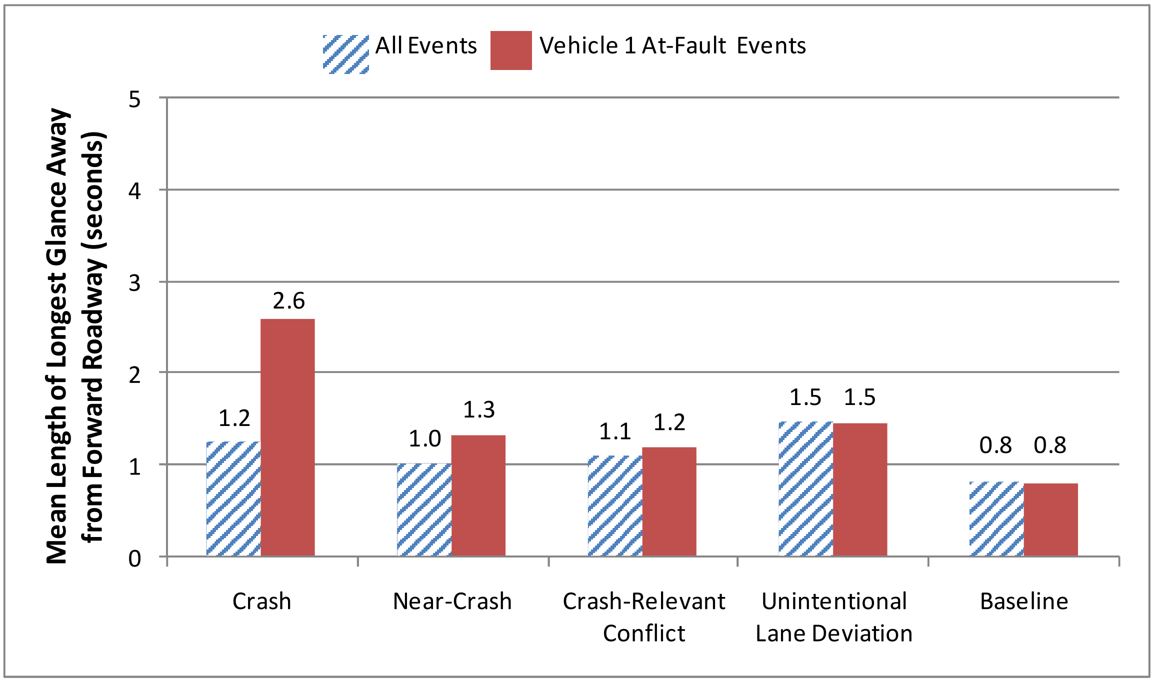


Figure 45. Graph. Mean Length of Longest Glance Away from Forward Roadway by Event Type for Moderate Tertiary Tasks

Figure 45 also shows the mean length of longest glance away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(3, 4123)} = 66.87$, $p < 0.0001$). Tukey t tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.5 s) was significantly longer than crash-relevant conflicts (1.2 s; $t_{(4}183_{)} = 4.07$, $p = 0.001$) and baselines (0.8 s; $t_{(4123)} = 12.86$, $p < 0.0001$). Crashes (2.6 s) were significantly long than crash-relevant conflicts (1.2 s; $t_{(4123)} = 2.86$, $p = 0.035$) and baselines (0.8 s; $t_{(4123)} = 3.78$, $p = 0.002$). Near-crashes (1.3 s; $t_{(4123)} = 2.77$, $p = 0.044$) and crash-relevant conflicts (1.2 s; $t_{(4123)} = 9.92$, $p < 0.0001$) had a significantly longer mean length of longest glance away from forward roadway than baselines (0.8 s).

5.5.4.5 Simple Tertiary Tasks

Figure 46 shows the mean length of longest glance away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any simple tertiary task (i.e., any safety-critical event or baseline epoch with only a simple tertiary task). A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "All" events ($F_{(4, 2063)} = 48.84$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.3 s) was significantly longer than crashes (0.1 s; $t_{(2063)} = 3.29$, $p = 0.009$), crash-relevant conflicts (0.7 s; $t_{(2063)} = 7.64$, $p < 0.0001$) and baselines (0.5 s; $t_{(2063)} = 14.35$, $p <$ 0.0001). Crash-relevant conflicts (0.7 s) were significantly longer than baselines (0.5 s; $t_{(2063)} =$ 6.79, $p < 0.0001$).

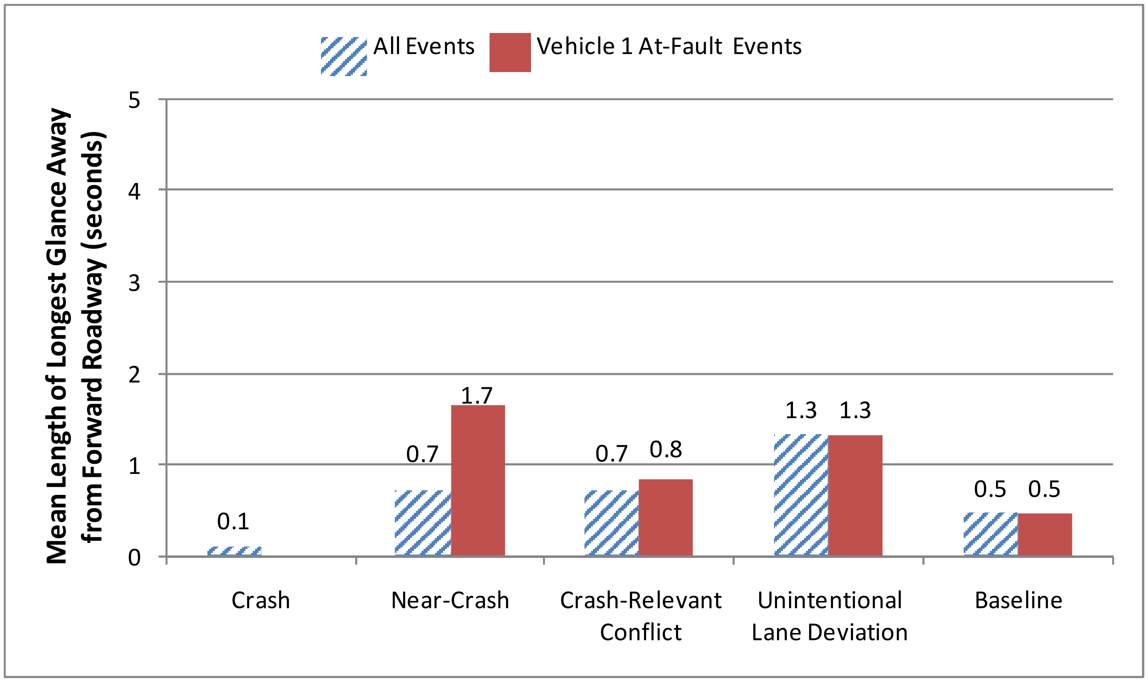


Figure 46. Graph. Mean Length of Longest Glance Away from Forward Roadway by Event Type for Simple Tertiary Tasks

Figure 46 also shows the mean length of longest glance away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(3, 2009)} = 72.62$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.3 s) was significantly longer than crash-relevant conflicts (0.8 s; $t_{(2174)} = 5.86$, $p < 0.0001$) and baselines (0.5 s; $t_{(2174)} = 13.29$, $p < 0.0001$). Near-crashes (1.7 s; $t_{(2174)} = 2.59$, $p = 0.048$) and crash-relevant conflicts (0.8 s; $t_{(2174)} = 6.83$, $p < 0.0001$) had a significantly longer mean length of longest glance away from forward roadway than baselines (0.5).

5.5.4.6 Secondary Tasks

Figure 47 shows the mean length of longest glance away from forward roadway for each event type across "All" and "Vehicle 1 At-Fault" events for any secondary task (i.e., any safety-critical event or baseline epochs with only a driving-related inattention task). A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "All" events ($F_{(4, 4704)} = 46.15$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.5 s) was significantly longer than crash-relevant conflicts (1.1 s; $t_{(4704)} = 5.98$, $p < 0.0001$) and baselines (1.0 s; $t_{(4704)} = 9.64$, $p < 0.0001$). Crashes (2.8 s) had a significantly longer mean length of longest glance away from forward roadway than near-crashes (1.5 s; $t_{(4704)} = 5.17$, $p < 0.0001$), crash-relevant conflicts (1.1 s; $t_{(4,}704_{)} = 6.94$, $p < 0.0001$), unintentional lane deviations (1.5 s; $t_{(4704)} = 5.27$, $p < 0.0001$), and baselines (1.0 s; $t_{(4704)} = 7.52$, $p < 0.0001$). Near-crashes (1.5 s) were significantly longer than crash-relevant conflicts (1.1 s; $t_{(4704)} = 4.34$, $p = 0.0001$) and baselines (1.0 s; $t_{(4704)} = 6.12$, $p < 0.0001$). Crash-relevant conflicts (1.1 s) were significantly longer than baselines (1.0 s; $t_{(4704)} = 5.24$, $p < 0.0001$).

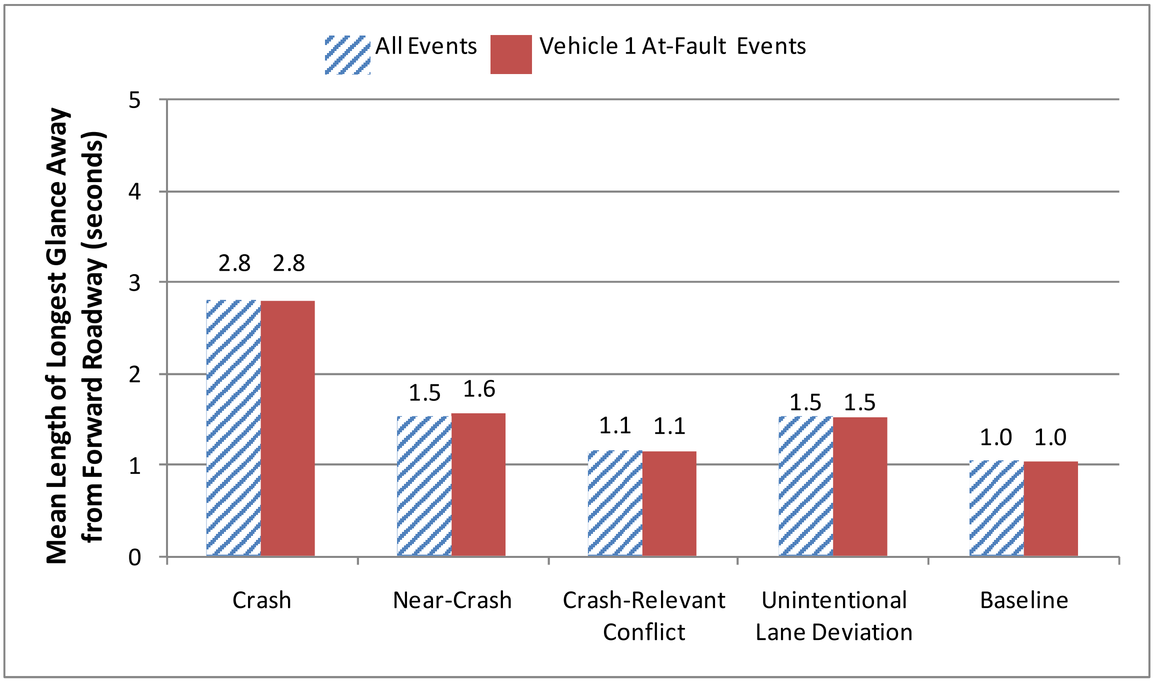


Figure 47. Graph. Mean Length of Longest Glance Away from Forward Roadway by Event Type for Secondary Tasks

Figure 47 also shows the mean length of longest glance away from forward roadway for each event type across "Vehicle 1 At-Fault" events. A one-way ANOVA found a significant difference in the mean length of longest glance away from forward roadway between the five event types across "Vehicle 1 At-Fault" events ($F_{(4, 4495)} = 46.80$, $p < 0.0001$). Tukey *t* tests indicated that the mean length of longest glance away from forward roadway during unintentional lane deviations (1.0 s) was significantly longer than near-crashes (1.3 s; $t_{(3742)} = 2.79$, $p < 0.043$) crash-relevant conflicts (1.1 s; $t_{(3742)} = 8.48$, $p < 0.0001$) and baseline epochs (1.0 s; $t_{(3742)} = 9.85$, $p < 0.0001$). Crashes (1.8 s) had a significantly longer mean length of longest glance away from forward roadway than crash-relevant conflicts (1.1 s; $t_{(3742)} = 2.79$, $p = 0.043$) and baseline epochs (1.0 s; $t_{(3742)} = 2.98$, $p = 0.024$).

5.5.5 Summary

There were several interesting results from the eye glance analysis; however, the primary finding was being involved in a safety-critical event was associated with longer and more frequent glances away from the forward roadway. For example, crashes had a mean duration of eyes off forward roadway of 2.1 s and 3.5 s for "All" and "Vehicle 1 At-Fault" events, respectively, compared to a mean duration of eyes off forward roadway of 1.2 s for baseline (normal) driving. This finding clearly shows the importance of drivers maintaining their eyes on the forward roadway. However, the results also indicated that drivers with a short mean duration of eyes off forward roadway (less than or equal to 0.5 s over a 6-s interval) may not be sufficiently scanning the environment. Thus, fixating on the forward roadway increased the risk of being involved in a safety-critical event; however, not looking at the forward roadway for longer periods of time (i.e., over 1.5 s) was also risky (with very long glances away from the forward roadway, over 2.0 s, being the most dangerous). One conclusion from this set of findings was that CMV driver tasks must not draw the driver's eyes away from the forward roadway and/or impede the driver's environmental scanning patterns (or situational awareness).

Several specific tasks stand out as being particularly dangerous. Texting while driving was the riskiest task that drivers engaged in during the study. The eye glance results indicate that drivers spent 77 percent of their eye glance time looking away from the forward roadway while engaged in texting during safety-critical events. More specifically, drivers spent 4.6 s (out of a 6-s interval) not looking at the forward roadway when texting while driving during a safety-critical event. Drivers spent almost 4 times longer not looking at the forward roadway while texting during a safety-critical event, compared to baseline epochs when not texting. This presents a significant risk and is an activity that drivers should avoid while driving. To highlight just how risky this is, consider that if the truck is traveling at 55 mi/h, and the driver is not looking at the forward roadway for 4.6 s (out of the 6-s interval), the truck would travel approximately 370 ft. This is equivalent to the truck traveling, essentially "blind," the length of a football field. It is the view of the authors that this activity, in no uncertain terms, should be prevented.

Texting while driving is not an essential task for CMV drivers and was not prevalent when the data was collected. However, manually interacting with a dispatching device is a common task CVM drivers engaged in while driving. Study findings suggest this task resulted in eye glance results that were particularly dangerous. The analyses for dispatching devices indicated that safety-critical events when drivers were manually interacting with dispatching devices significantly drew the drivers' eyes away from the forward roadway. More specifically, drivers spent an average of 4.1 s and 4.2 s not looking forward when interacting with a dispatching device during "All" and "Vehicle 1 At-Fault" events, respectively. Even during baseline epochs, while the driver was interacting with a dispatching device, the mean duration of eyes off forward roadway was 3.7 s. While texting may be a relatively novel behavior that is not performed by the greater population of CMV drivers, interacting with dispatching devices is a common CMV driver activity.

Other complex tertiary tasks had a dangerously high mean duration of eyes off forward roadway, including writing on a notepad, using a calculator, reading a book or newspaper, and looking at a map. These complex tertiary tasks had a mean duration of eyes off forward roadway of approximately 4 s or more (in a 6-s interval). Dialing a cell phone also resulted in a dangerously high mean duration of eyes off forward roadway. More specifically, drivers' mean duration of eyes off forward roadway was 3.8 s while dialing a cell phone compared to 1.2 s for baseline driving while not dialing a cell phone. The authors recommend that drivers avoid these tasks while driving.

The analyses from several of the moderate tertiary tasks also resulted in dangerously high mean durations of eyes off forward roadway, including personal grooming (3.7 s), reaching for an object (2.9 s), and looking back in the sleeper berth (3.4 s). When compared to the mean duration of eyes off forward roadway for baseline driving (1 s), each of these tasks or activities involved looking away from the forward roadway approximately 3–4 times longer. Another particularly interesting finding was the eye glance analysis for CB radio use. CB radio use during baseline driving resulted in a mean duration of eyes off forward roadway of 0.9 s, compared to the mean duration of eyes off forward roadway during baseline driving without CB radio use of 1.2 s. The mean duration of eyes off forward roadway during safety-critical events with CB radio use (1.3 s) did not significantly differ from baseline epochs where the driver was not using a CB radio (1.2 s). Therefore, these results suggest that CB radio use does not significantly draw the driver's eyes away from the primary driving task.

Eye glance analysis with the simple tertiary tasks indicated that seemingly routine activities, such as putting on sunglasses or adjusting the instrument panel, can significantly draw the drivers' eyes away from the forward roadway. It is important to stress to drivers how that activity can be risky. However, instrument panel interaction, which was shown to be risky, may be addressed through human factors design. Events when the driver was interacting with the instrument panel resulted in the driver's eyes off the forward roadway for 2.6 s and 2.8 s for "All" and "Vehicle 1 At-Fault" events, respectively, compared to eyes off the forward roadway of 1.1 s for baseline driving when the driver was not adjusting the instrument panel. Drivers' eyes were not looking at the forward roadway for 2.0 s during baseline epochs while adjusting the instrument panel. As such, it seems that drivers, for whatever reason, were spending too much time adjusting the instrument panel during safety-critical events (approximately 0.7 s longer). Perhaps with an improved instrument panel design drivers could more quickly make necessary adjustments without additional, or substantial, eye draw away from the forward roadway.

The secondary tasks analysis did not show as many significant results as did the tertiary tasks. One reason for this was that there were many more tertiary tasks than secondary tasks. A second reason for this was that through video review, it was difficult to distinguish between drivers checking mirrors or looking out the side window at a passing object. While data analysts were trained to assess if the driver's behavior was driving-related (e.g., checking the side mirror before a lane change) or not driving-related (e.g., observing oncoming traffic across the median), in some cases it was difficult to tell exactly where the driver was looking because of the camera placement in the truck. This is a limitation with the naturalistic method used to generate the data used in this study.

Analyses focusing on mean number of glances away from the forward roadway and mean length of glances away from the forward roadway were consistent with the previous results. Safety-critical events, when compared to baseline driving, tended to have more glances away from forward and these glances were generally longer glances away from forward. As shown in Figure 36, there was a decreasing trend in the mean number of glances away from the forward roadway as event severity decreases. Similarly, there was a decreasing trend in the mean length of longest glance away from forward roadway as events severity decreased (see Figure 42). Intuitively, this makes sense as near-crashes and crash-relevant conflicts may have required an evasive maneuver, while there was no evasive maneuver (or at least an ineffective evasive maneuver) during a crash. Therefore, the driver was more likely to have been looking forward in near-crashes and crash-relevant conflicts compared to crashes.

6. SUMMARY AND CONCLUSIONS

Research is clear that "driver error" is the predominant contributing factor in crashes. This is true for both light vehicles and CMVs. Estimates as to the prominence of driver error in crashes find human factors to be noted in as many as 93 percent of light-vehicle crashes (Treat et al., 1977). Driver distraction is one type of driver error that is known to be an important contributing factor in crashes. Though estimates vary widely depending on the research cited, perhaps the most reliable source comes from a naturalistic driving study with light-vehicle drivers that found "driver distraction" to be involved in 78 percent of light-vehicle crashes (Klauer et al., 2006). The scientific community now has a solid understanding of the negative consequences of distraction through a plethora of research directed at driver distraction, so much so that specific distracters, such as cell phone dialing, are now illegal in many states. However, despite the knowledge base that has grown with regard to light-vehicle driver distraction, relatively few research studies have been directed at assessing driver distraction in CMVs. Filling this knowledge gap was the primary goal of the current study.

As "driver distraction" was the focus of the current study, three research questions were raised and addressed. Briefly, these questions asked:

- What types of distraction tasks (or behaviors) do CMV drivers engage in? And, are these tasks risky leading to involvement of safety-critical events?
- Do environmental driving conditions impact the engagement of tasks?
- What is the impact of distraction tasks on drawing the driver's eyes away from the forward roadway?

Previous sections of this report detailed the data preparation and analyses that were conducted to answer these questions and summaries were presented at the end of each research question to highlight key findings. The remainder of this chapter will provide a summary and conclusions from this study and offer recommendations for moving forward.

6.1 RISK ASSOCIATED WITH DISTRACTING TASKS

Odds ratios were calculated to identify tasks that were high risk; that is, tasks that were associated with increased likelihood of being involved in a safety-critical event compared to baseline or uneventful driving. Odds of occurrence were defined as the probability of event occurrence (safety-critical event) divided by the probability of non-occurrence (baseline epoch). These probability estimates were conditioned on the presence/absence of the behavior of interest and then compared via ratios. For a given task, an odds ratio of 1.0 indicated the outcome was equally likely to occur given the condition (i.e., equally likely to occur in the safety-critical event data as in the baseline, uneventful driving data). An odds ratio greater than 1.0 indicated the outcome was more likely to occur given the condition, and odds ratios of less than 1.0 indicated the outcome was less likely to occur (Pedhazur, 1997). When considering odds ratios, it was also important to look at calculated CLs. Along with an odds ratio statistic, LCLs and UCLs were calculated. To interpret the odds ratio, the range of the LCL and UCL must be considered and ranges that did not include 1.0 were considered statistically significant (a 95 percent confidence interval was used in the current study).

Table 77 shows the results from the analyses that included “All” events. As detailed in the body of the report, tasks were analyzed individually, but grouped based on level of complexity (Klauer et al., 2006). Odds ratios, along with LCLs and UCLs, are shown in Table 77. Odds ratios greater than 1.0 that have an LCL and UCL range that does not include 1.0 indicate the task is risky (compared to baseline epochs). As shown in Table 77, the most risky behavior identified was “text message on cell phone,” with a significant odds ratio of 23.2 (as the LCL and UCL range does not include 1.0). This means that drivers who text message while driving were 23.2 times more likely to be involved in a safety-critical event, compared to a baseline epoch, than if they were not text messaging while driving.

Table 77. Odds Ratios and 95% Confidence Intervals to Assess Likelihood of a Safety-Critical Event While Engaging In Tasks for "All" Events

Task	Odds Ratio	LCL	UCL
Complex Tertiary Task			
Text message on cell phone	**23.24***	9.69	55.73
Other—Complex (e.g., cleaning side mirror, rummaging through a grocery bag)	**10.07***	3.10	32.71
Interact with/look at dispatching device	**9.93***	7.49	13.16
Write on pad, notebook, etc.	**8.98***	4.73	17.08
Use calculator	**8.21***	3.03	22.21
Look at map	**7.02***	4.62	10.69
Dial cell phone	**5.93***	4.57	7.69
Read book, newspaper, paperwork, etc.	**3.97***	3.02	5.22
Moderate Tertiary Task			
Use/reach for other electronic device	**6.72***	2.74	16.44
Other—Moderate (e.g., opening a pill bottle to take medicine, exercising in the cab)	**5.86***	2.84	12.07
Personal grooming	**4.48***	2.01	9.97
Reach for object in vehicle	**3.09***	2.75	3.48
Look back in sleeper berth	**2.30***	1.30	4.07
Talk or listen to hand-held phone	1.04	0.89	1.22
Eating	1.01	0.83	1.21
Smoking-related behavior—reaching, lighting, extinguishing	**0.60***	0.40	0.89
Talk or listen to CB radio	**0.55***	0.41	0.75
Look at outside vehicle, animal, person, object, or undetermined	**0.54***	0.50	0.60
Talk or listen to hands-free phone	**0.44***	0.35	0.55
Simple Tertiary Task			
Put on/remove/adjust sunglasses or reading glasses	**3.63***	2.37	5.58
Adjust instrument panel	**1.25***	1.06	1.47
Remove/adjust jewelry	1.68	0.44	6.32
Other—Simple (e.g., opening and closing driver's door)	2.23	0.41	12.20
Put on/remove/adjust hat	1.31	0.69	2.49
Use chewing tobacco	1.02	0.51	2.02
Put on/remove/adjust seat belt	1.26	0.60	2.64
Talk/sing/dance with no indication of passenger	1.05	0.90	1.22
Smoking-related behavior—cigarette in hand or mouth	0.97	0.82	1.14
Drink from a container	0.97	0.72	1.30
Other personal hygiene	**0.67***	0.59	0.75
Bite nails/cuticles	**0.45***	0.28	0.73
Interact with or look at other occupant(s)	**0.35***	0.22	0.55
Secondary Task			
Look at left-side mirror/out left window	**1.09***	1.01	1.17
Look at right-side mirror/out right window	0.95	0.86	1.05
Check speedometer	**0.32***	0.28	0.38

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

Along with texting, several other tasks had significantly high odds ratios. Interacting with a dispatching device (OR = 9.9) and dialing a cell phone (OR = 5.9) were two noteworthy complex tasks associated with substantially elevated risk in being involved in a safety-critical event. Reaching for objects—both electronic devices such as video cameras (OR = 6.72) or other objects (OR = 3.1)—was also noteworthy because of their common occurrence as found in the PAR analysis.

One noteworthy finding from the analyses was the result for cell phone use. As indicated above, reaching for or dialing a cell phone were associated as high-risk tasks. However, talking or listening on a hand-held phone was found to have an odds ratio that was not significantly different than 1.0 (thus, it did not elevate the likelihood of being involved in a safety-critical event); this finding was consistent with Klauer et al. (2006). Furthermore, talking or listening on a hands-free phone provided a significant protective effect (OR = 0.4). A similar significant protective effect was found for using a CB radio (OR = 0.6). One hypothesis for these results is that reaching for a phone and dialing a phone, like texting, requires manual manipulation (i.e., hand off wheel) and substantial visual attention to complete the task. This visual attention is directed away from the forward roadway (as found in eye glance analysis above) such that the driver is not effectively, or safely, operating the CMV. Listening and talking, on the other hand, allows drivers to maintain their eyes on the road; however this hypothesis does not consider "gaze concentration" (Reagan et al., 2009) and "cognitive distraction" which, as noted previously, has been associated with driving performance decrement (Redelmeier & Tibshirani, 1997; Goodman et al., 1999; Strayer & Johnston, 2001; Harbluk et al., 2002; Strayer et al., 2003; Patten et al., 2004); though it is important to note that these were not naturalistic studies. In addition, it could be that other performance decrements not assessed in this study (e.g., speed variability) may be affected by talking, though results from a recent naturalistic study with light-vehicle drivers suggests that such performance decrements would not be found (Sayer et al., 2007). The bottom line is that for safety-critical events, as defined and recorded in the current study, talking on devices (including cell phones, both hand-held and hands-free, and CB radios) did not increase the risk of being involved in a safety-critical event.

6.2 POPULATION RISK FOR DISTRACTING TASKS

Odds ratios and CLs only inform part of the story; that is, which tasks are shown to increase the likelihood of involvement in a safety-critical event. The other part of the story considers the frequency of occurrence of each task (i.e., which task, if removed, would provide the largest reduction in safety-critical events). For example, tasks that are rare occurrences, even though they might be risky, may not have a significant impact on the population.

Table 78 shows the results from the PAR analysis for the tertiary and secondary tasks with an odds ratio greater than 1.0. As shown in Table 78, tasks are ordered from largest PAR percentage to smallest PAR percentage. Specific tasks with the largest PAR percentage included: reaching for an object (PAR = 7.6), interacting with a dispatching device (PAR = 3.1), and dialing a cell phone (PAR = 2.5). Why were the PAR percentages for these tasks greater than the other tasks? The reason was that they were commonly performed tasks. Text messaging, on the other hand, though it had a very high odds ratio, was a task performed infrequently by drivers in the current study, thus it does not have a high PAR percentage. However, this does not mean that it should be ignored. On the contrary, it suggests that as more drivers text message while driving, the frequency of safety-critical events is likely to increase.

Table 78. Population Attributable Risk and 95% Confidence Intervals for Driver Tasks Across All Events

TASK	PAR Percentage	LCL	UCL
Complex Tertiary Task	**27.46**	**27.24**	**27.67**
Interact with/look at dispatching device	3.13	2.84	3.42
Dial cell phone	2.46	2.02	2.91
Read book, newspaper, paperwork, etc.	1.65	0.96	2.34
Look at map	1.08	0.48	1.68
Text message on cell phone	0.67	0.29	1.04
Write on pad, notebook, etc.	0.56	-0.16	1.28
Use calculator	0.22	-1.00	1.43
Other—Complex (e.g., cleaning side mirror, rummaging through a grocery bag)	0.18	-0.99	1.35
Moderate Tertiary Task	**11.77**	**11.32**	**12.23**
Reach for object in vehicle	7.64	7.27	8.02
Other—Moderate (e.g., opening a pill bottle to take medicine, exercising in the cab)	0.32	-0.92	1.55
Use/reach for other electronic device	0.23	-1.10	1.56
Personal grooming	0.21	-1.58	2.00
Look back in sleeper berth	0.23	-2.24	2.70
Talk or listen to hand-held phone	0.18	-1.29	1.64
Eating	0.02	-1.80	1.83
Simple Tertiary Task	**5.96**	**5.20**	**6.73**
Adjust instrument panel	0.82	-0.47	2.11
Put on/remove/adjust sunglasses or reading glasses	0.62	-0.56	1.80
Talk/sing/dance with no indication of passenger	0.23	-1.12	1.59
Put on/remove/adjust hat	0.06	-4.85	4.98
Use chewing tobacco	0.00	-6.75	6.76
Put on/remove/adjust seat belt	0.04	-5.84	5.92
Remove/adjust jewelry	0.03	-7.89	7.95
Other—Simple (e.g., opening and closing driver's door)	0.02	-7.57	7.62
Secondary Task	**11.71**	**11.29**	**12.13**
Look at left-side mirror/out left window	2.25	1.77	2.75

A driver interacting with a dispatching device was a commonly performed task in the current study. However, as indicated in the high odds ratio (OR = 9.9) and PAR percentage (PAR = 3.1), this is an issue that the authors recommend be addressed. The authors recommend that drivers not use these dispatching devices while driving, fleet safety managers stress to drivers the dangers of using this device while driving, and designers consider redesigning these devices for ease of use. An in-vehicle inventory (Llaneras & Singer, 2002) found that most technologies did not offer a "lockout" feature to prevent the driver from using the device while the vehicle was in motion. Instead, they found that limiting the number of available menu options and the use of auditory output may help to prevent the driver from taking his/her eyes off the forward roadway as frequently.

Reaching for an object was another task with a high odds ratio (OR = 3.1) and PAR percentage (PAR = 7.6). Again, the authors recommend fleet managers inform drivers that this common task should be avoided. Dialing a cell phone also had a high odds ratio (OR = 5.9) and PAR percentage (PAR = 2.5).

6.3 VISUAL DEMAND FOR DISTRACTING TASKS

The eye glance analyses that were conducted on the various tasks provided the "why" for the findings in the odds ratio analysis. Repeatedly, the eye glance analyses indicated that tasks that draw the driver's eyes away from the forward roadway were those with highest odds ratios for risk. For example, texting while driving, which had the highest odds ratio of 23.2, also had the longest duration of eyes off road (4.6 s over a 6-s interval). As noted above, this equates to a driver traveling the length of an entire football field, at 55 mi/h, without looking at the roadway during the 6-s interval. Other high visual attention tasks that reduced attention to the forward roadway included those tasks that involved the driver interacting with some type of technological device, such as: dispatching device (4.1 s), cell phone dialing (3.8 s), and calculator (4.4 s).

Technology-related tasks were not the only tasks with high visual demands away from the forward roadway. Non-technology, commonly performed daily activities with high visual demands included: writing (4.2 s), reading a book/newspaper/other (4.3 s), looking at a map (3.9 s), and reaching for an object (2.9 s). The authors recommend that fleet safety managers be aware of these tasks and educate drivers on their associated risks.

6.4 LENGTH OF GLANCES

CMV drivers' total eyes off forward roadway time was 2.1 s prior to the onset of a crash, 1.7 s prior to the onset of a near-crash, 1.6 s prior to the onset of a crash-relevant conflict, 1.2 s during the baseline epoch. In comparison, Klauer et al. (2006) reported that light-vehicle drivers' total mean eyes off forward roadway time was 1.8 s prior to the onset of a crash, 1.3 s prior to the onset of a near-crash, 1.1 s prior to the onset of a crash-relevant conflict, 0.9 s during the baseline epoch.

One of the analyses calculated the odds ratios of the total eyes off forward roadway time for five different time durations. Table 79 illustrates the odds ratios across "All" events in each of the five different time durations: the total eyes off forward roadway time was measured over a 6-s interval for events and epochs. Not surprising, longer glances over 1.5 s were associated with high risk (OR = 1.3) and very long glances over 2 s had the highest risk (OR = 2.9). These findings (i.e., that long eye glance durations away from the forward roadway increase risk) were consistent with previous light-vehicle results. For example, Klauer et al. (2006) reported that light-vehicle drivers were 2.2 times more likely to be involved in a crash/near-crash (compared to a baseline epoch) when total time eyes off forward roadway was greater than 2 s.

Table 79. Odds Ratios and 95% Confidence Intervals for All Events to Assess Likelihood of a Safety-Critical Event While Eyes Off Forward Roadway

Total Eyes Off Forward Roadway	Odds Ratio	LCL	UCL	Frequency of Safety-Critical Events	Frequency of Baseline Epochs
Less than or equal to 0.5 s	**1.36***	1.16	1.58	268	1,537
Greater than 0.5s but less than or equal to 1.0 s	0.91	0.80	1.03	434	3,712
Greater than 1.0s but less than or equal to 1.5 s	1.07	0.94	1.23	343	2,483
Greater than 1.5s but less than or equal to 2.0 s	**1.29***	1.12	1.49	317	1,903
Greater than 2.0 s	**2.93***	2.65	3.23	1,504	3,989

* Asterisk indicates a significant odds ratio. These ratios are also shown in bold.

An additional significant result was found for very short eyes off forward roadway time (less than or equal to 0.5 s). Klauer et al. (2006) found a similar trend with light-vehicle drivers in the 100-Car Study; however, the odds ratio was not significant. As shown in table 79, a significant odds ratio was found when the total eyes off forward roadway time was less than or equal to 0.5 s (OR = 1.4). One possible explanation was that the scanning behavior performed by CMV drivers was likely to be different than the scanning behavior of light-vehicle drivers. More specifically, CMV drivers are taught to monitor their environment continually and regularly scan their mirrors. Moreover, large trucks have many blind spots and it can be difficult for CMV drivers to locate other vehicles in their mirrors. It is possible that these mirror-checking behaviors lasted longer than 0.5 s in the current study and more complex tasks required many short duration glances. There is some support for this contention in the eye glance analyses results as the mean length of longest glance for secondary tasks (e.g., checking mirrors) was greater than 0.5s: 2.8 s for crashes, 1.5 s for near-crashes, 1.1 s for crash-relevant conflicts and 1.5 s for unintentional lane deviations (see Figure 47). Also, the mean number of glances away from the forward roadway was 2.7 for near-crashes, 3.1 for crash-relevant conflicts, and 3.2 for unintentional lane deviations when complex tertiary tasks were considered compared to 1.3 for crashes, 1.6 for near-crashes, 1.7 for crash-relevant conflicts and 2.3 for unintentional lane deviations when moderate tertiary tasks were considered (see Figure 38 and Figure 39). It is also possible that the significant finding for glances under 0.5 s was because drivers may have been in high-load situations, such as following closely behind a lead vehicle, which would require longer and more frequent glances to monitor the forward roadway. This situation would likely result in more safety-critical events and may help explain the significant odds ratio. Further analysis would be required to test these hypotheses by conducting a more detailed eye glance analysis with drivers who rarely scanned the driving environment and/or mirrors (i.e., primarily focused on the forward roadway). Such an analysis could investigate the risk implications of not regularly scanning the driving environment. At this point, it is an interesting finding that invites further exploration.

6.5 FINAL CONSIDERATIONS

One of the objectives of this study was to compare results between this CMV study and the Klauer et al. (2006) light-vehicle study. Though a few result comparisons have been described, perhaps the most important finding, common across both studies, is that driver distraction is prevalent in both light vehicles and CMV operations. It is difficult to make clear comparisons across studies because of the caveats noted previously, including:

- Mirror check as a distraction type and the expected mirror use differences between light-vehicle and CMV drivers.
- Different data collection time frames.
- Different distraction types.
- Small number of crashes in the CMV study.

Nonetheless, a key take-away when a side-by-side study comparison is made is that driver distraction is an important contributing factor in safety-critical events for both light-vehicle drivers and CMV drivers.

The current study resulted in a number of important findings related to driver distraction and CMV driver safety. Because this is one of the first studies to focus on CMV driver distraction, it will be important to conduct follow-on research to assess the robustness of these findings. As outlined, many of the results were consistent with previous distraction studies with light-vehicle drivers. However, some results (e.g., the high risk associated with short glances) may be novel to CMV operations.

6.6 STUDY LIMITATIONS AND NEXT STEPS

Before listing recommendations that are based on the results of this study, some study limitations should be discussed. It is important to keep these limitations in mind when considering the results. First, because the data used in this study was collected naturalistically, and not in a controlled environment, the “cognitive distraction” effects of driver behaviors could not be easily determined. Past research has found that cognitive demands impact the driver’s ability to focus on the driving task while talking on a cell phone (Redelmeier & Tibshirani, 1997; Goodman et al., 1999; Strayer & Johnston, 2001; Harbluk et al., 2002; Strayer et al., 2003; Patten et al., 2004), though this has not been shown in naturalistic driving research. In the current study, given the video camera placement, “visual distraction” and whether the driver was looking forward or not during task performance was more readily measurable. It may be possible to investigate cognitive distraction in a follow-up data mining effort with this naturalistic data set by looking at changes in eye scanning behavior as a function of task performance. A reduction in normal scanning patterns may indicate “cognitive distraction.” Also, vehicle speed (e.g., speed variation from the posted speed limit) while performing the task could be evaluated. However, based on research by Sayer et al. (2007), it should not be expected that findings from controlled studies will always be replicated in real-driving environments. For example, unlike the driving simulator studies referenced above, Sayer et al. also found benign cell phone effects in a naturalistic study with light-vehicle drivers.

A second limitation in the current study was the lack of continuous audio data. While the results found that manual dialing was the riskiest part of using a cell phone (talking on a hand-held phone was not significantly risky and talking on a hands-free phone decreased the risk of being involved in a safety-critical event), it was not possible to analyze dialing a hands-free cell phone as audio data was not available to hear the driver use a voice-activated phone feature.

A third limitation of the current study is the small sample size of some of the individual distractions. While approximately 200 drivers participated over 3 million miles of driving, some distraction types did not occur frequently. Due to small sample sizes of some distractions, there were no statistical approaches that could be used to examine interactions (e.g., text messaging and rain). It is believed that as future CMV naturalistic studies are conducted and the naturalistic data set increases, larger samples of distractions may enable the investigation of interaction effects. While the current study resulted in many interesting findings, it is important that the reader keep these study limitations in mind when interpreting the following recommendations.

Based on these study limitations, additional follow-on efforts and analyses could be conducted with these combined naturalistic CMV data sets including, as noted, investigating the effects of cognitive distraction on cell phone conversations and other secondary/tertiary tasks. For example, changes in eye glance scanning and vehicle speed changes (or difference from the posted speed limit) could be evaluated to assess cognitive distraction. Additionally, future research could explore in more detail the impact of texting on the driving risk. For example, measures including task completion time, eyes-off-road time, and hands-off-wheel-time (for the entire task rather than for the 6-s interval used in the current study) could be analyzed to provide a more complete picture of texting while driving. A similar evaluation of dispatching device and other tertiary tasks could also be conducted that focuses on the task itself (e.g., task duration) rather than limiting the evaluation to a window of time preceding a safety-critical event.

Finally, it is important to highlight that some results of the current study and other recent naturalistic driving studies (e.g., Klauer et al., 2006; Sayer et al., 2007) are at odds with results obtained from simulator studies (e.g., Beede & Kass, 2006; Strayer et al., 2003) and future research should be conducted to explore the reasons why such study results often differ from studies conducted in actual driving conditions (i.e., the full context of the driving environment). It may be, as Sayer et al. note; that controlled investigations cannot account for driver choice behavior and risk perception as it actually occurs in real-world driving. If this assessment is accurate, the generalizability of simulator findings, at least in some cases, may be greatly limited outside of the simulated environment.

6.7 SUMMARY FINDINGS AND RECOMMENDATIONS

The following findings and recommendations by the authors to address driver distraction in CMV operations were formulated through a review of this study. These findings and recommendations provide a summarized list of critical issues and are ordered from general recommendations (e.g., maintain eyes on forward roadway) to more specific recommendations (e.g., no texting). These recommendations focus on improving CMV safety by reducing driver distraction and are intended to provide key take-aways for fleet-safety managers on how they might improve safety by applying the findings from the current study. The authors found and recommended that:

- Fleet safety managers engage and educate their drivers, and discuss the importance of being attentive and not engaging in distracting tasks or behaviors. Even routine types of behaviors (e.g., reaching for an object, putting on sunglasses, or adjusting the instrument panel) can distract and may lead to a safety-critical event.
- Fleet safety managers develop policies to minimize or eliminate the use of in-vehicle devices while driving. The authors also urge fleet safety managers to be cognizant of devices that drivers may bring in the truck cab and use while driving. These may seem innocuous (e.g., calculator), but may increase crash risk, if used while driving.
- Drivers not use dispatching devices while driving and that fleet safety managers educate drivers on the danger of interacting with these devices while driving. Similar to manually dialing a cell phone, if drivers must interact with a dispatching device, the authors recommend that drivers do so only when the truck is stopped.
- Drivers not text while driving. This is a relatively new phenomenon, but data from the current study clearly show an increased risk when drivers text while driving.
- Drivers not manually dial cell phones while driving. If a call must be made, the authors suggest that drivers pull off the road to a safe area, and then dial to make the phone call. Another option, requiring further study, is the use of voice-activated, hands-free dialing, which would allow the driver to maintain eyes on the forward roadway. However, this approach may have implications for "cognitive distraction" (though visual distraction would be expected to be reduced).
- Drivers not read, write, or look at maps while driving. What may seem like quick, commonly performed tasks, such as reading, writing, and looking at maps, were found to significantly draw visual attention away from the forward roadway. These activities, which may be integral to the driver's job, are not integral to operating the vehicle and the authors recommend that such tasks never be performed while the vehicle is on and in motion.
- Drivers not be prohibited from talking on a cell phone or CB radio as this was not found to increase risk. Regarding cell phones, the findings from the current study clearly indicated that manual device interaction, and the associated high eyes off forward road time, was the key factor to increased risk. Though "visual distraction" is foremost in manual device interaction, potential "cognitive distraction" of talking/listening was not measured in the current study. However, based on the analysis of safety-critical events from the current study, talking or listening were not risk factors.

- Designers of dispatching devices consider the increased risk associated with using their devices and work to develop more user-friendly interfaces that do not draw the driver's eyes from the forward roadway. Possible solutions include a hands-free interface and/or blocking manual use while the vehicle is in motion.
- Designers of instrument panels consider the increased risk of adjusting panel controls. The authors suggest that designs be intuitive, user-friendly, and not require long glances away from the forward roadway.
- Further research be undertaken into the protective effects of performing certain tasks. Identifying the characteristics of tasks that had protective effects may lead to safety countermeasures.

APPENDIX A. DATA CODING DIRECTORY

EVENT VARIABLES

Event Classification

Note: Categories adapted from Dingus et al. (2006) and Hickman et al. (in press). Crash: Tire Strike category only used in Hickman et al. This variable is extremely subjective and is determined using the best judgment of an analyst.

- **01 = Crash.** Any contact with an object, either moving or fixed, at any speed. Includes other vehicles, roadside barriers, objects on or off of the roadway, pedestrians, cyclists, or animals.
- **02 = Crash:** Tire Strike. Any contact with an object, either moving or fixed, at any speed in which kinetic energy is measurably transferred or dissipated where the contact occurs on the truck's tire only. No damage occurs during these events (e.g., a truck is making a right turn at an intersection and runs over the sidewalk/curb with a tire).
- **03 = Near-Crash**. Any circumstance that requires a rapid, evasive maneuver (e.g., hard braking, steering) by the subject vehicle or any other vehicle, pedestrian, cyclist, or animal, in order to avoid a crash.
- **04 = Crash-Relevant** Conflict. Any circumstance that requires a crash-avoidance response on the part of the subject vehicle, any other vehicle, pedestrian, cyclist, or animal that was less severe than a rapid evasive maneuver (as defined above), but greater in severity than a normal maneuver. A crash-avoidance response can include braking, steering, accelerating, or any combination of control inputs.

Date

Note: Will be automatically obtained through GPS data.

Time

Note: Will be automatically obtained through GPS data.

Day of Week

Note: Using a calendar, please enter the day of week for which the event occurred.

Vehicles/Non-Motorists Involved

Note: For some events (e.g., those involving transient encroachment into an oncoming lane), it will be difficult to decide whether the event should be considered a one or two vehicle event. Consider the event a two-vehicle event if the crash resulting from the incident would likely have involved two vehicles, and/or if either driver's maneuvers were influenced by the presence of the other vehicle (e.g., if DV1 maneuvered to avoid V2). Consider the event a one-vehicle event if the presence of other vehicles presented no immediate threat and had no effect on DV1's maneuvers or behaviors.

- 00 = Not applicable (baseline epoch).
- 01 = 1 vehicle (Subject vehicle only or subject vehicle + object).
- 02 = 2 vehicles.
- 03 = 3 vehicles.
- 04 = 4 or more vehicles.
- 05 = Subject vehicle + pedestrian.
- 06 = Subject vehicle + pedal cyclist.
- 07 = Subject vehicle + animal.
- 08 = Other.

Vehicle/Non-Motorist 2 Type

Note: Highly abridged version of GES V5, Body Type; above codes do not match GES codes. Examples of heavy vehicles are shown in the tables below.

- 00a = Not applicable (baseline epoch).
- 00b = Not applicable (single vehicle event—no object).
- 01 = Automobile.
- 02 = Van (minivan or standard van).
- 03 = Pickup truck.
- 03a = SUV (includes Jeep).
- 04 = Bus (transit or motor coach)
- 05 = School bus.
- 06 = Single-unit straight truck (includes panel truck, U-Haul truck).
- 07 = Tractor-trailer.
- 08 = Motorcycle or moped.
- 09 = Emergency vehicle (police, fire, EMS = in service).
- 10 = Vehicle pulling trailer (other than tractor-trailer).
- 11 = Other vehicle type.
- 12 = Pedestrian.
- 13 = Pedacyclist.
- 14 = Deer.
- 15 = Other animal.
- 16 = Object (single vehicle event with relevant object).
- 99 = Unknown vehicle type.

Relevant Object

Note: Please choose the most relevant object; (i.e., one that was struck in a crash or which constituted a crash threat) for near-crashes and crash-relevant conflicts.

- 00a = Not applicable (baseline epoch).
- 00b = Not applicable (single vehicle event but no relevant object; e.g., shoulder only).
- 00c = Not applicable (two vehicle (or more) event, pedestrian, animal, etc.).
- 01 = Parked motor vehicle.

Fixed objects:

- 02 = Building.
- 03 = Impact attenuator/crash cushion.
- 04 = Bridge structure (e.g., abutment).
- 05 = Guardrail.
- 06 = Concrete traffic barrier or other longitudinal barrier (e.g., “Jersey Barrier”).
- 07 = Post, pole, or support (e.g., sign, light).
- 08 = Culvert or ditch.
- 09 = Curb.
- 10 = Embankment.
- 11 = Fence.
- 12 = Wall.
- 13 = Fire hydrant.
- 14 = Shrubbery or bush.
- 15 = Tree [not overhang—see below].
- 16 = Boulder.
- 17 = Loading dock.
- 18 = Loading equipment (e.g., fork lift, pallets).
- 19 = Cargo.

Overhanging objects (only if struck or potentially struck by top of truck/trailer):

- 20 = Tree branch.
- 21 = Overhanging part of sign or post.
- 22 = Bridge/overpass.
- 23 = Building.
- 24 = Telephone wires.

Non-fixed objects:

- 25 = Vehicle parts, including tire parts.
- 26 = Spilled cargo.
- 27 = Dead animal in roadway.
- 28 = Broken tree limbs or other tree/shrub parts.
- 29 = Trash/debris.
- 30 = Construction barrel.
- 31 = Construction cone.

Other:

- 98 = Other.
- 99 = Unknown object hit.

Note: GES A06, First Harmful Event. Options in italics are not A06 codes.

Vehicle/Non-Motorist 2 Position (in Relation to V1)

Note: The vehicle in Figure 48 represents the subject vehicle (V1, the truck). The relative position of Vehicle 2 (in relation to Vehicle 1) is coded for the time in which the Critical Event occurs (i.e., the event creating the crash risk). Vehicles in adjacent left lane are coded J, I, H, or G depending on position. Vehicles in adjacent right lane are coded B, C, D or E depending on position.

Please also code the position of animals, pedestrians, pedacyclists and objects.

- 00a = Not applicable (baseline epoch)
- 00b = Not applicable (single vehicle event—no object)
- K = Top of vehicle

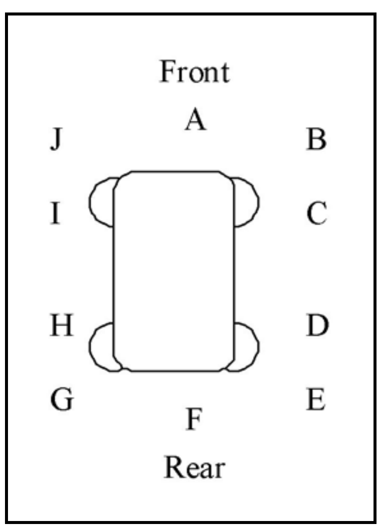


Figure 48. Vehicle/Non-Motorist 2 Position

Vehicle 1 Pre-Event Movement

Note: LTCCS Variable 4 with expanded choices for 8 and 9. The Pre-Event Movement is considered to be outside of the Critical Crash Envelope (Figure 49). For Baseline epochs, the primary movement of the vehicle during the epoch is coded.

- 01 = Going straight (and not known to be engaged in movements listed below).
- 02 = Decelerating in traffic lane.
- 03 = Accelerating in traffic lane.
- 04 = Starting in traffic lane.
- 05 = Stopped in traffic lane.
- 06 = Passing or overtaking another vehicle.
- 07 = Disabled or parked in travel lane.
- 08a = Leaving a parking position, moving forward.
- 08b = Leaving a parking position, backing.
- 09a = Entering a parking position, moving forward.
- 09b = Entering a parking position, backing.
- 10 = Turning right.
- 11 = Turning left.
- 12 = Making a u-turn.
- 13 = Backing up (other than parking).
- 14 = Negotiating a curve.
- 15 = Changing lanes.
- 16 = Merging.
- 17 = Successful avoidance maneuver to a previous critical event.
- 98 = Other.
- 99 = Unknown.

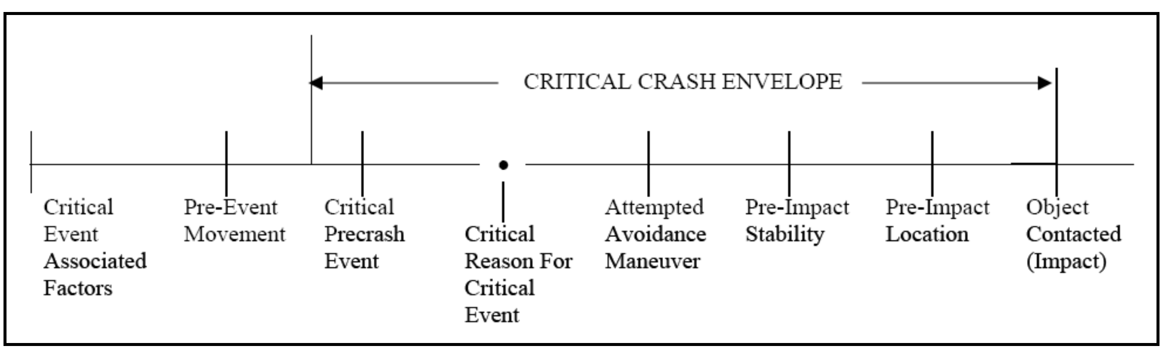


Figure 49. Critical Crash Envelope

Vehicle 2 Pre-Event Movement

Note: LTCCS Variable 4 with expanded choices for 8 and 9. The Pre-Event Movement is considered to be outside of the Critical Crash Envelope (Figure 49).

- 00a = Not applicable (baseline epoch).
- 00b = Not applicable (single vehicle event).
- 01 = Going straight (and not known to be engaged in movements listed below).
- 02 = Decelerating in traffic lane.
- 03 = Accelerating in traffic lane.
- 04 = Starting in traffic lane.
- 05 = Stopped in traffic lane.
- 06 = Passing or overtaking another vehicle.
- 07 = Disabled or parked in travel lane.
- 08a = Leaving a parking position, moving forward.
- 08b = Leaving a parking position, backing.
- 09a = Entering a parking position, moving forward.
- 09b = Entering a parking position, backing.
- 10 = Turning right.
- 11 = Turning left.
- 12 = Making a u-turn.
- 13 = Backing up (other than parking).
- 14 = Negotiating a curve.
- 15 = Changing lanes.
- 16 = Merging.
- 17 = Successful avoidance maneuver to a previous critical event.
- 98 = Other.
- 99 = Unknown.

Vehicle 1 Critical Pre-Crash Event

Note: This variable is coded for both vehicles in a two-vehicle incident. However, the Critical Reason (see above), is coded for only one vehicle. For consistency with the Accident Type variable (20), lane edges between travel lanes and non-travel lanes (e.g., shoulders) are considered road edges. Unlike the Accident Type variable, however, you should code the actual precipitating event and should not project or extrapolate the event. LTCCS Variable 5.

- 00 = Not applicable (baseline epoch).

THIS VEHICLE (V1) LOSS OF CONTROL DUE TO:

- 01 = Blow out or flat tire.
- 02 = Stalled engine.
- 03 = Disabling vehicle failure (e.g., wheel fell off).
- 04 = Non-disabling vehicle problem (e.g., hood flew up).
- 05 = Poor road conditions (wet road, puddle, pot hole, ice, etc.).
- 06 = Traveling too fast for conditions.
- 07 = Jackknife event.
- 08 = Cargo shift.
- 09 = Braking.
- 10 = Steering.
- 18 = Other cause of control loss.
- 19 = Unknown cause of control loss.

THIS VEHICLE (V1) TRAVELING

- 20 = Toward or over the lane line on left side of travel lane.
- 21 = Toward or over the lane line on right side of travel lane.
- 22 = Toward or off the edge of the road on the left side.
- 23 = Toward or off the edge of the road on the right side.
- 24 = End departure.
- 25 = Turning left at intersection.
- 26 = Turning right at intersection.
- 27 = Crossing over (passing through) intersection.
- 27a = This vehicle stopped.
- 28 = This vehicle decelerating.
- 28a = This vehicle accelerating.
- 29 = Unknown travel direction.

OTHER MOTOR VEHICLE (V2) IN LANE

- 50 = Other vehicle stopped.
- 51 = Traveling in same direction with lower steady speed.
- 52 = Traveling in same direction while decelerating.
- 53 = Traveling in same direction with higher speed.

- 54 = Traveling in opposite direction.
- 55 = In crossover.
- 56 = Backing.
- 59 = Unknown travel direction of other motor vehicle in lane.

OTHER MOTOR VEHICLE (V2) ENCROACHING INTO LANE

- 60 = From adjacent lane (same direction)—toward or over left lane line.
- 61 = From adjacent lane (same direction)—toward or over right lane line.
- 62 = From opposite direction - toward or over left lane line.
- 63 = From opposite direction - toward or over right lane line.
- 64 = From parking lane.
- 65 = From crossing street, turning into same direction.
- 66 = From crossing street, across path.
- 67 = From crossing street, turning into opposite direction.
- 68 = From crossing street, intended path not known.
- 70 = From driveway, turning into same direction.
- 71 = From driveway, across path.
- 72 = From driveway, turning into opposite direction.
- 73 = From driveway, intended path not known.
- 74 = From entrance to limited access highway.
- 78 = Encroachment by other vehicle - details unknown.

PEDESTRIAN, PEDALCYCLIST, OR OTHER NONMOTORIST

- 80 = Pedestrian in roadway.
- 81 = Pedestrian approaching roadway.
- 82 = Pedestrian - unknown location.
- 83 = Pedalcyclist or other nonmotorist in roadway.
- 84 = Pedalcyclist or other nonmotorist approaching roadway.
- 85 = Pedalcyclist or other nonmotorist - unknown location.

OBJECT OR ANIMAL

- 87 = Animal in roadway.
- 88 = Animal approaching roadway.
- 89 = Animal - unknown location.

- 90 = Object in roadway.
- 91 = Object approaching roadway.
- 92 = Object - unknown location.

OTHER

- 98 = Other critical pre-crash event.
- 99 = Unknown.

Vehicle 2 Critical Pre-Crash Event

Note: This variable is coded for both vehicles in a two-vehicle incident. However, the Critical Reason (see below), is coded for only one vehicle. LTCCS Variable 5.

- 00a = Not applicable (baseline epoch).
- 00b = Not applicable (single vehicle event).

THIS VEHICLE (V2) LOSS OF CONTROL DUE TO:

- 01 = Blow out or flat tire.
- 02 = Stalled engine.
- 03 = Disabling vehicle failure (e.g., wheel fell off).
- 04 = Non-disabling vehicle problem (e.g., hood flew up).
- 05 = Poor road conditions (wet road, puddle, pot hole, ice, etc.).
- 06 = Traveling too fast for conditions.
- 07 = Jackknife event.
- 08 = Cargo shift.
- 09 = Braking.
- 10 = Steering.
- 18 = Other cause of control loss.
- 19 = Unknown cause of control loss.

THIS VEHICLE (V2) TRAVELING

- 20 = Toward or over the lane line on left side of travel lane.
- 21 = Toward or over the lane line on right side of travel lane.
- 22 = Toward or off the edge of the road on the left side.
- 23 = Toward or off the edge of the road on the right side.
- 24 = End departure.

- 25 = Turning left at intersection.
- 26 = Turning right at intersection.
- 27 = Crossing over (passing through) intersection.
- 27a = This vehicle stopped.
- 28 = This vehicle decelerating.
- 28a = This vehicle accelerating.
- 29 = Unknown travel direction.

OTHER MOTOR VEHICLE (V1) IN LANE

- 50 = Other vehicle stopped.
- 51 = Traveling in same direction with lower steady speed.
- 52 = Traveling in same direction while decelerating.
- 53 = Traveling in same direction with higher speed.
- 54 = Traveling in opposite direction.
- 55 = In crossover.
- 56 = Backing.
- 59 = Unknown travel direction of other motor vehicle in lane.

OTHER MOTOR VEHICLE (V1) ENCROACHING INTO LANE

- 60 = From adjacent lane (same direction)—toward or over left lane line.
- 61 = From adjacent lane (same direction)—toward or over right lane line.
- 62 = From opposite direction - toward or over left lane line.
- 63 = From opposite direction - toward or over right lane line.
- 64 = From parking lane.
- 65 = From crossing street, turning into same direction.
- 66 = From crossing street, across path.
- 67 = From crossing street, turning into opposite direction.
- 68 = From crossing street, intended path not known.
- 70 = From driveway, turning into same direction.
- 71 = From driveway, across path.
- 72 = From driveway, turning into opposite direction.
- 73 = From driveway, intended path not known.
- 74 = From entrance to limited access highway.
- 78 = Encroachment by other vehicle - details unknown.

PEDESTRIAN, PEDALCYCLIST, OR OTHER NONMOTORIST

- 80 = Pedestrian in roadway.
- 81 = Pedestrian approaching roadway.
- 82 = Pedestrian - unknown location.
- 83 = Pedalcyclist or other nonmotorist in roadway.
- 84 = Pedalcyclist or other nonmotorist approaching roadway.
- 85 = Pedalcyclist or other nonmotorist - unknown location.

OBJECT OR ANIMAL

- 87 = Animal in roadway.
- 88 = Animal approaching roadway.
- 89 = Animal - unknown location.
- 90 = Object in roadway.
- 91 = Object approaching roadway.
- 92 = Object - unknown location.

OTHER

- 98 = Other critical pre-crash event.
- 99 = Unknown.

Vehicle 1 Critical Reason for the Critical Event

Note: "This vehicle" will always be used for the vehicle being coded. Note that vehicle-related factors will rarely be apparent to analysts. Analysts will choose one critical reason that appears to be the main critical reason. LTCCS Variable 6 with revisions in italics.

- 000a = Not applicable (baseline epoch).
- 000b = Critical reason not coded to this vehicle.

DRIVER RELATED FACTOR: Critical Non-Performance Errors

- 100 = Sleep, that is, actually asleep.
- 101 = Heart attack or other physical impairment of the ability to act.
- 107 = Drowsiness, fatigue, or other reduced alertness (not asleep).
- 108 = Other critical non-performance.
- 109 = Unknown critical non-performance.

DRIVER RELATED FACTOR: Recognition Errors

- 110 = Inattention (i.e., daydreaming).
- 111 = Internal distraction.
- 112 = External distraction.
- 113 = Inadequate surveillance (e.g., failed to look, looked but did not see).
- 118 = Other recognition error.
- 119 = Unknown recognition error.

DRIVER RELATED FACTOR: Decision Errors

- 120 = Too fast for conditions (e.g., for safe vehicle control or to be able to respond to unexpected actions of other road users).
- 121 = Too slow for traffic stream.
- 122 = Misjudgment of gap or other's speed.
- 123 = Following too closely to respond to unexpected actions (close proximity for 2 or more seconds).
- 124 = False assumption of other road user's actions.
- 125a = Apparently intentional sign/signal violation.
- 125b = Illegal U-turn.
- 125c = Other illegal maneuver.
- 126 = Failure to turn on head lamps.
- 127 = Inadequate evasive action (e.g., braking only not braking and steering; release accelerator only instead of braking).
- 128a = Aggressive driving behavior: Intimidation: any behavior emitted by a driver while driving that is intended to cause physical or psychological harm to another person.
- 128b = Aggressive driving behavior: Wanton, neglectful or reckless behavior: excessive risky driving behaviors performed without intent to harm others, such as weaving through traffic, maneuvering without signaling, running red lights, frequent lane changing, and tailgating.
- 138 = Other decision error.
- 139 = Unknown decision error.
- 140 = Apparent recognition or decision error (unknown which).

DRIVER RELATED FACTOR: Performance Errors

- 141 = Panic/Freezing.
- 142 = Overcompensation.

- 143 = Poor directional control (e.g., failing to control vehicle with skill ordinarily expected).
- 148 = Other performance error.
- 149 = Unknown performance error.
- 199 = Type of driver error unknown.

VEHICLE RELATED FACTOR

- 200 = Tires/wheels failed.
- 201 = Brakes failed.
- 202 = Steering failed.
- 203 = Cargo shifted.
- 204 = Trailer attachment failed.
- 205 = Suspension failed.
- 206 = Lights failed.
- 207 = Vehicle related vision obstructions.
- 208 = Body, doors, hood failed.
- 209 = Jackknifed.
- 298 = Other vehicle failure.
- 299 = Unknown vehicle failure.

ENVIRONMENT RELATED FACTOR: Highway Related

- 500 = Signs/signals missing.
- 501 = Signs/signals erroneous/defective.
- 503 = View obstructions by roadway design.
- 504 = View obstructed by other vehicles crash circumstance.
- 505 = Road design - roadway geometry (e.g., ramp curvature).
- 506 = Road design - sight distance.
- 507 = Road design - other.
- 508 = Maintenance problems (potholes, deteriorated road edges, etc.).
- 509 = Slick roads (low friction road surface due to ice, loose debris, any other cause).
- 518 = Other highway-related condition.

ENVIRONMENT RELATED FACTOR: Weather Related

- 521 = Rain, snow [Note: code loss-of-control as 509].

- 522 = Fog.
- 523 = Wind gust.
- 528 = Other weather-related condition.

ENVIRONMENT RELATED FACTOR: Other

- 530 = Glare.
- 531 = Blowing debris.
- 532 = Animal in roadway (no driver error).
- 533 = Pedestrian or pedalcyclist in roadway (no driver error).
- 534 = Object in roadway (no driver error).
- 538 = Other sudden change in ambience.
- 999 = Unknown reason for critical event.

Vehicle 2 Critical Reason for the Critical Event

Note: The remaining elements for DV2 are either maneuvers or conditions visible from outside the vehicle (e.g., most of the decision error choices) or reasonable general inferences. Analysts will choose one critical reason that appears to be the main critical reason.

- 000a = Not applicable (baseline epoch).
- 000b = Not applicable (single vehicle event).
- 000c = Critical reason not coded to this vehicle.

DRIVER RELATED FACTOR

- 109 = Apparent critical non-performance [includes any apparent driver impairment].

DRIVER RELATED FACTOR: Recognition Errors

- 119 = Apparent recognition error.

DRIVER RELATED FACTOR: Decision Errors

- 120 = Too fast for conditions (e.g., for safe vehicle control or to be able to respond to unexpected actions of other road users).
- 121 = Too slow for traffic stream.
- 123 = Following too closely to respond to unexpected actions (close proximity for 2 or more seconds).
- 124 = False assumption of other road user's actions.
- 125a = Apparently intentional sign/signal violation.
- 125b = Illegal U-turn.

- 125c = Other illegal maneuver.
- 126 = Failure to turn on head lamps.
- 127 = Inadequate evasive action (e.g., braking only not braking and steering; release accelerator only instead of braking).
- 128a = Aggressive driving behavior: Intimidation: any behavior emitted by a driver while driving that is intended to cause physical or psychological harm to another person.
- 128b = Aggressive driving behavior: Wanton, neglectful or reckless behavior: excessive risky driving behaviors performed without intent to harm others, such as weaving through traffic, maneuvering without signaling, running red lights, frequent lane changing, and tailgating.
- 138 = Other decision error.
- 139 = Apparent, unknown decision error.

DRIVER RELATED FACTOR: Performance Errors

- 149 = Apparent performance error.
- 199 = Type of driver error unknown.

VEHICLE RELATED FACTOR

- 200 = Tires/wheels failed.
- 201 = Brakes failed.
- 298 = Apparent other vehicle failure.
- 299 = Unknown vehicle failure.

ENVIRONMENT RELATED FACTOR: Highway Related

- 500 = Signs/signals missing.
- 501 = Signs/signals erroneous/defective.
- 503 = View obstructions by roadway design.
- 504 = View obstructed by other vehicles crash circumstance.
- 505 = Road design - roadway geometry (e.g., ramp curvature).
- 506 = Road design - sight distance.
- 507 = Road design - other .
- 508 = Maintenance problems (potholes, deteriorated road edges, etc.).
- 509 = Slick roads (low friction road surface due to ice, loose debris, any other cause).
- 518 = Other highway-related condition.

ENVIRONMENT RELATED FACTOR: Weather Related

- 521 = Rain, snow [Note: code loss-of-control as 509].
- 522 = Fog.
- 523 = Wind gust.
- 528 = Other weather-related condition.

ENVIRONMENT RELATED FACTOR: Other

- 530 = Glare.
- 531 = Blowing debris.
- 538 = Other sudden change in ambience.
- 999 = Unknown reason for critical event.

Which vehicle is considered to be at fault?

Note: The “at fault” vehicle is defined as the vehicle with the assigned Critical Reason with a few exceptions:

- Animal/pedestrian/pedal cyclist in roadway is considered to be “Vehicle 2” at fault.
- Object in roadway is considered to be “No fault.”
- All environmental factors are considered to be “No fault.”
- 00 = Not applicable (baseline epoch).
- 01 = Vehicle 1 (subject vehicle).
- 02 = Vehicle 2 (other vehicle, animal, pedestrian, pedacyclist).
- 03 = No fault (object, environmental).
- 04 = Unknown.

Vehicle 1 Attempted Avoidance Maneuver

Note: LTCCS Variable 7 and also GES V27, Corrective Action Attempted. “Released gas pedal” elements added because this evasive maneuver by subject drivers is sometimes observed.

- 00a = Not applicable (baseline epoch)
- 01 = No avoidance maneuver
- 02 = Braking (no lockup or lockup unknown)
- 03 = Braking (lockup)
- 05 = Releasing brakes
- 06 = Steered to left
- 07 = Steered to right

- 08a = Braked and steered to left (no lockup or lockup unknown)
- 08b = Braked and steered to left (lockup)
- 09a = Braked and steered to right (no lockup or lockup unknown)
- 09b = Braked and steered to right (lockup)
- 10 = Accelerated
- 11 = Accelerated and steered to left
- 12 = Accelerated and steered to right
- 13 = Released gas pedal without braking
- 14 = Released gas pedal (without braking) and steered to left
- 15 = Released gas pedal (without braking) and steered to left
- 98 = Other actions
- 99 = Unknown if driver attempted any corrective action

Vehicle 2 Attempted Avoidance Maneuver

Note: LTCCS Variable 7 and also GES V27, Corrective Action Attempted. "Released gas pedal" elements added because this evasive maneuver by subject drivers is sometimes observed.

- 00a = Not applicable (baseline epoch)
- 00b = Not applicable (single vehicle event)
- 01 = No avoidance maneuver
- 02 = Braking (no lockup or lockup unknown)
- 03 = Braking (lockup)
- 05 = Releasing brakes
- 06 = Steered to left
- 07 = Steered to right
- 08a = Braked and steered to left (no lockup or lockup unknown)
- 08b = Braked and steered to left (lockup)
- 09a = Braked and steered to right (no lockup or lockup unknown)
- 09b = Braked and steered to right (lockup)
- 10 = Accelerated
- 11 = Accelerated and steered to left
- 12 = Accelerated and steered to right
- 13 = Released gas pedal without braking
- 14 = Released gas pedal (without braking) and steered to left

- 15 = Released gas pedal (without braking) and steered to left
- 98 = Other actions
- 99 = Unknown if driver attempted any corrective action

Vehicle 1 Accident Type

Note: Since this variable "includes intent," analysts should project likely scenario roles for incidents where outcomes are not definite. In other words, if the trigger-related event had resulted in a crash, what would the crash scenario be? When specific scenarios cannot be projected, use the "Specifics Unknown" choices (e.g., 5, 10, 16, 33, etc.).

- 888 = Not applicable (baseline epoch)

  Additional clarifications:

  – Drive off road codes (e.g., 01 and 06) are used when a vehicle has crossed, or is projected to cross, a roadside delineation such as a lane edge line (going onto the shoulder or median), curb, or the edge of the pavement. This includes scenarios involving parked vehicles and stationary objects if those objects are outside of the roadway delineation (e.g., on an unpaved shoulder).
  – Forward impact codes (e.g., 11, 12) are used when the objects are in the travel lane or when there is no lane edge delineation as described above. Thus, a scenario involving a parked vehicle on the pavement where there is no lane edge delineation is coded 12.
  – If Single Driver codes (01-16) are used for V1, the V2 Accident Type code is 00b.
  – For left-side lane departures into the oncoming traffic lane, code 64/65 if the lateral encroachment is less than a few feet. Code 50/51 only if the lateral encroachment was sufficient to create a significant risk of a head-on crash.

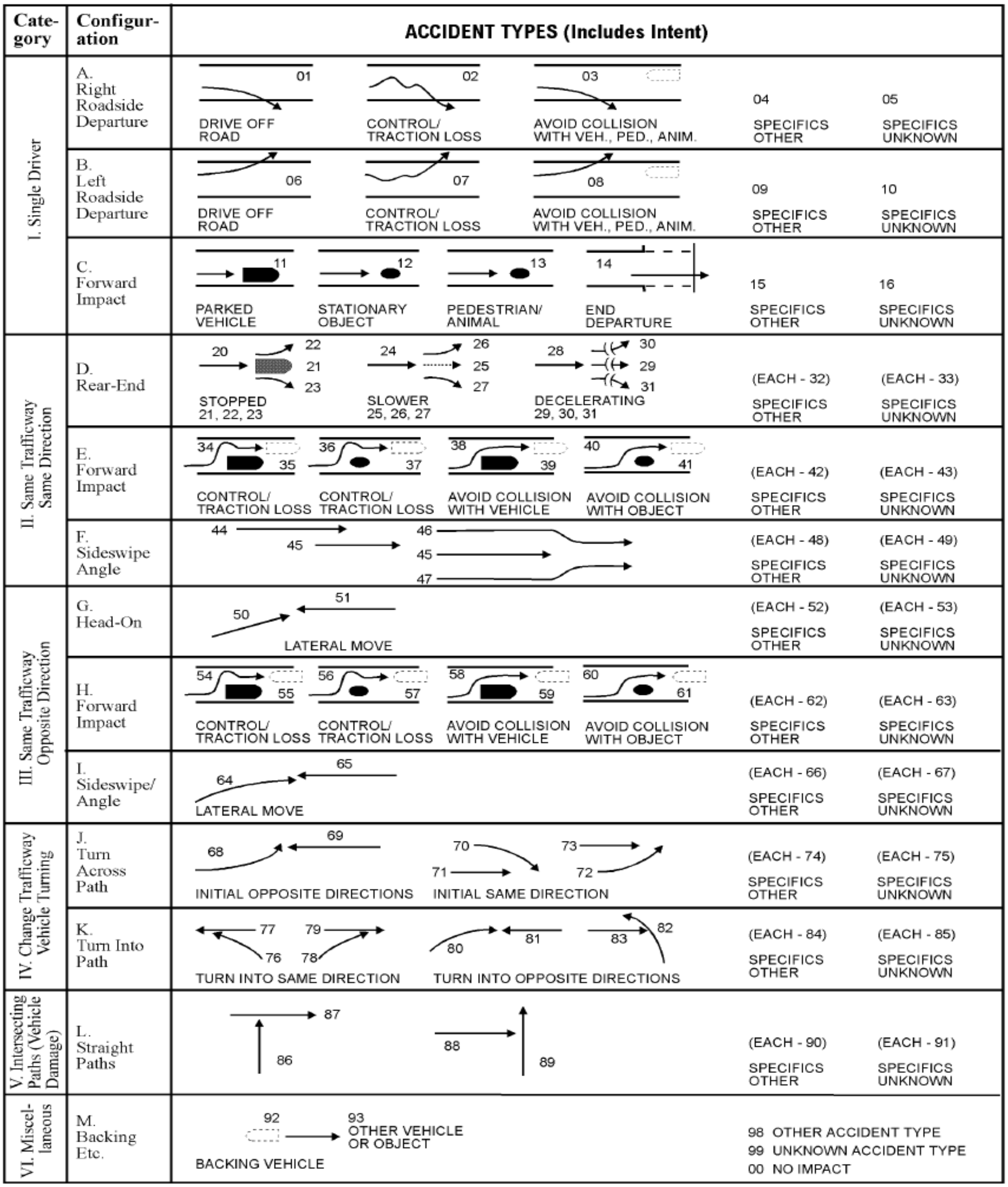
Vehicle 2 Accident Type

- 888 = Not applicable (baseline epoch)
- 777 = Not applicable (single vehicle event)
  Please note, 999 and 00 which are used to denote single vehicle event in other variables, are actual accident types, please use 777 for single vehicle event.

Note: Since this variable "includes intent," analysts should project likely scenario roles for incidents where outcomes are not definite. In other words, if the trigger-related event had resulted in a crash, what would the crash scenario be? When specific scenarios cannot be projected, use the "Specifics Unknown" choices (e.g., 5, 10, 16, 33, etc.). Figure 50 illustrates the Accident Types.

  Additional clarifications:

  – Single Driver codes (01-16) are not applicable to V2. If a Single Driver code (01-16) was used for V1, the V2 Accident Type code is 00b.
  – For left-side lane departures into the oncoming traffic lane, code 64/65 if the lateral encroachment is less than a few feet. Code 50/51 only if the lateral encroachment was sufficient to create a significant risk of a head-on crash.



Source: Thieriez, Radja, and Toth (2002)

Figure 50. Description of the Accident Types

Vehicle 1 Incident Type

Numbers listed below are shown in Table 80.

- 888 = Not applicable (baseline epoch)
- 01/02 = Aborted lane change
- 05/06/07/08 = Backing in roadway
- 09/10 = Clear path for emergency vehicle
- 68/69 = Close proximity to turning vehicle
- 11/12 = Conflict between merging and existing traffic
- 65 = Conflict with animal/pedestrian/pedacyclist/object in roadway
- 66 = Conflict with animal/pedestrian/pedacyclist/object on side of road
- 13/14 = Conflict with oncoming traffic
- 72/73 = Conflict with through traffic
- 15/16 = Exit then re-entrance onto roadway
- 17/18 = Following too closely
- 19/20 = Improper lane change
- 21/22/23 = Improper passing
- 24/25 = Improper u-turn
- 26/27 = Lane change without sufficient gap
- 28/29 = Lane drift
- 30/31 = Late braking for stopped/stopping traffic
- 32/33 = Lateral deviation of through vehicle
- 34/35 = Left turn without clearance
- 36/37 = Merge out of turn (before lead vehicle)
- 38/39/40 = Merge without sufficient gap
- 41/42 = Obstruction in roadway
- 43/44 = Proceeding through red traffic signal
- 45/46 = Roadway entrance without clearance
- 47/48 = Slow speed
- 49/50 = Slow upon passing
- 51/52/53 = Sudden braking in roadway
- 54/55 = Through traffic does not allow lane change
- 56/57/58 = Through traffic does not allow merge
- 59/60 = Turn without sufficient warning

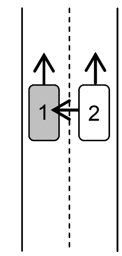
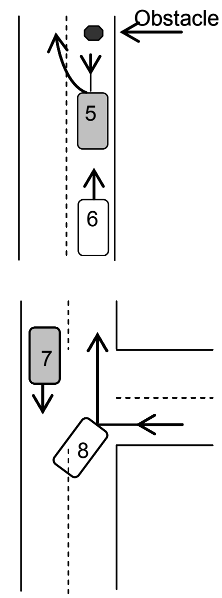
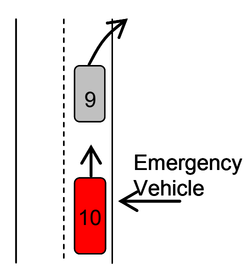
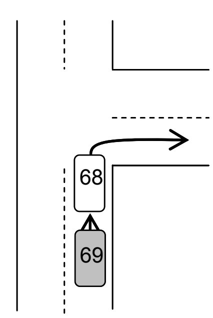
- 61/62 = Turn/exit from incorrect lane
- 63/64 = Wide turn into adjacent lane
- 67 = Other single vehicle event
- 70/71 = Vehicle passes through intersection without clearance
- 99 = Unknown

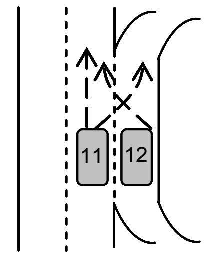
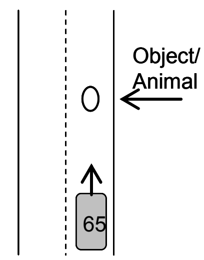
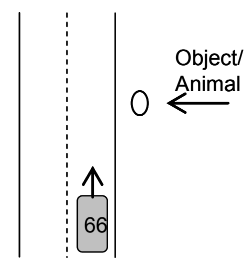
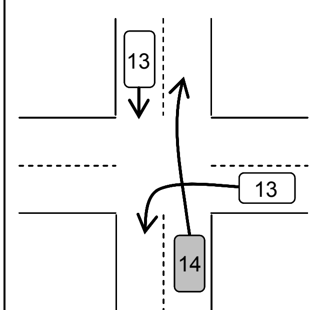
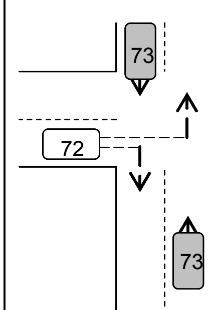
Vehicle 2 Incident Type

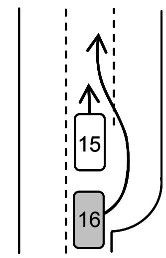
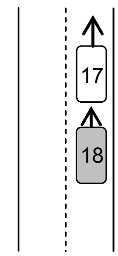
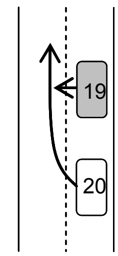
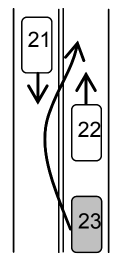
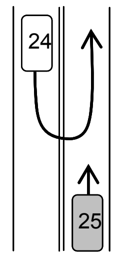
- 888 = Not applicable (baseline epoch)
- 00 = Not applicable (single vehicle event)
- 01/02 = Aborted lane change
- 05/06/07/08 = Backing in roadway
- 09/10 = Clear path for emergency vehicle
- 68/69 = Close proximity to turning vehicle
- 11/12 = Conflict between merging and existing traffic
- 13/14 = Conflict with oncoming traffic
- 72/73 = Conflict with through traffic
- 15/16 = Exit then re-entrance onto roadway
- 17/18 = Following too closely
- 19/20 = Improper lane change
- 21/22/23 = Improper passing
- 24/25 = Improper u-turn
- 26/27 = Lane change without sufficient gap
- 28/29 = Lane drift
- 30/31 = Late braking for stopped/stopping traffic
- 32/33 = Lateral deviation of through vehicle
- 34/35 = Left turn without clearance
- 36/37 = Merge out of turn (before lead vehicle)
- 38/39/40 = Merge without sufficient gap
- 41/42 = Obstruction in roadway
- 43/44 = Proceeding through red traffic signal
- 45/46 = Roadway entrance without clearance
- 47/48 = Slow speed
- 49/50 = Slow upon passing

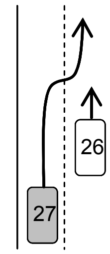
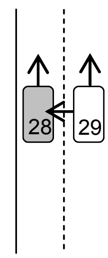
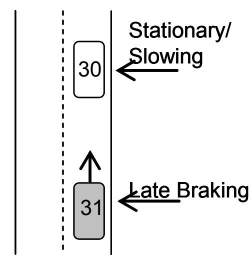
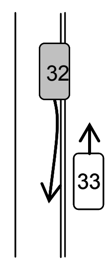
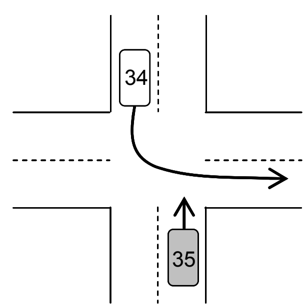
- 51/52/53 = Sudden braking in roadway
- 54/55 = Through traffic does not allow lane change
- 56/57/58 = Through traffic does not allow merge
- 59/60 = Turn without sufficient warning
- 61/62 = Turn/exit from incorrect lane
- 63/64 = Wide turn into adjacent lane
- 70/71 = Vehicle passes through intersection without clearance
- 99 = Unknown

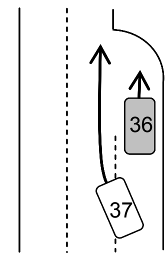
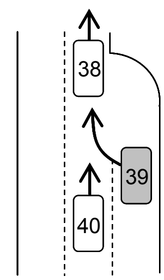
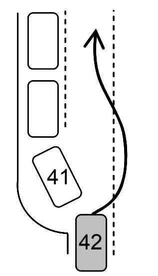
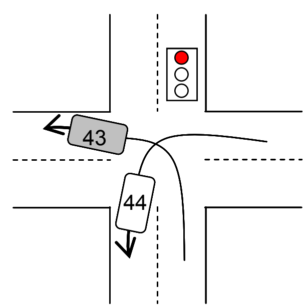
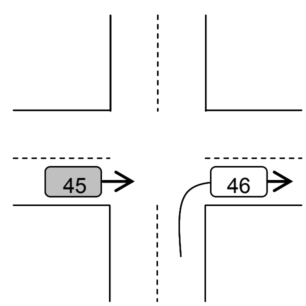
Table 80. Descriptions and Diagrams of Incident Types

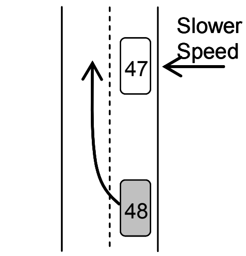
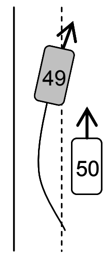
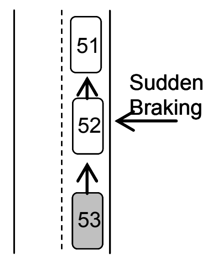
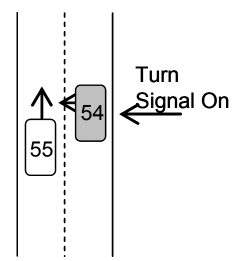
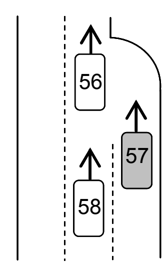
Incident Type	Description	Illustration
Aborted Lane Change	A driver tries to make a lane change into a lane where there is already a vehicle (driver doesn't see vehicle). The driver has to brake and move back into the original lane.	
Backing in Roadway	A driver backs the vehicle while on a roadway in order to maneuver around an obstacle ahead on the roadway.	
Clear Path for Emergency Vehicle	A driver is traveling ahead of an emergency vehicle (e.g., ambulance, fire truck) and has to move to the side of the road to let the emergency vehicle pass.	
Close Proximity to Turning Vehicle	The lead vehicle is making a right/left turn or changing lanes to the right/left, and the following vehicle comes close to the rear of the lead vehicle as they pass.	

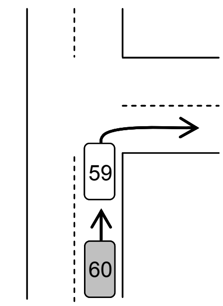
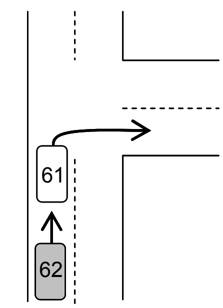
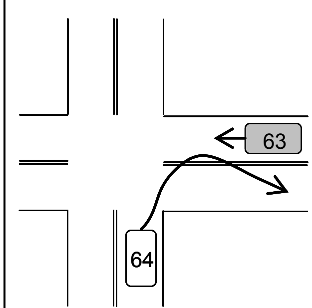
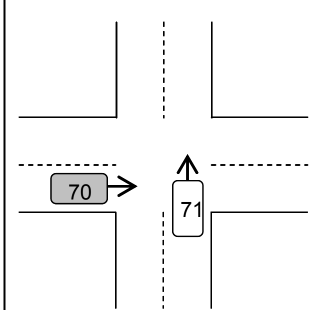
Incident Type	Description	Illustration
Conflict Between Merging and/or Exiting Traffic	Drivers entering and/or exiting a roadway, causing a conflict.	
Conflict With Animal/Pedestrian/Pedal cyclist/Object in Roadway	A vehicle approaches an animal/ pedestrian/pedal cyclist/object in the roadway (on the pavement) and either makes contact with it, or performs an evasive maneuver in order to avoid it.	
Conflict With Animal/Pedestrian/Pedal cyclist /Object on Side of Roadway	A vehicle approaches an animal/ pedestrian/pedal cyclist/object (including a guardrail) on the side of the road and either makes contact with it, or performs an evasive maneuver in order to avoid it.	
Conflict With Oncoming Traffic	A driver is approaching oncoming traffic (e.g., on an undivided road, at an intersection) and has to maneuver back into the correct lane to avoid an oncoming vehicle.	
Conflict with Through Traffic	A vehicle starts to turn (right or left) at an intersection, but has to brake to avoid a conflict with traffic passing through the intersection.	

Incident Type	Description	Illustration
Exit Then Re-Entrance Onto Roadway	A driver exits a roadway then crosses a solid white line to re-enter.	
Following Too Closely	A driver does not allow adequate spacing between their vehicle and the lead vehicle (e.g., tailgating).	
Improper Lane Change	A driver makes an improper lane change with regard to another vehicle (e.g., does not use blinker, changes lanes behind another vehicle then does not let vehicle change lanes, changes lanes across multiple lanes, etc.)	
Improper Passing	A driver passes another vehicle when it is illegal or unsafe (e.g., passing across a double yellow line or without clearance from oncoming traffic).	
Improper U-turn	A driver makes a u-turn in the middle of the road (over the double yellow line) and blocks traffic in the opposite direction.	

Incident Type	Description	Illustration
Lane Change Without Sufficient Gap	A driver enters an adjacent lane without allowing adequate space between the driver's vehicle and the vehicle ahead/behind it.	
Lane Drift	A driver drifts into an adjacent lane without intention to make a lane change.	
Late Braking (and/or steering) for Stopped/ Stopping Traffic	A driver fails to slow in advance for stopped or stopping traffic and must brake and/or steer abruptly.	
Lateral Deviation of Through Vehicle	A driver has substantial lateral deviation of a through vehicle. Vehicle may or may not deviate from the lane.	
Left Turn Without Clearance	A driver turns left without adequate clearance from either oncoming through traffic or cross traffic from the left. The driver crosses another driver's path while entering an intersecting roadway.	

Incident Type	Description	Illustration
Merge Out of Turn (Before Lead Vehicle)	A driver merges onto a roadway before the lead vehicle. The lead vehicle must wait for the merged vehicle to pass before it is safe to enter the main highway.	
Merge Without Sufficient Gap	A driver merges into traffic without a sufficient gap to either the front or back of one or more vehicles.	
Obstruction in Roadway	A stationary object blocks through traffic, such as traffic that is backed up or an animal in the roadway.	
Proceeding Through Red Traffic Signal	A driver fails to respond to a red traffic signal, conflicting with a vehicle proceeding through the intersection legally.	
Roadway Entrance Without Clearance	A driver turns onto a roadway without adequate clearance from through traffic.	

Incident Type	Description	Illustration
Slow Speed	A driver is traveling at a much slower speed than the rest of the traffic, causing following traffic to pass the slow vehicle to avoid a conflict.	
Slow Upon Passing	A driver moves in front of another vehicle then slows, causing the second (passed) vehicle to slow as well, or to go around the first vehicle.	
Sudden Braking in Roadway	A driver is traveling ahead of another vehicle and brakes suddenly and improperly in the roadway for traffic, a traffic light, etc., causing the following vehicle to come close to their vehicle or to also brake suddenly.	
Through Traffic Does Not Allow Lane Change	A driver is trying to make a lane change (with their turn signal on) but traffic in the adjacent lane will not allow the lane change to be completed.	
Through Traffic Does Not Allow Merge	Through traffic obstructs (either intentionally or unintentionally) a driver from entering the roadway or from performing any type of merging behavior.	

Incident Type	Description	Illustration
Turn Without Sufficient Warning	A driver slows and turns without using a turn signal or without using a turn signal in advance.	
Turn/Exit From Incorrect Lane	A driver turns onto a side road from the incorrect lane (e.g., a driver makes a right turn from the left lane instead of the right lane).	
Wide Turn Into Adjacent Lane	A vehicle partially enters an adjacent lane when turning. Traffic in the adjacent lane may be moving in the same or opposite direction.	
Vehicle Passes Through Intersection Without Clearance	A vehicle passes through an intersection (signal or non-signal) without adequate clearance from through traffic.	

Incident Type	Description	Illustration
Other Single Vehicle Event	A vehicle is involved in a single vehicle event. For example runs off the side of the road without a threat of hitting a fixed object.	67
Unable to Determine	It is not possible to determine which vehicle is at fault, therefore, it is not possible to assign an incident type to the event.	99

Source: Hanowski, Wierwille, Garness, and Dingus (2000); Hanowski, Olson, Hickman, and Dingus (2006); and Hickman, et al. (in press)

DRIVER/VEHICLE 1 VARIABLES

Driver/Vehicle 1 (DV1) is always the study subject driver/vehicle (i.e., the truck or truck driver).

Driver Safety Belt Worn?

- 00 = No
- 01 = Yes
- 02 = Unknown

Possible to do Observer Rating of Drowsiness?

- 00 = Yes
- 01 = No—wearing sunglasses
- 02 = No—not enough video
- 03 = No—cannot see driver's eyes

Driver 1 Vision Obscured by

- 00 = No obstruction
- 01 = Rain, snow, smoke, sand, dust
- 02 = Reflected glare, sunlight, headlights
- 03 = Curve or hill
- 04 = Building, billboard, or other design features (includes signs, embankment)
- 05 = Trees, crops, vegetation
- 06 = Moving vehicle (including load)
- 07 = Parked vehicle
- 08 = Splash or spray of passing vehicle [any other vehicle]
- 09 = Inadequate defrost or defog system
- 10 = Inadequate lighting system [includes vehicle/object in dark area]
- 11 = Obstruction interior to vehicle
- 12 = Mirrors
- 13 = Head restraints
- 14 = Broken or improperly cleaned windshield
- 15 = Fog
- 16 = Other vehicle or object in blind spot
- 97 = Vision obscured—no details
- 98 = Other obstruction
- 99 = Unknown whether vision was obstructed

Note: GES Variable D4. Element 16 added because of relevance to large trucks.

Driver 1 Potentially Distracting Driver Behaviors

Note: Up to four behaviors may be coded for the 5.0 s prior to and 1.0 s after the event onset trigger. If there are more than four, select the ones occurring closest in time to the trigger. Similar to GES Variable D7 (Driver Distracted By), with expansions of many elements to capture direct observations.

Table 81. Potentially Distracting Driver Behaviors

Distraction Type and Behavior	Description of Behavior
Internal Distraction: Person or Object	
Talk/sing/dance with no indication of passenger	Driver appears to be vocalizing either to an unknown passenger, to self, or singing to the radio. Also, in this category are instances where the driver exhibits dancing behavior or is whistling.
Interact with or look at other occupant(s)	Driver is talking to a passenger sitting in the passenger's seat or in the sleeper berth that can be identified by the person encroaching into the camera view or the driver is clearly looking and talking to the passenger.
Reach for object in vehicle	Driver may or may not remove attention from the forward roadway to reach for an object inside the vehicle. Objects may include, but are not limited to, cell phone, CB, food, drink, map, paperwork. This option should only be marked if the driver is not engaging in any other behavior at the same time.
Look back in Sleeper Berth	Driver turns body to look behind him/her into the Sleeper Berth.
Use calculator	Driver uses hand-held calculator. Assumes driver is looking at and may reach for object.
Read book, newspaper, paperwork, etc.	Driver reads a book, newspaper, paperwork, etc, which is visible in the driver's hands, on the driver's lap, on the driver's steering wheel, or on the passenger seat. Assumes driver is looking at and may reach for object.
Look at map	Driver reads a map which is visible in the driver's hands, on the driver's lap, on the driver's steering wheel, or on the passenger seat. Assumes driver is looking at and may reach for object.
Write on pad, notebook, etc.	Driver writes on some kind of paper which is visible in the driver's hands, on the driver's lap, on the driver's steering wheel, or on the passenger seat. Assumes driver is looking at and may reach for object.
Put on/remove/adjust seat belt	Driver puts on, removes, or adjusts his/her seat belt. Assumes driver is looking at and may reach for object.
Put on/remove/adjust sunglasses or reading glasses	Driver puts on, removes, or adjusts his/her sunglasses. Assumes driver is looking at and may reach for object.
Put on/remove/adjust hat	Driver puts on, removes, or adjusts his/her hat. Assumes driver is looking at and may reach for object.

Distraction Type and Behavior	Description of Behavior
Internal Distraction: Electronic Devices	
Dial cell phone	Driver dials a cell phone. This may also include answering the phone or hanging up the phone, if the driver presses a key during this time. Assumes driver is looking at and may reach for object.
Talk or listen to hand-held phone	Driver holds a hand-held phone to ear, appears to be talking and/or listening.
Talk or listen to hands-free phone	Driver talks or listens to a hands-free phone. This is apparent by an earpiece in the driver's ear.
Text message on cell phone	Driver appears to be text messaging using a cell phone. Driver is focusing on the cell phone for an extended amount of time while continuously pressing keys. Assumes driver is looking at and may reach for object.
Talk or listen to CB radio	Driver talks or listens to a CB radio. Assumes driver is looking at and may reach for object.
Interact with/look at dispatching device	Driver interacts with or looks at a dispatching device. The driver usually keeps the device on the passenger seat or on the floor between the two seats and holds the device on his/her lap or steering wheel while in use. Assumes driver is looking at and may reach for object.
Look at/handle DAS	Driver looks at/handles data acquisition system (DAS). This may include a system box under the driver's seat and, video cameras mounted on the windshield. Assumes driver is looking at and may reach for object.
Use/reach for other device	Driver reaches for or uses an alternate electronic device. Assumes driver is looking at and may reach for object.
Internal Distraction: Dining	
Eating	Driver eats with, or without, a utensil (i.e., fork or spoon). This also includes the driver opening a food bag or anything closely related to eating just prior to or after the trigger. Assumes driver is looking at and may reach for object.
Drink from a container	Driver drinks from a container. This also includes the driver opening/closing a drink container or anything closely related to drinking just prior to or after the trigger. Assumes driver is looking at and may reach for object.
Internal Distraction: Smoking-related	
Smoking-related behavior—reaching, lighting, extinguishing	Driver is reaching (ashing), lighting, or extinguishing a cigarette. May include behaviors such as driver reaching for a lighter or reaching for a pack of cigarettes. Assumes driver is looking at and may reach for object.
Smoking-related behavior—cigarette in hand or mouth	Driver has a cigarette in hand or mouth.
Use chewing tobacco	Driver is using chewing tobacco. This may include putting tobacco into mouth or spitting into container. Assumes driver is looking at and may reach for object.

Distraction Type and Behavior	Description of Behavior
Internal Distraction: Grooming	
Personal grooming	Driver is grooming him/herself. This may include combing/fixing hair, applying make-up, shaving, and brushing teeth. Assumes driver is looking at and may reach for object.
Bite nails/cuticles	Driver is biting nails and/or cuticles. Assumes driver is looking at hands.
Remove/adjust jewelry	Driver is removing or adjusting jewelry. This may include, watch, bracelet, necklace or earrings. Assumes driver is looking at and may reach for object.
Other personal hygiene	Driver is conducting some kind of other personal hygiene. This may include rubbing eyes/face, scratching face/neck, or picking nose.
Internal Distraction: Vehicle Related	
Adjust instrument panel	Driver is adjusting something on the instrument panel. This may include, radio, climate controls, head lights, and other switches to the front and right of the driver. Assumes driver is reaching for and/or looking at the instrument panel while adjusting.

Driver 1 Actions/Factors/Behaviors Relating to Event

Note: You may code up to four factors believed to have relevance to the occurrence of the incident; (e.g., as contributing factors). If there are more than four, select the four most important. This variable was used in Dingus et al. (2006) although some new elements have been added. Analysts code all that apply and in no order of importance.

- 00a = Not applicable (baseline epoch)
- 00b = None coded
- 01 = Apparent excessive speed for conditions or location (regardless of speed limit; does not include tailgating, unless above speed limit)
- 02 = Drowsy, sleepy, asleep, fatigued, other reduced alertness
- 03 = Angry
- 04 = Other emotional state
- 05 = Inattentive or distracted (mark only if related to event, not just because a potential distraction is marked)
- 07 = Driving slowly; below speed limit or in relation to other traffic
- 08 = Illegal passing (i.e., across double line)
- 09 = Passing on right
- 10 = Other improper or unsafe passing

- 11a = Cutting in, too close in front of other vehicle
- 11b = Cutting in at safe distance but then decelerated, causing conflict
- 12 = Cutting in, too close behind other vehicle
- 13 = Making turn from wrong lane (e.g., across lanes)
- 14 = Did not see other vehicle during lane change or merge
- 15 = Driving in other vehicle's blind spot
- 16 = Aggressive driving, specific, directed menacing actions
- 17 = Aggressive driving, other; i.e., reckless driving without directed menacing actions
- 18 = Wrong side of road, not overtaking [includes partial or full drift into oncoming lane]
- 19 = Following too close
- 19a = Inadequate evasive action
- 20 = Failed to signal, or improper signal
- 21 = Improper turn: wide right turn
- 22 = Improper turn: cut corner on left turn
- 23 = Other improper turning
- 24 = Improper backing, did not see
- 25 = Improper backing, other
- 26 = Improper start from parked position
- 27 = Disregarded officer or watchman
- 28 = Signal violation, apparently did not see signal
- 29= Signal violation, intentionally ran red light
- 30 = Signal violation, tried to beat signal change
- 31 = Stop sign violation, apparently did not see stop sign
- 32 = Stop sign violation, intentionally ran stop sign at speed
- 33 = Stop sign violation, "rolling stop"
- 34 = Other sign (e.g., Yield) violation, apparently did not see sign
- 35 = Other sign (e.g., Yield) violation, intentionally disregarded
- 36 = Other sign violation
- 37 = Non-signed crossing violation (e.g., driveway entering roadway)
- 38 = Right-of-way error in relation to other vehicle or person, apparent recognition failure (e.g., did not see other vehicle)
- 39 = Right-of-way error in relation to other vehicle or person, apparent decision failure (i.e., did see other vehicle prior to action but misjudged gap)

- 40 = Right-of-way error in relation to other vehicle or person, other or unknown cause
- 41 = Sudden or improper stopping on roadway
- 42 = Parking in improper or dangerous location; e.g., shoulder of Interstate
- 43 = Speeding or other unsafe actions in work zone
- 44 = Failure to dim headlights
- 45 = Driving without lights or insufficient lights
- 46 = Avoiding pedestrian
- 47 = Avoiding other vehicle
- 48 = Avoiding animal
- 48a = Avoiding object
- 49 = Apparent unfamiliarity with roadway
- 50 = Apparent unfamiliarity with vehicle; e.g., displays and controls
- 51 = Use of cruise control contributed to late braking (does not imply malfunction of cruise control system)
- 52 = Excessive braking/deceleration creating potential hazard
- 53 = Loss of control on slippery road surface
- 54 = Loss of control on dry (or unknown) surface
- 55 = Apparent vehicle failure (e.g., brakes)
- 56 = Other

DRIVER/VEHICLE 2 VARIABLES

Driver Behavior: Driver 2 Actions/Factors Relating to Event

Note: Analyst codes up to four factors believed to have relevance to the occurrence of the incident; e.g., as contributing factors. If there are more than four, select the four most important.
00a = Not applicable (baseline epoch)

- 00b = Not applicable (single vehicle event)
- 00 = None coded
- 01 = Apparent excessive speed for conditions or location (regardless of speed limit; does not include tailgating, unless above speed limit)
- 06a = Vehicle “drift” or “slow weave” consistent with possible drowsy/distracted driving
- 06b = Erratic steering, weaving, lane break, or other vehicle motion consistent with possible alcohol-impaired driving.
- 07 = Driving slowly; below speed limit or in relation to other traffic
- 08 = Illegal passing (i.e., across double line)

- 09 = Passing on right
- 10 = Other improper or unsafe passing
- 11a = Cutting in, too close in front of other vehicle
- 11b = Cutting in at safe distance but then decelerated, causing conflict
- 12 = Cutting in, too close behind other vehicle
- 13 = Making turn from wrong lane (e.g., across lanes)
- 14 = Did not see other vehicle during lane change or merge
- 15 = Driving in other vehicle's blind zone
- 16 = Aggressive driving, specific, directed menacing actions
- 17 = Aggressive driving, other; i.e., reckless driving without directed menacing actions
- 18 = Wrong side of road, not overtaking [includes partial or full drift into oncoming lane]
- 19 = Following too close
- 19a = Inadequate evasive action
- 20 = Failed to signal, or improper signal
- 21 = Improper turn: wide right turn
- 22 = Improper turn: cut corner on left turn
- 23 = Other improper turning
- 24 = Improper backing, [apparently] did not see
- 25 = Improper backing, other
- 26 = Improper start from parked position
- 27 = Disregarded officer or watchman
- 28 = Signal violation
- 30 = Signal violation, tried to beat signal change
- 31 = Stop sign violation
- 33 = Stop sign violation, "rolling stop"
- 34 = Other sign (e.g., Yield) violation
- 36 = Other sign violation
- 37 = Non-signed crossing violation (e.g., driveway entering roadway)
- 38 = Right-of-way error in relation to other vehicle or person
- 41 = Sudden or improper stopping on roadway
- 42 = Parking in improper or dangerous location; e.g., shoulder of Interstate
- 43 = Speeding or other unsafe actions in work zone
- 44 = Failure to dim headlights

- 45 = Driving without lights or insufficient lights
- 46 = Avoiding pedestrian
- 47 = Avoiding other vehicle
- 48 = Avoiding animal
- 48a = Avoiding object
- 52 = Excessive braking/deceleration creating potential hazard
- 53 = Loss of control on slippery road surface
- 54 = Loss of control on dry (or unknown) surface
- 55 = Apparent vehicle failure (e.g., brakes)
- 56 = Other
- 57 = Unknown

ENVIRONMENTAL VARIABLES

Environmental variables are coded at the time of the trigger for both events and baseline epochs.

Light Condition

Note: GES A19

- 01 = Daylight
- 02 = Dark
- 03 = Dark but lighted
- 04 = Dawn
- 05 = Dusk
- 09 = Unknown

Weather

Note: GES A20.

- 01 = No adverse conditions
- 02 = Rain
- 03 = Sleet
- 04 = Snow
- 05 = Fog
- 06 = Rain & fog
- 07 = Sleet & fog
- 08 = Other (smog, smoke, sand/dust, crosswind, hail)
- 09 = Unknown

Roadway Surface Condition

Note: GES A15.

- 01 = Dry
- 02 = Wet
- 03 = Snow or slush
- 04 = Ice
- 05 = Sand, oil, dirt
- 08 = Other
- 09 = Unknown

Relation to Junction

Note: GES variable A09.

- 00 = Non-Junction
- 01 = Intersection
- 02 = Intersection-related
- 03 = Driveway, alley access, etc.
- 03a = Parking Lot
- 04 = Entrance/exit ramp
- 05 = Rail grade crossing
- 06 = On a bridge
- 07 = Crossover related
- 08 = Other
- 09 = Unknown

Traffic-way Flow

Note: GES variable V A11. Coded in relation to subject vehicle; baseline epoch coded at time of trigger.

- 00 = Not physically divided (center 2-way left turn lane)
- 01 = Not physically divided (2-way trafficway)
- 02 = Divided (median strip or barrier)
- 03 = One-way trafficway
- 09 = Unknown

Number of Travel Lanes

Note: GES V A12. Per GES, if road is divided, only lanes in travel direction are counted. If undivided, all lanes are counted. Coded in relation to subject vehicle. Count all contiguous lanes at the time & location of the incident; e.g., include entrance or exit lanes if contiguous. Do not include lanes if blocked by cones or barrels.

- 01 = 1
- 02 = 2
- 03 = 3
- 04 = 4
- 05 = 5
- 06 = 6
- 07 = 7+
- 09 = Unknown

Roadway Alignment

Note: GES V A13, with expansion of curve choices. Coded in relation to subject vehicle.

- 01 = Straight
- 02a = Curve right
- 02b = Curve left
- 09 = Unknown

Roadway Profile

Note: GES V A14, with expansion of grade choices. Coded in relation to subject vehicle.

- 01 = Level (or unknown)
- 02a = Grade up
- 02b = Grade down
- 03 = Hillcrest
- 04 = Sag

Traffic Density

Code the traffic density for the time prior to the pre-crash event. LOS: Level-of-Service.

- 01 = LOS A: Free flow—Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to maneuver within the traffic stream is extremely high. The general level of comfort and convenience provided to the motorist, passenger, or pedestrian is excellent.

- 02 = LOS B: Flow with some restrictions—In the range of stable traffic flow, but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected, but there is a slight decline in the freedom to maneuver within the traffic stream from LOS A, because the presence of others in the traffic stream begins to affect individual behavior.
- 03 = LOS C: Stable flow, maneuverability and speed are more restricted—In the range of stable traffic flow, but marks the beginning of the range of flow in which the operation of individual uses becomes significantly affected by the interactions with others in the traffic stream. The selection of speed is now affected by the presence of others, and maneuvering within the traffic stream requires substantial vigilance on the part of the user. The general level of comfort and convenience declines noticeably at this level.
- 04 = LOS D: Unstable flow: temporary restrictions substantially slow driver—Represents high-density, but stable traffic flow. Speed and freedom to maneuver are severely restricted, and the driver or pedestrian experiences a generally poor level of comfort and convenience. Small increases in traffic flow will generally cause operational problems at this level.
- 05 = LOS E: Flow is unstable; vehicles are unable to pass, temporary stoppages, etc.—Represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and it is generally accomplished by forcing a vehicle or pedestrian to "give way" to accommodate such maneuvers. Comfort and convenience levels are extremely poor, and driver or pedestrian frustration is generally high. Operations at this level are usually unstable, because small increases in flow or minor perturbations within the traffic stream will cause breakdowns.
- 06 = LOS F: Forced traffic flow condition with low speeds and traffic volumes that are below capacity. Queues' forming in particular locations—This condition exists whenever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go waves, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, and then be required to stop in a cyclic fashion. LOS F is used to describe the operating conditions within the queue, as well as the point of the breakdown. It should be noted, however, that in many cases operating conditions of vehicles or pedestrians discharged from the queue may be quite good. Nevertheless, it is the point at which arrival flow exceeds discharge slow which causes the queue to form, and LOS F is an appropriate designation for such points.
- Unknown/unable to determine

Construction Zone Related

Note: Any area with one or more traffic cones, barrels, etc. is considered to be a construction zone.

- 00 = Not construction zone-related (or unknown)
- 01 = Construction zone (occurred in zone)
- 02 = Construction zone-related (occurred in approach or otherwise related to zone)

Truck Pre-Event Speed

Note: For events, coded for the period just prior to the occurrence of the critical event and/or just prior to any avoidance maneuver. For example, when braking is involved, the pre-event speed is the speed just prior to the beginning of braking. If there is no avoidance maneuver, enter the speed at the time of the trigger.

- 999 = Unknown

GENERAL

Event Comments

Note: This text variable will permit analysts to provide any comments on the event, including information not captured by data variables, assumptions made about the event affecting coding, and coding issues that arose. Ordinarily this will not contain information that is captured by the coded variables.

APPENDIX B. BASELINE EPOCH DATA DIRECTORY

Determine if trigger is valid. If any of the following conditions apply, then the trigger is invalid:

- It is the wrong driver → mark as ‘wrong driver’
- Face camera is not available → mark as ‘no video’
- The front camera is out and you cannot get ALL variables from the side cameras → mark as ‘no video’
- Truck is traveling below 15 mi/h (24.14 kph) at any point during trigger → mark as ‘speed below 15 mi/h’
- Driver is wearing sunglasses → mark as ‘wearing sunglasses’
- Trigger overlaps an existing event → mark as ‘overlaps event’
- You cannot see the drivers eyes clearly because the camera is misaligned or the video is too dark → mark as ‘cannot see drivers eyes’

VEHICLE 1 PRIMARY MOVEMENT

Note: Code this variable for what the truck is doing the majority of the 6-s trigger.

- Going straight
- Decelerating in traffic lane
- Accelerating in traffic lane
- Starting in traffic lane
- Stopped in traffic lane
- Passing or overtaking another vehicle—the vehicle that the driver is passing has to be in the adjacent lane; does not count if the vehicle is slowing in a turn lane or on an exit ramp
- Disabled or parked in travel lane
- Leaving a parking position, moving forward
- Leaving a parking position, backing
- Entering a parking position, moving forward
- Entering a parking position, backing
- Turning right
- Turning left
- Making a u-turn
- Backing up (other than parking)
- Negotiating a curve
- Changing lanes

- Merging
- Successful avoidance maneuver to a previous critical event
- Other
- Unknown

Note: For the remaining variables, enter what the conditions are at the end of the 6-s trigger.

Driver Safety Belt Worn?

- Yes
- No
- Unknown

Light Condition

- Daylight
- Dark
- Dark but lighted—lights have to be on drivers side of the road (if they're on a divided highway, and the lights are only on the opposite direction of travel, then it doesn't count)
- Dawn
- Dusk
- Unknown

Weather

- No adverse conditions
- Rain—automatically code wet below
- Sleet
- Snow—automatically code snow or slush below
- Fog
- Rain and fog—automatically code wet below
- Sleet and fog
- Other (smog, smoke, sand/dust, crosswind, hail)
- Unknown

Roadway Surface Condition

- Dry
- Wet
- Snow or slush

- Ice
- Sand, oil, dirt
- Other
- Unknown

Relation to Junction

- Non-junction
- Intersection
- Intersection-related
- Driveway, alley access, etc.—the driver has to be completely on the driveway, alley access, etc. in order to code this variable
- Parking lot—the driver has to be completely in the parking lot in order to code this variable; if the driver is turning into a parking lot, code as intersection
- Entrance/exit ramp
- Rail grade crossing
- On a bridge
- Crossover-related (A crossover is defined as a designated opening within a median used primarily for "U-turns")
- Other
- Unknown

Trafficway Flow

Note: Coded in relation to subject vehicle.

- Not physically divided (center 2-way left turn lane)
- Not physically divided (2-way trafficway)
- Divided (median strip or barrier)
- One-way trafficway
- Unknown

Number of Travel Lanes

Note: If road is divided, only lanes in travel direction are counted. If undivided, all lanes are counted. Coded in relation to subject vehicle; count all contiguous lanes at the time & location of the incident; e.g., include entrance or exit lanes if contiguous (including entrance/exit lanes that are separated by paint)

- 1
- 2

- 3
- 4
- 5
- 6
- 7 or more
- Unknown

Roadway Alignment

Note: Coded in relation to subject vehicle.

- Straight
- Curve right
- Curve left
- Unknown

Roadway Profile

Note: Coded in relation to subject vehicle.

- Level
- Grade up
- Grade down
- Hillcrest
- Sag (e.g., a valley)
- Unknown

Traffic Density

- LOS A: Free flow—Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to maneuver within the traffic stream is extremely high. The general level of comfort and convenience provided to the motorist, passenger, or pedestrian is excellent.
- LOS B: Flow with some restrictions—In the range of stable traffic flow, but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected, but there is a slight decline in the freedom to maneuver within the traffic stream from level-of-Service A, because the presence of others in the traffic stream begins to affect individual behavior.
- LOS C: Stable flow, maneuverability and speed are more restricted—In the range of stable traffic flow, but marks the beginning of the range of flow in which the operation of individual uses becomes significantly affected by the interactions with others in the traffic stream. The selection of speed is now affected by the presence of others, and

maneuvering within the traffic stream requires substantial vigilance on the part of the user. The general level of comfort and convenience declines noticeably at this level.

- LOS D: Unstable flow: temporary restrictions substantially slow driver—Represents high-density, but stable traffic flow. Speed and freedom to maneuver are severely restricted, and the driver or pedestrian experiences a generally poor level of comfort and convenience. Small increases in traffic flow will generally cause operational problems at this level.
- LOS E: Flow is unstable; vehicles are unable to pass, temporary stoppages, etc.—Represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and it is generally accomplished by forcing a vehicle or pedestrian to "give way" to accommodate such maneuvers. Comfort and convenience levels are extremely poor, and driver or pedestrian frustration is generally high. Operations at this level are usually unstable, because small increases in flow or minor perturbations within the traffic stream will cause breakdowns.
- LOS F: Forced traffic flow condition with low speeds and traffic volumes that are below capacity. Queues' forming in particular locations—This condition exists whenever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go waves, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, then be required to stop in a cyclic fashion. Level-of-Service F is used to describe the operating conditions within the queue, as well as the point of the breakdown. It should be noted, however, that in many cases operating conditions of vehicles or pedestrians discharged from the queue may be quite good. Nevertheless, it is the point at which arrival flow exceeds discharge slow which causes the queue to form, and level-of-Service F is an appropriate designation for such points.
- Unknown/unable to determine

Construction Zone

Note: For the purposes of the coding, consider any area with multiple traffic cones, barrels, etc. to be a construction zone.

- No construction zone.
- Construction zone (occurred in zone).
- Construction zone-related (occurred in approach or otherwise related to zone).
- Unknown.

Truck Speed

Event Comments

Note: This text variable will permit analysts to provide any comments on the event, including information not captured by data variables, assumptions made about the event affecting coding, and coding issues that arose. Ordinarily this will not contain information that is captured by the coded variables.

APPENDIX C. DRIVER TASKS, TASK CATEGORIES AND MANUAL/VISUAL COMPLEXITY

Table 82 lists all tasks and definitions, grouped into secondary and tertiary task categories that were identified in the DDWS and NTDS data sets. Note that these do not necessarily represent the universe of secondary and tertiary tasks, but only those that were observed in the video from the DDWS FOT and NTDS data sets.

Table 82. Driver Tasks, Task Categories and Manual/Visual Complexity

Task	Definition	Task Category	Manual/Visual Complexity
Dial cell phone	Driver dials a cell phone. This may also include answering the phone or hanging up the phone, if the driver presses a key during this time. Assumes driver is looking at and may reach for object.	Tertiary Task	Complex
Interact with/look at dispatching device	Driver interacts with or looks at a dispatching device. The driver usually keeps the device on the passenger seat or on the floor between the two seats and holds the device on his/her lap or steering wheel while in use. Assumes driver is looking at and may reach for object.	Tertiary Task	Complex
Look at map	Driver reads a map which is visible in the driver's hands, on the driver's lap, on the driver's steering wheel, or on the passenger seat. Assumes driver is looking at and may reach for object.	Tertiary Task	Complex
Other—Complex	Driver is engaging in an other complex task	Tertiary Task	Complex
Read book, newspaper, paperwork, etc.	Driver reads a book, newspaper, paperwork, etc, which is visible in the driver's hands, on the driver's lap, on the driver's steering wheel, or on the passenger seat. Assumes driver is looking at and may reach for object.	Tertiary Task	Complex
Text message on cell phone	Driver appears to be text messaging using a cell phone. Driver is focusing on the cell phone for an extended amount of time while continuously pressing keys. Assumes driver is looking at and may reach for object.	Tertiary Task	Complex
Use calculator	Driver uses hand-held calculator. Assumes driver is looking at and may reach for object.	Tertiary Task	Complex
Write on pad, notebook, etc.	Driver writes on some kind of paper which is visible in the driver's hands, on the driver's lap, on the driver's steering wheel, or on the passenger seat. Assumes driver is looking at and may reach for object.	Tertiary Task	Complex

Task	Definition	Task Category	Manual/Visual Complexity
Eating	Driver eats with or without a utensil (i.e., fork or spoon). This also includes the driver opening a food bag or anything closely related to eating just prior to or after the trigger. Assumes driver is looking at and may reach for object.	Tertiary Task	Moderate
Look at outside vehicle, animal, object	Driver looks outside the vehicle to another vehicle. May be out the front windshield or side window. Must be apparent that driver is focused on outside vehicle.	Tertiary Task	Moderate
Look back in Sleeper Berth	Driver turns body to look behind him/her into the Sleeper Berth.	Tertiary Task	Moderate
Other—moderate	Driver is engaging in a other moderate task	Tertiary Task	Moderate
Personal grooming	Driver is grooming him/herself. This may include combing/fixing hair, applying make-up, shaving, and brushing teeth. Assumes driver is looking at and may reach for object.	Tertiary Task	Moderate
Reach for object in vehicle	Driver may or may not remove attention from the forward roadway to reach for an object inside the vehicle. Objects may include, but are not limited to, cell phone, CB, food, drink, map, paperwork. This option should only be marked if the driver is not engaging in any other behavior at the same time.	Tertiary Task	Moderate
Smoking-related behavior—reaching, lighting, extinguishing	Driver is reaching (ashing), lighting, or extinguishing a cigarette. May include behaviors such as driver reaching for a lighter or reaching for a pack of cigarettes. Assumes driver is looking at and may reach for object.	Tertiary Task	Moderate
Talk or listen to CB radio	Driver talks or listens to a CB radio. Assumes driver is looking at and may reach for object.	Tertiary Task	Moderate
Talk or listen to hand-held phone	Driver holds a hand-held phone to ear, appears to be talking and/or listening.	Tertiary Task	Moderate
Talk or listen to hands-free phone	Driver talks or listens to a hands-free phone. This is apparent by an earpiece in the driver's ear.	Tertiary Task	Moderate
Use/reach for other device	Driver reaches for or uses an alternate electronic device. Assumes driver is looking at and may reach for object.	Tertiary Task	Moderate

Task	Definition	Task Category	Manual/Visual Complexity
Adjust instrument panel	Driver is adjusting something on the instrument panel. This may include, radio, climate controls, head lights, and other switches to the front and right of the driver. Assumes driver is reaching for and/or looking at the instrument panel while adjusting.	Tertiary Task	Simple
Bite nails/cuticles	Driver is biting nails and/or cuticles. Assumes driver is looking at hands.	Tertiary Task	Simple
Drink from a container	Driver drinks from a container. This also includes the driver opening/closing a drink container or anything closely related to drinking just prior to or after the trigger. Assumes driver is looking at and may reach for object.	Tertiary Task	Simple
Interact with or look at other occupant(s)	Driver is talking to a passenger sitting in the passenger's seat or in the sleeper berth that can be identified by the person encroaching into the camera view or the driver is clearly looking and talking to the passenger.	Tertiary Task	Simple
Other—simple	Driver is engaging in a other simple task	Tertiary Task	Simple
Other personal hygiene	Driver is conducting some kind of other personal hygiene. This may include rubbing eyes/face, scratching face/neck, or picking nose.	Tertiary Task	Simple
Put on/remove/adjust hat	Driver puts on, removes, or adjusts his/her hat. Assumes driver is looking at and may reach for object.	Tertiary Task	Simple
Put on/remove/adjust seat belt	Driver puts on, removes, or adjusts his/her seat belt. Assumes driver is looking at and may reach for object.	Tertiary Task	Simple
Put on/remove/adjust sunglasses or reading glasses	Driver puts on, removes, or adjusts his/her sunglasses. Assumes driver is looking at and may reach for object.	Tertiary Task	Simple
Remove/adjust jewelry	Driver is removing or adjusting jewelry. This may include, watch, bracelet, necklace or earrings. Assumes driver is looking at and may reach for object.	Tertiary Task	Simple
Smoking-related behavior—cigarette in hand or mouth	Driver has a cigarette in hand or mouth.	Tertiary Task	Simple

Task	Definition	Task Category	Manual/Visual Complexity
Talk/sing/dance with no indication of passenger	Driver appears to be vocalizing either to an unknown passenger, to self, or singing to the radio. Also, in this category are instances where the driver exhibits dancing behavior or is whistling.	Tertiary Task	Simple
Use chewing tobacco	Driver is using chewing tobacco. This may include putting tobacco into mouth or spitting into container. Assumes driver is looking at and may reach for object.	Tertiary Task	Simple
Check speedometer	Driver glances directly down to the speedometer. Must be apparent that the driver is looking at the speedometer and not in lap.	Secondary Task	N/A
Look at left-side mirror/out left window	Driver looks at the left-side mirror or out the left window for a driving-related reason (i.e., checking traffic before a lane change or turn).	Secondary Task	N/A
Look at right-side mirror/out left window	Driver looks at the right-side mirror or out the right window for a driving-related reason (i.e., checking traffic before a lane change or turn).	Secondary Task	N/A

APPENDIX D. T TEST TABLES

Post hoc Tukey *t* tests were conducted on all pair-wise combinations of event types to determine simple effects. The results of all these pair-wise *t* tests can be found in the following tables.

Table 83. Mean Duration of Eyes off Forward Roadway—Any Task—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	22616	1.31	0.686	21913	3.26	0.010
Crash and Crash-Relevant Conflict	22616	1.65	0.463	21913	3.96	0.001
Crash and Unintentional Lane Deviation	22616	2.27	0.156	21913	1.69	0.439
Crash and Baseline	22616	3.36	0.007	21913	5.61	< 0.0001
Near-Crash and Crash-Relevant Conflict	22616	0.79	0.935	21913	1.72	0.422
Near-Crash and Unintentional Lane Deviation	22616	9.95	< 0.0001	21913	5.25	< 0.0001
Near-Crash and Baseline	22616	5.76	0.001	21913	6.99	< 0.0001
Crash-Relevant Conflict and Unintentional Lane Deviation	22616	23.81	< 0.0001	21913	18.95	< 0.0001
Crash-Relevant Conflict and Baseline	22616	18.05	< 0.0001	21913	22.15	< 0.0001
Unintentional Lane Deviation and Baseline	22616	39.30	< 0.0001	21913	39.51	< 0.0001

Table 84. Mean Duration of Eyes off Forward Roadway—All Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	8277	1.62	0.485	8098	0.86	0.911
Crash and Crash-Relevant Conflict	8277	2.46	0.101	8098	1.14	0.788
Crash and Unintentional Lane Deviation	8277	5.05	< 0.0001	8098	0.31	0.998
Crash and Baseline	8277	0.13	1.000	8098	2.44	0.105
Near-Crash and Crash-Relevant Conflict	8277	1.11	0.804	8098	0.78	0.937
Near-Crash and Unintentional Lane Deviation	8277	5.70	< 0.0001	8098	1.91	0.314
Near-Crash and Baseline	8277	3.10	0.017	8098	5.11	< 0.0001
Crash-Relevant Conflict and Unintentional Lane Deviation	8277	14.81	< 0.0001	8098	10.46	< 0.0001
Crash-Relevant Conflict and Baseline	8277	19.50	< 0.0001	8098	23.31	< 0.0001
Unintentional Lane Deviation and Baseline	8277	34.97	< 0.0001	8098	35.19	< 0.0001

Table 85. Mean Duration of Eyes off Forward Roadway—Complex Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Near-Crash and Crash-Relevant Conflict	492	0.23	0.996	487	0.10	1.000
Near-Crash and Unintentional Lane Deviation	492	0.16	0.999	487	0.16	0.999
Near-Crash and Baseline	492	0.59	0.934	487	0.61	0.930
Crash-Relevant Conflict and Unintentional Lane Deviation	492	1.98	0.196	487	1.29	0.568
Crash-Relevant Conflict and Baseline	492	1.85	0.252	487	2.58	0.050
Unintentional Lane Deviation and Baseline	492	4.14	0.0002	487	4.23	0.0002

Table 86. Mean Duration of Eyes off Forward Roadway—Moderate Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	4218	0.30	0.998	4123	1.40	0.628
Crash and Crash-Relevant Conflict	4218	0.65	0.966	4123	1.80	0.371
Crash and Unintentional Lane Deviation	4218	2.78	0.044	4123	0.97	0.869
Crash and Baseline	4218	0.86	0.911	4123	2.83	0.038
Near-Crash and Crash-Relevant Conflict	4218	0.47	0.990	4123	0.77	0.940
Near-Crash and Unintentional Lane Deviation	4218	3.72	0.002	4123	1.30	0.688
Near-Crash and Baseline	4218	1.93	0.304	4123	3.37	0.007
Crash-Relevant Conflict and Unintentional Lane Deviation	4218	8.68	< 0.0001	4123	6.42	< 0.0001
Crash-Relevant Conflict and Baseline	4218	10.15	< 0.0001	4123	12.19	< 0.0001
Unintentional Lane Deviation and Baseline	4218	17.51	< 0.0001	4123	17.57	< 0.0001

Table 87. Mean Duration of Eyes off Forward Roadway—Simple Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	2063	1.34	0.665	–	–	–
Crash and Crash-Relevant Conflict	2063	1.74	0.407	–	–	–
Crash and Unintentional Lane Deviation	2063	3.29	0.009	–	–	–
Crash and Baseline	2063	0.87	0.906	–	–	–
Near-Crash and Crash-Relevant Conflict	2063	0.23	0.999	2009	2.03	0.177
Near-Crash and Unintentional Lane Deviation	2063	2.57	0.077	2009	1.07	0.706
Near-Crash and Baseline	2063	1.11	0.801	2009	3.10	0.011
Crash-Relevant Conflict and Unintentional Lane Deviation	2063	7.64	< 0.0001	2009	5.39	< 0.0001
Crash-Relevant Conflict and Baseline	2063	6.79	< 0.0001	2009	8.79	< 0.0001
Unintentional Lane Deviation and Baseline	2063	14.35	< 0.0001	2009	14.37	< 0.0001

Table 88. Mean Duration of Eyes off Forward Roadway—Secondary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	4704	2.48	0.094	4495	2.20	0.179
Crash and Crash-Relevant Conflict	4704	3.76	0.002	4495	3.77	0.002
Crash and Unintentional Lane Deviation	4704	2.23	0.170	4495	2.27	0.156
Crash and Baseline	4704	4.41	0.0001	4495	4.49	< 0.0001
Near-Crash and Crash-Relevant Conflict	4704	3.29	0.009	4495	3.10	0.017
Near-Crash and Unintentional Lane Deviation	4704	0.81	0.929	4495	0.14	1.000
Near-Crash and Baseline	4704	5.29	< 0.0001	4495	4.82	< 0.0001
Crash-Relevant Conflict and Unintentional Lane Deviation	4704	5.72	< 0.0001	4495	5.47	< 0.0001
Crash-Relevant Conflict and Baseline	4704	6.10	< 0.0001	4495	5.73	0.031
Unintentional Lane Deviation and Baseline	4704	8.73	< 0.0001	4495	8.89	< 0.0001

Table 89. Mean Number of Glances Away from Forward Roadway—Any Task—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	22616	0.48	0.989	21913	0.98	0.863
Crash and Crash-Relevant Conflict	22616	0.17	1.000	21913	1.13	0.788
Crash and Unintentional Lane Deviation	22616	2.27	0.156	21913	0.21	1.000
Crash and Baseline	22616	1.33	0.674	21913	2.28	0.153
Near-Crash and Crash-Relevant Conflict	22616	0.96	0.874	21913	0.34	0.997
Near-Crash and Unintentional Lane Deviation	22616	7.58	< 0.0001	21913	3.80	0.001
Near-Crash and Baseline	22616	2.39	0.117	21913	3.98	0.001
Crash-Relevant Conflict and Unintentional Lane Deviation	22616	14.82	< 0.0001	21913	11.30	< 0.0001
Crash-Relevant Conflict and Baseline	22616	12.31	< 0.0001	21913	15.38	< 0.0001
Unintentional Lane Deviation and Baseline	22616	25.16	< 0.0001	21913	25.19	< 0.0001

Table 90. Mean Number of Glances Away from Forward Roadway—All Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	8277	1.73	0.417	8098	0.11	1.000
Crash and Crash-Relevant Conflict	8277	2.50	0.091	8098	0.08	1.000
Crash and Unintentional Lane Deviation	8277	4.26	0.0002	8098	0.62	0.972
Crash and Baseline	8277	0.80	0.930	8098	0.89	0.908
Near-Crash and Crash-Relevant Conflict	8277	0.95	0.875	8098	0.11	1.000
Near-Crash and Unintentional Lane Deviation	8277	4.09	0.0004	8098	1.67	0.454
Near-Crash and Baseline	8277	2.11	0.215	8098	0.87	0.908
Crash-Relevant Conflict and Unintentional Lane Deviation	8277	10.11	< 0.0001	8098	6.94	< 0.0001
Crash-Relevant Conflict and Baseline	8277	14.25	< 0.0001	8098	16.92	< 0.0001
Unintentional Lane Deviation and Baseline	8277	24.66	< 0.0001	8098	24.71	< 0.0001

Table 91. Mean Number of Glances Away from Forward Roadway—Complex Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Near-Crash and Crash-Relevant Conflict	492	0.79	0.857	487	0.86	0.825
Near-Crash and Unintentional Lane Deviation	492	0.88	0.815	487	0.88	0.813
Near-Crash and Baseline	492	1.21	0.619	487	1.22	0.616
Crash-Relevant Conflict and Unintentional Lane Deviation	492	0.43	0.973	487	0.10	1.000
Crash-Relevant Conflict and Baseline	492	2.13	0.146	487	1.79	0.282
Unintentional Lane Deviation and Baseline	492	1.83	0.260	487	1.84	0.257

Table 92. Mean Number of Glances Away from Forward Roadway—Moderate Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	4218	0.80	0.931	4123	0.19	1.000
Crash and Crash-Relevant Conflict	4218	1.09	0.812	4123	0.31	0.999
Crash and Unintentional Lane Deviation	4218	2.70	0.055	4123	0.36	0.996
Crash and Baseline	4218	0.10	1.000	4123	0.96	0.873
Near-Crash and Crash-Relevant Conflict	4218	0.24	0.999	4123	0.25	0.999
Near-Crash and Unintentional Lane Deviation	4218	2.72	0.051	4123	1.41	0.621
Near-Crash and Baseline	4218	1.33	0.674	4123	1.92	0.309
Crash-Relevant Conflict and Unintentional Lane Deviation	4218	6.61	< 0.0001	4123	5.15	< 0.0001
Crash-Relevant Conflict and Baseline	4218	6.64	< 0.0001	4123	7.83	< 0.0001
Unintentional Lane Deviation and Baseline	4218	12.56	< 0.0001	4123	12.56	< 0.0001

Table 93. Mean Number of Glances Away from Forward Roadway—Simple Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	2063	1.26	0.713	–	–	–
Crash and Crash-Relevant Conflict	2063	1.46	0.591	–	–	–
Crash and Unintentional Lane Deviation	2063	2.57	0.077	–	–	–
Crash and Baseline	2063	0.69	0.959	–	–	–
Near-Crash and Crash-Relevant Conflict	2063	0.07	1.000	2009	1.97	0.200
Near-Crash and Unintentional Lane Deviation	2063	1.61	0.489	2009	1.32	0.551
Near-Crash and Baseline	2063	1.26	0.719	2009	2.89	0.020
Crash-Relevant Conflict and Unintentional Lane Deviation	2063	5.48	< 0.0001	2009	3.65	0.002
Crash-Relevant Conflict and Baseline	2063	6.00	< 0.0001	2009	7.59	< 0.0001
Unintentional Lane Deviation and Baseline	2063	11.14	< 0.0001	2009	11.14	< 0.0001

Table 94. Mean Number of Glances Away from Forward Roadway—Secondary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	4704	0.23	0.999	4495	0.41	0.994
Crash and Crash-Relevant Conflict	4704	0.20	1.000	4495	0.28	0.999
Crash and Unintentional Lane Deviation	4704	0.81	0.926	4495	0.82	0.925
Crash and Baseline	4704	0.23	0.999	4495	0.228	0.999
Near-Crash and Crash-248Relevant Conflict	4704	0.13	1.000	4495	0.38	0.996
Near-Crash and Unintentional Lane Deviation	4704	1.43	0.607	4495	0.79	0.934
Near-Crash and Baseline	4704	1.40	0.630	4495	1.56	0.523
Crash-Relevant Conflict and Unintentional Lane Deviation	4704	2.46	0.101	4495	2.10	0.219
Crash-Relevant Conflict and Baseline	4704	4.07	0.001	4495	4.13	0.0004
Unintentional Lane Deviation and Baseline	4704	4.38	0.001	4495	4.39	0.0001

Table 95. Mean Duration of Longest Glance Away from Forward Roadway—Any Task—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	22616	2.60	0.070	21913	5.36	< 0.0001
Crash and Crash-Relevant Conflict	22616	3.58	0.003	21913	6.40	< 0.0001
Crash and Unintentional Lane Deviation	22616	0.34	0.997	21913	4.49	< 0.0001
Crash and Baseline	22616	5.00	< 0.0001	21913	7.75	< 0.0001
Near-Crash and Crash-Relevant Conflict	22616	2.39	0.118	21913	2.51	0.089
Near-Crash and Unintentional Lane Deviation	22616	6.51	< 0.0001	21913	3.36	0.007
Near-Crash and Baseline	22616	6.56	0.001	21913	6.83	< 0.0001
Crash-Relevant Conflict and Unintentional Lane Deviation	22616	19.57	< 0.0001	21913	15.90	< 0.0001
Crash-Relevant Conflict and Baseline	22616	14.93	< 0.0001	21913	18.07	< 0.0001
Unintentional Lane Deviation and Baseline	22616	32.36	< 0.0001	21913	32.76	< 0.0001

Table 96. Mean Duration of Longest Glance Away from Forward Roadway—All Tertiary Tasks— across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	8277	0.82	0.926	8098	1.94	0.295
Crash and Crash-Relevant Conflict	8277	1.14	0.784	8098	2.46	0.100
Crash and Unintentional Lane Deviation	8277	3.20	0.012	8098	1.82	0.363
Crash and Baseline	8277	0.69	0.958	8098	3.50	0.004
Near-Crash and Crash-Relevant Conflict	8277	0.38	0.995	8098	2.46	0.100
Near-Crash and Unintentional Lane Deviation	8277	4.03	0.001	8098	0.67	0.962
Near-Crash and Baseline	8277	2.93	0.028	8098	4.87	< 0.0001
Crash-Relevant Conflict and Unintentional Lane Deviation	8277	11.75	< 0.0001	8098	8.19	< 0.0001
Crash-Relevant Conflict and Baseline	8277	15.35	< 0.0001	8098	18.48	< 0.0001
Unintentional Lane Deviation and Baseline	8277	27.64	< 0.0001	8098	27.76	< 0.0001

Table 97. Mean Duration of Longest Glance Away from Forward Roadway—Complex Tertiary Tasks— across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Near-Crash and Crash-Relevant Conflict	492	1.55	0.409	487	1.47	0.459
Near-Crash and Unintentional Lane Deviation	492	1.35	0.534	487	1.35	0.530
Near-Crash and Baseline	492	2.17	0.132	487	2.19	0.129
Crash-Relevant Conflict and Unintentional Lane Deviation	492	1.06	0.714	487	0.60	0.933
Crash-Relevant Conflict and Baseline	492	3.16	0.009	487	3.60	0.002
Unintentional Lane Deviation and Baseline	492	4.57	< 0.0001	487	4.59	< 0.0001

Table 98. Mean Duration of Longest Glance Away from Forward Roadway—Moderate Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	4218	0.77	0.939	4123	2.43	0.108
Crash and Crash-Relevant Conflict	4218	0.55	0.982	4123	2.86	0.035
Crash and Unintentional Lane Deviation	4218	0.90	0.898	4123	2.33	0.136
Crash and Baseline	4218	1.79	0.379	4123	3.70	0.002
Near-Crash and Crash-Relevant Conflict	4218	0.55	0.982	4123	0.66	0.966
Near-Crash and Unintentional Lane Deviation	4218	2.75	0.048	4123	0.659	0.965
Near-Crash and Baseline	4218	1.39	0.635	4123	2.77	0.044
Crash-Relevant Conflict and Unintentional Lane Deviation	4218	5.88	< 0.0001	4123	4.07	0.001
Crash-Relevant Conflict and Baseline	4218	8.24	< 0.0001	4123	9.92	< 0.0001
Unintentional Lane Deviation and Baseline	4218	12.83	< 0.0001	4123	12.86	< 0.0001

Table 99. Mean Duration of Longest Glance Away from Forward Roadway—Simple Tertiary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	2063	1.34	0.665	–	–	–
Crash and Crash-Relevant Conflict	2063	1.74	0.407	–	–	–
Crash and Unintentional Lane Deviation	2063	3.29	0.009	–	–	–
Crash and Baseline	2063	0.87	0.907	–	–	–
Near-Crash and Crash-Relevant Conflict	2063	0.23	0.999	2009	1.76	0.294
Near-Crash and Unintentional Lane Deviation	2063	2.57	0.077	2009	0.72	0.890
Near-Crash and Baseline	2063	1.11	0.801	2009	2.59	0.048
Crash-Relevant Conflict and Unintentional Lane Deviation	2063	7.64	< 0.0001	2009	5.86	< 0.0001
Crash-Relevant Conflict and Baseline	2063	6.79	< 0.0001	2009	6.83	< 0.0001
Unintentional Lane Deviation and Baseline	2063	14.35	< 0.0001	2009	13.29	< 0.0001

Table 100. Mean Duration of Longest Glance Away from Forward Roadway—Secondary Tasks—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Crash and Near-crash	4704	5.17	< 0.0001	4495	5.09	< 0.0001
Crash and Crash-Relevant Conflict	4704	6.94	< 0.0001	4495	7.33	< 0.0001
Crash and Unintentional Lane Deviation	4704	5.27	< 0.0001	4495	5.56	< 0.0001
Crash and Baseline	4704	7.52	< 0.0001	4495	7.93	< 0.0001
Near-Crash and Crash-Relevant Conflict	4704	4.34	0.0001	4495	4.10	0.0004
Near-Crash and Unintentional Lane Deviation	4704	0.07	1.000	4495	0.34	0.997
Near-Crash and Baseline	4704	6.12	< 0.0001	4495	5.484	< 0.0001
Crash-Relevant Conflict and Unintentional Lane Deviation	4704	5.98	< 0.0001	4495	6.25	< 0.0001
Crash-Relevant Conflict and Baseline	4704	5.24	< 0.0001	4495	4.45	< 0.0001
Unintentional Lane Deviation and Baseline	4704	9.64	< 0.0001	4495	9.10	< 0.0001

Table 101. Complex Tertiary Tasks—Text Messaging—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Text Messaging and Baseline with Text Messaging	22617	1.09	0.694	21914	1.31	0.557
Event with Text Messaging and Event without Text Messaging	22617	11.29	< 0.0001	21914	10.81	< 0.0001
Event with Text Messaging and Baseline without Text Messaging	22617	14.65	< 0.0001	21914	15.03	< 0.0001
Baseline with Text Messaging and Event without Text Messaging	22617	3.95	0.001	21914	3.58	0.002
Baseline with Text Messaging and Baseline without Text Messaging	22617	5.47	< 0.0001	21914	5.52	< 0.0001
Event without Text Messaging and Baseline without Text Messaging	22617	33.75	< 0.0001	21914	39.17	< 0.0001

**Table 102. Complex Tertiary Task—Other—
across All Events and Vehicle 1 At-Fault (V1) Events**

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Other—Complex Tertiary Task and Baseline with Other—Complex Tertiary Task	22617	0.34	0.987	21914	0.34	0.986
Event with Other—Complex Tertiary Task and Event without Other—Complex Tertiary Task	22617	5.46	< 0.0001	21914	5.04	< 0.0001
Event with Other—Complex Tertiary Task and Baseline without Other—Complex Tertiary Task	22617	7.24	< 0.0001	21914	7.31	< 0.0001
Baseline with Other—Complex Tertiary Task and Event without Other—Complex Tertiary Task	22617	3.45	0.003	21914	3.14	0.009
Baseline with Other—Complex Tertiary Task and Baseline without Other—Complex Tertiary Task	22617	4.70	< 0.0001	21914	4.75	< 0.0001
Event without Other—Complex Tertiary Task and Baseline without Other—Complex Tertiary Task	22617	34.45	< 0.0001	21914	39.95	< 0.0001

**Table 103. Complex Tertiary Task—Interact with Dispatching Device—
across All Events and Vehicle 1 At-Fault (V1) Events**

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Interact with Dispatching Device and Baseline with Interact with Dispatching Device	22617	2.46	0.067	21914	2.75	0.030
Event with Interact with Dispatching Device and Event without Interact with Dispatching Device	22617	20.59	< 0.0001	21914	19.08	< 0.0001
Event with Interact with Dispatching Device and Baseline without Interact with Dispatching Device	22617	27.00	< 0.0001	21914	27.97	< 0.0001
Baseline with Interact with Dispatching Device and Event without Interact with Dispatching Device	22617	27.64	< 0.0001	21914	10.27	< 0.0001
Baseline with Interact with Dispatching Device and Baseline without Interact with Dispatching Device	22617	16.23	< 0.0001	21914	16.37	< 0.0001
Event without Interact with Dispatching Device and Baseline without Interact with Dispatching Device	22617	31.28	< 0.0001	21914	36.44	< 0.0001

Table 104. Complex Tertiary Task—Write on pad, notebook, etc. — across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Writing and Baseline with Writing	22617	1.63	0.360	21914	1.65	0.352
Event with Writing and Event without Writing	22617	9.07	< 0.0001	21914	8.28	< 0.0001
Event with Writing and Baseline without Writing	22617	12.24	< 0.0001	21914	12.35	< 0.0001
Baseline with Writing and Event without Writing	22617	4.62	< 0.0001	21914	4.05	0.0003
Baseline with Writing and Baseline without Writing	22617	6.96	< 0.0001	21914	7.03	< 0.0001
Event without Writing and Baseline without Writing	22617	34.01	< 0.0001	21914	39.45	< 0.0001

Table 105. Complex Tertiary Task—Use Calculator— across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Use Calculator and Baseline with Use Calculator	22617	1.93	0.217	21914	1.95	0.029
Event with Use Calculator and Event without Use Calculator	22617	6.11	< 0.0001	21914	5.64	< 0.0001
Event with Use Calculator and Baseline without Use Calculator	22617	8.10	< 0.0001	21914	8.18	< 0.0001
Baseline with Use Calculator and Event without Use Calculator	22617	1.96	0.201	21914	1.61	< 0.0001
Baseline with Use Calculator and Baseline without Use Calculator	22617	3.37	0.004	21914	3.40	< 0.0001
Event without Use Calculator and Baseline without Use Calculator	22617	34.37	< 0.0001	21914	39.86	< 0.0001

Table 106. Complex Tertiary Task—Look at Map—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Look at Map and Baseline with Look at Map	22617	0.93	0.787	21914	0.94	0.782
Event with Look at Map and Event without Look at Map	22617	10.02	< 0.0001	21914	9.02	< 0.0001
Event with Look at Map and Baseline without Look at Map	22617	14.13	< 0.0001	21914	14.26	< 0.0001
Baseline with Look at Map and Event without Look at Map	22617	7.55	< 0.0001	21914	6.67	< 0.0001
Baseline with Look at Map and Baseline without Look at Map	22617	11.14	< 0.0001	21914	11.25	< 0.0001
Event without Look at Map and Baseline without Look at Map	22617	33.81	< 0.0001	21914	39.23	< 0.0001

Table 107. Complex Tertiary Task—Dial Cell Phone—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Dial Cell Phone and Baseline with Dial Cell Phone	22617	3.43	0.003	21914	3.74	0.001
Event with Dial Cell Phone and Event without Dial Cell Phone	22617	16.28	< 0.0001	21914	14.81	< 0.0001
Event with Dial Cell Phone and Baseline without Dial Cell Phone	22617	22.98	< 0.0001	21914	23.23	< 0.0001
Baseline with Dial Cell Phone and Event without Dial Cell Phone	22617	10.36	< 0.0001	21914	8.82	< 0.0001
Baseline with Dial Cell Phone and Baseline without Dial Cell Phone	22617	16.41	< 0.0001	21914	16.56	< 0.0001
Event without Dial Cell Phone and Baseline without Dial Cell Phone	22617	32.29	< 0.0001	21914	37.56	< 0.0001

Table 108. Complex Tertiary Task—Read book, newspaper, etc. — across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Reading and Baseline with Reading	22617	2.46	0.066	21914	2.53	0.055
Event with Reading and Event without Reading	22617	17.37	< 0.0001	21914	15.98	< 0.0001
Event with Reading and Baseline without Reading	22617	23.11	< 0.0001	21914	23.26	< 0.0001
Baseline with Reading and Event without Reading	22617	15.23	< 0.0001	21914	13.72	< 0.0001
Baseline with Reading and Baseline without Reading	22617	21.45	< 0.0001	21914	21.65	< 0.0001
Event without Reading and Baseline without Reading	22617	33.02	< 0.0001	21914	38.32	< 0.0001

Table 109. Moderate Tertiary Tasks—Use/Reach for Other Electronic Device— across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Use/Reach for Other Electronic Device and Baseline with Use/Reach for Other Electronic Device	22617	5.07	< 0.0001	21914	4.99	< 0.0001
Event with Use/Reach for Other Electronic Device and Event without Use/Reach for Other Electronic Device	22617	5.76	< 0.0001	21914	4.98	< 0.0001
Event with Use/Reach for Other Electronic Device and Baseline without Use/Reach for Other Electronic Device	22617	7.85	< 0.0001	21914	7.52	< 0.0001
Baseline with Use/Reach for Other Electronic Device and Event without Use/Reach for Other Electronic Device	22617	1.74	0.302	21914	2.23	0.116
Baseline with Use/Reach for Other Electronic Device and Baseline without Use/Reach for Other Electronic Device	22617	0.03	1.000	21914	0.03	1.000
Event without Use/Reach for Other Electronic Device and Baseline without Use/Reach for Other Electronic Device	22617	34.34	< 0.0001	21914	39.86	< 0.0001

Table 110. Moderate Tertiary Tasks—Other—
across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Other—Moderate Tertiary Task and Baseline with Other—Moderate Tertiary Task	22617	2.72	0.033	21914	2.75	0.030
Event with Other—Moderate Tertiary Task and Event without Other—Moderate Tertiary Task	22617	4.19	0.0002	21914	3.56	0.002
Event with Other—Moderate Tertiary Task and Baseline without Other—Moderate Tertiary Task	22617	6.70	< 0.0001	21914	6.76	< 0.0001
Baseline with Other—Moderate Tertiary Task and Event without Other—Moderate Tertiary Task	22617	0.16	0.999	21914	0.69	0.903
Baseline with Other—Moderate Tertiary Task and Baseline without Other—Moderate Tertiary Task	22617	1.83	0.260	21914	1.85	0.252
Event without Other—Moderate Tertiary Task and Baseline without Other—Moderate Tertiary Task	22617	34.36	< 0.0001	21914	39.86	< 0.0001

Table 111. Moderate Tertiary Tasks—Personal Grooming—
across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Personal Grooming and Baseline with Personal Grooming	22617	5.66	< 0.0001	21914	5.72	< 0.0001
Event with Personal Grooming and Event without Personal Grooming	22617	4.71	< 0.0001	21914	4.20	0.0002
Event with Personal Grooming and Baseline without Personal Grooming	22617	6.80	< 0.0001	21914	6.86	< 0.0001
Baseline with Personal Grooming and Event without Personal Grooming	22617	3.29	0.006	21914	3.87	0.001
Baseline with Personal Grooming and Baseline without Personal Grooming	22617	1.21	0.619	21914	1.22	0.611
Event without Personal Grooming and Baseline without Personal Grooming	22617	34.37	< 0.0001	21914	39.87	< 0.0001

Table 112. Moderate Tertiary Tasks—Reach for Object—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Reach for Object and Baseline with Reach for Object	22617	11.41	< 0.0001	21914	12.68	< 0.0001
Event with Reach for Object and Event without Reach for Object	22617	12.21	< 0.0001	21914	10.99	< 0.0001
Event with Reach for Object and Baseline without Reach for Object	22617	22.28	< 0.0001	21914	23.41	< 0.0001
Baseline with Reach for Object and Event without Reach for Object	22617	1.10	0.687	21914	4.89	< 0.0001
Baseline with Reach for Object and Baseline without Reach for Object	22617	14.16	< 0.0001	21914	14.29	< 0.0001
Event without Reach for Object and Baseline without Reach for Object	22617	31.68	< 0.0001	21914	36.75	< 0.0001

Table 113. Moderate Tertiary Tasks—Look Back in Sleeper Berth—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Look Back in Sleeper Berth and Baseline with Look Back in Sleeper Berth	22617	11.41	< 0.0001	21914	3.12	0.010
Event with Look Back in Sleeper Berth and Event without Look Back in Sleeper Berth	22617	12.21	< 0.0001	21914	4.41	< 0.0001
Event with Look Back in Sleeper Berth and Baseline without Look Back in Sleeper Berth	22617	22.28	< 0.0001	21914	7.31	< 0.0001
Baseline with Look Back in Sleeper Berth and Event without Look Back in Sleeper Berth	22617	1.10	0.687	21914	0.74	0.881
Baseline with Look Back in Sleeper Berth and Baseline without Look Back in Sleeper Berth	22617	14.16	< 0.0001	21914	4.67	< 0.0001
Event without Look Back in Sleeper Berth and Baseline without Look Back in Sleeper Berth	22617	31.68	< 0.0001	21914	39.91	< 0.0001

Table 114. Moderate Tertiary Tasks—Smoking–Lighting—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Smoking—Lighting and Baseline with Smoking—Lighting	22617	1.26	0.590	21914	2.16	0.136
Event with Smoking—Lighting and Event without Smoking—Lighting	22617	0.01	0.999	21914	0.54	0.950
Event with Smoking—Lighting and Baseline without Smoking—Lighting	22617	2.92	0.019	21914	3.67	0.001
Baseline with Smoking—Lighting and Event without Smoking—Lighting	22617	3.70	0.001	21914	5.99	< 0.0001
Baseline with Smoking—Lighting and Baseline without Smoking—Lighting	22617	5.17	< 0.0001	21914	5.22	< 0.0001
Event without Smoking—Lighting and Baseline without Smoking—Lighting	22617	34.77	< 0.0001	21914	40.24	< 0.0001

Table 115. Moderate Tertiary Tasks—Talk/Listen to CB—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Talk/Listen to CB and Baseline with Talk/Listen to CB	22617	1.63	0.363	21914	1.60	0.381
Event with Talk/Listen to CB and Event without Talk/Listen to CB	22617	3.46	0.003	21914	3.46	0.003
Event with Talk/Listen to CB and Baseline without Talk/Listen to CB	22617	0.49	0.962	21914	0.64	0.918
Baseline with Talk/Listen to CB and Event without Talk/Listen to CB	22617	15.17	< 0.0001	21914	18.16	< 0.0001
Baseline with Talk/Listen to CB and Baseline without Talk/Listen to CB	22617	3.73	0.001	21914	3.76	0.001
Event without Talk/Listen to CB and Baseline without Talk/Listen to CB	22617	34.58	< 0.0001	21914	40.11	< 0.0001

Table 116. Moderate Tertiary Tasks—External Distraction—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with External Distraction and Baseline with External Distraction	22617	6.19	< 0.0001	21914	7.74	< 0.0001
Event with External Distraction and Event without External Distraction	22617	1.46	0.460	21914	0.01	1.000
Event with External Distraction and Baseline without External Distraction	22617	19.04	< 0.0001	21914	19.16	< 0.0001
Baseline with External Distraction and Event without External Distraction	22617	9.05	< 0.0001	21914	15.77	< 0.0001
Baseline with External Distraction and Baseline without External Distraction	22617	32.18	< 0.0001	21914	32.53	< 0.0001
Event without External Distraction and Baseline without External Distraction	22617	38.28	< 0.0001	21914	43.70	< 0.0001

Table 117. Moderate Tertiary Tasks—Talk/Listen to Hands-Free Phone—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Talk/Listen to Hands-Free Phone and Baseline with Talk/Listen to Hands-Free Phone	22617	4.01	0.0004	21914	4.12	0.0002
Event with Talk/Listen to Hands-Free Phone and Event without Talk/Listen to Hands-Free Phone	22617	2.27	0.106	21914	2.49	0.061
Event with Talk/Listen to Hands-Free Phone and Baseline without Talk/Listen to Hands-Free Phone	22617	3.33	0.005	21914	3.52	0.002
Baseline with Talk/Listen to Hands-Free Phone and Event without Talk/Listen to Hands-Free Phone	22617	19.32	< 0.0001	21914	23.39	< 0.0001
Baseline with Talk/Listen to Hands-Free Phone and Baseline without Talk/Listen to Hands-Free Phone	22617	2.76	0.030	21914	2.79	0.027
Event without Talk/Listen to Hands-Free Phone and Baseline without Talk/Listen to Hands-Free Phone	22617	34.28	< 0.0001	21914	39.83	< 0.0001

Table 118. Moderate Tertiary Tasks—Put on/remove/adjust sunglasses or glasses—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Put on/remove/adjust sunglasses or glasses and Baseline with Put on/remove/adjust sunglasses or glasses	22617	3.24	0.007	21914	3.95	0.001
Event with Put on/remove/adjust sunglasses or glasses and Event without Put on/remove/adjust sunglasses or glasses	22617	1.37	0.519	21914	1.50	0.438
Event with Put on/remove/adjust sunglasses or glasses and Baseline without Put on/remove/adjust sunglasses or glasses	22617	4.59	< 0.0001	21914	5.35	< 0.0001
Baseline with Put on/remove/adjust sunglasses or glasses and Event without Put on/remove/adjust sunglasses or glasses	22617	3.46	0.003	21914	4.55	< 0.0001
Baseline with Put on/remove/adjust sunglasses or glasses and Baseline without Put on/remove/adjust sunglasses or glasses	22617	0.56	0.945	21914	0.56	0.943
Event without Put on/remove/adjust sunglasses or glasses and Baseline without Put on/remove/adjust sunglasses or glasses	22617	34.44	< 0.0001	21914	39.92	< 0.0001

Table 119. Moderate Tertiary Tasks—Adjust Sunglasses—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Adjust Instrument Panel and Baseline with Adjust Instrument Panel	22617	5.31	< 0.0001	21914	6.80	< 0.0001
Event with Adjust Instrument Panel and Event without Adjust Instrument Panel	22617	6.78	< 0.0001	21914	6.39	0.0002
Event with Adjust Instrument Panel and Baseline without Adjust Instrument Panel	22617	14.61	< 0.0001	21914	15.74	< 0.0001
Baseline with Adjust Instrument Panel and Event without Adjust Instrument Panel	22617	2.00	0.187	21914	1.82	0.263
Baseline with Adjust Instrument Panel and Baseline without Adjust Instrument Panel	22617	18.14	< 0.0001	21914	18.32	< 0.0001
Event without Adjust Instrument Panel and Baseline without Adjust Instrument Panel	22617	34.29	< 0.0001	21914	39.56	< 0.0001

Table 120. Simple Tertiary Tasks—Other Personal Hygiene—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Other Personal Hygiene and Baseline with Other Personal Hygiene	22617	5.84	< 0.0001	21914	6.72	< 0.0001
Event with Other Personal Hygiene and Event without Other Personal Hygiene	22617	5.24	< 0.0001	21914	6.40	< 0.0001
Event with Other Personal Hygiene and Baseline without Other Personal Hygiene	22617	5.45	< 0.0001	21914	6.38	< 0.0001
Baseline with Other Personal Hygiene and Event without Other Personal Hygiene	22617	25.06	< 0.0001	21914	30.23	< 0.0001
Baseline with Other Personal Hygiene and Baseline without Other Personal Hygiene	22617	1.86	0.245	21914	1.88	0.237
Event without Other Personal Hygiene and Baseline without Other Personal Hygiene	22617	34.28	< 0.0001	21914	39.89	< 0.0001

Table 121. Simple Tertiary Tasks—Bite Nails—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Bite Nails and Baseline with Bite Nails	22617	0.83	0.838	21914	1.02	0.738
Event with Bite Nails and Event without Bite Nails	22617	2.77	0.029	21914	2.65	0.041
Event with Bite Nails and Baseline without Bite Nails	22617	0.32	0.989	21914	0.02	1.000
Baseline with Bite Nails and Event without Bite Nails	22617	12.01	< 0.0001	21914	14.18	< 0.0001
Baseline with Bite Nails and Baseline without Bite Nails	22617	4.00	0.0004	21914	4.04	< 0.0001
Event without Bite Nails and Baseline without Bite Nails	22617	34.60	< 0.0001	21914	40.12	< 0.0001

Table 122. Simple Tertiary Tasks—Interact with Other Occupant(s)—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Interact with Other Occupant(s) and Baseline with Interact with Other Occupant(s)	22617	1.33	0.543	21914	1.50	0.440
Event with Interact with Other Occupant(s) and Event without Interact with Other Occupant(s)	22617	0.03	1.000	21914	0.35	0.985
Event with Interact with Other Occupant(s) and Baseline without Interact with Other Occupant(s)	22617	2.73	0.032	21914	2.78	0.028
Baseline with Interact with Other Occupant(s) and Event without Interact with Other Occupant(s)	22617	4.85	< 0.0001	21914	7.39	< 0.0001
Baseline with Interact with Other Occupant(s) and Baseline without Interact with Other Occupant(s)	22617	4.98	< 0.0001	21914	5.03	< 0.0001
Event without Interact with Other Occupant(s) and Baseline without Interact with Other Occupant(s)	22617	34.79	< 0.0001	21914	40.30	< 0.0001

Table 123. Secondary Tasks—Look at Left Mirror/Out Left Window—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Left Mirror/Window and Baseline with Left Mirror/Window	22617	8.58	< 0.0001	21914	9.21	< 0.0001
Event with Left Mirror/Window and Event without Left Mirror/Window	22617	3.90	0.0006	21914	0.30	0.990
Event with Left Mirror/Window and Baseline without Left Mirror/Window	22617	27.67	< 0.0001	21914	26.30	< 0.0001
Baseline with Left Mirror/Window and Event without Left Mirror/Window	22617	6.33	< 0.0001	21914	14.25	< 0.0001
Baseline with Left Mirror/Window and Baseline without Left Mirror/Window	22617	36.90	< 0.0001	21914	37.30	0.001
Event without Left Mirror/Window and Baseline without Left Mirror/Window	22617	35.89	< 0.0001	21914	42.45	< 0.0001

Table 124. Secondary Tasks—Look at Right Mirror/Out Right Window—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Right Mirror/Window and Baseline with Right Mirror/Window	22617	4.64	< 0.0001	21914	4.14	0.0002
Event with Right Mirror/Window and Event without Right Mirror/Window	22617	4.81	< 0.0001	21914	1.25	0.592
Event with Right Mirror/Window and Baseline without Right Mirror/Window	22617	18.93	< 0.0001	21914	15.68	< 0.0001
Baseline with Right Mirror/Window and Event without Right Mirror/Window	22617	0.10	1.000	21914	6.53	< 0.0001
Baseline with Right Mirror/Window and Baseline without Right Mirror/Window	22617	30.81	< 0.0001	21914	31.13	< 0.0001
Event without Right Mirror/Window and Baseline without Right Mirror/Window	22617	35.97	< 0.0001	21914	42.57	< 0.0001

Table 125. Secondary Tasks—Check Speedometer—across All Events and Vehicle 1 At-Fault (V1) Events

Event Type	ALL: df	ALL: *t*-value	ALL: p-value	V1: df	V1: *t*-value	V1: p-value
Event with Check Speedometer and Baseline with Check Speedometer	22617	1.98	0.194	21914	2.78	0.028
Event with Check Speedometer and Event without Check Speedometer	22617	0.98	0.763	21914	1.83	0.259
Event with Check Speedometer and Baseline without Check Speedometer	22617	7.26	< 0.0001	21914	7.68	< 0.0001
Baseline with Check Speedometer and Event without Check Speedometer	22617	9.10	< 0.0001	21914	14.71	< 0.0001
Baseline with Check Speedometer and Baseline without Check Speedometer	22617	18.71	< 0.0001	21914	18.90	< 0.0001
Event without Check Speedometer and Baseline without Check Speedometer	22617	36.71	< 0.0001	21914	42.12	< 0.0001

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This paper discusses the results of two studies conducted to evaluate the usability of a heads-up display (HUD). The first study, a field study, had participants driving a test vehicle equipped with two heads-down displays and a HUD. Participants were asked to read road signs and control speed limits on the displays. Results found that 85 percent of participants "accept and desire" the HUD while driving. The second study investigated the layout of the HUD and found that participants needed 4.9 s to mentally conceive four new symbols.

Abdel-Aty, M. (2003). Investigating the relationship between cellular phone use and traffic safety. *ITE* (Institute of Transportation Engineers) *Journal*, 73(10):38–42.

This investigation discusses the effects of cellular phone use on driver behavior and safety on the road. Study results show no significant difference in using hands-free mobile technology as opposed to a handheld cellular phone. Driver errors were shown to increase once a driver is distracted with using the cellular phone, and the dangers of using a cellular phone are still evident even after finishing a phone conversation on the road. In terms of truck driving safety, cellular phone use is identified as a secondary task. It is considered a driver distraction and may lead to vehicle crashes and near-crashes.

Barr, L.C., Yang, C.Y.D., Hanowski, R.J., & Olson, R. (2005). Assessment of driver fatigue, distraction, and performance in a naturalistic setting. *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 1937:51–60. Retrieved August 23, 2007, from: http://trb.metapress.com/content/h716785086k1g603/

This study focused on the effects of fatigue and drowsiness on driving performance in a naturalistic setting. Results show that higher levels of fatigue were found in younger and less experienced drivers and also drowsiness was twice as likely to occur between 6:00 a.m. and 9:00 a.m. The drowsy events were observed in a naturalistic setting in an effort to find effective countermeasures for drowsy driving and reduce fatality rates as drowsiness and driver fatigue may be identified as distracters in driving performance.

Beede, K.E., & Kass, S.J. (2006). Engrossed in conversation: The impact of cell phones on simulated driving performance. *Accident Analysis and Prevention*, 38(2):415–421.

The research examined distracted driving behavior and its effects on transportation safety. More specifically, the impact of cellular phones on driving performance indicates increased driver error in areas such as traffic violations, lane position maintenance, divided attention, and delayed response. These driver errors are also common among commercial vehicle drivers, in which distraction such as cell phone use can lead to dangerous vehicle crashes.

Blanco, M., Hickman, J.S., Olson, R.L., Bocanegra, J.L., Hanowski, R.J., Nakata, A., Greening, M., Madison, P., Holbrook, G.T., & Bowman, D. (in press). Investigating critical incidents, driver restart period, sleep quantity, and crash countermeasures in commercial vehicle operations using naturalistic data collection. Washington DC: Federal Motor Carrier Safety Administration, USDOT.

This report presents the results of an on-road naturalistic driving data collection effort to investigate light vehicle-heavy vehicle (LV-HV) interactions and other safety issues related to CMV crash risk. Three primary focus areas were work/rest parameters relating to driver fatigue and incident involvement, event causation, and LV-HV interaction and applicable functional countermeasures. The primary goal of this on-road study was to investigate crashes, near-crashes, and crash-relevant conflicts from the HV driver's perspective to help determine functional countermeasures.

Bunn, T.L., Slavova, S., Struttmann, T.W., & Browning, S.R. (2005). Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries. *Accident Analysis and Prevention*, 37(5):862–869.

This population-based case-control study observed fatigue and sleepiness as an element of inattention and driver distraction. Studies conducted determined that these factors greatly increased likelihood of fatalities in commercial motor vehicle collisions. Various factors contributed to identifying crashes as fatal, such as driver sleepiness/fatigue, distraction/inattention, ages of drivers, and the nonuse or misuse of safety belts. Safety belt law enactment and enforcement for all states and driver education focusing on fatigue and distraction for commercial vehicle drivers may decrease chances of commercial vehicle fatalities.

Consiglio, W., Driscoll, P., Witte, M., & Berg, W.P. (2003). Effect of cellular telephone conversations and other potential interference on reaction time in a braking response. *Accident Analysis and Prevention*, 35(4):495–500.

This study focused on the effect of cellular telephone conversations on driver behavior. Reaction time in braking response was affected by in-car telephone conversations, listening to the radio, and talking with a passenger. Hand-held phones and hands-free phones were found to have similar effect on reaction time, causing it to slow, whereas tasks such as listening to the radio did not show signs of slowing reaction time.

Cooper, P.J., & Zheng, Y. (2002). Turning gap acceptance decision-making: the impact of driver distraction. *Journal of Safety Research*, 33(3):321–335.

This experiment in driver distraction was specific to turning gap acceptance. Participants were exposed to a number of gaps in a stream of traffic and were given the task of deciding on a safe gap to turn left. The subjects experienced both dry and wet road conditions and were studied on their cognitive decision-making while being distracted by various tasks. Results showed that although the scenario was very artificial, the act of turning into a stream of traffic while being distracted significantly increased unsafe decision making.

Crundall, D. Van Loon, E., & Underwood, G. (2006). Attraction and distraction of attention with roadside advertisements. *Accident Analysis & Prevention*, 38(4):671-677.

Roadside distractions such as raised-level advertisements (RLAs) and street-level advertisements (SLAs) act as agents in driver distraction, as shown in this study. Roadside advertisements have a tendency to distract passing drivers, therefore affecting their ability to control the vehicle. The effect of this distraction was studied on a number of participants primed to attend to the advertisements in the study. SLAs were found to elicit longer fixations than RLAs and were more likely to distract.

De Waard, D., Brookhuis, K.A., & Hernández-Gress, N. (2001). The feasibility of detecting phone-use related driver distraction. *International Journal of Vehicle Design*, 26(1 special issue):85–95.

Similar to work by Abdel-Aty (above), this study observed 20 participants in a driving simulator under two conditions: 1) driving in normal conditions, and 2) driving while engaged in a cell phone conversation. Results showed deteriorated driving performance while drivers handled cell phone conversations.

Dingus, T.A., Antin, J.F., Hulse, M.C. & Wierwille, W.W. (1989). Attentional demand requirements of an automobile moving map navigation system. *Transportation Research, Part A: Policy and Practice*, 23A(4):301–315.

The objective of this research was to assess the driver visual attentional demand requirements of an operational in-car navigation system. Thirty-two driver subjects, aged 18–73 years, drove a specially instrumented vehicle on various types of public roadways with varying traffic conditions. Results show that the demand of most of the navigation tasks was comparable to that of one or more conventional tasks. Modifying the remaining navigation tasks to make information more readily available would reduce their demand

Dingus, T., Neale, V., Garness, S., Hanowski, R., Keisler, A., Lee, S., Perez, M., Robinson, G., Belz, S., Casali, J., Pace-Schott, E., Stickgold, R., & Hobson, J. (2002). Impact of sleeper berth usage on driver fatigue: Final report (Document No. FMCSA-RT-02-050). Washington, DC: Federal Motor Carrier Safety Administration, USDOT.

This report summarizes issues on driving safety and fatigue, resulting from a literature review and 10 focus groups. Specifically, the study focused on understanding the perspective of long-haul drivers, as opposed to Hanowski, Wierwille, Garness, and Dingus (2000, below). Focus groups results reveal concerns by drivers that include, but are not limited to, the quality of equipment, team driving, the lack of rest areas, driver education, cargo, and the pressure to drive. The results from the literature review and focus groups reveal a need for an on-road study to further evaluate and confirm the possible effects of fatigue.

Fuse, T., Matsunaga, K., Shidoji, K., Matsuki, Y., & Umezaki, K. (2001). The cause of traffic accidents when drivers use car phones and the functional requirements of car phones for safe driving. *International Journal of Vehicle Design*, 26(1 special issue):48–56.

The effects of cell phone use on driving behavior are examined in this study. Three situations were studied to measure reaction time: 1) cell phone conversation with a handset, 2) cell phone conversation during a manual task with handset, and 3) eyes on the road during a manual task with a handset. Results showed that the most significant effect of the car phone came from diverted visual attention rather than phone operation and conversation. This effect greatly influences truck safety, as complete visual attention is imperative in operating a CMV.

Goodman, M.J., Tijerina, L., Bents, F.D., & Wierwille, W.W. (1999). Using cellular telephones in vehicles: Safe or unsafe? *Transportation Human Factors*, I(1):3–42.

In this study, limited crash data revealed that the complexity of the conversation was the principal factor associated with most crashes. As opposed to dialing, hanging up, or reaching for the telephone, the complexity of the conversation proved to create a much greater risk for accidents; however, the general use of a cellular telephone in a vehicle increases risk of accidents and deteriorates driving performance.

Greenberg, J., Tijerina, L., Curry, R., Artz, B., Cathey, L., Kochhar, D., Kozak, K., Blommer, M., & Grant, P. (2003). Driver distraction: Evaluation with event detection paradigm. *Transportation Research Record*, 1843:1–9. Retrieved August 23, 2007, from: http://pubsindex.trb.org/document/view/default.asp?lbid=682271

Eight in-vehicle tasks and their effects on driver distraction were observed in this study. The study monitored participants of ages 16–66 as they coordinated cell phone tasks, took in sudden movements outside of the vehicle in surrounding traffic, tuned the radio, and adjusted the climate control. Performance of these in-vehicle tasks were compared between the adult group and the teenage group. Results showed the teens having poor vehicle control skills and are more prone to distraction than the adult group. These in-vehicle tasks are also seen as hazards in CMV safety and can lead to unsafe truck driving habits.

Hancock, P.A., Simmons, L., Hashemi, L., Howarth, H., & Ranney, T. (1999). The effects of in-vehicle distraction on driver response during a crucial driving maneuver. *Transportation Human Factors*, 1(4):295–309.

This study observed 10 volunteer drivers as they performed 60 repeated circuits on a light-controlled closed-loop test track. The study primarily observed the effects of an in-vehicle distracter (a telephone, number-matching task) on driver reaction. Vehicle speeds varied between approximately 20 to 30 mi/h. Results showed slower brake response times due to the presence of distracters. In addition, the margin of safety was significantly reduced by about 25 percent. These in-vehicle distracters can greatly affect reaction times for CMVs as they decrease the margin of safety.

Hancock, P.A., Lesch, M., & Simmons, L. (2003). The distraction effects of phone use during a crucial driving maneuver. *Accident Analysis and Prevention*, 35(4):501–514.

The study observed 42 drivers on a test track facilities. These participants were required to respond to an in-vehicle phone while negotiating a crucial stopping decision. To compensate for slowed response times, participants braked more intensely. An increased number of stop-light violations also resulted when participants were taken on the open road. The authors concluded that in-vehicle technologies such as telephones deteriorate driving performance and is a crucial concern for drivers of all vehicles and all in-vehicle device designers.

Hanowski, R.J. (2009). When Driving, Vision is King (commentary). In Knipling, R.R. (Ed.) *Safety for the Long Haul: Large Truck Crash Risk, Causation, & Prevention*. Arlington, VA: American Trucking Associations.

In this commentary, the author stresses the importance of visual attention while driving. He cites data from the 100-Car study (Klauer et al., 2006), which found that eye glances away from the forward roadway for greater than 2 s significantly increase the risk of a driver being involved in a crash or near-crash. The need for visual attention also applies to CMV drivers as traffic conflicts were more likely to occur in heavy traffic.

Hanowski, R.J., Blanco, M., Nakata, A., Hickman, J.S., Schaudt, W.A., Fumero, M.C., Olson, R.L., Jermeland, J., Greening, M., Holbrook, G.T., Knipling, R.R., & Madison, P. (2008). The drowsy driver warning system field operational test, data collection final report (Report No. DOT HS 810 035). Washington, DC: National Highway Traffic Safety Administration, USDOT. Retrieved August 26, 2009, from: http://www.nhtsa.gov/staticfiles/DOT/NHTSA/NRD/Multimedia/PDFs/Crash%20Avoidance/2008/810035.pdf

The focus of this report is the description of the data collection procedures of a naturalistic field operational test (FOT) to determine the safety benefits and operational capabilities, limitations, and characteristics of a driver fatigue monitor. Forty-six trucks, operated by 103 drivers, were instrumented with a data acquisition system that recorded more than 100 data variables. Other collected measures were video, actigraphy, and questionnaires. Drivers were randomly assigned to either control (24 drivers) or experimental groups (79 drivers).

Hanowski, R.J., Perez, M.A., & Dingus, T.A. (2005). Driver distraction in long-haul truck drivers. *Transportation Research Part F*, 8(6):441-458.

The study investigated driver fatigue during trucking operations via naturalistic data on 41 drivers collected as they worked their normal routes. The data collected from the study were used to examine a variety of fatigue-related factors in trucking operations. “Incident type” classifications were developed surrounding crashes or near-crashes for the data. One classification was “driver distraction,” which was identified as a causal factor for incidents involving long-haul trucks.

Hanowski, R.J., Wierwille, W.W., Garness, S.A., & Dingus, T.A. (2000). Impact of local/short haul operations of driver fatigue: Final report (Report no. DOT-MC-00-201). Washington, DC: Federal Motor Carrier Safety Administration, USDOT.

Before research for this particular report was conducted, focus groups assessed local/short-haul (L/SH) drivers and their concerns on safety and fatigue on the road. An on-road field study with 42 drivers was then conducted, the primary objective of which was to determine the significance of the presence of fatigue in L/SH operations. Results indicate fatigue was not caused by the job presented to the driver, but rather brought with the driver to the job. The results of the research have been used to help address fatigue and other safety issues involved in L/SH operations.

Harbluk, J.L., Noy, Y.I., & Eizenman, M. (2002). The impact of cognitive distraction on driver visual behaviour and vehicle control. TP# 13889 E. Ottawa, Canada: Transport Canada.

Twenty-one drivers participated in this on-road study in which they drove a designated route while performing difficult addition tasks, easy addition tasks, or no tasks; all tasks were communicated through a hands-free cell phone so drivers never had to remove their eyes from the forward roadway. Results show that while participants were under conditions of increased cognitive load, they spent less time checking instruments and the rear view mirror and also changed their inspection patterns of the forward view. In addition, drivers had more incidences of hard braking while experiencing an increased cognitive workload.

Hashemi, L., Simmons, L.A., Howarth, H.D., & Hancock, P.A. (1998). Effects of an in-vehicle distractor upon driver performance. *Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting*, 2:1626.

The effects of in-vehicle distracters were observed in this study, in which 10 participants drove on a closed test-track. Results revealed a slow reaction time among the drivers in response to changing of stoplights at a light-controlled stop. Once realizing a light change, more intense braking and a decreased stopping time occurred. In handling CMVs, the intense braking would cause a hazardous situation in that the larger and heavier commercial vehicles require a longer stopping time.

Hickman, J.S., Kipling, R.R., Olson, R.L., Fumero, M.C., Blanco, M., & Hanowski, R.J. (in press). Heavy vehicle-light vehicle interaction data collection and countermeasure research project: Preliminary analysis of data collected in the drowsy driver warning system field operational test. Washington, DC: FMCSA, USDOT.

This project instrumented vehicles to collect data used to improve aspects of CMV safety. These aspects include but are not limited to safety events, traffic conflict assessments, and light vehicle-heavy vehicle interactions. The report includes data collected in the Drowsy Driver Warning System Field Operational Test (DDWS FOT) between May 2004 and May 2005, and provides extensive data for the analysis of heavy-vehicle safety and driver risk.

Horrey, W.J., Wickens, C.D., & Consalus, K.P. (2006). Modeling drivers' visual attention allocation while interacting with in-vehicle technologies. *Journal of Experimental Psychology: Applied*, 12(2):67–78.

The authors completed two experiments to examine a simulated traffic environment and driver performance on in-vehicle tasks. The first experiment dealt with task priority; the second experiment examined task complexity, introducing infrequent traffic hazards. Overall, this study emphasized in-vehicle tasks and their impact on driver distraction. These in-vehicle tasks and task priorities increased scanning in both experiments and also challenged lane keeping. In-vehicle tasks are also a major influence in hazards for

CMVS, which are much larger and more difficult to control under the influence of such in-vehicle tasks.

Just, M.A., Keller, T.A., & Cynkar, J. (2008). A decrease in brain activation associated with driving when listening to someone speak. *Brain Research* Apr 18(1205):70–80.

In this study, the authors used brain imaging to determine the effects of language comprehension on driving. Data were collected using a driving simulator; participants were asked to drive a curving road either undisturbed or while listening to spoken sentences that they judged as true or false. Results show that listening to the spoken sentences significantly decreased the driving accuracy and provides support for the idea that cognitive distraction plays a significant role is driver distraction as drivers were not using a hand-held device.

Kantowitz, B. (1995). Simulator evaluation of heavy-vehicle driver workload. *Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting*.

In this study, the author reviews heavy-vehicle driver workload among 12 CMV drivers using a simulator module. Reaction time and the immediate recall of a 7-digit auditory number were found to provide effective measures of the driver workload. Overall, primary-task performance measures were relatively uninfluenced by the addition of a secondary task within a driving simulator.

Kass, S.J., Cole, K.S., & Stanny, C.J. (2007). Effects of distraction and experience on situation awareness and simulated driving. *Transportation Research Part F: Traffic Psychology and Behaviour*, 10(4):321-329.

This study observed cell phone conversations as a driver distraction and the impact cell phones have on situation awareness. A sample of 25 novice drivers, aged 14–16, and 26 experienced drivers, aged 21–52, were examined using a driving simulator where situation awareness was assessed. Subjects were observed using a driving simulator in which hands-free cell phone conversations were simulated. Novice drivers were found to make more driver errors than experienced drivers when faced with cell phone conversations. Regardless of the driver's experience behind the wheel, these results are relevant in many driving situations, including CMV safety and in-vehicle distractions. Cell phones, hands-free or hand-held, still prove to be a major distraction for many vehicles.

Klauer, S.G., Dingus, T.A., Neale, V.L., Sudweeks, J.D., & Ramsey, D.J. (2006). The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data. Washington, DC: National Highway Traffic Safety Administration, USDOT. Retrieved August 26, 2009, from: http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/NRD/Multimedia/PDFs/Crash%20Avoidance/Driver%20Distraction/810594.pdf

In the 100-Car Driving Study, naturalistic driving data were collected to evaluate near-crash/crash risks involving drowsy drivers. These authors later evaluated the data to find results indicating drowsy drivers have four- to six-times higher near-crash/crash risks than alert drivers. Drivers distracted by visually and/or manually complex tasks had a three-times higher near-crash/crash risk than attentive drivers.

Laberge, J., Scialfa, C., White, C., & Caird, J. (2004). Effects of passenger and cellular phone conversations on driver distraction. *Transportation Research Record*, (1899):109-116.

This study examined the distracting effects of cellular phone conversations in vehicles. A sample of 80 participants was assigned to one of three driving conditions: 1) driving alone in a vehicle, 2) driving with a passenger, and 3) driving with a simulated cellular phone conversation. Contrary to other experiments, little evidence was found in which passengers had to adjust phone conversations due to traffic demands in the surrounding environment. The results of this experiment indicate a possible need for further research; however, this study still indicates that increased driving demands influence lane and speed maintenance, which can impact driver behavior in CMVs.

Laberge-Nadeau, C., Maag, U., Bellavance, F., Lapierre, S.D., Desjardins, D., Messier, S., & Saidi, A. (2003). Wireless telephones and the risk of road crashes. *Accident Analysis and Prevention*, 35(5):649–660.

A questionnaire and letter of consent was sent from the Societe de l'Assurance Automobile du Quebec (SAAQ) to 175,000 license holders for passenger vehicles. Questionnaire recipients were asked about exposure to risk, driving habits, opinions of hazardous driving activities, and accidents occurring in the last 24 months. The SAAQ received over 36,000 completed questionnaires and were provided with various company files for four wireless phone companies to verify the association between cell phone use and accidents. Overall, results from the study have shown the association between higher crash risks and cell phone use is justified.

Llaneras, R.E., & Singer, J.P. (2002). Inventory of In-Vehicle Technology Human Factors Design Characteristics (Document No. DOT HS 809 457). Washington, DC: National Highway Traffic Safety Administration, USDOT. Retrieved August 26, 2009, from: http://www.nhtsa.gov/staticfiles/DOT/NHTSA/NRD/Multimedia/PDFs/Human%20Factors/Reducing%20Unsafe%20behaviors/DOT%20HS%20809%20457.pdf

This is a review of an inventory of in-vehicle devices to better understand their design and implementation. The authors reviewed 80 in-vehicle devices, focusing on human factors characteristics and interface features. Results indicated that devices tend to incorporate a large number of features and options, creating a potential challenge for drivers to learn all of the capabilities of a system and resulting in lengthy manuals. Although devices also tended to provide large amounts of information, some designs may allow for increased information presentation without necessarily sacrificing performance. Warnings or cautions against interacting with systems while driving were common; however, relatively few systems disable equipment when vehicles are in operation. A number of other observations and "industry trends" are presented and discussed.

Llaneras, R.E., Singer, J.P., & Bowers-Carnahan, R. (2005). Assessment of truck driver distraction problem and research needs. Washington, DC: National Highway Traffic Safety Administration, USDOT. Retrieved August 26, 2009, from: http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/14260.htm

The issue of driver distraction associated with the use of in-vehicle devices in heavy vehicles was explored through interviews with truck drivers and safety regulators. In order to characterize some of the interface designs and better understand their interaction demands, a sample of commercially available in-vehicle devices was examined. The extent to which these devices conformed to available human factors guidelines and accepted practices was assessed analytically. Industry device design and evaluation practices were also explored via contacts with equipment suppliers and industry original equipment manufacturers (OEMs). Truck driver distraction is perceived by many drivers and safety regulators to be a problem, although it is not generally viewed as a high priority issue. Fleet-based communication devices, which include text-based messaging functions, are widely available and used by the industry. These devices can potentially impose high levels of attentional demand if used while driving since they require numerous inputs and multi-line text displays which have been shown to impair driving performance. Manufacturers of these types of systems tend to provide the capability to restrict driver interactions with these systems while driving (e.g., lock-out the ability to read or send text messages); our interactions with drivers in our sample suggests that many organizations do not necessarily elect to fully implement these restrictions, and there is no uniformly adopted practice for dealing with these types of devices. Product developers and OEMs appear to involve drivers in product development and testing (primarily in order to ensure their products conform to the customers needs); however, objective testing to evaluate the attentional demands of devices may not be widely used.

Mannering, F. L., Kilareski, W. P., & Washburn, S. S. (2004). *Principles of Highway Engineering and Traffic Analysis* (3rd ed.). Hoboken, NJ: John Wiley & Sons, pp. 170-219.

[From the back cover] Given the continual and dramatic increase in vehicle ownership and travel, and the sheer number of people affected by our nation's highway system, there are few more important and far-reaching fields than highway engineering. Rather than addressing the broad expanse of the transportation engineering field, this book focuses primarily on highway and traffic engineering, providing the depth needed to solve real highway-related problems. Taking a concise, accessible, example-oriented approach, the authors bring clarity to the subject matter.

Patten, C.J.D., Kircher, A., Östlund, J., & Nilsson, L. (2004). Using mobile telephones: Cognitive workload and attention resource allocation. *Accident Analysis and Prevention*, 36(3):341–350.

This study examined the effects of mobile telephone conversations while driving. Forty participants were observed while operating a motor vehicle and engaged a phone conversation. The study focused on determining the effects of the conversation type versus the phone type itself. Results showed that the type of conversation the participant was having affected his/her control over the vehicle much more than the effect of the type of phone being used. The complexity of a phone conversation was more likely to have a significant effect on the driver's performance than whether or not the device being used was hand-held or hands-free. Overall, both of these effects can lead to driver distraction.

Pedhazur, E. J. (1997). *Multiple Regression in Behavioral Research: Explanation and Prediction* (3rd ed.). Fort Worth, TX: Harcourt Brace College Publishers

An introduction book to linear regressions, this book contains chapters on variance partitioning, analysis of effect, categorical independent variables, curvilinear regression analysis, Attribute-Treatment Interaction, analysis of covariance, multilevel analysis, and logistic regression.

Pettitt, M., Burnett, G., & Stevens, A. (2005). Defining driver distraction. Paper presented at World Congress on the Intelligent Transport Systems. San Francisco, CA.

Unlike other articles cited here, this paper discusses issues surrounding the creation of a precise definition of driver distraction as opposed to its specific causes and effects. The growing interest and concerns from the research community in driver distraction have created the need to reliably monitor the problem; however, there is a need to correctly and comprehensively define the term. To properly define the term, accident statistics on work-related road traffic accidents, specifically from the United Kingdom, have been gathered and assessed. The authors found that driving-related distraction should be discussed in terms of: 1) the difference between distraction and inattention, 2) distraction within and outside of the vehicle, 3) categorization of distraction, and 4) the effects on driving performance. A comprehensive definition of driver distraction is presented.

McEvoy, S.P., Stevenson, M.R., & Woodward, M. (2007). The prevalence of and factors associated with, serious crashes involving a distracting activity. *Accident Analysis and Prevention*, 39(3):475-482.

This study began with a survey of 1,367 drivers in western Australia who were hospitalized after a vehicle crash between April 2002 and July 2004. The questionnaire results reveal that more than 30 percent of the hospitalized drivers took part in at least one distracting activity at the time of their accident. These distracting activities include carrying on a conversation with passengers, lack of concentration, and external factors (e.g., road conditions). Results show that such injuries will decrease with stricter enforcement of existing laws and new devices such as collision warning systems. Additionally, an increase in driver awareness can decrease the likelihood of crashes relating to distracted driving.

McEvoy, S.P., Stevenson, M.R., McCart, A.T., Woodward, M., Haworth, C., Palamara, P., & Cercarelli, R. (2005). Role of mobile phones in motor vehicle crashes resulting in hospital attendance: A case-crossover study. *BMJ*, 2005 Aug 20;331(7514):428.

This study investigated drivers who had been hospitalized as a result of a crash. Participants were interviewed and phone records were identified for the approximate time of the crash and for trips during the same time of day in the week prior to the crash. Results show that drivers who were using a cell phone up to 10 minutes prior to the crash were four times as likely to be involved in a crash than times when they were not using a cell phone. Results also show that risk increased regardless of whether drivers were using a hands-free phone or hand-held phone.

McKnight, A.J., & McKnight, A.S. (1993). The effect of cellular phone use upon driver attention. *Accident Analysis and Prevention*, 25(3):259-265.

Complexity of cellular phone conversations is examined in a random sample of 150 participants observed in a 25-minute long driving simulation of 45 traffic situations under the following conditions: 1) placing a phone call, 2) having a casual conversation, 3) having an intense phone conversation, 4) tuning a radio, and 5) no distraction. All of these conditions led to significant increases in the number of situations where the subjects failed to respond. Responses in driver error varied by age, as participants older than 50 revealed many non-responses to cell phone distractions. Many younger participants were affected when driving while involved in an intense and complex conversation. The complexity of a cellular phone conversation may lead to higher likelihood in driver error.

Rakauskas, M.E., Gugerty, L.J., & Ward, N.J. (2004). Effects of naturalistic cell phone conversations on driving performance. *Journal of Safety Research*, 35(4):453-464.

In this study, a driving simulator was used to observe easy and difficult phone conversations and their effects on participants. Results show that intense cell phone conversation caused the driver to vary speeds more frequently. This research has concluded that the increasing use of cell phones in motor vehicles, especially CMVs, can cause disruptions in business and add to injury, disability, and personnel loss.

Ranney, T.A., Mazzai, E., Garrott, R., & Goodman, M.J. (2000). NHTSA Driver distraction research: Past, present, and future. Washington, DC: National Highway Traffic Safety Administration, USDOT. Retrieved August 26, 2009, from: http://www-nrd.nhtsa.dot.gov/departments/Human%20Factors/driver-distraction/PDF/233.PDF

This report focuses on rising concerns about distracted driving and its potential to increase with the introduction of new in-vehicle technologies. The National Highway Traffic Safety Administration (NHTSA) conducted research on driver distraction to understand the contributing factors and to develop methods to curb it. These authors define driver distraction as an activity that takes part or all of the driver's attention away from driving. This paper reviews past research performed by NHTSA on CMV driver workload, as there are many distractions (e.g., satellite tracking, wireless phones or CBs, and route guidance systems). The authors also outline further investigations to be performed on distracted driving to increase awareness of potential safety problems associated with the use of in-vehicle technologies.

Redelmeier, D.A., & Tibshirani, R.J. (1997). Association between cellular-telephone calls and motor vehicle crashes. *The New England Journal of Medicine*, 336(7):453–458.

This study of 699 drivers took place over a 14-month period to observe the risks of collision when using a cellular phone. During the study period, 26,798 cell phone calls were placed, resulting in a collision risk four times higher than when a phone was not being used by the driver. Overall, the association of use of a cellular telephone while driving was confirmed to be associated to a risk of a crash. Also, no safety advantages were seen when observing hands-free versus hand-held cell phones. Both versions were found to have an impact on driving performance and reaction times to traffic signals and external driving conditions. This study is not specific in terms of types of motor vehicles being driven.

Regan, M.A., Lee, J.D., & Young, K.L. (2009). *Driver distraction: Theory, effects, and mitigation*. Boca Raton, FL: CRC Press.

[From back cover] This book provides a comprehensive overview of this important road safety problem. It defines distraction, explains the mechanisms underlying it, reviews its effects on driving performance and safety, suggests practical strategies for mitigating its effects, and provides directions for future research. It brings together into one, all-inclusive, volume the wide array of literature on the topic.

Sahai, H., & Khurshid, A. (1996). *Statistics in Epidemiology: Methods, Techniques, and Applications*. Boca Raton, FL: CRC Press.

[From back cover] This book covers the broad range of data analytic topics in epidemiology. Written for epidemiologists and other researchers without extensive backgrounds in statistics, this new book provides a clear and concise description of statistical tools used in epidemiology. The book can be used as a text for students enrolled graduate programs in epidemiology, biostatistics and public health, as well as being a valuable reference for health science professionals and researchers.

Sayer, J.R, Devonshire, J.M., & Flanagan, C.A. (2007). Naturalistic driving performance during secondary tasks. *Proceedings of the Fourth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*.

This FOT investigates safety impacts of an integrated lane-departure system and curve-speed warning system. Video clips from 36 drivers were analyzed and secondary behaviors were identified. Researchers measured how often and how long drivers were not looking at the forward roadway and variability of steering wheel angle, lane position, speed and throttle position. Results show that drivers engage in secondary behaviors in about one-third of the video clips, with talking to a passenger being the most frequent. Glance durations away from the forward roadway were the shortest when drivers were talking on a cell phone. Overall, secondary behaviors showed little effect on basic driving performance.

Schattler, K.L., Pellerito Jr., J., McAvoy, D., & Datta, T.K. (2006). Assessing driver distraction from cell phone use: A simulator-based study. *Transportation Research Record*, 1980:87–94.

This study utilized a simulator to observe 37 drivers and their performance while handling a cell phone. The simulator engaged participants in typical real-life driving conditions and included a hand-held cell phone and scripted conversation with researchers. Drivers were instructed to handle conditions such as traffic signs and signals, pedestrians, and turns. Driver performance scores were significantly lower while subjects were using cell phones.

Shinar, D., Tractinsky, N., & Compton, R. (2005). Effects of practice, age, and task demands, on interference from a phone task while driving. *Accident Analysis and Prevention*, 37(2):315–326.

This experimental research revised an earlier study to better simulate real-world driving situations via a simulated driving environment. The simulator involved repeated experiences of a participant driving with multiple cell phone tasks of varying intensities. Although it is known that driving while holding a cell phone conversation decreases driving performance, results of this experiment revealed that with continued practice at multitasking while driving, the negative effects of multitasking would not be as severe, especially for experienced drivers.

Shutko, J., Mayer, J., Laansoo, E., & Tijerina, L. (2009). Driver workload effects of cell phone, music player, and text messaging tasks with the Ford SYNC voice interface versus handheld visual-manual interfaces (paper presented at SAE World Congress & Exhibition, April 2009, Detroit, MI). Warrendale, PA: Society of Automotive Engineers International. As of August 26, 2009, available online via: http://www.sae.org/technical/papers/2009-01-0786

This research utilized a driving simulator to compare driver performance and eye glance behavior while participants performed various tasks using a voice-activated system available in Ford vehicles. Twenty-five participants were asked to perform seven different tasks, once while using the system and once while using their own cell phone and hand-held music player. Results showed that driving distraction (i.e., eyes off road time) was less during the system tasks than during the cell phone and hand-held music player tasks.

Smiley, A. (2005). What is driver distraction? Paper presented at the International Conference on Distracted Driving. Toronto, Ontario.

This naturalistic study of more 100 drivers, vehicles, and 43,000 hours showed that distraction is a major factor in crashes. Numerous crashes and near-crashes resulted from this study; video footage revealed distraction in 78 percent of the crashes and 65 percent of the near-crashes. The report identifies distraction as “misallocated attention,” in which the driver’s focus is not solely on the driving task or environment. Forms of distraction, such as visual and auditory, and the impacts of distraction are also defined. The results indicate the need for further research to determine where the driver’s attention is allocated, if other than on the road. The driving environment must also be assessed, as it is essential to differentiate driving tasks between CMV drivers and light (automobile) drivers.

Strayer, D.L. & Drews, F.A. (2004). Profiles in driver distraction: Effects of cell phone conversations on younger and older drivers. *Human Factors*, 46(4):640–649.

A driving simulator was utilized to study the effects of cell phone use on younger and older drivers. Participants were asked to perform single-tasks conditions (driving-only) and multi-task conditions (driving and talking on a cell phone). There were no significant differences between younger and older participants, however when asked to talk on the cell phone while driving, their reactions were 18 percent slower, the following distance was 12 percent greater, and they took 17 percent longer to recover their speed after braking. The participants were also twice as likely to be involved in a rear-end collision while talking on the cell phone.

Strayer, D.L., Drews, F.A., & Johnston, W.A. (2003). Cell phone-induced failures of visual attention during simulated driving. *Journal of Experimental Psychology*, 9(1):23–32.

A driving simulator was used to examine the effects of hands-free cell phone conversations on driving performance. Driver inattention was analyzed using eye-tracking data to determine if the decreased attention to the visual scene was a form of inattention blindness.

Strayer, D.L. & Johnston, W.A. (2001). Driver to distraction: Dual task studies of simulated driving and conversing on a cellular phone. *Psychological Science*, 12(6)462–466.

This study examined 48 participants in a driving simulator to evaluate the effect of using a cell phone while driving. Participants were asked to engage in various conditions while watching for either a green light, continue, or red light, stop, which was displayed on a computer screen. Participants were asked to engage in a dual-task where they were asked to repeat words that an experimenter read to them over a hand-held cell phone, or they were asked to participate in a word-generation exercise where the experimenter would read a word and the participant was asked to generate a new word that started with the last letter of the previous word, also while using a hand-held cell phone. Results show that participants missed twice as many traffic signals when engaging in cell phone conversations and took longer to react to the signals that they did detect.

Stutts, J., Feaganes, J., Reinfurt, D., Rodgman, E., Hamlett, C., Gish, K., & Staplin, L. (2005). Driver's exposure to distractions in their natural driving environment. *Accident Analysis and Prevention*, 37(6):1093-1101.

This study sampled 70 participating drivers by outfitting vehicles with video cameras to observe drivers' exposure to distractions. As opposed to most studies revealing cell phones to be the greatest distracters, results show the most common distraction to be eating and drinking inside the vehicle. Other common distractions identified were reaching or looking for objects and manipulating vehicle controls.

Stutts, J.C., Reinfurt, D.W., Staplin, L., & Rodgman, E.A. (2001). The role of driver distraction in traffic crashes. Washington, DC: AAA Foundation for Traffic Safety.

This study includes data from the Crashworthiness Data System (CDS) to analyze potential causes for traffic crashes. This report defines driver distraction as a form of inattention, in which the driver may become "lost in thought." In addition to this psychological factor, environmental and situational factors (e.g., varying roadway conditions) play a role in driver distraction. Unlike other studies noted, results revealed that demographic factors, such as age, were found to be a cause for distraction. Driver gender was not found to be as significant when examining demographic factors. Results suggest that additional research may be needed to observe frequency and intensity of various distractions, as new in-vehicle technologies may increase.

Stutts, J.C. & Hunter, W.W. (2003). Driver inattention, driver distraction and traffic crashes. *ITE Journal*, 73(7):34–45.

These authors also used the CDS data to examine the role of driver distraction and its relationship with visual inattention, and the role of distraction to statistics on traffic crashes.

Törnros, J.E.B. and Bolling, A.K. (2005). Mobile phone use: Effects of handheld and handsfree phones on driving performance. *Accident Analysis and Prevention*, 37(5):902–909.

In this study, 48 participants were split into two groups, one group used a hand-held cell phone and the other used a hands-free cell phone; the majority of the participants participated in both a talking experiment and a dialing experiment. Participants were asked to drive two different routes using a driving similar; a longer route in an urban setting for the talking experiment and a shorter, straight route for the dialing experiment. During the talking experiment, participants were asked to use either a hands-free (only had to interact with the phone to pick up and hang up the call) or a hand-held (had to pick up and talk into the phone) cell phone to engage in an addition task. During the dialing experiment, the driver was asked to make a phone call (either on a hands-free or hand-held phone) when they heard the word "ring." Results show that participants engaging in the dialing task had more difficulty maintaining lane position and both the talking and dialing tasks led to reduced vehicle speed.

Treat, JR., Tumbas, N.S., McDonald, S.T., Shinar, D., Hume, RD., Mayer, RE., Stansifer, RL., and Catellan, N.J. (1979). Tri-Level Study of the Causes of Traffic Accidents: Volume I: Causal Factor Tabulations and Assessment (Document No. DOT HS-805 085). Washington, DC: National Highway Traffic Safety Administration, USDOT.

The final report presents analyses of data in terms of human and environmental factors. Major human errors found included improper lookout, excessive speed, and inattention to the situation. Environmental causes included obstructions in view and slick roads. Vehicular factors, like brake failure and under-inflation, were the least probable. The knowledge of the actual driving task at hand was seen as unrelated to other factors involved in the accident.

Tseng, W.-S., Nguyen, H., Liebowitz, J., & Agresti, W. (2005). Distractions and motor vehicle accidents: Data mining application on fatality analysis reporting system (FARS) data files. *Industrial Management and Data Systems*, 105(9):1188–1205).

This research applies data mining techniques to evaluate the relationship of driver distraction and car accidents. NHTSA's Fatality Analysis Reporting System (FARS) was used to obtain data used in the research, which focused on the Maryland and Washington, DC area between years 2000 and 2003. Findings suggest that the combination of inattention and certain physical and mental conditions lead to a driver having a higher tendency to crash into non-moving objects. Also, collision into a moving vehicle is much more harmful than into a stationary object. These authors support research in CMV safety in that the same areas for concern (e.g., driver inattention).

Uno, H., & Hiramatsu, K. (2000). Effects of auditory distractions on driving behavior during lane change course negotiation: estimation of spare mental capacity as an index of attention distraction. *JSAE Review*, 21(2):219–224.

Unlike other driver distraction studies, this study focused primarily on auditory distractions not accompanied by visual distractions in driving. Reaction times were observed on participants as their cognitive capabilities in dealing with auditory distractions were tested. As with previous studies, driving performance deteriorated with increased distractions.

Wallace, B. (2003). Driver distraction by advertising: Genuine risk or urban myth? *Proceedings of the Institution of Civil Engineers: Municipal Engineer*, 156(3):185-190.

As opposed to many studies focused on cell phones and in-vehicle tasks as driver distractions, this study examined driver distractions outside of the vehicle and addressed risks to safe driving caused by external distractions. Mainly theoretical discussions were produced and this will likely lead to future research on the topic.

Wang, J-S., Knipling, R.R., & Goodman, M.J. (1996). The role of driver inattention in crashes: New statistics from the 1995 Crashworthiness Data System. *Conference proceedings of the 40th annual meeting of the Association for the Advancement of Automotive Medicine: Vancouver, British Columbia*.

NHTSA has used the CDS to obtain in-depth information and statistics on crashes relating to driver inattention. The paper reports the results from the 1995 CDS data and relays the three forms of driver inattention found from the study: 1) distraction, 2) looked but did not see, and 3) sleepy/fell asleep. The authors focused on the CDS to support hypothesized causes for driver inattention crashes.

White, M.P., Eiser, J.R., & Harris, P.R. (2004). Risk perceptions of mobile phone use while driving. *Risk Analysis*, 24(2):323–334.

Two studies were conducted to observe risk perceptions among drivers. The first observed 199 participants using hand-held mobile phones and found it to be one of the riskiest tasks to perform while driving, as opposed to the relatively small risks found with the use of hands-free mobile phone kits. The second study observed 1,320 participants and found half used a mobile phone while driving. Ultimately, the two studies determined that policy makers act strategically rather than develop “hazard-specific” policies and regulations. The authors focused on impact and controllability in hazardous driving situations and the regulations needed to be made in respect to those situations.

Wogalter, M.S., & Mayhorn, C.B. (2005). Perceptions of driver distraction by cellular phone users and nonusers. *Human Factors*, 47(2):455–467.

This study examined the behavior and perceptions of cell phone users and nonusers on vehicle control and driver distraction. Among the issues studied were how often the drivers used their cell phones and their beliefs about in-vehicle cell phone use. Among a sample of 330 participants, the 28 percent of the participants that were nonusers more strongly believed in the negative effects of driving while talking on a cell phone. Also, cell phone users preferred no cell phone regulations. This study focused on driving risks and regulations that may be applied to limit driver distractibility.

Wierwille, W.W., & Ellsworth, L.A. (1994).Evaluation of driver drowsiness by trained raters. *Accident Analysis and Prevention*, 26(5)571–581.

This study develops a reliable drowsiness measure in CMV drivers during data analysis: the observer rating of drowsiness, a subjective measurement of how drowsy a driver appears in the video data. Six raters were viewed and rated 48 segments of video of the driver's face from a previous driving-simulator study. Participants rated the level of drowsiness from "Not Drowsy" to "Extremely Drowsy," and could choose any point on the continuous scale. Results found that the test-retest reliability was 0.80, showing that raters were consistent within themselves and that intrarater reliability correlations were 0.88. Overall, raters were reliable within themselves and among other raters.

Wierwille, W.W., Hanowski, R.J., Hankey, J.M., Kieliszewski, C.A., Lee, S.E., Medina, A, Keisler, A.S., & Dingus, T.A. (2002) Identification and evaluation of driver errors: Overview and recommendations. (Report no. FHWA-RD-02-003). Washington, DC: Federal Highway Administration, USDOT. Online executive summary retrieved August 26, 2009, from: http://www.tfhrc.gov/humanfac/02003execsum.htm

This report offers a definition for "driver error" as a general term used to develop taxonomies of driver error and determine the associated causes. Instead of focusing on in-vehicle distractions, the report emphasizes causes and concerns for driver error and outlines many cognitive mistakes drivers make while behind the wheel. The data from this report supports hypothesized concerns on driver error for all vehicles.

Young, K., Regan, M., & Hammer, M. (2003). Driver distraction: A review of the literature. (Report no. 206). Victoria, Australia: Monash University Accident Research Centre. Retrieved August 26, 2009, from: http://www.monash.edu.au/muarc/reports/muarc206.html

The authors provide a comprehensive review of the available driver distraction literature. The focus of the review is internal driver distraction, such as cell phone use and GPS systems and non-technology based behaviors such as eating and talking to passengers. The authors look at various methods used to measure driver distraction and indicate the most promising methods. Recommendations for the management of driver distraction are also provided at the end of the report.

Young, M.S., Mahfoud, J.M., Walker, G.H., Jenkins, D.P., & Stanton, N.A. (2008). Crash dieting: The effects of eating and drinking on driving performance. *Accident Analysis and Prevention*,40(1):142–148.

Many driver distraction studies focus on the effect of cell phones on driving performance. However, eating and drinking while driving is common. Although it is seen as a lower risk by many drivers, this distracter can affect vehicle control as much as cell phones. Eating and drinking while driving increases the mental workload, leading to more crashes when a driver is faced with a safety-critical event. This effect may be greater in long haul drivers as it is more common for these drivers to drink coffee or a soft drink to ward off sleepiness. Further research may help to evaluate the detrimental effects on driver safety.